

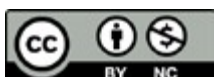
# Use of the CABI BioProtection Portal increases awareness of safer plant protection products among farmers and agricultural advisers in Kenya

## Authors

Mary Bundi  
Fredrick Mbugua  
Frances Williams  
Harrison Rware  
Henry Mibei

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Mary Bundi, CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya.  
Email: [m.bundi@cabi.org](mailto:m.bundi@cabi.org); ORCID: 0000-0002-6431-0273

Fredrick Mbugua, CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya.  
Email: [f.mbugua@cabi.org](mailto:f.mbugua@cabi.org); ORCID: 0000-0002-3168-3671

Frances Williams, CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya.  
Email: [f.williams@cabi.org](mailto:f.williams@cabi.org); ORCID: 0000-0002-6772-0753

Harrison Rware, CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya.  
Email: [h.rware@cabi.org](mailto:h.rware@cabi.org); ORCID: 0000-0002-8750-0811

Henry Mibei, CABI, Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, Kenya.  
Email: [h.mibei@cabi.org](mailto:h.mibei@cabi.org); ORCID: 0000-0002-3894-6809

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## Abstract

This working paper reports on a study that was conducted to assess two sets of information – awareness and use of biopesticide/biocontrol products, and awareness and use of CABI’s web-based BioProtection Portal (launched in Kenya in February 2020) – among a range of respondents in Kenya: fresh produce farmers, agro-dealers, and farmers’ advisers. A baseline assessment was conducted in September 2020, and the endline assessment was conducted in December 2020. Data for the study was collected through a household survey (for farmers) and key informant interviews (for agro-dealers and advisers).

The study found that although awareness about biopesticide and biocontrol products increased between baseline and endline among the various respondents, the use of these products among farmers remained low at endline. Awareness of the existence of the CABI BioProtection Portal increased. The Portal was found to have contributed to increased knowledge of biopesticide/biocontrol products among agro-dealers and farmers’ advisers. Both of these groups, as well as farmers, indicated that they used the Portal to identify suitable biopesticide/biocontrol products and to find registered products. Advisers stated that use of the Portal had changed their perceptions about the use of biopesticide/biocontrol products. However, the respondents reported that the use of these products is challenged by their low availability and high product price, which are challenges that the Portal alone cannot solve.

## Abbreviations

AAK	Agrochemical Association of Kenya
IPM	Integrated pest management
KII	Key informant interviews
PCPB	Pest Control Products Board
PHI	Pre-harvest intervals

## Background

Synthetic chemical pesticides used in agricultural production make a positive contribution to food security and the need to feed an increasing human population. They have contributed to a more than doubling of food production in the last century (Carvalho, 2017). However, the use of chemical pesticides has become of increasing concern in recent years due to their adverse effects on human and environmental health, including the presence of pesticide residues in soil, and aquatic and marine ecosystems (Carvalho, 2017). Pesticides also contribute to negative human health effects through direct and indirect exposure and residues in food (Nicolopoulou-Stamati, 2016). Pesticide use in countries outside Europe and the USA accounts for only 25% of worldwide pesticide usage (De *et al.*, 2013), with usage in India at only 0.5kg/ha. However, in many countries, smallholder farmers use these chemicals without always knowing what chemical they are using, without reading the instructions on use, or understanding the manufacturers' labelling (Ocho *et al.*, 2016). There is also low use of personal protective equipment (Riwthong *et al.*, 2017) and incorrect disposal of empty containers (Ocho *et al.*, 2016), therefore exposure to additional risks. In addition, where farmers buy pesticides from agro-dealers, who have a low understanding of manufacturers' labels or the product active ingredients, few of them receive any advice apart from on product choice and price (Staudacher *et al.*, 2021). Pesticide overuse has also been shown to be associated with a lack of farmer knowledge on pesticides, the influence of agro-dealers on choice, as well as the lack of availability of non-chemical options (Jallow *et al.*, 2017). These may all contribute to the fact that 99% of all pesticide-related deaths (Kesavachandran *et al.*, 2009), about 300,000 per annum (Sabarwal *et al.*, 2018), are in the developing world.

These concerns have led to an increasing focus on the use of integrated pest management (IPM) (Pretty and Bharucha, 2015) strategies, including the use of biopesticides and biocontrol products. Biopesticides are generally taken to include macro- and micro-organisms, botanical extracts and semiochemicals (Constantine *et al.*, 2020). They currently represent a small part of the plant protection market, at approximately US \$3 billion out of a pesticide market of \$56 billion (Marrone, 2014; Damalas and Koutroubas, 2018), or 2% of the products used globally, with production estimated at 3,000 tonnes per year, increasing at 10% per year (Kumar and Singh, 2015). In order to increase the use of biopesticides, there is a need to enhance the regulatory framework for biopesticides, including streamlining approval processes for new products (Arora *et al.*, 2016) and moving away from the use of regulatory processes designed for chemical pesticides (Chandler *et al.*, 2011). There is also a need to increase awareness, knowledge and use of the products among all stakeholders and ensure farmers are provided with clear advice on the use and benefits of IPM and biopesticides, including what biopesticide to use for specific crop pests and diseases, that agro-dealers and extension advisers have the information they need to provide that advice, and that agro-dealers stock biopesticides and biocontrol products, alongside chemical pesticides. This can lead to a reduction in chemical pesticide use, as shown by Schreinemachers *et al.* (2017), who found that farmers who adopted the use of biopesticides used 31% less chemical pesticides.

Information and communication technologies are increasingly being used as a method of providing the required information to agricultural advisers and farmers (Barber *et al.*, 2016; Fabregas *et al.*, 2019), with farmers showing trust in the information provided this way (Cole and Fernando, 2020). With this development, the CABI BioProtection Portal was developed and launched. The Portal is a country-based database of suitable, registered biopesticide products and their manufacturers. It is

also a digital information tool for farmers and extension workers to help them understand what products should be used, how they should be stored, how they should be applied, and where they can be obtained. It is accessible through a web-based platform that can be accessed through digital devices, including smartphones, tablets and desktop computers, and is designed to place information about biopesticide and biocontrol products at the fingertips of users, such as farmers and providers of advisory services. Specifically, users look up, on the Portal, the various biopesticide and biocontrol products that are registered to manage the pests of the crops that they produce or are advising on. The Portal provides detailed information on the appropriate use of the biopesticide and biocontrol products, and links to product labels. The Portal aims to:

- Provide users/advisers with information about appropriate alternative products to chemical pesticides
- Provide country specific information on products registered for use in each country
- Provide validated information about usage and modes of action of each product
- Facilitate linkages with distributors' market demand and contribute to a reduced use of highly hazardous pesticides
- Boost sales of biopesticides through raising awareness of alternative input solutions

The BioProtection Portal aims to overcome barriers to recommending biopesticides, including lack of knowledge of the products, by farmers' advisers, as few advisers receive training on biopesticides (Constantine *et al.*, 2020). The Portal aims to create positive awareness and knowledge of biopesticides among farmers, and agro-dealers, resulting in increased uptake, and increased willingness to stock and sell such products, respectively.

## Evaluation study

A study was carried out to assess the potential of the CABI BioProtection Portal to provide information about biopesticide/biocontrol products to various users, in addition to raising awareness and use of these products. It assessed whether the Portal satisfies the needs of commercial and smallholder farmers and their advisers for more information, to enable them to make better choices with respect to the use of biological control products.

The Portal was launched in Kenya in February 2020. The study first conducted a baseline assessment, implemented in September, via phone interviews due to COVID-19 restrictions. The baseline established the levels of awareness and use of biopesticide/biocontrol products, and willingness to use them, as well as potential uptake of the BioProtection Portal, among fresh produce growers, farmers' advisers, and agro-dealers in Kenya, before marketing activities started. During the baseline assessment, the interviewers shared the Portal link with the various target users, and provided information about the services the Portal provides.

In October and early December 2020, marketing and communications activities were conducted with the aim of: a) attracting visitors to the Portal; b) retaining visitors, by providing relevant and engaging content; and c) attracting new partners and donors, to provide additional funding for the Portal. The channels and media used in the marketing include Google AdWords, Facebook, Twitter, email, SMS and WhatsApp messaging. In particular, emails were sent to approximately 100 technical staff working with Farm Africa, and SMS and WhatsApp messages were sent to 14,000 farmers in the

Agrochemical Association of Kenya (AAK) database, as well as, 5,000 agro-dealers and 800 spray service providers.

The endline assessment was conducted in December 2020, again through phone interviews, after completion of the marketing campaign, to assess the potential of the CABI BioProtection Portal to provide information about biopesticides to various users, and to establish the levels of awareness and use of biopesticides and biocontrol products among fresh produce growers, farmers' advisers and agro-dealers in Kenya. It was conducted with the same groups as the baseline, to identify any changes that may have occurred in levels of awareness and use of biopesticides and biocontrol products.

