PROCEEDINGS OF THE SECOND HORTICULTURE SEMINAR ON

SUSTAINABLE HORTICULTURAL PRODUCTION IN THE TROPICS

6th to 9th August 2002, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Juja – KENYA

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PREFACE

Horticultural sector remains an important foreign exchange earner to Kenya and contributes significantly in the local diets. Fresh horticultural crops are identified as commodity group for which there is high demand and are of great value nutritionally for local and export markets. Development of this sector will stimulate economic growth and provide employment opportunities given the relatively high premium price attached to these crops. Due to growing competition for both domestic and export markets, growers require technologies which will exert less pressure on the available inputs, environment and guarantee good health. Consequently, there is need to strongly develop technological options for sustainable production and post-harvest handling.

The first seminar on sustainable horticulture production in the tropics was held between 3rd and 6th October 2001. At the end of this seminar, three working groups namely: **Export Crops, Biotechnology** and **Indigenous Vegetables** were installed. The aim of the seminar was to concentrate on important issues in the wide field of 'sustainable horticultural production'. The results of these discussions were published in the SvePiT Newsletter (http://www.gartenbau.uni-hannover/gem/svepit.htm) to complement the hard copy proceedings of the seminar (Wesonga *et al*. 2002).

In this second seminar, the first two days were spent on scientific exchange through oral and poster presentations. Half the sessions were dedicated to the working groups while the rest were plenary sessions where the discussions focussed on two key areas (i) **Ways to a pesticide-reduced horticultural production in the tropics** and (ii) **Efficient water and nutrient use in horticultural production in the tropics.** These discussions continued on field trips on days 3 and 4 to horticultural production sites in Eastern Kenya. The working groups identified various activities to be followed up and impelementd.

The Seminar Organising Committee would like to thank all the authors who presented papers contained in these proceedings. We would also like to express our appreciation to all the individuals who singly or collectively contributed to the organization and the ultimate success of the seminar.

Very special thanks go to the German Academic Exchange Service (DAAD) for the financial support that made the seminar a great success. Special thanks go to Mr. C. Etzold, The Regional Director, DAAD for officially opening the seminar. We are also indebted to the University of Hannover for the collaboration that made the workshop a great success.

We greatly thank the chairpersons of the sessions, rapporteurs, the editorial staff and all other Department of Horticulture staff members for their various contributions.

Finally, we wish to sincerely acknowledge the support received from the Vice-Chancellor of JKUAT, Prof. R.W. Michieka, Deputy Vice Chancellors, Prof. S. G. Agong, Prof. H. Thairu and Prof. S.K. Sinei. We in particular would like to thank Prof. S.K. Sinei, the Deputy Vice Chancellor (Research, Production and Extension) for officially closing the seminar.

OFFICIAL OPENING SPEECH

SPEECH BY MR. C. ETZOLD, REGIONAL DIRECTOR, DAAD ON THE OFFICIAL OPENING OF THE SECOND SEMINAR ON SUSTAINABLE HORTICULTURAL PRODUCTION IN THE TROPICS ON AUGUST 6th, 2002

The Ag Vice-Chancellor, JKUAT,

Deputy Vice Chancellors, JKUAT,

Directors of Institutes and Government Departments,

Distinguished Guests,

Ladies and Gentlemen.

It gives me great pleasure to participate in the opening ceremony of the Second Workshop on "Sustainable Horticultural Production in the Tropics." At the outset, I would like to welcome all participants to the Jomo Kenyatta University of Agriculture and Technology (JKUAT).

This workshop is a continuation of a similar workshop held here, at JKUAT, last year. Most of the sessions ahead of us, starting today, will provide us with various findings from the groups that were formed at the conclusion of the last workshop.

Participants, we are again gathered here at JKUAT for a timely and very important workshop in Africa as a whole, to discuss pertinent issues that affect our people in the area of horticulture.

In the recent past, experts in the agricultural sector have been holding seminars and conferences that address food issues in this continent where millions of people have been forced to depend on food aid. As noted earlier, about 50 per cent of Kenyans live below the poverty line. Such workshops seek to provide solutions to sustainable food production, hence food security in this continent. Indeed, indigenous food crops, among them the horticultural products have come in handy and have supported most families against the effects of drought and famine.

It is upon this realization that the deliberations from these workshops are expected to go a long way to spur development in the agricultural sector as a whole, hence creating an impact in the economies of our people. I am confident that we are handling a very crucial subject and perhaps the key to Africa's food sustainability.

Ladies and gentlemen, I wish to reiterate the importance of the horticultural sector in Kenya's economy. It has been noted in the previous workshops that this sector is a major foreign exchange earner for this country, coming second after tourism. Therefore, the growth of this sector is expected to create more employment opportunities and reduce the level of poverty among the farmers who depend on horticultural products for their income. It is estimatedf that horticulture contributes well over Kshs. 14 billion annually. This is a significant contribution that can strongly energize the country's economic growth.

However, the challenges in the local and international market, together with restrictions imposed on horticultural products have adversely affected small-scale farmers, especially in Africa. Although most of them have the zeal to reap maximum profits from the market, they lack the adequate information on the market, efficient means of production and processing of their products. The

pathetic situation has caused havoc among most small-scale farmers who have to grapple with poor infrastructure and lack of funds to purchase quality seed and pesticide.

Suffice to say that our main objective as researchers and stakeholders in the horticultural industry is to unravel the myriad problems affecting farmers who might not be endowed with the information and facilities at our disposal. The previous workshop had a rich menu ranging from socio-economic issues, plant propagation, plant nutrition, crop improvement and integrated horticultural production systems, among others. We look forward to explore the same during this second workshop.

Ladies and gentlemen, let me underscore the importance of field trips to horticultural sites during such workshops. The trips are part of the activities that bridge indoor discussions among the participants. As a matter of fact, we direly need to understand what the farmers are doing out there. This puts meaning to the case studies mentioned in various presentations; and the interactions between the farmers and experts are quite enriching.

Participants, the Kenya Government has continued to make major contributions to the agricultural sector, especially policies and recommendations aimed at improving the lifestyle of the farming community. It is our hope that the government will put down necessary structures to make the horticultural industry flourish both in the local and international market.

As local universities, we look forward to expanding our collaborations with other universities outside Kenya, including the relevant research institutions and the private sector.

Finally, ladies and gentlemen, I am proud of your heartfelt gratitude to the German Academic Exchange Service (DAAD) for the financial support that has facilitated these workshops. DAAD will continue to offer necessary support to various academic programmes and workshops, for the growth of education in Africa. Still, DAAD lauds the collaboration between Jomo Kenyatta University of Agriculture and Technology and the University of Hannover, Germany, which has added life to these workshops. We are proud of this joint initiative.

With these remarks, it is now my pleasure to declare this workshop officially open.

Thank you.

RAPD Profiling of Some Banana (*Musa* spp.) Varieties Selected by Small Scale Farmers in Kenya

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Abstract

Participatory Rural Appraisal (PRA) method was used to identify seventeen Musa cultivars that were rated highly by the small-scale farmers in Kenya. The cultivars were studied alongside five reference cultivars of genomic groups AA, AB, AAA, AAB, and ABB. This investigation was done to uncover the genomic groups prevalent among the Kenyan cultivars, as well as sort out synonyms to enable in vitro production of true-to-type plants. Random Amplified Polymorphic DNA (RAPD) markers with ten 10-mer primers was used for molecular characterisation. The primers generated sixty-nine genetic markers that were used in estimation of genomic groups and cultivar identification. Pairwise RAPDistance analysis of the data and subsequent generation of a dendogram using the 'Neighbour Joining Tree' programme grouped the cultivars into two major clusters depending on their genomic similarities. One cluster comprised of the Kenya-highland bananas, which grouped with the AAA reference cultivar 'Poyo'. The other cluster contained the coastal lowland cultivars, which grouped with the ABB, AAB, and AB reference cultivars 'Saba', `Kelong Mekindu`, and `Safet Velchi' respectively. The dissimilarity analysis between the samples did not indicate duplication among the banana accessions. Each cultivar was genotypically different although some were closely related.

Introduction

Bananas and plantains are important food crops throughout the tropical and sub-tropical regions of the world. They are the third world's most important starchy staple after cassava (*Manihot esculenta* Crantz) and sweet potato [*Ipomoea batatas* (L.) Lam.] (FAO, 1987). Africa is the largest consumer of this staple with production averaging 24 Mt out of a total world production of 88 Mt. The two main centres of banana production in Africa are the wet tropical zones of West and Central Africa and the East African Highlands. The latter region makes up around 70% of the total region production with an annual per-capita consumption of about 220-kg, the highest in the world.

Banana and plantains belong to the genus *Musa* whose center of origin is South East Asia (INIBAP, 1999). *Musa* clones producing edible fruits are derived from two species, *M. acuminata* (A genome) and *M. balbisiana* (B genome). While spontaneous polyploidisation within *M. acuminata* formed the triploid (AAA) cultivars, the natural interspecific hybridisation of both species formed plantains (AAB) and cooking bananas (ABB) characterized by starchy fruits and the diploid (AB). Domestication of edible forms was associated with the emergence of sterile parthenocarpic types, which have been selected and propagated vegetatively. Somatic mutation that occurred during long-term asexual propagation represents an additional source of genetic variation for the development of new clones.

It is estimated that commercial banana plantations account for only about 10% of the world production while the remaining 90% is grown on small-scale subsistence farms or in the backyard gardens (INIBAP, 1991). However, most of these small-scale farmers are faced with a number of problems such as lack of quick multiplication methods and unavailability of clean planting material. These factors have led to reduced yields, lack of expansion, and extinction of banana orchards. Agronomic improvement of banana through conventional breeding has been frustrated by the crops' high sterility levels and polyploidy. Micropropagation has been identified as an alternative to the conventional approaches as it is quick and enables the production of disease-free seedlings.

Jomo Kenyatta University of Agriculture and Technology (JKUAT) has an on-going project that involves the introduction of micropropagated (tissue-cultured) bananas to the small-scale farmers with limited resources. To be successful, however, there is need for proper selection and identification of cultivars of interest by involving the small-scale farmers themselves. Selection of farmer-preferred cultivars could be achieved through the use of Participatory Rural Appraisal (PRA). Characterisation and classification of the farmer-selected cultivars represents another essential step in the micropropagation of true-to -type *Musa* clones for high quality planting material.

Traditionally, characterisation and classification of bananas has been accomplished by use of morphological descriptors (Stover and Simmonds, 1987). Although classical phenotypic features are still extremely useful, age and/or developmental stage as well as environmental effects on measured traits may reduce the efficiency of identification. In the East African Highlands, the farming community complicates the matter even further by conferring local names (in local dialect), which has resulted in over 300 synonyms for banana cultivars. This has frustrated efforts to collect, identify, classify and micropropagate true-to-type banana cultivars while avoiding duplication. Close genetic relationships among cultivars as well as frequent spontaneous somatic mutations and the instabilities generated during *in vitro* culture (somaclonal variation) contribute further major obstacles to the correct identification of a clone.

Many of the constraints of the phenotype-based identification can be alleviated by direct characterisation using biochemical markers based on protein isoenzymes (Bonner et al., 1974; Jarret and Litz, 1986; Bhat et al., 1992a and 1992b; Lebot et al., 1993). Nucleic acid markers such as Restriction Fragment Length Polymorphism (RFLP) (Gawel et al., 1992; Jarret et al., 1993), rRNA spacer-length heterogeneity (Lanaud et al., 1992), variable number tandem repeats (VNTRs) (Kaemmer et al., 1992) and Random Amplified Polymorphic DNA (RAPD) (Kaemmer et al., 1992; Bhat and Jarret, 1995; Damasco et al., 1996) could also be used. This study was undertaken to assess RAPD polymorphism in 17 banana cultivars that were rated highly (in terms of eating quality, economic importance and cultural values) by small-scale farmers during a Participatory Rural Appraisal (PRA) survey in Kenya (Kahangi, 1999).

Specifically, the objectives of the study were;

- To identify and select economically important banana cultivars that are of value to the poor resource farmers in Machakos and Kakamega districts of Kenya.
- To characterise by means of RAPD, important cultivars to enable in vitro production of true- to- type plants in a pilot tissue culture laboratory (with a capacity of 0.5 million plants) at Jomo Kenyatta University of Agriculture and Technology (JKUAT).
- To sort out synonyms and thereby avoid culturing similar cultivars under different names.
- To examine the genetic diversity prevalent among these cultivars and possibly uncover their genomic groups.

Materials and Methods

Participatory Rural Appraisal (PRA)

PRA is a bottom-up social science approach that involves farmers in decision-making (giving great consideration to gender balance). A reconnaissance survey with the aim of gathering background information and selecting actual sites marked the first step of this study. Two districts were chosen for this study; Machakos and Kakamega (Table 1).

Table 1: Geographical Information of selected sites

District	Sub-Location	AEZ	Mean ann. R/fall (mm)	Mean Temp. (^{0}C)	Altitude (m ASL)	Soils
Machakos	Kithendu	LM4	700	21.6 - 28	900 –1200	Rhodic ferralsols and orthic acrisols
	Kauti	UM4	900	11.5 - 26	1340 - 1620	Chromic and ferric acrisols
Kakamega	Kigama	UM1	1875	11.4 - 25.8	1675	Chromic and orthic acrisols
	Emuhaya	LM1	1788	15.2 - 25.9	1615	rhodic and orthic ferralsols

A matrix scoring method was used to elicit information on crops grown in the study areas and how bananas compared with the other crops (Table 2).

Table 2. Ranking of Important Crops

	Machakos District		Kakamega District	
Crop	**Kithendu**	**Kauti**	**Emuhaya**	**Kigama**
Banana	2	5	3	1
Maize/Beans	1	1	1	3
Sweet potato	5	-	4	5
Cassava	7	-	2	6
Fruit trees	8	6	8	8
Sugar cane	-	-	5	9
Pawpaw	9	-	9	-
Vegetables (Kales, Tomato etc.)	6	4	-	4
Coffee	-	2	--	10
Tea	-	-	-	2
Pigeonpea	4	3	-	2
Asian vegetables	3	7	-	-
Cowpea	10	-	-	-
Sweet corn	-	8	-	-
Groundnut	-	-	6	-
Cocoyams	-	-	7	-
Sorghum	-	-	-	7

The PRA results showed that banana is an important food and cash crop to the small-scale farmers in the four sub-locations that were studied. The same method was used to list and rank the different banana cultivars that were grown in the study area (Table 3).

Table 3: Ranking of Banana Varieties in order of Importance

Machakos District		Kakamega District	
Kithendu	**Kauti**	**Emukaya**	**Kigama**
1. Ndivi	1. Mulalau	1. Shisikame	1. Kisigame
2. Mbogoyo	2. Mutavato	2. Olusolio	2. Sialumuli
3. Mulalau	3. Ndivi	3. Shinali	3. Jamaga
4. Kiganda	4. Kamunyuru	4. Bokoya	4. Mutuli
5. Mutavato	5. Kiganda	5. Mushira Kwangwe/ Sweet banana	5. Sweet banana
6. Sweet banana	6. Katithi	6. Mulalu	6. Mulalu
7. Kasukali	7. Sweet banana	7. Gonja	7. Ndizi fupi
8. Yellow banana	8. Kisukali	8. Nyoro	8. Uganda Red
9. Red banana	9. Red banana	9. Lisotsi	
	10. Kisukali kya Kiganda		

Plant material

From the PRA study, 11 cultivars from Kakamega, and 2 from Machakos were selected for characterization including 4 important cultivars from central and 2 from coastal regions (Table 4). Two diploid species, AA and AB, and three triploid AAA, AAB, and ABB were included as reference material. They were obtained from the INIBAP Musa Germplasm Transit Centre in Belgium. Molecular characterisation was done at the Biotechnology Centre in Rutgers, the State University of New Jersey, U.S.A. The banana cultivars were brought from JKUAT, Kenya; either in tissue culture form or as mature leaves maintained on ice.

Table 4: Characteristics of Banana Cultivars used in the study

Name/Region	*Uses*	*Source material*	*No. used*
Kakamega			
Shisikame	*Vegetable and dessert*	*TC*	*1*
Siaramule	*Vegetable and dessert*	*Mature leaf*	*2*
Kisii Sweet	*Dessert*	*TC*	*3*
Kisigame	*Vegetable and dessert*	*Mature leaf*	*11*
Jamaga	*Vegetable*	*Mature leaf*	*15*
Gonja	*Vegetable*	*Mature leaf*	*14*
Lisotzi	*Vegetable*	*Mature leaf*	*16*
Mutuli	*Vegetable*	*TC*	*12*
Mkira Kwa Ngwe	*Vegetable*	*Mature leaf*	*10*
Machakos			
Kiganda	*Vegetable*	*TC*	*5*
Mutahato	*Vegetable*	*Mature leaf*	*17*
Coast			
Mkono wa Tembo	*Vegetable*	*Mature leaf*	*9*
Bokoboko	*Vegetable*	*Mature leaf*	*8*
Central			
Kisii matoke	*Vegetable*	*TC*	*6*
Njuru	*Dessert*	*TC*	*7*
Golden Beauty	*Dessert*	*TC*	*4*
Munyegenya	*Dessert banana*	*TC*	*13*
Belgium			
Poyo	*AAA*	*TC*	*18*
Saba	*ABB*	*TC*	*19*
Kelong Mekindu	*AAB*	*TC*	*20*
Niyama Yik	*AA*	*TC*	*21*
Safet Velchi	*AB*	*TC*	*22*

Banana varieties ranked highly by small-scale farmers from Machakos, Kakamega, Central and Coastal regions in Kenya. Reference varieties were provided by INIBAP, Belgium

DNA extraction

Two methods of DNA extraction were applied. The first attempt made use of the procedure described by Dellaporta et al. (1983). The other method used was the 'Phytopure Plant DNA Extraction Kit' (Nucleon Bioscience). In both methods, 0.1 g of leaf tissue was ground to a fine powder in liquid nitrogen in a pre-cooled pestle and mortar. The DNA pellet was re-suspended in distilled water and stored at 4^{o}C. For quantification, 5 and 10 µl of banana DNA was separated by electrophoresis alongside known amounts of bacteriophage lambda DNA (250, 100, 50 and 25 ng). The concentration of banana DNA was estimated by comparing the intensity of the banana genomic DNA band with the uncut bacteriophage lambda DNA samples.

DNA amplification and electrophoresis

DNA amplification reactions were performed in volumes of 50 µl containing 40 ng of high molecular weight genomic template DNA, 2.5 mM $MgCl_2$, 400 µM each of dATP, dTTP, dCTP and dGCP, 0.6 µM primer (Operon Technologies), 1.25u recombinant Taq Polymerase, (Gibco BRL) and 10x PCR buffer (200 mM Tris-HCl pH 8.4, 500 mM KCl). These concentrations were derived by prior preliminary experiments. Amplifications were performed in a Perkin-Elmer PCR System 9700. PCR cycling conditions were 5 min denaturation at 94^{o}C followed by 40 cycles each at 94^{o}C for 1 min, 30^{o}C for 1 min primer annealing and 2 min extension at 72^{o}C. This was followed by a single final extension period of 10 min.

The Primer annealing temperature used was 2-3^{o}C below T_m depending on the primer. A sample of 20 primers that were reported by earlier workers (Bhat and Jarret, 1995; Kaemmer et al., 1992; Damasco et al., 1996) to produce good, consistent and informative results in DNA fingerprinting of bananas was tested in a preliminary experiment. Ten of these primers (OPA-03, 04, 07,08,10,11 and 16, OPC-08, 10 and 11) were selected for this study.

The amplification products were mixed with loading buffer containing bromophenol blue, separated electrophoretically on 1.8% agarose (Fisher Scientific) gels in 1 x TAE buffer, stained with ethidium bromide and PCR products visualised under UV light and photographed using Bio-RAD Gel Doc 1000.

Data analysis

For purposes of data analysis, only amplification products that were reproducible over two amplifications were included. PCR products were scored as discrete variables; a score of '1' for presence and '0' for absence of a homologous band. The resulting matrix was used to calculate Hamman pairwise RAPD distances between the samples. The latter were subsequently subjected to 'Neighbour Joining Tree' program to generate a dendogram. All data analysis was performed using the RAPDistance Package (Armstrong et al., 1996).

Results and Discussion

Participatory Rural Appraisal

The PRA results showed that banana is an important food and cash crop to the small-scale farmers in the two districts. This is probably because banana yields all year round, requires very little input, and because a lot of the landraces are drought tolerant. It was also clear that different regions of the country had named different banana cultivars in their own dialects, necessitating the need for characterisation to eliminate duplication. The farmers remarked that because of long years of cultivation, banana orchards had become old and unproductive. Tissue cultured banana was seen as an option of reviving banana production and farmers were willing to try them.

Molecular Characterisation

DNA extraction

The DNA extracted using the Dellaporta et al. (1983) method failed to reproducibly amplify by PCR. DNA extracted by 'Phytopure Plant DNA Extraction Kit' gave good and reproducible PCR products. The success with the latter protocol was attributed to its application of a resin that covalently binds polysaccharides resulting in a high quality DNA preparation. Polysaccharides are very common contaminants in plant DNA extracts that can be inhibitory to further enzymatic analysis of the DNA (Li and Midmore, 1999).

Estimation of genomic groups

The ten primers used in this study generated 69 markers from which was computed a dissimilarity matrix (Table 5) and a dendogram (Figure 1) using the RAPDistance Package (Armstrong et al., 1996). The dendogram showed a gradient from purely M. acuminata (A) genome to M. balbasiana (B) genome. Within the 22 cultivars examined, (inclusive of five reference cultivars) two clusters were evident; a group comprising the AAA and the other containing the AA, AB, AAB and ABB cultivars.

The AAA sub-species contained more than half of the 17 Kenyan banana cultivars included in this study and were separated from their ancestral diploid group (AA). The cultivars that clustered with the AAA reference 'Poyo' were; 'Njuru', 'Golden Beauty', 'Mutahato', 'Mutuli', 'Mukira Kwa Ngwe', 'Kisigame', 'Kisii Matoke', 'Kiganda', 'Siaramuli', 'Munyegenya', 'Kisii Sweet', and 'Shisikame'. The last three formed a separate sub-group within the AAA cluster. The M. acuminata sub-species complex is reported as being extraordinarily diverse and Tezenas du Montcel (1990) and Lebot et al. (1993) have proposed a role for specific sub-species in the evolution of individual cultivars. Variations within the M. acuminata sub-species complex may account for the rather wide separation of the fertile diploid (AA) from their cultivated AAA relatives. Alternatively the wide separation of the diploid AA types from the cultivated AAA triploids may be due to the effects of repeated selection/mutation among the cultivated M. acuminata that has resulted in a cultivated M. acuminata that is significantly different from its ancestral diploid progenitor(s) (Bhart and Jarret, 1995).

Table 5: Dissimilarity coefficients between 20 genomes based on DNA fingerprints

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1																			
2	0.85	1																		
3	0.67	0.60	1																	
4	0.64	0.62	0.81	1																
5	0.57	0.52	0.70	0.72	1															
6	0.68	0.61	0.51	0.54	0.65	1														
7	0.68	0.72	0.54	0.58	0.60	0.72	1													
8	0.70	0.62	0.56	0.54	0.48	0.59	0.64	1												
9	0.76	0.64	0.58	0.54	0.51	0.62	0.63	0.83	1											
10	0.79	0.82	0.56	0.52	0.46	0.65	0.75	0.66	0.69	1										
11	0.80	0.72	0.67	0.63	0.54	0.64	0.69	0.82	0.78	0.74	1									
12	0.85	0.72	0.63	0.55	0.54	0.65	0.70	0.76	0.88	0.80	0.81	1								
13	0.79	0.65	0.57	0.50	0.55	0.66	0.64	0.62	0.70	0.75	0.74	0.83	1							
14	0.78	0.76	0.56	0.57	0.55	0.66	0.76	0.71	0.69	0.77	0.78	0.78	0.74	1						
15	0.50	0.47	0.52	0.57	0.47	0.49	0.52	0.59	0.59	0.49	0.55	0.54	0.51	0.58	1					
16	0.52	0.49	0.58	0.56	0.51	0.50	0.51	0.60	0.64	0.52	0.57	0.59	0.56	0.60	0.87	1				
17	0.49	0.45	0.56	0.57	0.52	0.47	0.51	0.54	0.51	0.47	0.53	0.50	0.47	0.55	0.69	0.68	1			
18	0.62	0.65	0.53	0.53	0.55	0.59	0.74	0.62	0.62	0.60	0.61	0.61	0.58	0.67	0.49	0.51	0.67	1		
19	0.61	0.63	0.48	0.49	0.51	0.61	0.69	0.57	0.61	0.62	0.60	0.60	0.63	0.60	0.43	0.42	0.54	0.81	1	
20	0.76	0.63	0.54	0.52	0.49	0.66	0.62	0.77	0.83	0.69	0.74	0.80	0.76	0.67	0.56	0.56	0.48	0.59	0.69	1

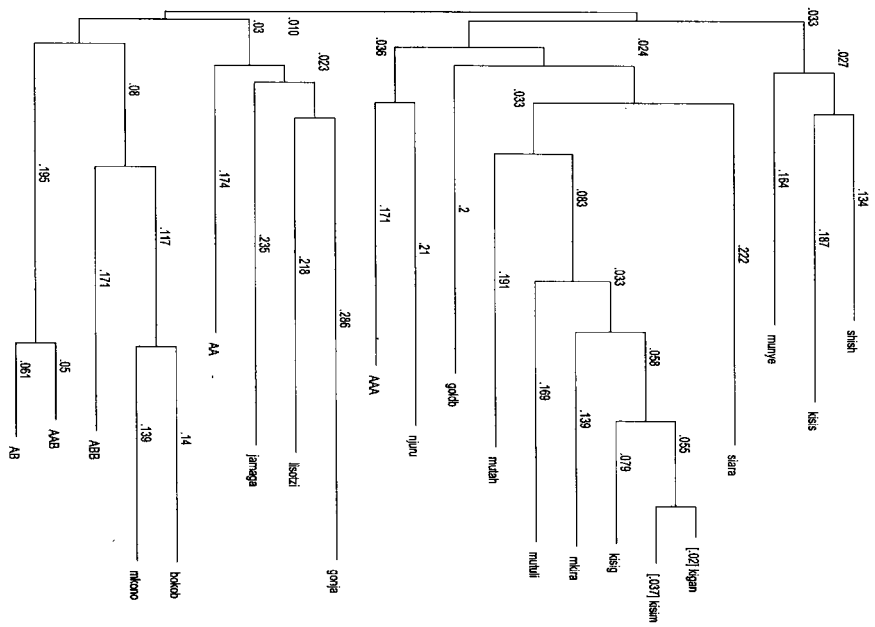

Fig. 1: Dendogram resulting from analysis of RAPDs depicting the relationships between 22 Musa accessions.

1	shish--Shisikame	12	mutuli --Mutuli
2	siara -- Siaramule	13	munye --Munyegenya
3	kisis -- Kisii Sweet	14	gonja --Gonja
4	goldb-- Golden Beauty	15	jamaga--- Jamaga
5	kigan-- Kiganda	16	lisotzi ---Lisotzi
6	kisim--Kisii Matoke	17	mutah --Mutahato
7	njuru-- Njuru	18	AAA --Poyo
8	bokob--Bokoboko	19	ABB --Saba
9	mkono --Mkono wa Tembo	20	AAB -- Kelong M ekindu
10	mkira -- Mkira kwa Ngwe	21	AA --Niyama Yik
11	kisig-- Kisigame	22	AB -- Safet Velchi

Lebot *et al*. (1993) reported that the genome of the AAB and ABB groups examined in their study was similar. RAPD analysis by Bhart and Jarret (1995) put the AB and ABB banana varieties in the same cluster. The RAPD analysis in this study showed similar results. The ABB, AAB and AB groups were put in the same cluster, but AB and AAB formed a closer sub-group within this cluster (Figure 1). The bananas that clustered with the AB, ABB, and AAB reference cultivars (Saba, Kelong Mekindu and Safet Velchi) were; 'Mkono Wa Tembo' and 'Bokoboko' which are grown at the coastal low region and are different from the upland bananas that clustered with the AAA reference cultivar. This is in agreement with Stover and Simmonds (1987), who observed that the upland cultivation is based primarily on AAA types, none of which is known with certainty anywhere else. Contrasted with the upland cultivation are the coastal cultivars, where the AAA types are relatively few and unimportant and edible (AA) and hybrid triploid types (AAB and ABB) predominate.

The (AA) diploid reference cultivar (Niyama Yik) formed a sub-group within the AB, AAB, and ABB cluster and included cultivars 'Jamaga', 'Lisotzi' and 'Gonja'. By use of morphological descriptors

Stover and Simmonds (1987) listed 'Bokoboko' as ABB and 'Mkono Wa Tembo' and Gonja as AAB which means that the last two are plantains.

Cultivar identification

The vegetatively cultivated varieties of Musa species have diversified mainly due to accumulation of spontaneous mutation (Simmonds, 1966; Simmonds, 1962). Daniells (1990) described 28 sports of the Cavendish (AAA) subgroup derived from a single clone. Distinguishing such closely related cultivars would require highly discriminating molecular markers. Use of highly discriminating markers based on simple sequence repeats (SSR) would help greatly in distinguishing relationships within the more narrowly defined AAB and ABB group cultivars (Bhat and Jarret, 1995). The 69 RAPD markers generated from ten primers were sufficient to distinguish all the 22-Musa accessions. Typical RAPD profiles obtained using four different 10-mer primers are shown in Figure 2.

Polymorphisms detected using these primers were sufficient to distinguish cultivars that are almost indistinguishable using morphological descriptors. For example, cultivar 'Kisii Matoke' and 'Kiganda' differ only in bunch size and are otherwise morphologically identical. These two cultivars were distinguishable with primer OPA-03 (results not shown). However, the two cultivars showed only 5% dissimilarity. Some cultivars had over 80% dissimilarity (Table 5). Kaemmer et al. (1992) were able to estimate the relatedness of 15 banana clones from 55 markers. The number of RAPD markers (and therefore the number of primers) needed varies with the test material. When the variation between cultivars is high, the use of a few primers will be sufficient (Li and Midmore, 1999). For instance, 11 navy bean genotypes were satisfactorily distinguished by only two primers (Graham et al., 1994) while Mori et al. (1993) identified 36 Japanese potato cultivars with 15 polymorphic RAPD markers generated by five primers. However, more primers will be needed for more closely related cultivars (Li and Midmore, 1999).

Problems associated with clonal classification emphasise the need for complementary keys for the identification and characterisation of Musa cultivars and demonstrate the usefulness of RAPDs for these purposes. This study indicates that RAPD markers are readily detected and analysed in Musa and that this technique lends itself to germplasm characterisation

The banana cultivars used in this study are being micropropagated for small-scale farmers in a pilot tissue culture laboratory at JKUAT, Kenya. One of the objectives of the study was to use RAPD to sort out synonyms resulting from the practice of conferring names in local dialects. From these results it can be concluded that there was no duplication among the banana accessions collected from Kakamega and Machakos districts, as well as in central and coastal regions of Kenya. Each cultivar is genotypically different although some are closely related.

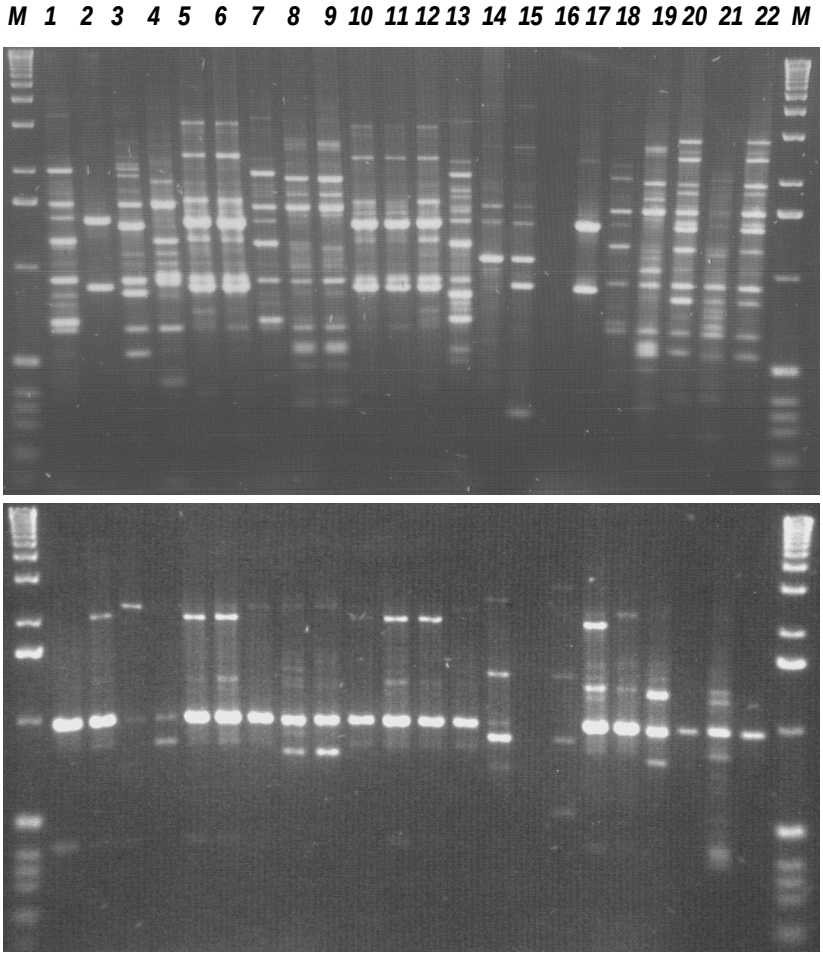

Fig. 2: RAPD profile of samples from Musa plants amplified with primer (OPD-16) above and (OPD-07) below. Lanes 1-22 are: (1) Shisikame (2) Siaramule (3) Kisii Sweet (4)Golden Beauty (5) Kiganda (6) Kisii Matoke (7) Njuru (8) Bokoboko (9) Mkono wa Tembo (10) Mkira Kwa Ngwe (11) Kisigame (12) Mutuli (13) Munyegenya (14) Gonja (15) Jamaga (16) Lisotzi (17) Mutahato (18) Poyo (AAA) (19) Saba (ABB) (20) Kelong Mekindu (AAB) (21) Niyama Yik(AA) (22) Safet Velchi (AB). 1kb DNA promega ladder (lane) was used.

Somaclonal variation is common in Musa in vitro cultures (Vuylsteke and Swennen, 1990; Daniells, 1997). A specific RAPD marker that differentiates dwarf mutants from tissue-cultured banana was identified (Damasco et al., 1996). This demonstrates that analysis using RAPD markers at the in vitro stage affords a reliable means for detection of dwarf mutants allowing for early elimination of dwarfs before planting of micropropagated plants in the field. In addition RAPD markers could be particularly useful for testing integrity of in vitro plants. The RAPD profiles for the principal cultivars that were developed in this study will be useful in monitoring genetic stability while micropropagating them for the small-scale farmers at JKUAT tissue culture laboratory. Daniells (1997) reported that DNA fingerprinting for the identification of plants is the only way to prevent variety mix-up in a tissue culture laboratory. It is very important that the genetic diversity of the cultivars studied here is now characterised and documented and the germplasm conserved and maintained at JKUAT in in vitro form and in the field.

The authors gratefully acknowledge the Council for International Exchange of Scholars for providing and administering the funds to do this work. The authors express their gratitude to INIBAP/Belgium for providing the five varieties used as reference material in this study.

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Questions/Comments and Answers

Koech: Did you try other methods like coenzyme of RFLP's for checking the micropropagated varieties?

Response: No. We did not but we have students working on AFLP for the same banana varieties and those from Mt. Kenya region.

Micropropagation of Disease-Free Planting of Passion Fruit (*Passiflora edulis* Sims)

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Abstract

Passionfruit is among the important fruits exported from Kenya, ranking third after mangoes and avocados. However, more than 50 % of the total hactarage is destroyed annually by diseases such as fusarium wilt (*Fusarium oxysporum*), brown spot (*Alternaria passiflorae*), phytophthora root rot (*Phytophthora* spp.) and passionfruit woodiness virus (Potyvirus complex).

Use of resistant varieties is the surest way to reduce disease problems and hence reduce usage of pesticides. However, where resistance is not available or not yet identified, using clean planting material goes along way in establishment of orchards with plants strong enough to withstand pest pressure for along time and sometimes throughout the economic lifespan. Starting with clean planting material also reduces spread of pests and hence reduces usage of pesticides.

A study was carried out on the possibility of using tissue culture technology for propagation of clean passionfruit planting material. Nodal segments were excised from passionfruit cuttings maintained under screen house conditions and initiated on MS (Murashige and Skoog, 1962) medium supplemented with 0.1 mg/L BAP, 0.2 NAA and 2.15 Kinetin and maintained under growth room conditions for 4 weeks. To eliminate

passionfruit woodiness virus, *in vitro* seed germination of the purple passion fruit was also initiated on different germination media so as to supply a clean source of explants.

Results indicated that endogenous contamination was a major problem when explants were obtained from mature field-grown vines. The multiplication rate *in vitro* was also limited to 1-2 shoots per nodal explants within 2-3 months. On *in vitro* seed germination hormone-free MS medium coupled with seed scarification gave more than 50% germination with vigorous seedlings.

It is hoped that explants derived from such seedlings if used for shoot proliferation may provide disease-free planting material. Tissue culture technology may also lead to multiplication of disease-free planting material of pest resistant cultivars derived from breeding programs thus leading to substantial reduction in pesticide use.

Introduction

The purple passion fruit (*Passiflora edulis*) is commonly grown in Kenya for juice extraction and fresh market both local and export. In terms of export, passionfruit are among the important fruits exported ranking 3rd after mangoes and avocadoes. Currently the acreage under passionfruit production is approximately 5,450 ha with an annual export production of approximately 900 tons. However, more than 50% of the total hectarage is destroyed annually by diseases such as fusarium wilt, brown spot, phytophthora root rot and woodiness virus. For example, in 1997, 18,913 tons were produced from an area of 2075 hectares (MOA, 1997), giving an average production of 9 tons/ha while the potential is over 15 tons/ha.

Selection and breeding of resistant varieties is the surest way to curb disease problems. However, with proper field management and competent IPM strategies, losses due to diseases can drastically be reduced, and one important strategy is to start off field establishment with clean planting material. However, inadequate clean planting material is one of the main production constraints affecting the passionfruit industry in Kenya.

Passionfruit can be propagated either from seed, cuttings grafting or by tissue culture techniques. However, seedling progenies segregate (Manicom *et al*., 2001) and propagation through cuttings pose a problem of propagating systemic viruses. In Kenya, planting material is mainly produced by grafting the purple passion fruit (*Passiflora edulis*) on the yellow passionfruit (*P. edulis f. flavicarpa*), which is resistant to the fusarium wilt, tolerant to phytophthora root rot, nematodes and brown spot (Cox, 1961; Fraser, 2000; Manicom *et al*., 2001). However, a clean, disease-free source of scion material is still a major limiting factor in Kenya.

Due to the problem of systemic viruses in passionfruit, propagation through tissue culture may offer a fast and efficient method of producing clean virus-free planting material. *Passiflora edulis* is self pollinated and genetically fairly homozygous and since potyviruses, which include passionfruit woodiness virus (PWV) is rarely transmitted through seed, a good selection of seed from good healthy producing vines can eliminate this virus. Such seed can be germinated *in vitro* to produce a fairly virus-free explant source (Vos, 2000).

Overall Objective

To develop a protocol for *in vitro* propagation of disease-free purple passion fruit

Specific objectives

i) To develop an efficient procedure for shoot proliferation from explants of pssionfruit

ii) To explore other suitable procedures for cleaning passionfruit of disease

iii) To develop suitable hardening procedures

iv) To ascertain freeness from virus of the produced plantlets using suitable screening procedures

In vitro shoot proliferation studies

Materials and methods

Shoot cuttings were obtained from healthy field grown vines and planted and maintained in the screen house in pots filled with about 500g of sterilised soil medium. New shoots were used as source of explants for *in vitro* shoot proliferation.

