Kale seed multiplication schemes take off in Kenya

Validated RNRRS Output.

Smallholders in Kenya are producing healthy, good quality kale seed thanks to a new model for sustainable multiplication. The first step was to establish the primary virus diseases responsible for crop loss. Then, researchers identified and compared new, improved varieties with resistance to the major threats to farmer varieties. They also surveyed farmer preferences to determine their preferred multiplication methods. The new model, together with a scheme for improved seed certification, has reached more than 1000 farmers, NGOs and micro-entrepreneurs. Multiplication plots are providing large batches of seed and farmers have been set up as seed producers in remote zones.

Project Ref: **CPP11:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **Central Science Laboratory, UK**
Source: **Crop Protection Programme**

Document Contents:

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Geographical regions included:

Kenya,

Target Audiences for this content:

Crop farmers,

Description

CPP11

A. Description of the research output(s)

1. Working title of output or cluster of outputs.

Management of virus diseases of vegetable crops and the promotion of quality Kale seed in Kenya

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

DFID Crop Protection Programme

3. Provide relevant R numbers

R7571 (ZA0376)
R8312 (ZA0582)
R8439 (ZA0663)

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3. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? ***(max. 400 words)****. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Smallholder vegetable production is an important and expanding component of rural livelihoods in Kenya, providing vital employment and income for poor farming communities. Although it is recognised that viral pathogens were/are responsible for major crop-losses, their nature and true impact have been poorly understood. Our projects arose as a result of concern expressed by KARI, CABI-ARC and the **periurban** (**PU**) PSL that the constraints these diseases place on vegetable crops were not being adequately addressed. The scope of these projects was **Kenya**, with an emphasis on **Brassicae** and **Swiss chard**.

In initial project R7571, the primary viruses responsible for most-common viral diseases of vegetables were identified and characterised. To compare the outcomes of either early- (seedling) or late- (post-nursery) stage infection on the impact of viral disease, effects timing of infection with ***Beet mosaic virus***, ***Cauliflower mosaic virus*** and/or ***Turnip mosaic virus*** on yields of Cabbage, Kale and/or Swiss chard were determined. Alternative **IPM** strategies (application of mulches, fleece, dimethoate), to reduce incidence of aphid vectors were identified. These were evaluated by farmers' groups, and cost analyses undertaken. In order to ascertain vegetable farmers' **perceptions of management strategies for viral diseases**, an extensive **Participatory Rural Appraisa**l (**PRA**) was undertaken, as well as a survey of farmers' **Indigenous Technical Knowledge** (**ITK**). It was clear that a large number of farmers ranked a lack of availability of **good quality seed** alongside incidence of pests and diseases, as equally limiting to their success as vegetable growers.

The overall emphasis of subsequent projects R8312 and R8439 became the promotion of a sustainable system for farmer-led multiplication of kale seed for smallholders. To understand farmers' perceptions/market needs w.r.t. seed purchases, we surveyed the availability, distribution, supply of brassica seed in the Kenyan **commercial seed sector**, and a seed inventory was also drafted. To ascertain health of existing kale seed, brassica seed lots from across Kenya were screened for ***Xanthomonas campestris pv. campestris*** *(**Xcc***) and *Alternaria* sp. High levels of these pathogens were found with farmers. Crop residue management practices to control incidence of black rot (Xcc) were evaluated, and the half-life for the inoculum was established (leaf only). To measure the potential for registering commercial (kale) seed business, farmers and local seed companies were canvassed. Constraints/opportunities were identified, and a recommended plan produced. In order to develop a production strategy for **improved kale seed, participatory on-farm-trials** were undertaken with key farmers' groups, alongside **Distinctiveness Uniformity and Stability** (**DUS**) trials at Njabini Research Station. As a result >20 Kale lines were fully characterised. Five Kinale superior kale lines, designated CAB 1-5, were identified, and their seeds were submitted to KEPHIS with documentation detailing respective characteristics. Preliminary results of DUS confirm that these "improved" lines are indeed distinct from existing commercial varieties. Seeds of all lines developed in R8312 deposited in KARI genetic resources unit, and in vegetable gene bank (Warwick-HRI). The performances of CABI 1-5 have been evaluated compared to local varieties, through multilocational trials, with farmer participatory input. To enable smallholders to produce healthy, good quality seed of acceptable market value, a suitable model for a **sustainable kale seed multiplication** system was identified. The preferred leaf-harvesting model was validated by farmers and project members. The use of good seed multiplication practice for kale and improved **seed certification** using the preferred model have been promoted through factsheets which were disseminated to >1,000 potential smallholder farmers, NGOs and micro-entrepreneurs through KARI, extension services, NGO's and other CPP uptake pathways in Kenya (also translated into Swahili), using preferred model. Local seed-testing capability was enhanced by reciprocal visits between key personnel from KEPHIS Plant Health Quarantine Station, who visited HRI for training in latest ISTA technical methodologies for seed testing/pathotyping of Xcc, HRI personnel who travelled to laboratories at KEPHIS & KARI-NARL.

