A SURVEY OF PESTICIDE USE AND APPLICATION PATTERNS AMONG FARMERS: A CASE STUDY FROM SELECTED HORTICULTURAL FARMS IN RIFT VALLEY AND CENTRAL PROVINCES, KENYA

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ABSTRACT
About 25-35% loss in agricultural produce is caused by pests and diseases which can be controlled by use of pesticides. These pesticides kill or deter the destructive activity of the target organism and they posses' inherent toxicities that endanger the health of the farmers, consumers and the environment. This leads to a need to study or assess pesticide usage patterns and applications on horticultural farms. To this effect a survey was carried out in Rift Valley and Central provinces of Kenya between October 2009 and January 2010 on horticultural farms producing either kales, french beans, cabbage, eryngium, morbydick and arabicum. Results indicated that pesticides are readily available and widely used in farms and the main herbicides in use were identified as linurex 50 wp and diurex 80wp while insecticides included diazol 60EC and methomex 90S, fungicides included folicur EW and dithane M45. Sixty (60%); of the respondents were Male and 40% female between the age of 20-60 years with an average age of 45 and a standard deviation of 13.3 years. Eighty (80%) of the respondents agreed to use hats, gloves for protection but they were not in good condition thus exposing them to pesticides. The pesticides affected the environment by citing death of fish in nearby rivers. The most frequently mentioned source of information on clinical usage was from commercial media (37.6%), government agricultural extension officers (26.4%), village leaders (25%) and finally the opinions of other community leaders. Educational interventions are essential for promoting safety during all phases of pesticide handling. Public policies should be developed to encourage farmers to change their pest management methods from chemical based to methods that are healthier and more environmentally friendly.

Key words: Pesticides, horticultural farms and pesticide application

1.0 Introduction

Agriculture accounts for about 24% of Kenya's GDP with an estimated 75% of the population depending on the sector either directly or indirectly. Much of the intermittent strength and overall weakness in GDP and income growth in Kenya can be attributed to changes in agricultural performance. The horticulture sub-sector of agriculture has grown in the last decade to become a major foreign exchange earner, employer and contributor to food needs in the country. Currently the horticulture industry is the fastest growing agricultural subsector in the country and is ranked third in terms of foreign exchange earnings from exports after tourism and tea. Fruits, vegetable and cut flower production are the main aspects of horticultural production in Kenya (Export processing zones authority, 2005).

As an agricultural economy, Kenya's demand for pesticides is relatively high. The import demand is further fuelled by regional consumption in land locked countries like Uganda, Rwanda and Burundi. Indeed the development of horticultural farming in Kenya equally increased the demand in the late 1990's (Paul, 2005). Kenya imports approximately 7,000 metric tones of pesticides worth billions of Kenya shillings (US$ 50 million). These pesticides are an assortment of insecticides, fungicides, herbicides fumigants, rodenticides, growth regulators, defoliators, proteins, surfactants and wetting agents. Of the total pesticide imports, insecticides account for about 40% in terms of volume (2,900 metric tones) and 50% of the total cost of pesticide imports (Ngaruiya, 2004).

Pesticides were brought into Kenya by the colonial government early in the 1920's. The earliest British government legislation, the Public Health Act, to protect human beings and regulate the use of pesticides by farmers in Kenya was enacted in 1921. Therefore, the toxic effects of pesticides were observed very early, soon after their application in the environment. It must be concluded that the early observed adverse effects of pesticides on humans necessitated the regulation of their use and handling (Shem, 2001). In recent years, concern has been growing that improper agrochemical use can create hazards for humans and the environment. Along with the green revolution policy around the world, the use of pesticides has skyrocketed over the past 40 years (Harris, 2000).

Challenges facing the horticultural industry in Kenya are to produce pest/damage free products, which are also pesticide residue free. The only way to come out of the puzzle is to adopt natural pest control methods. The Kenya horticultural industry is the second largest foreign exchange earner after tea. It earns US$300,000,000 annually. It creates employment to both the rural and the urban populations estimated at 500,000 and over 2 million people respectively (Mehrdad, 2004). Kenya is the largest flower exporter to the EU, with 25% of the market share, where 50,000 tonnes of flowers are exported annually. The horticulture industry is the major consumer of pesticides and the export market customers now demand a reduction in pesticide use (Mehrad, 2004).

1.1 Statement of the Problem

The heavy use of pesticides has resulted in various negative health, environmental and economic consequences (Ashburner and Friedrich, 2001). The Food and Agricultural Organization (FAO) FAO (2008), has been concerned about various reports of ill health associated with those applying pesticides. The World Health Organization had estimated that a million people were being poisoned annually with 20,000 cases resulting in death (WHO, 2006). Much of this problem was due to the toxicity of the pesticides that are used by many farmers but without adequate knowledge and failure to wear appropriate protective clothing. Health problems associated with pesticide application are usually blamed on the pesticides without considering how they are applied (PCPB, 2005).