## Methods

The baseline and endline assessments were both conducted in the counties of Kirinyaga, Meru, Nakuru and Trans-Nzoia. These counties were purposively selected because a majority of farmers in these sites produce fresh agricultural commodities under contracts for fresh produce exporters, who in turn largely supply international markets, as well as some domestic markets. Farmers who fit this profile are identified as key target users of the Portal.

The baseline study utilized a household survey and key informant interviews (KIIs) and was conducted via a phone survey approach, involving fresh produce growers, farmers' advisers (county agricultural extension officers and fresh produce company agronomists) and agro-dealers. The household survey was conducted among fresh produce farmers, and key informant interviews were conducted with agronomists, extension officers and agro-dealers.

The endline assessment again utilized a household survey of the same fresh produce farmers, as well as KIIs with farmers' advisers and agro-dealers. The household survey and KIIs were implemented by a team of interviewers composed of CABI staff and enumerators.

## Sampling

To obtain a representative sample of farmers for both the baseline and endline household survey, agricultural extension officers provided lists of fresh produce farmers in the selected counties, which were augmented by information obtained from AAK. For the KIIs, lists of extension officers, fresh produce company agronomists and technical assistants were obtained with the help of the respective county departments responsible for crop production, as well as by using CABI's Plantwise Online Management System (<https://www.plantwise.org/knowledgebank/clinics/Account/Login>), while the AAK provided the contact details of agro-dealers.

A refreshment<sup>1</sup> sample of farmers and agro-dealers was obtained at endline, to a) respond to attrition of the baseline sample; and b) obtain information from a fresh set of respondents that had not been interviewed during the baseline, but had received information on the BioProtection Portal through the marketing campaign.

With regards to the household survey, a total sample of 252 farmers were surveyed at endline (Table 1). Of these, 173 had been surveyed at baseline, while 79 were from the endline refreshment sample.

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<sup>1</sup> A refreshment sample is a new sample of respondents that are interviewed at the same time as the second round survey/interviews of the original respondents, thus offering information that can be used to adjust for bias due to attrition (Deng *et al.*, 2013).



The attrition rate of 17.6% corresponds to that found in other surveys, ranging between 3% and 20% (IPA, 2021). For the KIIs, 51 agro-dealers were interviewed, 26 from the baseline sample and 25 from the endline refreshment sample, while a total of 51 farmers' advisers (agricultural extension officers and agronomists) were interviewed, all from the baseline sample.

**Table 1.** Sample by category of respondents

Category	Full sample (n)	
	Baseline	Endline
Agronomists/ technical assistants	32	27
Plant doctors	10	7
Public extension officers	24	17
<b>Total advisers</b>	<b>66</b>	<b>51</b>
Agro-dealers	31	51
Farmers	210	252

## Data collection

Data from the fresh produce farmers was obtained through a structured questionnaire in a household survey. The KIIs with farmers' advisers and agro-dealers involved a checklist. As had been done at baseline, data were collected through phone interviews, using tablets, through the Open Data Kit platform (<https://opendatakit.org/>). For each questionnaire/interview targeted at the respective respondents, the interviewing team held discussions on the tool, to understand the questions in detail. They also conducted mock interview exercises in pairs to internalize the questions further. Based on the outcome of the discussions and mock interviews, appropriate adjustments were made to the digital survey tools, to ensure questions were clear and devoid of any ambiguities, along with ensuring that the skip logic on the digital tools was functioning properly and the flow of questions was logical and seamless.

## Data management and analysis

The quantitative data were processed, analysed and organized in tables and charts using SPSS, Stata and Microsoft Excel. Descriptive statistics, including frequency counts, percentages and averages, were calculated to explain the patterns and general characteristics of each component of the study. The qualitative data were analysed based on common themes to provide an in-depth description of and analysis for each output, and to complement the quantitative data.



# Findings

## Respondent characteristics

### Agro-dealer businesses

Most of the agro-dealers that were interviewed owned the businesses where they worked (63% at baseline, 62% at endline overall, 58% at endline,<sup>2</sup> and 64% for the endline refreshment sample) (Table 2), and were the key decision makers regarding the products stocked. Others who were found to make key decisions included the shop managers, shop stewards, the company headquarters, and, at times, the team at the shop.

**Table 2.** Role of the respondent in the business.

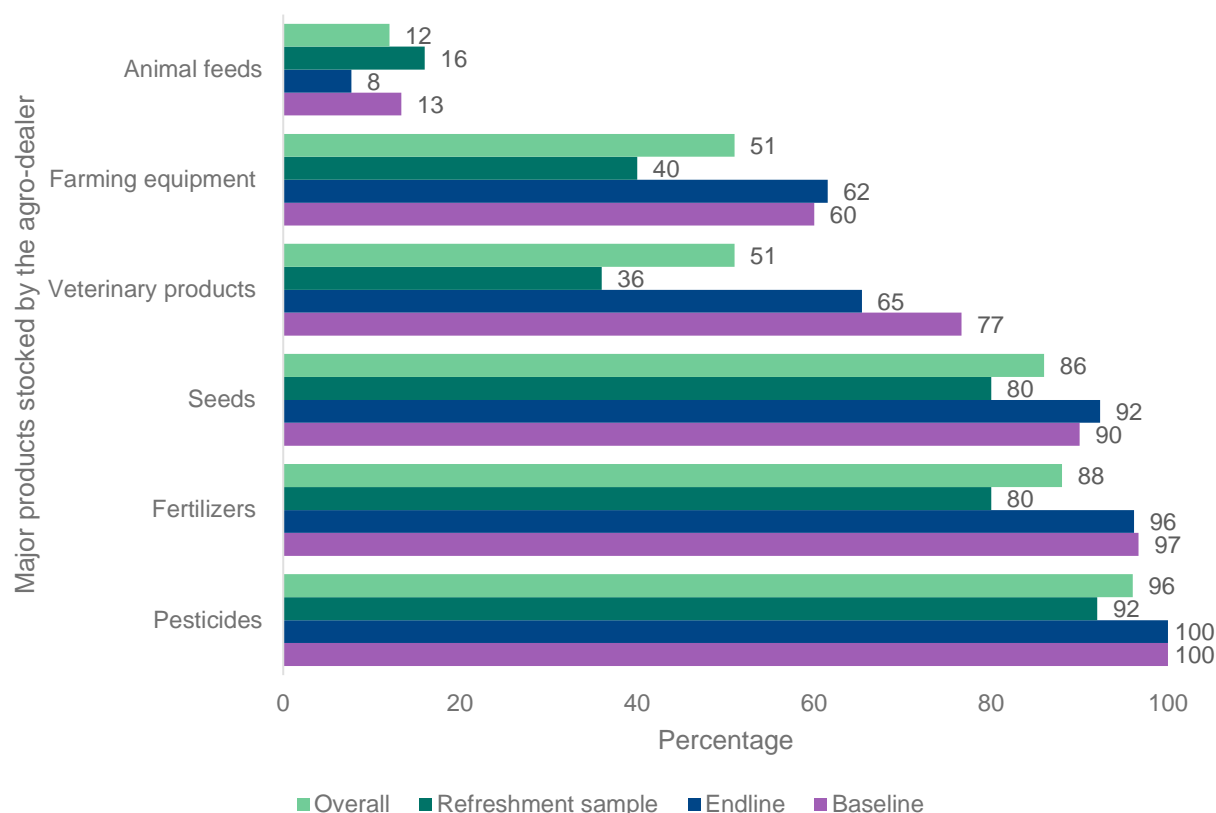
Ownership	Baseline				Role in the shop					
	Role in the shop (n=30)		Decision to purchase (n=30)		Endline (same sample as baseline) (n=26)		Endline refreshment sample (n=25)		Endline overall sample (n=51)	
	n	%	n	%	n	%	n	%	n	%
Owner	19	63	23	77	15	58	16	64	31	62
Sales person	6	20	0	0	5	19	6	24	11	22
Manager	5	17	7	23	6	23	3	12	9	18

The inputs most commonly stocked by agro-dealers included pesticides, fertilizers and seeds as these are the products that are most demanded by buyers (Fig. 1). The high level of pesticides stocked suggests that crop pests are a key challenge faced by farmers in the regions where agro-dealers operate.

### Farmers' advisers

The study categorized farmers' advisers (in the public and private sectors) into agronomists, technical assistants, plant doctors and public extension agents. Private sector agronomists and technical assistants advise both commercial and contracted farmers, while public extension officers (including plant doctors) under county governments mostly advise smallholder farmers (Table 3).

<sup>2</sup> Throughout this section, 'at endline' or 'endline' or 'endline sample' refers to the endline respondents who were also surveyed at baseline (i.e. those who did not drop out), as against the 'endline refreshment sample' (the respondents surveyed for the first time at endline) and 'overall endline' or 'endline overall' (which refers to the two previous categories combined).



