CROP PROTECTION PROGRAMME

Promotion of Quality Kale seed in Kenya

DFID Project Ref. R8439, NR Int. Code ZA0663

FINAL TECHNICAL REPORT

1 April 2005 – 31 January 2006

Project Leader: Nicola Spence

International Development Team
Central Science Laboratory (DEFRA)

FTR completed January 2006

"This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID." (DFID Project Ref. R8439, - Crop Protection Programme)

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Acknowledgements

The authors would like to acknowledge and thank the following persons who in one way or another contributed to the carrying out of this project (Project team members are indicated by *):

*Mr. Duncan Chacha (CABI)
Mr. Fulaha (KEPHIS)
Mr. R.N. Gachuiri (LARI extension officer)
Mr. Gikonyo (LARI Divisional Agricultural Office)
*Mr. Francis Kalangala (KEPHIS)
*Dr.. Daniel Karanja (CABI)
*Mr. Gilbert Kibata
*Mr. Simeon Kibet (KEPHIS)
*Dr. Esther Kimani (KEPHIS)
*Mr. Vhukile Kutywayo (CABI)
*Mrs. Elizabeth Lang'at (KEPHIS)
Ms. Gladys Maina (KEPHIS)
*Dr. Gay Marris (CSL)
Mr. Daniel Mbiri (KEPHIS)
Dr. Richard Musebe (CABI)
Mr. John Mark Njoroge (LARI Divisional Agricultural Officer)
Dr. George Oduor (CABI)
Mr. Patrick Onchieko (MoA)
*Dr. Moses Onim (CABI)
*Dr. Noah Phiri (CABI)
*Dr. David Pink (HRI)
Dr. Sarah Simons (CABI)
Mr. Wachira (KARI Njabini)

The project team also extend their sincere appreciation to the very many men and women famers from the Districts of Kajiado, Kiambu, Machakos, Maragua, Masaku and Thika, without who's feedback and enthusiasm, this project could not have been achieved.

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List of Abbreviations

ACTS	African Centre for Technology Studies
ARC	African Regional Centre
ASK	Agriculture Society of Kenya
CABI	CAB International
CAN	Calcium Ammonium Nitrate
CDA	Community Development Authority
CPP	Crop Protection Programme
CSL	Central Science Laboratory
DAP	Diammonium Phosphate fertilizer
DBM	Diamond Back Moth
DEFRA	Department for Environment, Food and Rural Affairs
DFID	Department for International Development
DUS	Distinctiveness, Uniformity and Stability
EASCO	East African Seed Company
FTC	Field Trial Centre
FTR	Final Technical Report
HCDA	Horticultural Crops Development Authority
HRI	Horticulture Research International
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	World Agroforestry Centre (Africa)
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
ISTA	International Seed TestingAssociation
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspection Service
KFA	Kenya Farmers' Association (KFA)
Ksh	Kenyan Shillings
Lagrotech	Lowlands Agricultural and Technical Services Limited
LASEGRO	Lari Seed Growers
LSC	Lagrotech Seed Company
MLT	Multilocational Trial
MoA	Ministry of Agriculture
NARL	National Agricultural Research Laboratories
NARO	National Agricultural Research Organisation
NGOs	Non Government Organisations
NPT	National Performance Trial
NRI	Natural Resources International
PRA	Participatory Rural Appraisal
QA	Quality Assurance
QVSP	Quality Vegetable Seed Project
SADC	Southern African Development Community
SPSS	Statistical Package for Social Sciences
Stpro	Seed Test analysis program
Xcc	*Xanthomonas campestris* pv. *campestris*

Executive Summary

Outputs for R8439 have been achieved. Seeds from the five best potential kale varieties identified in R8312 (CABI 1-5) were submitted to KEPHIS, with documentation detailing their specific characteristics. DUS trials were completed in December 2005 and the project team has been advised informally that CABI lines did perform significantly better than check varieties. Submission of seed to NPT proved unnecessary. CABI kales 1–5 were planted to evaluate their performance, compared to local varieties, in different agroecological zones in peri-urban Nairobi and Western Kenya respectively. In addition, over one hundred smallholders cultivated CABI kales on their farms, and completed evaluation questionnaires re. their relative attributes. The performances of CABI 1-5 varied considerably between sites, but in almost all of the MLTs, they consistently surpassed the commonly grown commercial variety, 1000 headed kale. In Western Kenya, CABI lines also out-performed variety Sikuma Siku. Although productivity of CABI lines rarely exceeded that of another commercial variety, Collards, it is the length of harvesting during the life of a kale crop that ultimately determines its final economic potential. Some CABI lines achieved particularly steady leaf yields, indicating their productivity could be sustained after yields decline in other kale varieties. Feedback received from farmers' participatory trials was overwhelmingly positive. CABI kale lines germinated faster, transplanted better, and provided a longer period for leaf harvesting prior to flowering than the farmers' own kale varieties. CABI lines were larger, and more resistant to attack by pests and diseases, and farmers perceived the colour and shape of their leaves to be superior to those of local counterparts. They had a shorter cooking time and were also more palatable. The vast majority of farmers ranked the CABI kale lines as having a greater consumer appeal than any other kale varieties they normally grow. They were willing to buy the seeds of CABI lines for their own use, and would recommend these lines to other growers. Multiplication plots have been established to ensure sufficient seed stocks to meet future demands of farmers for these improved kale lines. Large batches of seed will be ready for harvesting in February 2006. Following consultations with IPGRI and KARI, seeds of all lines developed in R8312, including CABI 1-5, have been deposited in the KARI genetic resources unit (Muguga), and in the vegetable gene bank (Warwick-HRI). To promote sustainable seed production technologies, on-farm participatory demonstration plots were established with existing farmer groups in Lari division. Farmers are very keen to learn more about seed processing activities. In preparation for continuous multiplication and commercialisation of the improved kale seeds, Lari Division farmers had extensive discussions amongst themselves and the CDA. As a result, they obtained official registration and authority from the District Social Development Officer (Kiambu District), under the National Community Development Programme in Kenya. Posters from R8312 have been translated into Swahili and multiple copies have been given to >70 farmers for further distribution. The project has contributed to sustainable rural livelihoods in that the outputs will help farmers to produce their vegetable crops (for consumption and sale) in a safe, more effective and economic way. Benefits will include improved nutrition for whole families, better cash returns from higher yields of better quality produce and an empowerment through agricultural knowledge which will help them to make informed choices on other cropping options.

Background

The use of quality seeds along with other inputs and appropriate cultural management practices is recognized as the most cost effective way of increasing crop production and productivity. In considering interventions that are likely to reverse the trend of recurring food shortages, seed security has been recognized as having the potential for achieving significant advances in food productivity and production. A previous CPP project R7571 engaged farmers in participatory research on selection criteria for kale plants for seed production. Both suitable (healthy) and unsuitable (diseased) plants were selected by both farmers and researchers for the production of seed, and the resulting seed was grown and evaluated. All of the 19 farmers chose plots with researcher-selected and farmer-selected healthy seed as their preferred plots and farmers were very keen to gain knowledge on how to improve the quality of farmer-collected seed. This research generated great demand from farmers to know good seed from bad in the local market because it is not possible to know what type of plants (diseased or healthy) the seed came from, when the seed is being sold.

In the recently completed project (R8312), significant progress was made in understanding farmers' perceptions and needs with respect to seed purchases and a strong interest from Kinale farmers in multiplying and marketing seed with improved seed health and quality was expressed. An inventory of brassica seed in Kenya was drawn up from commercial seed companies and local markets, and significant progress was made in analysis of Kinale kale as a variety in close collaboration with KEPHIS inspectors using International Union for the Protection of new varieties of Plants (UPOV) guidelines. Kinale farmers and the project research team have now selected five kale lines from a trial of 24 lines at the KARI field station at Njabini in the Kinangop for detailed varietal characterisation. These lines (CABI 1, CABI 2, CABI 3, CABI 4, CABI 5) now need to be tested for a further two seasons for KEPHIS to carry out trials for distinctness, uniformity and stability (DUS). This will give farmers the option to then choose whether to register varieties in a commercial seed business. Potential models for sustainable seed multiplication of kale are also being evaluated through on-farm participatory trials in Kinale and on-station at Njabini. This will allow farmers to establish a sustainable kale seed multiplication system that enables smallholders to produce healthy seed of good quality and that has an acceptable market value. The feasibility of a community-based approach to seed multiplication in Kinale and potential for establishing and registering a commercial seed business in Kinale has been examined and indications were that farmers are keen to pursue this approach. Good seed multiplication practice for kale and seed certification using a preferred model was promoted in project R8312, but there is now demand to go beyond this and to register and release Kinale kale seed varieties.

Project purpose

Farmers in the Kinale area of Kenya have expressed a need for improved kale varieties (see project reports R7571 and R8312), and this demand has been reiterated in other peri-urban CPP projects (Oruko & Ndun'gu, 2001; Lenné, 2002; Njuki, Kimani & Phiri, 2003). Moreover, farmers now seek to formally register kinale seed varieties under a community-based seed company model and to have a formal release of their varieties. The overall objectives of the current project were therefore twofold: Firstly, to continue to promote sustainable seed production technologies for farmer-led multiplication of improved kale varieties to smallholder farmers in the Kinale region of peri-urban Kenya, in order to improve the quality, health and availability of kale seed to smallholder farmers. Secondly, this project also sought to facilitate the registration and release process of new varieties of Kinale kale whilst also supporting existing informal farmer-to-farmer distribution under the regulation of KEPHIS and in collaboration with KARI and NGOs.

To this end, the specific aims of project R8439 were:

1. To evaluate new kale seed lines in trials to assess distinctness, uniformity and stability (DUS)
2. To initiate registration and release processes for new kale seed lines
3. To Promote sustainable seed production technologies

Research Activities and Outputs

1. Activity: Evaluation of new kale seed lines

1.1 Establish trials for distinctiveness, uniformity and stability (DUS)

As a procedural requirement that must take place prior to any process of registration, selfed seeds obtained from each of five kale lines identified as being the most promising potential varieties in previous project R8312 (CABI 1, CABI 2, CABI 3, CABI 4 and CABI 5) were submitted to KEPHIS headquarters to allow them to undertake DUS trials. Seeds of two local commercial kale varieties, (thousand headed and collards) were also submitted to KEPHIS to serve as local checks for the purposes of comparison. KEPHIS was also provided with details about the Njabini site where the lines had originally been cultivated in 2004/2005 (Table 1), along with details about the specific characteristics of each line (as identified in project R8312) (Table 2). Seed was originally given to KEPHIS in April 2005, and planting took place at their Nakuru site later in the year. Data collection is not yet complete. However, the following summarised account has been provided by Mr Daniel Mbiri (KEPHIS), the plant examiner with responsibility for testing the lines. (Seed technology input was provided by Mr. Fulaha):

1) Five lines, CABI 1 – 5 were sown together with two local checks (commercial kale varieties), a thousand headed and Georgia, on 8th August 2005.

2) Seedlings of the lines and the two varieties were transplanted on 6th September 2005.

3) The testing was completed on 28th December 2005. There was need to collect seed data, hence the trial was terminated, although the plants are still growing in the trial plots.

4) The Nakuru team collected the following data on characteristics of the kale line: Seedling anthocyanin colouration; colour of fully developed leaves; internode length; glycosity on the underside of the leaves; leaf blade length; leaf blade width; anthocyanin colouration of petioles; leaf blade curvature; length of petioles; midrib anthocyanin colouration; plant shape; plant height; Stem anthocyanin colouration.

5) The data are being summarised and will be sent to Dr Sikinyi at the KEPHIS Headquarters who will carry out the formal analysis of the data and make necessary decisions.

6) The project team (N. Phiri, CABI, pers. Comm..), have been told informally that some of our lines were performing much better than the checks.

7) The kale lines generated a lot of interest from the local community who were asking the Nakuru team for seed of the lines so that they could plant the lines in their gardens.