1.2 Justification

Pesticides abuse and misuse is common in Kenya and in Africa, although the use of pesticides in Africa represents a small fraction of the global total, misuse is disproportionately high Factors that lead to these high misuse rates include the high illiteracy levels and inaccessibility to reliable protective clothing. Smuggled products, unregistered products, open air sales, sale of banned product, cases of decanting and reweighing, faking of pest control products using counterfeit labels, sale of expired products with modified expiry dates are among the misuse cases that have been reported in Kenya. Spraying mistaken products has lead to the dead of hundreds of flock (PCPB, 2004). To promote appropriate use of pesticides and applications, it is critical to understand the current use of pesticides among farmers, who are the majority of the Kenyan agricultural labor force. Until now, there have been no published reports regarding the actual behavior of farmers pesticide use and applications patterns. For this reason, this study was conducted to determine pesticide use and application among farmers in Rift valley and Central provinces, Kenya.

1.3 Hypothesis

There is no misuse of pesticides and applications among farmers.

1.4 Objective

To determine the current pesticide use patterns and applications among farmers in Rift Valley and Central provinces of Kenya.

2.0 Materials and Methods

2.1 Description of Study Areas

The study was carried out in selected horticultural farms in Rift valley and Central Province, in Kenya. These are mainly agricultural provinces where the population producekales, cabbage, French beans and horticultural (flowers and vegetables) crop production. The majority of these produces are sold on the national market or exported. The survey sites selected were based on the proportion of full-time farm populations, cooperation from local leaders, and the willingness of farmers to participate. The farms selected were Wanduhi (1^{o} 02'49.98"S 37 ^{o}05'43.66"E elevation 4869ft), Jkuat (1 ^{o} 03'31.52"S 37 ^{o} 00'46.98"E elevation 5014ft), Langalanga (0^{o}18'27.87"S 36^{o} 04'15.53"E elevation 6303), Kariandusi (0^{o}26'58.39"S 36^{o} 15'42.92"E elevation 6299ft), Longonot (0^{o}50'27.08"S 36 ^{o} 28'37.25"E elevation 7008ft) and Sher agency (0 ^{o} 16'15.04S" 36 ^{o} 22'34.33"E elevation 7783ft).

2.2 Data Collection

The data was collected by means of a structured questionnaire (Appendix 1) for information on farming systems, pesticide use and practices, applicator precautions/averting behavior and health/ environmental effects. The survey was divided into two major sections, one dealing with the socio-economics of pesticide use (for example production, pesticides used, protection, training, etc.) and another strictly dealing with the health of the farmer (for example questions on self-reported health ailments/ health-related habits, a general physical exam, and patch-skin and blood tests for pesticides). The survey was conducted during October 2009- January 2010. To minimize any possible reporting bias, the survey was conducted under agreement that the team would not reveal the identity of the farmers surveyed or the r

2.3 Data Analysis

Data was presented in tables, graphs, charts and analyzed using descriptive statistics, ANOVA, L.S.D, Chi-square tests; Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization. a Rotation converged in 21 iterations.

3.0 Results

3.1 Population Dynamics

One hundred farmers voluntarily accepted to participate in this study. The majority were males (60%) and females 40%. The respondents were 20-60 years of age with an average age of 45 and a standard deviation of 13.3 years. A considerable number either had finished primary school (24%), Secondary school (50%), College (15%) and no schooling (8%) (Figure 1). Some farmers reported growing more than one kind of crop on their lands. Variety of flowers (50%) were found to be the major produce, followed by kales (40%), French beans (20%) and bananas (15%) Most farmers had worked on these farms for more than 5 years.

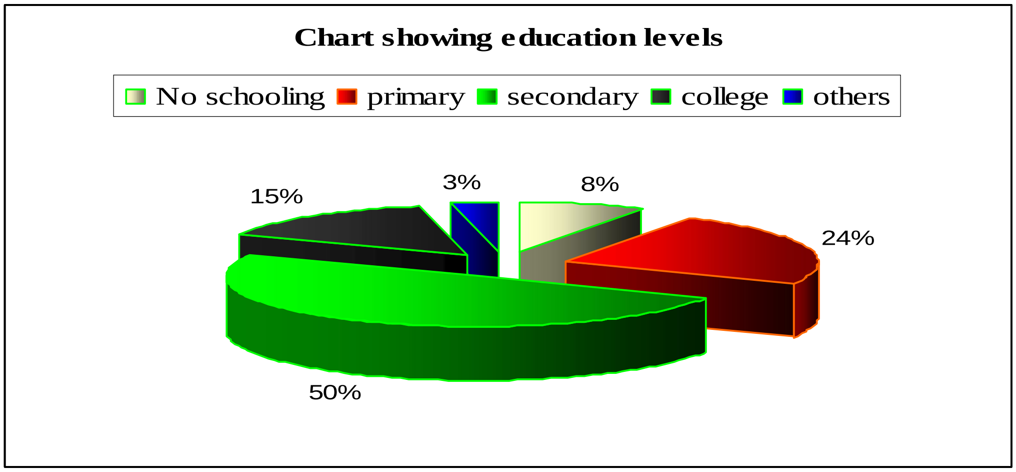

Figure 1: Showing education levels and % of response in each category

3.2 Pesticide Utilization

The vast majority (63%) of respondents reported using same dosage of pesticides in crop production, while (25%) decreased and (12 %) increased the dosage. All pesticides were stated by their trade names without any awareness of the common names. Among them, the most frequently mentioned were insecticides, followed by herbicides, fungicides, bactericides and nematicides as shown in Figure 2 below. Some of the pesticides were extremely hazardous or highly hazardous (World Health Organization, 2005). Diazol 60EC, a pesticide in the organophosphate family, was the most frequently used by farmers, followed by methomex 90sp, which is in the carbamate family. Glyphogan 48 SL was the most popular herbicide, whereas the combination of linurex and touchdown was the most frequently mentioned fungicidal agent.

