Assessment of Integrated Pest Management options on reduction of pesticide residues and production cost of Snap beans (Phaseolus vulgaris L.) In Tharaka Nithi and Machakos Counties of Kenya

By
HARON NJOROGE GORO

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A RESEARCH PROPOSAL SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN HORTICULTURE OF THE UNIVERSITY OF NAIROBI IN THE FACULTY OF AGRICULTURE

SUPERVISORS:

DR. RICHARD NYANKANGA
PROF. PAUL M. KIMANI
PROF. GEORGE N. CHEMINING’WA

DEPARTMENT OF PLANT SCIENCE AND CROP PROTECTION
FACULTY OF AGRICULTURE
UNIVERSITY OF NAIROBI
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Introduction

- Agriculture sector in Kenya in 2012 contributed 30% to the gross domestic product (GDP) (MoA & HCDA, 2012).
- Under Horticulture sector, with only 4% being exported, Kenya earned about Kshs 87.7b in 2012 from exports of 380,000 MT (MoA & HCDA, 2012).
- French beans (*Phaseolus vulgaris L.*) also referred to as Snap beans or Green beans are of growing importance in social economic systems and livelihoods in Kenya (Odero et al 2012).
- The crop is grown by small scale farmers as a source of income mainly for fresh export (Wahome et al 2011, Monda et al 2003), with only 11% being consumed locally especially in urban centers (Odero et al., 2012; HCDA Validated Annual report, 2012).
- French beans accounts for about 60% of all vegetables exports and 21% of all horticultural exports (Nderitu et al., 2010: Odero et al., 2012).
## Production of Snap beans in selected Counties of Kenya - 2012

<table>
<thead>
<tr>
<th>County</th>
<th>Area (ha)</th>
<th>Volumes (tons)</th>
<th>Value Kshs. (Millions)</th>
<th>Share Value</th>
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<tr>
<td>Muranga</td>
<td>627</td>
<td>18,945</td>
<td>601</td>
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<tr>
<td>Kirinyaga</td>
<td>1,857</td>
<td>10,965</td>
<td>472</td>
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<td>Embu</td>
<td>71</td>
<td>804</td>
<td>116</td>
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<td>Meru</td>
<td>185</td>
<td>311</td>
<td>2,905</td>
<td>7%</td>
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<td><strong>All Counties Total</strong></td>
<td><strong>4,128</strong></td>
<td><strong>44,139</strong></td>
<td><strong>1,697</strong></td>
<td><strong>100%</strong></td>
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</table>
• The main counties producing the crop are Murang’a, Kirinyaga and Meru accounting for 43 %, 25%, and 7 % of the total production respectively.
• It sustains livelihoods of about 2 million persons directly and indirectly (MoA & HCDA., 2012).
• The main markets for French beans are UK, France, Holland and Germany; other emerging markets are United Arabs Emirates, and South Africa (HCDA, 2012.)
• Medium and small scale producers 90 % of French beans realising low yields (2 to 8 Mt Ha\(^{-1}\)) (Ndegwa et al., 2003) verse over 14 Mt Ha\(^{-1}\) realized by large scale farmers (CIAT., 2006; Kaburu et al., 2012).
• Kaburu attributed the low yield to abiotic and biotic factors (Kaburu et al., 2012) with insect pests and diseases being reported as the main biotic constraints in eastern and central Africa
• It accounts for 60% of all vegetable exports and 21% of horticultural exports (Nderitu et al., 2003)
The overreliance of pesticides in combating biotic factors that affect snap beans among small-scale farmers have lead to increased cost of production (Monda et al 2003).

Recent increased sampling and notifications of snap beans from Kenya due to chemical residues, prioritizes need for alternative pest and disease management options . (Monda et al 2003)

For Snap beans over use of pesticides is common among small-scale farmers and about 31% of the farmers spray twice per week at an average cost of Kshs. 3000.00 per season (Monda et al., 2003).

Further losses are experienced due to rejections caused by damage by pests and diseases, presence of chemical residues, variety preference and lack of knowledge by farmers on alternative pest and disease management options (Monda et al., 2003)

High residual levels have led to increased rapid alerts and interceptions with about 32% in 2011 on Dimethoate, Acephate, Dicloropyriphos, Difenthiuron, Indoxacarb, Methomyl and Metahmidophos.

