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Farmers' knowledge, perceptions and management of vegetable pests and diseases in Botswana

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ABSTRACT

Vegetable farmers' knowledge and perceptions of pests, diseases and pest management practices were investigated by interviewing 112 growers in Botswana between April and June 2004. Most of the farmers grew brassicae crops, Swiss chard and tomato, and considered arthropod pest problems as the major constraint to vegetable production. *Bagrada hilaris* Burm., *Plutella xylostella* L. and *Brevicoryne barassicae* L. were the most serious pests on brassicas, with red spidermites (Tetranychus spp.) being the most serious pests on tomato. Ninety-eight percent of farmers relied heavily on the use of synthetic pesticides to control these pests. Their decision to apply pesticides was mostly on noticing the presence of a pest or disease. An integrated pest management programme is needed to reduce over reliance on pesticides.

1. Introduction

Most vegetables consumed in Botswana are imported from neighbouring countries because Botswana is only 15% self-sufficient in vegetable production (TAHAL, 2000). Incentives such as the Financial Assistance Policy, which operated from 1982 to 2000 (Rebaagetse, 1999), and the current Citizen Entrepreneurial Development Agency introduced in 2002 have attracted people to venture into vegetable production as a business.

The many different vegetable crops grown for the domestic market in backyard gardens, commercial plots and recently in greenhouses are subject to a range of insect pests and diseases (Ingram et al., 1973; Bok et al., 2006; Munthali et al., 2004). Pest management for vegetable pests and diseases requires a comprehensive assessment of these pests and diseases so that resources can be allocated prudently. The effectiveness of current tactics used by farmers needs to be evaluated so that suitable and affordable strategies can be developed. However, Morse and Buhler (1997) reported that farmers' primary concern for soil fertility and water was ahead of that for crop protection. In endeavouring to develop integrated pest management (IPM) to reduce reliance on pesticides, research is needed to determine the extent of farmers' knowledge.

In this paper results of a survey conducted in six agricultural regions in Botswana are presented. The objectives of the survey were to (1) assess farmers' knowledge and perceptions of various constraints to vegetable production; (2) identify pests and diseases that farmers perceive as important in vegetables; (3) evaluate farmers' knowledge of management of vegetable pests and diseases.

2. Material and methods

One hundred and twelve farmers were interviewed in the survey between April and June. A mostly open ended questionnaire allowed farmers to give their opinions freely. The number of respondents interviewed varied depending on the number of vegetable farmers in a particular district. The highest number of farmers interviewed was from Gaborone region ($n = 44$) followed by Southern ($n = 22$) and Central ($n = 22$), then Francistown ($n = 13$), Western ($n = 7$) and Maun ($n = 4$).

The interviews were conducted in a local language (Setswana)/ and or English by trained crop protection officers. Most questions centred on farmers' awareness of pests, diseases and pest management tactics with a few questions on the socio-economic background of the farmers. After recording their social profiles, farmers were asked to give and rank what they perceived to be the major constraints to vegetable production. They were then asked

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to list their major crops and rank the pests and diseases associated with the crops from the least to most destructive. For each pest or disease, farmers were asked to mention the management tactic used to control them. Where farmers mentioned the use of pesticides they were asked to name the pesticides or show them to the interviewer for recording. In addition, farmers were asked to state when and how frequently they sprayed their crop and to estimate the losses they encountered. Lastly, farmers were asked to suggest the solutions to pest and disease problems in vegetable production.