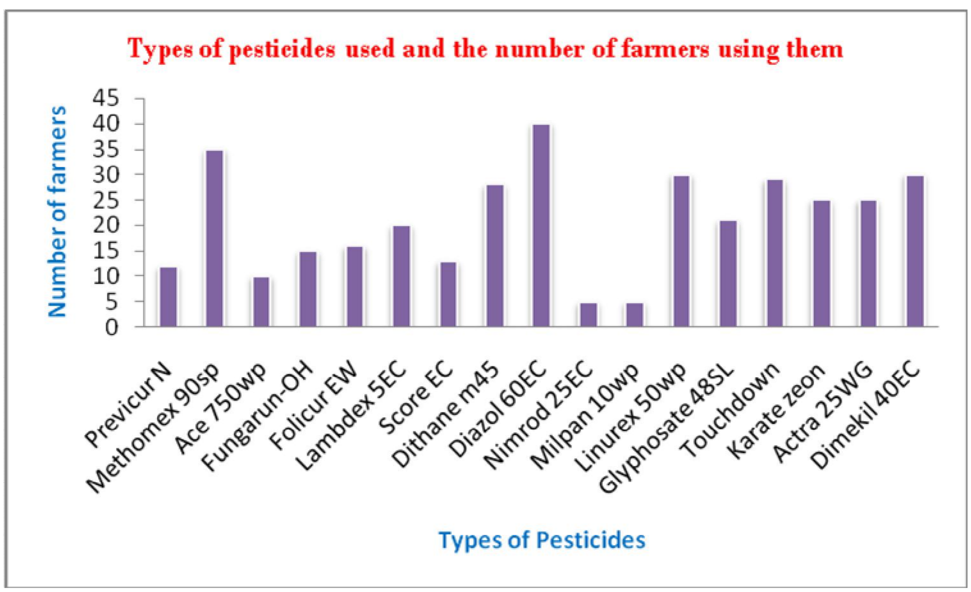

Figure 2: Showing the types of pesticides used and the number of farmers using them

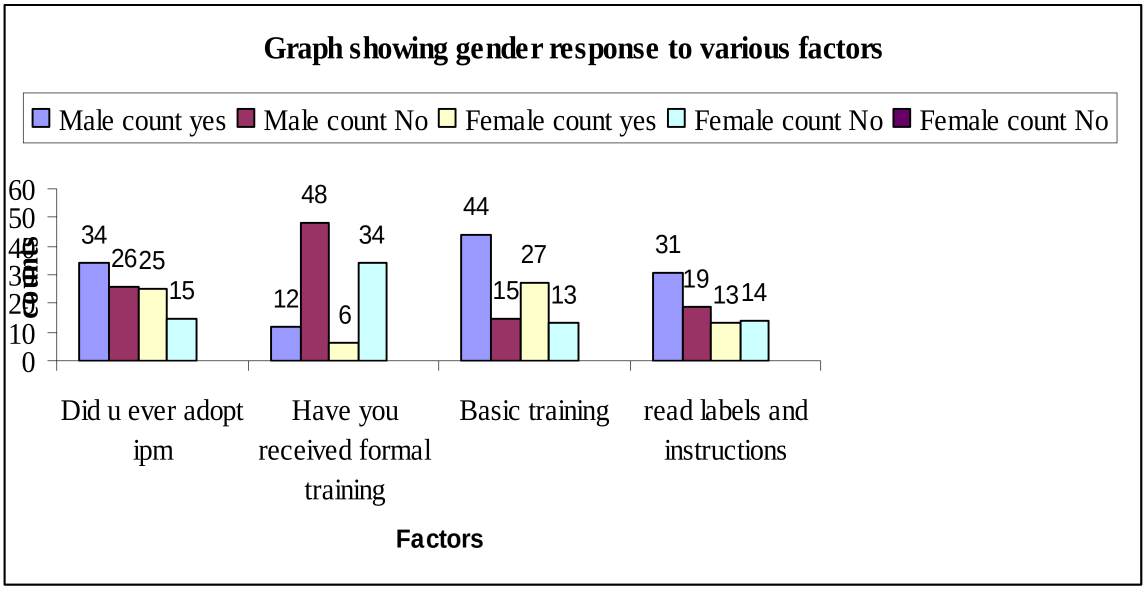

Figure 3a: A cross tabulation count of gender (Male and Female) response to various dependable variables

Cross Tabulation of Sex % Response within Sex and Within the Dependable Variables