To prepare for continuous multiplication/commercialisation of improved kale seeds, multiplication plots have been established to provide large batches of seed. Discussions have also been initiated with farmers on setting up as seed producers, and remote zones on forest edges of Njabini have been identified as suitable sites. A farmers' association, LASEGRO (Lari Seed Growers Self Help Group re. cert. 19012) has been registered. The project team is now looking to engage the private sector, and to establish landrace ownership models with farmers.

Outputs from the above projects include numerous datasets, conference presentations, and several fact sheets and posters. Other key written outputs are:
Njuki *et al*. (2003). *Socioeconomic report*, 56pp;
Njuki *et al*. (2003) *Survey Report*. CABI-ARC19pp.
Spence *et al*. (2006) *Plant Pathology* (in Press).

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
X			X		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

The main commodities upon which these outputs focussed were kale, cabbage, spinach and Swiss chard. However, outputs obtained from projects R8312 and R8439 could equally be applied to many other brassica/cruciferous crops grown in PU districts of Africa, or to any other crops from which seeds are harvested and could be commercialised for the benefit of local groups. The beneficial crop-management practices identified in R7571 (e.g. use of straw mulches on nursery beds to reduce aphid numbers and incidence of viral disease) could potentially be applied to many other crops that are vulnerable to vector-borne pathogens.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
				X			

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	Irrigated	Wetland rice based	Smallholder rainfed highland	Smallholder rainfed dry/cold	Dualistic	Coastal artisanal fishing
	X		X			

9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (***max. 300 words****).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

The main focus of the PU vegetable cluster since 1995 has been Kenya and brassica crops in PU vegetable systems. The virus management project (R7571) was conceived, and then further expanded (R8312/R8439), to address a research gap in the overall management of pests and diseases affecting brassica crops in these systems, insect pests, fungal diseases and nematodes being addressed through other CPP projects (R6764, R7403, R7449 and R7472). Outputs from R7571/R8312/R8439 were/are highly complementary to these other projects, and enhanced the cluster's ability to address major biotic constraints affecting brassica crops in PU vegetable systems in Kenya. These outputs could also be usefully clustered with any/all other projects that address viral disease of vegetables, seed quality, use of nurseries and farmer grower associations. For example:
CPP R8480 (also Swedish Development Council (SDC) funded) *Good Seed Initiative*: seed quality and farmer practices for saving seed.
CPP R8429/R8281 *Linking demand and supply of agricultural information* .
CPP R8104/R8435 *Farmer multiplication systems [potato/ground nut]*: Quality and seed; setting up a seed growers group;
CPP R8435/R8104/R7856 *Sustainable potato seed tuber management*: Focus on nursery plot management; Quality and seed; setting up a seed growers group;
CPP R8299/R8219/R8296/R8041/R7813/R7472/R7403/R6764 *Accelerated uptake and impact of CPP research outputs - for up-scaling*

Validation

B. Validation of the research output(s)

*10****. How*** *were the output(s) validated and* ***who*** *validated them?*

Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation ***(max. 500 words)****.*

- R7571 evaluated the feasibility/implications of different viral disease management strategies. Validators were >100 Kenyan smallholders (highland rainfed; irrigated), from PU Nairobi (project endusers): Some validators were already group-members, all farming along the Ruiru River. Others, at Athi River, were especially brought together to participate in PRA and on-farm trials. All farmers were growing vegetables for on-farm consumption and sale in neighbouring markets. Four treatments were evaluated: application of fleece, straw mulch, farmer practice treatment (dimethoate) and no treatment (control). Farmers selected criteria to assess alternative management strategies (labour requirements, availability of materials, ability to control the disease,

etc.). Farmers ranked each treatment (best = 1, worst = 4) according to these criteria, and indicated pro.s/con.s in each case.