Data from the questionnaire were encoded, entered in Microsoft Excel 2003 spreadsheet and checked prior to analysis. Some farmers gave multiple responses to the same questions, so percentages may not add to 100. Data were analysed using SAS for Windows, version 9.1 (SAS Institute, 2003). Frequencies and percentage variable occurrences were calculated using cross tabulation (PROC FREQ), and χ^2 was used to determine the association between categorical variables. Logistic regression was used to investigate the relationship between selected dependent variables and sociological parameters of respondents. We wanted to find out whether social background of farmers (age, gender or marital status) influenced farmers' knowledge of pests, disease and the management tactics which they used. We also investigated the influence of farmers' social background on the type of production system used, size of field and ownership of pesticide application equipment. The logistic regression relates proportions p_i of the dependent variable (y) to an independent variable (x_i) in the following model (Pampel, 2000):

$$P_i = \frac{(e^{b_0+b_i x_i})}{(1+e^{b_0+b_i x_i})}$$

where b is the coefficient corresponding to (x_i). The maximum likelihood estimation procedures were used to estimate the parameters of this model.

3. Results

3.1. Farmers' socio-economic background

The socio-economic background of farmers (Table 1) gives the range of ages and gender of those interviewed. Most farmers (82%) produced their vegetables in open fields, while fewer (21.4%) used greenhouses. The use of greenhouses was negatively associated with age ($P = 0.05$), indicating that most farmers who used them were relatively young. Gender and marital status did not influence the type of production system that a farmer chose to use. The total land holding ranged widely from 0.1 to 18 ha (average 2.7 ha). The age of the farmer negatively affected the size of the field plot owned by farmers ($P = 0.005$), with middle aged and younger farmers owning larger fields than older farmers. The majority of farmers used knapsack sprayers (Table 2).

Table 1
Socio-economic background of vegetable farmers interviewed

Farmers' background	Summary of responses
Age category (years)	
30	9.8
31–40	14.3
41–50	31.3
51–60	25.0
60	19.6
Gender (% of total respondents)	
Males	62.5
Females	37.5
Household (% of total respondents)	
Male headed	64.3
Female headed	35.7

3.2. Vegetable crops grown

The most commonly grown vegetables are shown in Fig. 1. The most commonly grown vegetable in Gaborone region was Swiss chard, followed by rape, tomato and cabbage. In the Southern region, Swiss chard and rape were considered equally important followed by cabbage, tomato and kale. Of the seven farmers interviewed in the Western region, six indicated Swiss chard as the main crop followed by tomato, cabbage, kale, rape, beetroot and onion. In Maun region, the four farmers interviewed cited both rape and tomato as the main crops followed by Swiss chard, onion, cabbage and green pepper. In the Central district the most commonly grown vegetable crops after rape were cabbage, tomato kale and onion.

3.3. Farmers' perceptions and knowledge of pests and diseases

Most farmers (94.6%) perceived invertebrate pests as the most important constraint in vegetable production followed by vegetable diseases (42.0%), water shortage (11.6%), soil fertility (8.9%), weeds (8.0%) and marketing (7.1%). The other constraints mentioned but perceived as less important were lack of irrigation facilities, damage by wild animal, poor transport, lack of capital and poor management skills. Farmers' awareness of vegetable pests differed significantly ($\chi^2 = 18.12$, $df = 5$, $P = 0.002$) among the regions. The same trend was observed on the knowledge of vegetable diseases where a highly significant difference ($\chi^2 = 26.09$, $df = 5$, $P < 0.0001$) was observed between the regions.

Table 2
Percentage of respondents who owned land and spraying equipment

Spray equipment (% of total respondents)	Summary of responses
Knapsack sprayer	93.8
Motorised sprayer	5.4
Boom sprayer	1.8
Size of plot (ha)	
Average	2.7