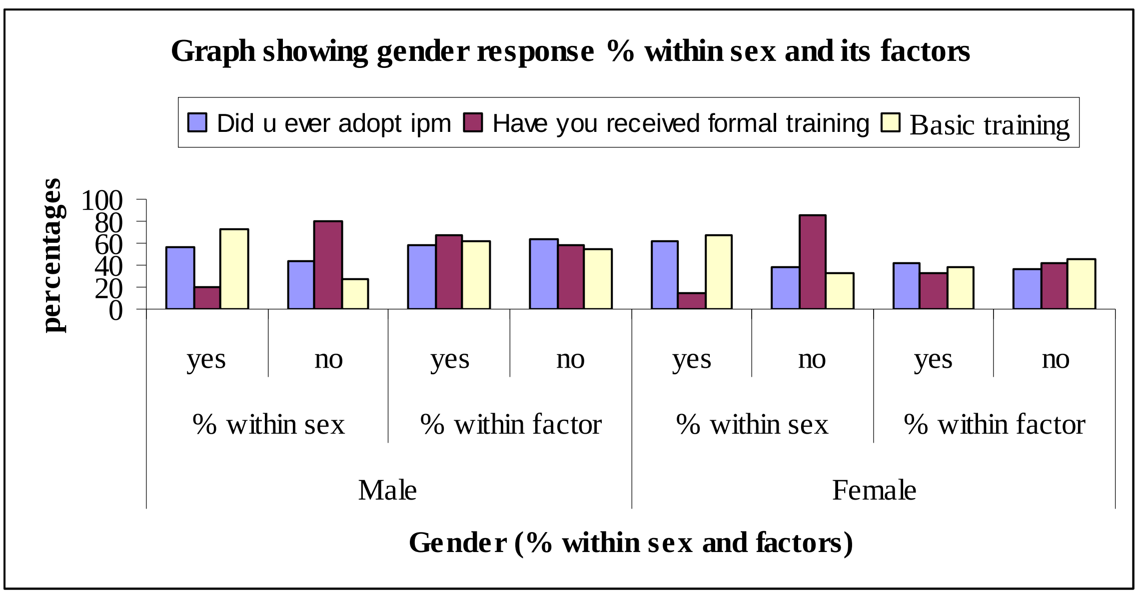

Figure 3b: Gender % response within sex and within the factors

The Table 1 below shows Pearson chi-square test for gender with different dependable variables

Table 1: Pearson chi-square test for sex (Gender)

Dependable variables	Value	Asymp. Sig(2-sided)
Did u ever adopt IPM technique	0.338	0.561
Have you received formal training	0.407	0.524
Basic training	0.397(b)	0.529

Cross Tabulation of Education Counts with other Dependable Variables

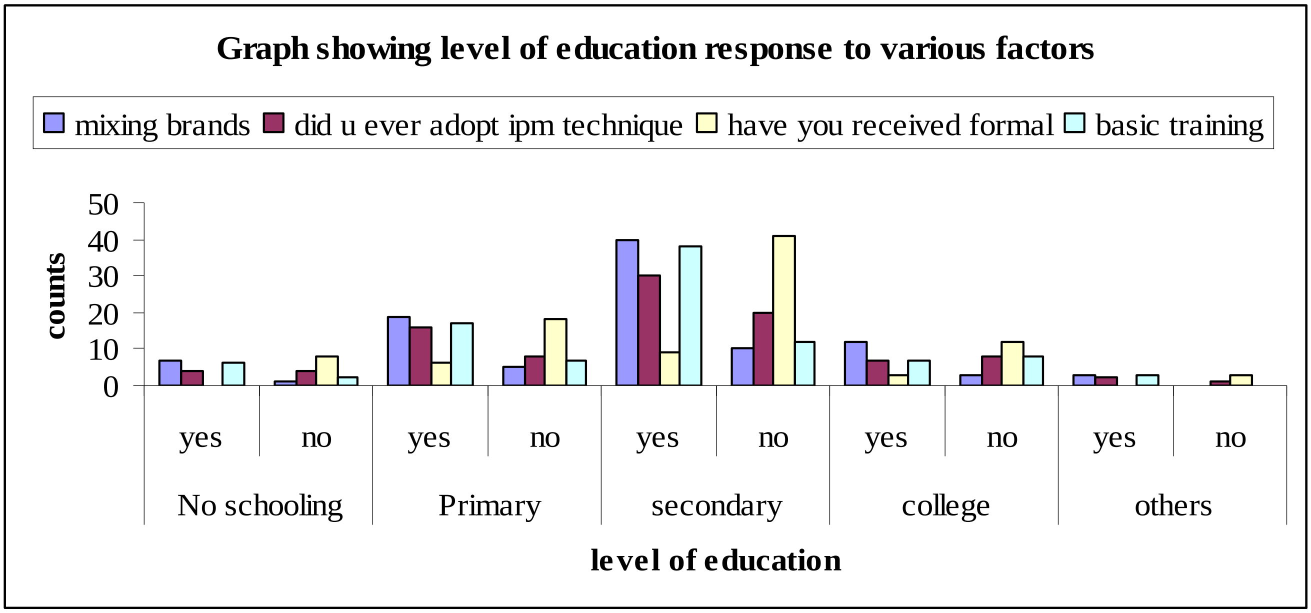

Figure 4a: Education level and response to various factors

The table 2 shows Pearson chi square tests for education and various dependable variables

Table 2: Shows Pearson chi square test for education		
Dependable variables	Value	Asymp.sig (2-sided)
Mixing brands	1.018(a)	0.907
Basic training	6.209	0.184
Have you received formal training	3.252(a)	0.517
Did you ever adopt IPM technique	1.888(a)	0.756