Table 1. Details for Njabini site, South Kinangop District, where Kinale kale lines were grown and characterised in 2004/05

Location/coordinates:	S. 00° 44´ 01.0˝, E 036° 38´ 58.3˝	
Altitude:	2551 m a s l.	
Temperature:	Mean minimum temperature = 6 °C (range: -3 to 22 °C). Mean maximum temperature = 20 °C (range: 13 to 28 °C). Mean average temperature = 13 °C (range: 8 to 22 °C).	
RH:	Mean average RH = 83 % (range 53 to 96 %)	
Total rainfall:	1110 mm/year	
Agronomic practices:		
Date of sowing in the nursery	26/02/2004.	
Date of transplanting to the field	06/04/2004.	
Plant spacing in the field	45 cm x 60 cm	
Fertiliser regimes	**Nursery:** Applied DAP before sowing at the rate of 5 g per 1 m drilled and lightly mixed with soil before sowing seeds.	**Field:** Basal dressed with DAP at 5 g in the planting hole and mixed with soil just before planting. Top dressed with CAN at 5 g per plant.
Pesticides used:	o Thuricide at the rate of 1g/1litre of water for controlling Diamond back moth (DBM)- applied when damage and DBM were seen. o Karate at the rate of 48.5 ml in 15 l of water for the control of aphids which spread viruses. Applied when observed and followed spot spray. Applied twice during the season. o Benomyl at the rate of 15g in 15 l of water (1 g in 1 litre) - for the control of *Alternalia* leaf and pod spot. Maconzeb can be applied for preventative purposes if there is threat from *Alternalia* leaf spot infection. o Thiram at the rate of 10 g powder per 3 kg of seed.	
Irrigation	o Supplementary irrigation was carried out during dry spells in the field. A bucket and a hose pipe were used in irrigating plants.	

Table 2a. Characterisation details for CABI 1 (Kinale line number 15, project R8312), submitted to KEPHIS, 2005

Seedling stage (34 days after sowing)	1	Anthocyanin of hypocotyls	Medium
	2	Cotyledon size	Medium to large
	3	Cotyledon shape	Broad
	4	Seedling colour	Green yellow to lawn green
Vegetative stage (3 months from transplanting)	1	Colour of young leaf	Dark green
	2	Leaf blade intensity of colour of young leaf	Light to medium
	3	Colour of fully developed leaf	Dark olive green
	4	Intensity of colour of fully developed leaf	Medium to dark
	5	Leaf blade shape	Narrow elliptic to elliptic
	6	Leaf blade length	29-34 cm
	7	Leaf blade width	24-31 cm
	8	Leaf blade curvature of midrib	Weak
	9	Leaf blade curling	Weak to medium
	10	Leaf blade cupping in cross section	Medium
	11	Petiole attitude	Erect
	12	Petiole length	23-31 cm
	13	Petiole width	1.1-1.5 cm
	14	Petiole number of lobes	6-10
	15	Plant position of growing point in relation to top of the plant	Deeply below
Flowering stage	1	Anthocyanin	Present (less than 10% of plants)
	2	Anthocyanin distribution	Midrib, leaf blade margin, petiole
	3	Anthocyanin intensity	Very weak
	4	Glucosity	Present – strong
	5	Plant shape	Pyramid
	6	Days to 50% flowering	167 days from sowing
	7	Number of anthers	6
	8	Colour of anthers	Yellow
	9	Number of sepals	4
	10	Colour of sepals	Gold
	11	Number of petals	4
	12	Colour of petals	Yellow
Pod stage	1	Pod width	0.3-0.52 cm
	2	Pod shape	Ovate
	3	Pod colour	Green
	4	Intensity of pod colour	Medium
	5	Pod secondary colour	Yes
	6	Pod secondary colour	Purple
	7	Pod curvature degree	Very slight
	8	Pod curvature shape	Concave
	9	Pod shape of distal part	Acute
	10	Length of pod stalk	1.8-2.5 cm
	11	Plant height	1.8-2.24 m
	12	Pod length	6.0-9.3 cm
Seed	1	1000 seed weight	3.89 g
	2	Seed colour	Majority dark grey. Generally dark grey to purple madder
	3	Seed shape	Majority oval
	4	Seed surface	Rough

Table 2b. Characterisation details for CABI 2 (Kinale line number 3H, project R8312), submitted to KEPHIS, 2005

Seedling stage (34 days after sowing	1	Anthocyanin of hypocotyls	Weak to medium
	2	Cotyledon size	Medium to large
	3	Cotyledon shape	Broad
	4	seedling colour	Green yellow to lawn green
Vegetative stage (3 months from transplanting)	1	Colour of young leaf	Dark olive green
	2	Leaf blade intensity of colour of young leaf	Light to medium
	3	Colour of fully developed leaf	Dark olive green
	4	Intensity of colour of fully developed leaf	Dark/strong
	5	Leaf blade shape	Narrow elliptic to elliptic
	6	Leaf blade length	29-37 cm
	7	Leaf blade width	24-33cm
	8	Leaf blade curvature of midrib	Weak to medium
	9	Leaf blade curling	Weak to medium
	10	Leaf blade cupping in cross section	Weak to medium
	11	Petiole attitude	Semi erect to erect
	12	Petiole length	22-30 cm
	13	Petiole width	1.1-1.5 cm
	14	Petiole number of lobes	6-12 lobes
	15	Plant position of growing point in relation to top of the plant	Slightly below to deeply below
Flowering stage	1	Anthocyanin	Present - weak (<7 % of plants)
	2	Anthocyanin distribution	Leaf margin, midrib, petiole
	3	Anthocyanin intensity	Weak
	4	Glucosity	Present, week
	5	Plant shape	Flat to dome
	6	Days to 50% flowering	194 days
	7	Number of anthers	6
	8	Colour of anthers	Bright gold
	9	Number of sepals	4
	10	Colour of sepals	Gold
	11	Number of petals	4
	12	Colour of petals	Yellow
Pod stage	1	Pod width	0.3-0.51
	2	Pod shape	Elliptic
	3	Pod colour	Green
	4	Intensity of pod colour	Medium
	5	Pod secondary colour	No
	6	Pod secondary colour	No
	7	Pod curvature degree	Slight
	8	Pod curvature shape	Concave
	9	Pod shape of distal part	Acute
	10	Length of pod stalk	1.8-3.8 cm
	11	Plant height	196-2.58 cm
	12	Pod length	6.9-9.0 cm
Seed	1	1000 seed weight	5.72 g
	2	Seed colour	Purple madder to dim grey
	3	Seed shape	Spherical through oval to triangular
	4	Seed surface	Rough

Table 2c. Characterisation details for CABI 3 (Kinale line number 18, project R8312), submitted to KEPHIS, 2005

Seedling stage (34 days after sowing	1	Anthocyanin of hypocotyls	Strong
	2	Size of fully developed cotyledons	Medium to large
	3	Cotyledon shape	Broad
	4	Seedling colour	Green yellow to lawn green
Vegetative stage (3 months from transplanting)	1	Colour of young leaf	Dark olive green
	2	Leaf blade intensity of colour of young leaf	Medium
	3	Colour of fully developed leaf	Dark olive green
	4	Intensity of colour of fully developed leaf	Strong
	5	Leaf blade shape	Elliptic (broad)
	6	Leaf blade length	31-40 cm
	7	Leaf blade width	22-31 cm
	8	Leaf blade curvature of midrib	Weak to medium
	9	Leaf blade curling	Weak to medium
	10	Leaf blade cupping in cross section	Medium
	11	Petiole attitude	Semi erect to erect
	12	Petiole length	24-36 cm
	13	Petiole width	1.2-1.5 cm
	14	Petiole number	7-15
	15	Plant position of growing point in relation to top of the plant	Slightly below
Flowering stage	1	Anthocyanin	Present
	2	Anthocyanin distribution	Midrib, petiole, leaf edges
	3	Anthocyanin intensity	weak
	4	Glucosity	Present
	5	Plant shape	Flat to dome
	6	Days to 50% flowering	221 days from sowing
	7	Number of anthers	6
	8	Colour of anthers	Golden
	9	Number of sepals	4
	10	Colour of sepals	Golden
	11	Number of petals	4
	12	Colour of petals	Yellow
Pod stage	1	Pod width	0.3 – 0.51 cm
	2	Pod shape	Elliptic
	3	Pod colour	Green
	4	Intensity of pod colour	Medium
	5	Pod secondary colour	Nil
	6	Pod secondary colour	Nil
	7	Pod curvature degree	Slight
	8	Pod curvature shape	Concave
	9	Pod shape of distal part	Acute
	10	Length of pod stalk	1.7-3.2 cm
	11	Plant height	1.67-2.52 m
	12	Pod length	6.4-9.5 cm
Seed	1	1000 seed weight	5.77 g
	2	Seed colour	Grey
	3	Seed shape	Oval
	4	Seed surface	Rough

Table 2d. Characterisation details for CABI 4 (Kinale line number 32, project R8312), submitted to KEPHIS, 2005

Seedling stage (34 days after sowing)	1	Anthocyanin	Weak
	2	Cotyledon size	Medium to large
	3	Cotyledon shape	Broad
	4	Cotyledon colour	Green yellow to lawn green
Vegetative stage (3 months from transplanting)	1	Colour of young leaf	Dark olive green
	2	Leaf blade intensity of colour of young leaf	Strong
	3	Colour of fully developed leaf	Dark olive green
	4	Intensity of colour of fully developed leaf	Strong
	5	Leaf blade shape	Elliptic
	6	Leaf blade length	31-40.5cm
	7	Leaf blade width	24-33cm
	8	Leaf blade curvature of midrib	Weak-medium
	9	Leaf blade curling	Weak to medium
	10	Leaf blade cupping in cross section	Weak to medium
	11	Petiole attitude	Semi erect to erect
	12	Petiole length	28-34 cm
	13	Petiole width	1.1-1.6 cm
	14	Petiole number of lobes	4-11
Flowering stage	1	Plant position of growing point in relation to top of the plant	Slightly below
	2	Anthocyanin	Present (in <10% of plants)
	3	Anthocyanin distribution	Midrib, petiole, leaf edges
	4	Anthocyanin intensity	Weak
	5	Glucosity	Present – weak to medium
	6	Plant shape	Flat to dome
	7	Days to 50% flowering	194 days from sowing
	8	Number of anthers	6
	9	Colour of anthers	Gold
	10	Number of sepals	4
	11	Colour of sepals	Gold
	12	Number of petals	4
	13	Colour of petals	Gold
Pod stage	1	Pod width	0.3-0.51
	2	Pod shape	Elliptic
	3	Pod colour	Green
	4	Intensity of pod colour	Medium
	5	Pod secondary colour	None
	6	Pod secondary colour	None
	7	Pod curvature degree	Slight
	8	Pod curvature shape	Concave
	9	Pod shape of distal part	Acute
	10	Length of pod stalk	1.2-2.6 cm
	11	Plant height	1.86-2.24 m
	12	Pod length	6.7-10.0 cm
Seed	1	1000 seed weight	6.01 g
	2	Seed colour	Purple madder to dim grey
	3	Seed shape	Oval to triangular
	4	Seed surface	Rough

Table 2e. Characterisation details for CABI 5 (Kinale line number 23, project R8312), submitted to KEPHIS, 2005

Seedling stage (34 days after sowing	1	Anthocyanin	Weak to medium
	2	Cotyledon size	Medium to large
	3	Cotyledon shape	broad
	4	Seedling colour	Green yellow to lawn green
Vegetative stage (3 months from transplanting)	1	Colour of young leaf	Narrow elliptic to elliptic
	2	Leaf blade intensity of colour of young leaf	Strong
	3	Colour of fully developed leaf	Dark olive green
	4	Intensity of colour of fully developed leaf	Strong
	5	Leaf blade shape	Narrow elliptic to elliptic
	6	Leaf blade length	31-38 cm
	7	Leaf blade width	24-34 cm
	8	Leaf blade curvature of midrib	Weak to medium
	9	Leaf blade curling	Weak
	10	Leaf blade cupping in cross section	Weak
	11	Petiole attitude	Semi-erect to erect
	12	Petiole length	20-36
	13	Petiole width	1.2-1.4 cm
	14	Petiole number of lobes	6-9
	15	Plant position of growing point in relation to top of the plant	Slightly below to deeply below
Flowering stage	1	Anthocyanin	Present (25% of plants)
	2	Anthocyanin distribution	Midrib, leaf blade margin, petiole
	3	Anthocyanin intensity	Medium/weak
	4	Glucosity	Present – medium
	5	Plant shape	Flat to dome
	6	Days to 50% flowering	189 days from sowing
	7	Number of anthers	6
	8	Colour of anthers	Yellow
	9	Number of sepals	4
	10	Colour of sepals	Yellow
	11	Number of petals	4
	12	Colour of petals	Yellow (Palegoldenrod)
Pod stage	1	Pod width	0.3-0.5 cm
	2	Pod shape	Around
	3	Pod colour	Green
	4	Intensity of pod colour	Medium
	5	Pod secondary colour	Yes
	6	Pod secondary colour	Rose brown, plum
	7	Pod curvature degree	slight
	8	Pod curvature shape	Concave
	9	Pod shape of distal part	Acute
	10	Length of pod stalk	1.7-3.2 cm
	11	Plant height	1.8-2.5 m
	12	Pod length	6.0-9.5 cm
Seed	1	1000 seed weight	6.41 g
	2	Seed colour	Purple madder to majority dim grey
	3	Seed shape	Spherical to oval
	4	Seed surface	Rough

1.2. Submit seed to National Performance Trial (NPT)

Kale is a crop that does not require mandatory testing, hence did not require NPT. As these trials were not considered necessary by KEPHIS, project resources were diverted into more extensive multilocational trials (see 1.3 below).