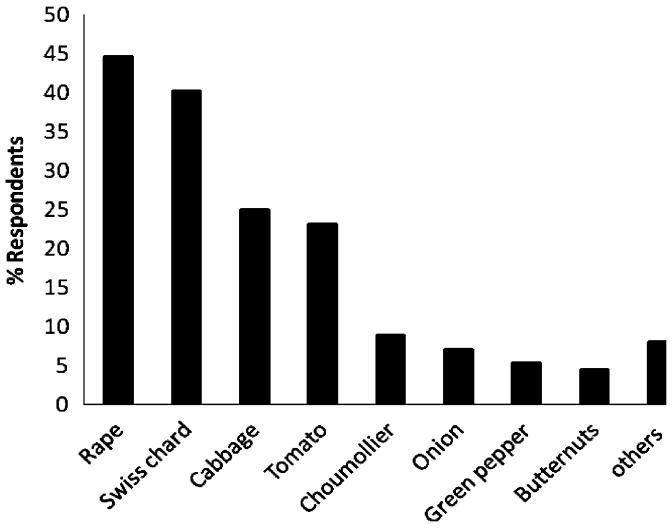

Fig. 1

Table 3
Farmers' perception of pests and diseases of vegetables (% respondents)

Pests/disease	Rape ($n = 49$)	Cabbage ($n = 28$)	Kale ($n = 10$)	Tomato ($n = 26$)	Onion ($n = 8$)	Butternuts ($n = 5$)	Swiss chard ($n = 45$)	Beetroot ($n = 4$)
Bagrada hilaris	55.1	35.7	60.0	0.0	0.0	0.0	0.0	0.0
Plutella xylostella	14.3	32.1	10.0	0.0	0.0	0.0	0.0	0.0
Brevicoryne brassicae	16.3	14.3	20.0	0.0	0.0	0.0	0.0	0.0
Hellula undalis	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Helicoverpa armigera	0.0	3.6	0.0	7.7	0.0	0.0	0.0	0.0
Tetranynchus spp	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0
Nezara viridula	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0
Bemisia tabaci	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0
Agrotis spp.	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0
Zonocerus variegatus	0.0	0.0	0.0	3.9	0.0	0.0	11.1	25.0
Acanthoplus discoidalis	2.0	3.6	0.0	3.9	12.5	0.0	2.2	0.0
Bactrocera spp.	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0
Thrips tabaci	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0
Meloidogyne spp.	4.1	7.1	20.0	7.7	12.5	0.0	11.1	25.0
Leaf spot	0.0	0.0	0.0	3.9	0.0	0.0	2.20	0.0

n = number of farmers that grew each vegetable crop.

Among the socio-economic variables (gender, marital status, type of production system), only the age of the farmer significantly influenced their knowledge of pests ($P = 0.036$).

The most commonly cited pests of brassicae crops were bagrada bug, diamond back moth and cabbage aphid (Table 3). Red spidermites, African bollworm and white fly were considered the most serious pests of tomato (Table 3). Red spidermites, African bollworm and whitefly were significantly associated with pest problems of tomato ($P<0.05$). The other pests that were considered less important in tomato production were variegated grasshopper (*Zonocerus variegatus* (L) and the armoured bush cricket (*Acanthoplus discoidalis* Walker). Root knot nematodes (Meloidogyne spp.), though perceived as the most important pest of vegetables, were not significantly associated with tomato production. The other vegetable disease cited but not significantly associated with tomato production was leaf spot.

More than half of the farmers who grew rape significantly associated it with bagrada bug ($P<0.0001$). The second most important pest that farmers significantly associated with rape was diamondback moth ($P = 0.0035$). The third most important pest of rape was cabbage aphid, which was weakly associated with the crop. The most commonly cited pest of cabbage was bagrada bug, although the relationship to cabbage production was not statistically significant. The second most important pest of cabbage was diamond back moth, which was significantly associated with low cabbage production ($P = 0.0096$). Like in rape, cabbage aphid was perceived as the third most important pest of cabbage, but the association with cabbage production was not statistically significant. Other pests of cabbage cited were cabbage borer, armoured bush cricket and root knot nematodes. Kale like other brassicae crops was mostly associated with bagrada bug followed by diamondback moth and cabbage aphid. The root knot nematodes were perceived as the most important pests of kale and were significantly associated with the crop ($P<.0001$).