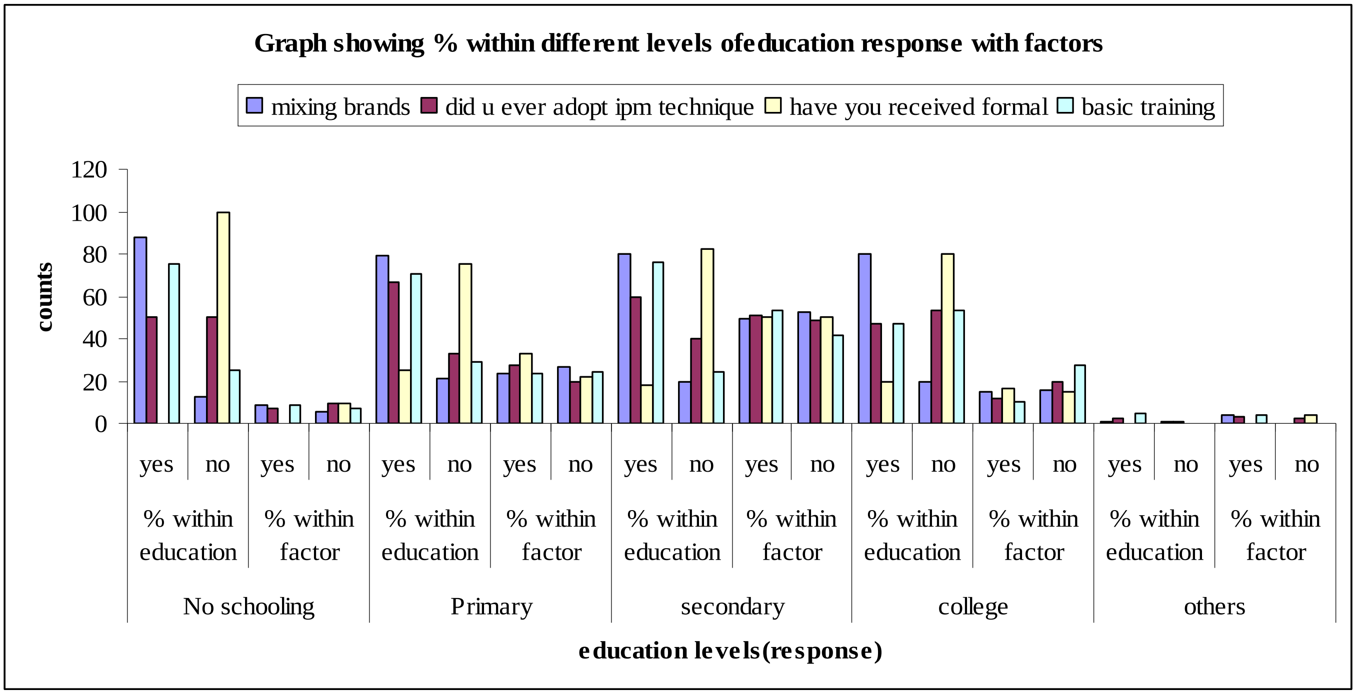

Figure 4b: Shows% within different levels of education and % within dependable variables

Cross Tabulation of Farm Counts to the Different Dependable Variables

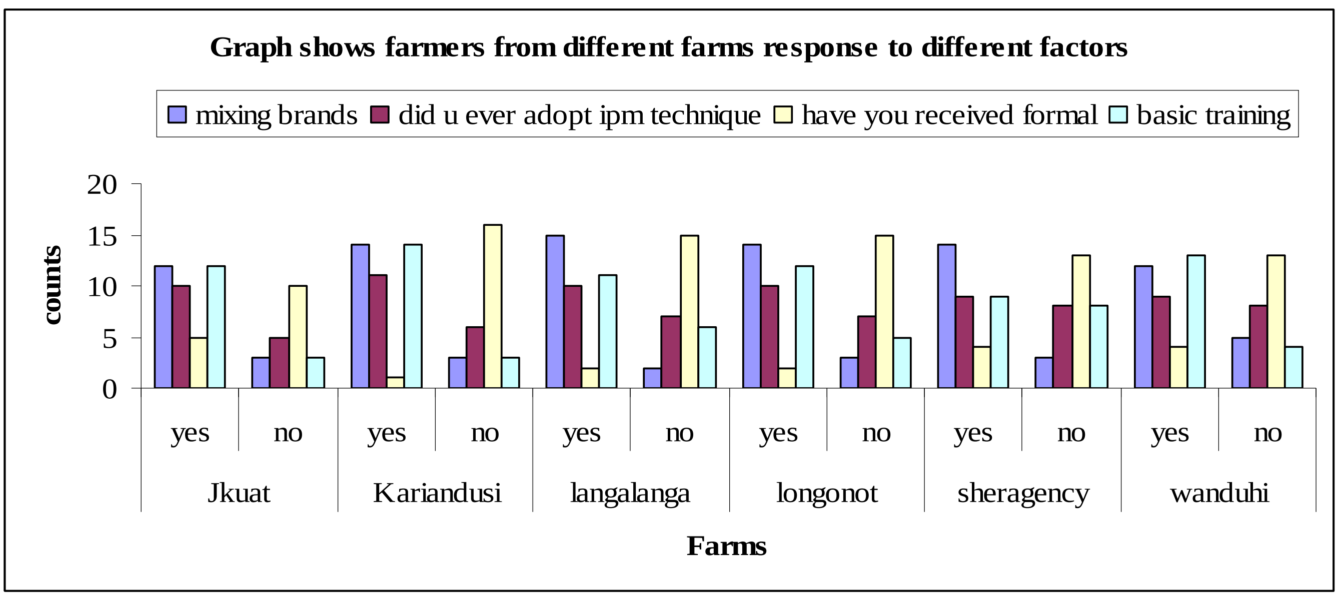

Figure 5a: Shows different farms and response to the various factors

The table 3 shows Pearson chi square tests for farms and various dependable variables.