EU FVO notification EC Reg. No. 1235/2012 effected January 1st 2013 resulting in increased frequency and identity checks and further threat by EU to increase sampling from current 10% to 50% if we cannot demonstrate action in reduction of MRLs.

In addition a mission from EU FVO visited in November 2013 in country to verify actions being taken.
Trend of notifications received since 1st Jan 2013 (organised by notification date) as at 20th Aug 2013

Source KEPHIS MD Brief to stakeholder - August 2013
Types Of Chemicals Causing Interceptions

Number of notifications received per pesticide since Jan 2013
(as at 20th August 2013)

- Trifloxystrobin: 2
- Carbendazim: 1
- Methoxyfenozide: 1
- Nicotine: 1
- Acetamiprid: 1
- Azoconazole: 1
- Tetradifon: 1
- Chlorpyriphos: 6
- Acephate & Methamidophos (as metabolite): 4
- Methomyl: 3
- Dimethoate: 14
Problem Statement

- There is further threat by EU to increase sampling from current 10% to 50% if Kenya cannot demonstrate its action in reduction of MRLs and a mission from EU – FVO (Food and Veterinary Office) are currently in the country verifying the actions being taken.

- This calls for immediate action by French beans producers in Kenya to ensure continued market share and market access and in response the Government have constituted a task force chaired by KEPHIS to spearhead activities aimed at reducing the interceptions (KEPHIS, 2013).

- A competent authority which consists of KEPHIS, HCDA, PCPB, FPEAK and MOAL&F (Horticulture Division) has developed an action plan on some immediate strategies like ensuring traceability, contract farming, pesticides residue analysis and practicing of ICM, PHI, and suspension of some pesticides and use of registered products.

- The long term recommendation to address the issue has been pesticide Residue trials for MRLs instead of use of limit of detection (KEPHIS 2012).

- The task force has formulated a four legged stool strategy for the Horticulture Competent Authority Structure (HCAS) to which is a multiagency as demonstrated here in:-
The major constraints of snap bean production include marketing, transport and diseases and pests (Monda et al., 2003).

This is also confirmed by Kedera and Kuria (2003) who highlighted the high yield and quality losses of snap beans due to pests and diseases.

This impacts negatively on increased pesticide use and thus production cost (Kimani, 2006 in Kaburu et al., 2012).

Other studies done at Meru indicate that 84 % and 79 % of farmers reported rust disease and bean fly as major disease and pest respectively (Monda et al., 2003).

Most farmers resort to expensive pesticides to effectively control the pests and diseases (Ndungu, 2004 and Monda, 2005 in Ndegwa, et al 2007)

According to Monda, 66% and 28% were still using chemicals with log Pre harvest Intervals (PHI) like Dimethoate and Anvil in their spray programme (Monda et al., 2003).

Repercussion of such chemicals makes the produce less marketable due to Maximum Residual Levels (MRL) requirements set by European markets (Kimani, 2002 in Wahome et al., 2011).

Strategies for controlling pests and diseases focus on single-method techniques (Mathew, 1999).
The Horticulture Competent Authority Structure (HCAS) - Implementation of Four Legged strategy in Kenya

Kenya Plant Health Inspectorate Service:
- Chair of NTH and pesticide residue monitoring plan

Horticultural Crops Development Authority:
- Enforcement of Good Agricultural Practice and Training of farmers

Pest Control Products Board:
- Pesticide formulation quality monitoring

Kenya Agricultural Research Institute:
- Research in “softer” alternatives; Integrated pest management and give spray regimes based on MRLs

Multi-agency system
Objectives

**Broad Objective**
The broad objective of this study is to identify ideal Snap beans IPM techniques with highest impact on reduction of both pesticides residues and production cost with the overall goal of enhancing competitiveness of Kenya’s Snap bean enterprise.