3.4. Farmers' use of pest management tactics related to pests and diseases

A majority of farmers (98%) reported that they controlled vegetable pests and diseases. Pest management tactics reportedly used included chemical control ($n = 107$), rotation ($n = 26$), weeding ($n = 19$), hand picking of insects ($n = 10$), crop sanitation ($n = 7$), tillage ($n = 7$), use of bio-pesticides ($n = 4$) and inter-cropping ($n = 4$). The most commonly used cultural control method was crop rotation. This was followed by controlling weeds around the fields by picking up some insects, sanitation and tillage. All the farmers from Gaborone region reportedly used at least one cultural control method ($n = 44$). In the Central and Francistown region more than half of the farmers in each region mentioned the use cultural control methods ($n = 14$ and $n = 7$, respectively). There were relatively few farmers in the Southern region ($n = 7$) and Western region ($n = 1$) who mentioned the use of cultural control methods. In Maun region three of the four farmers interviewed reported having used cultural control methods. Four farmers, three from Gaborone region and one from Francistown region cited the use of natural products to control pests and diseases on their vegetable plants. The use of various cultural methods was not influenced by age, gender or marital status.

The use of synthetic pesticides was a most commonly cited (95.4%) method of controlling pests and diseases of vegetables. Farmers who mentioned that they did not use pesticides (4.6%) were from the Western region. The use of pesticides was significantly influenced by the age ($P = 0.018$) of the farmer but not by gender or marital status.

The survey results showed that 24 pesticides (active ingredients) were used by farmers to control pests and diseases of vegetables in Botswana. The type of pesticides included 2 fungicides, 2 nematicides, 3 acaricides and 19 insecticides (Table 4). The highest number of active ingredients cited was from Gaborone region (17) followed by Francistown (13), Central (12), Southern (11), Maun (6) and Western region (2). The most commonly used pesticide was cypermethrin as indicated by 53.6% of the respondents followed by malathion (50%), alpha-cypermethrin (18.2%), dimethoate (17%), chlopyriphos (12.5%), mancozeb (9.82%), methomyl (7.1%), dicofol (6.3%) and carbaryl (5.4%). The rest of the pesticides, which were cited, are shown in Table 4. Fifty percent of the active ingredients mentioned were organophosphates, 16.7% pyrethroids, 8.3% carbamates and 8.3% organochlorines, 4.2% pyrazole, 4.2% inorganic copper and 4.2% dithiocarbamates. Seven of the pesticides cited by farmers in this survey are listed as extremely or highly hazardous (class Ia and Ib) by the World Health Organisation (WHO, 2005).

A test for significance of association between the most commonly cited pests of brassica crops and tomato, and the pesticides used against them showed that a significant number of farmers used cypermethrin ($P = 0.031$) and alpha-cypermethrin ($P = 0.034$) against bagrada bug. Diamond back moth was also significantly associated with the use of alpha-cypermethrin ($P = 0.050$) and cypermethrin ($P = 0.007$) but not with chlopyrifos, malathion, methomyl or chlorphenapyr. The cabbage aphid,