**Fig. 1.** The main products that agro-dealers stock for sale.

**Table 3.** Types of farmers supported by farmers' advisers.

Adviser	n	Both contracted and commercial %	Commercial %	Contracted / outgrower %	Smallholder %
Public extension agent	17				100
Agronomist	16	68.8		25	6.3
Technical assistant	11	36.4	18.2	27.3	18.2
Plant doctor	7	28.6			71.4
Overall	51	33.3	3.9	13.7	49

The top crops for which advisers offer pest control or protection advice to farmers are French beans (53%), maize (37%), cabbages (33%), tomato (31%), avocado (24%), beans (24%), chillies (22%), potatoes (22%) and garden peas (18%). Chemical or synthetic products are recommended by all the advisers. Eighty two percent of advisers at endline stated that they recommend that farmers use biopesticides as part of IPM practices, an increase from 73% at baseline (Table 4).

**Table 4.** Crop pest control product/approach recommended.

	Baseline (n=66)	Endline (n=51)
Chemical/synthetic products	99%	100%
Biopesticide products	73%	82%
Cultural	55%	59%
Homemade plant concoctions	42%	51%
Physical/mechanical	32%	29%

### Farmers

Out of the 252 fresh produce farmers that were interviewed at endline, 30% were women and 70% were men (Table 5). Cumulatively, at endline, 74% of the farmers had secondary school-level education and above, against 77% at the baseline.

**Table 5.** General household information for farmers.

		Type of farm			Farmers in each category			
		Commercial	Contracted	Small-holder	Endline overall	Endline sample	Endline refreshment sample	
Socio-demographic factors		%	%	%	n	%	%	%
Age category	19–35 years	13.3	31.4	17.0	49	19.4	21.4	15.2
	36–64 years	83.3	62.8	72.5	181	71.8	68.2	79.8
	Above 64 years	3.3	5.9	10.5	22	8.7	10.4	5.1
Gender	Women	16.7	31.4	31.6	75	29.8	27.8	34.2
	Men	83.3	68.6	68.4	177	70.2	72.3	65.8
Education	None	0	0	0.6	1	0.4	0.6	0.0
	Primary	23.3	21.6	26.9	64	25.4	28.9	17.7
	Secondary	40.0	33.3	45.6	107	42.5	45.1	36.7
	Tertiary	36.7	45.1	26.9	80	31.8	25.4	45.6

Information about the land cropped by farmers is presented in Table 6, disaggregated by use and non-use of biopesticides/biocontrol products in producing fresh produce. The Grubbs test (Couderc, 2007) was used to detect outliers in the fresh produce farmers dataset, remove the outliers and estimate the resultant mean to use as a replacement for the removed outlier values. In the production season, which occurred between the baseline assessment in September 2020 and the endline assessment in December 2020, fresh produce farmers cultivated an average of 2.5 hectares (ha), endline sample 1.0 ha and endline refreshment sample 5.9 ha. There were variations in the area of cropped land between commercial/contracted farmers and smallholder farmers: commercial farmers who used biopesticides/biocontrol products cultivated an average of 15.1 ha, contracted farmers 9.0 ha, and

smallholder farmers 1 ha. It should be noted that among the refreshment sample, there were a few fresh produce farmers that cultivated more than 80 ha, thus inflating the mean acreage for this group.

**Table 6.** Cropped area.

Type of farm	Total land cultivated (mean acreage, ha)			Land cultivated under fresh produce (mean acreage, ha)			Land cultivated under fresh produce (mean acreage, ha)	
	Endline overall	Endline	Endline refreshment sample	Endline overall	Endline	Endline refreshment sample	Used bio-products	Not used bio-products
Contracted /outgrower	6.6	1.3	25.8	4.1	1.2	17.8	9.0	5.9
Commercial	4.6	1.7	14.3	4.3	1.4	13.8	15.1	2.0
Smallholder	2.0	1.1	3.4	1.7	0.9	3.1	1.0	2.2
Overall mean	3.4	1.2	7.6	2.5	1.0	5.9	4.0	3.0

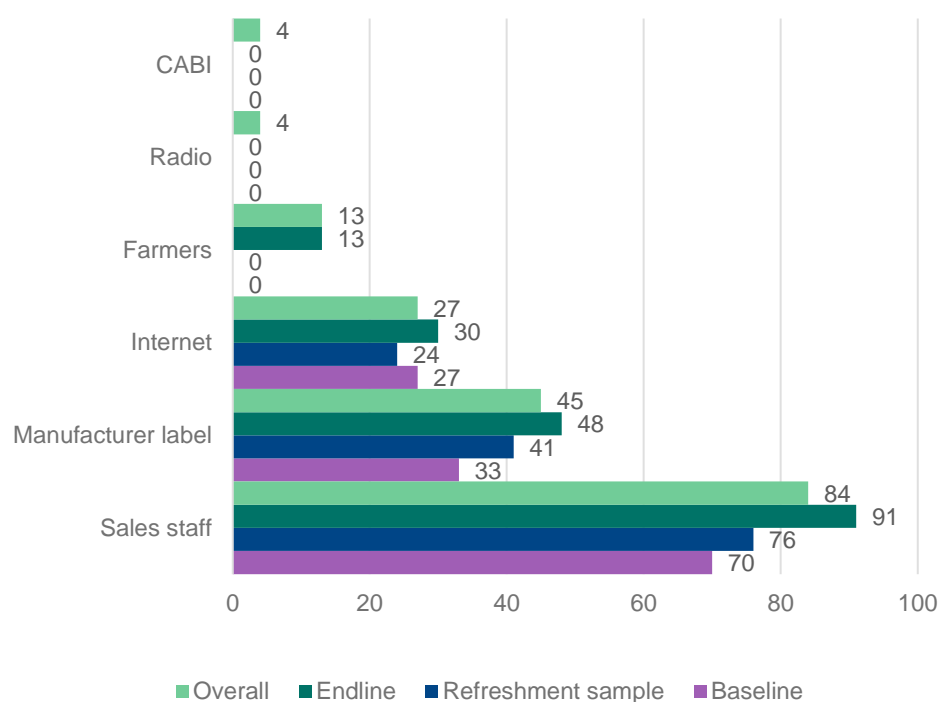
Similarly to the baseline, the endline focused its inquiry on fresh agricultural produce, which was categorized into three broad groups: vegetables (exotic), fruits and food crops. Food crops formed the bulk of the crops produced, including kale (43%), tomato (30%), maize (25%) and cabbages (16%). Other food crops included spinach, beans, Irish potato, cassava and onions. The most common exotic vegetable produced by farmers was French beans (20%). Fruit production was limited, with 3%, 2% and 2% of farmers growing avocado, mango and passion fruit, respectively.

## Awareness and use of bioprotection products

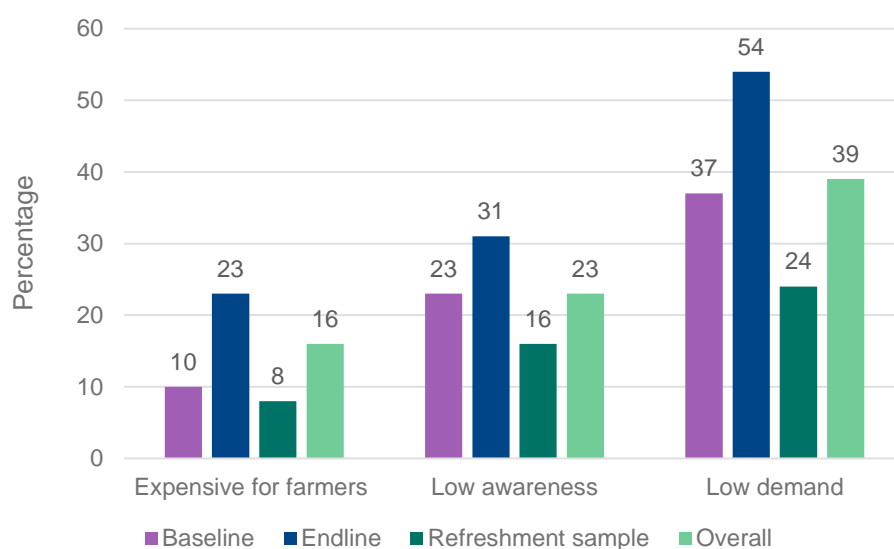
### Agro-dealers

Most agro-dealers (90% baseline, 88% endline, 60% endline refreshment sample) were aware of biopesticides and biological control products, and half (50% baseline, 27% endline, 24% endline refreshment sample) reported that they stocked these products. Most of those that were aware of biopesticide/biocontrol products learnt about these products through the product sales staff, manufacturers' product labels and the internet (Fig. 2). Manufacturers' sales staff therefore appear to be a key channel for raising awareness of biopesticide/biocontrol products among agro-dealers.