1.3. Carry out participatory multilocation trials

Seeds CABI kales 1–5, were planted to evaluate their performance, in comparison with two local commercial varieties (collards and thousand headed) in different agro-ecological zones in Kenya. These zones were in Central Kenya, (peri-urban Nairobi, where 4 different sites were planted), and in Western Kenya (2 sites planted), respectively. These activities are reported in sections 1.3.1. and 1.3.2. In addition to conducting trials at these locations, kale-growing farmers (>100 individuals) from villages from within a number of different districts were also supplied with seeds from the improved kale lines, which they grew on their farms, and subsequently completed evaluation questionnaires. This activity is reported in section 1.3.3.

1.3.1. Central Kenyan trials

In central Kenya, on-station trials were established at Kabete (University of Nairobi's College of Agriculture and Veterinary Services' farm) (Plate 1), Njabini (Kenya Agricultural Research Institute's farm) and Thika (Kenya Agricultural Research Institute - National Horticultural Research Centre's farm). In addition, an on-farm trial was established in Mwea. At each site, the trial was laid out in a randomised design with four and three replicates for the on-station and on-farm trials, respectively. Seeds were raised in nursery beds and transplanted (four weeks after sowing) on 9 May 2005, 10 May 2005, 12 May 2005 and 13 May 2005 at Thika, Njabini, Kabete and Mwea, respectively. Each plot (3.60 x 3.15m) consisted of 42 plants with a plant spacing of 0.45 x 0.60m (within and between rows), at all sites. The inter-plot and inter-block spacing was 1.50m and 2.00m respectively.

Harvesting began four weeks after transplanting i.e. on 07 June 2005 (at Thika), 09 June 2005 (at Kabete and Njabini) and 10 June 2005 (at Mwea), and continued every fortnight until 03 January 2006 (at Thika), 05 January 2006 (at Kabete and Njabini) and 23 December 2005 (at Mwea). During harvesting, the number and weight of leaves harvested from only 20 plants in the inner rows (net plot) in each plot was recorded at each site. In addition, the number of plants infected by viral and black rot diseases, and the number of plants bolted/flowered, in each plot, were recorded during harvesting. Summaries of the leaf yield and flowering data for the duration of the trials at Kabete, Njabini and Thika are shown in Figures 1 – 3. At the time when the last yield data was collected (23 December 2005), from the trial site at Mwea, all the improved kale lines and the commercial varieties at the site had not flowered, hence only the yield data is presented in this report (Figure 4). The total yield ($plot^{-1}$) for all sites is presented in Figure 5.

Plate 1: Multilocation trial of improved Kinale kale lines at Kabete, Central Kenya.

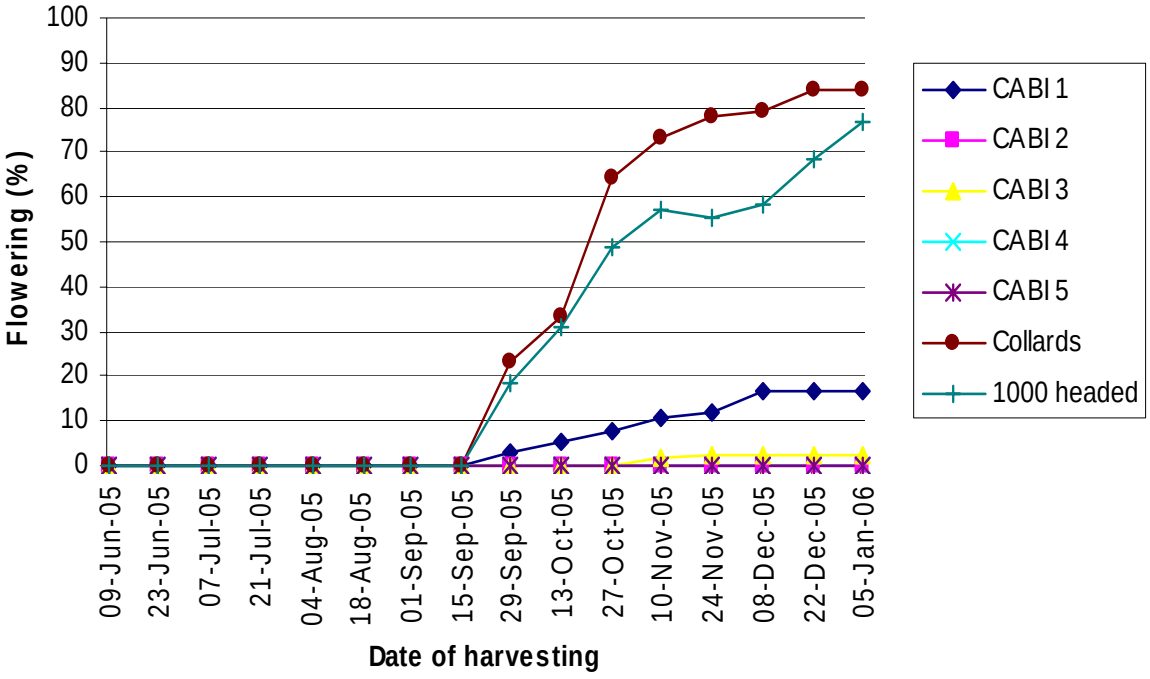


Figure 1a: Flowering of improved Kinale kale lines and local commercial varieties at Kabete, Central Kenya during the 2005/06 growing period.

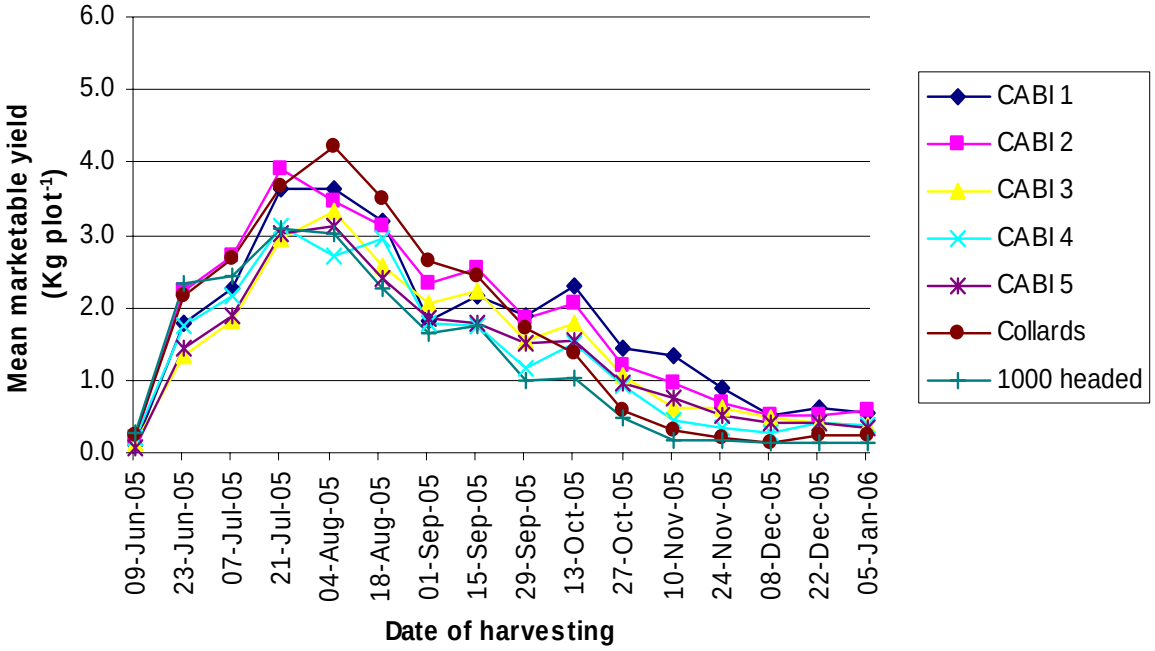


Figure 1b: Leaf yield of improved Kinale kale lines and local commercial varieties at Kabete, Central Kenya during the 2005/06 growing period.

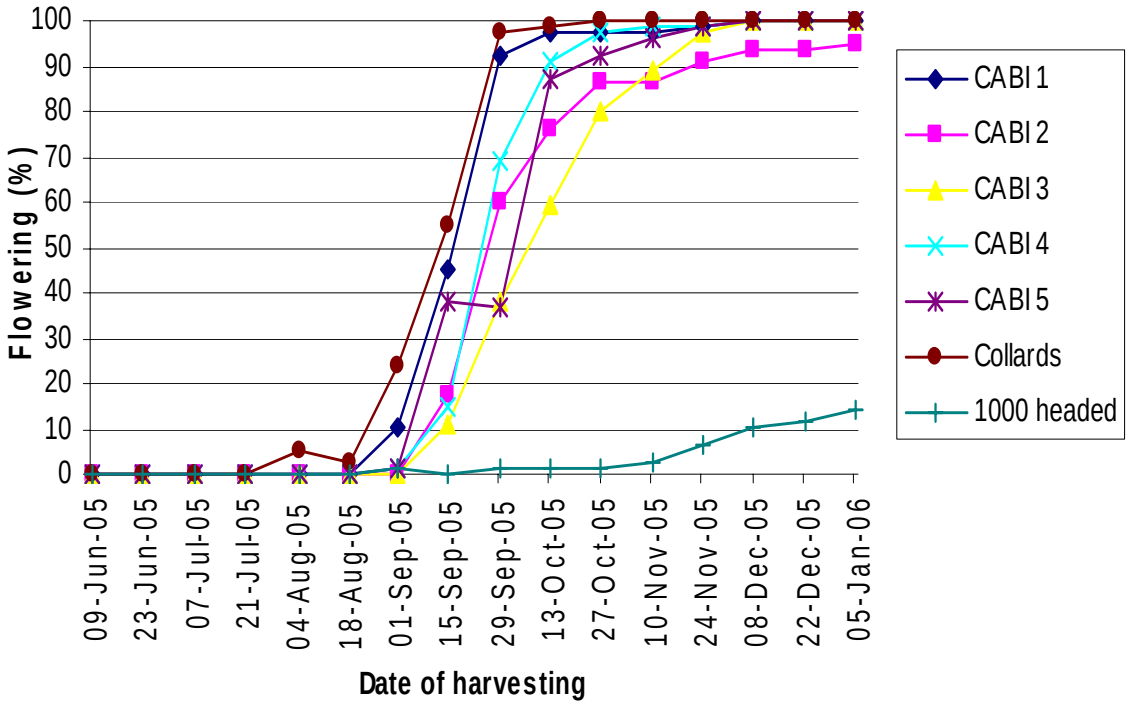


Figure 2a: Flowering of improved Kinale kale lines and local commercial varieties at Njabini, Central Kenya during the 2005/06 growing period.