Axillary buds with about 5 mm internodes were excised and washed with distilled water added detergent. They were then surface sterilized with 70% ethanol for 30 sec and then 10% Jik (Reckitt & Beckiser) for 5 minutes. Aseptically, explants were then inoculated in test tubes half-filled with MS (Murashige and Skoog, 1962) medium supplemented with 0.1 mg/L BAP, 0.2 mg/L NAA and 2.15 mg/L Kinetin. Cultures were maintained at 27^{o}C under 16 hours light/8 hours dark photoperiod and sub-cultured in similar medium every 2 weeks.

Results

Bacterial and fungal overgrowth was observed on cut ends of explants at the 4th week resulting to 80% death of cultures. To optimize on surface sterilization, cultures were washed with 0.1% mercuric chloride for 5 minutes, which reduced contamination to 60%. Surviving cultures produced 1-2 microshoots within 2-3 months.

Due to the endogenous contamination (ie exudation of bacteria and fungi from within plant tissue) and low shoot proliferation rate, *in vitro* seed germination was tried in order to produce a clean source of explant material.

In vitro seed germination studies

Materials and methods

Purple passionfruit seed was extracted from healthy fruits and fermented for 3 days, washed thoroughly to remove pulp and dried under shade for 3 days. They were surface sterilized in 70% ethanol for 5 minutes, then in 12.6% Jik for 30 minutes (Vos, 2000) and after rinsing 3 times with sterile distilled water, they were dipped in hot water at 50^{o}C for 30 minutes. According to Dias (1990), treatment of seed with hot water before planting reduces the incidences of bacterial spot.

Aseptically, some seeds were scarified by cutting the polar end with a scapel while others were not. Seeds were then germinated using three treatments as follows:

i) Seeds were placed horizontally and half embedded in hormone-free MS medium
ii) Seeds were placed horizontally on paper wick suspended in sterile distilled water
iii) Seeds were placed horizontally on sterile cotton wool saturated with sterile distilled water

Cultures were maintained under 16 hours light/8hours dark photoperiod at 26$\pm$1^{o}C for 2 months.

Results

- Germination was noted in the 2nd wk when scarified seed was used but in the 4th wk in unscarified seed
- Seed scarification improved seed germination by more than 50% in both treatments 1 & 2
- Seed did not germinate on cotton wool in both scarified or unscarified seed

- There was no significant difference in germination % when scarified seed was germinated on either MS medium or paper wick. However, cultures on MS medium were vigorously growing, turgid and with well spread out leaves, while cultures growing on paper wick were weak, thin and flacid with rolled up leaves.

Discussion and Conclusions

On *in vitro* shoot proliferation studies from nodal segments, endogenous contamination resulted to >80% death of cultures despite sound surface sterilization procedures and maintenance of sterile conditions. This suggests that most of the bacterial and fungal diseases of passionfruit are systemic. Exudation of bacteria and fungi from within plant tissues of passionfruit has been reported by Vos (2000) who suggested incorporation of antibiotics in culture medium. Various procedures will be tested for cleaning explants of this contamination.

On *in vitro* seed germination studies, seed scarification improved seed germination by 50% in both MS medium and paper wick and could hence be adopted as a suitable seed pre-treatment. However, MS medium gave the highest germination % and vigorously growing seedlings than paper wick and cotton wool. This could be attributed to additional nutrients available in MS medium particularly sugars. There was also better anchourage of roots immediately after germination in MS medium than in the other media. MS medium has therefore been adopted for use in subsequent studies.

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Questions/Comments and Answers

Ngamau: Was the MS media used for *in vitro* seed germination gelled? If yes, what would the difference between the germination on MS media and paper wick be attributed to?

Response: Yes, MS media was gelled with 8mg/L agar. The vigour of seedlings grown on MS media could be attributed to additional nutrients in the MS medium especially sugars and better anchorage of roots on the MS media.

Ngumi: What hormones did you use for your growth media?

Response: 0.1mg/L BAP, 2.15mg/L Kinetin and 0.2mg/L NAN

MOA Onyango: It has been documented that you get virus free planting material from meristematic tissues. What can you comment of how applicable this can be for passion fruit?

Response: If we can succeed in producing virus free material by just using explants derived from purple passion fruit seeds, I believe is an easier and cheaper technique than going into meristem tip culture. However this suggestion is incorporated in future studies.

Stuetzel: What is the advantage of plant propagation by tissue culture vs. from hybrid seed in passion fruit?

Response: Plant tissue culture helps to produce clonal planting material and in case of passion fruit woodness virus, tissue culture by explants derived from purple passionfruit seed may help to produce plantlets free of the virus. Hybrid seed approach would also be useful to incorporate some degree of resistance to virus; Only there is no currently know resistance in the available accessions for passion fruit.

Hunja: What are the implications of using seeds as opposed to mature vines as explants in terms of physiological maturity?

Response: Even currently grafting in passionfruit is not done using scions from mature vines due to diseases. Rootstock and scion seeds are germinated simultaneously before the purple passionfruit is infected by diseases. We hope grafting rootstocks with scions from the lab will equally be successful. We can still explore the idea of raising both rootstocks and scions *in vitro* and micrografting and thus hardening off already grafted seedlings.

Koech: You mentioned the constraints you faced in your study in from of overgrowth of bacteria and fungi on the media used in the tissue culture. Was it not possible to modify the medium so as to discourage the growth of these microorganisms?

Response: We actually did not go into that. There has been actually suggestion of changing the media, for example the use of antibiotics to discourage the growth of bacteria.

Bulblet Production from Bulbs of *Ornithogalum saundersiae* Bak.

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Abstract

Experiments were done to compare various methods of producing bulblets from bulbs of *O. saundersiae* Bak. The methods compared included scaling and use of cuttings, scooping, scoring and coring of bulbs. Comparisons were also made between various initial storage conditions for all the bulbs or bulb materials used. In scaling, comparisons were also made between scale pieces with or without a piece of the basal plate (disc) and twin scale pieces. The average number of bulblets per bulb produced by scooped bulbs, scales, cuttings, scored and cored bulbs was 40.7, 21.2, 19.8, 10.1 and 7.4, respectively. In scaling, scale pieces without a piece of the basal plate formed the biggest and the highest number of bulblets compared to scale pieces with disc and twin scales. Initial storage of propagation materials in the open enhanced bulblet production compared to storage in the dark or under polyethylene sheeting. Flowered bulbs produced more bulblets than non-flowered bulbs.

Introduction

Ornithogalum saundersiae Bak, commonly known as giant chincherinchee is a popular cut flower that is propagated commercially by bulbs and offsets. This method yields only a few bulbs for subsequent propagation. Availability of planting materials for floricultural crops is a major constraint to increased production of cut flowers among many farmers in Kenya (Kariuki,1993; M'Ribu *et al*.,

1993). Even when available such materials are usually too expensive due to particularly the need for importation cost and payment for breeders rights/royalties. It would, therefore, be of great benefit if alternative methods of producing planting materials were introduced to farmers. Such methods would possibly give higher yields and good quality of planting material.

Ornithogalum saundersiae still has no improved varieties, therefore, a method of increasing planting material that also offers the possibility of being a source of variation would be of great value to the Floricultural industry in Kenya. If developed, such a method could lead to selection of superior plants in terms of production and quality of cut flowers. Plants with attractive morphological characteristics could also be selected in order to increase the number of varieties available for cultivation. This may be achieved through adventitious production of bulblets.

Although most bulbous ornamentals were originally propagated by use of bulbs and offsets, other vegetative methods of propagation have been successfully used. These include scooping, scoring, coring, reaming, scaling, bulb cutting or chipping (Hartman and Kester, 1975; Preece, 1986). Scooping and reaming or scoring (cross-cutting) is used in hyacinth (Hartman and Kester, 1975). Scales, twin scales or single scale sections with a piece of the basal plate are used in *Narcissus, Hippeastrum, Hyacinthus, Lachenalia,* and *Lilies* (Rees, 1972; Yanagawa and Sakanishi, 1980b; Nel, 1983; Okubo *et al*, 1990, Niederwieser and Vielar, 1990; Niimi, 1995; Huang *et al*, 1990; Fernado *et al*; 1994; Miller, 1990).

The objective of this study, therefore, was to investigate various bulblet production methods in *Ornithogalum saundersiae* that may be used for increased production of planting materials and for introduction of varieties of this important cut flower through adventitious bulblet production.

Materials and Methods

Bulblet production from scaling and bulb cuttage.

This experiment was carried out at JKUAT in 1995

Five medium sized bulbs of *Ornithogalum saundersiae* were selected in August 1995 for each treatment and prepared as follows:

a) Bulb cutting : Each bulb was cut into 8 pieces and further divided into cuttings that consisted of 2-4 scales joined by portion of basal plate.
b) Scaling: Each bulb was cut into 8 pieces each and further divided into individual scale pieces without a piece of the basal plate
c) The cuttings and scales were then planted in trays containing moist vermiculite with the proximal end down and put in a green house.
d) Scooping: the entire basal plate was scooping out leaving only the concentric scales.
e) Scoring: the base of the bulb was cut 3-4 times ensuring that the growing point was destroyed.
f) Coring: the centre of basal plate was cored out (about 1cm diameter) to remove the growing points.

The scooped, scored and cored bulbs were each sub-divided into two groups, one group was dipped in a Benlate solution (1g/litre), a fungicide, while the other group was not treated. The materials were then placed in three different conditions: at high humidity under clear polythene sheets; in the open in a greenhouse and in the dark inside a carton in the laboratory. The bulbs were left to callus for three months after which the cuttings and scales as well as scooped, scored and cored bulbs were removed from the three storage conditions and then replanted in November

1995. The remainder, bulblets mainly from cuttings and scales that had been too small to replant and others that arose later were replanted six months after the bulb treatment.

The scales and cuttings were planted on trays with vermiculite while the cored, scored and scooped bulbs were planted in polybags that also contained vermiculite. Five months later, bulblets were separated and planted individually in polybags containing loam soil, sand and farm yard manure in the ratio of 3:2:1, respectively. Routine practices such as watering and pest control was done as necessary.

Data collection commenced at 3 months after bulb treatment, and thereafter was done at 3 month intervals.

The experiment was in a completely randomized block design with 2 factors namely

- bulb treatment methods: scaling; cutting; scoring; coring and scooping and
- bulb storage condition: at high humidity under clear polythene sheets; in the open in a greenhouse, and in the dark inside a carton in the laboratory.

The blocks were fungicide treatment or no treatment.

Data collection

The following measurements were taken on plantlets every 2 weeks; plant height; average number of shoots and average number of leaves. This continued for eighteen months after which it appeared that no new shoots/ bulblets were being formed. At this time all bulblets/plantlets/ shoots formed upto that time were counted.

Bulblet production from various types of scales

Another experiment was done in 1996 at Yamaguchi University, Japan, using only scales. Bulbs were first washed with mild detergent then dippped in Benlate solution (1g/litre) for 1 hour. They were then divided into 8 sections from which scales without a portion of the disc and others with a portion of the disc were obtained. These were then planted on trays containing medium size vermiculite.

The design of the experiment was completely randomized block design with 3 blocks i.e position from which scales were obtained: outer, middle or inner; and 2 factors. The factors were:

- type of bulb from which scales were obtained i.e flowered or non-flowered where the scales were with or without disc portion attached, and
- conditions under which the scales were kept i.e in the open in a greenhouse, inside cartons or under high humidity provided by covering with clear polyethylene sheets. Scales in the dark and under polyethene were kept in the open 1 months later.

Data collection

Three months after planting the scales (9/8/96), the number of bulblets/ plantlets produced by the scales were counted and their length (measured in centimeres) from a sample of 10 bulblets / shoots were in measured and recorded.

In vivo regeneration of bulblets from scales, scale and disc and twin scales of O. saundersiae Bak.

Five experiments were done between April 1997 and June 1997 to compare bulblet production from scales with or without piece of the basal plate and from twin scales. Each of the experiments

was layed out in a completely randomized design with 3 treatments represented by the type of scale i.e scale (S), scale plus a portion of the disc (S+D) and twin scales (TS). 20 scales were planted per treatment. In two of the experiments the data that was collected from the scales pieces included total number of bulblets and their sizes. Bulblets formed were counted from each scale piece and the size of the bulblets was measured from a sample of 10 bulblets. In the other three experiments the data collected also included number of roots per bulblet but only among the bulblets with roots.

Bulblets from these experiments were replanted into polybags after data collection and placed in a greenhouse for observation.

Data analysis

All the data was subjected to analysis of variance and the means were separated using the Duncan's Multiple Range Test.

Results

Bulblet production from scaling and bulb cuttage

The number of bulblets produced by the bulbs treated in different ways and by scales and cutting were significantly different (Table 1). The numbers represent production from five bulbs. Scooped bulbs produced the most bulblets both at 3 months after treatment and at the last count 18 months after treatment (The bulblets produced were 63.8 and 139.8 respectively). These were followed by scales and cuttings which produced 34.3, 71.7 and 3.7, 66.3 bulblets, respectively, but these were not significantly different. Scored and cored bulbs produced the least bulblets 15.2, 35.5 and 13.7, 23.2, respectively and these were not significantly different.

Bulbs, scales and cuttings left in the open for three months before planting or replanting produced the highest number of bulblets, followed by those under high humidity and finally those in the dark. The differences between number of bulblets produced by scales left in the open and the rest was significant (0.1%) but not between those left in the dark and under high relative humidity. At 18 months also, bulbs, scales and cuttings that had been placed in the open produced the most bulblets. The number of these was significantly different but the difference between dark and high humidity conditions was not. There was also a highly significant (0.1%) interaction between the type of material from which bulblets were produced and the conditions under which they were kept.

The plants from bulbs of the experiment started in August 1995 started flowering in December 1997, but most flowered between February 1998 and April 1998.

Table 1: **Effect of bulb cuttage and storage conditions on bulblet production in O. saundersiae Bak.**

	Months from treatment/planting					
Bulb Material	**3**	**6**	**9**	**12**	**15**	**18**
Cored	13.7c[y]	16.2c	17.7c	18.3c	23.2c	23.2c
Scored	15.2c	18.8c	19c	21.5c	35.5c	35.5c
Cuttings	32.7b	66b	66b	66.2b	66.3b	66.3b
Scales	34.3b	71.3ab	71.5ab	71.7b	71.7b	71.7b
Scooped	63.8a	82.7a	82.7a	96a	139.8a	139.8a
Significance[z]	***	***	***	***	***	***
Condition						
Open	40.3a	70.2a	70.3a	73.3a	93.4a	93.4a
Dark	27.3b	43.9b	44b	48.3b	60.1b	60.1b
High Humidity	28.2b	38.9b	39.8b	42.6b	48.8b	48.4b
Significance	***	***	***	***	***	***
Bulb mat.x Cond.	***	ns	*	*	**	**

[y] ***Mean seperation by Duncan's Multiple Range Test. Values followed by the same letter within column are not significantly different at 5% level.***

[z] ***ns,*,**,*** not significant, significant at 5,1, 0.1%, respectively.***

Bulblet production from various types of scales

In this experiment only the number of bulblets/shoots was counted and their sizes were measured. The results of bulblets/plantlets produced by different types of scales are presented on Table 2. The highest number of bulblets per scale three months after planting were produced by flowered bulb scales, especially those stored in the dark from the middle section of the bulbs and the differences were slightly significant (5%). The average number of bulblets per scale piece ranged from 0.9 to 1.4 bulblets. Generally the innermost scales produced a significantly lower number of bulblets per scale and especially those under high humidity. For the scales left in the open and those stored in the dark, the outer scales produced the most bulblets per scale but for the scales kept under high humidity the middle scales produced more bulblets than the outer scales. There was no significant difference between the number of bulbs produced by outer and middle scales, for all conditions and types of scales although scales stored in the dark produced slightly more bulblets but the differences were not significant. Inclusion of a piece of disc on the scale did not significantly affect bulblet production. Most of the disc portions joined to the scales rotted, but where the discs did not rot, those scales had more roots.

The size of the bulblets/plantlets produced by the various scales was highly significantly different for all the treatments and treatment interactions or factor interactions (Table 2). The flowered bulbs produced bigger bulblets than the non-flowered ones and the differences were significant. Scales from the flowered bulbs produced the highest number of bulblets, while among bulbs that had not flowered, scale with a piece of disc produced larger bulblets. The scales from flowered bulbs produced the larger plantlets, with the scales without a portion of the disc producing the largest plantlets followed by S+D from flowered bulbs. The shoots were on average 7.32 and 5.85cm, respectively, while the smallest size that was produced by scales without disc from non-flowered bulbs was 3.7cm. Scales stored under polyethylene sheeting (to increase relative humidity) produced the smallest bulblets (4.5cm) while those kept in the open and in the dark both produced bulblets of 5.9cm. Scales from the outer parts of the bulb produced the largest bulblets/shoots compared to the innermost scales. The sizes were 7.2, 6.7 and 2.6cm for outer, middle and inner

scales respectively. However, the size of plantlets from the outer and middle sections was not significantly different but these two were significantly bigger from those from inner scales.

Table 2: **Effect of scale type, scale position and storage conditions on bulblet production in O. saundersiae Bak.**

			Scale type		
	Fld S[x]	*Fld SD*	*Nfld S*	*Nfld SD*	*Significance*[z]
Bulblet no./bulb	1.4a[y]	1.3a	0.9b	1.1ab	*
Bulblet size (cm)	7.3a	5.9b	3.7d	5c	***
			Condition		
	Open	*Dark*	*High humidity*	*Significance*	*Bulb typexCondition*
Bulblet no/bulb.	1.1a	1.2a	1.2a	ns	ns
Bulblet size (cm)	5.9a	5.9a	4.5b	***	***
			Scale position		
	Outer	*Middle*	*Inner*	*Significance*	*Bulb type x Position*
Bulblet no./bulb	1.4a	1.4a	0.6b	***	ns
Bulblet size (cm)	7.2a	6.6a	2.6b	***	***

[x] ***Fld, flowered bulb;S, scale without disc; SD, scale with disc; Nfld, non-flowered bulb.***

[y] ***Mean seperation by Duncan's Multiple Range Test. Values within rows followed by the same letter are not significantly different at 5% level.***

[z] ***ns,*,**,*** not significant, significant at 5,1, 0.1%, respectively.***

The scales stored in the dark produced the largest plantlets (average of 5.9cm), followed by those in the open (5.9cm) and those under high humidity produced the smallest (4.5cm).

In vivo regeneration of bulblets from scales, scale and disc and twin scales of O. saundersiae Bak.

Number of bulblets produced by scales, scale and disc and twin scales decreased in that order in four of the five experiments (Table 3). In experiment 1 and 2 the average number of bulblets produced per scale ranged from 2.13 to 3.25 with a few scales producing more than 10 bulblets. Each of all the three types of scales produced at least one bulblet. The number of bulblets produced in these two experiments was not significantly different. In experiment 4, 5,and 6, however the differences in number of bulblets produced were significant at 1%, 5% and 0.1% and the average number of bulblets produced were 4-7, 4.63-7.34 and 4.04-13.69, respectively. Most scale pieces and a few of the scale plus disc produced more than 20 bulblets per section. On single scale pieces with or without a piece of the disc bulblets were produced on the adaxial side at the base of the scale and very rarely on the abaxial side. On a few scales, bulblets were produced on both adaxial and abaxial sides. On twin scales, bulblets were produced on adaxial sides and in between the two scale pieces. Most of the bulblets were however between the scale pieces. Very rarely were bulblets produced on the abaxial side of the scales. In all types of scales, bulblets were produced at the base of the scale i.e next to the basal plate but a few bulblets were also produced at the cut edges on the sides of the scale pieces. The size of bulblets produced was measured in only experiment 1and 2. In experiment 1 there was no significant difference between the sizes while in experiment 2 there was a significant difference at 5% significance level, but only between bulblets produced by scale pieces without a piece of the disc and the rest i.e. 10.34 and 6.32, 6.8 cm respectively. Actual size of bulblets ranged between 0.2 and 28cm. Some of the scales also had swellings that would later become bulblets but these could not be included in the counts and measurements. When only the size of the largest bulblet on each of the scales was measured, the

scales without disc were found to have the largest bulblets/ shoots. This means that they were initiated earliest. The latest bulblets to be initiated were those from twin scales.

Table 3 **Comparison of bublet production from different types of scale pieces of *O. saundersiae* Bak.**

Scale type	**No. [x](1)[y]**	**Size [cm](1)**	**No. (2)**	**Size [cm](2)**	**No. (3)**
Scale	3.3a	6.1a	3.0a	10.3a	7.0a
Scale + Disc	2.9ab	8.3a	2.3b	6.3b	4.5b
Twin scale	2.1b	8.1a	2.7ab	6.8b	4.0b
Significance[a]	Ns	ns	ns	*	**

Scale type	**Root No. (3)**	**No. (4)**	**Root No. (4)**	**No. (5)**	**Root No. (4)**
Scale	1.3b	7.3a	2.4b	13.7a	1.0b
Scale + Disc	2.7a	5.5b	4.3a	10.3b	1.8a
Twin scale	2.3a	4.6b	4.3a	4.0c	2.1a
Significance[a]	ns	*	*	***	ns

[x] No. represents average number of bublets or roots per scale pieces.[y] (-) represents different experiments
[z] Mean separations by Duncan's Multiple Range Test. Values within column followed by the same letter are not significantly different at 5% level.[a] ns,*,**, not significant, significant at 5,1, 0.1%, respectively***

No correlation was found between the number and size of bulblets/shoots produced.

The number of roots produced by the bulblets was counted in experiments 3, 4 and 5. The results are also presented in Table 3. There was a significant difference between the number of roots produced by scale pieces without the disc and the rest in experiment 4 only. In all 3 experiments there was no difference between the number of roots produced by scale without disc and twin scales These two materials, however produced more roots than the scales without a piece of disc.

Discussion

Many bulbous ornamentals propagate naturally through offsets but this method yields very few bulbs for commercial purpose. For this reason, artificial means of increasing the number of bulbs produced have been used in bulbs such as *Narcissus, Hippeastrum, Hyacinthus, Lachenalia, Lilium* and *Ornithogalum* (Rees, 1972; Yanagawa and Sakanishi, 1980b; Nel, 1983; Kariuki, 1993; Okubo *et al*, 1990, Niederwieser and Vcelar, 1990; Niimi, 1995; Huang *et al*, 1990; Fernado *et al*; 1994; Miller, 1990). In *Ornithogalum saundersiae* scales produced the most and largest bulblets compared to scales with a portion of the disc and twin scales. Rees (1972) stated that a piece of the basal plate attached to the scale prevents bulblet formation. This may explain why in this study scales without a piece of basal plate produced more bulblets. Scooped bulbs, scales and cuttings also produced more bulblets compared to scored and cored bulbs. In these materials apical dominance was destroyed. In bulb cuttage or scooping and scoring, the removal of apical dominance by destroying the growing points results in the formation of numerous daughter bulbs (adventitious) along the cut edges of the scales. It also results in growth of lateral bulblets or buds (axillary) at the axils of scales (Rees, 1972). The lower numbers of bulblets from scored bulbs may have been due to the fact that the cuts through the basal plate were not deep enough to reach any of the scales and therefore not many adventitious bulblets were produced. While scored and cored bulbs produced only axillary bulblets, scales, cuttings and scooped bulbs produced both adventitious and axillary bulblets. The many cut edges provided a big surface area for adventitious formation of bulblets.

Rees (1972) and Hartman and Kester (1985) stated that after bulb cuttage, bulbs should be kept dry, at 21^{o}C and at low humidity. In *O. saundersiae*, bulbs kept at high humidity produced the

fewest and smallest bulblets. The bulbs, scales and cuttings left in the open in JKUAT produced the highest number of bulblets. This may be due to the low relative humidity and dry conditions in the open greenhouses compared to the covered ones. The environmental conditions under which most bulblets were produced differed between Juja and Yamaguchi. In Yamaguchi, the best condition for initial growth of the scales (2 months) was in the dark while at Juja it was in the open. In Yamaguchi the scales were planted in summer when the temperatures and relative humidity was quite high in the open. These conditions may have inhibited callusing. In the dark however, the temperatures were lower due to shading and the relative humidity may have been less than in the open, conditions that may have enhanced callusing hence production of more bulblets. Good bulblet production in terms of yield and size was obtained from the outer and middle scales of *O. saundersiae* bulbs. Similar observations were made in *Lilium speciosum* and *L. longiflorum* (Miller, 1990; Fernado *et al*., 1994). In the 1996 experiment done at Yamaguchi the number of bulblets per scale was very low (0.2 to 2.4). It is noteworthy that counting and measurements were done only 3 months after planting. If the scales were given more time, they probably would have produced more bulblets. Many scale pieces had swellings at the base, on the sides or edges but it was not possible to take measurements of the swelling

Conclusion and Recommendation

It was possible to induce bulblet formation in *O. saundersae* using all the bulb cuttage methods investigated. These methods yielded more planting material than the conventional propagation method, that is, use of bulbs and offsets. Scales, cuttings and scooped bulbs produced the highest number of bulblets. These flowered in about two years which is comparable to seed propagation. The great numbers of bulblets formed through these methods and the short time within which they flowered means that there is a possibility of introducing new varieties. In scaling, scales pieces without a piece of the basal plate, obtained from the outer scales of flowered bulbs, which were left in the open for one or three months before planting produced the biggest (earliest) and greatest number of bulblets. It is recommended that growers use such scales under the same conditions in scaling. Since bulb cuttage methods, including scaling, are cheaper and easier methods of multiplying *O. saundersiae* bulbs, it is therefore recommended that Kenyan farmers adopt these methods of propagation. These methods could also help in maintenance of vegetative characteristics of superior plants that may arise from adventitious formation of bulblets. It is recommended that in multiplying *O. saundersiae* bulbs using these methods, growers should ensure that the conditions of culture are warm and dry to hasten callusing of the materials. Treatment with a fungicide and/or bactericide is also recommended to reduce the chances of infection.

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Questions/Comments and Answers

Ngamau: Did you use any growth regulators for bulblet production?

Response: Not for *invivo* production, but for *in vitro.*

Ngamau: The use of adventitious production for bulblets can lead to variation. Could this not affect the quality of cutflowers produced by farmers for export?

Response: Variation might be desirable if it improves yiled, quality and morphological characteristics. However, the methods of propagation being vegetative, we expect very little variation.

Ngamau: Don't you think that it would be better to have people specialize in bulblet production than leave it to the farmers?

Response: Yes, propagation should be done by specialists e.g. at JKUAT

Kibaki: You rightly mentioned that Erwinia is a major problem in Ornithogalum and recommended use of bactericide in propagation. But do any of the propagation methods predispose the propagule to Erwinia infection more than the others?

Response: No, Clean bulbs are selected for all propagation methods. Infection occurs after planting in the soil.

Agong: For sustenance of this technology, have you informed flower growers about your findings?

Response: Not yet. This is the first public forum where the findings are being disseminated. It is hoped that meetings and consultations with farmers will follow later. In the meantime it was hoped that extension officers and researchers from KARI would get this information and start passing it on to farmers.

Kahangi: Have the findings of your research trickled down to the farmers?

Response: Not yet as explained above.

Comment/Suggestion

Etzold: More should be done for the farmers' education so that interesting research studies doesn't disappear in the shelves

Response: After this presentation, the next step will be to pass on information to farmers and train them in these propagation techniques.

Effect of Lime and Fertilizer Application on Growth and Production of Selected Common Bean (*Phaseolus vulgaris*, L) Cultivars on an Acid Soil in Uasin Gishu District Kenya

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Abstract

Many large, cereal farms in Uasin Gishu district have been subdivided and converted to small scale subsistence holdings, with the common bean (*Phaseolus vulgaris*, L) as one of the most important food crops. Soils in many parts of the district are acidic and deficient in phosphorus (P) and nitrogen (N). Common beans are generally sensitive to acidity and require application of N and P for good yield. A study was carried out at Chepkoilel Campus farm in Uasin Gishu district to assess the response of three common bean cultivars (GLP 1127, GLP 1004 and GLP 585) to application of N+P fertilizer and lime on an acid (pH 4.5) ferralsol. Fertilizer application alone significantly increased leaf number in GLP 1004 and GLP 585; LAI in GLP 1004; relative growth rate (R) in GLP 1127 and GLP 1004; stover weight in GLP 1127 and grain yield in GLP 585. Application of lime alone induced a significant increase in mean number of leaves per plant, leaf area and leaf area index (LAI) and maintained a higher R in all cultivars but had no significant effect on grain yield in all cultivars. Combined lime and fertilizer application induced a significant increase in number of leaves per plant in GLP 1127 and GLP 585 and Leaf area index in all cultivars, but did not significantly affect grain yield in any cultivars. It was concluded that N and P application could increase bean production in these soils, but lime application requires further study.

Keywords – common bean, pH, nitrogen, phosphorus, lime.

Introduction

The common bean (*Phaseolus vulgaris*, L) is the most important leguminous food crop in Kenya (Anonymous, 1996). Beans are an important source of protein and supplement starchy foodstuffs like maize, sorghum, rice and other cereals.

Beans, like most other crops, are adversely affected by soil acidity (Franco and Munns, 1982; Mugai *et al*., 1999). Acid soils usually have high levels of exchangeable and soluble aluminium but tend to be deficient in available phosphorus and calcium (Robson, 1989). Phosphorus is deficient in such soils because it is fixed in iron and aluminium silicates (Marschner, 1995). Consequently Phosphorus application promotes growth and production of beans in acid soils (Mckenzie and Nybor, 1984; Maina *et al*., 1997), but various cultivars differ in their phosphorus use efficiency (Yan *et al*., 1995).

Phosphorus deficiency in acid soils is a significant growth limiting factor (Yan *et al*., 1995). Identification of beans that are tolerant to acid soil could help increase yield in affected soils. Liming of acid soil has been reported to increase phosphorus availability to plants (Soon, 1988) and promote legume growth (Loneragan *et al*., 1995). Although, many of the problems associated with soil acidity can be corrected by liming (Noble *et al*., 1995), most farmers in Kenya cannot afford such amendments. Use of acid tolerant common bean cultivars could provide a sustainable solution in increasing bean production on acid soils.

Growth and production parameters of three selected common bean cultivars were assessed on an acid soil in Uasin Gishu district in Kenya. Soil liming and N+P application singly or combination were also used to assess the response of the beans to soil amendments.

Materials and Methods

Site of study

The study was carried out at Chepkoilel Campus farm in Uasin Gishu district of Kenya. The farm is located at 2140 m above sea level with a mean temperature of 18^{o}C, and receives 900-1300 mm of rainfall per year. The soils in this region are acidic ferralsols with low to medium fertility (Jaedzold and Schmidt, 1983).

Plant materials

Commercial seed for three common bean cultivars (GLP 1004, GLP 1127 and GLP 585) used in this study were obtained from Kenya Seed Company Ltd.

Experimental design and treatments.

The field plots were laid out in a factorial design with cultivar, lime and fertilizer as the independent factors. The fertilizer was a combined N+P that was applied at the rate of 200 kg/ha. The lime was local agricultural lime that was applied at the rate of 4 t/ha. Each treatment was replicated 9 times. The field was ploughed, harrowed and then divided into three blocks each having three plots, which were further, subdivided into 3.5 x 2 m subplots. Beans were hand-sowed at a spacing of 50 cm between rows and 15 cm within the row. The treatments included control (no lime, no fertilizer), lime only, lime and fertilizer and fertilizer alone.

Three randomly selected seedlings per cultivar per replicate were harvested from centre rows at 14 day-intervals to determine total leaf area (one side), shoot fresh and dry weight. Leaf area was determined using a leaf area meter (System - Area Meter -MK 2 Delta-T- Devices; Monitor - Hitachi Vm-900C/K; Camera - Burle TC100501X), and the leaf area index (LAI) was calculated as described by Hunt (1982).

Harvested shoots were dried at 70^{o}C and weighed. The dry weight was used to calculate relative growth rate (R) (Hunt, 1982). Three random plants per replicate hence 27 plants per cultivar per treatment were collected from the central rows at maturity and assessed for stover weight and seed yield.

The data was subjected to Multivariate analysis of variance (SPSS Ver. 7.5; SPSS. Inc). Differences were accepted as significant at $P \leq 0.05$, and post hoc seperation of means was done using Tukey's HSD test (Zar, 1984).

Results and Discussion

Between 46 and 64 days after sowing (DAS) there was a significant difference in effect of treatments on leaf number in GLP 1004 and GLP 585 (Figure 1). Lime and fertilizer application singly or in combination induced a significant increase in leaf number in these two cultivars. For GLP 1127, response to lime and fertilizer application was evident at later stages of vegetative growth (64 DAS) where the two treatments significantly increased mean number of leaves per plant.

At 46-64 DAS the lime-fertilizer combination maintained a higher leaf number especially in GLP 1127 and GLP 585. Increased number of leaves per plant signifies reduced leaf senescence and

dropping. This would maintain high LAI, and probably lead to high crop growth rate through increased interception of photosynthetic active radiation (PAR). Phosphorus has been reported to increase number of leaves and leaf size in plants (Lynch & Epsein, 1991).

GLP 585 had a significantly higher LAI than the other two cultivars under control conditions (Figure 2). LAI in all cultivars significantly increased between 35-71 DAS and decreased thereafter. LAI reduced at later stages of growth probably because of senescence and dropping of the older leaves. Furthermore, canopy photosynthesis does not increase further at this stage because the lower leaves no longer receive adequate light and soon senesce (Langer and Hill, 1991).

Positive response to lime and fertilizer application in terms of LAI was noted between 71-85 DAS. However at 71 DAS lime application alone had no significant effect on LAI in GLP 1004; decreased LAI in GLP 585, but maintained a higher LAI in GLP 1127. Fertilizer alone maintained a significantly higher LAI in GLP 1004, but had no significant effect on the LAI of GLP 1127 and GLP 585 at 71 DAS. Combined lime and fertilizer application maintained a higher LAI in all cultivars at both 71 and 85 DAS.

Increasing leaf area per plant in common beans in response to high phosphorus and nitrogen availability was reported by Al-Karaki *et al*., (1995) and Wild and Jones (1988). Larger leaf area intercept more light for more photosynthesis (Ishii, 1998).

Fertilizer effect on LAI could have been due to increased extension rate. Apart from light interception, LAI also plays a role in water use efficiency (WUE). A higher LAI leads to a higher WUE, which eventually results in better growth for every unit of water transpired (Kramer, 1983). Intervarietal differences in leaf area have also been reported for common bean (Fernandez & Ascecio, 1994).

The relative growth rate (R) of all the cultivars decreased between 50-85 DAS (Figure 3). Some treatments induced negative R between 50 and 85 DAS most probably through accelerated leaf senescense. The control had significantly higher R at 50 DAS but dropped rapidly below the other treatments at 71 DAS in GLP 1004 and GLP 585.

Lime application alone maintained a significantly ($P \leq 0.05$) higher R in GLP 1127 at 50 DAS. Fertilizer application singly and in combination with lime induced a significant ($P \leq 0.05$) decrease in R in GLP 1127. Lime and fertilizer application singly and in combination induced a significant decrease in R in GLP 1004 and GLP 585. GLP 585 plants that had been treated with both lime and fertilizer had significantly ($P \leq 0.05$) higher R than control plants at 71 DAS.

Lime and fertilizer application singly or in combination maintained a significantly ($P \leq 0.05$) higher R in GLP 1004 and GLP 1127 at 85 DAS. For GLP 585 lime application alone maintained a higher R, while lime-fertilizer combination had no significant effect, and fertilizer alone induced a significant ($P \leq 0.05$) reduction on R.

Lime application alone maintained a higher R in all cultivars at later stages of growth. Fertilizer application alone maintained a significantly higher R in GLP 1004 and GLP 1127 because nitrogen is a constituent of all proteins and nucleic acids and it also increases leaf size and is therefore the potential for greater photosynthesis which will increase total dry matter (Wild, 1988).

Lime and fertilizer application singly or in combination had no significant effect on stover weight of GLP 1004 (Table 1a). Fertilizer alone significantly increased stover weight in both GLP 1127 and GLP 585. The other treatments did not induce significant changes in these two cultivars. Under control conditions, GLP 1004 had the highest stover weight while GLP 585 had the lowest. There

were intercultivar differences in response to lime and fertilizer application. GLP 1004 did not respond while GLP 1127 and GLP 585 responded positively to fertilizer application. The increase in stover weight due to fertilizer application is because nitrogen tends to increase the of straw (Wild and Jones, 1988).

There were intercultivar differences in total yield per hectare under control conditions. GLP 1004 had the highest yield, while GLP 1127 had the lowest. Intercultivar yield differences have also been reported for common bean (Hampton *et al*., 1997). Lime and fertilizer application singly and in combination had no significant effect on grain yield in either GLP 1004 or GLP 1127 (Table 1b). Fertilizer alone significantly increased grain yield in GLP 585, but lime alone or fertilizer-lime combination had no significant effect on yield of GLP 585. GLP 585 responded positively to fertilizer application implying that this cultivar can do well with application of N+P fertilizer. Owino-Gerroh (1999) reported that nitrogen and phosphorus fertilizers increased yield of GLP2, another popular common bean cultivar.

Conclusions and Recommendation

I. The three selected common bean cultivars had variations in their response to application of lime and N+P fertilizer. GLP 585 was identified as a cultivar that can produce much more with application of N+P fertilizer.
II. GLP 1004 did not respond to either lime or fertilizer application, but it had relatively higher yield under control conditions (no lime or fertilizer). Therefore it was concuded that farmers that cannot afford fertilizer or lime can still get good yield by growing GLP 1004.
III. Lime application had no significant impact on yield of the selected common beans, and so further work should be done to determine the level of lime that can improve bean growth and production on the acid soils of Uasin Gishu.

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Questions/Comments and Answers

Anon: Are you considering pursuing the use of natural soil amendment procedures other than chemical since chemicals are becoming increasingly expensive to farmers and we are also trying to encourage the move from chemical to organic farming?

Response: Yes

S. Ngugi: What was the soil pH at the end of the experiment

Response: It was 5.1

S. Ngugi: How did you determine the level of lime you used in the experiment?

Response: It was obtained from some author

G. Mwago: What are the effects of aluminium toxicity at your pH levels and how much would it have influenced your results?

Response: Aluminium toxicity impairs plant root growth by inhibiting cell division. Aluminium toxicity eventually reduces crop yield due to poor root development, inefficiency in water and nutrient uptake.

H. Stuetzel: It is s pity that in your fertilizer treatment you combined N and P so that you can not identify which element caused the observed effects.

Response: Under low soil pH conditions nodulation is impaired and phosphorus availability low and so there is need for external supply of both N and P

J.B.M. Njoroge: What are the specific characteristics of the bean cultivars used in the study (like acidity tolerance etc)?

Response: GLP is classified as acid tolerant.

J.B.M. Njoroge: What are the causes of soil acidity in the study area of Uasin Gishu?

Response: Soil acidity occurs mainly due to the leaching of bases like calcium etc. It is aggravated by application of ammonium fertilizers such as Di-Amonium Phosphate (DAP).

M.O.A. Onyango: Did you do nutrient analysis before the experiment?

Response: No, we didn't

Drip Irrigation Frequency and Mulching Types Influence Yield and Quality of Greenhouse Grown Fresh Market Tomato ('Money Maker')

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Abstract

Conventional open-field tomato production encounters myriad problems, which may be ameliorated by protected cultivation in the form of low cost greenhouses. Drip irrigation reduces tomato water requirement by upto 50% compared to furrow and flood irrigation, which are commonly used. Mulching reduces soil water losses through surface evaporation and leaching thereby influencing irrigation frequency. However, the combined effects of mulching types and drip irrigation frequency on yield quality of fresh market tomato ('Money Maker') under greenhouse conditions in the tropics is not well understood.

The study was conducted at Egerton University, Horticultural Demonstration Field within a plastic tunnel greenhouse. The experimental design was split plot embedded in randomized complete block design replicated three times. The main plot factor was irrigation treatment, which consisted of irrigation once per day, irrigation once every two days and irrigation once every three days. The sub-plot factor was mulching types, which included transparent plastic, dry grass and no mulch (control). Daily irrigation rate varied between 1 to 2 litres of water per plant.