- The relative effect(s) of three different leaf-harvesting regimes on quantity/quality of kale-seed were evaluated. Trials were replicated in test beds (Njabini Research Sub-Centre), and on-farm, by participatory farmers' groups. 300 farmers (50 families) participated, s.t. a preferred model was validated at a wide range of smallholdings. Validators were therefore primarily PU Kenyan smallholders (highland rainfed), from Nairobi (project endusers), and also KARI personnel. Farmers provided land and labour; the project provided seeds, pesticides and fertilizers. Farmers participated in land preparation, sowing, transplanting, crop protection, leaf/seed harvesting. Each harvesting regime was evaluated once/selected farm and four times on-station. On-station trials were arranged in a randomised split-plot design, with seed production models as main plots, and four CABI lines as subplots. Randomisations were generated using Genstat. Cost-Benefit analyses of leaf and seed yields w.r.t. harvesting regimes at different sites, were undertaken by Steven J. Roberts (Consultant Plant Pathologist, Plant Health Solutions, Warwick UK), and CABI-Africa Project members)).
- Prior to registration, selfed-seeds from improved kales, designated CABI 1-5, were submitted to KEPHIS to allow completion of DUS trials. (Seeds of two commercial kale varieties served as local checks for comparison). KEPHIS also received full characterisation details for each line.
- Validation of CABI 1–5 performance compared with local commercial varieties was carried out b.m.o. multilocational trials in different agro-ecological zones of Central and Western Kenya. Kale-growing farmers (~500 individuals) from different districts were also supplied with seeds to grow on their farms; they subsequently completed evaluation questionnaires. Most participating farmers were male, came from the Lari or Ruiru Divisions of Kiambu district, and had grown kale for 10-40 years. >100 responses were returned; data was summarised using SPSS statistical package. Validation was therefore conducted by PU Kenyan smallholders (highland rainfed), from various districts within Nairobi (project endusers), and also CABI and KEPHIS personnel. (At each site, trials were laid out in a randomised design with four and three replicates for the on-station and on-farm trials, respectively).
- Two participatory seed-production demonstration plots were established on-farm with existing farmer groups (see above). Sites were selected by farmers, and CABI 1-5 seeds were sown by farmers' group representatives. Seed crops are managed by the farmers themselves (Bathi), or farmers employ someone to tend the crop (Njabini). Farmers' group representatives visit once/week, to monitor progress. CABI/KARI staff provided technical backstopping.

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

Validation of viral disease-management strategies: on working farms in 2 districts (Ruiru River; Athi River), in growing seasons between March 2000-2003. (Production System: PU; Farming system: Smallholder rainfed highland, also irrigated; Social groups: Smallhoder farmers, male/female, moderate poor (endusers)).
Validation of preferred harvesting model: at Njabini KARI Research Sub-Centre, South Kinangop, (foot of Aberdare mountain ranges) and at highland rainfed PU smallholdings at Kinale, Gitithia and Bathi. Initial plantings February 2004; trials continued throughout subsequent growing season (Production System: PU; Farming system: Smallholder rainfed highland; Social groups: Smallhoder farmers, male/female, moderate poor (endusers)).
DUS trials: KEPHIS Nakuru site (rainfed highland) in 2005 (Production System: PU; Farming system: Smallholder rainfed highland).
Multilocational validation trials: In central Kenya, on-station trials were established at Kabete (Univ. Nairobi's College Agriculture and Veterinary Services' farm), Njabini (KARIs farm) and Thika (KARI-National Horticultural Research Centre's farm). An on-farm trial was also established in Mwea. In Western Kenya, lines were validated at 3 stations, including Lagrotech Research Station at Lisuka Farm (on the shores of Lake Victoria 10 km from Kisumu City), KARI Kakamega, and Kisii FTC. Seeds were raised in nursery beds and transplanted four weeks later, in May/June 2005. Harvesting continued fortnightly until Spring 2006 (Production System: PU; Farming system: Smallholder rainfed highland; Social groups: Smallholder farmers, male/female, moderate poor (endusers)).
Farmer participatory trials: Farmers received seed in Kinale, Fathi, Gitithia, Nyathona, Athi River, Ruiru and Karig'uine, before the 2005 growing season (Production System: PU; Farming system: Smallholder rainfed highland; Social groups: Smallhoder farmers, male/female, moderate poor (endusers)).
Demonstration plots: located at Bathi and Njabini, in Nyandarua and Kiambu Districts, respectively. Farmers selected sites in April 2005. Sowing/transplanting took place in May/June 2005. Harvesting took place in 2006 (Production System: PU; Farming system: Smallholder rainfed highland; Social groups: Smallhoder farmers, male/female, moderate poor (endusers)).