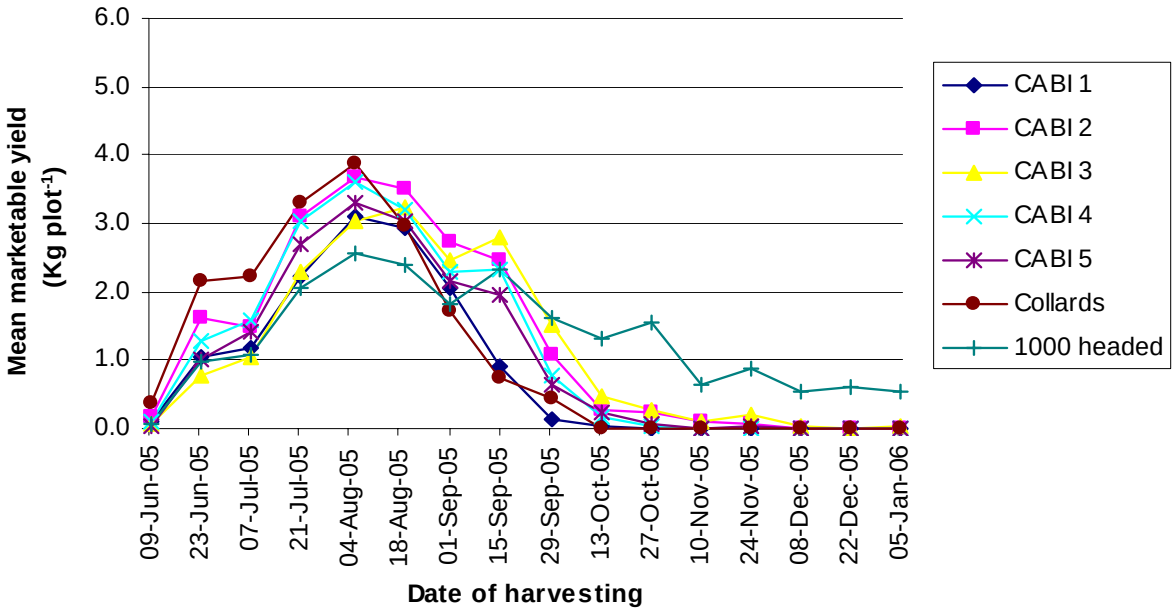


Figure 2b: Leaf yield of improved Kinale kale lines and local commercial varieties at Njabini, Central Kenya during the 2005/06 growing period.

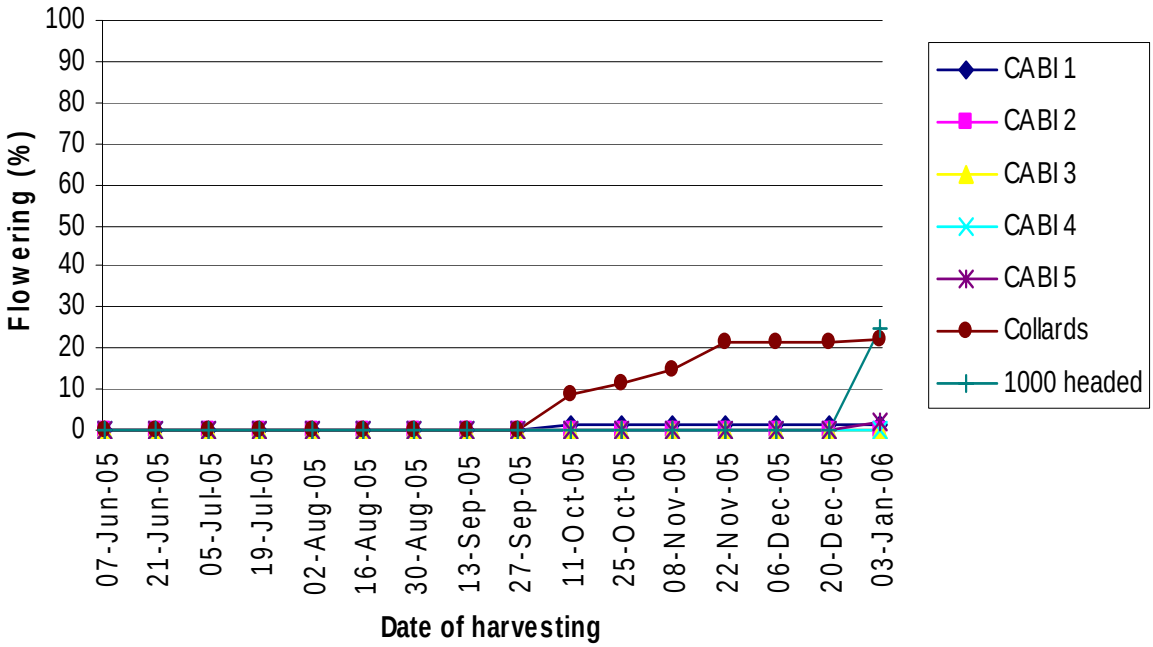


Figure 3a: Flowering of improved Kinale kale lines and local commercial varieties at Thika, Central Kenya during the 2005/06 growing period.

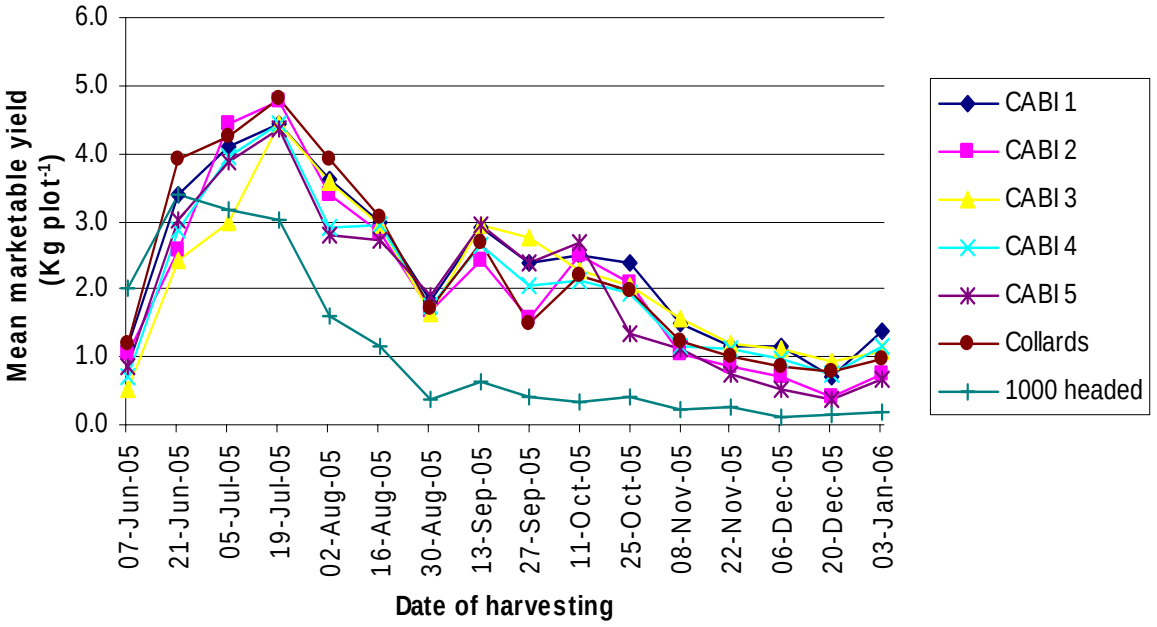


Figure 3b: Leaf yield of improved Kinale kale lines and local commercial varieties at Thika, Central Kenya during the 2005/06 growing period.

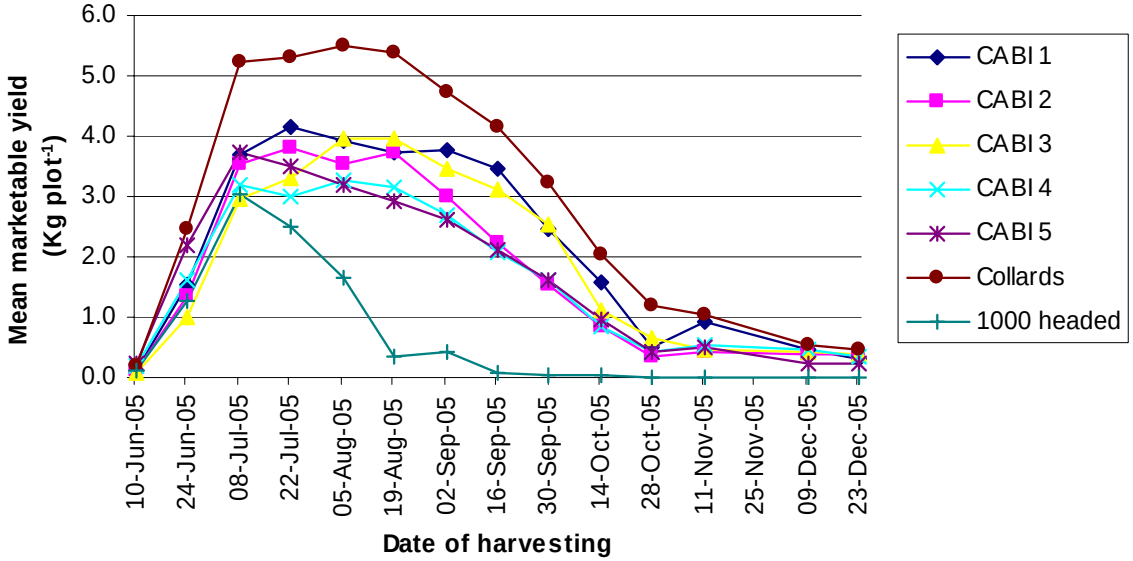


Figure 4: Leaf yield of improved Kinale kale lines and local commercial varieties at Mwea, Kenya during the 2005/06 growing period.

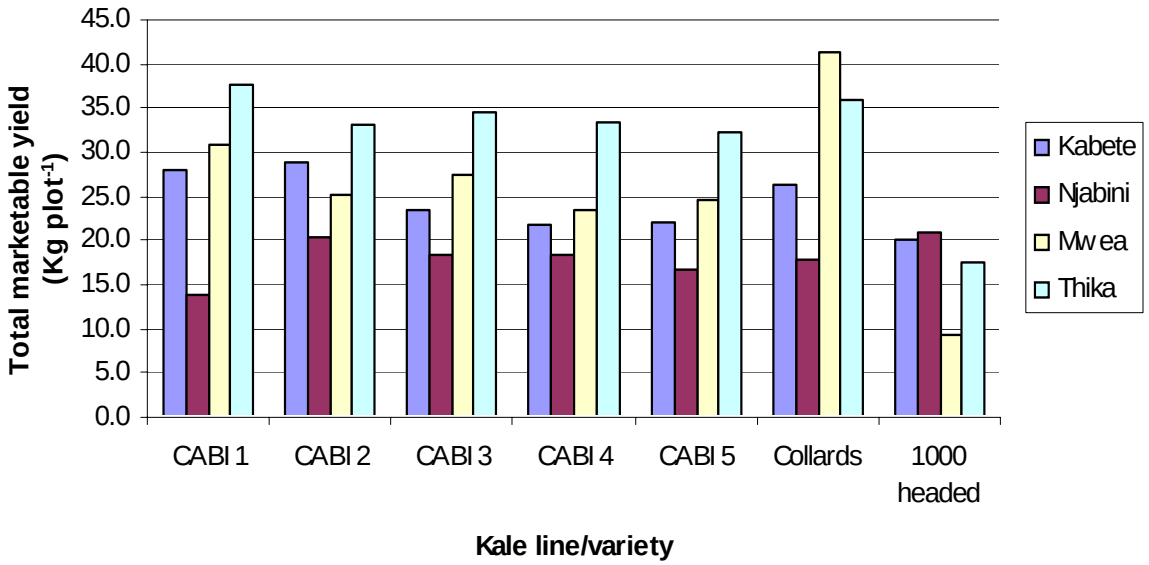


Figure 5: Total leaf yield of improved Kinale kale lines and local commercial varieties at Kabete, Njabini, Mwea and Thika, Central Kenya Kenya during the 2005/06 growing period.

In the participatory trials undertaken at the four Central Kenyan locations, the performance of the five CABI kale lines varied considerably between sites. Generally speaking, the CABI lines consistently out-performed 1000 headed kale, especially CABI 1 and CABI 3. At Kabete, Mwea and Thika, CABI 1-5 all produced a higher total marketable yield than this commonly grown variety. At Njabini, however, this situation was reversed and1000 headed produced a greater yield than any of the CABI varieties.

The marketable yield produced by the other commercial variety used in these trials, Collards was, by contrast, at least as good as that yielded by the CABI lines at almost all sites. Exceptions were CABI 1 and CABI 2, that produced the highest marketable yields at Kabete, and CABI 1, that produced the highest marketable yield at Thika.

1.3.2. Western Kenyan trials

Seeds of 8 kale varieties were given to Lagrotech Seed Company to be tried at 6 locations in Western Kenya, including Lagrotech Research Station at Lisuka Farm, KARI Kakamega, Maseno FTC, Siaya FTC, Kisii FTC and Kisumu Show Ground. However, several sites were dropped for various reasons, including highly acidic soils (Maseno FTC), Siaya FTC (very unreliable rains with no irrigation possibility), and Kisumu Show Ground (only active for about three months before the ASK Show). Therefore, only three sites were planted, including Lisuka Lagrotech Farm, KARI Kakamega and Kisii FTC. However, Kisii FTC was planted latest, and therefore harvesting was not completed within the timeframe of this project. The standard detailed methodology used for all the trials can be obtained from CABI Nairobi office. The data presented below include: The total marketable leaf yields per variety (kg) adjusted for 20 plants per plot and site; the total number of marketable leaves corrected for 20 plants per plot and site; across locations for Lisuka and KARI Kakamega for the same parameters.