Table 3: Shows Pearson chi square test for farms

Dependable variables	Value	Asymp.sig (2-sided)
Mixing brands	1.846(a)	0.870
Basic training	4.922(a)	0.425
Have you received formal training	5.680(a)	0.339
Did you ever adopt IPM technique	1.110(a)	0.953

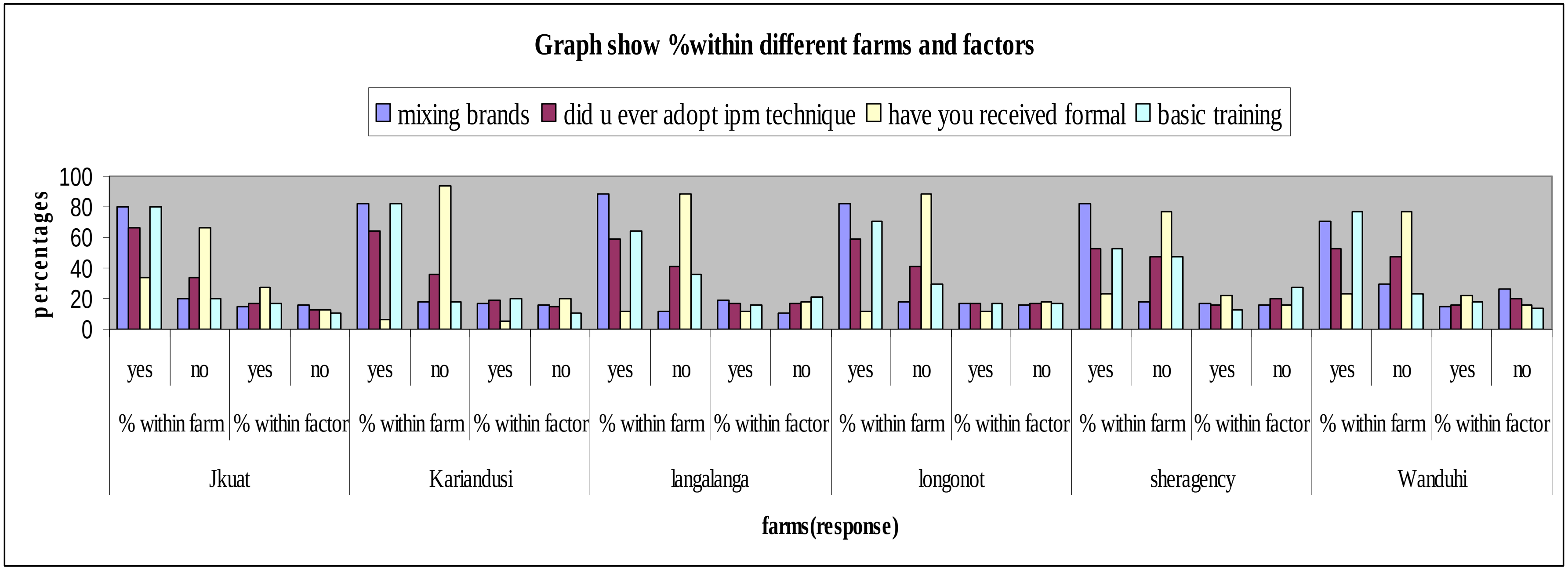

Figure 5b: % within different farms and % within dependable variables

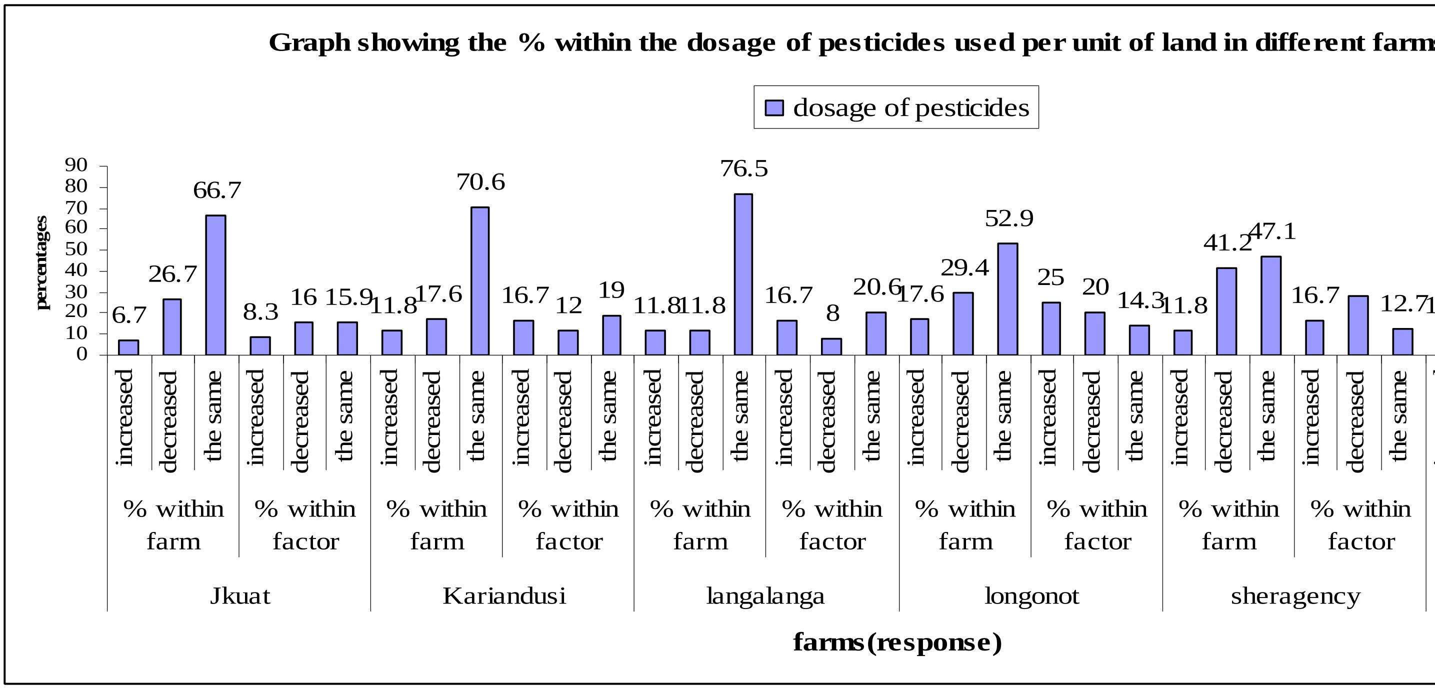

Figure 6: Shows the percentage within the dosage of pesticides applied/ used per unit of land in different farms

Table 4: Shows ANOVA table comparing Education with other dependable variables

dependable variables	*means*	*coefficient of variance*	*Significance (P)*	*F value*
Dosage of pesticides	83.6667	28.49201	0.9393	0.2
adoption of ipm technique	70.5	35.44855	0.7671	0.46
basic training	64.5	34.9509	0.188	1.57
mixing brands	59.5	33.65028	0.9125	0.24
do u practice reading labels and instr.	99	10.01201	0.2262	1.44

Table 5: ANOVA table comparing Farms with other dependable variables

dependable variables	*means*	*coefficient of variance*	*Significance (P)*	*F value*
Dosage of pesticides	83.6667	28.35083	0.7387	0.55
adoption of ipm technique	70.5	35.77765	0.9571	0.21
basic training	64.5	35.37639	0.4383	0.97
mixing brands	59.5	33.68699	0.8788	0.35
do u practice reading labels and instr.	99	10.10733	0.4371	0.98

Table 6: ANOVA table comparing Sex with other dependable variables

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Dependable variables	means	Coefficient of variance	Significance (P)	F value	Mean (M)	Critical va
Dosage of pesticides	83.6667	27.93584	0.2033	1.64	86.111	1.9
adoption of ipm technique	70.5	35.1764	0.5658	0.33	71.667	1.9
basic training	64.5	35.46194	0.5336	0.39	66.25	1.9
mixing brands	59.5	33.18555	0.4102	0.68	60.833	1.9
do u practice reading labels and instr.	99	10.11817	0.417	0.66	98	1.9

4.0 Discussion