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words)**.*

Kale lines CABI 1-5 have remained with farmers (i.e. male/female, moderate poor endusers), who are retaining/bulking seed; KEPHIS are using project methods for identifying the Black rot pathogen *Xcc* when testing seeds, but

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

In Kenya (by KEPHIS, and by smallholder farmers of PU Nairobi, in rainfed highland systems).

14, What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

The project team have received anecdotal accounts of spread and unofficial exchange of seed between farmers, but no formal feedback has been received. Only when this information has been collected from farmers will we have a clear indication of the usage, both in terms of scale, and impact(s) on poverty (see Q. 20). Current extent of use by KEPHIS is only occasional, due to problems in obtaining chemicals required for diagnostics.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

There is a robust history of collaboration between project partners, which has continued to grow since the 1990s, with very strong links with KEPHIS developed for all regulatory aspects of the work. This relationship has been key to project success. Local links to district offices have been equally valuable (e.g. the Community Development Authority, and the District Social Development Officer (Kiambu District), under the National Community Development Programme Kenya, were instrumental in obtaining official registration for Lari Division farmers in preparation for continuous multiplication/commercialisation of improved kale seeds). North south linkages technology transfer has been effective in a number of ways. Notable examples are: 1. - Knowledge of seed-selection trial design was devised at HRI (UK), and implemented locally (Kenya) both on-farm and at Njabini Research Station; 2. - Reciprocal training visits between key personnel from KEPHIS Plant Health Quarantine Station (& KARI-NARL) and HRI, re. seed health issues and development of protocols, proved very successful; 3. - Existing threshold levels of *Xcc* in local and imported seed was determined at KEPHIS, thus providing baseline data re. African (Kenyan) kale seed health. Prior to project R7571, there was no descriptor in existence for kale DUS, but by drawing on existing experience with other crops, as well as through gaining new knowledge, these were put in place. Farmer knowledge in IPM, seed production and seed quality/health have all been strengthened through participatory activities undertaken in R7571/R8312/R8439.

Current Promotion

D. Current promotion/uptake pathways

16. ***Where*** *is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion* ***(max 200 words).***

- Promotion is taking place in PU rainfed highland districts of Kenya, and is aimed at smallholder farmers, (male/female; moderate poor endusers). To promote sustainable seed-production technologies, on-farm participatory demonstration plots were established in Lari Division, where smallholders are very keen to learn more about seed-processing. In preparation for continuous multiplication/commercialisation of improved kale seeds, Lari Division farmers have had extensive discussions amongst themselves and the Community Development Authority. They have obtained official registration from the District Social Development Officer (Kiambu District), under the National Community Development Programme (Kenya). Posters and factsheets*, encouraging alternative management of viral diseases, good seed multiplication practices, and emphasising the value of producing/purchasing good quality vegetable seed, were translated into Swahili and distributed to >1,000 potential smallholder farmers, NGOs and micro-entrepreneurs through KARI, extension services, NGO's and other CPP uptake pathways in Kenya. Farmers who received factsheets/posters were also given packets of CAB 1-5 seeds for personal use.
  *Phiri *et al*. (2003) On-farm epidemiology and management of virus diseases of Brassica crops
  *Phiri *et al*. (2003) Potential of self selection of seed of tolerant/resistant components of land races of kale for disease management in Kinale.
  *Phiri *et al*. (2003) Promotion of improved kale seed in Kinale).
- Experience gained during R7571/R8312/R8439 can have additional impact through the implementation of the *Good Seed Initiative* (CPP R8480) as funded and promoted by The Swedish Development Council.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