Agro-dealers reported that they did not stock biopesticides and biocontrol products due to low demand, low awareness among farmers of these products, and because they are expensive and so farmers cannot afford to purchase them (Fig. 3).



**Fig. 2.** Sources of biopesticide/biocontrol product information for agro-dealers.



**Fig. 3.** Reasons agro-dealers do not stock biopesticides and biocontrol products.

In addition to the challenges related to the high cost of the products and the lack of farmer awareness, about 40% of the baseline sample and 14% of the endline sample indicated that it is a challenge to sell biopesticides/biocontrol products because of their short shelf-life and the low demand from farmers (Table 7). The differences between the baseline/endline refreshment samples and the endline sample indicate some changes in attitudes towards stocking biopesticides, with fewer challenges seen by those who were exposed to the baseline assessment and the marketing campaign. These changes may potentially lead to more agro-dealers selling biopesticides and biocontrol products.

**Table 7.** Challenges experienced by agro-dealers when selling biopesticide/biocontrol products

Challenges of biopesticide / biocontrol products	Baseline % (n=10)	Endline % (n=7)	Endline refreshment sample % (n=6)	Overall (n=13)
Expensive to buy, and so costly for farmers	80	71	50	61
Farmers are unfamiliar with them, so do not buy	70	57	50	54
Low demand	60	71	50	61
Short shelf-life	40	14	-	14
Require cold storage	30	14	33	24
Not easy to obtain from suppliers	20	14	21	18
Don't kill instantly	10	-	-	-
Available in large quantities	10	-	-	-
Not experienced any disadvantages	10	0	33	17
Farmers' resistance to change	10	-	-	-

Approximately 90% of the baseline sample and 62% of the overall endline sample (Table 8) indicated that stocking and selling biopesticide and biocontrol products increased their business (more referrals); 80% at baseline and 23% at endline overall indicated that it is profitable; while 60% at baseline and 39% at endline overall indicated that they enjoy credit facilities on these stocks from suppliers. Therefore, despite the challenges related to stocking these products, it appears that when agro-dealers do stock them, there are business benefits. Indeed, these results show that business benefits are the key motivating factor for increasing the level of biopesticides and biocontrol products stocked by agro-dealers, as opposed to issues regarding food safety and other similar concerns.

**Table 8.** Benefits that accrue to agro-dealers from stocking/selling biopesticides and biocontrol products.

Benefits of selling biopesticides/ biocontrol products	Baseline % (n=10)	Endline % (n=7)	Endline refreshment sample % (n=6)	Endline overall sample % (n=13)
Increased business (more referrals)	90	57	100	62
Receive stock on credit from suppliers	60	29	50	39
Profitable	80	29	17	23
Food safety	10	7	-	-
Easy to sell since it is a new product	10	7	-	-
None	10	7	-	7

### Farmers' advisers

The most common biopesticide products mentioned by advisers were homemade plant extracts or concoctions (77%), and commercial products that contain the following active ingredients: azadirachtin (22%), methyl eugenol, *Metarhizium anisopliae* ICIPE 78, *Metarhizium anisopliae*, *Bacillus subtilis* BS-01, *Trichoderma asperellum* TRC 900 and pyrethrin (all by 11% of advisers).

The main sources of information for advisers on biopesticide and biocontrol products are the Kenya Pest Control Products Board (PCPB) website (50%, up from 34% at baseline) and manufacturers' product labels (44%, up from 40% at baseline) (Table 9). At endline, 18% of advisers stated that they had used the CABI BioProtection Portal as an information source. This is a relatively high level of usage of the Portal, only nine months after its launch in Kenya. The increase in the use of the PCPB website from 34% to 50% is interesting to note, as is the increase in the use of other internet sources (from 14% to 40%) and may reflect the fact that advisers are turning to focused information sources, rather than relying on more general training.

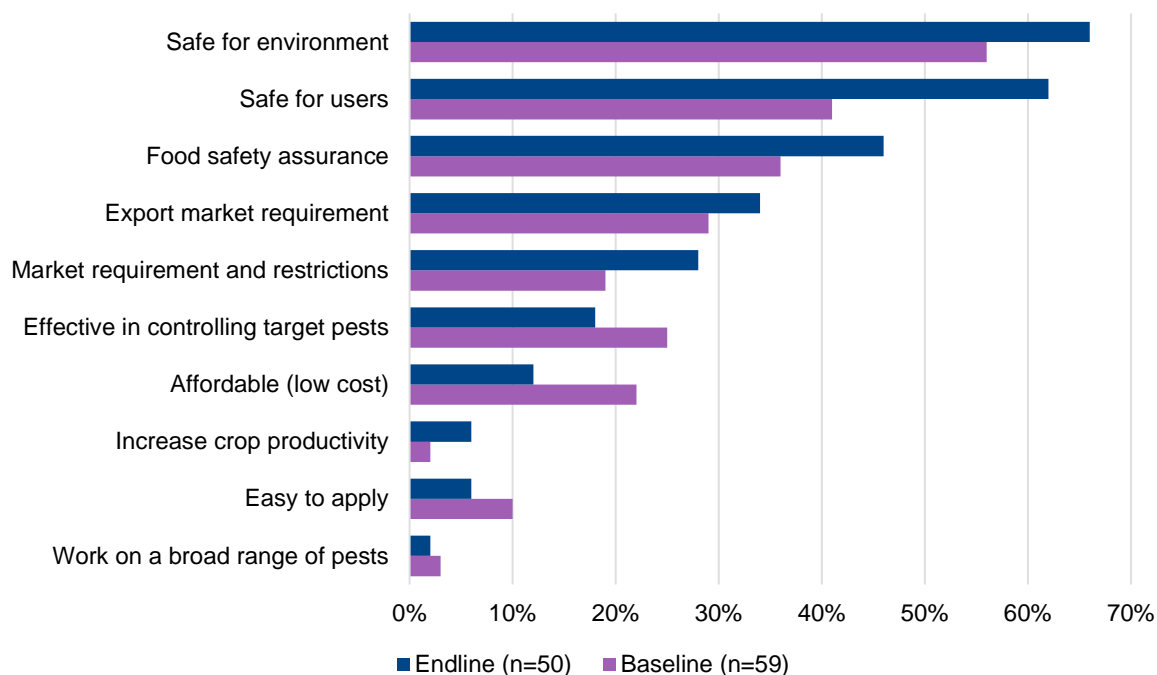
**Table 3.** Advisers' sources of information about biopesticide/biocontrol products.

	Baseline (n=59)	Endline (n=50)
Training materials	55%	34%
Manufacturers' product labels	40%	44%
Manufacturers' websites	36%	38%
PCPB website	34%	50%
Pest Management Decision Guides /factsheets	28%	24%
Other internet content	14%	40%
CABI BioProtection Portal	-	18%
Radio	-	10%
Social media (WhatsApp and Facebook)	-	4%
Agrovets	-	4%
Farmer field days	-	4%

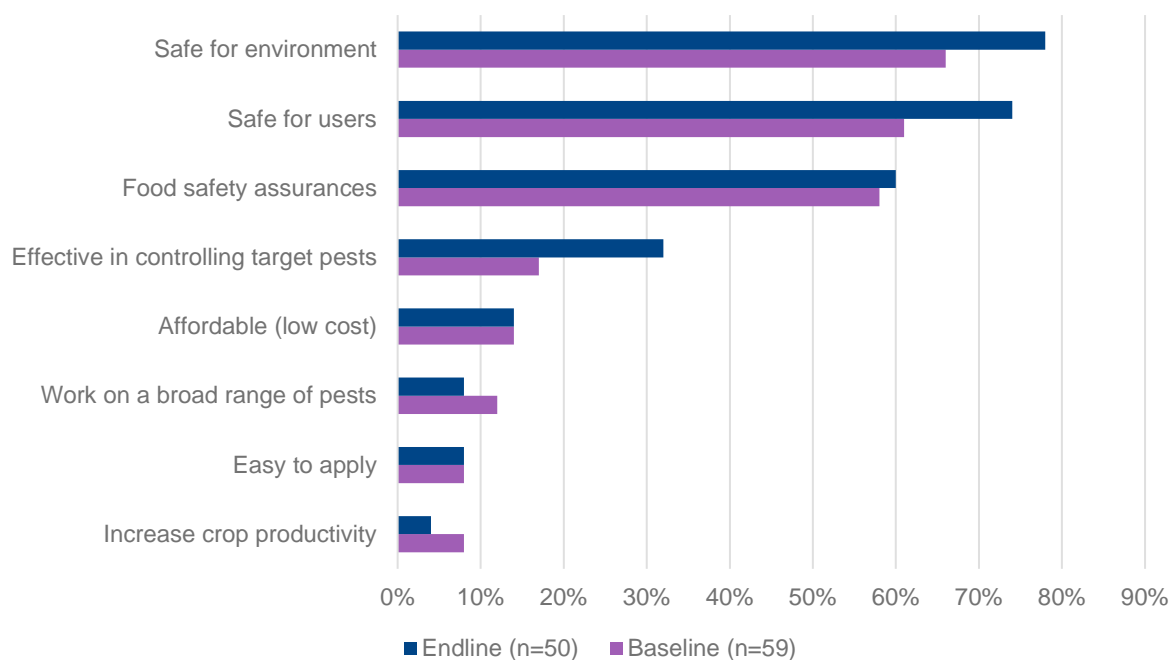
The main reasons given by farmers' advisers for recommending biopesticide/biocontrol products included safety to the environment and safety of users, at 66% and 62%, respectively – a slight increase from the baseline (56% and 41%, respectively) – as well as food safety assurances, at 46% (compared to 36% at baseline), because of these products' low toxicity and short pre-harvest intervals (PHIs) (Fig. 4).