Daily irrigation applied once resulted into the lowest yield (148.33 t/ha) while irrigation once every three days yielded highest (160 t/ha). Highest yield was realized with transparent polyfilm mulch, followed by dry grass mulch (158.38 t/ha) while no mulch produced lowest yield (146.67 t/ha). Irrigation once every three days and transparent polyfilm yielded highest (186.4 t/ha). Yield was poorest with daily irrigation and no mulch (139.8 t/ha). Dry grass mulch produced individual fruits "with largest cross-sectional diameter (52.42 mm).

Improving Nitrogen Supply to Common Bean through Inoculation with Local *Rhizobium* Isolates.

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Abstract

Nitrogen is often the limiting mineral nutrient to crop production in tropical soils. Legumes in association with *Rhizobia*, can obtain a significant percentage of their nitrogen through biological nitrogen fixation, thus reduce the need for chemical N fertiliser. Common bean *Rhizobium* utilization in Kenya is minimal because of the variability of effectiveness of the commercial inocula, the many bean varieties and land races, and relatively low knowledge of the technology among smallholder farmers. Four local *Rhizobium* isolates (CRH, EMB, Ro, Kk) were used to inoculate seven selected popular common bean varieties (GLP2, GLP24, GLP585, GLP1004, GLP1127, Nyayo and Okwodo) in the field at Chepkoilel Campus farm, whose soil is acidic (pH 4.5) with high percentage (44 %) of aluminium saturation. A commercial inoculum based on Common bean *Rhizobium* strain USDA2674 was included as a reference. The plants were grown to maturity and assessed for number of pods per plant, mean pod length, number of seeds per pod and mean seed yield. CRH significantly increased the number of pods per plant in GLP24 and Okwodo; Ro increased number of pods per plant in GLP2 and GLP24; Kk increased the number of pods in GLP24 and GLP1004; and USDA2674 increased pods in GLP24, GLP1004 and GLP1127. EMB and Ro significantly increased pod length in GLP2; and USDA2674 increased pod length in GLP2 and GLPl004. CRH significantly increased the number of seeds per pod in GLP2, Nyayo and Okwodo; EMB increased the number of seeds in CLP24 and Nyayo; Ro and Kk increased the number of seeds in Nyayo; and USDA2674 increased the number of seeds in Okwodo. CRH significantly increased mean seed yield in GLPl004 and GLP1127; EMB, Ro, Kk and USDA2674 increased seed yield in GLPl004. The results showed significant variation in effectiveness of the *Rhizobium* isolates and common bean cultivars. USDA267, CRH, Ro and Kk improved more plant attributes than EMB. GLPl004, CLP24, Nyayo and Okwodo were the most, and GLP585 the least, responsive to inoculation. The full data will be presented and discussed

Efficient Water and Nutrient Use in Horticultural Production in the Tropics

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Abstract

Horticultural Sector is an important source of foreign exchange earning, employment and consumption. Most of Horticultural crops are a rich source of essential minerals and vitamins. Tanzania and other countries in the tropics depend heavily on the Horticultural sector as a base of economic growth, employment creation and foreign exchange generation. The production also contributes to the country's food security and plays an important role in the provision of raw materials for existing processing industries. Increased production, particularly that of smallholder farmers will increase rural income, consumption, employment and savings. Unlike field crops, which can be grown under rainfed conditions, horticultural crops with few exceptions depend mainly on good water management (irrigation).

Horticultural crop production depends on many factors such as soil type, nutrients levels; moisture and management. Soil scientists use several methods to assess soil productivity for various crops. The potential productivity of a specific soil may be evaluated based on the physical, chemical and biological features of the soil. Soil fertility, a concept, which ensures the supply of the proper kind and amount of the elements (nutrients) needed for plant growth. The quality of horticultural crop products is determined by the quality and quantity of water management. Many defects of horticultural crop products may be traced directly or indirectly from mismanagement of nutrient and water supply.

A good proportion of investment in horticultural crop production is allocated to water management, whether it is in a traditional form where water is applied by manual labour (furrow irrigation) or in automated drip irrigation system. Plants require nutrient elements, which are in the soil or may be supplemented (mineral

elements) to support growth and development. Decrease in the amount of nutrient elements to levels, which are not enough for growth and development will lower production. Nutrient elements in the soil, however, are not always readily available. Deficiency symptoms occur even where the total amount of nutrient elements in the soil is high. Essential elements may either be required in large quantities (macro elements) or in small amounts (micro or trace elements). However, as we continue to encourage farmers to engage in horticultural crops production, caution should be taken, especially with regard efficient water and Nutrient and Nutrient Use to achieve good quality and higher yields.

Introduction

Tanzania is a large country with an estimated area of 939,700km^2. The current population of Tanzanians is about 32,000,000. The altitude varies from the sea level to summit of Mt. Kilimanjaro at 5895 metres above seal level. The country can broadly be divided into coastal plains, the semi tropical belt and temperate belt. Water is the vital part of the country and it has an average rainfall of 750-850mm. More than 85% of the population is directly or indirectly engaged in Agricultural activities including horticultural crop production. More than 75% of the foreign exchange earnings and 50% of Gross Domestic Production (GDP) accrue from Agricultural Sector.

Horticultural Industry in Tanzania

Tanzania is among of several countries in the tropics, which deals with horticultural crop production. There are several classes of Horticultural crops grown in the country. People of Tanzania are totally engaged in horticultural activities mainly because they want to support their life and modernnifying their standard of living. They intend to raise their income as well as to produce various foods for consumption and surplus for financial aspects. Therefore, it increases National Income by getting foreign money. Horticultural Industry in Tanzania is one way of utilizing natural resources i.e. land and water.

Climatical Consideration for Horticultural Industry in Tanzania.

Rainfall patterns show great variation from year to year thus greater uncertainity particularly in semi arid areas. Due to environmental conditions, horticultural crop production varies widely from place to place. Periods of time variation is a result of adapting cropping patterns, farm practices conditions of each location and farming systems.

In regional terms, where adequate moisture is available during growing season horticultural crops can be produced without problems in the following altitudes low altitude (500 – 700 m.a.s.l.), the uplands (1500 – 2000 m.a.s.l.), intermediate altitude (1000- 15000 m.a.s.l.) and the high altitude areas about (2500 m.a.s.l.). But above (3500 m.a.s.l.) the most hazard becomes critical, and the absence of the proper dry period for harvesting precludes.

Importance of Horticultural Crop Production

Horticultural crop production is labour intensive. Production of horticultural crops creates a number of job opportunities in the rural and suburban areas, to the farms where business arises such as marketing, processing and transportation. There are some Industries for processing horticultural crops where farmers sell their crops and get employments. Processing industries are found in Arusha, Kilimanjaro, Dar es Salaam, Iringa and Morogoro. Also, big cut flower farms exist in Arusha and Moshi Regions.

Horticultural crops production is also important for education purposes like Horticultural Research and Training Institute (HORTI) Tengeru and Southern African Development Community (SADC) Asian Vegetables Research Development Centre (AVRDC) Madiira Tengeru in Arusha. Some

horticultural crops are also valued for the **medicinal** uses as handed down from generation to generation, especially in the rural areas of developing countries. Garlic and cloves for example, are used for curing high blood pressure and rheumatism. Some are known to have **insecticidal** properties such as the hot pepper fruits. Still others are valued for **cosmetic** purposes.

Horticultural crops as a group constitute an important component in **man's diet**, especially in developing countries. Horticultural crops are **rich sources of essential minerals and vitamins**. The minerals needed by the body such as **calcium** and **iron** deserve the most attention. Calcium is necessary for the development and proper functioning of bones and teeth, while iron is needed to prevent anemia. Some horticultural crops are excellent source of vitamins with many different roles to play in body development; e.g. lack of vitamin A causes poor growth and night blindness. Vitamin C or ascorbic acid prevent scurvy a disease of the gums characterized by sponginess and bleeding. It also increases the resistance of the body to colds, coughs and other respiratory diseases.

There is little chance for malnutrition to occur where enough horticultural crops are eaten. Malnutrition reduces the working capacity of farmers and their families. In several cases, serious physical and mental retardation or even death may occur. As a result of reduced working capacity incomes may decrease and poverty may increase. This relationship between productivity and nutrition is a cycle that continuously gets worse over time.

Major Probrems of Horticultural Crop Production in Tanzania

Pests and Diseases

Pests and diseases damage crops, they contaminate crops hence reducing the quality and crop yield. This leads to increase cost of production.

Ecological Factors

Variable climate or weather conditions may automatically vary the production from one area to another.

Poor Infrastructure

This is the most important media during production process where goods and services are moved from production area to the consumers.

Lack of Storage Facilities

Lack of storage structures and processing facilities in Tanzania lowers horticultural crop production.

Poor Marketing System

Marketing system in Tanzania is traditional unorganized and inefficient. There is also a problem of poor handling of commodities in the market.

Lack of Knowledge

Very few farmers are trained in horticultural crop production in Tanzania.

Research work in Tanzania

Although there is a good research work, but there is a problem of communication between research workers and farmer findings.

Soil

The soil holds up the plant and acts as reservoir for water. It is also the main source of plant nutrient elements. Its physical and chemical characteristics greatly influence the nature and rate of plant growth. The mineral particles tend to group together so that there are spaces (the pore spaces within the soil which are partly occupied by air and partly by water).

Soil Types

The solid part of the soil is composed of a mixture of broken down rocks (mineral particles) of different sizes and the remains of plants and animals at different stages of decomposition (organic matter). The mineral particles are clay, silt and sand. The relative proportion of these particles determines the soil texture. Particles with **sand** are described as **course textured**, with **clay** described as **fine textured** or **heavy** and with no **predominant particle** size are called **moderately course** textured.

Sandy soils are best suited for the root, bulb and tuber crops. It allows fast development and easy harvesting. But if the soil is too sandy cannot hold much water and nutrients, therefore need fertilization.

Loamy soils are ideal for horticultural crop production. They have a good mixture of sand and clay, so having good nutrients, water holding capacities and provide good aeration.

Clay soils are difficult to work when dry but have very good water and nutrient holding capacity.

Soil Fertility

When a previously forested land area is used for growing horticultural crops for the first time, the soil usually contains all the nutrients (elements) that the plant needs. However, as it is continuously used for producing a crop, the amount of nutrients decreases to levels, which are not enough to support growth and development without the use of fertilizer, hence the yield is expected to decrease.

The nutrients in the soil, however, are not always immediately available. Hence, even if the total amount of nutrients in the soil is high, deficiency symptoms still occur.

Nitrogen (N) is the most commonly lacking nutrient. Followed by **phosphorus (P)** and **potassium (K)**, which are the most components of commercial fertilizers.

Nutrients Required by Plants

Plants require sixteen (**16**) nutrients, thirteen (**13**) of which come directly from the soil (mineral nutrients). Not all are required for plants but all have been found to be essential to some, hence are termed as **essential nutrients**. They may either be required in small amounts (micronutrients or trace nutrients).

The **macronutrients** are nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, and the rest are **micronutrients**. An adequate supply of N is indicated by vigorous vegetative growth and deep green colour. However, excessive quantities can prolong the growth period and delay crop maturity. Nitrogen is a major component of proteins. The amount of nitrogen determines the amount of protein produced. Nitrogen is also a part of the chlorophyll molecule.

Nitrogen (**N)** If the plant absorbed too much nitrogen, it would become too succulent. Nitrogen is absorbed mainly as nitrate but also as ammonium.

Deficiency symptoms of Nitrogen: Light green to yellow leaves starting with lower leaves, and plants are shorter than normal.

Phosphorus (P) is involved in all the energy transformations also a component of other compounds involved in photosynthesis and respiration and essential to seed formation, root growth, and disease resistance.

Deficiency symptoms of phosphorus: leaves and stem turn purple and plants are shorter than normal.

Potassium (K). It is essential to the growth and development of plants. Potassium is a mobile nutrient, which is translocated to young growing tissues when there is a shortage and it controls stomata opening.

Deficiency symptoms of potassium: Yield may decrease without any visible symptoms and plants are shorter than normal. Leaf margins turn brown in severe cases.

Calcium (Ca). It is a component of the middle lamella of cells. Middle lamella cements cells together. It does not move once if is deposited in plant part, so the leaves that are newly formed or are forming show symptoms first.

Deficiency symptoms of calcium: New leaves fail to come out or if they do, they do not unfold, they tend to stick to each other. Apical roots also fail to develop, and yellowing of young leaves.

Magnesium (Mg): It occupies the center of the chlorophyll molecule, hence it is very important in photosynthesis. It also activates many enzymes and is mobile.

Deficiency symptoms of magnesium: Old leaves appear light green or yellow usually in between the veins.

Sulfur (S). Is a component of some amino acids, which are the building units of proteins.

Deficiency symptoms of sulfur: Plants appear uniformly yellow, light green, or thin stemmed and spindly. Plants are shorter than normal.

The Micronutrients: Intensive cultivation of horticultural crops makes soils prone to deficiencies, not only macronutrients but also of micronutrients. While micronutrients deficiencies are relatively uncommon, their incidence if uncorrected, could severely reduce the yield and quality of horticultural crops.

Organic Matter

Organic matter represents the remains of plants and animals at various stages of decomposition. It improves drainage, aeration, nutrient and water holding capacities of the soil and it provides nutrients. It is especially a very good source of some micronutrients. However, the nutrients from organic matter are released slowly over time, so it is used to maintain or to improve good yield over a long period of time, but not to correct deficiencies. Soils high in **organic matter**, which are usually dark-coloured, are ideal for horticultural crop production. When a soil is low in **organic matter**, it becomes hard and forms crusts during the dry (rainless) months.

Soil Reaction

Soil reaction refers to the degree of **acidity** or **alkalinity** of a soil. It is measured in terms of **pH**. At pH7, the soil is neither acidic nor alkaline (**neutral**). At pH7, the soil s acidic in reaction, at pH more than 7, the soil is alkaline in reaction.

Horticultural crops usually grow well in slightly acidic or slightly alkaline soil.

Crop Production

Horticultural crops are highly produced in areas with temperate climates like Arusha, Kilimanjaro, Mbeya, Iringa and Morogoro; other areas with horticultural crops are along the coastal plains like Tanga, Pwani, Lindi and Mtwara (Figure 1). At the lowlands where the low rainfall limits, horticultural crops can only be produced under irrigation system.

Women in developing countries play a major role in horticultural crop production. In addition to the family, women also tend gardens, harvest and sell the produce, and prepare meals. But nowadays, horticultural crop production is a business attended by all generation. Data on the extent of Horticultural crop production are only estimated and generally not very reliable because of the difficulty of accounting for all crops produced in small farms or home gardens. Horticultural crops are more efficient converters of farm resources than other crops in terms of yield per unit area per unit time since they grow very fast.

Horticultural crop production ventures can vary in farm size, amount of investment put in, methods employed, and economic role. In horticultural crop production, all management operations and techniques are aimed at creating or modifying the crop's microenvironment in order to enhance production and quality.

In most cases, most of these operations are aimed at modifying the soil environment like soil moisture and soil fertility. When addressing principles of horticultural crop production, it is

necessary to look at the whole environmental factors and their effect on crop growth and development, each factor acting alone or in combination with others. Horticultural crops differ in growth requirements; some can be grown under a wide range of conditions, while others have more specific requirements for water, temperatures and nutrients.

Efficient Water Use in Horticultural Crop Production

Some horticultural crops are succulent products by definition, generally with more than 90% water. Thus, water determines the weight and yield of the crops. The quality of horticultural crop products is also determined by the quality of water management. Many defects of horticultural crop products may be traced directly or indirectly to mismanagement of water supply in the production field.

A good proportion of investment in horticultural crop production is allocated for water management, whether it is in a traditional farm where water is applied by manual labour or in an automated drip irrigation system. Unlike field crops, which can be grown under rain fed conditions, horticultural crops with few exceptions are always irrigated, at least partially. It is every grower's at most concern to use irrigation water in the most efficient way. It is equally important to provide adequate drainage facilities in the field because most horticultural crops cannot tolerate prolonged water logged conditions. In the humid tropics, horticultural crops may be classified according to adaptation to wet or dry seasons roughly corresponding to their adaptation to excess or deficiency of moisture.

Water is essential for plant growth and development. A plant usually absorbs several times more water than the amount in its cells. Most of it is lost through the stomata during transpiration. Horticultural plants get water from several sources for its growth. However, the amount of water available to plants in the tropics is primarily by rainfall.

Under poor water management, plants react to these extreme conditions by abnormal growth even before definite signs of stress become visible. In many cases, definite signs of stress are only observed when irreversible damage to the crop already occurred either in quality or yield.

Deficiency in water can cause direct as well as indirect damage.

Direct damage consists of poor stand when water stress occurs during germination and yields reduction or decline in quality: such as deformity in the fruits when water stress occurs later in the growing season.

Indirect damage may consist of calcium deficiency which causes blossom end rot or tip burn in some horticultural crops.

Excess water can also cause direct damage, such as leaching of fertilizers, reduced root development, and development of adventitious roots. Indirect damage due to excess water consists of root rot and other diseases which are favored by high soil moisture.

Efficient water means applying adequate quantities of water at the right time. It includes the delivery of water (irrigation) and removal of excess water (drainage). Therefore, the yields will depend on efficient water, good soils, weather conditions, as well as the crop variety.

Methods for Applying Irrigation Water

Choosing the most suitable method for applying irrigation water depends on soil texture, topography, water supply and the crop. Irrigation water is applied to horticultural crops through the following methods:-

- Overhead irrigation
- Surface irrigation
- Drip irrigation

The first two methods are the most common used and generally are preferred.

The last method is relatively new, not yet commonly practiced and expensive to ordinary farmers.

Overhead Irrigation: In this method, water is applied in the form of spray or artificial rain. In non-mechanized farming, this is done by using watering cans. The source is usually **river, a shallow well, or tap water**. Since the method is labour intensive, the farm size per person is limited to approximate 500 m^2 if the water source is adjacent to farm. In relatively large farms that are operated manually or with small machines, the horticultural crop field is laid out in such a way that the water is conveyed close to the horticultural plots to shorten the walking distance during watering.

In medium size to big farms where labour is expensive, sprinkler irrigation is applied through a pipe system under pressure.

Surface Irrigation: Horticultural crops that do not specifically require frequent and light irrigation, surface irrigation is preferred over sprinkler irrigation. Surface irrigation can be applied to horticultural crops raised on the furrows. **Furrow irrigation** is done by running water through small channels (furrows) while it moves down or across the slope of the field. The **flooding method** is applicable in areas, which have flat to uniform and gentle slopes. Relatively large irrigation streams are required compared to furrow irrigation. The flooding method does not require elaborate land preparation. The flooding method can be done in several ways, however, for horticultural crops the border strip flooding techniques is most applicable.

Drip Irrigation: Also known as trickle irrigation. This method refers to the application of water to the soil through small emitters, which are designed, to discharge water at rates of 1-8 Litres/hour. The emitters are installed close to the plant, wetting only these areas leaving the rest of the field dry – unlike sprinkler irrigation and flooding which wet the entire field. Water is therefore, used efficiently.

Drip irrigation is expensive in terms of labour for irrigation, weeding, fertilizer and pesticide application. In many, instances, these can off set the high initial cost of equipment for the drip irrigation system. Drip irrigation system is expensive to ordinary farmers in the tropics but some advantages are realized when using it.

Sanitation: The foliage is kept dry and spread of soil diseases and a weed seed through

- Surface flow of water is prevented.
- Uniform water distribution
- Ease in combining irrigation with fertilizer and pesticide application.
- Flexibility in farm operation.

Summary

Horticultural crop production is a base of economic growth, employment creation and foreign exchange generation.

The production of horticultural crops contributes food security, consumption especially to small holder farmers, and savings.

Some horticultural crops are excellent source of vitamins and nutrients, which reduce Malnutrition. Also they are valued for medicinal, insecticidal and cosmetic.

Horticultural crop production is important for education purposes.

Quality and higher yields will depend on efficient water, use of nutrients, good soils, weather conditions as well as the crop variety

Recommendations

However, as we continue to encourage, farmers to engage in horticultural crop production, caution should be taken especially with regard of efficient water and nutrient use to achieve good quality and higher yields.

Lastly, there should be a good link and communication between researchers, extension officers and farmers.

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Questions/Comments and Answers

Anon: I would like to know some of the major horticultural crops in Tanzania.

Response: The list is actually given in the main paper that is already submitted to the organisers.

V. Anjichi: Could you please mention the five major horticultural crops in Tanzania so that we can think of ways of collaboration between our two institutions/countries?

Response: Flowers: Roses; Fruits: Oranges, mangoes and Avocadoes; Vegetables: Onions, Tomatoes, Cabbages and Amaranth.

Market Survey on African Indigenous Vegetables in Western Kenya

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Abstract

A market survey was carried out in three markets in Western Kenya in June 2001, to assess farm produce sold on these markets, to establish and assess trading network system of these markets, to determine the importance of African Indigenous vegetables and to ascertain traders constraints and their effect on availability and prices of vegetable crops.. A systematic random sampling scheme was adopted to select traders to be interviewed during the survey. A check list together with a structured questionnaire were used to collect data from the traders. The interview considered all farm produce sold on these markets. Other information gathered was types of merchants involved in the business, origin of the produce, quantities, wholesale and retail prices, consignment that sells first and the traders constraints. The survey at Kakamega was conducted for seven days consecutively. An extra survey of the same was conducted in two rural marketing centers Chavakali and Kiboswa on Kakamega-Kisumu road. In a period of seven days 400 traders were interviewed in Kakamega Municipal market and 35 and 30 traders were interviewed in Chavakali and Kiboswa respectively. In Kakamega Municipal Market 70% of traders interviewed were women and 30 % were men, most produce at the Municipal market originated from production areas in other provinces. Out of the traders interviewed 10 % were farmers selling their own produce and 90% brought consignments from the farmers or other merchants. Survey on Kiboswa market revealed that 95 % of the vegetables were indigenous and about 70% of the indigenous vegetables were packed for Kisumu and Nairobi city markets where there was a high demand. In both Kiboswa and Chavakali markets, 60% of the traders for African Indigenous Vegetables had produce from their own farms. The traders in Kakamega Municipal market identified the major constraints as poor prices during the rainy season, exploitation of farmers by traders and poor infrastructure and marketing system among others. The most important African Indigenous Vegetables identified in these markets included: Cowpeas (*Vigna Unguiculata)*, Amaranths (*Amaranthus lividus /blitum),* Jute Mallow (*Corchorus olitorius)*, Ethiopian kale (*Brassica carinata*), Sunnhemp (*Crotalaria brevidens & ochroleuca*), Spiderplant (*Cleome gynandra)*, African nightshades (*Solanum villosum/scabrum*) and pumpkin leaves (*Cucurbita moschata*)

Introduction

The majority of the people in Western Kenya live in rural areas and mainly depend on farm produce. The demand for foods continue to rise in both rural and urban centres. Most people in rural areas depend on both introduced and indigenous food plants among them indigenous vegetables. Cereals and root crops supply a major part of the calories, protein and carbohydrates requirements in the diet. The diet of most people in the region is lacking in Vitamins and minerals that the African indigenous vegetables can supply. According to Maundu, 1997, indigenous vegetables are those vegetables whose natural home is known to be in a specified region in this case Africa while traditional vegetables are either indigenous or introduced species which due to long use has become part of the culture of the community. Other terms that have been used to refer to these group of vegetables are local and under-utilized vegetables. Local vegetables can be defined as traditional vegetables that are locally available while under-utilized vegetables are those whose potentials have not been fully exploited. African Leafy Vegetables (ALVs) are traditional vegetables whose leaves and petioles only are consumed and this study concentrated more on these vegetables. African Leafy Vegetables have been documented to have high nutritive value with high contents of Vitamin A and C, minerals and supplemental proteins, they also possess

medicinal properties and have several agronomic advantages. Western Kenya is endowed with a lot of biodiversity among them indigenous vegetables and yet 50% of the population is living below the poverty line normally manifested in malnutrition and poor health. Despite these advantages these vegetables have been neglected for many years by policy makers, agriculturalists, educationists and even funding agencies normally despised and refereed to as minor or poor mans crop or just weeds and therefore their potentials have not been fully exploited. There is hardly any documentation on the importance of these vegetables in Western Kenya.

Objectives

The objectives of this study therefore were to:

- Assess farm produce sold on three markets in Western Kenya.
- Establish and Assess trading network system of these markets.
- Determine the importance of African Leafy vegetables in these markets.
- Ascertain traders constraints and their effect on availability and prices of ALVs.

Methodology.

Three markets in western Kenya were selected and used in the study and these included Kakamega Municipal Market, Chavakali and Kiboswa Rural Markets

Kakamega Municipal Market is situated in Kakamega town, which is the district and provincial headquarters of Kakamega District and Western Province respectively. A systematic random sampling scheme was adopted to select traders to be interviewed during the survey. A check list together with answer form sheets (structured questionnaires) were used to collect data from the traders. The interview considered all farm produce on Kakamega municipal market. Other information gathered was types of merchants involved in the business, origin of the produce, quantities, wholesale and retail prices and the traders constraints. The survey was conducted for seven days consecutively running from 15th to 21st June, 2001, each day starting from 6.00am to 6.00 pm. In one week 400 traders were interviewed.

Chavakali Rural Market is situated a long Kakamega-Busia road in Vihiga district. The interviews were conducted on 26th June 2001, which was a market day and 35 traders were interviewed.

Kiboswa Rural Market is on Kisumu-Kakamega road on the boundaries of Kisumu, Vihiga and Nandi districts but adminstratively it falls under Kisumu district. On this market the questionnaires were also administered on a market day 27th of June 2001 when 30 traders were interviewed.

Qualitative Analysis was used to analyze the data.

Results and Discussions

In a period of seven days a total of 400 traders were interviewed in Kakamega municipal market and 35 and 30 traders in Chavakali and Kiboswa rural markets respectively.

Produce sold on three markets in Western Kenya

The total number of farm produce which were observed on Kakamega Municipal market were forty eight (Table 1a). This observation is in agreement with the report of Otukho and Obiero (1996) in a similar study in the same market carried out in 1996, where they found 50 different types of produce. The largest consignment was of cabbages while the smallest was the oil crops. Cabbage, an exotic vegetable still remains the most traded vegetable in the country because, it is one of the

vegetables that has been given priority by agriculturalists in terms of research and extension. The variation of the produce found in the rural markets was lower with 13 types of produce for both Chavakali and Kiboswa markets.(Tables 1b&c) In the rural markets the ALVs contributed over 50% of the total traded commodities. On Chavakali market commodities sold were exotic and indigenous vegetables, ripe bananas, avocadoes, sweet and irish potatoes. And dry maize grain. On Kiboswa market the commodities included indigenous and exotic vegetables and also avocadoes, pawpaws, mangoes, ripe bananas and dry maize grain.

Table 1a: Types of Produce traded at Kakamega Municipal market (15th –21st June 2001.

Produce category	**Types of produce**	**Type of merchant**	**Quantity (%)**	**Value (%)**
Cereals	4	M2	6	8
Roots and tubers	6	M2+M1	18	14
Grain Legumes	2	M2	17	23
Oil Crops	4	M2	4	12
Fruits	12	M2+M1	5	5
Exotic vegetables	10	M2+M1	44	32
ALVs	10	F+M1	6	6
Total	**48**	**-**	**100 (145,980 kg)**	**100(2,998,944/=)**

Note:
F-Farmer; M1-merchant 1 buys from farmer; M2-merchant 2 buys from merchant 1

Table 1b: Types of Produce traded at Chavakali Rural market (26th June 2001)

Produce category	**Types of produce**	**Type of merchant**	**Quantity (%)**	**Origin**
Cereals	1	M2	10	Kitale
Roots and tubers	2	F+M2	7	Turbo, Local.
Fruits	2	M2+M1	18	Kisii, Local
Exoticvegetables	2	M2+M1	8	Kapsabet
ALVs	6	F+M1	57	Local farmers
Total	**11**	**-**	**100 (1,260 kg)**	

Table 1c: Types of Produce traded at Kiboswa Rural market (27th June 2001)

Produce category	**Types of produce**	**Type of merchant**	**Quantity (%)**	**Origin**
Cereals	1	M2	6	Kitale
Fruits	4	F+M1	38	Kisii, Local
Exoticvegetables	2	M2+M1	3	Kapsabet
ALVs	6	F	53	Local
Total	**13**	**-**	**100 (4,160 kg)**	

Trading network system of the surveyed markets

Most of the heavily traded commodities on Kakamega municipal market originated from outside the province and some from neighbouring countries like Uganda (Table 2).

Various agencies were found to be engaged in farm produce marketing in Kakamega Municipal market. A variety of well established, although informal marketing channels for distribution and sale in the domestic market exist. The traders could be categorised as farmers, M1 and M2.(Table 1a) The M1 were the merchants buying from farmers and M2 were traders that were buying from the M1 traders. Most of the produce was handled by M1 and M2 and only the ALVs were being handled by farmers selling their own produce.

In the rural markets all indigenous vegetables were cultivated by farmers in the villages near the markets. Exotic vegetables were from Kapsabet and fruits were from farms near the markets, and some of the bananas originated from Kisii.(Tables 1b&c). In the rural markets 95% of the traders

interviewed were women while in Kakamega market it was 70% as shown in table 3. In the city market 10% of the traders were farmers while in the rural markets 60% of the traders were farmers.

Table 2: Origin of produce traded at Kakamega market

Produce category	Types of produce	Origin of produce
Cereals	4	Kitale, Busia, Kisumu
Roots and tubers	6	Mumias, Butsotso, Mt Elgon, Malava
Grain Legumes	2	Kitale, Luanda, Kakamega
Oil crops	4	Luanda, Butsotsa, Busia, Mumias
Fruits	12	Kisii, Butsotso, Kakamega, Kitale, Limuru, Kisumu, Kiboswa, Busia.
Exotic vegetables	10	Kapsabet, Mt Elgon, Uganda, Kitale, Nairobi.
ALVs	10	Malava, Bungoma, Kakamega
Total	48	--

Table 3:Categorization of traders and importance of ALVs

MARKET	**% women traders**	**%traders who are farmers**	**%ALVs to all commodities**	**%ALVs to Vegetables**
Kakamega municipal market	**70**	**10**	**6**	**20**
Chavakali rural market	**95**	**60**	**57**	**70(9)**
Kiboswa rural market	**95**	**60**	**53**	**95(70)**

( ) the % of the ALVs packed for Kisumu and Nairobi cities.

The importance of African Leafy vegetables in these markets.

In Kakamega municipal market the highest contribution from vegetables was observed for the Leafy Vegetables (72%) most of which was contributed by cabbage, while ALVs contributed only 12%. (Table 4). The lowest contributor was root vegetables(1%) which consisted mainly of carrots. Among the African leafy vegetables cowpeas was highly traded in Kakamega municipal market contributing 30% of the total quantity of ALVs.

In Chavakali and Kiboswa rural markets the contribution of ALVs was 57 and 53% respectively (Tables 1b&c) while 95% of the traded vegetables on these markets were African Indigenous Vegetables (table 3). 9% and 70% of the ALVs in Chavakali and Kiboswa respectively were packed for Kisumu and Nairobi city markets.

Most of the vegetables on all the three markets were freshly harvested mainly by uprooting, however the mature vegetables were harvested by decapitating. Although the quantities of the ALVs on the municipal market were low, a lot of selling was taking place in the farmers fields or on transit to the market. Also some farmers/traders chose to sell the vegetables in the estates from door to door in Kakamega town. The African Leafy Vegetables that were identified at Kakamega municipal market were 8 and are listed in table 5. Table 6 shows that the six vegetables that were found in the three markets included cowpeas, amaranths, african nightshades, Jute mallow, Spiderplant and slenderleaf. Chweya and Eyzaguire (1999) identified spiderplant, cowpeas, vine spinach, jute mallow, cassava leaves, amaranthus, African nightshades and pumpkin leaves as the priority species in the Kisii area of Western Kenya some of the species overlap with the findings of this study. The absence of Ethiopian kale and pumpkin leaves in the rural markets is an indication of the commodities being sold at the farm level or in transit and may not reach the formal market.

Table 4: Percentage contribution of various vegetables at Kakamega municipal market

Type of vegetable	Quantity (%)	Value (%)
Leafy	72	62
Root	1	1
Bulb	7	8
Fruit	8	9
ALVs	12	20
Total	**100 (72,990 kg)**	**100 (Kshs 959,662)**

Table 5: Percentage contribution of different ALVs at Kakamega municipal market

African Leafy Vegetables			**Quantity (%)**	**Value (%)**
Scientific names	**Local names**	**English names**		
Vigna unguiculata	Kunde, Bo, Likhubi	Cowpeas	30	36
Amaranthus blitum	Mchicha, Ododo, Libokoi	Leaf amaranths	21	13
Solanum villosum & scabrum)	Mnavu, Osuga, Lisutsa	African Nightshades	12	15
Corchorus olitorius	Mlenda, Apoth, Murere	Jute or Jew's mallow	11	9
Cleome gynandra		Spiderplant, cat's whiskers	7	10
Crotalaria brevidens and ochroleuca	Marejea, mitoo, Emiro	Rattlepod, sunnhemp Slenderleaf	7	5
Brassica carinata	Loshuu, Kanzira, Kanjira	Ethiopian kale/mustard	7	6
Cucurbita moschata	Malenge, Budho, Lisebebe	Pumpkin leaves	5	6
TOTAL	-	-	100 (8759kg)	100 (135,159/=)

Table 6. The nine most important vegetables in the three markets in Western Kenya

AFRICAN LEAFY VEGETABLES	**QUANTITY (%)**		
	MARKETS		
	Kakamega	**Chavakali**	**Kiboswa**
Cowpeas	30	18	31
Leaf amaranths	21	18	15
African Nightshades	12	14	15
Jute Mallow	11	18	15
Spiderplant	7	18	16
Rattlepod	7	14	8
Ethiopian kale	7	-	-
Pumpkin leaves	5	-	-
Total	100 (8,759 kg)	100 (660kg)	100 (2,060 kg)

Major Constraints

- Abundance of vegetables during the rainy season leading to low prices which are unattractive to growers, on the contrary vegetables are scarce and expensive during the dry season.
- Growers are exploited by traders since they lack market information
- Lack of essential infrastructure and limitation of space leading to deterioration of produce.
- Lack of organized marketing channels

Possible Interventions

- Increase domestic production of indigenous vegetables to a commercial level of production

- Variety and quality improvement of farm produce through research to address problems of seasonality in production
- Small scale vegetable farmers to organise groups for efficient marketing.
- Contract growing of vegetables between growers and traders to ensure regular supply of quality produce.
- Growers to be provided with reliable market information.
- Post harvest handling and preservation of vegetables during the period of plenty to be used during the scarcity period.

Conclusions and Recommendations

- Farm produce sold at Kakamega municipal market varied from cereals, roots, tubers, grain legumes, fruits and vegetables but less variation was observed in the rural markets.
- Most of the produce in Kakamega market came from outside the province while in the rural markets most of the produce was from local farmers.
- The highest contribution of ALVs was obtained in the rural markets.
- 95% of the vegetables traded in one of the rural markets were ALVs and 70% of these were packed for Kisumu and Nairobi cities.
- The major constraints faced by traders included poor marketing system and price fluctuation due to seasonality in production.
- Six ALVs were identified as the most important in the three markets studied.

Suggestions for further Research

- Systematic and comprehensive country wide market survey to establish the important species in the country..
- Market surveys should be compared with other surveys like baseline and production surveys to really establish the priority ALVs.

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Questions/Comments and Answers

Fricke: Why isn't African kale listed as one of the six most important ALVs?

Response: There is need for baseline survey. African kale is not among top six in the markets. Possibly, because it is used at home or sold before it reaches the market.

Watako: Handling, preparation traditional vegetables may influence palatability.

Response: Younger generation do not like bitter types (*Solanum vilosome*) as opposed to *Solanum scabrum*. Options are available for different tastes. Preparation methods are not a hindrance.

Fidelis: convenience of introduced vegetables to urban lifestyles

Njue: How are you promoting the indigenous vegetables? Is it via the local administration, schools (student diets) etc?

Response: Several organisations are promoting usage. Data is necessary and research is required for promotional strategies.

Saha: Abundance during rainy seasons may require preservation for off season usage? Did you look into off season production?

Response: Traditional preservation methods and working on the improvement on off storage – part of the intervention. Water harvesting and mode side production during off season encouraged irrigation.

Fidelis: Farmers participatory involvement? How will they be involved?

Response: farmers involvement at study level – status on vegetables was obtained from farm and preferences. Farmers Identified problems e.g. seed availability. Indigenous practices and knowledge sourced from farmers.

Potential Salinity Resistance in Spiderplant (*Cleome gynandra* L.)

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Abstract

Seeds of spiderplant (Cleome gynandra L.) were sown in soil-filled 20-litre plastic pots. The study was conducted to investigate the potential for the existence of salinity resistance in C. gynandra. The experimental design was randomized complete blocks (RCBD) with four replications. Two to four weeks after germination, the plants were subjected to five levels of salinity, applied by irrigating the pots daily with salt solutions of concentrations: 0 mol/kg (control), 0.07 mol/kg, 0.13 mol/kg, 0.20mol/kg and 0.26 mol/kg; respectively exerting osmotic potentials of 0 MPa (control), -0.3MPa, -0.6MPa, -0.9MPa and –1.2MPa in the rooting medium. Data on growth parameters was collected weekly, including fresh and oven-dried weights of the whole plant as well as roots, shoots and leaves; water content, chlorophyll content, leaf number, leaf weight ratio, root/shoot ratio and days to 50% flowering.

Results showed that salinity significantly decreased growth in roots, shoots and leaves and reduce chlorophyll content. Spiderplant was therefore concluded to possess a poor capacity for regulating the entry, translocation and compartmentalization of salts, thus allowing large amounts of salt to be absorbed and translocated to the shoots and leaves, leading to retardation/inhibition of cell division and expansion, decreased photosynthesis and increased respiration. Observed root death was attributed to the deterioration of soil structure in the presence of high exchangeable sodium percentage (ESP) in the soil.

Water content and some growth parameters were initially reduced but recovered after some time. This was attributed to reduction of transpiration and osmotic adjustment. Since plants were able to survive, grow and reproduce when subjected to up to –0.9 MPa of salt stress in the soil, spiderplant was concluded to have a moderate degree of salt resistance. Factors contributing to this resistance may include the species' capacity for osmotic adjustment and the presence of a C_4 (Hatch-Slack) photosynthetic pathway.

Key Words: Cleome gynandra L., salinity, compartmentalization, osmotic adjustment.

Introduction

Soil salinization is the accumulation of salts in the rhizosphere to concentrations high enough to make soils unproductive and unmanageable, and affect plant growth and development (Hansen *et al.*, 1980; Young, 1976; Wild, 1988; Rajan and Rao, 1976). The degree of salinization is an important determinant of a soil's productivity (Flowers *et al.*, 1976; Hansen *et al.*, 1980; Moons *et al.*, 1995; Yeo and Flowers 1985; 1986). Understanding the physiology of salt tolerance in agricultural plants is therefore essential for an effective approach to solving the problem of salinity

in irrigated agriculture (Ziska *et al.,* 1989). Salinity effects on plants include reduced water uptake, reduced leaf expansion, lower photosynthetic rates, raised CO_2 compensation points, reduced stomatal conductance and altered patterns of respiration, metabolism and assimilate partitioning (Shalhevet and Hsiao, 1986; Kaiser, 1987; Kennedy, 1976; Rawson, 1986; Ziska *et al.*, 1989; Ashraf *et.al.*, 2001).

Although most crops tolerate only modest amounts of salt (McCree, 1986; Richardson and McCree, 1985), they exhibit a wide range of salt resistance (Wild, 1988; Scheurmann *et al.*, 1990; Kingsbury *et al.*, 1983; Yeo and Flowers, 1986), indicating that plants adapt to salinity (Nagy *et al*, 1994; Kefu *et al.*, 1991). These differences can be used to investigate the nature of salt resistance and as a basis to select and breed salt-resistant crops (Wild, 1988; Kingsbury *et al.*, 1983; Ashraf *et.al.*, 2001). The salt-resistance of a plant depends on its physiological age, ability to withstand high soil pH, low calcium, waterlogging and low oxygen conditions, ability to withstand high concentrations of salt ions in the tissues, ability to extract water from the rooting medium under saline conditions, the soil nutrient status, soil structure, and the moisture content release curve of the soil (Moons *et al.*, 1995; Nagy *et al.*, 1994; Wild, 1988; Ziska *et al.*, 1989).

