PESTICIDE USE KNOWLEDGE, ATTITUDE AND PERCEPTION INFLUENCE RESIDUE OCCURRENCE IN FRENCH BEAN (*Phaseolus vulgaris*) PODS IN MURANG'A COUNTY, KENYA

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ABSTRACT
Some Kenyan horticultural products are rejected in export markets due to excess Maximum Residue Levels. Farmers need assistance on pesticide use to meet stringent quality crop, freedom from pests and pesticide residues standards. This study assessed farmers' knowledge, attitude and practice that may influence pesticide residue occurrence on their crop and health. A cross-sectional survey was done among French bean farmers in Murang'a County. Stratified random sampling was done based on use of synthetics or biopesticides for organic production. Questionnaires were administered to 100 French bean farmers via face-to-face interview in Kikuyu language by trained enumerators. Pesticide use knowledge, attitudes, and practices were scored and dichotomized and Chi-square-tested at P=0.05. The pesticide use practices were significantly different across the demographics such as education level and years of practice. The knowledge on pesticide use was very high but there was ignorance of protective clothing use and proper pesticide container disposal, which strongly correlated with the health ailments such as headaches at R=0.6. The biopesticides from common plant extracts (*Trichoderma, Azandchatra*, *Mexican marigold*) were reported to have better protection against frost but they were slightly lower in crop pest protection than insecticides such as Aster, Cyrux and Extrim. The overall attitude towards biopesticide use was 76%, but most farmers were hindered by lack of knowledge on preparation. Most farmers require the knowledge on mixing, adoption of safer, less expensive and locally available biopesticides, which will catalyze the move towards organic production for good human and environmental health.
Keywords: Biopesticides, Maximum Residue Level, Pesticide practices

INTRODUCTION

Global agricultural production should increase by 70% by the year 2050 (Searchinger et al*.,* 2013; Kumar, 2012) to provide economic opportunities and sufficient food for the world's population (projected to 9.1 billion by 2050). Use of pesticides is key to this further increase especially with the rise in pests and disease as the climate changes (Kumar and Singh, 2014; Dhaliwal and Koul, 2010). However, extensive use of synthetic pesticides may generate long-term residues in food and in the environment (EFSA, 2009) where they may lead to pesticide resistance (Raja, 2014; Dhaliwal and Koul, 2010; Aktar et al*.,* 2009); death of beneficial non-target organisms (Dhaliwal and Koul, 2010; Angeluz, et al*.,* 2008) and change in microbial activities (Singh and Walker, 2006). In attempt to solve these problems, there has been a rigorous search on biopesticides that have diversified secondary metabolites (Raja, 2014; Kumar, 2013) that have broad spectrum of activity and are readily biodegradable (Kumar and Singh, 2014; USEPA, 2013; Palacios, 2010) hence, they have no residues. However doubts of their efficacy have led to slow adoption (Monda et al*.,* 2003).

There is a need to study the pesticide use practices in Kenya's horticultural industry, where French bean (*Phaseolus vulgaris L*.) being the signature crop since 1980s (Odero et al*.,* 2012, Jaffee, 2003) is on pesticide intensive production. French beans are attacked by bean fly *(Ophiomyia spp*), aphids, mites, thrips, the African bollworm (*Helicoverpa armigera*) (Godfrey and Long, 2008) among others. The crop is infected by wilt caused by *Fusarium oxysporum* f.sp *phaseoli*, nematodes (*Meloidogyne* spp), bean rust (*Uromyces appendiculatus*), bacterial blight and bean anthracnose (*Colletotrichum lindemuthianum* (INFONET, 2012). Overuse of pesticides to control pests and diseases has led to high pesticide residue levels on the crop leading to its rejection at the European market that has led to a decrease in export earnings to 83.4 billion shillings in 2013, down from 89.3 billion in 2012 (Fresh plaza, 2014). Pesticide residues are related to the pesticide use practices as well as degradation rate of the pesticide which depends on the environmental factors and the chemical properties (Jorge et al. 2008; Fishel 2014). Pesticide use practices such as poor handling during application; applying the wrong pesticides to an unregistered crop; application rate, frequency of application, type of equipment used; calibration of nozzle-output to the desired dosage; safe wash water disposal; record keeping; weather considerations and storage (Fishel and Nesheim, 2000) the pre harvest interval (Dan Mahr 2001, Keikotlhaile and Spanoghe, 2011) determine residue occurrence. Proper pesticide use practices could minimize human exposure to pesticides and their potential adverse effects on the environment (Damalas and Elefthero, 2011). This