In the KIIs, farmers' advisers indicated that the benefits of using biopesticides and biocontrol products to farmers are that these products are safe for the environment and for users (humans). Fifty eight percent of advisers at baseline and 60% at endline also referred to food safety assurances as a key benefit. These results show an increasing awareness of some of the key benefits of biopesticide/biocontrol products. The least frequently cited benefit (8% at baseline and 4% at endline) was an increase in crop productivity (Fig. 5), demonstrating that advisers may not view these products as being very effective in controlling plant pests and diseases.





**Fig. 4.** Main reasons for recommending biopesticide/biocontrol products.



**Fig. 5.** Benefits of using biopesticide/biocontrol products.

Over half (54% at both baseline and endline) of the farmers' advisers indicated that the main challenge experienced by farmers in using biopesticides and biocontrol products was the fact that they are expensive. Low availability was the main challenge mentioned during the baseline, by 61% of advisers, but this dropped to 54% of advisers at endline, which suggests that availability increased during this period, or possibly that awareness of where to source the products increased. The large package size

of products, beyond what farmers need for application, was not considered to be a key challenge for farmers, according to the advisers, despite the fact that some products cannot be stored for use in the future once the package has been opened (Table 10).

**Table 10.** Challenges to using biopesticides and biocontrol products.

Challenges	Baseline (n=54)	Endline (n=50)
Low availability	61%	54%
Expensive for farmers	54%	54%
Selectivity, slow action etc	37%	36%
Variable efficacy (ability to work to a satisfactory degree)	26%	26%
Require cold storage	13%	14%
Short shelf-life	9%	10%
Large packages beyond need of farmers	6%	8%
Farmers not aware of bioproducts/lack information	-	14%

### Fresh produce farmers

The proportion of farmers who were aware of biopesticides and biocontrol products increased from 60% (n=210) at baseline to 83% (n=173) at endline. In the endline assessment, as with the baseline, the interviewers read 11 statements, one at a time, to the farmers to obtain their awareness and perceptions about biopesticides/biocontrol products. The farmers were required to indicate 'true' or 'false', after each statement had been read to them. Figure 6 presents the results of the statements that farmers perceived to be 'true'. Statements that received extremely high ratings as 'true' (96%) at endline were that biopesticides or biocontrol products are safe for humans and safe for the environment. This is similar to the baseline, where farmers rated the two statements as true at 97% and 94%, respectively. In addition, at endline, 75% of farmers indicated that biopesticides/biocontrol products are effective in controlling pests, a drop from 86% at baseline. This change is explored further below, as it could be expected that an increase in awareness of biopesticides, and their modes of action, should have been related to the perception that they were effective in controlling pests.

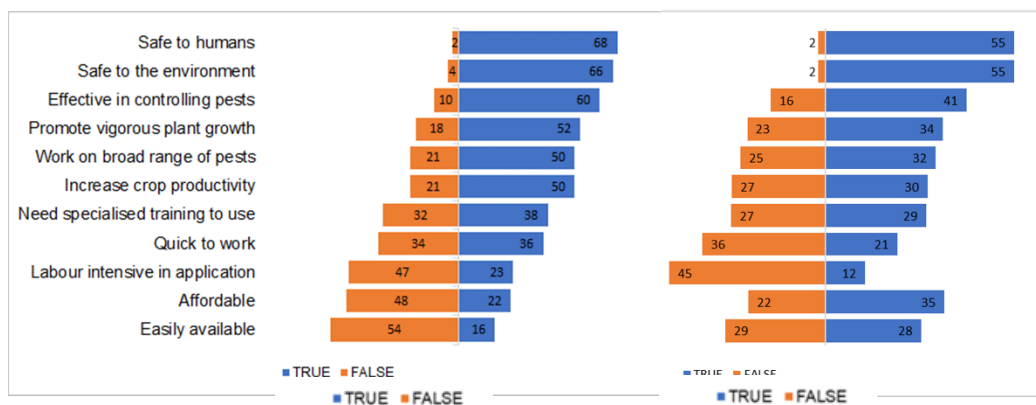
Figure 7 shows charts representing both the 'true' and 'false' statements. During the baseline survey, farmers considered biopesticides/biological control products as affordable (22%) and easily available (16%). In the endline survey there was a slight change of perception, with slightly more farmers considering biopesticides/biological control products as affordable (endline overall 35%) and easily available (endline overall 28%). This implies that farmers are more aware of the availability of biopesticides/biocontrol products they can use.



**Fig. 6.** Perceptions of farmers about biopesticides and biocontrol products.

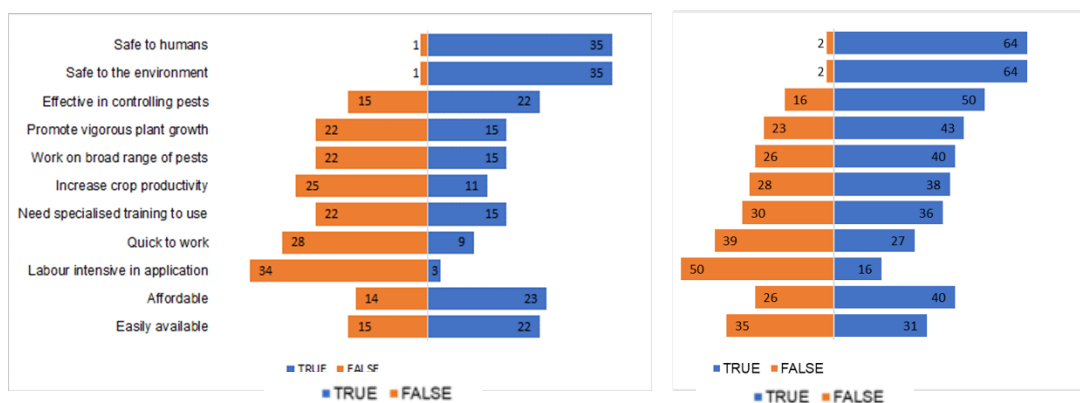
Baseline (n=210) – No opinion = 30%

Endline Overall (n= 252) – No Opinion = 43%



Additional sample (n= 79) – No opinion = 63%

Endline repeat sample (n=173) – No opinion = 34%



**Fig. 7.** Perceptions about the benefits and challenges of biopesticides and biocontrol products

The endline assessment found mixed results in the understanding of how biopesticide/biocontrol products work, compared to the baseline. There appears to be a better understanding that these products target specific pests (fewer farmers at endline stated that they work on a broad range of pests) and that they are not designed specifically to promote plant growth (fewer farmers stated that they promote vigorous plant growth). However, fewer farmers at endline stated that these products are effective at controlling pests. This could be related to farmers wanting to use broad-acting control methods, as Constantine *et al.* (2020) reported that farmers perceived a limitation of biopesticides to be that they target a single pest.

In general, an estimated 35% of the 202 surveyed farmers who were aware of biopesticides or biocontrol products (including cultural practices, such as plant extracts and local concoctions) were using them at baseline, while 28% were doing so at endline. Approximately 29% used biopesticides/biocontrol products during the growing season between baseline and endline. In 89% of cases, the most commonly used products were plant extracts, concoctions, and local remedies that farmers constituted at home (Table 11). These concoctions are diverse, including chillies mixed with soap, ash mixed with cow dung or tobacco, and extracts from tephrosia, the neem tree, or Mexican marigold. A variety of commercial biopesticides were used. These figures are higher than the 10% of farmers reported as using biopesticides in Constantine *et al.* (2020), and may relate to the broad definition of biopesticides and biocontrol products used in this study.