Salt resistance may be achieved by either salt stress avoidance or salt stress tolerance (Levitt, 1980). Avoidance allows the plant to maintain low concentrations of salts in its cells by exclusion, excretion, or dilution due to rapid growth, succulence or stomatal closure (Flowers *et al.*, 1988; Yeo and Flowers, 1986). But if the osmotic stress is high enough to induce turgor loss, the plant must tolerate osmotic stress in order survive (Itoh *et al.*, 1986; Ziska *et al.*, 1989). Two or more salt resistance mechanisms may be involved in the salt resistance of one plant (McCree, 1986; Levitt, 1980). Phenotypic salt resistance is therefore not conferred by a single factor, but is the sum of a number of contributory traits (Yeo and Flowers, 1986; Flowers *et al.*, 1988; Levitt, 1980; Ashraf *et.al*, 2001).

Since the cell membrane is freely permeable to water, the first response to salinity is loss of turgor due to osmotic dehydration (Wild, 1988; Levitt, 1980; Ziska *et al.*, 1989). Resistance to this is achieved by increasing the cell's solute content to lower its osmotic potential below that of the surrounding solution to compensate for the external osmotic stress and maintain turgor i.e. osmotic adjustment (Munns, 1988; Morgan and Condon, 1986; Richardson and McCree, 1985). Since osmotic stress is the principal factor limiting growth, the capacity for osmotic adjustment is important for salt resistance in many species (Nagy *et al.*, 1994; Itoh *et al.*, 1986).

Osmotic adjustment may occur via the uptake and accumulation of salt ions (Yeo and Flowers, 1985; Clipson and Flowers, 1986; Levitt, 1980). As the presence of large amounts of salt in plant tissues may cause ion toxicity, salt damage may be avoided by compartmentalizing them in the vacuole away from sensitive metabolic sites (Levitt, 1980; Kingsbury *et al.*, 1983). Other levels of compartmentalization include older leaves to protect growing, metabolically active young leaves; apoplast and symplast with higher accumulation in the former; vascular and bundle sheath tissues to protect the photosynthetic mesophyll tissue; and in roots to protect the more sensitive shoot organs (Yeo *et al.*, 1988; Greenway and Osmond, 1971; Yeo and Flowers, 1983, 1985, 1986; Itoh *et al.*, 1986; McCree, 1986; Kingsbury *et al.*, 1983). Sequestering salts necessitates generation of non-toxic, osmotically active organic solutes to maintain ionic balance across the tonoplast (Itoh *et al.,* 1986; McCree, 1986; Shalhevet and Hsiao, 1986). Species that have poor capacity for compartmentalization and are too salt-sensitive to withstand high salt amounts in their tissues (Yeo *et al.*, 1988) exclude salts at the root surface and attain osmotic adjustment by producing osmotically active organic solutes (Stewart and Lee, 1974; Allison, 1964; Russell *et al.*, 1988).

Invariably, osmotic adjustment exacts a metabolic cost in terms of growth and biomass production (Van der Moezel *et al.,* 1988; Ziska *et al.,* 1989).

African indigenous food crops constitute a complement of crops that is both nutritionally rich and well adapted to the region. However, these crops have been ignored by policy makers, researchers and farmers as possible solutions to food insecurity problems in Africa. Considering the role of leafy vegetables in the typical African diet, the need to promote leafy Indigenous Vegetables (AIVs) is apparent (Eyzaguirre, 1997; Chweya and Mnzava, 1997). The spiderplant is among the three most important leafy AIVs. Yet, little research has been carried out regarding its responses to environmental stresses, agronomic traits and selection/breeding (Schippers, 2001; Chweya and Mnzava, 1997). Following promotion of its growth and utilization, increased cultivation in low-rainfall areas in Uganda, Zambia, Zimbabwe and Cameroon is reported (Diouf, 1997; Eyzaguirre, 1997; Schippers, 2001).

The nutritional value of the spiderplant is reported to be comparable to that of other vegetables (Chweya and Mnzava, 1997), being a good source of vitamins A and C, iron, calcium and magnesium (Schippers, 2001) and proteins (Imbamba *et. al*., 1977). It's also used as medicine, insecticide, acaricide, forage crop, crop protectant and anti-feedant, for oil extraction and as a source of yellow dye (Chweya, 1997).

Materials and methods

The experiments were conducted at Maseno University, Department of Botany experimental shed and laboratory between June 2000 and February 2001. The altitude at Maseno is 1500m above sea level, average annual precipitation is 1750mm with a bimodal distribution, mean temperature 23^{o}C and relative humidity 40% respectively. Soils are acrisol, well-drained, deep reddish brown friable clay with pH range between 4.6 and 5.4 (Netondo, 1999). Seeds of spiderplant were obtained from researchers at Maseno University, Botany Department, and subjected to a germination test to confirm suitable viability. 20 litre PVC pots with perforated bottoms were filled up to ¾ full with fine-tilled soil from the Department of Botany experimental plot. Seeds were broadcast at the rate of 20 per pot on the soil surface and covered with a thin layer of soil. Pots were placed in a wall-less shelter with a transparent polythene roof, and irrigated daily with tap water until the plants were ready for treatment. Seedlings emerged from the fifth day after sowing. Two weeks after emergence, seedlings were thinned to leave twelve uniform plants per pot, and treatment applications were started. Fertilizer application included diammonium phosphate at 200kg/Ha at sowing, and calcium ammonium nitrate at 100kg/Ha topdressing at thinning (Chweya and Mnzava, 1997).

The treatments included a control experiment (S_1) in which the pots were irrigated daily with tap water, and the saline treatments S_2, S_3, S_4, and S_5 comprised irrigating respective pots daily with salt solutions of concentrations 0.07mol/kg, 0.13mol/kg, 0.20mol/kg and 0.26mol/kg, to exert osmotic stress of -0.3MPa, -0.6MPa, -0.9MPa, and -1.2MPa respectively. Treatments were formulated by calibrating water potentials and corresponding concentrations from the data of Lang (1967) (appendix 1 and 2). The salt solutions were made by dissolving commercial table salt (Kensalt: Na=36%; K=1.1%; Ca=1.2%; Cl=55%-) in tap water (Onkware, 1986).

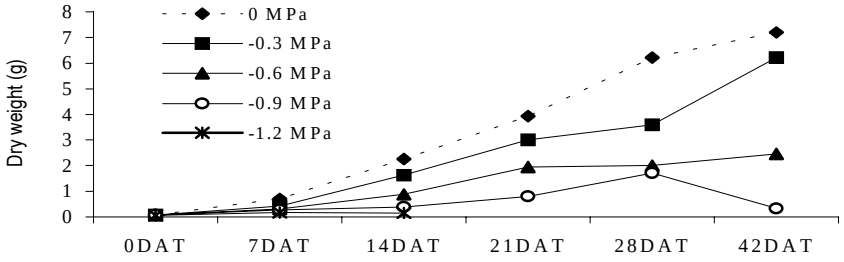
Experimental design was completely randomized blocks with five treatments and four replicates. On each day of measurement, a single plant per pot was selected randomly and carefully uprooted taking as much of the root system as possible. The first harvest was at thinning and subsequent weekly harvests continued for six weeks. Data collected included plant height, root length, whole

plant fresh and dry weights, partitioned fresh and dry weights for leaves, roots and shoots, root to shoot dry weight ratio, leaf number, leaf weight ratio (%LDW**=** 100 X **(**leaf dry weight**)/(**whole plant dry weight**)**), relative shoot growth rate (RSGR) as described by Kingsbury *et al.* (1983), days to 50% flowering, and leaf chlorophyll content according to Arnon (1949) and Coombs *et al.* (1987). Analysis of variance was done on all data using a statistical computer package (MINITAB Release 10.2). L.S.Ds at 5% level were calculated according to Clewer and Scarisbrick (1991).

Results and Discussion

Salt stress significantly reduced the growth of spiderplant, and the degree of inhibition increased with increasing salt stress (Fig.1, Table 1). The least salinized plants (-0.3 MPa) had dry weights that were statistically similar to the control (0 MPa), and the values were significantly higher than those of –0.6 MPa, -0.9 MPa and –1.2 MPa treatments (Fig.1). This would indicate that spiderplant is sensitive only to salt solutions exerting a water stress more than –0.3MPa. From the results on relative shoot growth rates (Table 1), it was found that shoot growth was highly sensitive to salt stress. Root growth was also reduced by salt stress. In addition to reduced cell expansion and division, reduction in root growth may have been contributed by the death of root cells, ascribed to salt-induced loss of turgor and ion toxicity in the root meristems, and poor aeration of the rhizosphere due to deterioration of soil structure occasioned by high exchangeable sodium percentage(ESP) in the soil. However, roots were generally more salt resistant compared to the shoot (Fig.2). Salt stress led to remarkable reduction in leaf number, leaf fresh and dry weights, hence decreased leaf growth (Fig.3). Salt stress may have reduced leaf growth by retarding the initiation and emergence of new leaves, and accelerating the senescence of old ones.

Results on chlorophyll content (Fig.5) revealed that salt stress significantly decreased the content of chlorophyll in the leaves. This was especially true when the level of salt stress was high (more than –0.9MPa), whereby all the three chlorophyll parameters were reduced by up to 80%. This was attributed to salt effects in damaging the chloroplast membranes, reducing the rates of chlorophyll synthesis, and increasing the rate of chlorophyll breakdown (Netondo, 1999).



L.S.D.Values: 0DAT= ns; 7DAT=0.21***; 14DAT=0.41***; 21DAT=1.13***; 28DAT=2.17**; 42DAT=2.44***

Fig. 1: The effect of salinity on total plant dry weight in *Cleome gynandra* L.

The above results agree with those reported for other crops (Allison 1964; Kingsbury *et al.*, 1983; Richardson and McCree, 1985; Onkware, 1986; Van der Moezel *et al.,* 1988; Wild, 1988; Netondo, 1999; Yeo *et al.*, 1991). Reduced growth was attributed to the effects of salts in retarding cell division and cell extension via osmotic dehydration, ion toxicity, nutritional imbalance, or a combination of these (Hsiao, 1973; Ashraf *et al*, 2001), ultimately resulting in production of fewer and smaller cells (Richardson and McCree, 1985; McCree, 1986; Turner, 1986). Reduction in plant growth may also be explained by indirect physiological effects of salinity such as increased

mesophyll and stomatal resistances leading to reduced CO_2 assimilation and photosynthetic rates, hence smaller quantities of metabolites being available for growth. Furthermore, salt stressed plants have higher rates of tissue respiration, which would expectedly exert its demand on the already low metabolite levels at the expense of growth (Onkware, 1986). Root damage may also have resulted due to soil deflocculation occasioned by high Na^+. Symptoms of deflocculation in salinized soils such as poor drainage of the irrigation water (Allison, 1964; Rajan and Rao, 1976; Wild, 1988) were observed in the potted soil at the end of each experimental period.

Table 1: The effect of salt stress on relative shoot growth rate (RSGR) in *Cleome gynandra* L.

Treatment	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**R^2 value**
Control (0MPa)	0.333	0.172	0.077	0.059	0.023	0.8634
-0.3Mpa	0.263	0.191	0.083	0.029	0.076	0.7823
-0.6Mpa	0.227	0.145	0.119	-0.004	0.033	0.8547
-0.9Mpa	0.197	0.06	0.085	0.109	-0.066	0.6281
-1.2Mpa	0.157	0.002	****	****	****	0.5096
P value	0.079^{ns}	0.008^{**}	0.833^{ns}	0.308^{ns}	0.566^{ns}	
L.S.D (5%)		0.089				

Key: [**a**]. ns- nonsignificant differences. [**b**].**-Significant at 1% level.
[**c**]. ****- missing values- all S_5 plants had died off by start of week 3.

Plants have several mechanisms by which they deal with the presence of toxic concentrations of salts in the growth medium. Most glycophytes avoid ion toxicity by excluding the salt ions at the root surface, or by excluding the toxic ions from metabolically active (and presumably salt-sensitive) sites such as the photosynthetic apparatus and enzymes via compatrmentalization. This may be at the whole-plant, organ, tissue or cellular levels (Ashraf *et al*, 2001). Plants that cannot regulate salt ion concentration in this way, and whose tissues are not innately salt-tolerant *per se*, encounter severe physiological dysfunction (Netondo, 1999), leading to decreased growth rates and eventually, tissue and organ death. Spiderplant, being a glycophyte, seems to be a poor regulator of salt entry at the root surface, as well as translocation and compartmentalization in the shoot. This was deduced from observed severe leaf damage produced by high salt concentrations.

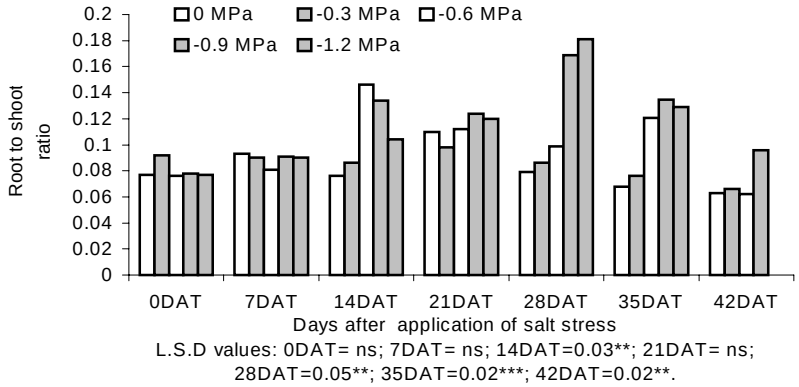


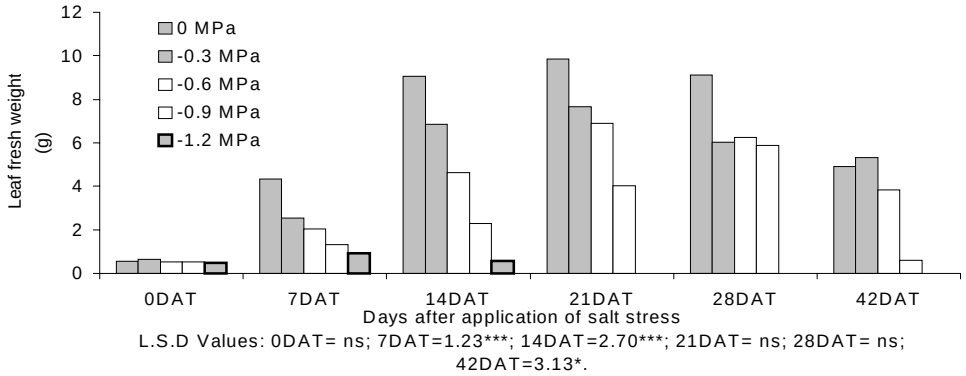
Fig. 2: The effects of salt stress on the root to shoot ratio in *Cleome gynandra* L.

Salt stress affected the plant water status (Fig.5), and the response was complex, varying with both time of exposure and degree of salt stress. At the onset of salt treatment, percentage water content

(%WC) of the highly stressed plants declined sharply in the first week, such that there were highly significant differences between the treatments at 7 DAT, with control plants having the highest value, which generally decreased as salt stress increased. This was followed by apparent recovery by salinized plants such that at 14 DAT, the values for all treatments were statistically similar. In the third and subsequent weeks, significant differences between treatments reappeared. However, the values now increased with increasing salt stress, with control plants having the lowest value and highly salinized (-0.9 MPa and –1.2 MPa) the higher values. %WC for the control and –0.3 MPa plants declined over the entire experimental period. It is noteworthy that the recovery in %WC of moderately salinized plants after two weeks was so remarkable as to exceed the pre-salinization values.

Lowering the osmotic potential of soil by addition of salt lowers the total soil water potential, making soil water less available for absorption by the plant. Since the cell membrane is freely permeable to water, it is inevitable that a plant exposed to a hypertonic solution will experience osmotic dehydration as its cells lose water to the surrounding medium (Ziska *et al.*, 1989), which explains the observed initial sharp decline in %WC as soon as the plants were exposed to salt stress. Such an osmotic dehydration, if severe enough, leads to loss of turgor and a decrease in cell volume (Wild, 1988; Richardson and McCree, 1985). Turgor loss has been blamed for subsequent depression of growth and yield, and decrease in transpiration. Decrease in transpiration is due to increased hydraulic resistance to water movement at the leaf and root surfaces (Kingsbury *et al.*, 1983; Van der Moezel *et al.*, 1988; Baum *et al*, 2000). Cell extension growth depends on positive turgor, and is reportedly inhibited by water potentials below –0.3MPa (Hsiao, 1973). Therefore, dehydration due to the high osmotic stress (-0.6, -0.9 and –1.2PMPa) applied in the current work would explain the rapid decrease in %WC.

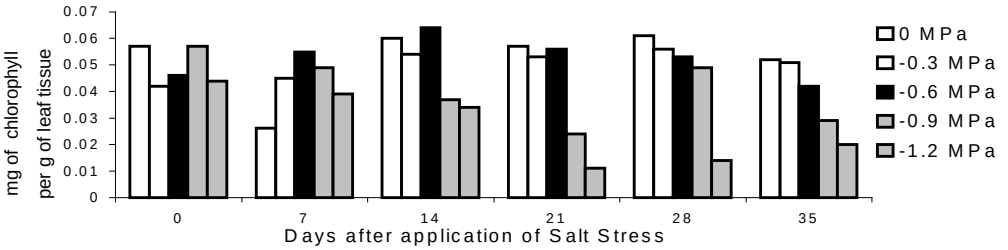
Another effect of reduced cell turgor is decreased transpiration as a result of increased diffusive root and leaf resistances (Onkware, 1986). Netondo (1999) reported a positive correlation between stomatal conductance and transpiration, indicating that stomatal closure is mainly responsible for reduced transpiration in salt stressed sorghum, hence lower photosynthetic capacity. However, stomatal closure also has the effect of reducing salt loading into the leaves by the same action of limiting the transpiration stream, thereby maintaining tissue salt concentration at sub-toxic levels for longer periods (Netondo, 1999). Reduced transpiration also conserves water. Thus reduced leaf area complements reduced transpiration in raising the water use efficiency of the plant to reduce salt loading in the leaves. Many researchers view this as a mechanism aiding the survival of plants exposed to salinity in both glycophytes and halophytes (Nagy *et al.*, 1994; Shalhevet and Hsiao, 1986; Ziska *et al.*, 1989; Kingsbury *et al.*, 1983; Netondo, 1999). A lag in the plant's stomatal response in the just-described manner has been related to the degree of salt tolerance (Kingsbury *et al.*, 1983; Levitt, 1980). Thus, salt sensitive plants suffer a net loss of water via root dehydration and stomatal transpiration before equilibrium is established via stomatal closure. Such a lag explains the decrease in % WC in the first week of exposure to salinity. Reduction in transpiration rate in salt stressed plants has also been attributed to morphological changes, such as increase in cell wall thickness and lignification (Bongi and Loreto, 1989).



L.S.D Values: 0DAT= ns; 7DAT=1.23***; 14DAT=2.70***; 21DAT= ns; 28DAT= ns; 42DAT=3.13*.

Fig. 3: Effects of salinity on leaf fresh weight in *Cleome gynandra* L.

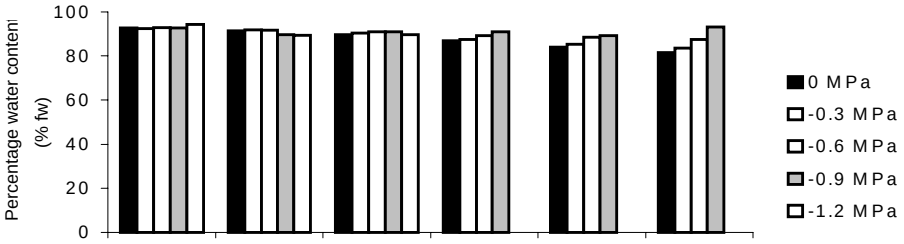
Most plant species have the capacity to recover from adverse effects of environmental stresses exposure for a long time (Levitt, 1980). Such an acclimation has been observed in wheat (Kingsbury *et al.*, 1983) and sorghum (Netondo, 1999), and may explain the increase in % WC after the first week of salt treatment. Plants may adapt to osmotic stress by regulating the loss of water through the leaves and roots, and reduction in transpiration is achieved via stomatal closure and change in stomatal rhythms (Onkware, 1986). However, osmotic dehydration of the roots can only be regulated by lowering the osmotic potential of root cells below that of the surrounding soil solution. This is the only way that the observed increase in % WC in the second week of salinization (Fig. 5) can be explained since for %WC to increase, the plant had to absorb water from the salty soil. This would only have been possible if root cells had lower water potential compared to the soil. Such dehydration avoidance and recovery of %WC by way of lowering the plant's water potential is possible only due to a net increase in the solute content of the plant cells sufficiently to lower the plant's osmotic potential to compensate for the external osmotic stress i.e. osmotic adjustment (Turner and Jones, 1980; Munns, 1988). Thus, observed increase in %WC in the second week of salinization is attributed to osmotic adjustment and agrees with the findings of Kennedy (1976), who attributed a net increase in the water content of salt stressed *Zea mays* L. and *Portulaca oleracea* L. to osmotic adjustment. Thus, the increase in %WC in the current study may be interpreted as evidence that spiderplants achieved osmotic adjustment under salt stress. The capacity for osmotic adjustment has been associated with the degree of salt resistance (Kingsbury *et al.*, 1983; Flowers *et al.*, 1988), and various mechanisms exist by which different plants attain osmotic adjustment (McCree, 1986; Shalhevet and Hsiao, 1986). In glycophytes, for example, salt resistance depends on the ability to exclude salt ions at the root surface, coupled with osmotic adjustment via accumulation of organic solutes (Nagy *et al.*, 1994; Onkware, 1986; Netondo, 1999). The effect of osmotic adjustment was reflected as recovery of previously reduced growth parameters in almost all parameters measured.



L.S.D values: 0DAT=0.0031***; 7DAT=0.0041***; 14DAT=0.0036***; 21DAT=0.0037***; 28DAT=0.0031***; 35DAT=0.004***.

Fig.4: Effect of salt stress on total chlorophyll content in *Cleome gynandra* [L.].

Available data indicates that spiderplant is neither good at regulating salt entry, nor at compartmentalizing the absorbed salts. Observed high mortality of highly salinized plants (-1.2 MPa) (Fig.1) supports this argument. However, the fact that moderately salinized plants (-0.6 MPa and –0.9 MPa) survived and indeed continued growth (albeit at retarded rates) under salt stress for relatively long periods indicates that the species may possess some degree of salt resistance. The findings of Chweya and Mnzava (1997) that the species is moderately resistant to water stress, coupled with the fact there exists an inseparable and direct relationship between salt stress and water stress (Ziska *et al.*, 1989; Levitt, 1980), support this conclusion.



L.S.D values: 0DAT=0.97*; 7DAT=0.48*; 14DAT= ns; 21DAT=2.66***; 28DAT=2.00***; 42DAT=2.05***.

Fig.5: The effect of salt stress on percentage water content in *Cleome gynandra* L.

Salt stress is reported to stimulate C_4 photosynthesis in some plant species due to apparent stimulation of the enzyme phosphoenol pyruvate carboxylase by salt (Levitt, 1980). Furthermore, C_4 plants are known to be relatively more drought resistance, which is associated with high water use efficiency and high photosynthetic rates (Kennedy, 1976). Given the close relationship between water stress and salt stress (Ziska *et al*., 1989), the fact that spiderplant is a C_4 plant, is moderately drought resistant (Chweya and Mnzava, 1997), the finding that salt stress enhances a plant's water use efficiency (Netondo, 1999), and the current results that the species survived moderate salt stress, it is safe to conclude that the species is moderately resistant to salt stress.

It is hereby concluded that spiderplant, being a glycophyte, is expectedly salt sensitive. Hence the growth and yield of this species are depressed by salt stress. However, the data also shows that the species can survive and continue to grow under conditions of moderate salt stress. A salt stress exerting an osmotic potential stress of –0.3MPa does not affect the growth of this species. From the observations, it has also been concluded that the species can survive, grow and reproduce when exposed to a salt stress of up to –0.9MPa, albeit at retarded rates. This ability,

attributed to the species' capacity for osmotic adjustment, and the C_4 photosynthetic pathway is hereby viewed as a promising trait which through further investigation may form a criterion in the selection and breeding of salt-resistant spiderplant cultivars. As yet, very limited selection for desirable agronomic traits in spiderplant has been done (Schippers, 2001). There is therefore, need to incorporate screening for salt resistance in the selection process.

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Appendices

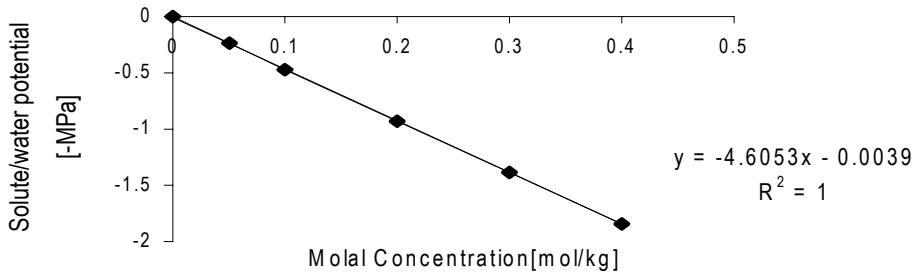
Appendix 1: How the water potentials of sodium chloride solutions in MPa were obtained from the data of Lang (1967).

Water potentials of sodium chloride solutions in J/kg (Lang, 1967).

Molality (Mol/kg)	Ψ_w 0° C	Ψ_w 5° C	Ψ_w 10° C	Ψ_w 15° C	Ψ_w 20° C	Ψ_w 25° C	Ψ_w 30° C	Ψ_w 35° C	Ψ_w 40° C
0.05	-214.4	-218.4	-222.3	-226.2	-230.1	**-233.9**	-237.7	-241.6	-245.4
0.1	-423	-431	-439	-447	-454	**-462**	-470	-477	-485
0.2	-836	-852	-868	-884	-900	**-915**	-930	-946	-961
0.3	-1247	-1272	-1297	-1321	-1344	**-1368**	-1391	-1415	-1437
0.4	-1658	-1693	-1727	-1759	-1791	**-1823**	-1855	-1886	-1917
0.5	-2070	-2115	-2158	-2200	-2241	**-2281**	-2322	-2362	-2402
0.6	-2484	-2539	-2593	-2644	-2694	**-2744**	-2794	-2843	-2891
0.7	-2901	-2967	-3030	-3091	-3151	**-3210**	-3270	-3328	-3385
0.8	-3320	-3398	-3472	-3543	-3612	**-3682**	-3751	-3818	-3885
0.9	-3743	-3832	-3917	-3998	-4079	**-4158**	-4237	-4314	-4390
1.0	-4169	-4270	-4366	-4459	-4550	**-4640**	-4729	-4815	-4901
1.1	-4599	-4713	-4820	-4924	-5026	**-5127**	-5226	-5322	-5418
1.2	-5032	-5160	-5278	-5394	-5507	**-5620**	-5730	-5835	-5941
1.3	-5470	-5611	-5742	-5869	-5994	**-6119**	-6239	-6354	-6471
1.4	-5912	-6068	-6210	-6350	-6487	**-6623**	-6754	-6880	-7006
1.5	-6359	-6529	-6684	-6837	-6986	**-7134**	-7276	-7411	-7548
1.6	-6811	-6996	-7163	-7330	-7491	**-7652**	-7805	-7950	-8097
1.7	-7260	-7460	-7640	-7820	-8000	**-8170**	-8330	-8490	-8650
1.8	-7730	-7940	-8130	-8330	-8520	**-8700**	-8880	-9040	-9210
1.9	-8190	-8430	-8630	-8840	-9040	**-9240**	-9430	-9600	-9780
2.0	-8670	-8920	-9130	-9360	-9570	**-9780**	-9980	-10160	-10350

NB: ***Only the figures in the 25°C column (in bold type) were used for the purposes of this experiment, based on the premise that the average temperature at Maseno is approximately 25°C.***

Appendix 2: Graph showing the relationship between the solute potential (water potential) of sodium chloride solutions in –MPa and the molal (moles of solute/kg of water) concentration.



Molal solutions of NaCl with their corresponding solute potentials in -MPa (adapted from Lang, 1967)

NB: The water potential units in appendix 1 (in J/kg) were converted to Mpa by multiplying the values in appendix 1 by the density of water at 25^{0}C (0.9962g/mL), the approximate average temperature of Maseno [Netondo, 1999]. This gave the water potential in kiloPascals (KPa), which were then divided by 1000 to give the values in MPa.

Questions/Comments and Answers

Njue: Is data sufficient to say that osmotic adjustment is responsible for tolerance? Exclusion may have been a factor! No analysis for elements associated with salt tolerance/uptake was done.

Response: 2 week acclimatization period based on results of water content vs. time. as per the methods of Kennedy (1976) were used.

Stuetzel: You worked with soil vs. other media. Colloidal absorption of salt ions may take place initially. Then assimilation with increased salty water irrigation. I suggest working with nutrient solutions.

J.C. Onyango: Objective was to look at expanding production to solution areas. So soil media was used to reflect production methods. There is already documented evidence.

Njoroge J.B: You should have measured osmotic potential of the plant.

Responses: That was one of the recommendations that arose from the study.

Factors Affecting Development of Floriculture in Traditional Maize Growing Areas (Trans-Nzoia and Bungoma)

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Abstract

Maize growing farmers are being encouraged to diversify and grow other crops including flowers such as arabicum, tuberose and eryngium that can be produced with relative ease and low capital investment. Parts of Transnzoia get hailstones during the peak of the flower production period. A study was undertaken to come up with recommendations for farmers in the hail prone areas. The report is expect to establish the choice of flowers that can be grown with and without protection and cultural practices the would limit the effects of hailstone damage.

Introduction

Hailstones are formed in most mid-latitude thunderstorms. The thunderstorms are important in these areas are they are responsible for the rains that make these areas the breadbasket for the country. For maize the hail causes severe damage to the shoot but because the growing point is protected, the new leaves emerge and can compensate for the damage. Since the edible part of the cereal is the grain that forms later, usually the damage is no noticeable and does not lower the quality of the grain.

Flowers on the other hand are harvested on the shoot and the peak harvest period is during the October – January. Damage from these rains is manifested all the way through to December and January. This apart from rendering the flowers poor quality it contributes to disease prevalence since the injured area creates an entry point for the pathogens. Once there is no recovery a farmer will have no crop to deliver for the whole season leading big financial losses.

Trans-Nzoia District lies to the North West of Kenya and its agricultural land is part of the fertile Uasin Gishu plateau. The plateau is at an altitude of 1800 –1900 m.a.s.l. It has good soils and with adequate rainfall good enough moisture for late maturing maize varieties. The average mean temperatures are 18.3 °C but can dip to temperatures low temperatures of 8-11 °C. It has a high rainfall that is fairly well distributed. These climatic conditions make the district suitable for most flowers grown for export in Kenya. Therefore with low prices realized from growing maize farmers are encouraged to diversify especially venture in growing high value crops such as flowers. For small scale farmers outdoor flowers which are less capital intensive are advised.

The survey carried out in Trans Nzoia was in response to the quick turn-over of farmers venturing into growing flowers (Sirikwa 1998). At an awareness /sensitisation workshop held for stake holders in Western Kenya –the farmers claimed they had tried growing flowers but had lacked market or fallen prey to the middleman. Most were in the venture for less than two years and yet were ready to claim that it was not feasible to grow flowers in Western Kenya even with the airport opening its doors to the cargo.

Method

A questionnaire was used to interview the farmers. The target group was small scale flower growers in Trans Nzoia. The questionnaire was administered by the researchers who were accompanied by an HCDA officer.

The following are some growers in Trans Nzoia who were supposed to be active in the production and export of cut flowers.

- Sote Flowers
- *Panacol International
- *Anderson Orchards
- Peter Muhauni
- Samuel Koech
- WilliamTabut
- D. Wanyenya
- *Ndola Flowers

* Visited

Results

Nine farmers were visited and interviewed but only three were still growing flowers. The farmers had varied reasons for choosing floriculture during their diversification efforts. Below are some of the reasons for growing flowers:

1. Introduction by a third party as a high income earner
2. Moved from flower growing area
3. Given planting material free – research
4. New airport sensitisation
5. Sourced technology and planting material after visit to flower growing area

Cut flowers and foliage grown by the small scale growers:

- Gladiolus
- Tuberose
- Eryngium
- Lilies
- Statice
- Ferns (leather leaf, asparagus and sword)
- Birds of paradise

Constraints contributing to abandoning enterprise:

1. Lack of marketing information and channels
2. Exploitation by middlemen –cost of transportation
3. Pests are expensive to control and lead to rejection due to poor quality
4. Flower growing -labour intensive and interferes with the production of other crops
5. Lack of new varieties of the flowers popular in the market

Discussion

Poor quality was the main constraint due to disease and disease that may have been aggravated due to physical injury. Generally, hail in maize growing areas is a common phenomenon and does not warrant much notice. Samples of diseased tuberose stems carried back to the pathology laboratory at the National Horticultural Research Centre were found to have fungal diseases at points where there were breaks on the surface of the stem. Application of pesticides did not make any difference. Tuberose seemed to be the most affected as the shoot takes a longer to grow to maturity ie the point of shoot emergence to point of harvest is more than 4 weeks.

The rainfall in Trans-Nzoia is almost always accompanied by thunderstorms and the thunderstorms accompanied with hail. Hailstones cause great damage to crops. Maize recovers sufficiently to produce acceptable yields. For cut flowers where the whole shoot is harvested the injury to the shoot does not usually heal but creates an avenue for pathogens to attack the plant. This is the most probable reason why unprotected flower growing may not be feasible in hail prone areas. Other factors include the distance to the Nairobi airports, because summer flowers are not as high value as the Roses and *Eustoma*, which are normally grown under cover.

Conclusion

Some of the factors that are affecting floriculture development in Trans Nzoia include climatic factors and there is need to document these conditions so that appropriate guidance is given to farmers who are would like to grow flowers.

Recommendation

1. Further studies by concerned departments to map out the hailstone belt if any.
2. Research on structures that are cost effective for small- scale farmers for protection against hail.
3. Research on hardy flowers that can recover or do well under these conditions.

Acknowledgement

We wish to acknowledge the support given by the HCDA officers in locating the flower growers and DALEO –Trans Nzoia for agricultural information of the district. The research was funded by the USAID through KARI.

Questions/Comments and Answers

Anjichi, V.E: During June – August, some production occur in Europe. Local production is geared towards November to January. These regions have hailstone coincidentally usually at this time.

Kibaki: Did you find out the diseases affecting the flower? Were there management problems that may have increased the impact of the problem? Were plant materials analysed and diseases determined

Response: Hailstone damage was irreparable and Fungal infection predominant in tuberose

Secondary Metabolites from Fungi as Potential Pesticides in the Tropics

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Abstract

The realization of dietary importance, crop diversification and export potential of vegetables has led to the need to increase their productivity in the tropics. Nonetheless this industry faces many constraints which include lack of quality, high yielding and resistant varieties, poor crop seed supply, unstable vegetable prices, processing technology, lack of post harvest handling and support services. Among these, pest and disease emerge as the main crippling factors. It is estimated that between 5 and 40 percent of crop losses each year are due to insects, weeds, diseases and other pests.

The traditional method has been to rely on chemical pesticides for effective control of pests. It is acceptable that although chemical pesticides have helped boost agricultural output, their continued use is challenged however by the growing problem of contamination of land and water resources, dangers to human health, the widespread indiscriminate killing of plants, insects, birds and wildlife as well as increasing insect resistance and pest resurgence. Also of concern are the residual levels of toxic pesticides in fruit and vegetables.

The growing concern over the serious problems associated with chemical pesticides has led to efforts to reduce pesticide use as much as possible and to seek alternative pest control methods that are effective against target organisms, benign to non-target organisms and are biodegradable.

Secondary metabolites (mycochemicals) with commercial potential isolated in Actinomycetales – a group of micro-organisms producing mycelium and occupying the same in-vitro habitat as fungi but often classified

with bacteria, have been found to possess these properties and therefore have significant potential as microbial pesticides.

Introduction

The economic challenges that face pest management programmes in developing countries are numerous. At the moment about 80 percent of the world's population is in developing countries where there is an urgent need to increase agricultural productivity in order to feed a fast-growing population. Producing horticultural crops in the tropics under humid conditions is not simple. Pest and disease problems are major constraints, with root knot nematodes (*Meloidogyne spp.*), Fusarium wilt, bacterial wilt, viral diseases, and insects being common problems. The loss of horticultural produce due to pests and diseases is estimated to be between 5 and 40 percent each year (Stephens, 1991). Pest problems on vegetables are more serious because of the favourable conditions that are provided for pest multiplication by the present conditions of cultivation. The crops are grown intensively and two or more crops grown where weather conditions permit. The plants are closely spaced for maximum utilization of land. Such cropping conditions create a suitable microclimate for pests to multiply.

Pests mainly affect vegetable crops by feeding directly on plants either by biting and devouring the tissue or by piercing it to feed on the sap. Damage done to vegetables near harvest is of obvious importance, since it has a direct effect on both quality and quantity of produce. Thus, increasing the number of people in the developing world facing food insecurity.

Over the centuries, horticultural farmers around the world have devised different management methods to reduce pest damage. These practices include use of resistant cultivars; selection of planting times to avoid unacceptable pest pressures (Ezueh, 1982); selection of various crop management practices that reduce pest pressure, including tillage practices and maintenance of sanitary growing conditions designed to reduce host plants or materials harboring insects or diseases; use of floating row covers to reduce pest contact with crops (Trumble, 1990). Pest control was revolutionized by the introduction of synthetic pesticides in the early 1950's. This provided the means to reduce pest populations massively in a more effective and large-scale manner than had ever before.

Although chemical pesticide is fairly well recognized as an economic approach to control pests, their widespread use over the past century has not brought an end to the pest problem whilst, in the recent decades, many of their drawbacks and dangers have become increasingly evident. There is greater awareness that chemical pesticides, besides being toxic to humans, can pollute the environment and other species in the environment. Environmental pollution, especially of surface waters, is one serious consequence of pesticide run-off. Chemical pesticide has been singled out as the likely cause of death of fresh water fish. Another issue of concern is the residual levels of toxic pesticides in fruits and vegetables due to cases of over generosity in pesticide applications. The excess often ends up in the food consumed. Pest resistance is one other serious problem. Often the individuals that are able to withstand or avoid exposure to pesticides survive to reproduce. Repeated exposure therefore selects for resistant individuals.

Food safety concerns and the desire to minimize pesticides on vegetables and fruits have increased the desire to seek alternative pest control methods that reduce pest populations without harming people, their livestock or the environment. It is has therefore become of necessary to look at natural products that can provide farmers with alternatives to the present broad-spectrum synthetic pesticides.

The Importance of Microbial Pesticides

There are currently in excess of 1500 naturally occurring microorganisms or microbial metabolites that are known to possess insecticidal properties (reviewed by Jutsum, 1988). Pathogenesis by entomopathogens occurs by invasion through the integument or gut of the insect, followed by multiplication of the pathogen resulting in the death of the host. Studies have demonstrated that the pathogens produce insecticidal toxins important in pathogenesis (Burges, 1981). There is abundant evidence to show that a number of ancient civilizations were indirectly exploiting toxins from entomopathogenic fungi for medicinal purposes (Milner, 1987; Samson *et al*., 1988) from *Cordyceps militaris* and *Tolypocladium inflatum* that are now being employed in medical science. Many toxic compounds, such *Beavericin* and destruxins of *Metarhizium anisopliae* and *aphidicolin* of *Verticillium lacanii* have now been isolated and characterized. However, within the present context of pest control secondary metabolites from Actinomycetales especially the genus *Streptomyces* have stimulated great interest for both insect and mite control.