**Specific Objectives**
1. To determine the effect of selected IPM techniques in reduction of residue levels of priority pesticides in Snap beans.
2. To evaluate the potential of 8 new rust disease tolerant snap bean lines on plant growth vigor, pod quality, yield, market acceptability and disease control chemical residue levels.
3. To undertake a profitability analysis of IPM strategy in French beans production.
The hypothesis to be tested will include:

i. Pesticides residues levels are the same for Snap beans produced under IPM and farmers practice in the study area.

ii. The new disease tolerant lines are superior in yield, pod quality and market acceptability than conventional varieties

iii. There is no economic benefit of using IPM in snap beans production.
Smallscale Horticulture Development Project Schemes Location

1. Namelok Scheme in Kajiado County (429 Ha)
2. Ngurumani Scheme in Kajiado County (1,000 Ha)
3. Mosiro scheme in Narok County (325 Ha)
4. Lari Wendani Scheme in Nakuru county (72Ha)
5. Kabanon Kapkamak Scheme in Elgeyo Marakwet County(589Ha)
6. Kauti Scheme in Machakos County (72 Ha)
7. Kabaa Scheme in Machakos County (320 Ha)
8. Kathiga Gacheru Scheme in Embu County (80 Ha)
9. Mbogoni Scheme in Tharaka County (100 Ha)

Ministry of Agriculture, Livestock & Fisheries
State Department of Agriculture-,Hill plaza
P.O.BOX 30028-00100
Tel020-4933000
Email: npcsghdp@yahoo.com
Study Sites Description

Mbogoni Irrigation Scheme (Mr. Luka Mutisya’s farm)
- Location - Meru South district, Tharaka Nithi County.
- Log: 37°69’ East and S: 0° 41’ South with
- Altitude of 1200 in AEZ- LM 3
- Rainfall- Bimodal rainfall of 650- 1050 mm with Oct – Dec being the long rains.
- Soils are a mixture of Volcanic red soil, sandy loam and black cotton.
- Diannual temperature ranges between 15° C to 30° C.

Kabaa Irrigation scheme (Mr. Japheth Gitonga’s farm)
- Location- Mwala Sub county, Machackos County.
- Coordinates- 0° 58’ South and 37° 02’ East,
- Altitude 980 m in AEZ LM3 .
- Rainfall- Minimum 800mm and maximum of 1200mm mostly un-reliable and un-evenly distributed.
- The mean annual maximum and minimum temperatures are 18°C and 33°C
- Soils being a mixer of sandy loams and black cotton soils in some areas
Materials & Methods

• The experimental design to be applied to achieve the three objectives will be independent of each other. This will ensure achievement of each objective of the experiment.

Objective 1. To determine the effect of selected IPM insect control techniques in reduction of residue levels of priority pesticides in Snap beans.

• The experiment will involve three treatments to control bean fly, leaf minor, and aphids, the experimental lay out will be **Randomised Complete Block design with four treatments and two replications**.

• Two new disease tolerant lines (KSB13-01 & KSB13-02) from university of Nairobi and two popular varieties (Solia and Samantha) will be used.

• The sub plots for this experiment will 3m by 2 m (6m²) which will accommodate 4 rows (2 m long) spaced at 60 cm with intra row spacing of 10 cm. *(See lay out design)*
Planting & Cultural practices (See soil results in Annex)

- For Mbogoni site (PH of 6.45 - Top soil and 6.15 -Sub soil and deficient in N and P),
  - Planting use decomposed manure at rate of 2 MT/ acre (5 MT / Ha) and 100 kgs / Acre (250kg/ Ha) N:P:K 23:23:0
  - Top dressing with CAN at rate of 50 kg /Acre (125 kg/Ha) during 2-3 leaf stage and equal amount during onset of flowering.

- For Kabaa site acidic soil ( PH of 5.84 -Top soil and 4.90-Sub soil) and deficient in N, P and Zn,
  - Planting use decomposed manure at rate of 4 MT/ Acre (10 MT / Ha) and 100 kgs / Acre (250kg/ Ha) N:P:K 23:23:0
  - Top dressing with CAN at rate of 80 kg /Acre (200 kg/Ha) during 2-3 leaf stage and equal amount during onset of flowering.
  - Foliar feed like Bayfolan which is rich in Zinc will be used from fourth week to mid podding stage.
For this experiment, the data to be collected will include:

1. Number of plants affected by bean flies at two weeks for each treatment, (taking counts of plants with bean fly symptoms) at 2 weeks after germination.