necessitates the study of knowledge, attitude and practices of pesticide use among French beans farmers that may lead to excess residues on the crop and the environment in order to devise crop protection strategies based on the farmers' needs. Excessive pesticides on orchards was noted in Brazil and Colombia leading to excessive residues on crops (FAO, 2003). According to FAO 2013, the technology used to spray pesticides, safety aspects and indiscriminate use of pesticides in developing countries, reflects technical standards of 40 years ago, resulting in pesticides waste and environmental damage.

The environmental factors affect residue occurrence in that, once the pesticide is applied onto a crop, pesticide become adsorbed on to the surface or absorbed into the tissues. The persistence of the chemical as a toxic metabolite (Nasir et al 2001), depends on its solubility and volatility and the plant metabolic activity of organic compounds as well as environmental conditions such as radiation, temperature, precipitation and wind regime. In a study of effect of rain characteristics on dithane wash off from apple seedlings, dithane washed-off was (9% for light rain, 55% for heavy rain, and 80% for torrential rain showing high influence of rain intensity (Hunsche et al 2007). The period of use may also influence the concentration of pesticide in the soil and the possibility of the current crop absorbing pesticides that were applied to the site previously. For instance, a research on pesticide accumulation confirmed that copper compounds used as fungicides in citrus groves accumulate after many years of use in Florida (Fishel, 2014). The occurrence of excess pesticide residues in the market product may also be due to short pre harvest intervals and other pesticide handling practices (Fishel, 2014b).

MATERIAL AND METHODS

This paper is a preliminary study to inform a major study in the environmental impacts of long-term pesticide use in growth of French beans. Descriptive survey design was appropriate to determine and report the findings.

The study site was carried out in Murang'a County in Central Kenya. The study location was chosen because this area has most production of French beans. It lies between 0°34' South and 1°07'South and longitudes 36°East and 37°9'East lying at an altitude of 1100 -1400 m above the sea level. The temperature ranges between 14 and 30°C. The average rainfall is 900 mm /yr on low potential areas but rises to 1400-1600 mm/yr in high potential areas. The rainfall is bimodal with long rains from March-May and short rains in Oct –Nov.

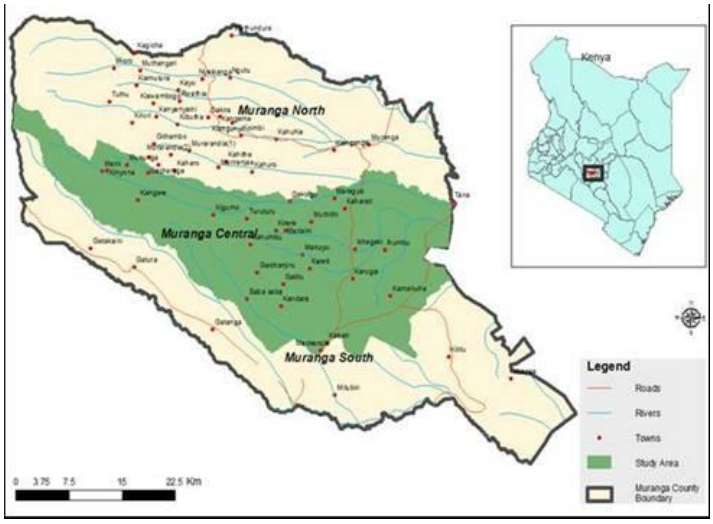

Figure 1.1: Study Site map: Murang'a (0° 34' 0" South, 37° 9' 0" East) Central Subcounty

Higher areas have rich brown loamy soils while the lower area has black cotton and clayey soils dominated by horticultural crop production (District Environmental Action Plan, 2006-2011). The study sub catchments are drained by Irati, Maragua and Sabasaba streams namely Kaharati, Nginda, Kandani respectively. It's on volcanic foot ridges very eroded and depleted (Jaetzold et al., 2007).