**Table 11.** Biopesticide/biocontrol product used by crop commodity in the 2020 production season

Biopesticide/biocontrol product active ingredient	n	Crop category			Total
		Vegetables	Fruits	Food crops	
Plant extracts and local concoctions	87	10%	4%	75%	89%
Azadirachtin	6	3%	-	3%	6%
Benzoic acid	2	-	-	2%	2%
<i>Pseudomonas fluorescens</i>	1	-	-	1%	1%
Pyrethrin + azadirachtin	1	-	-	1%	1%
E3, Z8, Z11-tetradecatrienyl acetate 0.76mg + E3, Z8-tetradecadienyl acetate 0.04mg	1	-	-	1%	1%
Total	98	13.3%	4.1%	82.7%	100.0%

The key pests targeted in the use of biopesticides/biocontrol products included whiteflies, aphids, cutworms, *Phthorimaea (Tuta) absoluta*, and fall armyworm, which are pests of economic importance in fresh produce and maize production. These pests are similar to the ones mentioned in the baseline assessment, indicating the persistent challenge they pose to farmers engaged in both fresh produce and food crop production.

Farmers gave various reasons as to why they used biopesticides/biocontrol products: they are effective on target pests (49% at baseline, 35% at endline), safe for health, for animals, for the environment, and for food products (42% at baseline, 41% at endline), and are affordable (20% at baseline, 27% at endline) (Table 12). Farmers also considered that the products are easily available (39% at baseline, 35% at endline), which is unexpected, given there is evidence that many farmers

consider biopesticides hard to obtain (Constantine *et al.*, 2020) through current market structures (Guo *et al.*, 2021). However, this can be explained by the fact that, in this study, plant extracts and local concoctions were included in the definition of biopesticides and biocontrol products. This included products containing the active ingredient azadirachtin derived from the neem tree, which most farmers were easily able to mention.

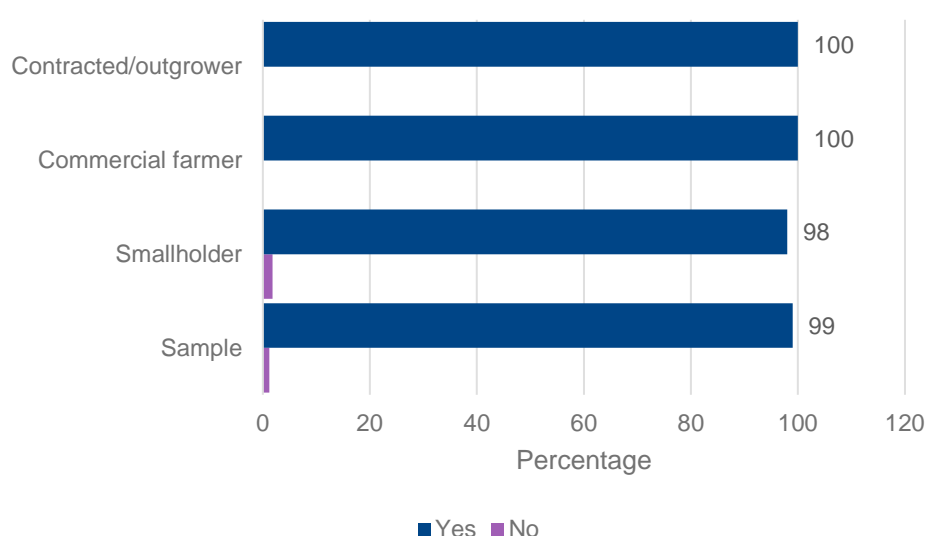
**Table 12.** Reasons farmers choose to use biopesticides/biocontrol products.

Reasons for choosing biopesticides/biocontrol products	Baseline (n=41) %	Endline (n=49) %	Endline refreshment sample (n=10) %	Endline overall (n= 59) %	% Change (Endline overall – baseline)
Recommendation from friend/family	7	16	20	17	10
Recommendation from extension agent	15	23	30	23.7	8.7
Affordable	20	27	20	25.4	5.4
Influenced by company selling the product	10	16	10	15.3	5.3
Type of target pests/diseases	5	8	20	10.2	5.2
Ease of application	2	6	-	5.1	3.1
Easily available	39	35	60	39	0
Recommendation from agro-dealer	7	4	-	3.4	-3.6
Safe for health, animals, environment, and for food products	42	41	10	35.6	-6.4
Have short PHIs	20	6	-	5.1	-14.9
Effective on target pests	49	35	20	32.2	-16.8
Previous use	-	6	30	10.2	-
Meet EU requirements	7	-	-	-	-
Recommended by produce buyers	5	-	-	-	-

As more farmers at endline than at baseline reported that the products were affordable and had been recommended by both extension agents and families/friends, and were influenced to use them by sales companies, it is unclear why overall usage decreased at endline. This may be due to the fact that the majority of farmers at endline still found commercially available biopesticide/biocontrol products were not easily available and were expensive. A further reason may be that the understanding of what a biopesticide or biocontrol product is has changed. While at baseline biopesticide/biocontrol products were taken to include local concoctions and plant extracts, it is possible that at endline some farmers changed their understanding of these products and only considered commercial products. This may also explain why the majority of the refreshment sample group thought that these products were easily available, as they still considered plant extracts etc., to be biopesticide/biocontrol products.

It is also worth noting that, at endline, more farmers thought that biopesticide/biocontrol products targeted specific pests and diseases, and that they were easy to apply. This increase, could, in the long term, help to increase the use of these products.

During the endline assessment, farmers were asked whether they would be willing to use biopesticides and biocontrol products in subsequent crop production seasons. Almost all (99%) farmers – commercial/contracted/outgrowers and smallholders – indicated that they would be willing to use them in future crop production seasons (Fig. 8).



**Fig. 8.** Farmers' willingness to use biopesticides/biocontrol products in future seasons.

A comparison was made between the highest level of education the farmer completed and the use of biopesticide products. Use of biopesticide/biocontrol products was lowest among farmers with just a primary level of education (Table 13), and highest among farmers that had a secondary level of education and above. In fruit farming, use of these products was highest among those with tertiary-level education. These results are in line with those of Nyangau *et al.* (2020) that state that those with a higher level of education, and a higher income level have an increased willingness to pay for biopesticides. This shows that education contributes to awareness and use of biopesticides/biocontrol products, and going forward these groups may increase their use of biopesticides more quickly. However, efforts should still be made to target farmers with lower education levels to ensure they are not excluded.

**Table 13.** Comparison between level of education and use of biopesticide/biocontrol products.

Bioproducts used	Endline (n=173)		Endline refreshment sample (n=79)		Endline overall (n=252)	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Education level						
None		0.6				0.4
Primary school	7.5	21.4	2.5	15.2	6	19.4
Secondary	14.5	30.6	2.5	34.2	10.7	31.8
Tertiary	6.4	19.1	7.6	38	6.8	25
<b>Overall</b>	<b>28.3</b>	<b>71.7</b>	<b>12.7</b>	<b>87.3</b>	<b>23.4</b>	<b>76.6</b>

When the results were disaggregated by gender (Table 14), there is little difference in the use of biopesticide/biocontrol products between women and men farmers, apart from in the endline refreshment sample (22.2% women, and 7.7% men). The reasons for the higher stated usage of biopesticides and biocontrol products by women in this group is unclear, but it could be related to an assumption that local concoctions fall into this product group, while women exposed to the baseline survey had excluded those products from their positive responses to product use.

**Table 14.** Use of biopesticide/biocontrol products disaggregated by gender of farmer.

Bioproducts used Gender	Endline n=173 (m=125, f=48)		Endline refreshment sample n=79 (m=52, f=27)		Endline overall n=252 (m=177, f=75)	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Women	25	75	22.2	77.8	24	76
Men	29	70	7.7	92.3	23.2	76.8
<b>Overall</b>	<b>28.3</b>	<b>71.7</b>	<b>12.7</b>	<b>87.3</b>	<b>23.4</b>	<b>76.6</b>

## CABI BioProtection Portal – awareness, use and opinions

During the endline survey, farmers, agro-dealers and farmers' advisers were all asked about their awareness of the BioProtection Portal, their use of the Portal, and their opinions about its future use. Questions related to the Portal were not asked at baseline.

### Agro-dealers

Sixty two percent of the agro-dealer endline sample and 44% of the endline refreshment sample stated they were aware of the CABI BioProtection Portal. Agro-dealers that were aware of the Portal learned about it through SMS, or from CABI staff (Table 15). The refreshment sample group heard about the Portal through SMS, for the most part because AAK used SMS to send information to all agro-dealers about the Portal. This suggests that the AAK has found SMS to be an effective way to raise awareness of the Portal among its members, and that online marketing may not be as effective for this group of users. It may also be a reflection that agro-dealers have limited engagement with organizations or companies (Rutsaert *et al.*, 2019) beyond their own trade associations, and may depend on these associations for product updates and information rather than searching for this information themselves.