2. Data on rejections due to damage by Thrips and Boll worms to will be taken once per week for all plots.

3. Data on pesticides residues where, the harvested pods from each treatment menu will be harvested and processed for pesticide residue levels.

4. Sampling in line with the provisions indicated in directive 79/700/EEC, which stipulates the EU methods of sampling for the official control of pesticides residues in and on products of plant and animal origin (Tsakiris, et al., 2007.) will be done by selected and trained HCDA field staffs.
5. Samples will be collected once per week for four weeks (total of 16) and taken for analysis at the ISO certified KEPHIS laboratories.

6. Residue levels of selected pesticides by gas chromatography-mass spectrometry following solid phase extraction.

7. The samples from IPM plots for insect control will be analyzed for Imildacropid (Gaucho\textsuperscript{R}) and Hexaconazole (Anvil\textsuperscript{R}).

8. Samples from farmers’ practice will be tested for all active ingredients including Tebuconazole (Orius\textsuperscript{R}), Axosystrobin (Amister\textsuperscript{R}), Mancozeb, Deltermenthrin, Alphercypermethrin and any other recommended pesticides.

9. The results from each management strategy will be recorded and analysis done to determine the mean levels for comparison through ANOVA.

10. This will help in determining the extent to which specific IPM management strategies have been effective in reduction of pesticide residue levels of priority pesticides in Snap beans.
Methodology

The proposed details of the four treatments are as follows:-

• **Treatment 1:** Will involve Seed dressing (SD) where seeds will be dressed with Imidacropid (Gaucho<sup>R</sup>) at the rate of 8 Mls /Kg for control bean fly, Leave minor and Aphids before flowering

• **Treatment 2:** Use of Alphacypermenthrin (Decis<sup>R</sup>) spray (SP) will be sprayed once per week from 5<sup>th</sup> Week to end of harvesting to control leaf minor, Aphids and Thrips.

• **Treatment 3:** Will be a combination of both Imildacropid & Alphacypermenthrin (SD & SP) will be done

• **Treatment 4:** Farmers’ practice (FP) as a control for control of Bean fly, Leaf Minor, Aphids and Thrips will be done. *(See spray programee)*

• The crop will be irrigated as required using furrow irrigation method at Kabaa site and drip method for Mbogoni site.

• Other cultural practices including weed control, harvesting and grading will be uniform for all sites and plots.

• At green pod maturity; the crop will be harvested 3 times per week at one day interval.
Methodology

Objective 2.
To evaluate the potential of 8 new rust disease tolerant snap bean lines on plant growth vigor, pod quality, yield, market acceptability, disease control chemical residue levels.

- The experiment will be undertaken in the two schemes and the crop management will be as in experiment 1. Eight lines from university of Nairobi with tolerance to rust will be planted alongside 2 commercial varieties (Solia and Samantha).
- The pest control will by use of seed dressing and spray with alphacypermenthrin as in experiment one third treatments.
- The experimental design to be deployed will be Complete Randomised Block design with three treatments replicated twice in the two sites.
- Each sub plot will be 3m by 2m with two rows spaced at 60 cm and intra plant spaced at 10 cm and for each case the treatments will be as follows:

  **Treatment 1**- The 8 lines without the pre flowering Hexaconazole (Ortiva\textsuperscript{R} ) spray
  **Treatment 2**- The 8 lines with the pre flowering Hexaconazole (Ortiva\textsuperscript{R} ) spray
  **Treatment 3**- Farmers’ normal practice as a control where spray Ortiva\textsuperscript{R} at 20ml/20 lts water on second week will be done to control Rust.
Data to be collected for Exp. 2

- For each line/variety data will be taken on growth habit and crop vigor score at 6 weeks on scale of 1-9 where score 1-3 will be high vigor, 4-6 moderate vigor and 7-9 low vigor (CIAT, 1987; Ndegwa et al., 2007).