- PRA data obtained in project R7571 showed that smallholder farmers are enthusiastic about the use of alternative control strategies (such as the use of fleece and/or mulches on nursery beds), in the management of viral diseases in vegetables, and that they are keen to participate in further trials. Constraints identified are that fleece is currently unavailable in Kenya and that some farmers are unable to gain access to straw mulch. (Avenues of investigation to find alternative sources were initiated at the end of this project).
- Farmers were also keen to increase the use of resistant varieties to overcome virus disease, but the need for further research in this area remains outstanding.
- Good seed multiplication practice for kale and seed certification using a preferred model were promoted in R8312 and follow-on project R8439, but there is now a demand to go beyond this and to register and release Kinale kale seed varieties. There are several barriers that must be overcome to allow registration to be achieved. This are listed in our response to Q. 23.
- Farmer groups are not currently in a position to take seed-registration, multiplication and marketing opportunities forward;
- Access to seed, access to inputs and access to markets are limited;
- There is a need to establish a landrace ownership model, not just for kale, but also as a template for other crops of value to poor farmers in developing countries.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

- There is a need to raise awareness of advantages of good integrated pest management strategies with farmers, and also the issues re. *Xcc*;
- In order to allow endusers (PU Kenyan smallholders) to fully exploit all potential opportunities afforded by project outputs (seed-registration, multiplication, marketing/branding of product, use of improved kale lines), commercial management capacity and farmers' group dynamics need to be clarified and strengthened.
- Appropriate diffusion pathways must be used to continue promotion of project outputs; Access to seed, access to inputs and access to markets must be improved;

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

- Data obtained through PRAs, conducted not only for quality kale seed in Kenya projects, but as part of other CPP projects carried out in Uganda within the same timeframe (R7568/R8316/R8478), provided valuable information about diffusion pathways in PU farming systems. We learnt that even when farmers have a good understanding of viral diseases based on their observations and extensive experience, there may also be aspects that they neither know nor understand (causal agents, predisposing factors, bases of management practices). Therefore, when disseminating information/outputs, participatory farmers activities and smallscale growing plots at local schools, both represent ideal opportunities for raising awareness of improved kale varieties. They also provide forums at which to identify appropriate extension materials.
- Available diffusion pathways for smallholder farmers include places of worship, friends, community members, relatives, markets, local farmers groups, newspapers, public notice boards, local council secretaries, local leaders, bars and burial places. By contrast, market places, radio, politicians, seminars, workshops and filmshows may only be rarely-utilised. Of all sources identified, farmers groups are likely to be most important.
- Kale farming is not an exclusively-male occupation. Women are thus potential assets as adopters of new technologies and products, and a suitable diffusion pathway since they share more than men. Strategies designed to increase adoption must target women.
- Promotional material (factsheets, posters etc.) must also be in a format with meaning to endusers (e.g. translated into Swahili).
- It is important to acknowledge any communication-bias in favour of close relations that will impede fair "trade" of improved kale lines throughout communities. This is particularly relevant when one considers that, at present, almost three quarters of seed used on farms is either own-grown, or passed-on between immediate family.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

No formal poverty impact studies have been undertaken. However, less formal studies including extensive validation of alternative virus-disease control strategies, and of the performance of CABI 1–5 kale lines compared with local commercial varieties, have been completed. In all cases, validation was undertaken by enduser groups, and the feedback obtained from them reflected their perceived benefits (both nutritional and financial), of applying outputs obtained from this project cluster. In addition to this, full cost benefit analyses were applied to data obtained from harvesting regime trials (as described below, Q.21). It is important to note that, if comprehensive data could be collected from farmers, detailing their own experiences of growing CABI 1-5, this would be invaluable in providing a critical assessment on impacts on poverty.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

- In general terms, projects R7571/R8312/R8439 contributed to sustainable rural livelihoods in that their outputs will help farmers to produce their vegetable crops (for consumption and sale) in a safe, effective and economic way. We involved a wide range of stakeholders including KARI and CABI, named target institutions, as well as Extension services and NGOs. Target beneficiaries (smallholder farmers), were closely involved throughout, directed research according to their needs. When fully realised, the advantages of using alternative virus disease management strategies, and improved kale lines will include improved nutrition for whole families, better cash returns from higher yields of better quality produce and an empowerment through agricultural knowledge to help them make informed choices on other cropping options.