Commercial Interest in Mycopesticides

Mycopesticides has been a component of pest management strategies in developing countries for many years, enjoying particular success in Asia and South America. In Africa too, there are a few examples of sustained microbial pest control programmes. It is hoped that the anticipated demand for these products will develop leading to their commercialization. In Europe and North America particularly, the market for microbial pesticides represents less that 1% of world insecticide sales (Jutsum *et al*., 1989) and is based on products based on *Bacillus thuringiensis* (Berliner) (*Bt*). Clearly to date the impact of entomopathogenic fungi on crops has been minimal. A move towards safer forms of pest control has been slow, primarily because chemicals have been comparatively cheaper and effective.

There are a number of constraints on the use of fungi as insecticides (Quilan, 1986; Jaronski, 1986):

i) Fungi can be relatively expensive to produce. However, the long-term control exerted by the spread of the disease may make multiple applications unnecessary, removing the cost between mycoinsecticide and comparable chemical insecticide.

ii) The short shelf life of spores necessitates cold storage.

iii) They can be highly specific, thus additional control measures may be required for other members of a pest complex.

iv) Kill takes up to 2-3 weeks compared with 2-3hours for some chemical insecticides.

Despite these problems increasing awareness of the benefits of biological control, as well as of the economic and environmental costs of chemical pesticides, many large multinationals are now pursuing projects on biological control. However, the most interest has come from the recent discovery of a group of pesticidal antibiotics in culture filtrates of soil actinomycete *Streptomyces* spp.

Mycopesticides from *Streptomyces* Spp.

Actinomycetales, the order to which *Streptomyces* belong can be mostly recognized by their pleuromorphic phenotype, which in many genera results in the formation of branched filaments;

there are usually non-motile and aerobic. They are unique amongst bacteria within which they are often classified (Hawksworth *et al*., 1983), in that they possess a mycelial sporulating life cycle.

Antibiotics from *Streptomyces* were originally developed for use against human rather than plant protection. For example streptomycin, which has proved to be active against a wide range of bacterial diseases, particularly fire blight (*Erwinia amylovora*) of rosaceous tree crops and walnut blight (*Xanthomonas juglandis*). Streptomycin sprays have been routinely employed in the USA in fireblight and walnut blight control programmes, being marketed under the names Agrimycin and Phytomycin.Other Stretomyces-derived metabolites, with activity against bacterial plant pathogens, include the tetracylines, especially oxytetracyline (Terramycin) which has been widely used in conjunction with streptomycin to avoid the possibility of resistant pathogen strains developing. Antifungal activity has been shown by cycloheximide (Actidione), another metabolite of *Streptomyces* origin which has been successfully employed against a wide range of fungal diseases, including both powdery and downy mildews, once problems with phytotoxicity and poor translocation had been resolved.

There is evidence to show that secondary metabolites from *Streptomyces* have been employed as insecticides within the present context of pest control other Streptomyces –derived compounds, the avermectins have stimulated great interest in mycochemicals for both insect and mite control. Naturally occurring avermectins have been found to be toxic to many species of insects although tolerance varies and death can be slow (reviewed by Strong and Brown, 1987). The avermectins consist of eight closely related compounds of which Avermectin B_{1a} is the major component, and is considered to have potential as a control agent in the feeding stages of Lepidoptera, Coleoptera and Hemiptera (Dybas and Green, 1984). Avermectins function by disrupting the pest nervous system resulting to paralysis. They also affect the mating behaviour, egg development, oviposition and egg hatching, as well as inhibiting feeding at sub lethal doses. They are selective to arthropods, and non-toxics to mammals, and because they act on a specific site they can be used to control arthropods pests, which have become resistant to conventional pesticides. An added advantage is that they have a low solubility in water and are rapidly degraded in soil. Thus, presenting negligible environmental risks. One such product, Affiom, has been specially formulated for use against fire ants and acts by inhibiting reproduction in the queen ant. Analogues are currently being developed to expand its spectrum of activity to include other agricultural pests and success has been achieved against citrus and pear rust mites, spider mites, leaf miners, diamondback moth (*Plutella xylostella*) and the Colorado potato beetle (*Leptinotarsa decemlineata*).

During the course of screening metabolites from *Streptomyces,* a number of compounds were found to possess significant attributes to weed control. Among these mycochemicals with herbicidal activity and cycloheximide, anisomycin, herbimycin and bialaphos, which have been or are being marketed as herbicides in Japan (Misato & Yamaguchi, 1984).

Implementation of Mycopesticides for Pest Control in the Tropics

A large part of tropical African agriculture comprises the traditional agriculture and staple food crops. These staple foods are largely produced for family consumption. While farmers can afford crop protection in staples, shortages can lead to inappropriate use of insecticides targeted for commercial crops. Thus, causing serious health hazards.

Maize is a staple crop in tropical Africa is attacked by a number of lepidopteran stem- and cob borers such as *Sesamia calamistis* Hampson and *Busseola fusca* (Fuller) and *Mussidia*

nigrivenella Ragonot. Yield losses due to multiple-species attack vary greatly with season, ecozone and country (Schulthess *et al*., 1997). Studies reveal that secondary metabolites from *Streptomyces* spp mentioned in the previous section attack these species, therefore presenting challenges to traditional implementation routes.

Process and Product Development

One of the greatest challenges realizing the use of microbial control agents is to find an economically competitive means of mass production. This process must be sufficiently reliable to provide a product, which is both safe and effective. In addition, the production cost must allow the manufacturers to make a profit.

Many systems for controlling pests are successful in the laboratory. However, they fail when tried in the greenhouse or in the field. Products must be manufactured and formulated in a way which makes them stable for the longest time and as convenient as possible to use.

Recommendations must be developed for the use of the product an actual agricultural practice. These recommendations should not be so complex or require such unconventional equipment that people refuse to use the product. These should be developed in collaboration with the appropriate advisory service to ensure that they will be accepted by the trade.

In the case of new products, testing should be done to establish that they are safe to use; in addition, quality control tests must be devised which will ensure that every batch will be safe and effective. Once this is completed and quality control protocols developed, the appropriate government authority must be approached for permission to sell the product. Once a product has been sold, investigations should be carried out to confirm its success or failures and the causes determined.

There are often obstacles to selling alternative pesticides. Users are unfamiliar with how to use these products and how they work. Marketing requires extra efforts both to familiarize growers with the new product and to provide a substantial back-up service for the product.

Conclusions and Prospects

In the future, microbial agents will probably become an important alternative to chemical pesticides for plant protection. The future of entomopathogens is promising and there is increasing awareness and broad enthuthiasm for their widespread introduction. Many groups including multilateral and bilateral donors, beyond the boundaries are playing a role in biopesticide and microbial pesticide promotion. The International Biopesticide Consortium for Development, a joint venture between CABI Bioscience UK, the international Pesticide Application Research Centre, NRI, IITA and Biologische Bundes-Anstalt, Darmstadt, Germany (BBA) is an example of an initiative addressing the needs of biopesticides in developing countries and which has a focus on Africa. Other organizations include SIDA, FAO and USAID.

It is acceptable microbial control will not necessarily provide a complete solution to the pest problems in the tropical Africa and in order to take advantage of the long term benefits of microbial control, integrated systems must be pursued.

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Questions/Comments and Answers

B. Hau: In some countries, for instance Germany antibiotics are not allowed to control plant pathogens. Are you thinking that the use of streptomycin can therefore really solve the problem?

Response: I should think that streptomycin would be very safe to use because they are selective to arthropods and non-toxic to mammals due to their mode of action. Also, the fact that they have low solubility in water and are rapidly degraded in the soil present negligible environmental risks.

E.O. Auma: Would the same secondary metabolites be used to control weeds, diseases, insect pests or is it that the formulations of the metabolites would differ depending on the organisms you are targeting to control?

Reponse: No, different formulations of the metabolites are used depending on the micro-organisms in question. For instance, streptomycin has proved to be active against bacterial diseases while cycloheximide is used as an antifungal. Some other compounds e.g. avermectins have potential as insecticides.

Pesticide Use and Implications in Horticultural Export Crops in Kenya

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Abstract

Horticultural exports earned Kenya 14 billion and 20 billion shillings in the years 2000 and 2001 respectively, from an estimated volume of 99 million tonnes and 93 million tonnes respectively. This indicates an increase in value of the exports, and makes horticulture the second highest foreign income earner after tea. Pesticides are a major production cost in the large-scale enterprises. Every year large amounts of pesticides are used to manage pests in horticulture, so as to ensure high quality production especially for export market. Local markets have also evolved as to demand high quality blemish free horticultural products. This has made farmers to increase use of pesticides and other agrochemicals. The types, quantities and market value of pesticides imported and sold for various crops would indicate the trend of pesticides usage in Kenya. The horticultural exports from this country are subject to stringent European Union (EU) requirements on Maximum Residue Levels (MRLs). The EU being the most important export destination, the issue of MRLs should urgently be addressed. Measures need to be put in place to ensure that Kenya does not lose its horticultural export niche. These may include, developing and devising crop protection strategies based on the farmers' needs, strengthening various relevant institutions and developing sound pest management policies.

Introduction

The economy of Kenya largely depends on agriculture. An estimated 80 % of Kenya' s population live in the rural parts of the country and relies on agriculture directly or indirectly for food, provision of employment opportunities, production of raw materials for industry and for generating foreign exchange. The urban dwellers depend heavily on supplies of food both fresh and dry from the rural parts of the country. Horticulture is a major component of agriculture in the country. Besides being the second highest foreign income earner (Anon., 2001), it is also a source of food and income to many people across the country.

With the increase of population there is an ever-increasing necessity to increase food production. Rural-urban migration is causing unprecedented reduction of the available manual labour in the rural areas. These together with the ever increasing threat of pests to horticultural crops, use of pesticides has become the easiest way out of ensuring production of enough and high quality produce both for the local and export market.

Indiscriminate use of pesticides and their misuse, over-use and under-use, has created pest situations that are difficult to manage or which necessitate increased use of pesticides. Pest resistance to pesticides, pest resurgence and emergence of secondary pests have been reported in farms across the country. This misuse necessitated the Government of Kenya to enact legislation, the Pest Control Products Act cap 346. Pest Control Products Board (PCPB), an organization established under the Act, has over time improved the pesticide regulation in the country. The Board regulates pesticides through licensing of imports and exports, registration of new pesticides, licensing of the distribution and use of the products in Kenya.

PCPB has set up complex registration system and monitoring requirements that have to be met before a pesticide can be registered for general use. Data is required on the toxicity to mammals and other organisms, degradation pathways and fate, pesticide residues in the soil, water and food as well as flora and fauna (Anon., 2002a). However many pesticides are still being used in Kenya without adequate registration requirements or suitable precautions (Anon., 2002b).

PCPB in collaboration with the Agrochemical Association of Kenya (AAK), an association of the pesticide manufacturers and distributors, together with the Ministry of Agriculture and Rural Development (MoARD) and other relevant institutions has embarked in an active training programme to streamline the industry. This will ensure delivery of information on safety to the user, his environment and the produce for export and consumption.

Pesticide Usage

There are currently more than 1600 pesticides available (Hayes and Lawes, 1991) and their worldwide use is increasing. In 1989 about 4.4 million tonnes of pesticides were used annually with a value of US$20 billion (EPA, 1989). In the same year Kenya imported about 7711 tonnes, which accounted for about 0.02 % of the global consumption then (Table 1). Over time these volumes have not changed a lot, though they have somewhat gone down to the current 6210 tones.

Table 1: Quantities of Pesticides Imports into Kenya (in Metric Tonnes) 1986–2001

Year	Insecticides & acaricides	Herbicides	Fungicides	Others	Total
1986	1076.0	1129.0	6584.0	808.0	9597.0
1987	1206.0	1311.0	7157.0	697.0	10371.0
1988	1089.0	2108.0	4259.0	801.0	8257.0
1989	1571.0	1148.0	4327.0	665.0	7711.0
1990	1572.0	1134.0	1330.0	857.0	4893.0
1991	1072.0	844.0	1568.0	570.0	4054.0
1992	1670.0	1122.0	2634.0	1164.0	6590.0
1993	839.0	882.0	1503.0	309.0	3533.0
1994	1049.9	747.4	1671.8	563.3	4032.4
1995	1413.3	870.0	2323.0	501.9	5108.8
1996	1876.2	997.9	3469.8	602.5	6946.4
1997	2077.8	703.1	2391.0	655.6	5827.5
1998	1814.4	1407.8	4225.4	158.8	7606.4
1999	2186.0	593.0	2284.0	1116.0	6179.0
2000	1762.0	633.4	1665.9	370.0	4431.9
2001	2320.0	1398.0	1779.0	713.0	6210.0
Mean	1537.14	1064.30	3073.24	659.54	6334.28

Source: Pest Control Products Board Annual Reports 1986 – 2001.

Over the years the value of these pesticides has changed tremendously. In 1986 – 1992 the value of imports ranged between KShs 580 – 1292 million. In 1993 – 2001 the value ranged from KShs 1206 – 3636 million (Table 2).

In just less than ten years the value of pesticides tripled while the volumes decreased. In 1986, 7353.3 tonnes of pesticides were imported into Kenya, 6590 tonnes in 1992 and 6210 tonnes in 2001 (Table 1). The obvious result of the increase in value and reduction in volumes is increased cost per unit of the pesticides reaching the farmer. And true to this there are reports of complaints by farmers, of the high cost of farm inputs, with pesticides taking the lead.

The reduction of pesticides volume as from 1988 onwards has been attributed to the great slump in the coffee industry. Coffee took the largest volume of pesticides accounting for 44.4 % by value in 1989 (Anon., 1989). The slump in the market of coffee led to the neglect of the crop by the farmers and even destruction of some of the plantations leading to the sharp drop in pesticides consumption in 1988.

Table 2: Importation of Different Groups of Pesticides into Kenya (1986-2001) by Value (C + F)

Year	Insecticides & acaricides	Herbicides	Fungicides	Others	Total
1986	134.5	121.3	281.3	42.6	580.1
1987	182.3	173.4	357.3	28.1	741.1
1988	134.9	121.3	281.3	42.6	580.1
1989	208.1	154.2	328.8	30.7	721.8
1990	260.3	159.4	169.2	55.6	644.5
1991	202.2	146.8	223.8	41.8	614.6
1992	505.0	228.5	457.1	101.7	1292.3
1993	428.7	272.2	441.8	64.1	1206.8
1994	479.3	286.5	432.8	84.5	1283.1
1995	707.0	312.1	682.6	74.4	1776.1
1996	1405.4	389.9	1049.1	102.1	2946.5
1997	1164.0	301.5	827.2	113.0	2405.7
1998	1196.9	521.3	1358.5	37.7	3114.4
1999	1178.0	259.0	891.0	181.0	2509.0
2000	1114.1	298.6	713.9	74.7	2201.3
2001	2201.0	324.0	957.0	154.0	3636.0
Mean	718.23	254.4	590.8	76.8	1640.8

Source: Pest Control Products Board Annual Reports 1986 – 2001.

Crop protection continues to consume the biggest percentage of pesticides that come into the country. This is estimated at 90 % of the total volumes. Fungicides continue to lead in volumes followed by insecticides and acaricides for agricultural use, herbicides and acaricides for veterinary use. The total annual tonnage for acaricides for veterinary use is just over 600. Farmers continue to pay more for insecticides and acaricides compared to other pesticides (Table 3).

Table 3: Percentage of the Total Monetary Value Pesticides Imported into Kenya (1986 – 2001)

Year	Insecticides & acaricides	Herbicides	Fungicides	Others
1986	23.2	20.9	48.6	7.3
1987	24.6	23.4	48.2	3.8
1988	24.0	21.9	49.8	4.3
1989	28.9	21.4	45.4	4.3
1990	40.4	24.7	26.3	8.6
1991	32.9	23.9	36.4	6.8
1992	39.1	17.7	35.4	7.9
1993	35.5	22.6	36.6	5.3
1994	37.4	22.3	33.7	6.6
1995	39.8	17.6	38.4	4.2
1996	47.7	13.2	35.6	3.5
1997	48.4	12.5	34.4	4.7
1998	38.4	16.7	43.6	1.2
1999	47.0	10.3	35.5	7.2
2000	50.6	13.6	32.4	3.4
2001	60.5	8.9	26.3	4.3

Source: Pest Control Products Board Annual Reports 1986 – 2001.

Among the insecticides and acaricides those for agricultural use are relatively more expensive than others (Table 4).

Table 4: Percentage Value of Insecticides and Acaricides Imported into Kenya (1997-1999)

Year	Agricultural use	Veterinary use	Public health	Termite control	Total
1997	54.2	37.3	7.0	1.5	100
1998	54.8	33.3	11.1	0.8	100
1999	63.5	10.5	25	1	100

Source: Pest Control Products Board Annual Reports 1997 – 1999

Pesticide Use and Horticultural Production

The growers and/or exporters of horticultural produce are subjected to international market requirements relating to employment and labour, use of pesticides, maintenance of the environment and produce traceability. The produce must be produced and handled under acceptable conditions through out all the stages of production. Besides these requirements, the EU has harmonized the MRLs within the EU member countries, and it requires that all products grown or imported into the EU markets must comply with the permitted MRLs regulations.

The growers and/or exporters have had to adjust and subscribe to these conditions as set out by the market, especially the EU. This has been done in collaboration with the relevant institutions. Some of the steps taken include the following.

A list of pesticides-crop combinations recommended by PCPB and KARI

A temporary list of pesticides and crop combinations approved by the PCPB and KARI (Anon., 2000) has been released. The list identifies the list of pesticides that are registered for use against various pests and diseases per crop, for the major export vegetables and fruits from Kenya. A summary table is given below (Table 5).

Table 5: Pesticides Registered for Vegetables and Fruits for Export (Anon., 2000)

No.	Crop	Pesticides (Common names)
1.	French Beans	Dimethoate 40 EC, Lambda cyhalothrin 1.75 EC, Cypermethrin 5 EC, Alpha cypermethrin 10 EC, Deltamethrin 2.5 EC, Malathion 50 EC, *Bacillus thuringiensis,* Triforine 20 EC, Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Sulphur 80WP, Linuron 50 WP, Alachlor 48 EC.
2.	Snow peas and sugar snaps	Cypermethrin 5 EC, Alpha cypermethrin 10 EC, Malathion 50 EC, *Bacillus thuringiensis,* Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Sulphur 80WP, Chlorothalonil 75 WP, Mancozeb 80 WP
3.	Sweet corn	Deltamethrin 2.5 EC, Beta cyfluthrin 0.05% granules, *Bacillus thuringiensis,* Metalachlor/ Atrazine 250gm/lit
4.	Okra	Cypermethrin 5 EC, Lambda cyhalothrin 1.75 EC, Alpha cypermethrin 10 EC, Deltamethrin 25 EC, Malathion 50 EC, *Bacillus thuringiensis,* Copper oxychloride 50 WP, Cuprous oxide 50 WP, Sulphur 80WP, Dicofol 18.5 EC
5.	Chilies/Aubergines	Lambda cyhalothrin 1.75 EC, Dicofol 18.5 EC, Malathion 50 EC, *Bacillus thuringiensis,* Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Sulphur 80WP/DF
6.	Cucumber, dudhi, courgettes, karella, turia	Lambda cyhalothrin 1.75 EC, Dicofol 18.5 EC, *Bacillus thuringiensis,* Triforine 20 EC, Copper oxychloride 50 WP, Copper hydroxide 40%, Sulphur 80WP
7.	Mangoes	Benomyl 50 WP, Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Sulphur 80WP/DF Deltamethrin 2.5 EC, Glyphosate 36 % (acid equivalent), Thiabendazole 41.8 % FW
8.	Avocadoes	Deltamethrin 2.5 EC, Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Glyphosate 36 % (acid equivalent), Thiabendazole 41.8 % FW, Fosetyl-AL 80WP
9.	Passion fruit	Deltamethrin 2.5 EC, Copper oxychloride 50 WP, Cuprous oxide 50 WP, Copper hydroxide 40%, Chlorothalonil Benomyl 50 WP, Glyphosate 36 % (acid equivalent)

Source: Pest Control Products Board

The objective of the list is to ensure that farmers know and use the right products for the intended target problem while observing the right dosages and pre-harvest intervals (PHI). This is aimed at reducing the possibilities of selling produce with higher MRLs than those permitted by the EU.

Subscription to codes of conduct

The growers and/or exporters subscribe to various programmes initiated to ensure compliance of the horticultural produce with the required commercial quality standards and maintenance of our share of the EU market. The draft National Code of Practice has been finalised by stakeholders in the horticultural industry and is awaiting accent of the MoARD. Meanwhile the growers and exporters are encouraged to subscribe to the HCDA' s code of conduct, while members of FPEAK and KFC continue to voluntarily subscribe to their individual codes of practice and various codes emanating from the market (Anon., 2002c). The objective of this is to address comprehensively, all through the crop production period all the aspects relating to employment of labour, use of pesticides, traceability of the produce and environmental maintenance.

Training on safe and effective use of pesticides

The AAK in collaboration with relevant institutions like PCPB and MoARD, has for some time now been involved an ambitious training programme on safe and effective use of pesticides. The programme targeting farmers, extension officers of MoARD and the members of the pesticide industry, boasts of having trained over 300,000 farmers all across the country (Anon., 2002d). The major question regarding farmer training is whether the farmers practice what they have learnt and been trained on. Monitoring and evaluation work among the farmers trained indicates poor adoption rate. This shows that there is gap between theory and practice of the trainings.

Pesticide disposal

The AAK is also involved in pesticide disposal in collaboration with PCPB and MoARD. A lot of obsolete and unregistered chemicals have been disposed by incineration at the Athi River Cement factory through financing from AAK. The obsolete chemicals arose mainly from Government offices and institutions, which were remains of pesticide subsidies, given by the Government to farmers all around the country. Unregistered chemicals were products collected by the PCPB inspection teams, during their inspection of pesticide premises around the country. This has gone a long way in ensuring that unregistered and illegal products don't get to the farms and be used on horticultural crops and cause negative effects on the environment.

Challenges of Pesticide Use on Export Crops

While pesticides are important and necessary for pest management in horticulture, there is an ever increasing need to re-engineer pesticide use strategies in the country, and address current pertinent issues on pesticides in this era of globalization, including MRLs, environmental safeguard, labour and employment etc. In addressing these issues the following are some of the challenges that arise.

Modes of pesticides application

The Government has for along time encouraged routine prophylactic application of pesticides as well as use of broad-spectrum pesticides, practices which kill both the target and non-target organisms. This is in direct conflict with the principals of ecological and biodiversity conservation. Modern pest management practices give due considerations to pest populations as the basis for any management strategy.

At the same time pesticides have been used in this country as the panacea of pest problems. They have been used as the first, last and best answer to many pest problems. Little or no recognition of other methods of pest control like cultural, mechanical or even biological has been made. This continues to be seen among many farmers especially the small-scale ones, who may serve as contract farmers for exporters.

Pesticide regulations

Manufacture, importation and use of pesticide in the country should be based on the premise of reduction of pest problems while at the same time safeguarding against the possible side effects of misuse. Entry and distribution of pesticides in Kenya has not been found to be water tight, against illegal traders. This has been augmented by the fact that, the regulating agency, PCPB is based in Nairobi. This has created some room and loopholes for entry and distribution of illegal pesticides, which products may find their way into horticulture.

Profits and ethics

Lack of strict adherence to ethics and good business practice has been associated with some members of the pesticides industry (AAK). In their bid to make profits some have got involved in malpractices like illegal importations and distribution of unregistered products as seen above. Such issues raise anxiety amongst the consumers of food both locally and abroad of the possibilities of consuming water and food carcinogens. Besides this casts a threat to our quickly expanding horticultural industry as regards the MRLs.

Availability and flow of information on pesticide use

Pertinent information from research findings and elsewhere seldom gets to the farmers. Sometimes if it does, it is often late and probably distorted and hence defeating the whole purpose of the information. A good example is, information on MRLs. Not many farmers including those growing for export understand what they are all about, and how they may affect their horticultural enterprises. This is also true to some extent about extension staff. Research extension linkage is weak or non-existent. Research should not just be a fund of information, enriching the source institutions but should also be flow resource to actual end users. Otherwise research will remain abstract and non-beneficial to those it is intended to benefit.

The Way Forward

The pesticide use in Kenya has to continue evolving with the global changes especially as pertains to pesticides and horticulture. The following are some of the steps that can be taken corporately by the pesticides and horticultural industries stakeholders to ward off a business catastrophe similar to and even bigger than that of fish in the year 2000.

Establishment of an Integrated Pest Management (IPM) policy

The Government needs to establish a crop protection policy expressed in the implementation of IPM, with pesticides used when other control measures are not effective or inefficient. When used pesticides should be used wisely adhering to legal requirements and ensuring correct and safe use. The future of crop protection in Kenya depends upon the use of IPM approaches within the context of holistic development of natural resource production systems. In this policy routine prophylactic application of pesticides should be discouraged and pesticide subsidies withdrawn.

Pesticide regulation

There is an ever-increasing need to tighten registration requirements, particularly those relating to the safety of the pesticides to the people and the environment. Re-evaluation of all registered pesticides should be done, basing it on the data/information currently available, especially on aspects of safety to people and environment. Upon this, pesticides proven to be unsuitable or unsafe for use should be deregistered. Procedures of registration and regulation in the neighbouring countries (for example in the East African Community) should be harmonised in order to curtail entry of illegal products from the neighbouring countries. This harmonization should be done with the view of maintaining or improving the already existing standards.

Information and training

Research findings and other information should be passed to extension staff and onward to farmers in order to reduce pesticides risk strategies. For research to be strategic and adaptive, it must respond both to demand and need and react to new emerging opportunities offered by the science. This is the only way it can support development in horticulture.

Pesticide use

Pesticide use should be managed by a number of ways:

Minimizing pesticide input

This can be achieved by minimizing the number and rate of applications. For example monitoring pest pressure by direct counts can allow delay of spraying, until the pressure has become tolerable according to some threshold.

Containing the pesticide to the application site

By minimizing erosion the transport of chemicals-associated eroded soil may be minimized. This can also be improved by use of improved application methods like the use of ULV sprayers, granule applicators, slow release formulations like granules and so on.

Selection of pesticides

Pesticides with minimal environmental impact and those with established MRLs should be the products of choice.

Baseline data

There is urgent need to obtain baseline data on the current situation on pesticide use. This will provide an accessible database for taking informed decisions regarding pesticides use and horticulture.

Conclusion

Pesticide use in the country is going through a rapid change in tune with the global developments. This withstanding, pesticides continue to be an imperative in sustainability of food production for a rapidly increasing human population and ever increasing and changing pest situations. Horticultural exports from Kenya should be sustained in spite of the changing trend in pesticide use. This is an issue that can be achieved through collaboration of the stakeholders in the Government and outside. The urgent need of integrated pest management approaches to reduce traditional pesticide treadmill cannot be understated. That is the only way out in ensuring sustainable use of pesticides in production of horticultural crops for export.

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Abbreviations

AAK – Agrochemical Association of Kenya

EPA – Environmental Protection Agency

EU – European Union

FPEAK – Fresh Produce Exporters Association of Kenya

HCDA – Horticultural Crop Development Authority

IPM – Integrated Pest Management

KARI – Kenya Agricultural Research Institute

KFC – Kenya Flower Council

KShs – Kenya Shillings

MoARD – Ministry of Agriculture and Rural Development

MRLs– Maximum Residue Levels

PCPB – Pest Control Products Board

Questions/Comments and Answers

Anon: From the list of recommended pesticides karate seem to be one but how sure are you that it will control pests because most pests are resistant to it?

Response: The pesticides are registered for specific pests and crops and this is indicated on the product label. Otherwise, upon development of resistance, registering companies willingly replace or withdraw the product.

J.M. Wesonga: Considering costs of chemical pesticides and application equipment wouldn't you think that licensing specialist operators would be useful?

Response: PCPB has the mandate of registering/ licensing pest control operators. There are some in large scale cereals growing like wheat and barley. Majority are in Public health. Whether this will cut down on costs will I think will depend on market forces. But for sure this will ensure efficient application.

J.M. Kibaki: How effective do you think safe use programmes have been in modifying farmer's pesticide use practices?

Response: Ther has been increased awareness among farmers. About 3000 farmers have been trained on safe use. But implementation, particularly on safe use of protective clothing has been low.

J.M. Kibaki: How did you comment on the pesticide use among farmers for non-export crops?

Response: Farmers are basically using the same products to manage pests in non-export crops.

Good Agricultural Practice (GAP) and Improved Spray Regimes for the Kenyan Export Horticultural Farmers

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Abstract

Maximizing yields of agricultural produce is an ever-increasing challenge facing the world today due to the rising world population especially in developing countries.

This challenge is partly solved by increased use of pesticides and fertilizers to keep pests and diseases incidences low while improving the growth performance of crops.

Whereas horticultural crop exports have been rising from developing countries to the developed ones, stiff pesticide-use regulations are being imposed which must be adhered to failure, which will lead to a rejection of these exports.

This paper highlights some good agricultural practices (GAP), which can be adopted by Kenyan horticultural export farmers so as to ensure a high safety level of their exports as well as protecting the integrity of the environment.

Some suggestions are given on the way forward which will help improve Kenyan export horticultural crop farmers position in the European Union market where most of the Kenyan exports crop end.

Explants, Sucrose and Hormones Influence *In Vitro* Regeneration and Rooting of Calla Lily (*Zantedeschia albomaculata* Spreng.)

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Abstract

Zantedeschia **is an important, rapidly expanding cut flower in Kenya today. A protocol for rapid in vitro shoot multiplication of** ***Zantedeschia,*** **using tuber, leaf and shoot primordium explants in combination with 6-benzyalamino purine (BAP) or Kinetin, sucrose and Murashige and Skoog (MS) (1962) basal salts is described. Of the four levels each of BAP and Kinetin, 2 mg/l BAP induced the highest number of shoots per explant (2.5)**

and the longest shoots (3.7 cm) on shoot explants. No response was observed in both leaf and tuber explants in all media tested. A 34-fold shoot multiplication rate was achieved in a culture period of 10 weeks. Combining 2 mg/l BAP with sucrose (15, 20, 30 or 45 g/l) revealed variations in shoot regeneration on shoot explants. Root induction was best and highest (84%) in the medium containing 20 g/l sucrose + 1 mg/l IBA within one week, compared to 70% in the medium augmented with 30 g/l sucrose plus 2 mg/l NAA, which occurred in two weeks. This study determined that shoot explants of *Zantedeschia albomaculata* 'Black Magic' can produce high quality multiple shoots in vitro, and hence are suitable material for clonal multiplication through micropropagation.

Introduction

Calla lilies (*Zantedeschia* species) and their hybrids can be grown as commercial cut-flowers in temperate and sub-tropical climates. Calla lily belongs to the Araceae family. While other genera of the Araceae family are endemic to S. America, Asia and Africa, the genus *Zantedeschia* is confined to Africa. It is most prevalent in the southern Africa, but it also extends north up to Nigeria (Letty, 1973).

The horticultural industry contributes significantly to the Kenyan economy, being the third leading foreign exchange earner, after tea and tourism. The cut flower industry constitutes a larger percentage of commercial horticulture in Kenya. *Zantedeschia* is an important, rapidly expanding cut flower in Kenya. It is improving both in volume and value in the export market.

Commercially, multiplication is achieved using seed and offsets, but only four selections are commercially produced from seed. Multiplication using offsets is a slow method. In addition, there has been a problem in obtaining disease-free calla lily planting materials, because continuously subdivided conventional tubers accumulate pathogens. This cut flower has not been extensively investigated through biotechnology, especially tissue culture under Kenyan conditions. Cohen (1981) has reported tissue culture of calla lily hybrids, but scanty information concerning regeneration of calla lily from different explants on different media appears in the literature. In Kenya, tissue culture techniques are not currently applied for clonal propagation of *Zantedeschia,* forcing growers to import clean starting materials for bulking. Importation increases the cost of production for *Zantedeschia.*

In plant tissue culture, it is now well known that no two genotypes give similar responses under a given set of culture conditions (Nehra et al., 1990). Many genotype-dependent effects are caused by interactions between the plant's genotype and the culture environment. The results obtained in vitro can be influenced by the way that stock plants are treated as well as the environment in which they are grown. Starting in vitro culture of any species requires basic experimentation to standardize the nutritional, growth regulator and environmental requirements of plants at each stage of the culture process (Williams and Taji, 1989; Williams, 1996). The use of tissue culture is advantageous in valuable crops, because it can supplement conventional breeding by accelerating the clonal multiplication and release of new cultivars to growers. Moreover, efficient in vitro regeneration is a prerequisite for genetic engineering of crops (Jain and Minocha, 2000). Using tissue culture as a rapid method to create an initial stock of *Zantedeschia* would provide the foundation for creating healthy stocks of selected clones in a commercially acceptable time. This study, therefore, was an attempt to apply tissue culture techniques to calla lily, using *Zantedeschia albomaculata* 'Black Magic' as an experimental species. The objectives of the study were to determine effects of explants and media on in vitro shoot regeneration and rooting. Three types of explants (leaf, tuber and shoot) were cultured on various levels of growth regulators (BAP, Kinetin), MS (1962) basal salts and sucrose. Root induction was evaluated using IBA and NAA in combination with three levels of sucrose.

Materials and Methods

Explant preparation

Tubers that were freshly harvested and air-dried in an open sheltered place for at least one week were obtained from a commercial flower farm (Agriflora (K) Limited). Some of the tubers were planted in containers in the greenhouse to supply leaf explants. Others were kept in the laboratory until buds produced small shoots that were then used as shoot explants. Initial surface-sterilization involved washing explants

separately for 30 minutes in running tap water, followed by vigorous shaking in soapy water for 15 minutes, and thereafter immersion in 70% ethanol for two minutes. The explants were then treated with sodium hypochlorite (5% for tubers and 2% for leaves) for 10 minutes, followed by four rinses in sterile distilled water. Explants were then trimmed by cutting off damaged parts and sectioned into desired sizes. Tuber explants and sections containing the shoot tip were cut into cubes, measuring 5 mm x 5 mm x 5 mm, while leaf explants were cut into 5-mm diameter discs. Sterile explants were placed in flasks, containing 25 ml of the initiation medium. This procedure was followed in all the experiments.

Tissue culture conditions

The initiation medium consisted of MS (1962) basal salts, gelled with 0.8% agar. Sucrose and hormone concentration varied with the experiment. Media were prepared from stock solutions prepared for MS (1962) macronutrients, micronutrients, vitamins, iron-EDTA and hormones. The pH of all media was adjusted to 5.8 prior to autoclaving for 18 minutes at 121º C and 100 kPa. All cultures were incubated in a culture cabinet maintained at 27 ± 1º C and 16 hours of light.

Experiments

In experiment I, four levels each of BAP (0, 1, 2 and 4 mg/l) and Kinetin (0, 1, 2 and 4 mg/l) were tested on three types of explants to determine the level that would best stimulate shooting and subsequent shoot multiplication. Each treatment was assigned 6 explants of each kind, and replicated three times. The experiment was set up as a 4 x 3 factorial in a Completely Randomized Design for each type of hormone.

In experiment II, the hormone level (2 mg/l BAP) that gave the best shooting response in experiment I was combined with varying levels of sucrose (15, 20, 30 and 45 g/l) to determine the effect of sucrose on shoot regeneration and multiplication on the three-explant types. The medium contained full strength MS (1962) basal salts. Each treatment was assigned 6 explants of each kind and replicated three times. The experiment was set up as a 3 x 4 factorial arrangement in a Completely Randomized Design. In experiments I and II, observations began 7 days after initiation of cultures and data was recorded for the number of shoots per explant and percentage of explants with shoots. Explants were subcultured every four weeks. The total number of shoots produced per cultured explant at the end of 3 subcultures was recorded for each treatment.

In experiment III, in vitro-regenerated shoots were cultured on full strength MS (1962) basal salts, augmented with IBA (0,1 and 2 mg/l) or NAA (0,1 and 2 mg/l) plus sucrose at various levels (15, 20 and 30 g/l) to determine the best rooting hormone for calla lily. Six shoots and three replications represented each treatment. The experimental design for each hormone was a 3 x 4 factorial in a Completely Randomized Design. Thus, the IBA and NAA effects were analyzed separately. Observations on root induction were conducted on a weekly interval. Data on time taken to rooting and percentage of shoots that formed roots after 3 weeks were recorded. Data of all the measured variables was subjected to analysis of variance, and where the F-test at $P = 0.05$ was significant, mean separation was performed using either the Least Significant Difference test or the Duncan's Multiple Range test, depending on the number of means that were separated.

Results and Discussion

Effect of BAP and Kinetin on shooting

The initial responses of explants included tissue browning, bacterial and fungal contamination plus shoot elongation in shoot meristem explants (Table 1). Tissue browning was observed at the bases of explants within the first week, but it was not severe to kill or adversely affect the growth of explants. This condition, however, did not persist after explants were subcultured. Explant contamination in shoot, leaf and tuber explants was 90%, 8% and 5%, respectively, within the first week of culture. This was considered primary contamination, which occurs during the first two weeks in culture due to surface bacteria and fungi not killed

during sterilization. Secondary contamination occurs after two weeks if plants are infected by systemic contaminants (Lightbourn and Deviprasad, 1990).

Frequent contamination problems are encountered at initiation stages of most root and tuber explants (Taji and Williams, 1996). Such tissues require extensive disinfection, which may be hampered by the sensitivity of tissues to high concentration of disinfecting chemicals. As a result, long periods of time elapse before the next stages in micropropagation can be undertaken (Taji and Williams, 1996). However, techniques to rid explants of contamination must be developed to suit individual species and explants. The use of an additional disinfectant, 0.1% mercuric chloride ($HgCl_2$) produced encouraging results. Primary contamination reduced to less than 10% in shoot explants and 2%in both tuber and leaf explants.

During the first week, shoot explants elongated rapidly and produced one to two axillary shoots, although those in the medium without hormones stunted and regenerated no axillary shoots (Table 1).

Table 1. Effect of explant, BAP and Kinetin on shooting of calla lily (after 4 weeks in culture)

Hormone (mg/l)	Type of explant	Percent shooting	Shoots per explant	Shoot length (cm)
BAP				
0	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	2
1	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	3
2	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	4
4	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	3
Kinetin				
0	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	1	1
1	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	2
2	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	2
4	Leaf	0	0	0
	Tuber	0	0	0
	Shoot	100	2	2

Shoot growth and elongation occurred after 3 to 4 days of explant transfer to the culture medium. There was 100% shooting in shoot explants, compared to 0% in both tuber and leaf explants in all media tested, even after 8 weeks in culture. The tuber explants, however, darkened and deteriorated in culture.

Regeneration of leaf tissues is routinely used for plant propagation of a few plant species (Evans and Sharp, 1986). In a number of plant species, genetic transformation has employed inoculation of leaf discs in vitro with a strain of *Agrobacterium tumefaciens,* which harbours an engineered plasmid (Billings et al., 1988). Park et al. (1995) reported regeneration of potato shoots from leaf tissues, but responses to published regeneration regimes showed cultivar specificity (Wheeler et al., 1985). Geier (1982), working with *Anthurium scherzerianum,* induced plantlets from spadix explants and later from leaves (Geier, 1986).

Efficient, repeatable and rapid in vitro regeneration systems are a prerequisite for using recent advances in biotechnology to improve crop plants (Mohammed et al., 1992). Genetic transformation is one of the interesting areas of biotechnology for plant breeders, because characteristics can be added with minimal alteration of the target plant's genome. Therefore, direct shoot morphogenesis from primary tissues is more desirable than going through an intermediate callus phase (Stiekman et al., 1988). It is generally accepted that regeneration of plantlets from callus tissue frequently results in chromosome abnormalities that would be undesirable in commercial propagation (Evans and Sharp, 1986).