- Later, when mature, harvesting will be done and samples from each line picked and the quality of the pods recorded on a scale of 1-10, where 1 would be the poorest quality and 10 the best quality.

- The quality of the pods will be determined by the shape and size and the presence/absence of scars.

- The harvested pods from each variety/treatment will be weighed to determine the mean yields for comparison.
Data Analysis Exp. 2

- The comparisons will be done by use of ANOVA and if significant differences occur mean separation will be done to specify the actual varietal/treatment yield differences.

- Disease assessment will be initiated 4, 6 and 8 weeks after germination respectively, based on a 1-9 severity score according to Van Schoonhoven and Pastor-Corrales (1987) and Wahome, 2011).

- This is similar to what was used in KARI with 1-3 being resistant/tolerant, 4-6 moderately tolerant and 7-9 being susceptible.

- A comparison in terms of disease tolerance within the treatments and between the treatments will be done.

- Harvests from the sprayed lines will be sampled and tested for Hexaconazole residue levels and measured against the international standards (MRLs).

- Similarly, harvests from farmers’ practice will be sampled and the chemical residue levels determined and compared.

- On these bases, the high yielding superior varieties will be determined, described and recommended.
Methodology for Objective 3

To undertake profitability analysis of IPM strategy in French beans production

For us to achieve this objective, we intend to assess the following IPM strategies:

[1]. Use of dressed seed from improved varieties in experiment one.
[2]. Use of improved varieties in experiment two
[3]. Use of Alphacypermenthrin spray at flowering stage in experiment one
[4] Combination of Seed Dressing, Hexaconazole pre-flowering and Alphacypermenthrin spray in experiment two.

➢ In all cases, the costs and benefits will be assessed in relation to farmers’ practice as the baseline.
• Costs of seed, seed dressing, fertilizers, planting, irrigation, weeding, harvesting and handling and transportation will be determined for the plots and extrapolated to a hectare.
• Similarly, the yields per plot will be extrapolated to a hectare and the total revenue generated determined given the prevailing French beans producer price.
• For each of the IPM production strategy, a gross margin per hectare will be determined and comparisons made with others for ranking. Gross margin is usually calculated as

\[ GM_i = TR_i - TVC_i \]

where:
- \( GM_i \) is the gross margin for French beans where IPM strategy \( "i" \) will be employed
- \( TR_i \) is the total revenue for French beans where IPM strategy \( "i" \) will employed
- \( TVC_i \) is the total variable cost for French beans production where IPM strategy \( "i" \) will be used.

• The gross margins for French beans where the various IPM strategies will be employed will be ranked amongst themselves and against that of French beans produced using the normal farmers’ production practices.
• The study will conducted as described in the overall methodology and the 8 disease tolerant line will be evaluated on growth parameters.
• The data will be taken for all the lines / varieties in each replicate, site/ location and seasons. It will be analyzed to compare growth vigour for the new lines/ varieties against the commercial varieties.
Expected outputs

The expected outputs of this validation will be:

- Identification and adoption of ICM strategies with highest impact on reduction of pesticide residuals.
- Snap beans ICM will be evaluated and adopted by stakeholders.
- Locally breed snap beans lines with best market quality attributes and potential to increase farmers income identified and adopted.
- Reduction of notifications for snap beans due to reduced pesticide residuals.
- An Master of Science thesis written and submitted.
- Publications in refereed journals and presentation in conferences.
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<th>Task name</th>
<th>Unit</th>
<th>Amount</th>
<th>Total Cost</th>
</tr>
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Progress Report

• Finalization of proposal and concurrence with KARI (Proposal is ready)
• Farmers & Exporters/ Processors in both locations identified and land prepared
• Soil sampling and analysis
• Planning & Briefing to KARI Work plan and Budget agreed on.
• Staff from Ministry & KARI Selected and briefed.
• Funds allocated to KARI Headquarters.
Pending work

• Approval by BPS- May
• Release of funds to KARI Embu & Katumani and Inputs acquisition- May
• First crop planting and data collection- Mid May to July.
• Second planting, planting and data collection- Mid June to July
• Data analysis, Thesis compilation- August to September 2014
• Graduation December 2014
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