Table 4
Type of pesticides used in Botswana and the target pests and diseases

Active ingredient	WHO hazard class	No. of farmers	Crop	Target pest/disease
Cypermethrin (Pyr)[(i)]	II	60	Tomato, onions *brassicae	*H. armigera*, *P. xylostella*, *B. brassicae*, *H. undalis*, *B. tabaci*, *B. hilaris*
Malathion (OP)[(i)]	III	56	Butternuts, brassicae, onion	*Bactrocera* spp., *B. tabaci*, *P. xylostella*
Alpha-cypermethrin (Pyr)[(i)]	II	21	Tomato, brassicae	*H. armigera*, *B. hilaris*, *B. brassicae*
Dimethoate(OP)[(i)]	II	19	Brassicae, onion	*B. brassicae*, *B. tabaci*
Chlorpyrifos (OP)[(i)]	II	14	Tomato, cabbage	*H. armigera*, *P. xylostella*
Methomyl (Carb)[(i)]	1B	8	Brassicae, tomato	*P. xylostella*, *H. armigera*
Carbaryl (Carb)[(i)]	II	6	Tomato, cabbage	*Agrotis* spp.
Fenthion (OP)[(i)]	II	3	Butternuts	*Bactrocera* spp
Diazinon (OP)[(i)]	II	3	Butternuts, onion	*Bactrocera* spp.
Demeton-*s*-methyl (OP)[(i)]	1B	3	Brassicae	*B. brassicae*
Trichlorfon (OP)[(i)]	II	2	Tomato	*L. trifolii*
Endosulfan (OC)[(i)]	II	2	Tomato, onion, cabbage	*H. armigera*, *B. tabaci*
Deltamethrin (Pyr)([i)]	II	2	Brassicae, onion	*B. tabaci*, *B. hilaris*
Parathion (OP)[(i)]	1A	2	Cabbage, onion	*B. hilaris*
Dichlorvos (OP)[(i)]	1B	2	Brassicae	*P. xylostella*, *B. brassicae*
Methamidophos (OP)[(i)]	1B	1	Tomato, cabbage	*B. brassicae*
Beta-cyhalothrin (Pyr)[(i)]	II	1	Tomato	*Tetranynchus* spp.
Dicofol (OC)[(a)]	III	7	Tomato	*Tetranynchus* spp.
Chlorphenapyr (Prz)[(i)(a)]	II	5	Tomato, cabbage	*Tetranynchus* spp. *P. xylostella*
Abamectin (Avermetin)[(a)]	not listed	4	Tomato	*Tetranynchus* spp.
Fenamiphos (OP)[(i)(n)]	1B	1	Tomato, spinach	*Meloidogyne* spp.
Carbofuran (Carb)[(i)(n)]	1B	1	Cabbage	*B. hilaris*
Mancozeb (Dithio)[(f)]	U	11	Swiss chard	Leaf spot
Copper oxychloride (Cu)[(f)]	III	2	Cabbage	Powdery mildew

OP = organophosphate; Pyr = pyrethroid; OC = organochlorine; Carb = carbamates; Dithio = dithiocarbamate; Prz = Pyrazole; Cu = inorganic-copper. I = insecticide; a = acaricide; f = fungicide, n = nematicide; 1A = extremely hazardous; 1B = highly hazardous; II = moderately hazardous; III = slightly hazardous; U = unlikely to present acute hazard in normal use; *brassicae = cabbage, choumollier, rape.

which was cited as the third most important pest of cabbage, was significantly associated with alpha-cypermethrin ($P = 0.0003$) and cypermethrin ($P = 0.0068$), but not with malathion ($P = 0.084$) and dimethoate ($P = 0.188$). Unlike on brassica crops the use of cypermethrin and alpha-cypermethrin on tomato was not significantly associated with the African bollworm. The African bollworm was also not significantly associated with the use chlorpyrifos and methomyl on tomato. The use of chlorphenapyr was significantly associated with the control of red spidermites on tomato ($P = 0.016$), while dicofol was not.

3.5. Farmers' decision making in pesticide applications

Sixty-six percent of farmers stated that they initiated management tactics when they noticed pests in their crop. Twenty-six percent based their decision to apply pesticide on calendar spray schedules, 17% on noticing crop damage and only 2% on economic thresholds. When asked how often they spray their crops, 30% mentioned that they spray every week, 19% every 2 weeks, 9% sprayed at least once a month and 6% twice a week. Thirty-one percent of farmers stated that their frequency of spraying was determined by the presence of a pest or a disease symptom on the crop. Most farmers (94%) stated that they incurred losses due to pest and disease problems in their vegetable production.

3.6. Farmers' suggestions on improvements of pests and diseases management strategies

Most farmers (69%) mentioned that they used cultural control methods (crop rotation, sanitation, tillage and weeding) to manage pests and diseases. Thirty-one percent of them recommended that cultural control methods be encouraged among vegetable farmers. Eighteen percent suggested that farmers need training on crop protection techniques. Some of the farmers (18%) also singled out training on the proper use of pesticides as an important aspect of improving pest control on vegetable crops. Nineteen percent suggested that government could also consider subsidising pesticides used in vegetable production. Nine percent of farmers mentioned that lack of access to pesticides delays timely spraying of crops. A small percentage (5%) of farmers proposed that the approach be introduced in vegetable cropping systems.