In the current research, *Zantedeschia* tuber explants failed to respond to both Kinetin and BAP. However, shoot regeneration has been achieved in other species. Ng' (1988) obtained direct plant regeneration from tuber discs of *Dioscorea rotundata* (White yam) on MS (1962) medium, supplemented with 0.5 or 1 mg/l BAP. Complete formation of plantlets occurred within 3 months in culture. George (1985) also reported plantlet regeneration in potato tuber discs cultured in MS (1962) medium, which developed into normal plantlets after 8 weeks. The medium was supplemented with Nistch and Nistch organic addenda, BA (4.4 x 10^{-6} M), Kinetin (2.3 x 10^{-6} M), Zeatin (1.8 x 10^{-6} M), GA_3 (1.4 x 10^{-6} M), NAA (1.0 x 10^{-7} M), IAA (5.7 x 10^{-6} M), casein hydrolysate (1 g/l) and sucrose (7.3 x 10^{-2} M).

In the current research, once tuber and leaf explants failed to respond in both BAP and Kinetin media, the experimental design was changed to a one factor Completely Randomized Design and data was subjected to analysis of variance testing the effect of hormone on shoot explants. The initial growth rates among treatments were similar until after two weeks when a significant difference in the number of shoots was observed (Table 2). The highest number of shoots (2.2) was obtained in the medium containing 2 mg/l BAP, while the maximum length of shoots (3 cm) was obtained in medium augmented with 1 mg/l BAP. In contrast, 1.5 shoots in 4 mg/l Kinetin and 1.4 cm in 2 mg/l Kinetin resulted. After four weeks in the initial culture, the highest shoots per explant (2.3) resulted when the medium was supplemented with 4 mg/l BAP, compared to 1.8 in the best Kinetin (4 mg/l) concentration.

Shoots obtained in 1 mg/l BAP medium were very small, difficult to handle and not suitable for rooting. It is not necessarily desirable to obtain the largest possible number of adventitious or axillary shoots from cultures, because shoots are then of poor quality, with short stems, small internodes and difficult to separate. To overcome this problem, Rugini and Verma (1983) used two media for stage II of almond shoot tip cultures. The first incorporated 0.7 mg/l BAP and 0.1 mg/l NAA to induce shoot multiplication. The second with a lower level of BAP (0.2 mg/l) and no auxins induced the shoots to grow to a sufficient size for rooting.

Subculturing shoots every four weeks to fresh medium of the same composition essentially enhanced shoot proliferation in BAP media (data not shown). Few axillary shoots were obtained in a growth-regulator-free and Kinetin medium. The number of excisable shoots (0.5 to 1.5 cm) per explant was summed over 10 weeks and a concentration of 2 mg/l BAP favoured the highest multiplication rate (34--fold), compared to the medium with 4 mg/l kinetin (3.5-fold). The number of axillary shoots increased markedly in BAP treatments and this difference remained constant throughout the three subcultures.

Table 2. Effect of BAP and Kinetin on shoots and shoot length of calla lily

	BAP (mg/l)[Z]				Kinetin (mg/l)				
Time	0	1	2	4	0	1	2	4	
(weeks)	Number of shoots per explant								LSD
1	1.0	1.5	1.6	1.7	1.0	1.1	1.3	1.4	NS
2	1.5bc	1.8ab	2.2a	1.8ab	1.2c	1.3c	1.3c	1.5bc	0.46
3	1.5c	1.8abc	2.5a	2.4ab	1.2c	1.5c	1.5c	1.7bc	0.77
4	1.5	1.8	2.2	2.3	1.3	1.7	1.7	1.8	NS
	Shoot length (cm)								
1	0.8	1.2	1.3	0.7	0.9	1.0	0.9	0.9	NS
2	1.23cd	3.0a	2.3ab	1.9bc	1.0d	1.3cd	1.4cd	1.3cd	0.90
3	1.4b	3.2a	3.2a	2.2b	1.3b	1.4b	1.5b	1.5b	0.98
4	1.5c	3.4ab	3.7a	2.5bc	1.4c	2.0c	1.7c	1.7c	1.13

[Z]Means not followed by a letter or followed by the same letter within rows are not significantly different, according to the DMRT at P = 0.05

These results are similar to those obtained by Clemente et al. (1991) in *Artemisia granatensis*, in which the highest shoot proliferation rate was achieved with 0.44 μM BA, although most of the axillary shoots were vitrified by the fourth subculture. Although elongation of the main shoot was greatest on the medium without BA, the number of axillary shoots increased markedly with BA treatments throughout the four subcultures. Debergh and Maene (1977) found that several axillary shoots and later adventitious shoots were obtained in

Pelargonium if apices of individual buds developing on proliferating meristems were subcultured to fresh medium. In the current study, nearly all concentrations of BAP produced more axillary shoots than the Kinetin levels tested (data not shown). Axillary and adventitious shoot proliferation is stimulated after adding high cytokinin levels in the medium (George, 1993; Taji et al., 1995; Hartmann et al., 1997). From these results, probably higher than 4 mg/l Kinetin could be required for enhanced shoot proliferation in calla lily. In Geraldon wax, a medium supplemented with 4.4 or 22.0 μM BA resulted in the highest number of explants that displayed enhanced axillary bud growth (Page and Visser, 1989). It is apparent from the current experiment that optimum adventitious shoot formation on shoot explants of calla lily is promoted by subculturing.

Effect of sucrose on shooting

Unlike tuber and leaf explants, shoot explants (100%) in all treatments responded by rapid elongation within 4 days in culture whereas leaf and tuber explants did not exhibit any growth response. These results are similar to those obtained in the preceding experiment in which both tuber and leaf explants failed to respond to all concentrations of Kinetin and BAP.

The initial growth rates of shoot explants were similar in all treatments until after day 14 when significant differences in shoot length and number of shoots per explant were observed (Table 3). The tallest shoot length (2.1 cm) by day 14 was observed in medium augmented with 15 g/l sucrose + 2 mg/l BAP, compared to 1.8 cm in the medium augmented with 30 g/l sucrose + 2 mg/l BAP. The shortest (1.6 cm) during this period were obtained in the medium supplemented with 45 g/l sucrose + 2 mg/l BAP. After the 2 weeks in culture, there was no further significant difference in plant height among the treatments. This could be due to the fact that there was no further significant influence by sucrose. However, by the end of week four in culture, shoots in the medium containing 15 g/l sucrose + 2 mg/l BAP still were tallest (2.2 cm), compared to 1.9 cm shoots in the medium supplemented with 30 g/l sucrose + 2 mg/l BAP. Shoots in the medium supplemented with 45 g/l sucrose remained the shortest (1.7 cm).

Significant differences in number of shoots per explant were observed among the media. The highest number of shoots per explant (2.5 and 2.1) at day 7 were achieved when the explants were supplemented with 20 g/l and 30 g/l sucrose + 2 mg/l BAP, respectively (Table 3).

Table 3. Effects of sucrose on shoots and shoot length of calla lily

	Sucrose (g/l)[Z]				
Time (weeks)	**15**	**20**	**30**	**45**	LSD
	Shoot length (cm)				
1	**1.7**	**1.6**	**1.4**	**1.5**	NS
2	**2.1a**	**1.7b**	**1.8ab**	**1.6b**	0.30
3	**2.1**	**1.8**	**1.8**	**1.7**	NS
4	**2.**	**1.9**	**1.9**	**1.7**	NS
	Shoots per explant				
1	**1.7b**	**2.5a**	**2.1a**	**1.6b**	0.41
2	**3.2c**	**4.9a**	**3.7b**	**2.8c**	0.49
3	**3.7b**	**5.7a**	**3.9b**	**2.9c**	0.60
4	**3.8b**	**5.8a**	**3.9b**	**3.0c**	0.66

[Z]Means not followed by a letter or followed by the same letter within rows are not significantly different, according to the DMRT at* P = *0.05

Only 1.6 shoots were obtained in medium augmented with 45 g/l sucrose + 2 mg/l BAP. However, by the end of 2 weeks shoot number per explant increased significantly (Table 3). The highest number of shoots (4.9) were produced in the medium containing 20 g/l sucrose + 2 mg/l BAP, compared to 3.7 in the medium containing 30 g/l sucrose plus 2 mg/l BAP. After four weeks in culture, an average of 5.8 shoots were obtained in the medium containing 20 g/l sucrose + 2 mg/l BAP, compared to 3.9 and 3.8 in media supplemented with 30 g/l and 15 g/l sucrose, respectively. The fewest shoots (2.9) were obtained in the

medium supplied with 45 g/l sucrose. The medium supplemented with 20 g/l sucrose plus 2 mg/l BAP proved to be the best at the multiplication stage of *Zantedeschia* 'Black Magic'.

Experiments of Molnar (1988) have shown that the optimum level of sucrose may depend upon the amendments added to a culture medium. Seingre et al. (1991) have reported an interaction between sugar and gelling agents, in which shoot proliferation of *Malus* 'EM.9' in media gelled with six commercial products was greatest when 15 g/l sorbitol was added to the medium, but with Phytogel P 8169, it was better with sucrose. Although the sucrose concentration had no significant effect on shoot height, the medium supplemented with 20 g/l sucrose proved to be the best for producing a greater number of shoots per explant. In Chinese cabbage, established shoot cultures grew best on media containing 30 g/l sucrose. Reducing the concentration to 20 g/l halved the number of shoots formed, while high concentrations enhanced callus-growth and inhibited shoot multiplication (Kee et al. 1987).

Subculturing shoots after four weeks in culture significantly increased the rate of shoot multiplication, although there was no significant difference in multiplication rate among media augmented with 15, 20 and 30g/l sucrose plus 2 mg/l BAP (data not shown). The highest rate (16-fold) was obtained when shoots were transferred to fresh medium augmented with 15 g/l sucrose + 2 mg/l BAP for three culture passages. This value was higher than 11-fold and 7-fold obtained in media supplemented with 30 g/l and 20 g/l sucrose + 2 mg/l BAP, respectively. However, the lowest rate of multiplication (5-fold) was obtained in the medium supplemented with 45 g/l sucrose + 2 mg/l BAP. This suggests that 15 g/l to 30 g/l sucrose is suitable for multiplication of *Zantedeschia*. Above this concentration, sucrose seemed to inhibit shoot growth rate and the number of shoots produced per explant.

Effect of sucrose, NAA and IBA on rooting

The rooting stage is the most critical step in the micropropagation of plant species if clonal mass production of material is to be possible. Both in vitro and in vivo methods have been used to induce roots in different plants with varied success rates. In the current study, significant differences among the rooting media were found, when the effect of NAA and sucrose on rooting were analyzed weekly for four weeks (Table 4). In the first week, no roots formed in all NAA-augmented media (Table 4a). The highest rooting (80%) was achieved in the medium supplemented with 15 g/l sucrose with no NAA, compared to 69% and 67% in media containing 30 g/l and 20 g/l with no NAA, respectively.

Table 4. Effect of sucrose, NAA and IBA on in vitro rooting of calla lily shoots

(a)		Time in culture (weeks)[z]			
Sucrose (g/l)	NAA (mg/l)	1	2	3	4
15	0	80a	93a	100a	100a
20	0	67b	87ab	87ab	100a
30	0	69b	93a	100a	100a
15	1	0c	7e	40c	65c
20	1	0c	64c	76 ab	88ab
30	1	0c	70bc	76ab	76bc
15	2	0c	8de	14d	23d
20	2	0c	0e	80ab	88ab
30	2	0c	24d	66b	66c
	LSD	37	21	27	13
(b)		Time in culture (weeks)			
Sucrose (g/l)	IBA (mg/l)	1	2	3	4
15	0	80ab	93	100	100
20	0	80ab	87	87	100
30	0	69ab	93	100	100
15	1	27cd	80	80	93
20	1	84a	89	100	100
30	1	52bc	67	92	92
15	2	17d	56	83	94
20	2	52bc	90	82	89
30	2	61ab	79	86	86
	LSD	29	NS	NS	NS

[z]Values not followed by a letter or followed by the same letter within a column of each hormone are not significantly different, according to the LSD test at P = 0.05

However in the second week, there was a significant interaction between NAA and sucrose, whereby 70% rooting occurred when 20 g/l sucrose was combined with 1 mg/l NAA. This value was, however, lower than the 93% achieved with 0 mg/l NAA plus 15 g/l or 30 g/l sucrose (Table 4a).

By the end of three weeks, there was no significant difference among the media supplemented with 20 g/l sucrose + 1 mg/l NAA, 15 g/l sucrose + 2 mg/l NAA and 30 g/l sucrose + 1 mg/l NAA. These were significantly different from 0 mg/l NAA plus 15 g/l or 30 g/l sucrose, which had achieved 100% rooting after three weeks. After four weeks, 100% of the shoots had rooted in all media without NAA, but augmented with 15 g/l, 20 g/l or 30 g/l sucrose, whereas 88% shoots formed roots in the medium augmented with 20 g/l sucrose + 1 mg/l NAA (Table 4a). Thus, rooting in hormone-free media was better than in NAA-augmented media. Microcuttings of *Brassica oleracea* Capitata group also rooted readily on growth-regulator-free medium (Lillo and Shahin, 1986).

Although most species root satisfactorily with the addition of 20 to 30 g/l sucrose to the rooting medium, there was no significant difference in percent rooting in media supplemented with 15 g/l, 20 g/l and 30 g/l sucrose alone, suggesting that sucrose did not directly influence rooting of *Zantedeschia* shoots. This proved that any of the three levels of sucrose 15, 20 and 30 g/l tested is suitable for rooting of calla lily shoots. Page and Visser (1989) have reported that a decrease of either the MS (1962) components or the sucrose level increased the number of shoots that rooted in Geraldon wax (*Chamelaucium uncinatum*) shoots. A simultaneous decrease of both MS (1962) components and sucrose further enhanced root formation. However, a decrease of these constituents, but with omission of NAA from the medium reduced the number of shoots that rooted.

Most shoots cultured in the medium supplemented with or without IBA rooted in 4 to 8 days (Table 4b). The highest rooting percentage in the first week (84%) was achieved in medium containing 20 g/l sucrose + 1 mg/l IBA, compared to 80% with 15 g/l and 20 g/l sucrose and no IBA, respectively.

From the second week in culture, no significant difference in rooting percentage was observed among the rooting media augmented with 15, 20 or 30 g/l sucrose alone and those with IBA (Table 4b). Nevertheless, the medium with 15 g/l and 30 g/l sucrose alone induced the highest (93%) rooting percentage in the second week, compared to 90% and 89% in the media augmented with 20 g/l sucrose + 2 mg/l IBA and that with 20 g/l sucrose + 1 mg/l IBA, respectively (Table 4b).

By the end of three weeks, the highest rooting percentage (100%) was achieved in rooting media augmented with 15 g/l or 30 g/l sucrose and no IBA, respectively, and that with 20 g/l sucrose + 1 mg/l IBA. The lowest rooting (80%) was achieved in the medium augmented with 15 g/l sucrose + 1 mg/l IBA (Table 4b). After 4 weeks in rooting media, most shoots in all IBA-augmented media and the control had developed roots, but no significant difference in rooting percentage was observed among the media. Nevertheless, media augmented with sucrose alone and that supplied with 20 g/l sucrose + 1 mg/l IBA had achieved 100% rooting, while 94% and 93% rooting were achieved in media with 15 g/l sucrose + 2 mg/l IBA and 15 g/l + 1 mg/l IBA, respectively. From these results, it can be deduced that there was an interaction between sucrose and IBA concentrations on the rooting of *Zantedeschia albomaculata* shoots.

Visual comparison of IBA and NAA effects showed that in the first week no roots formed in all the NAA media tested, while at most 84% shoots rooted in the medium augmented with 20 g/l sucrose + 1 mg/l IBA. Although roots formed in the absence of auxins, addition of IBA increased the rooting percentage better than NAA (Table 4). These results are similar to those obtained in Chinese cabbage (Kee et al., 1987), whereby roots formed in the absence of auxins, but addition of auxins (IBA and NAA) increased the percentage of rooting.

There was a difference in root morphology between IBA and NAA treatments. Roots formed in hormone-free media with 15, 20 and 30 g/l sucrose and in IBA-augmented media were long, thin and branched with root hairs, compared to short, thick and without root hairs in NAA-augmented media. These results are similar to those obtained by Kee et al. (1987) with Chinese cabbage, in which roots induced by IBA or IAA were elongated, but those developing in the presence of NAA were stumpy and thick.

A greater percentage of shoots produced roots (84% vs. 70%) within a shorter period of time (1 week versus 2 weeks) when placed on 20 g/l sucrose + 2 mg/l IBA versus 30 g/l sucrose + 2 mg/l NAA, respectively. This and previous findings proved that IBA is a better rooting hormone than NAA for *Zantedeschia* shoots. Contrary to these results, Clemente et al. (1991) reported that incorporation of IBA at 0.49 to 14 μM or NAA at 0.53 to 16 μM into the basal medium for 3 days did not enhance either the rooting percentage (70%) or the number of roots per culture (3.5) relative to those obtained in controls. The presence of IAA during the entire culture period decreased the rooting percentage to 50% at 0.57 μM and 0% at 17 μM, whereas roots did not form with IBA and NAA at any of the levels tested. However, the overall best rooting medium in the current study contained 15 to 30 g/l sucrose and no hormones.

In conclusion, it is clear from the current study that *Zantedeschia albomaculata* 'Black Magic' can be induced in vitro to produce high quality multiple shoots from shoot primordia explants, using MS (1962) medium supplemented with 15 to 30g/l sucrose and 2 mg/l BAP. Root induction is best in hormone-free medium supplemented with 15 g/l to 30 g/l sucrose and gelled with 0.8% agar.

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Questions/Comments and Answers

B. Hau: Will the findings be used for commercial application?

Response: Aim of research is to provide clean planting material for commercial production of the flower

Companion Cropping As Management Component Of Flower Thrips (Thysanoptera: Thripidae) In French Beans (*Phaseolus Vulgaris* L.).

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Abstract

Six companion crops, (*Tagetes spp* L. (African marigold), *Daucus carota* L. (carrot), *Coriandrum sativum* L. (coriander), *Brassica spp.* L. (kale), *Capsicum spp* L. (Chili) and *Zea mays* L. (maize)) were evaluated for their efficacy in suppressing field populations of the French bean flower thrips,(*Frankliniella occidentalis* (Pergande), *Frankliniella schultzei* (Trybom) and *Megalurothrips sjostedti* (trybom)). The companion crops were compared to two insecticides, Labda cyhalothrin (Karate 1.75% EC) and Methiocarb (Mesurol 500 SC) and untreated mono-crop of French beans. Three of the treatments, coriander, maize and African marigold were found to be effective in that order, by repelling the pest away from the crop. It is concluded that these crops could be recommended to farmers for use and therefore are able to minimise the high use of chemical insecticides.

Introduction

French beans are ranked first among Kenya's vegetable foreign exchange earners accounting for a volume of more than 20% of horticultural export (Kibanga, 1996; HCDA, 2000). They are grown sorely for export market mostly by small-scale farmers. The crop production is continuous all year-round and thus it does not allow for a break in pest cycle but instead allows continuous breeding of the thrip pests.

Among the arthropod pests of French beans, flower thrips (*Frankliniella occidentalis (*Pergande) and *Megalurothrips sjostedti* (Trybom)) are ranked as major pests and have been known to contribute to over 60% yield loss of the marketable fresh pods (Nderitu, *et al*., 2001). Of the two species, *F. occidentalis*, being an introduced pest in Kenya, has the widest host range, is resistant to many chemical insecticides (Gitonga, 1999) and its management is challenging. Thrips causes flower abortion and malformation of pods (Tamo *et al.,* 1993), which are not fit for the export market. Farmers are known to rely wholly on chemical insecticides to control this pest, but there is no universally ideal thripsicide known for control of the thrip pests. L-cyhalothrin has been reported to be the most widely used insecticide against flower thrips by farmers although not effective on *F. occidentalis* (Nderitu and Anyango, 1993; Nderitu *et al*., 2001), while methiocarb is reported to be effective on both *F. occidentalis* and *M. sjostedti* (Michalik and Seif, 1999). The recommended insecticides are very expensive for the poor farmers while the chemical insecticides results to build up of resistance by the pest. Kyamanywa and Ampofo, (1988) reported inter-crop of maize and cowpeas to be effective in minimizing legume flower thrips in cowpea. In view of this there was a need for evaluation of various companion crops along with French beans for management of the flower thrips. The study aimed at coming up with certain crops, which could be used as companion crops with French beans to effectively minimise the flower thrip infestations and therefore reduce crop damage while at the same time targeting reduction of insecticide sprays in a season.

Materials and Methods

The study was carried out at Kenya Agricultural Research Institute (K.A.R.I)—National Fibre Research Centre (NFRC), Mwea-Tebere, Central Kenya. This locality is one of the major French bean growing zones in Kenya. Land preparation was carried out by use of tractor mould board plough and fine tilled by human labour who also made ridges to facilitate furrow irrigation. Six companion crops; *Tagetes spp* L. (African

marigold), *Daucus carota* L. (carrot), *Coriandrum sativum* L. (coriander), *Brassica spp.* L. (kale*), Capsicum spp* L. (Chili) and *Zea mays* L. (maize), untreated French bean mono-crop, Labda cyhalothrin (Karate 1.75% EC) and Methiocarb (Mesurol 500 SC), were evaluated for their efficacy in suppression of bean flower thrips population. The experiment was in a Randomized Complete Block Design replicated three times. Each block was separated by a distance of 50 m while plots were separated by a distance of 10 m within each block. The companion crops were planted one week prior to bean planting such that they were one week older as the French bean crop mature early compared to these other crops. French bean seeds were dressed with Imidacroprid (Gaucho 350FS) and Thiram (Thiram 800WP) for control of early insect pests and seedling diseases of French beans respectively. Immediately after the French bean emergence, the crop was sprayed with Dimethoate to prevent beanfly attack. Two rows of the French beans were alternated with one row of the companion crop in a plot of 10m x 3m. The spacing of French beans was maintained at 60cm between rows and 8cm within rows. Each row of French beans contained 39 plants to give a plant density of approximately 856 bean mono-crop/plot and 546-bean inter-cropped/plot equivalent to 286,000 plants/ha and 182,000plants/ha respectively. Diammonium phosphate fertilizer was well mixed with the soil at the rate of 50 kg per acre during planting. Top dressing was applied in two splits of calcium ammonium nitrate at the rate of 50 kg per acre on day 14 and the same rate on day 28, after emergence. Weeding was done on day 14 and repeated on days 28 and 42 after French bean emergence. Furrow irrigation was done at an interval of 3 days from planting throughout the crop development. All the agronomic activities were carried out by hand. Insecticide treatments were applied at the rate of 1Kg a.i/ha (50ml/20l water) and 200g a.i/ha (40ml/20l water) for Karate and Mesurol respectively on days 20, 27 and 34 after French bean emergence by use of Knapsack sprayer calibrated at 4 bars psi. Flower sampling was done by picking of 20 flowers per plot after 50% of the main crop had flowered. This was done at 3 days interval until the crop senesced. After picking, the flowers were immersed into a glass vial containing 70% ethyl alcohol where they were preserved for laboratory analysis. In the laboratory, the contents of the glass vials were emptied into a Petri dish with square grids engraved on its bottom to facilitate thrips counting. The flowers were macerated and washed thoroughly with 70% alcohol, removing the flower debris to make sure no thrips were discarded. Thrips were finally counted under a dissecting microscope by use of tally counter. They were separated to three groups, *Frankliniella spp*, *Megalurothrips sjostedti* and thrips larva.

Results

Table 1 shows that all treatments were significantly different in reducing thrips infestations on French beans. Insecticides were significantly different from companion crops but were not different from French bean mono-crop. L—cyhalothrin was significantly different from companion crops and methiocarb but was not significantly different from mono-crop French beans. Methiocarb was not significantly different from companion crops but was different from the French bean mono-crop. French bean mono-crop was significantly different from the companion crops.

Table I: P-values of flower thrips at different treatment effects

EFFECTS	F.occidentalis (a)	M.sjostedti (b)	Larva of a and b(c)	Total thrips (a+b+c)
All treatments	<.001	0.165	0.294	<.001
Insecticides vs companion crops	<.001	0.896	0.402	0.013
Insecticides vs French bean mono-crop	0.348	0.728	0.756	0.930
L—cyhalothrin vs companion crops	<.001	0.748	.050	<.001
L—cyhalothrin vs French bean mono-crop	0.499	0.637	0.199	0.60
L—cyhalothrin vs methiocarb	0.002	0.733	0.042	0.003
methiocarb vs companion crops	0.332	0.901	0.483	0.958
methiocarb vs French bean mono-crop	0.041	0.896	0.454	0.120
French bean mono-crop vs companion crops	<.001	0.767	0.l99	0.048
Residual df	178	178	178	178
Replicates	21	21	21	21
Sed	**0.3870**	**0.2329**	**0.657**	**0.897**

Table 2 shows that *C. sativum, Z. mays,* and *Tagetes spp* were significantly different from mono-crop, while *D. carota, Brassica spp* and *Capsicum spp* were not significantly different from mono-crop

Table 2: P—value of Mono-crop when compared to companion crops

EFFECTS	*F.occidentalis* (a)	*M.sjostedti* (b)	Larva of a and b(c)	Total thrips (a+b+c)
French bean mono-crop vs *Tagetes* spp	0.009	0.737	0.407	0.043
French bean mono-crop vs *D. carota*	0.011	0.706	0.931	0.207
French bean mono-crop vs *C. sativum*	<.001	0.536	0.216	<.001
French bean mono-crop vs *Z. mays*	<.001	0.670	0.950	<.001
French bean mono-crop vs *Brassica spp*	0.461	0.022	0.516	0.487
French bean mono-crop vs *Capsicum spp*	0.106	0.956	0.875	0.489

Table 3 indicates that *C. sativum, Z. mays,* and *Tagetes spp* had the lowest mean counts of flower thrips followed by methiocarb followed by *D. carota, Brassica spp* and *Capsicum spp* which recorded medium to high counts of flower thrips while L-cyhalothrin and mono-crop had the highest counts of flower thrips.

Table 3: Flower thrips mean population counts

Treatment	***F. occidentalis* (a)**	***M. sjostedti* (b)**	**Larva of a and b(c)**	**Total (a+b+c)**
Coriandrum sativum	1.405	0.505	2.07	3.98
Zea mays	1.658	0.550	2.92	5.13
Tagetes spp	2.425	0.571	2.34	5.33
Methiocarb	2.695	0.680	2.39	5.76
Daucus carota	2.462	0.737	2.82	6.02
Capsicum spp	2.894	0662	2.98	6.54
French bean Mono-crop	3.634	0.649	2.88	7.16
L-cyhalothrin	3.943	0.759	3.73	8.43
Sed	**0.3870**	**0.2329**	**0.657**	**0.897**

Discussion

From the results, there is evidence that *C. sativum, Z. mays,* and *Tagetes spp* were effective in minimizing infestation of flower thrips and thus could be used as a component of IPM in managing thrips pest in French beans. Effectiveness of Coriander as a companion crop of French beans confirms the importance of this crop in thrip management system as it has been shown to be effective against thrips when used as a companion crop on onion crop (Devalash and Sugha, 1997). Coriander is a common spice herb in the local market with high demand. If farmers are aware of its importance as an inter-crop of beans, they can be able to incorporate it in their French bean production instead of raising it from the kitchen garden. Maize – cowpeas intercrop has already shown to be effective on *M. sjostedti* (Kyamanywa and Ampofo, 1988). The knowledge of Maize effectiveness on *Frankliniella occidentalis* is important, as this pest is the most serious thrip species of the French bean flower thrips. Inter-crop of maize and French beans is a common practice by some small-scale local farmers and therefore the technology transfer may not be a big problem even though most farmers prefer the mono-crop. Those farmers who practice inter-cropping do not know the crop effects on the thrips as they use same amount of pesticide as if the crop is a mono-crop. African marigold is known in Europe as an important IPM tool for control of plant parasitic nematodes as a trap crop. It is also reported to greatly reduce the attacks of aphids when planted near roses. It is known to kill weeds especially coach grass and when planted near potatoes infected by nematodes, it drastically reduces their effects (Louise, personal communication). These are added advantages if farmers could take it as a control option and not a weed as they already presume. French bean crop is harvested on relatively short intervals (2-3 days) and thus may require workers to be in the field frequently. Synthetic insecticide use may pose personal safety or crop residue problems. As long as the technology of companion cropping is not costly, farmers could adopt it. Use of these companion crops could minimize the insecticide usage and thus reduce the environmental pollution by the insecticides. Furthermore, the worldwide trend is to target zero tolerance

of pesticides used especially on fresh export vegetables. Use of these companion crops could be a best combination with insecticide to reduce sprays in a season.

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Water Hyacinth (*Eichhornia crassipes*) Management and Utilization in the Lake Victoria Region

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Abstract

Water hyacinth has long been perceived as a problem for shipping and fishing industries and only more recently as a threat to bio-diversity. It can undergo rapid proliferation, forming dense mats of plants that cover water bodies, so reducing light and oxygen and changing the water's chemistry, fauna and flora. It poses a real risk to human activities especially horticultural around the Lake region. The undesirable effects of water hyacinth, which has been over emphasized, are strongly due to its ability to multiply and spread rapidly as a weed covering the fresh water surfaces causing several problems. However, the plant can be used as bio-fertilizer in horticultural production, for animal feed and biogas production. Physiological experimentation have shown that water hyacinth has a high nitrogen and phosphorus loading that can be made available to the growing crop on decomposition.

Key words: Eichhornia crassipes, reproductive biology, uses, Lake Victoria Region

Introduction

Kenya, Tanzania and Uganda border Lake Victoria, also known as Victoria Nyanza. It has an area of 69,482 sq. km and lies about 1,151 m above sea level. The lake is about 337 km long at its greater length, and

stretches about 240 km at its greatest width. The Nile drains it and its chief effluent is the Kagera River. Kenya has the smallest portion of the lake but has the highest number of effluent rivers. It is economically important to the surrounding regions, which has one of Africa's highest population densities.

Water hyacinth reached Lake Victoria about 12 years ago through the Kagera headwaters at the Tanzania – Uganda border. It is a native of the Neotropic Amazonian region in South America and was first recorded in Africa from river Nile in Egypt in 1890. The source at that time must have been through the White Nile since no occurrence was recorded at the Victoria region. In the twentieth century it spread from, the Nile and colonized most of the major freshwater lakes and rivers in Africa.

Water hyacinth has long been perceived as a problem for shipping and fishing industries and only more recently as a threat to biodiversity. It can undergo rapid proliferation, forming dense mats of plants that cover water bodies, so reducing light and oxygen and changing the water's chemistry, fauna and flora. It poses a real risk to human activities in lake Victoria region where it has thrived in the eutrophic conditions notably in the shallow Kenyan coastal waters especially around the Winam gulf (Ochiel and Wawire 2001). The prolific growth of water hyacinth on the Lake's coastal waters has been accelerated by the eutrophication from agricultural affluent and siltation from major rivers draining into the lake.

Objectives

The objectives of the experiments reported in this paper was to study:

- The effect of Nitrogen and Phosphorous on the growth parameters of water hyacinth;
- The overall aim is for an agriculture that maintains the integrity of agro-ecosystems through a reduced dependence on chemicals, greater care of soil and conservation of water.
- the pollution effect arising from agricultural production from a global perspectives on the positive commercial uses of water hyacinth in the Lake Victoria basin.

Materials and Methods

Water hyacinth was grown in the glasshouse under tropical conditions. The experiment was set-up with 5 treatments and four replications. Yoshida *et al.,* (1972) nutrient solution for hydroponics culture was used.

1. Culture solution at 800 ppm for all nutrients except Nitrogen and Phosphorous
2. Full culture solution at 800 ppm
3. Full culture solution at 800 ppm with Nitrogen at 2400 ppm
4. Full culture solution at 800 ppm with Phosphorous at 2400ppm
5. Full culture solution at 800 ppm with both N and P at 2400 ppm

The rate of new plants (rhizomes) proliferation, flowering, transpiration and photosynthesis were measured. Elemental analysis was done on the plant tissue to assess the nutrient loading or uptake by the plant.

Results

Occasionally, when humans introduce a non-native species to an ecosystem, dramatic disruptions occur, often because the natural predators of the introduced species are not present. The introduction of water hyacinth [Eichhornia crassipes], which has become one of the noxious weed in Lake Victoria provides good example of human disturbance to an ecosystem.

The growth proliferation of water hyacinth was accelerated at high N and P levels in this experiment. Transpiration rates were significantly ($P \leq 0.5$) high especially for N at 800 ppm and 2400 ppm (Fig. 1). The photosynthetic rates were significantly ($P \leq 0.5$) high for N and P treated plants (Fig. 2). The P treated plants had better water use efficiency when the photosynthetic and transpiration rates were compared.

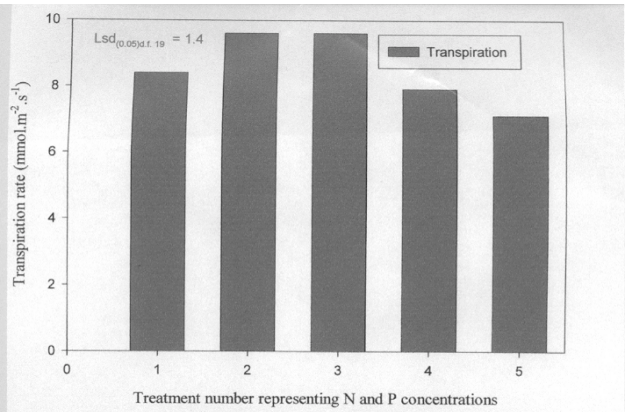

Fig. 1. Transpiration rates for water hyacinth grown at different levels of Nitrogen and Phosphorous fertilization in the glasshouse

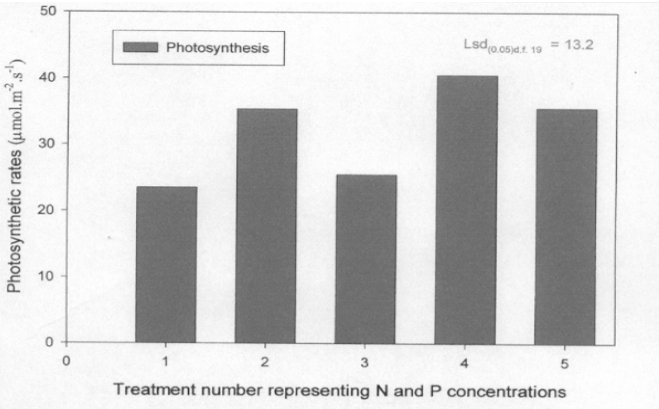

Fig.2. Photosyntheitic rates for water hyacinth grown at different levels of Nitrogen and Phosphorous fertilization in the glasshouse.

The rate of new plants proliferation and flowering were significantly ($P \leq 0.001$) high for treatments at 2400 ppm for N and P combined (Fig. 3 and 4). The data reported support the fact that water hyacinth can remove high concentrations of agricultural chemicals from water bodies. The field observation also showed high efficacy from the biological control methods managed by KARI on the Kenyan portion of the Lake (Ochiel and Wawire 2001).

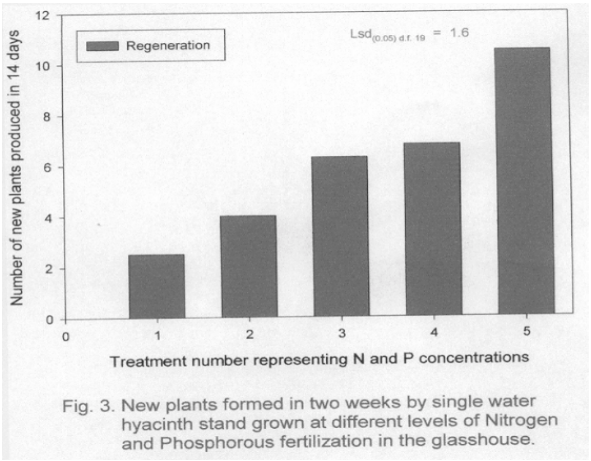

Fig. 3. New plants formed in two weeks by single water hyacinth stand grown at different levels of Nitrogen and Phosphorous fertilization in the glasshouse.

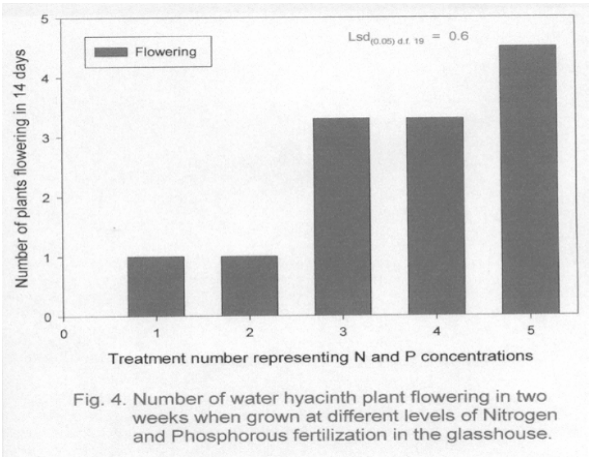

Fig. 4. Number of water hyacinth plant flowering in two weeks when grown at different levels of Nitrogen and Phosphorous fertilization in the glasshouse.

Table 1. Ionic uptake by water hyacinth from the hydroponics culture

Constituent	Content (%)
Nitrogen	4.5±1.1
Phosphorus	3.6± 0.9
Potassium	4.2± 0.8
Calcium	2.3 ± 0.4
Magnesium	0.95± 0.3
Iron (ppm)	949±39.0
Manganese (ppm)	330±25.0
Copper (ppm)	18±3.0
Zinc (ppm)	136±15.0

All figures on dry Weight basis

Discussion and conclusion

Although there is considerable literature on the bioaccumulation capacity of water hyacinth and its potential for metal removal from wastewater, its use for the removal of organic contaminants from industrial wastewater has not received much attention. The ability of the water hyacinth to survive under stress and wide ranging temperature, pH and saline conditions enhances its ability for treating wastewater. Further more the plant can be used for animal feed, rehabilitation of wetlands, biofertilizer and biogas production, paper and furniture manufacture. The undesirable effects of water hyacinth, which has been over emphasized, are strongly due to its ability to multiply and spread rapidly as a weed covering the fresh water surfaces causing several problems listed above. The plant needs proper management programme if both its useful attributes can be realized while at the same time preventing biotic and abiotic problems it causes. The biological control would therefore be the best management programme because it is cheap to maintain over a long period of time.

Horticultural implications of water hyacinth [*Eichhornia crassipes*]

This plant is the only free floating species in the family Pontederiaceae. It is native to Central and South America especially the Amazon valley (Gopal 1987). When it first became known outside South America, it was valued as a horticultural plant because of its curious morphology, unusual habit and strikingly beautiful flowers. For these reasons it was transported to North America and European botanic gardens and from there to a number of countries in a process which probably started in the 1880s and still continues for example it first invaded Lake Victoria waters through River Kagera delta in 1982 (Holm *et al*., 1977), though presently it is probably pantropical in distribution.

The normal pattern of invasion is for a few living plants of water hyacinth to be placed or washed into water body. Initial colonization is by vegetative growth and spread. Each plant is capable of producing daughter plants by stoloniferous offshoots. In good conditions the plant can double its numbers in less than 10 days (Gopal 1987). Growth is therefore exponential, at least initially, until one or several growth requirements become limiting. *Eichhornia crassipes* exhibits floral trimorphism expressed a tristyly, anther / pollen trimorphism, and other features such as colour. Seed set is highest when crosses occur between different flowers forms (Barrett 1980). Consequently populations, both in native and alien situations, may set relatively little seed. Germination into seedlings is stratum and fluctuating temperatures. However, seeds can remain viable for several years so that reinfestation could occur for a number of years, even if control measures had successfully eliminated infestations of adult plants.

Eichhornia crassipes also has a series of growth forms to cover the different range of environmental conditions, because it is a floating species it is well suited to survive in such varied environments. Plant which grow aggressively and are a potential problem in both native and alien situations, especially when the former are altered by the addition of excessive nutrients or engineering constructions of man-made lakes of irrigation canal systems, conditions which favour the growth of water hyacinth.

The high nutrient content, particularly of potassium and nitrogen is an important attribute as the weed can be composted or ashed for application in a variety of crops. The potash content in ash is reported (Day 1918) to vary from 6.27% - 34.1%. Addition of water hyacinth compost along with calcium phosphate or bone meal has been reported to permanently reclaim alkaline soils. This treatment improves the physico-chemical properties of soils and the yields of wheat, potato and paddy rice increased by several fold. Compost of this plant is also recommended for increasing available phosphorus in saline soils. Compost when mixed with soil, can also fix atmospheric nitrogen and this fixation was more in light than dark (Dhar and Hassan 1961). However, usage of water hyacinth compost has been shown to decrease the yield of Okra and tomato as compared to that obtained with other fertilizers (Singh 1962.