- Feedback obtained from evaluation questionnaires, completed by >100 smallholders (working in PU rainfed highland Kenya) who had been provided with kales CABI 1-5, was overwhelmingly positive, reflecting their perceived benefits (nutritional and financial) of these improved lines: CABI kale lines germinated faster, transplanted better, and provided a longer period for leaf-harvesting than farmers' own varieties. CABI lines were larger, more resistant to attack by pests and diseases, and farmers perceived the colour/shape of their leaves to be superior to local counterparts'. They had a shorter cooking time and were more palatable. The vast majority of farmers ranked the CABI kale lines as having greater consumer appeal than any other 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.
- Three seed production models were evaluated (R8312): A. Full leaf harvesting – kale leaves were picked continuously for the entire growing period up to flowering; B. Half harvest - Leaf harvesting for half the frequency undertaken in regime A; C. No leaf-harvesting. A full cost benefit analysis was then undertaken, comparing seed yields obtained under each alternative harvesting regime, taking into account all costs incurred and all benefits accrued to the kale production process. Prices used were farm gate prices per kilo of seeds and per kilo of leaves produced. Computations for leaves referred only to marketable leaves. Total costs referred to an aggregation of labour, seeds, fertilizers and pesticides. Labour costs included land preparation, sowing, transplanting, weeding, pesticide application and harvesting. These labour costs were derived from discussions with farmers. The costs for seeds, fertilizers and pesticides were derived from market prices. It was found that, irrespective of the site at which trials were undertaken, the no leaf harvesting model generated the highest net benefits. Farmers utilizing this regime could expect to obtain up to twice the gross income from their seed crop, compared to regimes in which leaves were also harvested:
  Gross income, full harvest seed multiplication model: 1,418,375 Ksh/hectare
  Gross income, half harvest seed multiplication model: 1,807,375 Ksh/hectare
  Gross income, no harvest seed multiplication model: 3,280,250 Ksh/hectare
- Indirect impacts on poverty to date (unmeasured) include: increased vegetable production, increased nutrition, increased health and, in turn, improved resilience to HIV and other human diseases.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)*** *This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.*

- Recent population explosions in towns and cities are major phenomena in developing countries, challenging agricultural-production sectors to provide enough food for expanding urban centres. Intensive farming techniques allow smallholders to generate relatively high incomes, but they foster ideal environments for pests/diseases, which build up to very high levels. To minimise crop losses, farmers' respond with heavy pesticide-applications. These are expensive and often ineffective. Reliance on pesticides has led to increasing concern about residues in produce, operator-safety, pesticide resistance and environmental damage. By obtaining reliable baseline data regarding the true threat posed by viral diseases in Kenya, R7571 hasprovided a first crucial step towards development of alternative, sustainable disease-management practices for PU vegetable crops.
- Use of mulches, as advocated in projects R7571/R8312/R8439, has a strong environmental component based on sustainable, low-input control strategies. Such practices also reduce soil erosion, improve soil texture and enhance water conservation.
- Besides their importance as food, the value of landraces of crops typical of developing nations as sources of germplasm, is increasingly acknowledged: they harbour unique genes that may be used in breeding programmes, and landrace stands provide environments that are more biodiverse and thus more buffered against biotic and abiotic factors than their formal-seed equivalent. To identify, protect and exploit landraces, various international treaties have been developed; notably, the Convention of Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture. Such international interest proceeds against a background of concern that the landrace gene pool is under significant threat of erosion from physical displacement and/or genetic pollution by commercialised varieties that are higher-yielding and/or marketed more purposefully by large seed companies. The combined outputs of R7571/R8312/R8439, through the identification and promotion of farmer-selected "improved" local kales CABI 1-5, have made a significant contribution to the conservation of these landraces.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

No direct adverse environmental effects have been recorded. However, increased productivity of farms may be associated with bigger farms that, in turn, may translate into landscape change and reduced biodiversity. Also, there is potential for a concomitant increase in demand for water for irrigation purposes.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

Not directly applicable. However, increased productivity on farms, leading to improved nutrition and incomes will, in turn, increase endusers health thus reducing vulnerability to HIV and other diseases.