The performance of kale varieties tested at Lisuka Lagrotech Research Station, on the shores of Lake Victoria 10 km from Kisumu City, is presented in Tables 3 and 4. Table 3 shows the number of harvests and mean yields of marketable leaves from 20 plants and three plots (replicates) of each kale variety. Six harvests were done and mean marketable yields of each kale variety are presented. These were ranked for each variety. Commercial variety “Collards” from Kenya Seed Company was the highest yielder (14.12 kg for 20 plants), followed by CABI 1, CABI 3 and CABI 4, which ranked second, third and fourth respectively. The worst yielder was 1000 headed commercial variety, with a mean marketable leaf yield of 11.40 kg for 20 plants. The other Kenya Seed Company kale variety called “Sukuma Siku” in the trial had seeds with very low germination and was therefore not included at this site. It is interesting to note that of the 8 kale varieties in the trial, one commercial variety performed best, and the other two had the worst performance. The five CABI kale entries in this site were very promising after six harvests. In terms of the mean number of marketable leaves per variety at this site (Table 4), commercial variety Collard had the highest (412). The other high performing varieties were CABI 2, CABI 1 and CABI 5 in that order respectively. Again, the variety with the fewest number of leaves was a commercial variety, 1000 headed.

The respective performances of kale varieties at KARI Kakamega Research Station are presented in Tables 5 and 6. At this site, enough seedlings of the commercial kale variety, Sukuma Siku, were raised and this variety was included in the trial. The data presented in Table 5 shows that the Commercial kale variety Collards had the highest yield of marketable leaves, with a mean of 8.72 kg for 20 plants. The next good yielders were CABI 1, CABI 3 and CABI 2 respectively. The worst leaf yielders were commercial kale varieties, Sikuma Siku and 1000 headed, raking 8 and 7 respectively. The best and worst leaf yielding kale varieties at both sites agree quite well. However, Leaf yields at Lisuka were much higher than those at KARI Kakamega, being 12.27 kg and 7.09 kg for 20 plants respectively (Table 6). The kale variety at KARI Kakamega with the highest mean number of marketable leaves was the commercial variety Sukuma Siku (488). The other kale varieties with high mean number of leaves were the commercial kale variety, Collard (395), followed by CABI 1 (353) and CABI 2 (328) respectively. The kales with the lowest mean

number of leaves were commercial variety 1000 headed (210) and CABI 3 (284) respectively. Leaf size and number of leaves should be critically considered during kale selection to give the highest marketable leaf yield. The commercial variety, Collards, has this balance and this is the reason for its very good leaf yield performance in both sites. However, the length of harvesting during the life of a kale crop determines the final economic potential of the variety. This is what the CABI kale selections seem to offer above the current commercial kale varieties.

Table 3. Total marketable leaves (kg) from three plots corrected for 20 plants, at Lisuka Lagrotech Research Station.

Kale Varieties	**Harvest number**						**Means**	**Ranking**
	1	**2**	**3**	**4**	**5**	**6**		
CABI 1	6.06	20.47	19.57	13.37	7.79	8.05	**12.55**	**2**
CABI 2	6.22	20.96	18.28	13.00	6.96	6.50	**11.99**	**5**
CABI 3	5.64	18.86	19.54	15.21	8.21	7.23	**12.45**	**3**
CABI 4	4.40	16.59	19.64	15.31	9.14	7.20	**12.05**	**4**
CABI 5	5.66	15.93	16.95	14.00	8.27	7.68	**11.42**	**6**
Collards	8.53	22.21	24.09	13.46	8.41	7.37	**14.12**	**1**
1000 Headed	4.77	15.72	20.16	12.63	7.62	7.48	**11.40**	**7**
Harvesting Means	**5.90**	**18.68**	**19.75**	**13.85**	**8.06**	**7.36**		

Table 4. Total number of marketable leaves from three plots corrected for 20 plants at Lisuka Research Station.

Kale Varieties	**Harvest number**						**Means**	**Ranking**
	1	**2**	**3**	**4**	**5**	**6**		
CABI 1	313	404	455	381	283	305	**356.83**	**3**
CABI 2	313	441	472	412	270	262	**361.67**	**2**
CABI 3	237	302	345	313	233	243	**278.83**	**6**
CABI 4	249	351	395	367	290	249	**316.83**	**5**
CABI 5	289	343	379	316	289	289	**317.50**	**4**
Collards	350	425	536	461	380	320	**412.00**	**1**
1000 Headed	216	247	316	247	198	219	**240.50**	**7**
Harvesting Means	**281.00**	**359.00**	**414.00**	**356.71**	**277.60**	**269.57**		

Table 5. Total marketable leaves (kg) from three plots corrected for 20 plants at KARI Kakamega Research Station

Kale Varieties	Harvest number						Means	Ranking
	1	2	3	4	5	6		
CABI 1	7.98	12.55	8.81	6.05	5.71	5.90	**7.83**	2
CABI 2	5.96	12.18	7.64	6.18	7.00	6.94	**7.65**	4
CABI 3	6.93	12.55	7.29	6.94	7.00	6.16	**7.81**	3
CABI 4	5.82	11.07	7.67	6.45	7.23	5.70	**7.32**	5
CABI 5	5.15	9.75	7.35	4.80	6.21	5.77	**6.55**	6
Collards	9.76	14.62	9.62	6.25	6.44	5.64	**8.72**	1
Sukuma Siku	5.90	8.22	3.84	4.18	5.34	4.30	**5.30**	8
1000 Headed	6.03	11.41	6.61	2.78	3.29	3.23	**5.56**	7
Harvesting Means	**6.69**	**11.54**	**7.35**	**6.08**	**6.03**	**5.46**		

Table 6. Total number of marketable leaves from three plots corrected for 20 plants at KARI Kakamega Research Station.

Kale Varieties	Harvest number						Means	Ranking
	1	2	3	4	5	6		
CABI 1	431	371	342	328	312	336	**353.33**	3
CABI 2	336	395	318	320	304	295	**328.00**	4
CABI 3	354	340	215	289	246	257	**283.50**	7
CABI 4	330	342	284	318	294	252	**303.33**	6
CABI 5	347	354	324	257	305	305	**315.33**	5
Collards	335	460	438	440	377	317	**394.50**	2
Sukuma Siku	635	612	380	552	444	306	**488.17**	1
1000 Headed	319	282	182	128	166	184	**210.17**	8
Harvesting Means	**385.88**	**394.50**	**310.38**	**329.00**	**306.00**	**281.50**		

A comparison of mean leaf yields of the kale varieties at both Lisuka and KARI Kakamega is presented in Figure 6. When presented graphically, the data from both sites clearly show that kale performance at Lisuka and KARI Kakamega was about equal in the first harvest (Figure 6). However, in the second harvest, Lisuka site out-performed KARI Kakamega by a very large margin. This gap was made worse for KARI Kakamega site after the second harvest when a big hailstorm hit the crop and destroyed most of the leaves. Although the crop struggled to recover, it maintained a slowly decreasing leaf yield just barely above 5.0 kg for 20 plants from harvest three to six. On the other hand, Lisuka site attained a peak leaf yield of about 20.0 kg for 20 plants in harvests two and three. Thereafter, leaf yield drastically dropped to 13.9 kg in harvest four, to 8.1 kg and finally to 7.4 kg for harvests five and six respectively.

Figure 7 compares the mean number of leaves harvested from 20 plants at various harvesting times in both Lisuka and KARI Kakamega. At Lisuka site, the mean number of leaves for 20 plants was 281 in the first harvest, and this rose to 359 and peaked at 414 in the second and third harvest respectively. Then the mean number of leaves started dropping to 357 and 278 in the fourth and fifth harvests respectively, then levelling off to 270 in the sixth harvest. For KARI Kakamega, in the first harvest, the mean number of leaves was 386, peaking to 595 in the second harvest before the hailstorm hit the crop. The number of leaves maintained the same level of 310, 329, 306 and 282 for third, fourth, fifth and sixth harvests respectively. There was a severe drought after the sixth harvest, when the harvesting could not be maintained at a frequency of 14 days. The data collection was therefore discontinued. However, for both KARI Kakamega and Lisuka sites, the mean number of leaves levelled off at above 200 for 20 plants. After the fourth harvest, some plants in the commercial collards kale variety started flowering and this increased in the subsequent harvests.

Figure 6. Comparison between mean leaf yields (kg)/20 kale plants, obtained at Lisuka and KARI Kakamega Research Stations respectively, during six successive harvests (i-vi) carried out in the period July-September 2005.

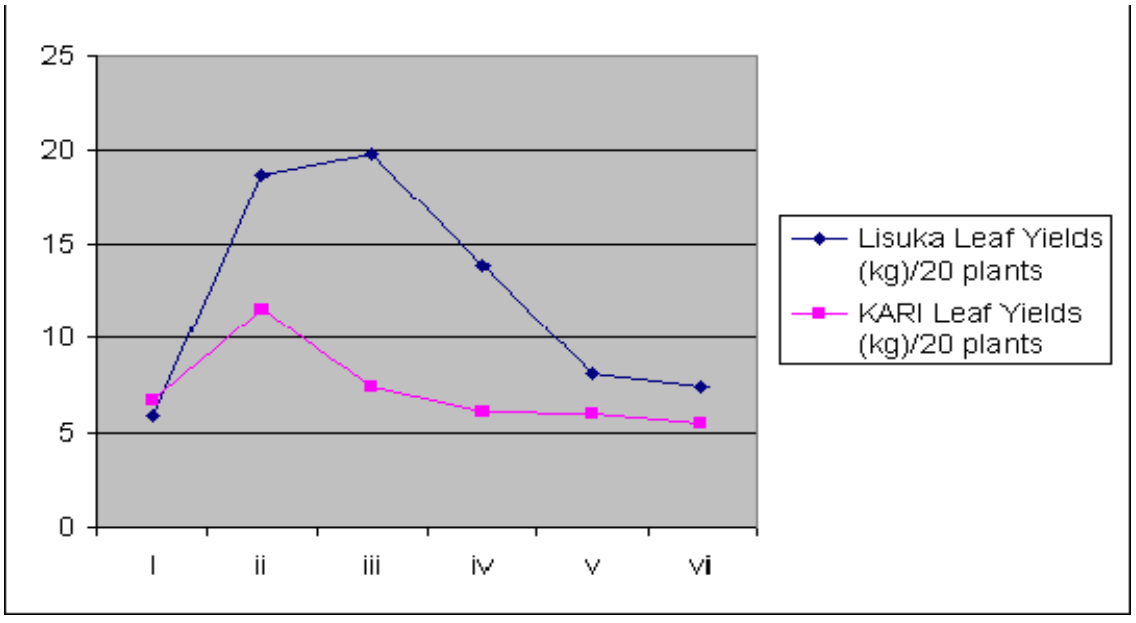
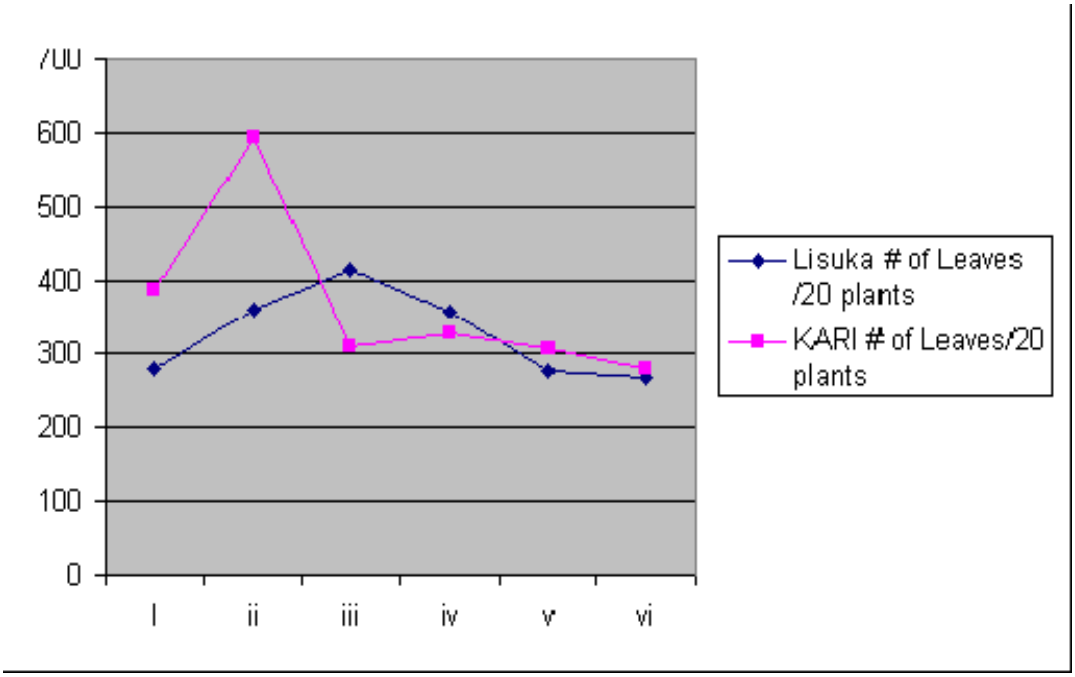


Figure 7. Comparison between mean numbers of leaves/20 kale plants, obtained at Lisuka and KARI Kakamega Research Stations respectively, during six successive harvests (i-vi) that were carried out July-September 2005.