Details of Survey Procedure

Survey was carried out to collect data on background and biographical information; knowledge, perception and cultural practices of pesticide use in French bean cultivation in Murang'a central sub county. A cross sectional research design was adopted to gather information on pesticide use practices on 100 stratified along use of either biopesticide or synthetics from an approximated four hundred French bean farmers (Murang'a County Assembly report, 2014). The sample size was determined by specifying the confidence level of 95% and error of 0.1.

$$n = \frac{z^2.N.\sigma^2 p}{(N-1)e^2 + z^2.\sigma^2 p}$$

Where: N = size of population, n = sample size, z = the standard variate at the 95 % confidence level, e = the acceptable error from the true value 0.1, $\sigma^2 p$= standard deviation of population. If standard deviation is not given, it is estimated from the range value within which 95% of population lie (+1.96 to -1.96) (Kothari, 2004). N = 1.96^2 .400.1 = 100 farmers. 399. 0.1^2+ 1.96^2.1

Ethical issues considered included confidentiality, objectivity and freedom to withdraw. Before the actual data collection, pretesting was done with 15 respondents to improve reliability and validity. A correlation coefficient of 0.72 was obtained with Cronbach coefficient alpha method. A face-to-face interview schedule with the farmer was used to ensure timely response and clarification of information from the respondent (Appendix I). The information sought was basically on pesticide use practices during wet and dry seasons, the environmental and health effects of pesticide as observed by the respondent and the attitude towards biopesticide and synthetics.

Data Analysis

Questionnaires were checked to remove outliers, multiple entries and incomplete items. Data was analysed using SPSS version 22 for windows. The research yielded both qualitative and quantitive data. The study employed descriptive statistics and limited inferential statistic to analyse data. Descriptive statistic included frequencies, counts, andpercentages. Inferential statistics employed Cross tabulation of nominal variables; Spearman rank correlation of the ranked variables and Pearson correlation of the continuous variables. The statistical procedures were performed using statistical Package for Social Sciences (SPSS).

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

Age: The age distribution of respondents is indicated in Table 1. With the modal age being 40, majority of respondents (71%, n=96) were 40 years and below.

Gender: Most of the respondents in the survey (66%, n=100) were female, probably because females were more patient than their male counterparts in responding to the questionnaire and they were found at home at the time of interview.

Category of employment: Asked to indicate the category of their employment from the alternatives provided in the questionnaire, a majority of respondents (89%, n=100) indicated that they were farmers. The average farm size was 2.4 hectares and French bean production took approximately a 34.15% of this especially on the foot slopes where there's availability of water for irrigation.

Pesticide Use Practices and Attitude

All farmers rely heavily on pesticides with 86% of the 100 farmers using synthetics while the other 14% uses botanicals. 93% of farmers owned a hand operated knapsack sprayer and all the farmers use a sprayer for pesticide application. They use thirteen different insecticides and seven types of fungicides. The pesticides are mostly applied on a calendar prophylactic basis other than on economic injury point. Pesticide usage in the study area is highly influenced by the companies and the farmers are also not aware of which pest is controlled and the quantities of application are determined by the company rather than on need basis. About 60 % of the farmers apply an average of six time during a growing season. The pesticides are applied in a mixture of two or three; an insecticide and a fungicide oblivious of the resulting reactions and possible phytotoxicity on the plant (Smit et al. 2002).

Pesticide Use Knowledge

Approximately 30% of the farmers have had training on pesticide use from field demonstration on how to spray. The knowledge on pesticide storage and disposal practices is high among farmers 68% of 86 and they are aware of the adverse effects of the pesticide. Lack of training of users in pesticide handling and application in Pakistan led to ground water pollution; equipment leakage was the major concern in Thailand and Phillipines (FAO, 2003). Improper disposal of pesticide containers with small amounts of residues and rinse water can also cause environmental contamination (Fishel and Nesheim 2000). They also suggested measures to reduce the hazard of harmful pesticide residues such as; complying with label directions for application rate, timing, and placement; avoiding incompatible mixtures that create pesticide wastes; avoiding pesticide spills on to soil or water; use of protective clothing, and use of calibrated application equipment. Most farmers store pesticides outside in store or in the farm. Use of protective clothing is not common with most farmers but only those contracted by companies to spray on farms uses nose mask hence the likelihood of contamination through inhalation. 88 % use ordinary home clothes when spraying that are deemed protective. The most commonly used Protective clothing were boots (81% of all), followed by long-sleeved shirts (74%), head cover 60%, overalls (40%), impermeable gloves 20% and nose mask (3%). The farmers claim that they are expensive to buy. But, most farmers do not know the pesticide they use by name especially farmers affiliated to a company that applies chemicals for them. Consequently, there's need for farmers training on the dangers of inhalation during application and the effects can be correlated to the recurrent headaches reported by most farmers.