This study was conducted on a small group of farmers in both rift valley and parts of central province, Kenya. Therefore, the results should be considered as a case study, generalizing these results to the national level should be done with extreme caution. The data relied mainly on the farmers' recollection. Discrepancies might have occurred due to recall bias and social factors.

Pesticides are used extensively on large farms and by parastatals organizations, largely concerned with export crops. The results of this survey indicate a wide variety of chemicals were utilized as pesticides in the area. The use of extremely and highly hazardous insecticides was observed. Other less hazardous agents create a health risk to the farmers as well (Epstein and Bassein, 2003).

A hundred respondents 60% being male and 40% being female agreed to participate in this survey. The age bracket of participants was between 20 -60 years with the average being 45 years. The level of education showed quite a number of respondents with no schooling (8%), primary (24%), secondary (50%), college (15%) and others (3%) as shown in figure 1. From this statistics it was evident that primary and secondary school students were the majority in these farms. Most of those with no or lesser education levels said it was due to lack of fees to further there education while for others it was due to lack of jobs and the need to earn money to sustain themselves.

Most of the farmers (85%) who were interviewed had stayed in the farms for more than 5 years, with others close to 15 years in the same farm and or lived in villages right next to the farms where they were working. The respondents (100%) agreed there was pesticide use on there farms and 75% were also responsible for what pesticide to buy. They also agreed that the pesticides were bought from more than one retailer (67%). The brands of pesticides used in the farms were regularly changed (60%) so as in order to combat resistant strains affecting farm produce.