The mean marketable leaf yield data from the two sites are presented in Figure 8. The commercial kale variety Collard takes a clear lead as a very good leaf yielder in the first harvest in both Lisuka and KARI Kakamega. However in the second harvest at Lisuka, CABI 1, CABI 2 and CABI 3 start chasing it dramatically. Collard maintains the lead at Lisuka in harvest three, but is overtaken at Lisuka in harvest four onwards. After six harvests at both sites, Collards was still the highest leaf yielder (22.73 kg from 40 plants), followed by CABI 1 (20.39 kg), then CABI 3 (20.26 kg) and CABI 2 (19.57 kg) being ranked second, third and fourth respectively. However, CABI 1, CABI 3 and CABI 4 overtook Collards from the harvest onwards at Lisuka site. The poorest leaf yielders were commercial kale variety 1000 headed (16.96 kg) followed by CABI 5 (17.92 kg).

The project team noted that CABI 2 showed a very interesting trend in leaf yield across both Western Kenyan locations. This line was one of the top yielders throughout. From fourth to sixth harvests, CABI 4 also achieved a very steady leaf yield, indicating that this productivity could be maintained beyond the time when all the other kale varieties start to show clear drop in leaf yields (i.e. from the fourth harvest onwards). It would be interesting to see how CABI 2 performs after the sixth harvest in the other locations in Central and Coastal Kenya. However, it was clear that the new CABI kale entries in these trials were quite superior, outyielding commercially 1000 Headed and Sukuma Siku, and perhaps beating Collards as well over a longer period of harvesting. The perceived weaknesses of the various varieties as assessed during the Western Kenyan trials are summarized in Table 7.

Figure 8. Comparison between combined mean leaf yields (kg)/plot (40 plants) obtained from seven kale varieties at Lisuka and KARI Kakamega Research Stations respectively, during six successive harvests (i-vi) carried out July-September 2005.

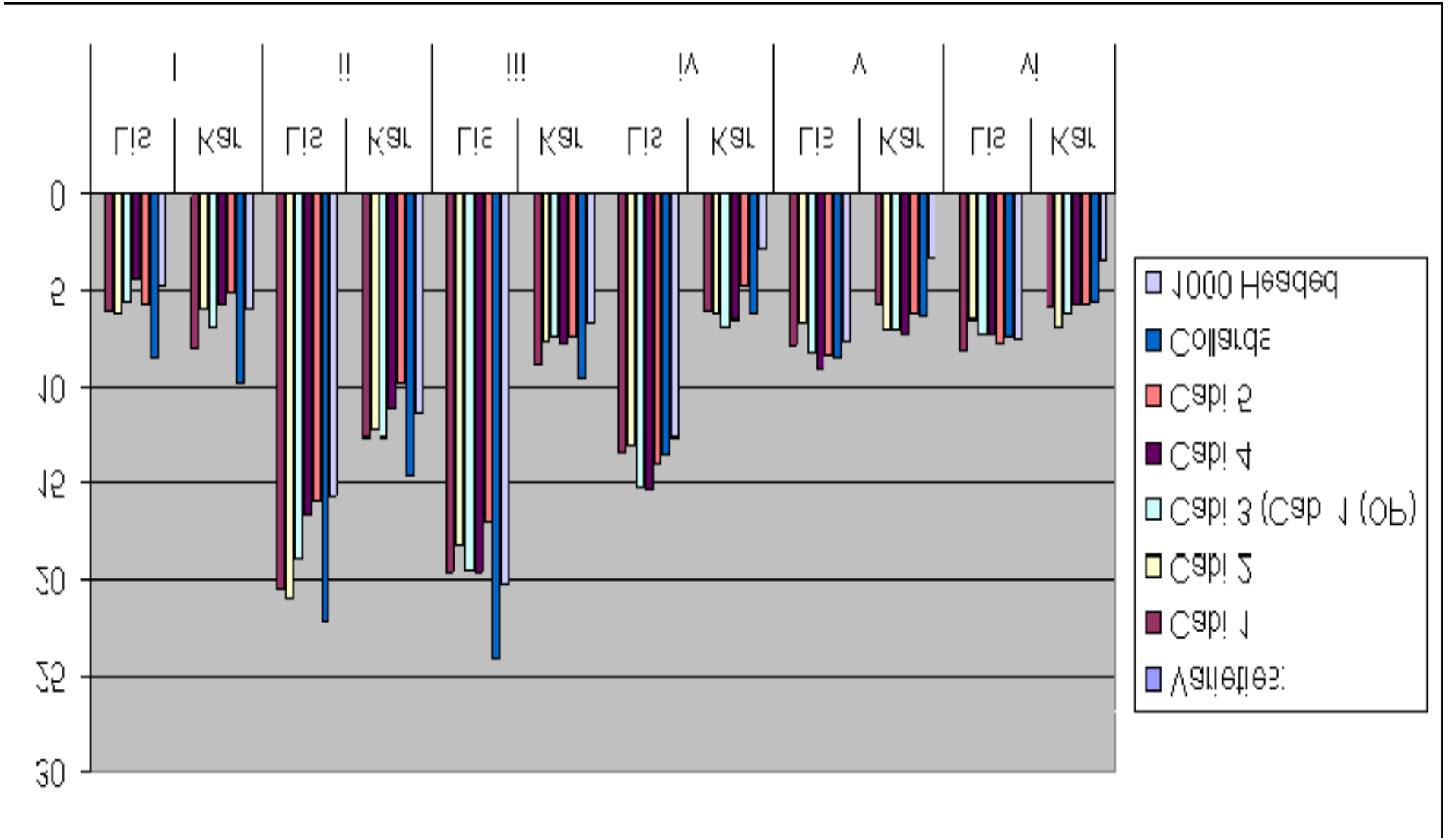


Table 7. Weaknesses of the three commercial kale varieties as tested against 5 CABI varieties, during trials conducted in Western Kenya.

Name of Variety	Observed Weaknesses at Lisuka and KARI Kakamega
Collards	Starts flowering very early, at the fourth harvest
1000 Headed	Very susceptible to black rot disease; also many stems crack and split
Sukuma Siku	very low seed viability; and severely wrinkled small leaves resulting in very low yields
CABI Varieties	No noticeable weaknesses so far.

1.3.3. Farmers participatory trials

Local growers who were taking part in the farmers' participatory evaluation of the five Kinale kale were issued with 5g of seed for each of the five lines (CABI 1 – 5). The farmers were asked to grow the lines along side the kales varieties that they normally cultivate, and that they should also provide feed back on several aspects of these lines' relative growth and performance by completing an evaluation questionnaire (see Appendix: *Questionnaire for evaluating CABI Kale lines by farmers who were given seed for testing in their gardens (2005*)). More than 500 farmers received seed in Kinale, Fathi, Gitithia, Nyathona, Athi River, Ruiru and Karig'uine. A total of 112 responses were returned and, where appropriate, data summarised using SPSS statistical package (for full analyses of raw data, see Appendix: *Descriptives collated from farmer evaluation surveys of CABI kale lines*).

The majority of participating farmers were male, came from the Lari or Ruiru Divisions of Kiambu district, and had been growing kale for ten or more years, some for as long as 40 years. The varieties of kale most frequently grown first by farmers were Kinale (31.3% of farmers), Collard (29.5%) and Kigaru (15.2%). Only about half of farmers chose to grow a second kale variety, but amongst those that did, Kale, Kinale, 1000 headed and Kamoro were favoured. Very few farmers normally grew a third kale variety (<22%), but in these instances, Kinale was the preferred variety (2.7%). The results of these farmers' evaluations of the CABI kales in comparison to their own varieties are presented in Table 8.

All of the CABI kale lines germinated more rapidly (about 24 earlier) than the farmers' own kale varieties. Farmers consistently found the success rates of transplanting CABI varieties to the field as high, and on average better than those recorded for their own varieties. CABI kale lines all provided a longer mean period for leaf-harvesting prior to flowering (4.6 - 4.8 months) compared to farmers' varieties (mean 4.3 months). Farmers perceived the general appearance of CABI lines, and the colour and shape of their leaves, to be better than those of their own varieties. Moreover, CABI lines were larger, and apparently more resistant to attack by pests and diseases. The incidence of aphids and powdery mildew, black rot, chlorosis, viral disease symptoms and general decay was recorded as being lower in the CABI lines than in other commonly grown varieties (for full data see Appendix: *Descriptives collated from farmer evaluation surveys of CABI kale lines: Diseases present*). CABI kale lines had a shorter cooking time and were also more palatable than local counterparts. In the light of all the above observations, farmers who took part in these comparative trials and responded to the feed back questionnaire, evaluated the CABI kale lines as possessing a higher % consumer preference than commercial varieties or any other kale lines that they normally grew, with CABI 5 scoring the highest (85.7%), and lines CABI 3 and 4 scoring joint lowest (82.1%). The vast majority of farmers confirmed that they were willing to buy the seeds of the CABI lines for their own use, and that they would recommend these lines to other growers. The line that farmers indicated they would be most willing to purchase was CABI 5 (88.4% of farmers); the lines that they were most happy to recommend were CABI 3 and CABI 5 (88.4% of farmers in each case).

Table 8. Summary of the results of farmers' evaluation of the 5 CABI kale lines

	CABI 1	CABI 2	CABI 3	CABI 4	CABI 5	Farmers' variety
Mean number of days to germination	4.71	4.70	4.68	4.69	4.67	5.81
Establishment post-transplanting (%):						
Good	90.2	89.3	89.3	92.9	95.5	55.4
Poor	8.0	8.0	9.8	4.5	3.6	33.9
Don't know	1.8	2.7	0.9	2.7	0.9	5.4
Mean period of harvesting before flowering (months)	4.59	4.66	4.67	4.72	4.80	4.27
General appearance (%):						
Excellent	39.3	47.3	33.0	36.6	58.0	16.1
Good	34.8	36.6	47.3	43.8	28.6	30.4
Fair	19.9	9.8	11.6	12.5	7.1	41.1
Not sure	8.0	6.3	8.0	7.1	6.3	12.5
Colour of leaves (%):						
Excellent	62.9	57.1	53.6	57.1	55.4	39.3
Good	25.8	28.6	24.1	24.1	29.5	22.3
Fair	11.3	3.6	10.7	8.9	5.4	24.1
Not sure	13.4	10.7	11.6	9.8	9.8	14.3
Shape of leaves (%):						
Excellent	27.7	31.3	23.2	24.1	33.0	12.5
Good	42.0	34.8	41.1	48.2	40.2	32.1
Fair	10.7	14.3	15.2	9.8	7.1	30.4
Not sure	19.7	19.7	20.5	17.9	19.7	25.0
Disease & insect pests present (%):						
Yes	29.5	23.2	33.0	27.7	29.5	64.3
No	70.5	76.8	67.0	72.4	70.5	34.8
Don't know	0.0	0.0	0.0	0.0	0.0	0.9
Comparison between CABI kales and farmers' variety – size						
Larger	76.6	83.9	81.3	87.5	87.5	18.8
Same	15.2	13.4	15.2	7.1	8.0	21.4
Smaller	4.5	0.9	1.8	2.7	3.6	58.9
Don't know	1.8	1.8	1.8	2.7	0.9	0.9

Table 8. continued……..