**Table 15.** Sources of information about CABI BioProtection Portal.

Source of information	Endline % (n=25)	Endline refreshment sample % (n=11)	Endline overall sample % (n=36)
SMS	36	100	68
CABI	28	-	14
Extension officer	8	-	4
Plant clinic	8	-	4
Friends/neighbours	8	-	4
Online resources	8	-	4
Community groups	4	-	2
Technical assistant/agronomist	-	-	-



From those that were aware of the Portal, 8% of the endline group had used it once and 4% had used it between two and six times. Among the endline refreshment sample, despite some of them being aware of the Portal, none had used it. Those agro-dealers who had used the Portal said it was useful and helped them to increase their knowledge about biopesticides and biocontrol products. However, only one individual reported that exposure to the Portal had changed their opinion on biopesticide/biocontrol products, and that they would most likely recommend the use of these products to clients in the future. This finding should be investigated further, to understand why agro-dealers' increased knowledge of biopesticides does not translate into increased recommendations, and whether this is due to agro-dealers primarily supplying products that farmers demand (Rutsaert *et al.*, 2019).

At endline, overall, 88% of agro-dealers indicated that they would be willing to use the Portal in the future. Most of those willing to use the Portal (75%) reported that they would use it to identify suitable biocontrol and biopesticide products. Additionally, 57% of agro-dealers from overall endline reported that they would use the Portal to find registered biopesticides and biocontrol products (Table 16). Furthermore, 31% overall reported that they would use the Portal to understand how biocontrol and biopesticide products should be applied, while 22% overall reported that they would use the Portal to know where to source biopesticides, which is a key service of the Portal.

**Table 16.** How agro-dealers would use the BioProtection Portal in future.

Use of BioProtection Portal	Endline % (n=14)	Endline refreshment sample % (n=11)	Endline overall sample % (n=25)
To identify suitable biocontrol and biopesticide products	86	64	75
To find registered biocontrol and biopesticide products	57	56	57
To understand how biocontrol and biopesticide products should be applied	43	18	31
To know where to obtain these products	7	36	22
To understand how biocontrol and biopesticide products should be stored	29	9	19
To find out the prices of these products	7	9	8

### Farmers' advisers

Sixty three percent of the endline sampled farmers' advisers indicated that they were aware of the CABI BioProtection Portal, while half had used it. Those who had not used the Portal indicated that they would be willing to use it (Table 17). Half of the advisers who had used the Portal had visited it once, while 38% had visited it between three and six times, and 13% had visited it more than 10 times.

**Table 17.** Awareness and use of the CABI BioProtection Portal.

Category	Aware of Portal (n=51)	Used Portal (n=32)
Plant doctor	86%	33%
Technical assistant	73%	75%
Public extension agent	59%	30%
Agronomist	50%	63%
<b>Overall</b>	<b>63%</b>	<b>50%</b>

The majority of farmers' advisers sampled at endline who were aware of the CABI BioProtection Portal mentioned that they became aware of it through SMS and CABI staff, while 25% heard of it through extension officers and 19% through online resources (Table 18). Although SMS remains a key channel, these results suggest that more diverse awareness raising channels can be used for farmers' advisers, compared to those used for agro-dealers.

**Table 18.** Sources of information about the CABI BioProtection Portal.

Sources of information (n=51)	Percentage
SMS	41%
CABI staff (Telegram, SMS and WhatsApp groups)	41%
Extension officers	25%
Internet and other online resources	19%
Newspapers	9%
Plant clinics	6%
Agro-dealers	3%

The majority of the farmers' advisers who had used the Portal, had used it to identify suitable biopesticide and biocontrol products. Ninety three percent of those who had not used the Portal said they would be willing to use it in the future. Price information was mentioned by 27% of the advisers who had not used the Portal as key information they would look for if they visited the Portal (Table 19). These results suggest that the key information that should be maintained and updated in the Portal, from an adviser's point of view, is product/pest information and registered sources of products.

**Table 19.** Uses/potential uses of the BioProtection Portal, by farmers' advisers.

Uses of the Portal	How many used (%) n=15	Willing to use (%) n=15
To identify suitable biocontrol and biopesticide products	80%	93%
To find registered biocontrol and biopesticide products	60%	67%
To know where to obtain biopesticide products	40%	13%
To understand how biocontrol products should be applied	13%	33%
To understand how biocontrol products should be stored	7%	40%
To know the prices of different biopesticides and biocontrol products	-	27%

Of the advisers who had used the Portal, 75% indicated that they had found the information they were looking for. Ninety four percent indicated that the Portal had increased their knowledge of biopesticides and biocontrol products. Furthermore, 88% of them indicated that the Portal had changed their opinion of biopesticides or biocontrol products. This may be because the Portal has filled a knowledge gap for advisers, as Constantine *et al.* (2020) reported that only 33% of extension agents had received training in the use of biopesticides. All of the advisers who had used the Portal indicated that it is an important tool in their work.

The farmers' advisers were further asked whether there was information they could not find on the Portal: they reported that they could not find information on some biopesticides/ biocontrol products for some crop pests and diseases, and they could not find any information on the prices of the biopesticide/biocontrol products. It will take some time before the Portal is able to display information about the products available for all pests. In addition, price information is fluid, with frequent adjustments, so if price information were made available on the Portal it would require regular updates, otherwise it could be a source of misinformation.

The farmers' advisers were also asked about the ways in which the Portal was an important tool for their work. Table 20 shows that 93% of advisers used the Portal to understand which registered biopesticide/biocontrol products exist in the market, 79% used it to increase their knowledge of these products, and 50% used it to source or obtain them. These results demonstrate that once the advisers find which registered products are available in the market, they use the information and product labels to learn about the target crops, pests and mode of application.

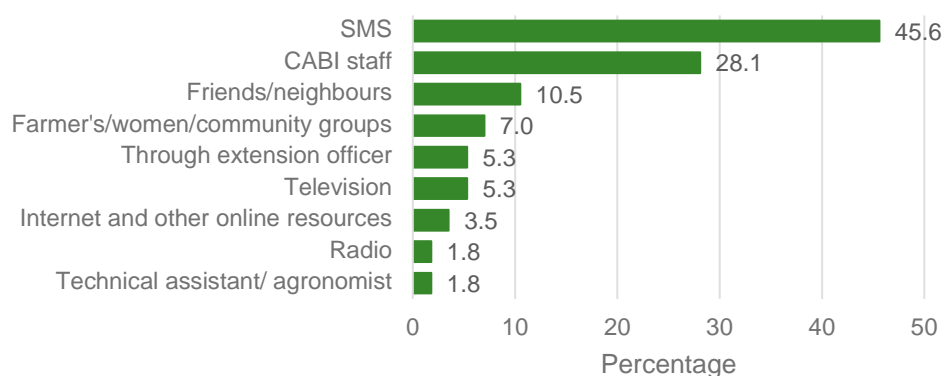
**Table 20.** Use of BioProtection Portal in farmers' advisers' work.

Information that advisers seek in the Portal	Percentage
Knowing the registered biopesticide/biocontrol products in the market	93%
Increased knowledge of biopesticide/biocontrol products	79%
Knowing where to source/obtain biopesticides/biocontrol products	50%
Knowing the target crops	36%
Knowing the target pests	29%
Knowing recommended mode of application	29%

## Farmers

Among the sampled farmers, 23% of farmers were aware of the Portal, out of which about half (12%) had used the Portal and most of the other farmers indicated that they would be willing to use it in the future. Despite the proliferation of smart phones, the low use of the Portal by farmers is largely driven by poor internet broadband connections, which can be erratic and weak in rural areas, thus limiting connectivity to the internet and visits to the Portal. It should also be noted that, while the use of web-based applications, such as the BioProtection Portal to provide agricultural extension has broadened the reach of information, it can also disenfranchise some farmers e.g. women and those who are not technologically literate (Barber *et al.*, 2016), or who do not have access to smart phones.

The majority of farmers became aware of the Portal through SMS, followed by CABI staff and friends and neighbours (Fig. 9). Again, this indicates that SMS is a key awareness raising technique that should be used going forward.



**Fig. 9.** Sources of information about the CABI BioProtection Portal

Among the farmers who used the Portal, the majority (43%) visited the Portal once, or two to six times (also 43%), while a few farmers (14%) visited more than six times. They visited the Portal to identify suitable biocontrol and biopesticide products, identify registered biocontrol and biopesticide products, and learn where they can obtain the products. Of the users of the Portal, about 71% found the information they were looking for on it. A similar proportion indicated that the Portal increased their knowledge about biopesticides/biocontrol products, and also helped to shape their opinion about them. Given that lack of knowledge on biopesticides is a key reason for low use (Guo *et al.*, 2021), this increase in knowledge should help to increase usage. Further knowledge increase at farmer level may be achieved through promotion and use of the Portal by farmers' advisers and agro-dealers, the key target audience, given that adoption of new technologies by farmers is higher when there is direct engagement (Barber *et al.*, 2016), especially through private sector advisers (Dar *et al.*, 2020).