Aquatic weeds like water hyacinth can scavenge some organic and inorganic compounds including heavy metals from waste waters (NAS 1976). The weeds absorb and incorporate the dissolved materials into their own structure. The effluent is thus stripped off its pollutants and hence becomes less toxic. Furthermore the weed also shows profuse growth in such wastewater and can be harvested for use, thus giving additional benefits. Water hyacinth has also been used for paper making although the paper had high shrinkage and dark in appearance.

Water hyacinth is rich in chemical constituents and can be used in various production lines in both horticulture and environment. Water hyacinth leaves have about 22.12% protein, 18.3% fibre 0.87% Phosphorous 0.87% and ash 17.8%. The leaves have a higher concentration of protein as compared to other plant sections. If dried on an economic scale, water hyacinth can be a very good animal feed since it is rich in vitamins (little 1968). It can also be used in agricultural production as source of nutrients and growth substrate.

Recommendations and action plan

- A concerted effort to boost agricultural production through mechanization and addition of value to farm produce is imperative to reduce the poverty trends experienced in the region.
- The need to improve agricultural mechanization hence accelerates food production and creation of wealth through horticultural produce is necessary to start the long path of economic growth and stability.
- Teamwork between politicians and citizens is what is most need in the great lake region, if sustainable benefits are to be felt from environmental management and utilization of water hyacinth.

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Survey On Knowledge, Attitudes and Practices Among Small Holder Flower Growers in Central Kenya

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Abstract

A diagnostic survey was conducted in 4 districts (Thika, Nyandarua, Kiambu and Maragwa) of Central Kenya to collect baseline information as a first step towards modification/improvement of crop protection practices among smallholder flower growers. Data was gathered on general farming situation, sources of farm inputs, pesticide supply and use, knowledge of pests and diseases and their control as well as investment and returns.

A total of 66 farmers were interviewed. Majority of the farmers had between 1 to 5 acres of land of which 1-3 acres or slightly more was cultivated. Area used for production of flower crops was mainly below 0.5 acres. All farmers used pesticides as the main pest control option. Pesticides were mainly sourced from stockists. Peer farmers, agricultural officers, stockists and Kenya Agricultural Research Institute (KARI) were the main sources of information on the usage of pesticides. Over 30 different brands of chemical pesticides were being used to control insect pests and diseases. The most popular were Karate (Alpha cyhalothrin), Furadan (carbofuran), Benlate (benomyl) and Ridomil (metalaxyl). Half of the farmers agreed that their expenditure on pesticides had increased in a span of three years, mainly due to increase in prices. The use of cultural practices for the management of pests in flowers, was found among 37.8% of farmers.

Among the highest ranking flower production problems were: marketing, availability of irrigation water, insect pests and diseases, shortage of capital and inadequate knowledge on flower agronomy. Technical information requested by the farmers was on pest control, crop agronomy, soil analysis, and the choice of the variety to produce. Farmers would also benefit from seminars, market information and assistance, and credit facilities.

Introduction

The flower industry in Kenya has experienced steady growth in the last decade or so. The volume of flowers exported in the year 2000 accounted for 36.7% of the total volume of horticultural produce exported, up from 24.9% in 1985. The corresponding cash values were 52.7% and 44.6% of the total value of horticultural exports in 2000 and 1985 respectively (Muthoka, 2002).

The main pioneers of commercial flower growing in Kenya were large-scale farms, who produced several hectares of either summer flowers or in-house crops such as roses, lisianthus etc The number of these large growers continues to rise by the day. However, the last decade has also seen a considerable increase in the number of medium and smallholder flower growers, dealing mainly with summer flowers such as arabicum, tuberose, ornis, etc Smallholder farmers produce flowers on land areas ranging from a few square metres to slightly above or below an acre. This trend has come about upon the realisation that flower growing gives better return per unit area than most agricultural crops (Muthoka, 2002). With proper organization, choice of flower type and market links, these smallholder flower growers are reaping benefits of increased incomes, reduced poverty and creation of employment.

Flower research in Kenya Agricultural Research Institute (KARI) has continued since 1978. Constraints that required intervention at its inception were relatively few, and were mainly in the areas of inadequate clean planting material of fashionable varieties, appropriate production techniques and post harvest practices. These still continue to be important research themes.

However, with introductions of new flower crops of different varieties and expansion of acreage under flowers in different ecologies, new challenges have come up that merit the attention of research. Top on the list is the complex of insect pests, diseases and nematodes, some of which may have inevitably been introduced through exotic material. With new introductions, expansion of production and the diversity of control strategies applied by different categories of farmers, pest problems have been as dynamic as the industry itself. Consequently pest management in floriculture takes the larger portion of production costs.

Heavy usage of (mainly synthetic) pesticides has therefore characterized flower growing. This is chiefly because aesthetic quality more than anything else is the primary selling characteristic for flower crops, demanding zero or near zero tolerance of pest infestation or blemish on material availed to the market. Pest management in flowers is, however, likely to become more challenging as Maximum Residue Levels (MRLs) continue to be lower and the range of environmentally acceptable pesticides is reduced. An example of such a major blow is the phasing out of methyl bromide, a popular highly effective soil fumigant.

Availability of capital for purchase of farm inputs and the necessary infrastructure has been a major bottleneck in Kenyan horticulture. Flower production, being the capital-intensive venture it is, is therefore still out of reach for the majority of small-scale farmers. The level of production amongst those who have attempted to adopt the technology is therefore far below the average potential. Hence, introduction of sustainable crop and pest management practices will go a long way in promoting the production of flowers by smallholder farmers and reduce poverty levels in rural households. The current work was undertaken to compile baseline data as a first step towards modification/improvement of crop protection practices among smallholder flower growers. This paper focuses on crop protection and related practices as were derived from the first phase of the planned countrywide diagnostic survey.

Materials and Methods

A diagnostic survey was carried out in 1999 in 4 districts of Central Kenya (Thika, Nyandarua, Kiambu and Maragua) to obtain baseline information on production and pest control practices among smallholder flower growers. A structured questionnaire was administered on a total of 66 farmers (46 males and 20 females). 6 divisions were covered: Limuru (Kiambu), Kandara and Kigumo (Maragua), South Kinangop (Nyandarua), Gatanga and Kamwangi (Thika). Farmer selection was random based only on the fact that the farmer was growing at least one flower cultivar commercially. Farmer selection was done with help of the MOARD extension staff in the respective areas. Information collected from the farmers was on:

a) Flower types under production.
b) Knowledge of and source of inputs.
c) Pesticide supply and source of information on their use.
d) Farmers' knowledge of insect pests and diseases on flower crops under production.
e) Soil analysis and perception of its importance.
f) Flower farming problems (general).
g) Availability of credit facilities.
h) Pesticide efficacy and awareness of the effects of pesticides on natural enemies, users and the general environment.
i) Methodology of pesticide selection and awareness of residue levels.
j) Cultural control practices for pests.
k) Indigenous pest control practices in use in flower production.

Confirmation of insect pests and diseases mentioned was done through direct/visual observations of each flower plot.

Results

Farmer Characteristics

Majority of those interviewed were aged between 31 to 60 years, and 81.8% had at least elementary level of education. Most of the interviewees were male, though the ratio of male: female flower growers was nearly equal in two districts.

Table 1: Characteristics of smallholder flower growers in Central Kenya

District	No. of Farmers interviewed			Age Group *(Those who disclosed only)*				Level of Education *(Those who disclosed only)*		
	Males	Females	Total	<30	31-40	41-60	>60	Elem	Sec	Above
Thika	11	10	21	2	7	8	3	8	8	3
Nyandarua	10	0	10	1	0	6	3	6	2	0
Kiambu	3	5	8	2	1	4	0	2	3	-
Maragua	22	5	27	7	5	10	4	12	8	2
Total	46	20	66	12	13	28	10	28	21	5

Among the farmers interviewed, 73.7% of the farmers owned 1 – 5 acres of land, 10.5% had between 6 and 10 acres of land, and a further 10.5% had more than 10 acres. The rest owned less than an acre (Fig 1). Of the total land owned, 58.5% of the farmers cultivated between 1 – 3 acres. 34.1% cultivated more than 3 acres, and others less than an acre. However of the total land area cultivated, Only a small proportion is allocated for flower production: The greater majority of the farmers (53.6%) used between 0.25 to 0.5 acre for flower growing; 25% used less than 0.25 acre. Only 8.9% of all the farmers interviewed used more than one acre for flowers.

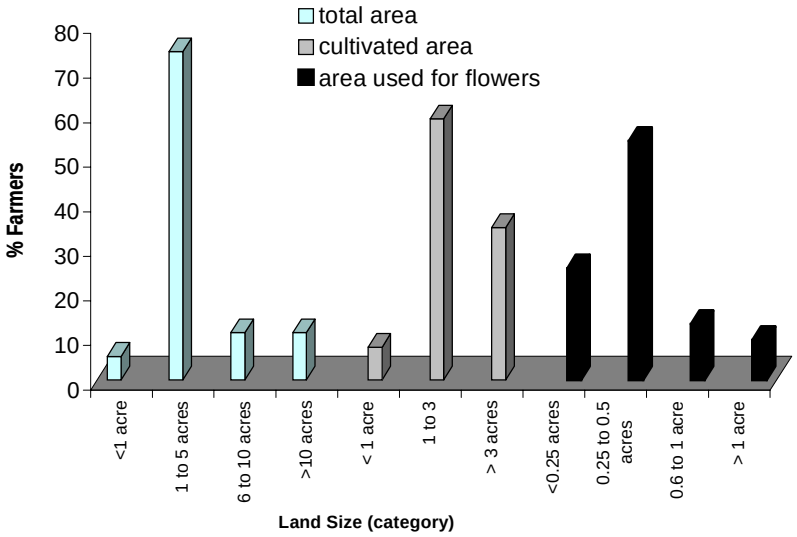

Fig 1: Proportion of total land owned that is allocated to flower production by small-scale farmers in Central Kenya

Types of Flower Being Grown

The farmers interviewed were growing a total of 19 types of flowers. These were: Arabicum, Eryngium, Tuberose, Ornithogalum, Alstroemeria, Statice, Mollucella, Gladiolus, Rudbeckia, Orion, ,Carthamus, Solidago, Carnation, Bulplerium, Agapanthus, Amaranthus, Easter lilies, Arum lilies,

and Atriplex. Most of the planting material was either bought from neighbouring farms or far away farmers, particularly from Limuru (where small-scale flower growing was popularised first).

Pesticide Use, Supply and Source of Information

All the farmers used pesticides to control diseases and other pests of flowers. Pesticides were sourced from stockists, apart from one farmer who reported to have sourced pesticides from KARI. There were, however, various sources of information on pesticide use, with peer farmers toping the list with 33.9% followed by agricultural officers with 23.2%, stockists 19.6% and KARI 17.9%. Farmers also obtained information on pesticide use from exporters' agents, and seminars, each accounting for 7.1%. Only 1.8% said they were their own advisor on pesticide use.

Commonly Used Pesticides, Efficacy and Change on Expenditure in Pesticides

Up to 30 different brands of chemical pesticides were being used to control insect pests and diseases on flowers (Table 2). The most popular were Karate (alpha cyhalothrin), Furadan (carbofuran), Benlate (benomyl) and Ridomil (metalaxyl)

Table 2: Pesticides commonly used by smallholder flower growers in Central Kenya

Trade Name	Active Ingredient	% Farmers Using	Trade Name	Active Ingredient	% Farmers Using
Karate	Alpha cyhalothrin	53.0	Milraz	Propineb + Cymoxanil	3.0
Furadan	carbofuran	34.8	Malathion	Malathion	1.5
Benlate	Benomyl	33.3	Diazinon	Diazinon	1.5
Ridomil	metalaxyl	24.2	Hostathion		1.5
Copper oxychloride	Cu oxychloride	12.1	Green copper	Cu oxychloride	1.5
Antracol	Propineb	10.6	Bayleton	Triadimefon	1.5
Brigade	Bifenthrin	9.1	Nimrod	Hexaconazole	1.5
Dimethoate	Dimethoate	7.6	Acrobat	Dimethomorph + Mancozeb	1.5
Fastac	Alpha cypermethrin	7.6	Decis	Deltamethrin	1.5
Kocide		7.6	Folimat	Omethoate	1.5
Dithane M45	Mancozeb	6.1	Vidate		1.5
Ambush		6.1	Lasset		1.5
Captan		3.0	Sumithion	Fenitrothion	1.5
Rovral	Iprodione	3.0			

It was found out that 77.8% of the farmers said their expenditure on pesticides had changed in the previous 3 years, mainly because prices had increased (46.6%), and to a lesser extent due to declining efficacy (6.7%) or because the pesticides they are using now are different from those they used 3 years back (5%). The survey revealed that 1.7% of the respondents said they have to apply pesticides at higher rates to control the pests. Asked their perceived efficacy of the pesticides they were using for the same 3-year period, 56.8% said pesticides are moderately efficacious now, while 40.9% felt pesticides were indeed highly efficacious; only 2.3 % said pesticides were not efficacious at all.

Constraints in Flower Production

There were numerous constraints mentioned by the farmers. Ranking highest was marketing (65.5%), followed by shortage of irrigation water (50%) and pests (41.4%). Also cited were availability/accessibility of farm inputs, inadequate knowledge in flower agronomy, labour and adverse weather. Though soil fertility was not mentioned as a constraint, only 11.8% had ever analysed their soils for nutrient content.

Diseases and Insect Pests Associated With Flowers

Most farmers would describe and name insect pests on various flowers, and associate them with environmental conditions. Few, however, could name diseases; diseases were therefore described

according to symptoms. Most pest problems were said to occur during drought conditions, though a few were said to occur or increase during wet weather. Caterpillars, aphids, thrips, spider mites and whiteflies and some other unspecified flies were among the most commonly mentioned insect pests. Among the diseases those most frequently mentioned were root rots, leaf blights, botrytis, stem rots and bulb rots. Arabicum, tuberose and eryngium had the most pest problems. No pest problems were mentioned for orion and agapanthus, and only leaf blights were said to affect arum lilies. Mollucella had only basal rot problems.

Pests with widest geographical distribution were caterpillars, thrips, aphids, rots (basal, bulb, roots, and stem). Aphids, caterpillars, spider mites and thrips were the arthropods with the widest host range. Among the diseases, the order was root rots, leaf blights, botrytis, leaf yellows and dieback according to the farmers. Others were mentioned in three or less of the nineteen flower crops.

Birds, rodents, snails and slugs were also mentioned as flower pests. Some farmers also believed that millipedes and earthworms were feeding on their flower crops.

Pest control

For most of the pest problems mentioned, use of chemical pesticides was the most popular remedy among the farmers interviewed. Only in arabicum was rouging mentioned as a cultural control method for bulb rots, and only one farmer reported using hand picking for the control of caterpillars. One farmer got discouraged and simply neglected his crop of tuberose when the flower got retarded and its productivity severely declined. Leaf yellows were usually treated by using foliar fertilizers. There were also many flower pests that the farmers said they didn't know how to control.

Technical Information Requested by The Farmers

Majority of the farmers (68%) sought technical information on pest control, while 28% sought technical knowledge on flower agronomy. Technical information on soil analysis, information on variety to plant, and credit was in each case requested by 12% of the farmers. A few farmers (10%) requested assistance in terms of credit, marketing, and a similar proportion felt they would benefit from seminars in flower growing. Only 4% sought assistance in farm inputs.

Discussion

The survey indicates growing interest in commercial flower growing among middle-aged smallholder farmers, particularly those with some level of formal education. The enterprise offers an opportunity for farmers in densely populated areas to utilize the small land acreages available to grow income-generating crops. This is good in reducing poverty levels among the rural populations. The diversity of flower types is also large and is fast increasing in response to market demands.

Pioneer areas have become important sources of planting material for new growers. Farmer-to-farmer exchange is currently the most important source of information on production, with minimal support from other informed quarters. However, with sharing of material across farms, production problems e.g. diseases such as root rots that may be borne in planting material or adhering soil have also spread rapidly. Besides, with the addition of new crops in the ecosystem, pest management, even for non-flower crops is likely to become more complex. This calls for the sensitisation of farmers on the need to use clean planting material, and how to obtain it. Relevant authorities should also intervene to harmonize movement of plant material and to sensitise seed

producers on seed health. There is great need for agricultural extensionists and research personnel, as well as other informed stakeholders to take a more proactive role in guiding farmers on what flower crops to grow and how, and particularly how to manage pest problems. Methods to be used in this training should seek to exploit this farmer-to-farmer exchange of information to enhance local capacity in flower production.

Pesticide use among smallholder flower farmers is wanting of guidance. This study indicates a tendency to use a few "super pesticides" to control flower pests, which could lead to resistance build up in the medium and long term. With rising costs of pesticides, farmers may resort to underdosage, aggravating this potentially dangerous situation.

Though knowledge of arthropod pests of flowers is fairly widespread among farmers, information is required to assist the farmers to identify and distinguish disease problems, and make quick decisions on appropriate control with confidence. With introduction of new flower crops and varieties to meet the fairly dynamic market demands, pest problems will inevitably become more complex. The study shows that the highest number of pests was reported on arabicum, tuberose and eryngium, which were among the first flower crops to be introduced to small-scale farmers. The farmers' understanding of the pests of these flowers is therefore better compared to other relatively new crops. There is, therefore, a likelihood that with time more pests will be reported on the other flowers as farmers' understanding of the crops and associated pests increases, and as more local pests adopt the new crops as alternate hosts. This calls for an early study of pests infesting, or likely to invade new crops, and the spread of already existing problems in space and time to prevent major epidemics. Of particular concern is the pesticide use habits among farmers to ensure sustainable control of flower pests while maintaining profitability of the enterprise, satisfy market demand for top (visual) quality in flower crops and conserve the environment.

Observations in export vegetable production has shown a declining interest among exporting companies to engage smallholder farmers in production supposedly due to increasing pressure from the market to supply high quality relatively pesticide residue-free produce and the intricacies of managing pesticide use among some small growers. As a result the companies have opted to contract medium-scale growers or establishing their own farms except when market demand is higher than can be supplied by these two measures. Many small-scale farmers have therefore been frustrated by lack of market for their produce. Such a situation must be avoided at the earliest opportunity for smallholder flower growers if indeed Kenya shall hope to reduce poverty by creating employment especially among rural populations.

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Challenges and Opportunities in Commercial Production of Indigenous Vegetables in Kenya

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Abstract

Indigenous leafy vegetables are widely consumed in Kenya. However, their production and utilization are carried out mainly at subsistence level. This is in contrast to exotic vegetables, whose production enjoys a large degree of commercialization and presence in formal trading outlets. Commercial production of indigenous vegetables will help enhance sustainable increased production and utilization of the vegetables. As has been the case with French Beans, commercialization and market demand of these vegetables will be a strong motivation for their production. The market demand will be the driving force in the production of the vegetables. Farmers are more likely to be motivated to meet customer quality demands, such as pesticide free vegetables, under conditions of commercial production. There are several opportunities for increasing utilization and demand of the vegetables. Most large hotels and restaurants do not serve these vegetables, and there are opportunities to increase the use of these vegetables by promoting their inclusion in the menus of such hotels. Some of these vegetables were traditionally used as functional foods, where they were claimed to serve a specific purpose in the diet. Such claims should be investigated, so that the commercial utilization of these foods can also be expanded in their application as functional foods. The vegetables that serve as functional foods are prepared in specific ways. These methods also require investigation. These vegetables are consumed not only in Kenya, but also in all the neighbouring countries. With increased liberalization of cross border trade in the East African Community and COMESA region, there are opportunities for exporting these vegetables to the neighbouring countries. There are many varieties of some of the vegetables. For successful promotion of their utilization, it may be necessary for suitable varieties for specific end uses or preparation methods to be identified.

Introduction

The great diversity of communities coupled with the varied agro-ecological zones (AEZ), has resulted in a wide range of species used as traditional leafy vegetables (TLVs) in Kenya. Altogether, over 220 TLVs are used in the country (Juma, 1989; Maundu *et al.* 1993). These vegetables have in the past significantly contributed to the nutritional well-being of communities. Currently, the priority species among these TLVs, that are grown countrywide include *Vigna unguiculata, Amaranthus spp., Cucurbita spp., cleome gynandra; Solanum nigrum and Corchorus spp.* (Chweya and Eyzaguirre, 1989; Maundu *et al.* 1999). The TLVs are mainly grown in Kitchen gardens for home consumption, and little for the urban market.

Since the onset of of the market economy and modernization of agriculture, prominence has been given to crops that offer a potential for export. Exotic vegetables, therefore have become more prestigious than the TLVs as the official policy has either intentionally or by omission discouraged traditional crops (Makokha *et al.* 1999). They have been largely neglected in terms of research on agronomic improvements. In most cases, they have been left to regenerate with the onset of rains without a serious effort to plant or apply other cultural practices on them. As a result, some of the TLVs are threatened with extinction as they have to compete for attention with the more popular exotic ones.

The TLVs are as nutritious as the exotic vegetables. They supply much, if not most, of the requirements for vitamins, minerals, dietary fibres and even substantial proportion of protein (Ruberto, 1984; Martin, 1984; Okigbo, 1983; Chweya, 1994). They have several advantages. They are fast growing, and adapt to a wide range of AEZ. They are also less susceptible to diseases and

pests, and require little or no inorganic fertilizers. They are already an important part of income generation, particularly for rural women who sell them in the rural and urban markets.

Opportunities for commercialization

The horticulture industry in Kenya has developed considerably for the last two decades. The export market has been the major thrust for this rapid development. In recent years, horticulture has consistently been among the top two most important foreign exchange earning industries in the country (CBS, 2002; CBS 2001). The most important export vegetable in terms of quantity and value is French beans, which are the immature green pods of *Phaseolus vulgaris L.*. The French beans account for more than half of the vegetable exports from Kenya. It is remarkable that most of the French beans for the export market are mainly produced by smallholder farmers, to whom the crop has been introduced during the last twenty years (MOA, 2000). These beans require more inputs than the TLVs, and the produce for export is subjected to rigorous quality requirements. There is little doubt, therefore, that if adequate demand for TLVs is realized, smallholder farmers will be able to respond quickly and meet the supply requirements

There has been considerable trade of these TLVs within the country, as noted by supply of these vegetables from the rural areas to the urban centres. They are then mainly sold for domestic consumption in the urban households. There is potential to increase domestic utilization by targeting outlets such as the big hotels and restaurants. The clientele of these establishments is mostly Kenyans, but most of them only serve exotic vegetables. There is little doubt that with proper promotion, such establishments can include these vegetables on their menu.

Many of the TLVs were also traditionally used as functional foods, where they did not only provide nutrients, but served another distinct purpose. Some of them were reported to have medicinal value. For instance, among the Kisii community in Kenya, *Cleome gynandra, Basella alba,* pumpkin leaves and amaranths are used for treatment of a variety of diseases (Maundu *et al.*, 1999). The older women in the community not only identified the TLVs with medicinal value, but they also knew the parts of the plants that were used for maximum medical benefits. They also described in detail the procedures for maximum medical benefits. Regrettably, this is one aspect of the application of TLVs that is most neglected, while the issue of functional foods is becoming increasingly important in the rest of the world. Commercial promotion of this aspect of TLV utilization will no doubt also increase the utilization of these vegetables.

There is potential to increase the production of TLVs by targeting the export market, once the demand has been identified. Such demand is likely to exist in the neighbouring African countries. These countries utilize TLVs which are similar to those grown in Kenya. None of these countries has taken steps to significantly commercialize the production of these TLVs. With proper marketing and conducive policies, an export market of TLVs to these countries can be established. Such a development will be an important diversification in the vegetable export sector, which currently is mainly dependent on French beans. The export of these beans, mainly to the European countries, faces stiff competition from suppliers in other developing countries with similar products and growing conditions (MOA, 2000). Export of TLVs will result in diversification both of the type of vegetables available for export and the export market.

The challenges

Assuming that the agronomic problems will be addressed once the demand increases, commercialization of the production and marketing of the TLVs face several challenges . Among such challenges is the identification and production of the right cultivar of a given species of vegetable for the market. For most of the species of TLVs, there are several cultivars, which differ in nutritional and organoleptic properties (Maundu *et al,* 1999). These differences also influence the acceptability of the different cultivars. It is therefore important to carry out a market survey and establish which cultivars are preferred in the different market segments. It is possible that one group of consumers sharing a common geographical or ethnic background may prefer one cultivar, while another group prefers the other.

For the export market, another challenge that may be likely have to be addressed is the quality criteria. Currently, there are no quality criteria for these vegetables which can be applied in export trade. Some of the criteria, such as pesticide residue levels may be borrowed from that applied to exotic vegetables. However, other criteria, such as the cultivar, leaf size and maturity have to be developed among the trading partners.

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Tissue Culture as a Novel Method of Introducing Resistance Genes to Fungal Pathogens in *Brassica* Crops

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Abstract

An assessment was made to investigate the incidence and severity of fungal pathogens of Brassica crops in Uasin Gishu district. The study indicates that most of the Brassica species that are grown have a high susceptibility to fungal pathogens and are responsible for a substantial amount of losses incurred in the farmers' fields. The assessment further indicates that Stem Canker (Black-leg) was the most prevalent fungal disease.

Intraspecific hybridization with *B. oleracea* and interspecific hybridization with resistant wild *B. rapa* species was used to introduce resistance genes in the susceptible cultivars towards the stem canker pathogen. Tissue culture and embryo rescue was used to improve the success of achieving the hybridization between the wild cultivars and the cultivated forms.

Introduction

Most of the Brassica crops grown in Kenya are utilized as vegetables. Kale (*B. oleracea* var. *acephala*) is the most popular leafy vegetable in most parts of Kenya as well as in several other parts of East Africa (Chweya, 1984). The kale crop is utilized by the majority of the population as green vegetables eaten along with the traditional "ugali". Cabbage is the next popular variety being used by a large group of people as a vegetable crop. The other *Brassica* species utilized in smaller quantities include cauliflower, broccoli, brussels sprouts, turnips etc. The use of rape as a source of cooking oil is minimal.

A range of fungal pathogens affects the cultivated Brassica crops. Some of the important pathogens that are responsible for losses incurred in these vegetable crops include clubroot caused by *Plasmodiophora brassicae*, Damping off and *Rhizoctonia* disease caused by *Rhizoctonia solani* Kuhn.; Leaf spot caused by *Alternaria brassicae* and *A. brassicola*; Downy mildew caused by *Peronospora parasitica* (Pers.) Fr.; White rust disease caused by *Albugo candida* (Lev.) Kunze.; Leaf spots caused by *Alternaria brassicola* (Schw.); Ring spot caused by *Mycosphaerella brassicola* (Fries ex. Duby) Lindau.; Black-leg or canker disease caused by *Letosphaeria maculans* (Desm.) Ces; *Yellows* disease caused by *Fusarium oxysporum* f. sp. c*onglutinans*.

The species of *B. rapa,* which includes the wild *Brassica* species, are known to posses resistance genes against most of these pathogens. Hybridization of these wild cultivars with the cultivated forms cannot be achieved easily due to incompatibility. Tissue culture and embryo rescue is used to improve the success of achieving the hybridization. This technique may overcome the self-incompatibility system and could increase the success rate of the interspecific crosses. The time when pollen is applied to the stigma of the emasculated bud may also influence the number of hybrids obtained. Olsson (1960) found pollen application immediately following emasculation resulted in a higher proportion of successful crosses than when applied 36 hours after emasculation. Eenink (1974) reported that a delay in pollination for a period of 25 to 96 hours resulted in an increased number of hybrid seeds set.

Objectives

The aim of the study was to introduce resistance genes to the most common and destructive fungal pathogen(s) on the popular cultivated *Brassica* species. This was done through intraspecific hybridization within *B. oleracea* and interspecific hybridization with the resistant wild *B. rapa* species (Sarat). In order to meet the above objective, it was necessary to assess the incidence and severity of the fungal pathogens.

Materials and Methods

Growth of the Parental Lines

Seeds were sown separately in small round plastic pots measuring 9-cm in diameter. One seed was placed in each pot in a peat/sand mixture (1:1 in proportion) amended with 20 g or 1 tablespoonful of diammonium phosphate. A moderate amount of water, enough to keep the growing medium moist was sprayed over the prepared pots. The seeds were sown and then left for germination to occur. At two-leaf stage, the plants intended for inoculation were used directly. The plants to be utilized in the crosses were transferred and re-potted in compost in plastic pots measuring 9 cm in diameter. Emasculation and pollination can be facilitated by growing plants in individual pots rather than in beds since plants can be moved as required. When the plants were about to flower, they were repotted in 18-cm diameter pots in fresh compost.

Isolation of the Pathogen

Diseased plants were collected from the field and then taken to the laboratory. After surface sterilization of the infected tissue with sodium hypochloride, the portion was cut out with sterilized instruments and then transferred onto PDA medium and malt extract in petri-plates. The inoculated media were then sealed and kept in an incubator at 20 ∓ 5˚C for the growth of the pathogen to occur.

Pathogenicity Test

Seedlings of all *Brassica* species raised separately in pots containing sterilized soil were inoculated with suspension of the pathogen prepared from sporulating growth on PDA medium. 1ml of the fungal suspension was injected into the rhizosphere of each seedling by means of a pipette. The pathogen suspension was injected into the rhizosphere of each seedling immediately after an overhead irrigation. 50 seedlings of each species were inoculated while another set of 50 seedlings was left un-inoculated to act as control. A replicate set of experiment was done in the laboratory by inoculating seedlings raised on PDA medium in petriplates. After inoculation, the seedlings were kept at room temperature and observation for symptom development was done from the third day after inoculation.

Disease Assessment

Seedlings at two leaves stage were transplanted from the nursery to the field experimental plots. The plots were prepared in a randomised complete block design. The field plot was divided into blocks each with four plots. The plots were subdivided into subplots measuring 6m x 17m, each with 280 plants, planted in 10 single rows, with a spacing of 60cm x 60cm. Each variety was planted into two plots. The assessment of the amount of disease on the crop was done from the fourth week after transplanting. Disease incidence and severity was assessed. Incidence of a fungal disease was recorded as either presence (+) or absence (-). Disease severity was

determined using six score categories, i.e., 0 = 0%, 1 = 1%, 2 = 5%, 3 = 10%, 4 = 25% and 5 > 50% plant area infected (Jones, 1987; Sutherland *et al*., 1996). Disease assessment was done at weekly intervals throughout the growing season.

Disease incidence and severity were assessed at the same time in each plot. The diseased plants in each case were recorded and the score category of each diseased plant was also recorded.

Crosses

As soon as the plants started flowering and ready for pollination, they were covered with perforated cellophane bags in order to isolate them from stray pollen. Prior to carrying out the pollination, the fingers were moistened with 70% ethanol to kill any stray pollen. Forceps and other pollination aides were also decontaminated to kill live pollen. The forceps were dipped in alcohol after use and allowed to dry before re-use.

In intraspecific crosses, partially resistant *B. oleracea* var. *capitata* L. and *B. oleracea* var. *acephala* were used in reciprocol crosses. The morphological characteristics such as the flower colour of the parental lines were noted since that would be useful in identifying hybrids. In interspecific crosses, the *B. oleracea* parent plant was used as the female parent in the crosses while the wild *B. rapa* species (Sarat) was used as the male parent. The anthers containing abundant pollen were taken from the male parent plant and dusted onto the mature stigma of the emasculated bud. Reciprocal crosses were not carried out because the *B. oleracea* parent plant had flowers that were easier to emasculate and furthermore flowers of the *B. rapa* species produced more pollen.

Emasculation

Buds were emasculated just prior to opening. During emasculation, all open flowers were removed from the inflorescence; thereby eliminating accidental self-pollination of emasculated flowers and preventing accidental harvest of self-pollinated seeds. The under-developed buds were left on the plant and emasculated when about to open. Anthers were removed with forceps and emasculating scissors, as described by Nieuwhof (1969). The six undehisced anthers were removed with forceps and discarded. The petals and sepals were left intact in the emasculated buds in order to protect the stigma. Emasculation was done mainly in the afternoons or evenings, the most favourable times (Downey, Klassen and Stringam, 1980).

Tissue Culture

Ovary culture:- Pods were removed from the plant 15 – 20 days after emasculation and transferred onto Nitch's media following surface sterilisation. Depending on their sizes, 3 – 5 pods were placed in each petri-plate and completely sealed to avoid any contamination. The plates were kept in an incubator at 20 ∓ 5 ˚C for 20 – 30 days.

Ovary rescue:- After a period of 20 – 30 days in the Nitch's media, the pods were removed from the incubator and the ovaries dissected longitudinally. Surviving embryos were extracted and transferred into petri-plates containing Gamborg's B5 media. Between 5 and 10 embryos were placed on each medium. The petri-plates were again kept in an incubator at 20 ∓ 5˚C. Once the embryos had germinated and the first leaves were initiated, they were transferred under sterile condition into fresh Gamborg's media in larger glass containers. At the stage when the young

seedlings had formed enough leaves and roots, they were transferred into sterilised soil in pots or utilised directly in laboratory based experiments.

Results and Discussion

Based on symptom development, several pathogens were observed in the field experimental plots and confirmed through isolation and microscopic observation. *Leptosphaeria maculans* was found to be the most prevalent pathogen. The highest percentage of plants was found to be infected by the pathogen. The characteristic symptoms comprises mainly death and drying up of tissues of the stem near the soil level and the hypocotyl region. Other pathogens identified in order of importance included *Pythium aphanidermatum, Sclerotium sclerotiorum, Alternaria brassicae* and *Erysiphe cruciferum*. Assessment of the prevalence of stem canker caused by *Leptosphaeria maculans* indicated that the most susceptible varieties were Collards (16.8%), Kale (10.7%) and Cabbage CM (9.1%). The varieties, which were less susceptible, included Cabbage-G.A. (8.4%), Drumhead (8.1%) and Cabbage-G.E. (6.5%).

Table 1. Severity of Stem Canker on different *Brassica* species.

Variety	No. of Plants	**Average Score Category**	**% Area Infected**
Cabbage-C.M.	30	4	25
Drumhead	47	3	10
Collards	22	5	50
Cabbage-G.E.	15	3	10
Kale-M.S.	17	5	50
Cabbage-G.A.	13	3	10

The results indicated that disease severity was high in *B. oleracea* L. ssp. *acephala* DC. (Kale and Collards). *B. oleracea* L.var. *capitata* L. (Drumhead, cabbage-G.E. and Cabbage-G.A.) were found to be fairly resistant.

Crosses and Tissue Culture

Many of the crosses were successful. Nearly 15% of the pollinated buds failed to develop mature pods. Up to 10% of the ovaries rescued and transferred into B5 media failed to develop in the culture media. There was variation in the number of embryos rescued within each cross. Many of the ovaries when dissected were found to have failed to form embryos. An average of 6 embryos was rescued from 100 ovaries (Table 2).

Table 2**. Efficiency of Ovary and Embryo Rescue in Interspecific Crosses between *B. rapa* species (Sarat) and the Cultivated *Brassica* species**

Crosses with	No. of Pollinations	Ovaries rescued	Embryos rescued	Ratios of Embryo/Ovaries rescued
Kale	172	110	12	0.11
Collards	115	100	4	0.04
1000-headed	140	121	8	0.06
Cabbage-GA	108	105	3	0.03
Cabbage-G.E.	136	125	5	0.04
Cabbage CM	125	115	6	0.05

Several studies have indicated that interspecific hybrids between *B. rapa* and *B. oleracea* are difficult to obtain when sexual crosses are used (Wojciechowski, 1985; Akbar, 1987b). Fertilization and the early stages of embryo development proceed normally in many interspecific crosses, however, due to some irregularities in the growth of the endosperm and the surrounding tissues, it can result in the death of the embryo (Raghavan, 1976). The failure of endosperm development has been attributed to abortion of interspecific hybrid embryos (Inomata, 1975; Wojciechowski, 1985). The use of *in vitro* embryo rescue culture technique here has helped to increase the survival rate of interspecific hybrids from crosses between *B. oleracea* and *B.rapa* species (Sarat).

The variation in the success of embryo culture in the different crosses indicates that the protocol may be more successful with some crosses than others. It may therefore become necessary to understand the main reasons for variation in order to deploy resistance genes effectively. This efficiency in the survival of the derived embryos may be influenced by the media used for the rescue as suggested by Brettel and Ingram, (1979). Such an understanding may be useful with other interspecific crosses. It could allow an easier and more efficient means of developing resistance from a diverse genepool. Harberd (1976) has shown that many cultivated and wild *Brassica* species can be hybridized with the aid of embryo culture and is possible to exploit the extensive reservoir of disease resistance characteristics in the wild *Brassica* species.

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Anticipated Promises and Problems for Snap Bean Seed Production in Kenya

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Abstract

The fresh snap bean production in Kenya is considerable in volume and value, but the seed production is limited. Most of the seed for sowing is imported. The current snap bean improvement programme at Moi University is described and the anticipated technical and marketing promises and problems for the production of breeder's and certified seed are discussed.

Keywords***: Kenya; Snap bean; seed production; breeding; marketing***

Introduction

Snap bean, also called French bean, fillet bean, string bean and haricot vert, is an important export crop of Kenya (van Rheenen, 2001). FAO (2002) gives the following production estimates (Table 1).

Table 1 Snap bean production in Kenya for the years 1997 – 2001

Year	Production (Mt)	Area (ha)	Yield (kg/ha)
1997	21,000	7,500	2,800
1998	23,000	8,000	2,875
1999	22,000	7,800	2,820
2000	21,000	7,500	2,800
2001	21,000	7,500	2,800

Source: FAO (2002)

Ngugi *et al.* (1990) give higher yield estimates than the tabulated ones. They estimate yields of three-quarter developed pods at 8000 kg/ha.

The Horticultural Crops Development Authority (2001) recorded the export volume and value of snap beans as shown in Table 2.

Table 2: Export volume and value of snap beans from Kenya for the years 1996 – 2000

Year	Volume (Mt)	Value (*K.Sh.* x 10^6)
1996	11,722	891
1997	11,569	1,334
1998	10,829	1,343
1999	15,041	2,241
2000	14,834	1,856

Source: HorticulturalCrops Development Authority (2001)

During 1998 Kenya earned *K.Sh.*14 billion from horticulture with fresh horticultural produce earning *K.Sh.*7 billion (Daily Nation, 1999). Comparing this amount with the value presented in Table 2, it appears that snap bean export takes 19.2 percent of the fresh produce earning. It is further noted that the difference between production and export, being 23,000 – 10,829 = 12,171 Mt, is large. Apparently, a considerable portion of the snap bean production is not exported as fresh produce, but is possibly consumed locally (Saturday Nation, 2002) or canned (Daily Nation, 2001c). The snap bean farming business is potentially lucrative, but may face severe marketing problems (Daily Nation, 2000). It was observed that most seeds for sowing snap beans are imported and that the price of such seed is high; a figure of *K.Sh.* 900 was quoted (van Rheenen, 2001). One seed producing company of locally grown seed estimated his production and sales at 27 Mt. The seed was sold at *K.Sh.*210. One of the varieties is Monel. If the seed rate is taken at 60 kg per ha (East African Seed Co. Ltd., Growers Guide), the seed quantity would sow 450 ha. It is noted that the total area under snap beans in Kenya is about 7,500 ha. Another seed company reported that it had discontinued local production of Monel seed as the demand had gone down considerably. New varieties were still under commercial trials. Considering the information that current locally produced varieties such as Monel are old and that their demand is decreasing, it seems advisable to breed new varieties that meet the standards for export and have desired traits of stable and high yield potential.

The present paper looks at promises and problems in producing breeder seed and certified seed and pays attention to marketing aspects of such seed.

Snap bean seed production

Breeding aspects

In view of the situation that the locally produced varieties such as Monel have been in the market for a long time and are loosing appeal, and because seed of imported varieties is expensive, it was decided to start a crop improvement programme for snap bean at Moi University, Eldoret in 1998.