Most of the respondents indicated that the pesticides Methomex 90sp and Diazol 60EC were the most frequently used as shown in figure 2. In cross tabulation of sex count with other dependable variables 34 Male accepted and 26 rejected having adopted the IPM technique while on the other hand 25 female accepted and 15 rejected having adopted the IPM technique. Most men (48) and women (34) denied having received formal training on the use of pesticides as shown in figure 3a. This so alarming because it leads to the misuse of pesticide applications and can lead to deaths. The percentage within sex in males (56.7%) who accepted adopting IPM was higher compared to the one's who denied (43.3%). While on the other hand (62.5%) of women % within sex accepted adopting IPM and (37.5%) denied as shown in figure 3b. This number is high compared with that of men who were the majority respondents with 60% at the beginning. We conclude that women are more willing compared to men. Asymp. Sig. is the estimated probability of obtaining a chi-square value greater than or equal to 0.338 if the experiment is repeated several times. For the variable did you ever adopt IPM technique the p = 0.561 meaning there will be no variations in the observed versus expected values in the experiment.

A huge percentage of men and women denied to having received formal education with the percentage within sex accounting for (80%) who denied in men and 85% in women as shown in figure 4a and b. It can be concluded that lack of formal education has contributed greatly to the misuse of pesticides and there applications.

As compared to education levels secondary (40) and primary (19) had the highest number of respondents who agreed to mixing of different brands of pesticides as shown in figure 4a and 4b. The main reason was to counter the different resistant strains affecting farm produce. In all the farms there was a majority (all farms) response compared to whether they changed the dosage of pesticides applied per unit of land. Most farmers maintained the same dosage while others increased because the early dose did not work for them as shown in Figure 6.

In this survey, insecticides were the most frequently mentioned chemical utilized, followed by herbicides and fungicides. This may be due to differences in the types of crops cultivated in the area, for example, bananas in our survey, compared to kales. In general, weeds grow more rapidly where there is strong sunlight. The banana tree canopy is not suitable for the growth of weeds. For this reason, farmers in our survey reported the use of herbicides to the lesser extent than those at the national level.

Farmers relied mainly on commercial sources for information about pesticides, along with the influence of suppliers, whose goal was to maximize their sales volumes, resulting in down playing the negative impact of pesticides. Personal protection equipment and personal hygiene were inadequate. The main concern of farmers was to wear gloves and long sleeved shirts, and this was found to be practiced by more than half of the farmers. This finding indicates a correct knowledge of pesticide routes of absorption, where skin absorption, not inhalation, has been reported to be the most important. This finding is consistent with many other studies regarding handling of pesticide by rural farmers (Burleigh *et al.*, 1998; Berg, 2001; Matthews *et al.*, 2003; Isin and Yildirim, 2007).

In less developed countries, adequate protective clothing is often neglected for reasons of discomfort and/or high cost. No national regulations require farmers working with pesticides to observe specific precautions (Wilson and Tisdell, 2001). Proper pesticide waste disposal is also an important part of responsible pesticide use. Accidental release or uncontrolled discharge of pesticide waste into the environment can harm people and contaminate the environment (Damalasb *et al.*, 2008). In this study, the disposal of pesticide containers was found to be careless. Empty pesticide containers may often retain unacceptable quantities of pesticide residue if not rinsed properly (Miles *et al*, 1983). As in many other developing countries where empty pesticide containers are highly valued and sold or exchanged as storage containers for other materials, the majority of farmers in this survey sold empty containers to buyers who picked up the waste from the community. It is unclear what the buyers do with such containers.

Damalasb *et al.,* (2008), strongly against such practices, recommended puncturing empty containers to prevent re-use. In regards to pesticide acquisition, proximity to stores was the most important factor influencing farmers' practices. The most frequently mentioned source of pesticides was agro-chemical shops in their community. Contrary to concerns regarding the influence of commercial personnel on farmers' pesticide use patterns, sales persons from agro-chemical companies were rarely mentioned as a source of pesticide information. This may be because of the small size and isolation of the farm area surveryed, which made the survey areas unattractive for company sales persons. Promotional strategies often utilized for such areas are commercial media and public broadcasts, as was the case in this study. In any case, caution should be exercised regarding the misleading nature of the content of the advertisement. For example, advertisements on television regularly used movie stars and celebrities as role models to promote pesticides.

Evidence from this survey pointed toward the need for a comprehensive intervention to change farmers' pesticide use patterns. Short- and long-term measures, tackling determinants of inappropriate pesticide use in a holistic manner, should be implemented. This, of course, implies close collaboration between government at different levels and the private sector. The short-term remedy to the problem is to limit access to hazardous pesticides. All class I and II pesticides according to WHO classification should be banned from the market. Long-term measures should include an array of activities to empower farmers to healthier choices for pest management. This must include knowledge of chemical hazards which should be disseminated to all farmers. Knowledge regarding personal protective equipment should be propagated.

Unfortunately, knowledge alone rarely translates into practice (Murray and Tayler, 2000). A broad variety of factors play a role in shaping farmers' actual pesticide practices since they act rationally within the context of their available resources and socioeconomic objectives (Rola and Pingali, 1993). Presently, chemical pesticides are currently the cheapest and most effective means to for pest control in the short run. The supply agents have been subsidized by the government to accelerate national crop production. Moreover, the popularity of chemical pesticides stems from their rapid action and prolonged duration (Food and Agriculture Organization of the United Nations, 2008).

5.0 Conclusion

The study indicates pesticide use in selected horticultural farms among farmers in rift valley and central provinces of Kenya. Findings of this study clearly suggest that it is necessary to reduce possible health and environmental risks associated with pesticide use by documenting risk perceptions and developing ways to address them. Further studies are warranted to generate appropriate data on which to base policies.

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