## Conclusions

This study found that awareness about biopesticide and biocontrol products increased steadily among the various respondents, between the baseline and endline assessments. For agro-dealers, product sales representatives were the key to this increased awareness, while for farmers' advisers it was the PCPB, product labels and the internet that boosted awareness. Despite the increased awareness, the use of biopesticide and biocontrol products among farmers remains low, mainly due to the low availability of the products and their relatively higher price, in comparison to synthetic products which serve the same purpose. Both agro-dealers and farmers' advisers noted the low availability and high prices of biopesticides, and the high supplier price reduced the willingness of agro-dealers to stock the products.

Agro-dealers' recommendations were mainly motivated by business decisions, while farmers' advisers were willing to recommend biopesticides based on the lower risk to human and environmental health. Farmers' understanding of the safety aspects of biopesticides for human health, the environment and food use motivated their willingness to use biopesticide/biocontrol products in the future. This high level of potential use contradicts the drop in actual use that was identified by the study between baseline and endline, which would be worth investigating further. It may be linked to farmers' knowledge of biopesticide/ biocontrol products, which showed both an increase and decrease in understanding as compared to the baseline, and may indicate the need for clearer information around

these products. It may also reflect a change in understanding of what products are considered as bioprotection/biocontrol products: local concoctions and plant remedies, or just commercial products.

The CABI BioProtection Portal was launched in early 2020 in Kenya, and agro-dealers and the majority of farmers became aware of the Portal through the SMS campaign, while advisers also became aware of the Portal through CABI staff (through the baseline and endline studies reported here) and extension staff. Little or no mention was made of online marketing. This suggests that SMS campaigns are key to promoting the Portal and should be used in other locations where the Portal is launched. Use of the Portal, nine months after its launch was relatively high: at endline, 50% of farmers' advisers, 8% of agro-dealers and 12% of farmers reported already using the Portal, with the level of farmer use surprisingly high given that it is an online tool, with considerable technical information, which might be considered more suitable for advisers and agro-dealers.

The study found that use of the BioProtection Portal increased knowledge of biopesticide/biocontrol products for agro-dealers and advisers, and it found that both groups, as well as farmers, reported using the Portal to identify suitable products and to find registered products. Users indicated a willingness to continue to use biopesticide products and also use the Portal for information on these products. This underlines the key features of the Portal that are most useful, which should be updated and maintained as a priority.

Overall, use of bioprotection and biocontrol products is still relatively low in Kenya, with issues around knowledge, availability and affordability of the products being key challenges. These early results from use of the BioProtection Portal in Kenya demonstrate that it is a useful tool for agro-dealers, farmers' advisers and even farmers to increase their knowledge about bioprotection products, as well providing information on product availability. An increase in knowledge and availability should lead to an increase in use and demand, and therefore in the long term, lead to a reduction in price as supply increases to match the demand increase. Further use of the BioProtection Portal over a longer period is needed to assess whether it really does have the desired effect of increasing use of bioprotection and biocontrol products, as an alternative to chemical pesticides.

## Limitations

Limitations of the study include:

- There was a very short time between the baseline survey, and the endline survey, leading to limited ability to detect any changes as a result of the introduction of the Portal to Kenya, with the focus of the study being on changes in awareness of bioprotection products only.
- The baseline survey was delayed for a few months after the launch of the BioProtection Portal due to the COVID-19 pandemic. This also led to both the baseline and endline surveys being carried out through phone interviews, rather than face to face. This created challenges in carrying out the farmer interviews, and potentially reduced the quality of the data.
- The study focussed on fresh commodity producers, thus providing a narrow view of awareness and use of biopesticide products among farmers. A wider view could be obtained through including farmers who grow other crops e.g. maize and rice, in the survey.

- There may have been a lack of clarity on the meaning of biopesticides and biocontrol products, as some farmers may have understood this to include cultural practices as well as commercially produced products. Additional clarity on this at the start of both surveys may have resulted in different responses to some questions.

## Recommendations

- The most effective promotion of the BioProtection Portal and associated products was through SMS campaigns from sources that the recipients were familiar with and therefore trusted. Further promotion of the Portal should be carried out through fora such as the Ministry of Agriculture, PCPB and AAK.
- The BioProtection Portal is proving to be a critical resource that provides specific and focussed information on biopesticides and it should be promoted and marketed widely to increase awareness.
- There is need to continue creating awareness and educating farmers about biopesticides to enable a change in knowledge and attitudes towards biopesticides, so they are seen as safe and effective pest management products.
- The Portal was received very positively and to maintain this opinion it is necessary to keep the product information up to date, including information on where to buy the products listed. Increasing the range of products included in the Portal would also be of benefit.
- Product affordability is still an issue, and going forward, work should continue with manufacturers to explore ways to reduce prices, including considering loss leader products to promote increased use of bioprotection products.

## Acknowledgements

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## contact CABI

### Africa

#### Kenya

**CABI**, Canary Bird  
673 Limuru Road, Muthaiga  
PO Box 633-00621  
Nairobi, Kenya  
**T**: +254 (0)20 2271000 / 20  
**E**: [africa@cabi.org](mailto:africa@cabi.org)

#### Ghana

**CABI**, CSIR Campus  
No. 6 Agostino Neto Road  
Airport Residential Area  
P. O. Box CT 8630, Cantonments  
Accra, Ghana  
**T**: +233 (0)302 797 202  
**E**: [westafrica@cabi.org](mailto:westafrica@cabi.org)

#### Zambia

**CABI**, Southern Africa Centre  
5834 Mwange Close  
Kalundu  
P.O. Box 37589  
Lusaka, Zambia  
**T**: +260 967 619 665  
**E**: [southernafrica@cabi.org](mailto:southernafrica@cabi.org)

### Americas

#### Brazil

**CABI**, UNESP-Fazenda Experimental  
Lageado, FEPAF (Escritorio da CABI)  
Rua Dr. Jose Barbosa de Barros 1780  
Fazenda Experimental Lageado  
CEP:18.610-307  
Botucatu, São Paulo, Brazil  
**T**: +55 (14) 3880 7670  
**E**: [y.colmenarez@cabi.org](mailto:y.colmenarez@cabi.org)

#### Trinidad & Tobago

**CABI**, 59 Gordon Street, Curepe  
Tunapuna 331323  
Trinidad and Tobago  
**T**: +1 868 6457628  
**E**: [caribbeanLA@cabi.org](mailto:caribbeanLA@cabi.org)

#### USA

**CABI**, 7200 Portland Street  
Boston, MA 02114, USA  
**T**: +1 (617) 682-9015  
**E**: [h.jansen@cabi.org](mailto:h.jansen@cabi.org)

### Asia

#### China

**CABI**, Beijing Representative Office  
Internal Post Box 85  
Chinese Academy of Agricultural Sciences  
12 Zhongguancun Nandajie  
Beijing 100081, China  
**T**: +86 (0)10 82105692  
**E**: [china@cabi.org](mailto:china@cabi.org)

#### India

**CABI**, 2nd Floor, CG Block,  
NASC Complex, DP Shastri Marg  
Opp. Todapur Village, PUSA  
New Delhi – 110012, India  
**T**: +91 (0)11 25841906  
**E**: [india@cabi.org](mailto:india@cabi.org)

#### Malaysia

**CABI**, PO Box 210,  
43400 UPM Serdang  
Selangor, Malaysia  
**T**: +60 (0)3 89432921  
**E**: [cabisea@cabi.org](mailto:cabisea@cabi.org)

#### Pakistan

**CABI**, Opposite 1-A,  
Data Gunj Baksh Road  
Satellite Town, PO Box 8  
Rawalpindi, Pakistan  
**T**: +92 51 9292062  
**T**: +92 51 8434979  
**E**: [cabi.cwa@cabi.org](mailto:cabi.cwa@cabi.org)

### Europe

#### Switzerland

**CABI**, Rue des Grillons 1  
CH-2800 Delémont, Switzerland  
**T**: +41 (0)32 4214870  
**E**: [europe-CH@cabi.org](mailto:europe-CH@cabi.org)

#### UK

**CABI**, Nosworthy Way  
Wallingford, Oxfordshire, OX10 8DE, UK  
**T**: +44 (0)1491 832111  
**E**: [corporate@cabi.org](mailto:corporate@cabi.org)

**CABI**, Bakeham Lane  
Egham, Surrey, TW20 9TY, UK  
**T**: +44 (0)1491 829080  
**E**: [cabieurope-uk@cabi.org](mailto:cabieurope-uk@cabi.org)  
**E**: [microbialservices@cabi.org](mailto:microbialservices@cabi.org)