The objectives of the programme were to improve current varieties in respect of:

- Yield stability
- Yield potential
- Product quality

Materials and methods

To achieve the above objectives, crosses were made during 1998/99 between four parents (CPST-B: 8, 34, 39 and 40) that were selected for traits listed above. The crosses were advanced following a bulk population and pedigree-breeding programme as depicted in Fig. 1.

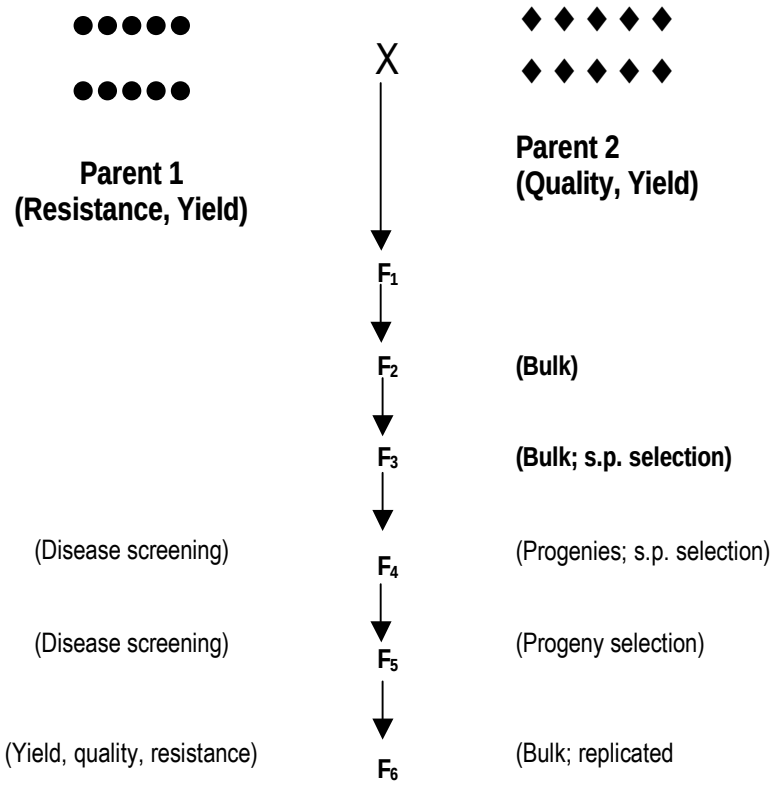

Fig 1: Snap bean breeding scheme at Moi University, 1998 – 2002

The breeding programme reached the end of the F_5-stage by June 2002 and the progenies were visually evaluated for the traits listed earlier.

The pod characteristics are naturally of all-importance. A panel of 16 evaluators assessed a number of breeding lines on such traits during the second half of June 2002 in comparison with a control. The assessment was on colour, shape, length, and cross-section while an overall appraisal was also given (Raymond, 1999). The visual evaluation was based on a scale of 1 to 5, where 1 = poorest, and 5 = best. There were 17 samples. The results of the overall observations are shown in Table 3.

Results

Table 3: Mean overall assessment of pod quality of 15 breeding lines and two control snap bean varieties by 16 panellists. The scoring was on a scale of 1 (poorest) to 5 (best)

Entry	Score	
	Mean1)	Standard Deviation
1 (control)	2.88 ef	0.78
2 (control)	2.79 f	0.92
3	3.58 abc	0.85
4	2.98 def	0.73
5	3.70 ab	0.82
6	3.57 abc	1.08
7	3.97 a	0.68
8	3.82 ab	0.73
9	2.76 f	0.59
10	3.35bcde	0.60
11	3.35bcde	0.93
12	3.55 abc	0.62
13	3.32bcde	0.93
14	3.15cdef	0.52
15	3.49 abc	0.97
16	3.44 bcd	0.55
17	2.88 ef	0.78

Means with a common letter don't differ significantly

Apparently, encouraging significant differences were observed between breeding lines and controls. However, the quality assessors were not always in agreement. This was clear from the correlation analysis of their scores. In Table 4 the correlation coefficients are shown for the evaluators, selecting experienced number 13 as standard.

Table 14: Correlation coefficients for scores from 16 evaluators, taking number 13 as standard. The asterisk shows significance at the P = 0.05 level

Evaluator number	Correlation Coefficient
1	0.44
2	0.17
3	- 0.07
4	0.55*
5	0.27
6	0.17
7	-0.13
8	0.07
9	-0.17
10	0.01
11	0.14
12	1.00
13	0.11
14	0.27
15	0.41
16	0.04

Apparently evaluators differed in their assessment as their scores showed a lack of significant correlation.

Discussion

These discrepancies pose a problem that has to be given due attention

Disease screening is to be done from July 2002. The control variety showed symptoms of rust, anthracnose and possibly bean common mosaic. Replicated, small-scale trials are being planned for the last quarter of 2002. Weather conditions will determine whether this will be successful.

The promises of the programme are that the objectives will be achieved and that one or more outstanding varieties will be obtained.

Problems so far experienced were of expected nature: Weather conditions were regularly adverse; disease spread in the field was not always optimal. Problems anticipated are those that may be experienced when multilocational experiments will be conducted during the coming years and when selected lines will be tested for distinctness, uniformity and stability. They need to be entered in National Performance Trials. However, during a workshop on sustainable horticulture at Jomo Kenyatta University of Agriculture and Technology in 2001, it was noted that Kenya Agricultural Research Institute (KARI) and Kenya Plant Health Inspection Services (KEPHIS) don't have an operational variety testing and release programme for beans. This may obstruct variety release. A promising development is that in the current review of the Seed and Plant varieties Act of 1991 a Plant Breeders Rights Office is proposed to be established. This may promote variety testing and release procedures. Once one or more outstanding selections have been accepted for release, problems of good maintenance have to be faced, but commonly adopted practices will be followed (Fehr, 1987; Drijfhout, 1982). Subsequently promises and problems of demand and marketing will be experienced, as will be discussed in the next section.

Marketing aspects

Success in marketing the seed will depend on the demand from bean growers and that in turn will depend on consumer markets. The local fresh snap bean consumption will probably be limited in quantity. The fresh produce market seems to be promising if proper storage, packing and transport facilities are available or constructed. Already such facilities exist with Kenya-based foreign companies such as Homegrown, which has modern processing, storage and transportation facilities. The Horticultural Crops Development Authority (HCDA) attempts to collect and ferry snap beans from farmers in Mwea. It was reported that a *K.Sh.*170 million horticultural depot was

constructed in Kirinyaga which was expected to boost snap bean production (Daily Nation, 2001a and b). It was further confirmed that a multi-million snap bean and coffee farming project was to be funded in Machakos, aiming at a weekly export of snap beans of 100 tons (Daily Nation, 2002). A major player in the snap bean industry is the Fresh Produce and Exporter Association of Kenya (FPEAK) which avails overseas market prices for member bean farmers.

If facilities as described are not available, there will be the option of canning. Involved in canning are several companies such as Kenya Orchards Ltd., Trufoods Ltd., Premier Foods Co. in Nairobi and Njoro; and Kabazi Canners in Nakuru. If the fresh snap bean production is sizeable, the seed demand will follow suit, as on-farm seed production is limited to approximately 5 %.

If a company links fresh produce export with input supplies, including seed for sowing, a problem may arise for the breeder who wishes to promote her or his variety independently. How to overcome such obstacle is a question that requires transparent discussion.

All in all, noting the progress so far made and considering the above observations, there seem to be promising signs for snap bean variety improvement and seed production. It is suggested that stakeholders in snap bean variety development and release; and in seed distribution and produce marketing establish a forum for discussion of issues related to the aspects mentioned.

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Pests of *Amaranthus* spp. and Their Effects on the Consumer

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Abstract

Knowledge of control measures for important disease and insect pests is essential to successful vegetable growing. Both diseases and insects are becoming more serious owing to the concentration of vegetable crops in the most favourable areas for production. New pests appear from time to time because of changes in cultural practices which may then favour their development to injurious proportions or they may be introduced from other areas. This paper highlights the prevalence of insect pests associated with Amaranths (*Amaranthus spp).* The thick, succulent stems of Spinach Amaranths, with much lower protein and dry matter contents than the leaves, are very susceptible to rots caused by *Pythium aphanidermatum* from the soil and *Choanephora cucurbitacea* rum on cut portions of the stems, when harvesting is staggered.

The two pests cause losses to Amaranthus growers. The exact damage estimates have not been established because there are so many factors involved. In some cases these pests greatly reduce the expected yield so that the price goes up because of the short supply. Damage estimates calculated on the basis of this high price are misleading since the price would not have been so high if damage had not occurred. While the grower applies the control measures, the ultimate consumer pays for the cost of disease and insect control. Control measures greatly increase the cost of production of vegetables, and for some crops, disease and insect control is one of the largest items in the cost of production.

P. aphanidermatum and *C. cucurbitacea* greatly lower the quality of the *Amaranthus spp*. Excessive damage lowers the market grade and price may even result in rejection of the vegetable by market buyers. The presence of insect fragments or certain plant diseases may result in siezure of processed vegetables by health authorities. Insects and diseases continue to damage vegetables through marketing and handling processes and even in the consumer's home. With all these factors considered, some suggestions have been given on pests associated with *Amaranthus spp*. and establishment of possible control measures against these pests.

Introduction

Use and Nutritional Composition

Amaranths spp. are important dietary components and are easier to grow. Research also indicates that these vegetables have high nutritive value (Imbamba 1973). The mineral and vitamin contents supersedes that found in popular exotic vegetables like cabbage, lettuce and cucumber. The nutritional content of the leaves of various species of amaranths varies but, in general the leaves of plants of most species contain a high level of vitamin A, calcium and potassium. Table 1 gives an

indication of the average nutritional value of various species of *Amaranthus*; the nutritional contents of the leaves of several species of *Amaranthus* have also been reported by Grubben (1976). The seeds of *Amaranthus* species are used as a food in some tropical areas and a protein content of upto 15% has been reported. High contents of lysine (6.2%) of the total protein and methionine (2.3%) have been recorded.

Cultural Requirements

Most species and cultivars of *Amaranthus* grow rapidly and may be harvested 30 - 50 days from sowing when they are 15 - 20 cm high. Either the whole plant may be uprooted, or established plants may be cut back to within 15 cm of the base to encourage lateral growths, which will provide successive harvests.

Seeds, which are often mixed with dry sand to ensure uniform distribution are normally sown broadcast on prepared beds at a rate of 3 - 10g/m (1.5 - 2Kg/ha) Martin and Telek, (1979). They may also be sown on nursery beds and the seedlings transplanted to rows 20 - 30 cm apart, 10 - 15 cm between plants. Very vigorous species or cultivars may be transplanted to 30 - 40 cm x 30 - 40 cm square spacing. Broadcast sown seedlings may also be thinned to 15 - 22cm apart each ways or at more liberal spacings if they have branching habit (Choudhury, 1977). A grass mulch is sometimes used for covering freshly sown seeds to protect them from heavy rain. This mulch may be removed when the seeds have germinated.

Pests and Diseases

In a family garden, parasites are generally of little importance, because there is usually a wide variety of more or less hardy plants being grown at one time. In single crop farming (commercial vegetable growing) a large area is planted with one type of vegetable and damage caused by disease and insects become more serious. The most common diseases of *Amarantheceae* are *Pythium aphanidermatum* (Damping-off) and *Choanephora cucurbitacoarum* (leaf and stem wet rot).

Pythium spp. attack the vegetables from the soil and stay in the soil after the vegetables are harvested. They together with mineral deficiency aggravate soil exhaustion. This results in lower yields, especially after several years of cultivation. The young *Amaranthus* plants die shortly after germination. Rotting seeds, roots and stems, especially at the base, are noticeable.

The seedlings appear water-soaked at ground level and topple over often with the leaves still green. Under conditions favouring the disease such as high humidity and overcrowding of plants it spreads rapidly in widening circles.

Control:

Ensuring a good start by using quality seed planting material, planting under optimum conditions for rapid growth avoiding overcrowding and overwatering of plants and Soil disinfection.

C. cucurbitacea rum (leaf and stem wet rot). This is the principal disease of *Amaranthus*. The disease is a saprophytic mould. The soft rot of leaves and young stems is covered with grey sporangiophores with black heads. Young or weak plants may die, older plants may recover and produce secondary shoots. Yields may be halved and this is sometimes allowed for by close planting. The disease is most prevalent in hot, humid weather and attacks the weaker plants, particularly those damaged by insects.

Control:

Promoting vigorous growth and growing less sensitive cultivars.

Table 1: REPRESENATIVE VALUES FOR NUTRIENTS OF AMARANTHACEAE, PER 100g OF EDIBLE PORTION

Botanical name (Common name)	Parts of Plant	Water (ml)	Calories	Protein (g)	Fat (g)	Carbohydrate (g)	Fibre (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	β-carotene	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)
Amaranthus spp. (Amaranth, African Spinach)	Leaves	85	48	5.0	0.7	5	1.5	250		4.0	1800	0.10	0.30	1.5	100
	Leaves	85	42	4.6	0.2	8	1.8	410	103	8.9	5716	0.05	0.42	1.2	64
	Leaves	85	43	4.4	0.4	5	1.3	230	55	5.0					
	Leaves	85	26	3.6	0.1	4		154	74	2.9	6545	0.04	0.22	0.7	23
Celosia argentea (Cock's Comb, Sokoyokoto)	Leaves	84	44	4.7	0.7	8	1.8	260	43	7.8					
Celosia trigyna (Silver Spinach)	Leaves	89	33	2.7	0.4	6	1.2	154	32	5.0	1925		0.10		10

Adapted from: FAO (1972)

Amaranthaceae

TABLE 2: PESTS AND DISEASES OF AMARANTHACEAE

PESTS	African Spinach	Cock's Comb	DISEASES	African Spinach	Cock's Comb
Aspavia armigera (Stink Bug)	X	X	*Albugo blitii* (Powdery Mildew, White Rust)		X
Baris planetes		X	*Cercospora beticola Saccardo* (Leaf Spot)		X
Cletus capensis		X	*Cercospora brachiata* Ell. And Ev. (Leaf Spot)		X
Cletus fuscescens	X	X	*Choanephora cucurbitarum* (Berk, and Rav. Thaxt. (Leaf and Stem Wet Rot)		X
Gasteroclisus rhomboidalis	X	X	*Cladosporium variabile* (Cke) de Vries (Leaf Spot)		X
Gryllotalpa gryllotalpa L. (African Mole Cricket)		X	*Pythium aphanidermatum* (Eds.) Fitzp (Damping-off)		X
Hymenia recurvalis F. (Leaf Caterpillar, Beet Webworm)	X	X	*Thanatephorus cucumeris* (Frank) Donk (= *Rhizoctonia solani* Kuhn.) (Damping-off)		X
Lixus trunculatus F. (Stem Borer)		X			
Meloidogyne spp. (Root-knot Nematodes)		X			
Piesma dilutus		X			
Psara bipunctalis	X	X			
Psara pallidalis		X			
Spodoptera littoralis (Boisd.) (=*Prodenia litura* (F.)) (Cotton Leafworm, Cutworm)		X			
Sylepta derogata (F.) (Cotton Leaf Roller)		X			
Zonocerus variegatus L. (Variegated or Stink Locust)		X			

Pests and Disease Management

The production of high quality horticultural produce entails adequate crops protection throughout the growing stage as well as between harvest and before consumption or processing. Based on the opinion of different authors, pests and diseases of *Amaranthus* are controlled by use of

sanitation measures such as collection and destruction of affected leaves and shoots, discouraging of inter-planting in affected vegetable gardens with mature plants.

The use of pesticides of low toxicity ratings is also recommended in controlling pests of *Amaranthus spp*. The farmers are not expected to exceed maximum residue levels (MRLs) on fresh vegetables if the recommended pre-harvest intervals of these pesticides of low or no residues on the fresh vegetables will enable the farmers to sell their produce to the international market.

Nevertheless, the use of chemical plant protection agents is steadily increasing in the tropics and there is a risk that the environment will become even more polluted. This fear is particularly justified in the case of residues which break down very slowly, such as those from preparations of DDT, although such substances are still widely used (CIAT 1987). In addition, a boost is being given to the selection of resistant harmful organisms which do not undergo diapause in the tropics. The natural biological equilibrium which is frequently very unstable is being irreparably damaged.

Environmentally compatible horticultural production is nevertheless possible and the use of chemical agents (fungicides, pesticides, herbicides) can be reduced by adopting the following procedures.

- Cultivating resistant varieties with perhaps varying degrees of resistance. It is very rarely possible to attain immunity. Other forms of specific (vertical) resistance, using multiline cultivars, can at best prevent epidemics of very dangerous leaf diseases (mycoses). Varieties having different resistance genes are cultivated as artificial populations. Field resistant varieties possess a non-specific (horizontal) resistance. They tolerate harmful organisms which do not cause any serious damage and cannot propagate in epidemic fashion.
- Cultivate different crops (species diversity) in mixed croppings. Small areas each containing one species should be sown separately (patch carpet system), more or less regularly alternating with one another in the field or in a crop rotation system (temporal and spatial diversity).
- Preservation of natural ecosystems.

Conclusion

While chemical use may not be abandoned there is need to incorporate other control strategies which can help also reduce the pesticide application, minimize resistance build up and reduce dangers to the farmers during pesticide application in the field. Reliance on one chemical by the farmer to control the pests for the whole season could result in resistance build up by the pests and thus it is necessary to inform farmers of these dangers and how they can overcome them.

It is necessary to make farmers aware of the actual losses caused by each pest and the effectiveness offered by the other control strategies. There's also need for researchers to collaborate with farmers and come up with control thresholds of each pest as this will enable the farmer to understand safe use and appropriate pesticide handling and application procedures.

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Osmotic Adjustment and Plant Growth of Spiderplant (*Gyandropsis gynandra* (L.) Briq) and African Nightshade (*Solanum vilosum* Miller) under Water-Limited Conditions

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Abstract

In a greenhouse study the osmotic adjustment and plant growth of landrace and commercial types of spiderplant (*Gynandropsis gynandra* (L.) Briq) and African nightshade (*Solanum vilosum* Miller) under water-limited conditions were investigated. The fraction of transpirable soil water (FTSW) was used as an indicator of stress. Both spiderplant and African nightshade showed an osmotic adjustment of about 0.1 MPa at the highest drought stress (FTSW = 0) with no significant genotypic differences. Drought significantly reduced plant height and number of leaves after FTSW fell below 0.60 for both spiderplant and African nightshade, which corresponded to a drop in soil moisture to below 60% field capacity. Increase in plant dry weight declined below about 0.50 and 0.40 for spiderplant and African nightshade, respectively. It is concluded that in both crop species, osmotic adjustment is not a major mechanism for adaptation to drought. Plant height and leaf number were relatively more sensitive to drought as compared to dry matter production and also in both crop species, there were no significant genotypic differences in the process studied. For higher leaf yields, the soil moisture should be kept above 60% field capacity.

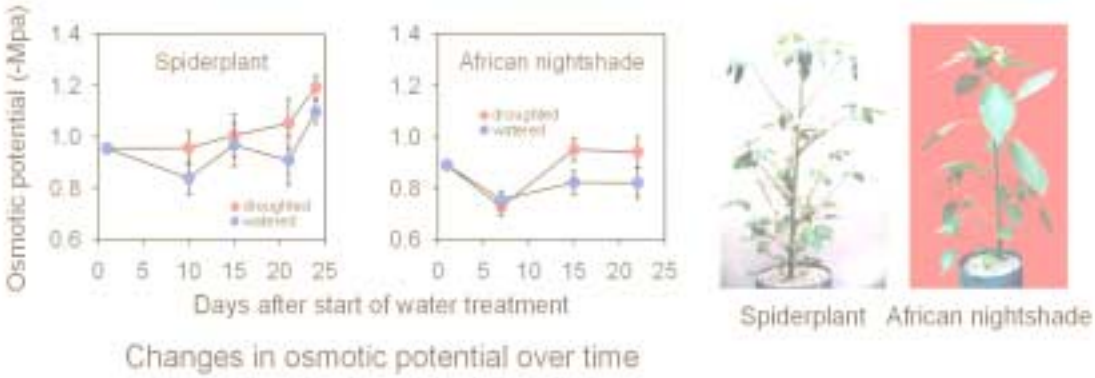
Introduction

Spiderplant (Gynandropsis gynandra) and African nightshade (Solanum vilosum M iller) are two important traditional leafy vegetables grown and consumed in Kenya. Little has been reported on their adaptation to drought with respect to osmotic adjustment (OA) and plant growth. These two processes are known to be sensitive to available soil water.

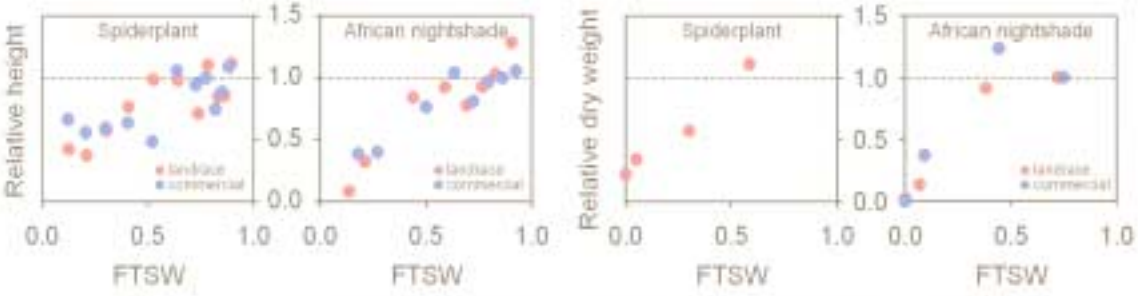
Materials and Methods

In a pot experiment, the OA (expressed as difference in osmotic potential at full turgor between stressed and non stressed plants) and plant dry weight of two genotypes (landrace and commercial) for each crop species was determined under droughted and watered conditions at five dates. Fraction of transpirable soil water (FTSW) was determined by daily pot weight changes while plant height was determined at two days interval from onset of stress.

Results



Changes in osmotic potential over time



Relative plant height and dry weight as functions of FTSW

Conclusions

In both species, OA was about 0.1 at the highest stress level, suggesting that it was not a major mechanisms of drought adaptation. Plant height increase began to decline at higher FTSW values as compared to dry matter production, thus appearing to be more sensitive to drought in both species. There were no significant differences in the OA and plant growth responses to drought between the genotypes tested for both species.

Impact of Root-Knot Nematodes on Efficient Water and Nutrient Use in Vegetable Production in the Tropics

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Introduction

Vegetables are an extremely important component of the diet in the tropics as they are rich in proteins, vitamins, minerals and fibres. In addition, they are a high value cash crop for both small and large-scale farmers. The demand for and production of vegetables is expanding rapidly with large amounts of land near urban centres being devoted to vegetable production. In 1981-1985, for example, vegetable production increased by >18%.

Pests and pathogens, unavailability of water and low soil fertility are among the major constraints to vegetable production in the tropics (Bafokuzara, 1978). The impact of these constraints is further aggravated by pathogen and pest infections. Among the pests are the plant parasitic nematodes

that affect the functioning of the roots. Of this, root-knot nematodes (*Meloidogyne* spp.) are the most important, with nearly all vegetables having been reported as hosts to root-knot nematodes. Some vegetables are infected by more than one species of the nematode. Vegetable crop losses associated with root-knot nematodes in the tropics range from 17-20% for egg plants, 18-33% for melon, 36% for okra 24-38% for tomato and up to 33% for spinach (Waceke and Waudo, 1993; Waudo and Mbugua, 1987; Bafokuzara, 1978).

Importance of root-knot nematodes in vegetables in the tropics

Root-knot nematodes (*Meloidogyne* spp.) are obligate sedentary endoparasites. They survive in weed hosts or as eggs in egg masses or in a state of anhydrobiosis under dry conditions. The females exhibit sexual dimorphism; initially being vermiform and becoming spherical, pear or lemon shaped on maturation. The males are vermiform throughout their life cycle. The second stage juvenile (J-2) is vermiform and is the infective stage of the nematode.

Root-knot nematodes are major pests in vegetable production in the tropics mainly because of the warm humid tropical climate that allows for more rapid development of degree-day dependent life-stages. This ultimately increases the number of reproductive cycles and nematode population. Optimum temperatures for nematode development corresponds to those found in tropical vegetable growing regions (25-34C), a factor that insures serious root-knot infestations. Root-knot nematodes increase to damaging levels within a few seasons under a susceptible vegetable crop and in the tropics they are taken to represent 'nematodes' in general. In addition to favorable tropical climate, farmers in the tropics have fewer chemical control options or lack the financial resource to purchase the chemicals. The presence of biotypes within *Meloidogyne* populations causes a breakdown of resistance and this poses a major challenge to the use of resistant varieties. Furthermore, the lack of natural nematode checks such as winter or fallow periods allows high nematode populations to be maintained once established. The long growing seasons and the practice of continuous and intensive monoculture further increase nematode pressure on vegetable production systems in the tropics. The polyphagus nature of the root-knot nematodes also contributes to their importance in the tropics.

Although there are > 50 species of root-knot nematodes worldwide, only four species are most important to vegetable production in the tropics; *Meloidogyne arenaria, M. incognita, M. javanica* and *M. hapla*. Out of 1000 root-knot populations collected in 75 countries in the tropics, for example, 53, 30, 8, 8, and 2% were *M. incognita, M. javanica, M. arenaria, M. hapla* and other species, respectively (Luc *et al*., 1990). The first 3 are more common in warm, humid areas where the average temperature is <36C. *Meloidogyne javanica*, however, prevails in extreme moisture conditions (wet and dry). *Meloidogyne hapla* is limited to the upland tropics and has temperature optima of 5C lower than for the other 3 species. The nematode is limited to the regions with average temperature of <27C in the warmest month (Luc *et al*., 1990).

The nematodes also interact synergistically with other important vegetable pathogens to form disease complexes that result in relatively higher vegetable damages and yield losses resulting from combined pathogenicity and an accentuated degree of pathogenicity (Luc *et al*., 1990). For example, root-knot nematodes caused the loss of resistance to *Fusarium oxysporum* f. sp. lycopersici in tomato. *Meloidogyne incognita* and *M. hapla* caused an earlier development and appearance of symptoms and an increase in disease severity on tomatoes infected by a wilt bacterium (*Ralstonia solanacearum*). Damage by root-knot nematodes increased disease severity by *Rhizoctonia solani* (a root rot pathogen) and *Corynebacterium michiganense* (a bacterial canker pathogen) on various vegetables crops. Root-knot nematode infection also predisposes plants to weak pathogens and secondary invaders further affecting the proper functioning of roots.

Besides, root-knot nematodes galls also disfigure and reduce the market value of vegetables especially root and tuber vegetables.

Symptoms of damage

The presence of galls on the root system is the primary symptom associated with *Meloidogyne* spp. infection. Root-knot nematodes damage plants by devitalizing root tips and retarding or stopping their growth during the penetration and intra and/or intercellular migration of the J-2 through the cortex of the cells. The nematode become and establishes a feeding site in the xylem plerome where it secretes plant growth regulators or induces the host plant to produce them. The growth regulators induce hypertrophy and hyperplassia, inhibits cell elongation, differentiation, lignification and cytokinesis. These metabolic changes result in development of coenocytic giant cells that serve as feeding sites for the nematodes. The presence of syncytia and nematodes within the differentiating parenchyma cells interfere with the formation of xylem elements or may crush the existing ones resulting in the malformation and retardation of the vascular bundles. Water transportation and mineral translocation through the poorly formed vessels are impaired. The syncytia serve as nutrient sinks thus depriving plants of nutrients and water. Infection of seedlings in seedbeds lead to total loss and those that survive cannot survive transplanting.

Effect on water and mineral uptake and use

Nematode invasion damages the epidermis, cortex, and /or stellar elements and causes anatomical changes, alters water absorption and transport thus leading to wilting. Nematode feeding and intra root migration destroys root tissue and alter root growth hence host water relations. Besides, growth inhibition of root-tips by the nematodes interferes with cytokinin and gibberellin production. This interference coupled with mobilization of the same to the developing giant cells further decreases the amounts available for utilization by the plants. Nematodes therefore, alter nutrient flow patterns in the plant tissues and retard growth. Physical interruption of the transpiration stream by the nematodes due to their physical presence may result in embolism and resultant dysfunction of the affected vascular system. The presence of galls in nematode-infected plants, the reduction of number of roots and rootlets and the presence of the nematodes in the plant's vascular bundles seriously hamper uptake and transportation of water and nutrients thereby leading to growth retardation, stunting, chlorosis, wilting and poor yields. These non - specific symptoms of nematode infection are therefore a result of the host's inability to maintain water status sufficient for optimal growth. The reduced ability of infected root system to take up water and nutrients impacts heavily on the efficient use of available water and soil nutrients by the plants.

Root-knot nematodes infections affect water and fertilizer efficient use through their reduction on leaf water potential, leaf/stomatal conductance, transpiration and root conductivity (Meon *et al*., 1978). The magnitude of the leaf water potential reduction depends on the host variety, the initial nematode population density and the length of time the host has been infected by the nematode. The reduction is greatest late in the growing season but can be exhibited as early as 1 week with high nematode densities. Direct effect of nematodes on leaf water potentials is via the disruption of vascular system or membrane damage. Indirectly, the progressive death of nematode-infected roots and the consequent involvement of the secondary pathogens are responsible for reduced water potential most apparent in the season. Root-knot nematodes greatly reduce the flow of water through plant roots and consequently lower leaf water potentials and leaf conductance.

Stomatal conductance decreases over time both in healthy and in infected plants. The conductance decreases faster and is consistently lower in infected than in uninfected plants. In

healthy tomato plants, for example, conductance ranged from 0.16 to 0.6sec/cm over 8 weeks whereas in tomato plants infected with 6000 J2 the range was from 0.11 to 0.25sec/cm. Tobacco infected by either *M. hapla* and *M. incognita* exhibited decreased transpiration and visible wilting 8 weeks after infection. Transpiration is dependent on the stomatal aperture, which in turn is related to diffusive resistance.

The damage on root cell membrane by root-knot nematodes contributes significantly to the reduced root conductivity. Reduction in water uptake affects the physiological functions of the plant. The physiological effects of decreased water availability include inhibition of leaf expansion, reduced photosynthetic rates, partitioning of carbohydrates among plant organs and decreased nutrient uptake and translocation of solutes. Reduced photosynthetic rate is due to reduction in leaf area, closure of stomata, decreased efficiency of carbon fixation and decreased chloroplast activity. Other effects of decreased water availability include decomposition of proteins and nucleic acids, increased levels of hydrolytic enzymes and reduced phytohormone production and translocation. The proportion of starch to sugar is often reduced because of greater hydrolysis of the starch. (Meon *et al*; 1978; Wilcox and Loria, 1986). Shoot growth is also reduced more than root growth thus increasing the root/shoot ratios The plants loss turgor, wilt and eventually part or the whole plant dies.

Normal plant growth requires an optimum balance of nutrient elements together with their normal uptake and distribution within the plant. Root deformation by nematodes directly diminishes absorption and nutrient elements resulting in an inadequate supply to the plants. This also limits uptake of the applied fertilizers and therefore their efficient use by the plants.

Conclusions

- Root knot nematode infection affects the functioning of roots and therefore affects water and fertilizer uptake and use by the plants. Nematode management would therefore increase the efficiency of water and fertilizer use by the plants.
- Controlling the nematodes would also minimize the effects of the opportunistic pathogens and pests which also affect the functioning of roots.
- In considering the factors that affect water and fertilizer use by the plants, the impact of root-knot nematodes and other root pathogens should not be ignored, otherwise the efforts will be counter productive.

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Cabbage Yield Loss Assessment from Diamondback Moth (*Plutella xylostella* L.)

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Abstract

The study was conducted to evaluate the yield loss caused by Diamondback moth (DBM) and to determine the efficacy of pesticides. The assessment involved experimental and secondary data. Three different pesticides and a control were used for comparison, in control of DBM in two different varieties of cabbage, at two different sites (Wundanyi, Taita Taveta district and Limuru, Kiambu district. The monitoring and scouting system, in which spraying was done after every fortnight was based on a threshold level of two DBM. The information monitored included, population density of different pests, crop yields and overall production costs in different treatments. In general it was found out that thuricide and neemroc gave a better result than karate and control. Karate had a higher DBM density than even control in these two varieties A negative correlation was obtained between yields and density of different pests in different treatments meaning that as pest density increased, cabbage yield decreased To substantiate data, farmers' and researchers (subjective) estimates of losses and the incidence of infestation were used for estimation. The yield loss was estimated to be 22-32%, amounting to 158 -23 tons per hectare with an estimated value of Ksh 158,000- 230,000 per hectare.

OFFICIAL CLOSING SPEECH

CLOSING REMARKS BY PROF. S. K. SINEI DURING THE CLOSING CEREMONY OF THE 2ND SEMINAR ON SUSTAINABLE HORTICUL TURE IN THE TROPICS ON 7TH AUGUST 2002

Deputy Vice Chancellor (APD), Prof. Agong

Chairman, Department of Horticulture, Dr. Ndung'u

Course Participants

Invited Guests

Ladies and Gentlemen

It gives me great pleasure to be with you this evening during the official closing ceremony of the 2nd Workshop on Sustainable Horticulture Production in the Tropics.

I note that the workshop covers 4 days; 6th - 9th August 2002 and that you have already covered the scientific papers, and poster presentations and the remaining two days will be spent in excursion in Machakos District. There are about 40 scientists drawn from universities and research institutions in Kenya and Tanzania and three professionals from the University of Hannover, Germany. This is an extension program supported by DAAD.

Having looked at the Workshop program, I observed that the topics covered are mainly in four areas i.e.

- Biotechnology
- Water and Nutrients Management
- African Indigenous Vegetables
- Crop Protection

All the areas are of critical importance particularly to the small-scale farmers whose land acreage dwindles with every subsequent generation. Thus while the population keeps increasing, the land available for crop production becomes less and less.

It is therefore a challenge for a farmer to be able to feed his/her family and at the same time have produce to sell to generate income for other essential services like school fees and for medical use.

The outcome of deliberations from a seminar of this nature must be measured in terms of applicability of the scientific knowledge so gained to the alleviation of poverty and improvement of quality of life of the African people particularly the rural areas where majority of our people live.

The people out there are yearning for scientific knowledge and the incorporation of a very strong and efficient extension services to whatever scientific program is of great importance if you have to make an impact so that this does not just become an academic exercise.

Ladies and Gentlemen, as you proceed with the remaining part of the program, I wish you success and I believe that farmers are going to benefit from the recommendations of your proceedings. Before I conclude, may I take this opportunity to thank DAAD for sponsoring the Workshop and for all the participants particularly our visitors from Germany and Tanzania for coming to participate in this Workshop to make it the success it has become.

With this few remarks, I now declare this Workshop officially closed.

PROGRAMME

DAY 1: TUESDAY, AUGUST 6TH 2002

8:00 - 10:00 AM	**REGISTRATION AND POSTER PLACEMENT**
9:30 - 10:00 AM	TEA
10:00 - 11:00 PM	OFFICIAL OPENING, Chairman: Prof. S.G. Agong Welcome addresses From the organizers: Prof. Dr. S.G. Agong, JKUAT Prof. Dr. H. Stuetzel, University of Hannover, Germany From the hosts: Dr. C.K. Ndung'u, Chairman, Department of Horticulture, JKUAT Prof. Dr. F. Lenga, Dean, Faculty of Agriculture, JKUAT Keynote address Dr. C. Etzold, Regional Director, DAAD (German Academic Exchange Service)
11:00 - 12:30 PM	**SESSION 1: BIOTECHNOLOGY**

Chairperson: Dr. V. W. Ngumi / Prof. S.G. Agong
Rapporteur: Hunja Murage

RAPD Profiling of Some Banana (*Musa* spp.) Varieties Selected by Small scale Farmers in Kenya
E. M. Kahangi

Micropropagation of Disease-Free Planting of Passion Fruit (*Passiflora edulis* Sims)
L. Gitonga

Bulblet Production from Bulbs of *Ornithogalum saundersiae* Bak
W. Kariuki

Biotechnology vs Organic Farming in Kenya
J. W. Njoroge

12:30 - 1:30 PM LUNCH

1:30 - 3:00 PM SESSION 2: WATER AND NUTRIENT USE EFFICIENCY

Chairperson: Prof. Dr. H. Stuetzel
Rapporteur: Mr. G. Mwago

Effect of Lime and Fertilizer Application on Growth and Production of Selected Common Bean (*Phaseolus vulgaris*, L) Cultivars on an Acid Soil in Uasin Gishu District Kenya
E. J. Too, A.O Onkware and S. Gudu

Drip Irrigation Frequency and Mulching Types Influence Yield and Quality of Greenhouse Grown Fresh Market Tomato ('Money Maker')
G.M. Kere

Improving Nitrogen Supply to Common Bean through Inoculation with Local *Rhizobium* Isolates
A.O. Onkware, S. Gudu, E.J. Too and J.R. Chemwetich

Efficient Water and Nutrient Use in Horticultural Production in the Tropics
E. Bujulu

3:00 - 3:30 PM	POSTER SESSION with Tea Break
3:30 - 4:30 PM	HORTICULTURAL ASSOCIATION OF KENYA
4:30 - 6:00 PM	WORKING GROUPS
6:30 - 8:30 PM	WELCOME PARTY

DAY 2: WEDNESDAY, AUGUST 7TH 2002

8:30 - 10:00 AM **Session 3: AFRICAN INDIGENOUS VEGETABLES, FLOWERS AND TEA**

Chairperson: Dr. Andreas Fricke
Rapporteur: Mr. Francis Ombwara

Market Survey on African Indigenous Vegetables in Western Kenya
M.O. Ahukutsa Onyango

Potential Salinity Resistance in Spiderplant (*Cleome gynandra* L.)
G.N. Mwai, J.C. Onyango and M.O.A. Onyango

Factors Affecting Development of Floriculture in Traditional Maize Growing Areas (Trans-Nzoia and Bungoma)
A.N. Muriithi

Effects of Time of Pruning, Lungs, and Resting Period on Total Non-Structural Carbohydrates, Re-growth and Yield of Tea Bushes (*Camellia sinensis* [L.] O. Kuntze)
J. K. Bore, D. K. Isutsa and F. M. Itulya

10:00 - 11:00 PM POSTER SESSION WITH TEA

11:00 AM - 1:00 PM **SESSION 4: CROP PROTECTION**

Chairperson: Prof. B. Hau
Rapporteur: Dr. J.B.M. Njoroge

Evaluation of Some *Pseudomonas* Isolates in *Striga hermonthica* Germination
O.O Babalola, A. M. Emechebe , A. I. Sanni and A. A. Onilude

Secondary Metabolites From Fungi as Potential Pesticides in the Tropics
L. A. Mwamburi

Pesticide Use and Implications in Horticultural Export Crops in Kenya
I.H. Nderitu, E.W Wambua and M.I. Machini

Within Season Management of Field Insect Pests of Cowpea (*Vigna unguiculata* L. Walp) With Neem, Karate and Marshal
F. M. E. Wanjala, B. M. Khaemba and S.M. Mbogoh

Thrips Populations Associated With Tomato Spotted Wilt Virus in Kenya
E.W. Macharia, A. Wangai, D. Lelgut and M. Kinyua

Banana Streak Virus: Is It a Threat to Banana Industry in Kenya?
L. S. Karanja, A. W. Wangai, S. Kilonzo, F. Nguthi and J. Ndung'u

1:00 - 2:00 PM	LUNCH
2:00 - 3:30 PM	WORKING GROUPS
3:30 - 4:00 PM	TEA BREAK
4:00 - 5:30 PM	JOINT WORKING GROUPS PRESENTATION AND DISCUSSION
5:30 - 6:00 PM	CLOSING CEREMONY
	Chairman: Dr. C.K. Ndung'u

DAY 3: THURSDAY, AUGUST 8TH 2002

8:00 AM - 6.00 PM EXCURSION:
Sunrose Nurseries
UoN, Kibwezi Farm

DAY 4: FRIDAY, AUGUST 9TH 2002

7.30 AM - 3:00 PM EXCURSION:
Machakos district

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