4. Discussion

Farmers' ranking of the important vegetable crops generally agrees with reports by Bok et al. (2006) and Munthali et al. (2004) that brassicas, Swiss chard and tomato are the most popular vegetable crops grown in Botswana. These crops (except Swiss chard) were significantly associated with major pests of vegetable crops listed in Tables 3 and 4, which were also reported as the most destructive pests of brassica crops and tomato (Ingram et al., 1973; Munthali et al., 2004). Unlike in Cameroon (Kekeunou et al., 2006) and Nepal (Gurung, 2003), where gender influenced farmers' knowledge of pests, the knowledge of vegetable pests in Botswana was not influenced by gender or marital status. The small size of vegetable fields and high value attached to them possibly compel vegetable growers to monitor pests and their damage more closely than they would do on field crops.

In this study the majority of farmers ranked invertebrate pests as the major constraint to vegetable production followed by plant diseases. This perception is consistent with reports (Ingram et al., 1973; Munthali et al., 2004) that pests and disease problems are a limiting factor in vegetable production. However the ranking of pests and diseases by farmers is inconsistent with the report on the master plan for agriculture that ranked vegetable production-related constraints as the most important (TAHAL, 2000). However, farmers did not agree with the TAHAL report, which was based on scientific literature available in Botswana. It is important that research and extension know what farmers perceive as their main problem so that they can prioritise activities in line with farmers' needs. The survey shows that

farmers have knowledge of pests, diseases and their management, but they still rely heavily on pesticides. Based on this information, researchers and extension need to work with farmers in developing IPM strategies that will reduce their heavy reliance on pesticides.

Only two farmers from Western regions did not use pesticides in their vegetable crops, indicating a heavy reliance on chemical pesticides as in many developing countries. In Ghana it is estimated that more than 80% of farmers used pesticides on vegetables (Gerken et al., 2000), while in India vegetable production is estimated to accounts for 30% of all pesticides used (Lanting et al., 1998). More pesticides were recorded in the urban and peri-urban areas of Gaborone and Francistown during this study than other agricultural regions (Central, Southern, Western and Maun) where the majority of farmers are rural dwellers. Similar results were reported in Zambia (Drescher, 1997). Nearly a third of the active ingredients used by vegetable farmers in Botswana are classified either as extremely hazardous or highly hazardous by WHO. This has implications on the safety and health of farmers due to high risks associated with pesticides use.

Changes in the recommendations to reduce the availability of the most hazardous may now be achievable with the establishment of a registrar of agrochemicals to regulate or restrict the use of pesticides. Most of the older and cheaper pesticides may be of poor or adulterated quality since registration of pesticides had not started at the time of this study in Botswana.

Rather than deciding to apply pesticides when the presence of a pest or damage symptoms has been observed, or on a weekly or calendar spray schedule farmers need better guidance to reduce the risks of pesticide residues, pest resistance, pest resurgence and adverse effects on natural enemies. Although the educational background and experience of the farmers were not determined, some of these farmers might not be able to read or understand pesticide labelling and instructions on mixing of pesticides.

Although almost all farmers rely heavily on pesticides to manage vegetable pests and diseases, there is a potential for the introduction of an IPM programme for vegetable pests and diseases. Currently, there is no IPM policy in Botswana, although the Ministry of Agriculture has established a Division of Plant Protection. IPM is supported by farmers who use several cultural control methods, and considered that they should be encouraged among the vegetable growers. Training on efficient and safe use of pesticides is needed to minimise their use in an IPM strategy. Considering the high frequency of spraying reported by vegetable farmers, economic injury levels and economic thresholds are required to guide farmers on decision making in pest management and to minimise the use of pesticides.

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