	CABI 1	CABI 2	CABI 3	CABI 4	CABI 5	Farmers' variety
Comparison between CABI kales and farmers' variety – cooking time (%)						
Longer	18.8	7.1	10.7	13.4	14.3	-
Same	21.4	22.3	25.9	23.2	20.5	-
Shorter	58.9	68.8	61.6	62.5	64.3	-
Don't know	0.9	1.8	1.8	0.9	0.9	-
Comparison between CABI kales and farmers' variety – palatability (%)						
Better	72.3	78.6	66.1	73.2	87.5	-
Same	18.8	12.5	23.2	17.9	5.4	-
Worse	3.6	3.6	5.4	2.7	2.7	-
Don't' know	5.4	5.4	5.4	6.3	4.5	-
Comparison between CABI kales and farmers' variety – consumer preference (%)						
Higher	84.8	84.8	82.1	82.1	85.7	-
Same	4.5	5.4	8.9	7.1	6.3	-
Lower	5.4	5.4	4.5	5.4	4.5	-
Don't know	5.4	4.5	4.5	5.4	3.6	-
Farmers' willingness to buy the seed of CABI lines (%):						
Yes	79.5	85.7	80.4	87.5	88.4	-
No	20.5	14.3	19.6	12.5	11.6	-
Farmers' willingness to recommend CABI lines to other growers (%):						
Yes	83.9	85.7	88.4	85.7	88.4	-
No	16.1	14.3	11.6	14.3	11.6	-

1.3.4. Summary of participatory multilocation trials findings:

- In the participatory trials undertaken at the four Central Kenyan locations, the performance of the five CABI kale lines varied considerably between sites. Generally speaking, however, CABI 1-5 consistently out-performed 1000 headed kale, especially lines CABI 1 and CABI 3.

- The marketable yield produced by the other commercial variety used in the Central Kenyan trials, Collards was, by contrast, at least as good as that yielded by the CABI lines at almost all sites.

- The trials undertaken in Western Kenya, at Lisuka, also found that the worst yielder was 1000 headed commercial variety, both in terms of the weight of marketable leaves produced, and in terms of its very low number of marketable leaves/plant.

- Collards from Kenya Seed Company was the highest yielder at Lisuka in terms of leaf weight, followed by CABI 1, CABI 3 and CABI 4, which ranked second, third and fourth.

- In terms of mean numbers of marketable leaves per variety, at Lisuka the five CABI kales were very promising. Although commercial variety Collard produced the most leaves, the other high performing varieties were CABI 2, CABI 1 and CABI 5, in that order.

- At the Western Kenyan site Kakamega, Collards had the highest yield of marketable leaves, followed by CABI 1, CABI 3 and CABI 2 respectively. The worst leaf yielders were commercial kale varieties, Sikuma Siku and 1000 headed.

- Leaf size and number of leaves should be critically considered during kale selection to give the highest marketable leaf yield. The commercial variety, Collards, has this balance and this is the reason for its very good leaf yield performance in both sites. However, the length of harvesting during the life of a kale crop determines the final economic potential of the variety. This is what the CABI kale selections seem to offer above the current commercial kale varieties.

- The project team noted that CABI 2 showed a very interesting trend in leaf yield across both Western Kenyan locations. This line was one of the top yielders throughout. From fourth to sixth harvests, CABI 4 also achieved a very steady leaf yield, indicating that this productivity could be maintained beyond the time when all the other kale varieties start to show clear drop in leaf yields.

- At the on-farm sites, all of the CABI kale lines germinated more than the farmers' own kale varieties.

- Farmers consistently found the success rates of transplanting CABI varieties to the field as high, and on average better than those recorded for their own varieties.

- CABI kale lines all provided a longer mean period for leaf-harvesting prior to flowering compared to farmers' varieties.

- Farmers perceived the general appearance of CABI lines, and the colour and shape of their leaves, to be better than those of their own varieties.

- Farmers perceived CABI lines to be larger, and apparently more resistant to attack by pests and diseases.

- CABI kale lines had a shorter cooking time and were also more palatable than local counterparts.

- The vast majority of kale farmers evaluated the CABI kale lines as possessing a higher % consumer preference than any of the other the kale varieties that they normally grow, with CABI 5 scoring the highest (85.7%), and lines CAB 3 and 4 scoring joint lowest (82.1%).

- The vast majority of farmers confirmed that they were willing to buy the seeds of the CABI lines for their own use, and that they would recommend these lines to other growers.

- The line that farmers indicated they would be most willing to purchase was CABI 5 (88.4% of farmers); the lines that they were most happy to recommend were CABI 3 and CABI 5 (88.4% of farmers in each case).

1.4. Scaled up multiplication of seed for release

Multiplication plots were established at Njabini, in central Kenya, to ensure that there is enough seed to meet the demand of farmers for improved kale lines in subsequent years. Kale seeds of the five lines (CABI 1, CABI 2, CABI 3, CABI 4 and CABI 5), which were submitted to KEPHIS for seasonal distinctness, uniformity and stability (DUS) trials (see Activity 1.1), were sown in raised nursery beds on 6 May 2005 and transplanted on 6 June 2005. Before sowing the seeds, the soil in the nursery beds was drenched with Pencyron® (mencyron). The five kale lines, raised in separate nursery beds, were transplanted to five separate plots (each 11.2 x 2.8m in size, consisting of a total of 72 plants (four rows x 18 plants row $^{-1}$, with a plant spacing of 60 x 60cm) as shown in Figure 9. Each plot was enclosed in a wooden/metallic structure covered with a screen-house material (Tygun, 50 mesh; Amiran (K) Ltd., Nairobi, Kenya) to prevent cross pollination (Plate 2).

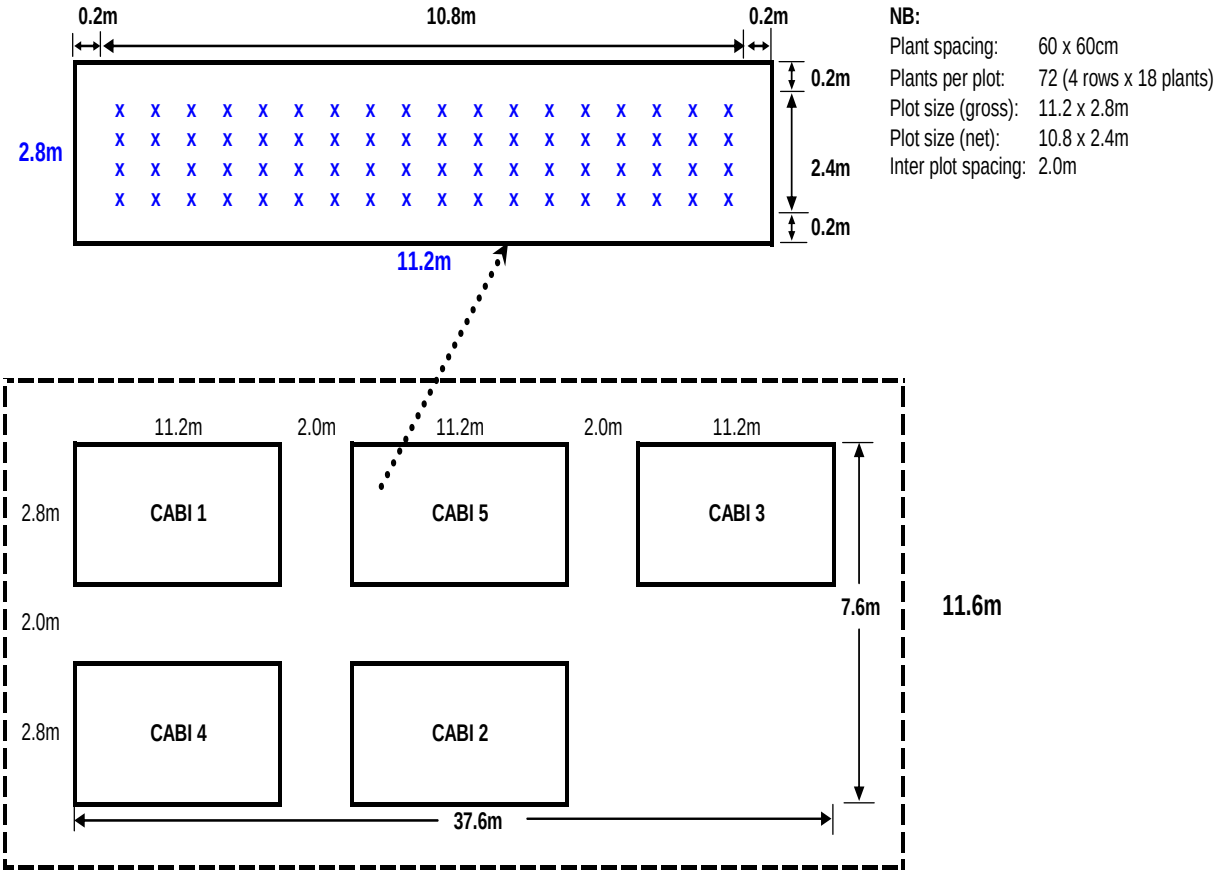


Figure 9: Field layout of the multiplication trial of improved Kinale kale lines at Njabini, Central Kenya.

Plate 2: Screen-houses used for the multiplication of improved Kinale Kale lines at Njabini, Central Kenya.

Diammonium phosphate (DAP) (2g plant^{-1}) and Calcium ammonium nitrate (CAN) (4g plant^{-1}), fertilisers were applied twice; first during transplanting, and then two weeks later, respectively. Plants were routinely inspected, and any off-type plants observed in each plot were uprooted before the flowering stage. At the onset of flowering, a colony of bees (*Aphis indica*) was introduced in each "screen-house" to serve as pollinators. By the end of December 2005, the majority of plants, for all the five kale lines had formed pods, but the seeds will not be ready for harvesting until the end of January 2006. Hence, the data on the quantity of seeds harvested, from this bulking up trial was not available by the end of the project.

Thirty representatives of farmers, including the respective leaders of farmer groups, from LARI Division, central Kenya, who were actively involved in establishing and monitoring of the on-farm participatory demonstration plots (for promotion of seed production technologies under Activity 3.1) visited the above multiplication plots in Njabini, on 22 November 2005.

1.5. Assessment and monitoring genetic stability of kale

Consultations with IPGRI and KARI on options for assessing and monitoring genetic stability have taken place. Seed of all lines developed in the previous project, including the 5 lines used in this phase, will be deposited in the KARI genetic resources unit at Muguga and in the vegetable gene bank at Warwick-HRI.

1.6. Monitor the incidence of seed-borne pathogens of kale in seed production systems

It was intended that the scientist who was supposed to have carried out this project was do so as part of her M.Phil studies. The protocol was to be agreed upon with her main supervisor before any field activities were carried. Unfortunately, due to unforeseen circumstances that resulted in delays, the scientist did not start her studies. However, the following observations were made during the course of other activities undertaken during R8439:

It was generally recorded in the participatory multilocation trials carried out in Central Kenya (Activity 1.3.1), that the majority plants of the commercial variety 1000 headed kale were infected by black rot (*Xanthomonas campestris*) disease (Plate 3) at Kabete, Thika and Mwea. However, there was a very low incidence of this disease on the same variety at the trial site in Njabini. When the performance of three commercial kales (Collards, 1000 headed and Sukuma Siku) were compared against the 5 CABI varieties in Western Kenya, 1000 headed kale was, once again, found to be very susceptible to black rot disease. Of the 112 farmers who completed the evaluation questionnaire provided in activity 1.3.3 (farmer participatory trials), 66 individuals (59%) recorded at least some incidence of pest/disease in their usual kale crop (i.e. non CABI lines) (see Table 9, below). Of these infected plants, approximately 14% showed symptoms of black rot.

Plate 3: A plot planted with a local commercial variety showing plants infected by black rot (*Xanthomonas campestris*) in the multilocation trial at Thika, Central Kenya.