Table 1: Summary of protective clothing use by farmers

Protective gear	Number	Frequency %
Impermeable gloves	20	25
Overalls	40	44
Long sleeved	74	80
Boots/shoes	81	95
Body wash every day	98	100
Nose masks	2	3
Head cover	60	70

The association between increasing levels of pesticide usage and human and environmental health

The prevalence of self-reported symptoms is in tandem with the use of protective clothing in that shown in headache was reported by majority of farmers due to disuse of nose masks and the farmers inhale the pesticides, body fatigue, blurred vision, dizziness and nausea are the most commonly reported symptoms. A similar observation was made in India where insufficient protective clothing contributed to poisoning among operators (FAO, 2003). Regarding the adverse effects on the environment (water, soil insects, and animals, there was hardly any noticeable poisoning but definitely these organisms are not even present in the farms as compared to a natural non cultivated farm. Crissman et al (2012) also found that the effects

of pesticides vary spatially according to pesticide use and found out that improved farm worker practices combined with improved pest management practices reduced use and adverse health effects of carbofuran by 50 % without reducing potato production.

Factors to consider when applying pesticides

Most farmers consider the stage of growth informed by days from planting to determine when and how much to spray the pesticide.

Table 2: The factors that inform pesticide application

Source	Number	percentages
Manufacturers information	12	16
Pest disease incidence	6	18
Advice from extension	2	6
Stage of growth	85	91

Effect of pesticide on human health and environment

About 40% of the farmers interviewed said that their crop has ever been rejected due to high residues, pests and disease damage and excess production. Surprisingly the reasons depended on the company of affiliation. All the rejection cases were from the companies that allow farmers to manage the crop while all surplus produce rejection was by farmers from the export company.

Respondents' Overall Comments on French bean production

The last question on the questionnaire requested respondents to provide overall comments on French bean production in the light of answers they had provided in the rest of the questionnaire. Below is a summary derived from those comments. Poor market price was regarded as a serious problem by most respondents. They felt that it was necessary to establish a policy on the minimum price so that cases where middlemen took advantage of their little produce would be stamped out. It was felt that low prices could affect small scale farmers, since in many cases they were put in fixed positions with nowhere to sell their crop once it was ready yet it is perishable.

CONCLUSION

The main conclusion to be drawn from the surveys is that the farmers are solely dependent on pesticides and no effort has been made to diversify to other integration that are non chemical methods of pest control which leads to high human health issues, environmental pollution and high cost of production. The pesticide use practices especially the use of biopesticides and synthetic pesticides greatly influence crop rejection due to pesticide residues. A general observation is that the farmers have been tied in a persistent poverty yet they are endowed with natural and human capital. Poor economic status was a characteristic of all farmers attributed to suboptimal production as they literary lend out their farms under the care of export and local companies to manage the pests and disease at low residue levels. However, the complaints were different in two fundamental ways: (i) that the farmers in local marketing company cried of poor prices but had guaranteed market (ii) the farmers of exporting companies had limited market for surplus production hence they could not exploit the full potential of their natural and human capital.

RECOMMENDATIONS

Murang'a has an economic edge in exploiting the horticultural export market due to its favourable climate, soil, water and its proximity to Nairobi airports.

The recommendations arising out of the study are four-fold:

- Training intensification to creating awareness on safe pesticide use and embrace integrated pest management especially biopesticides.
- Carry out research on the environmental constraints such as polluted water or soil over the years
- Research on market for farmers. The destination countries can focus on pro poor economic opportunities by providing stable market channels
- Intervention is needed in devising crop protection strategies that does not lead to excessive residues but ensures optimal production. This will unlock the current situation where farmers' production is limited and stagnating farmers to persistent poverty in a land of plenty where natural capital of climate, soil and water is available.

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