Local (farmer's variety) indicate disease (or describe symptoms)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	leaf chlorosis	1	.9	.9	.9
	aphids and powdery mildew	1	.9	.9	1.8
	aphids and yellowing	1	.9	.9	2.7
	black leaf spots	2	1.8	1.8	4.5
	black leg	1	.9	.9	5.4
	Black rot	7	6.3	6.3	11.6
	Black rot and chlorosis	1	.9	.9	12.5
	brown leaf spots	1	.9	.9	13.4
	insects and blight	1	.9	.9	14.3
	Leaf chlorosis	1	.9	.9	15.2
	leaf rust	1	.9	.9	16.1
	leaf spot	1	.9	.9	17.0
	leaves curling	1	.9	.9	17.9
	leaves turning purple	1	.9	.9	18.7
	moths	1	.9	.9	19.6
	muthingithu	1	.9	.9	20.5
	n/a	46	41.1	41.1	61.6
	powdery mildew	2	1.8	1.8	63.4
	purple leaves	2	1.8	1.8	65.2
	some have spot blight	2	1.8	1.8	67.0
	spot blight	3	2.7	2.7	69.6
	spots	4	3.6	3.6	73.2
	top decaying	3	2.7	2.7	75.9
	turning yellow and spot blight	1	.9	.9	76.8
	virus	7	6.3	6.3	83.0
	Virus	3	2.7	2.7	85.7
	white flies	1	.9	.9	86.6
	Yellow patches and rotting (Black Rot)?	1	.9	.9	87.5
	yellowiing +blackrot	1	.9	.9	88.4
	yellowing	13	11.6	11.6	100.0
	Total	112	100.0	100.0	

Table 9. Farmer's evaluation of the incidence of diseases found in commonly grown kale varieties (excluding the CABI lines 1 - 5)

2. Activity: Register and initiate the release process for new kale seed lines

2.1. Draw up and agree intellectual property (IP) agreement

The IP agreement has not yet been developed. We will wait to see if we have new varieties before proceeding, depending on the outcome of the KEPHIS trials. There have been extensive discussions on how best to proceed. Consultations with lawyers at ACTS, ICRAF Complex resulted in the decision that IPR issues should be addressed in a separate project. However, there was no provision for such an arrangement in the existing project.

2.2. Prepare appropriate release documentation for submission to KEPHIS

Documentation was prepared and submitted to KEPHIS in April. This included the characteristics of kale and descriptions of each of the 5 lines submitted (see Activity1.1).

3. Activity: Sustainable seed production technologies promoted

3.1. Establish on-farm participatory demonstration plots for promotion of seed production technologies

Two participatory demonstration plots (each 0.25ha) on seed production were established on-farm with existing farmer groups (Gitithia, Bathi and Kinale) in Lari Division, in two different agro-ecological zones (Plates 4 and 5). The two sites (i.e. Bathi and Njabini, in Nyandarua and Kiambu Districts, respectively) were selected by farmers during a field day held on 01 April 2005. One of the improved kale lines (CABI 5), which was selected with farmers during the previous project (R8312), also submitted to KEPHIS for DUS trial and bulked up at Njabini (under Activities 1.1 and 1.4, respectively) was planted in the pilot multiplication plots at both sites. The kale seeds were sown by representatives of the Lari group of farmers on 6 May 2005 (at both sites), and transplanted on 8 June 2005 and 10 June 2005 (at Bathi and Njabini, respectively). The plant spacing and fertiliser application adopted by the farmers was as described in Activity 1.4. The seed crop at Bathi was managed by the farmers themselves, whereas the farmers employed someone to take care of the seed crop at Njabini. At least three of the representatives of the farmers' group visited, at least once a week, to monitor the progress of the seed crop at Njabini. The scientist from CABI and KARI provided technical backstopping to the farmers.

Plate 4: On-farm pilot plot for the multiplication of one of the improved Kinale kale lines at Njabini, Central Kenya.

The majority (> 60%) of the kale plants had already flowered (Plate 5) and started producing pods, by the end of December 2005. However, harvesting of the seeds has not yet started because the seeds have not matured - an activity that would commence by end of January 2006. The farmers were enthusiastic and are keen to learn more on seed harvesting and processing (see Activity 3.2), an activity that could only be effectively demonstrated when the seeds are ready for harvesting.

Plate 5: On-farm pilot plot for the multiplication of one of the improved Kinale kale lines at Bathi, Central Kenya.

In preparation for possible continuous multiplication and commercialisation of the improved kale seeds (if approved by KEPHIS), the participating farmers from Lari Division, has been having extensive discussions and consultations amongst themselves and the community development authority. A key progress arising from the consultation is that the farmers group has obtained official registration and authority from the District Social Development Officer (Kiambu District), under the National Community Development Programme in Kenya. The group was registered as, *LASEGRO* (Lari Seed Growers) *Self Help Group* (Registration Certificate No. 19012).

3.2. Establish demonstrations for small-scale post harvest seed processing (i.e. drying, grading, storage and packaging)

The activity could not be completed within the current project period because the seeds were not yet ready for harvesting. This activity will be undertaken at harvesting period. Farmers will have the opportunity to see this at Agricultural Shows in Kenya.

3.3. Produce and disseminate dissemination materials such as leaflets and posters.

Posters of factsheets* from previous project (R8312/ZA0582) translated into Swahili and distributed to ~70 farmers. Each farmer given 3 posters; 1 to keep, 2 to distribute. (*Phiri, N, Chacha, D, Kuria, A, Mwaniki, A, Achieng, B, Ndirangu, S, Simons, S, Kibata, G, Njuki, J, Spence, N (2003) Potential of self selection of seed of tolerant/resistant components of land races of kale for disease management in Kinale. *Phiri, N, Chacha, C, Kuria, A, Mwaniki, A, Achieng, B, Ndirangu, S, Simons, S, Kibata, G, Njuki, J, Spence, N (2003) Promotion of improved kale seed in Kinale).

Contribution of Outputs to Developmental Impact

The submission of seeds from lines CABI 1-5, and the initiation of DUS trials, comprise critical steps in the evaluation, registration and release processes for new kinale kale seed varieties. The parallel activities of evaluation of CABI 1-5 in a series of multilocational trials at contrasting agroecological zones have confirmed that these lines are robust. Moreover, variations in their relative performances at different sites will accommodate the needs of farmers who cultivate kale under different growing conditions. The overwhelmingly positive response obtained by participating farmers to the improved kinale lines not only lends further support to the strengths of CABI 1-5. The process of obtaining this valuable feedback from local growers has also, in itself, contributed immensely to the promotion of sustainable seed production technologies in peri-urban Kenya. Seeds from CABI 1-5, and accompanying questionnaires inviting feedback re. the relative performances of these lines, were distributed to several hundred farmers who cultivate kale crops in a total of 39 villages, located in six different Districts of Kenya. Responses were obtained from 112 farmers, who grew these kales on their farms. In the previous project R8312, promotional materials encouraging good seed multiplication practice, and emphasising the value of producing/purchasing good quality vegetable seed, were developed and disseminated to >1,000 potential smallholder farmers, NGOs and micro-entrepreneurs through KARI, extension services, NGO's and other CPP uptake pathways in Kenya. Posters of these factsheets have now been translated into Swahili and multiple copies have been passed on to further 70 farmers, for even wider distribution. Participatory farmers' groups are very enthusiastic about what they have seen at on-farm participatory demonstration plots, regarding the management of a seed crop, seed multiplication methods, harvesting and germination. The establishment of seed-producing farmer groups during the pilot study undertaken during R8439 is likely to result in sustainable community–based seed production in the future, with a significantly improved product. Commercial seed companies may wish to access varieties in the future for scaled-up production. The commercial sales generated would result in wider availability and distribution of improved seed across Kenya and beyond.

In general terms, R8439 has therefore contributed to sustainable rural livelihoods in that the outputs will help farmers to produce their vegetable crops (for consumption and sale) in a safe, more effective and economic way. Benefits will include improved nutrition for whole families, better cash returns from higher yields of better quality produce and an empowerment through agricultural knowledge which will help them to make informed choices on other cropping options. Potential beneficiaries of this project not only comprise smallholders from the lower income categories who lack financial resources for whom sustainable production systems are needed for producing food for domestic and local markets. In addition, the producers of seed could receive added value for their enterprises from the commercial production of the seed. Commercial smallholders supplying urban markets and those out-growers contracted to the exporting companies may also benefit from the outputs of R8439, as will rural communities who will gain from the employment opportunities provided by horticulture. Micro-entrepreneurs or communities who can brand and market seed who could benefit from the economic returns of selling seed.

Dissemination Outputs:

Scientific papers

LENNE JM, PINK DAC, SPENCE NJ, WARD AF, NJUKI J AND OTA M (2005). The vegetable export system: a role model for local vegetable production in Kenya. Outlook on Agriculture (*in press*)

SPENCE N, PHIRI NA, HUGHES SL, MWANIKI A, SIMONS S, ODOUR G, CHACHA D, KURIA A, NDIRANGU S, KIBATA GN AND MARRIS GC (2006). Economic impact of Turnip Mosaic virus and Cauliflower Mosaic virus in Cabbage and Kale in Kenya. (*In submission to Plant Pathology, December 2005*)

PHIRI NA, SPENCE N, HUGHES SL, MWANIKI A, SIMONS S, ODOUR G, CHACHA D, KURIA A, NDIRANGU S, KIBATA GN AND MARRIS GC (2006). Identification of Beet mosaic potyvirus (BtMV), and its effect on the yield of Swiss chard in Kenya. (*In submission to Plant Pathology, January 2006*)

SPENCE N, CHACHA D, KARANJA D, KIMANI M, MUSEBE R, NJUKI J, PHIRI N, KIBATA G, KOECH S, KIMANI E, LANG'AT E, ONIM M, ROBERTS S AND MARRIS GC (2006). Promotion of quality vegetable seed in Kenya. *Perspectives on Pests: Achievements of Research under the UK DFID's Crop Protection Programme* (*In Press*).

Published abstract

SPENCE, N.J., LENNE, J.M., PINK, D.A.C., NJUKI, C., WANYONYI, C., KIMANI, P.M. (2005) Opportunities and Constraints for Future Economic Development of Sustainable Vegetable Seed Businesses in Eastern and Southern Africa. The International Conference on Agricultural Research for Development: European Responses to Changing Global Needs 2005. Session 6. Food Issues: Food Quality, Food Safety and Trade Regulations. Swiss Federal Institute of Technology Zurich, Switzerland: 121. (Published Abstract).

Magazine article

LENNE, JM, SPENCE NJ & WARD, A (2005). Reap what you sow. *African farming and food processing* **47**, 15-16.

Posters/Factsheets

Posters of factsheets* from previous project (R8312/ZA0582) translated into Swahili and distributed to ~70 farmers. Each farmer given 3 posters; 1 to keep, 2 to distribute. (*Phiri, N, Chacha, D, Kuria, A, Mwaniki, A, Achieng, B, Ndirangu, S, Simons, S, Kibata, G, Njuki, J, Spence, N (2003) Potential of self selection of seed of tolerant/resistant components of land races of kale for disease management in

Kinale. *Phiri, N, Chacha, C, Kuria, A, Mwaniki, A, Achieng, B, Ndirangu, S, Simons, S, Kibata, G, Njuki, J, Spence, N (2003) Promotion of improved kale seed in Kinale).

Questionnaire

Questionnaire for evaluating CABI Kale lines by farmers who were given seed for testing in their gardens (2005). (word document, 3pp.)

Internal Reports

Minutes of CABI Project meeting – 11/04/05
Minutes of CABI project meeting 12/04/05
Short report of Seed Distribution visit, Nyalhona (Kibika) – 13/04/05
Minutes of Participatory Farmers meeting – 14/04/05
Short report of meeting with Gilbert Kibata – 15/04/05
Summary report of Nicola Spence's visit to Kenya (April 2005) – 12/05/05

Project Progress Reports

Crop Protection Programme PPR1 – April-September 2005

Datasets generated

CABI (2005) Dataset: Farmer Evaluation of CABI kale lines. Details of participating farmers' genders, village/sublocation/division/district of origin, the period for which they have been growing kale, and data on the 1st, 2nd and 3rd kale varieties grown. Includes the following comparative data on line CABI 1-5, and a locally grown "farmers' variety" of kale: number of days to germination; how well lines become established after transplanting, overall quality of general appearance, colour and shapes of leaves, the incidence and nature of any diseases found (aphids, mildew, viral symptoms etc.), overall height, cooking time, palatability, consumer preference, period (months) until harvesting, and willingness of farmers use each variety and recommend them to other growers. Microsoft Word Document (76.5kb). Author N. Phiri. CAB International Africa Regional Centre (CABI ARC), Kenya.

KEPHIS (2005) Dataset: Raw data for above word file. Microsoft Excel spreadsheet (470kb). Author: D. Kimani. Kenya Plant Health Inspection Service (KEPHIS), Kenya.

CABI (2005) Dataset: QVS Kale Multilocation trials data 2005. Microsoft Excel spreadsheet (945kb). Author: D. Chacha. CAB International Africa Regional Centre (CABI ARC), Kenya.

CABI (2005) Dataset: Colour codes (for characterisation of kinale kale plants). Microsoft Word Document (135kb). Author: N. Phiri. CAB International Africa Regional Centre (CABI ARC), Kenya.