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A Survey on Use of Agrochemicals in Farms in Uasin Gishu and Homa Bay Counties, Kenya

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Abstract

The Kenya agricultural sector is an important segment of the national economy generating employment, outputs and incomes. Currently, agriculture directly represents 26 % of the gross domestic product (GDP). Due to the significant contribution of the agricultural sector to the overall economic growth, it is important to invest commensurately in order to meet the targeted growth rate of 6% per year. In trying to expand the agricultural production, farmers face several challenges which include inadequate farm inputs and poor soils. Fertilizers and pesticides are frequently added to soils to supply sufficient nutrients for plant growth which could contribute to environmental pollution. This study was conducted to assess farming practices, agrochemical usage and its potential impact on environment in Uasin Gishu and Homa Bay Counties, Kenya. Field surveys involving key informant interviews and questionnaires were administered to farmers in the study areas of Homa Bay and Uasin Gishu counties. Five sub-locations were randomly sampled from the two regions where intensive farming was practised. The sampling sites were considered in different agro ecological zones. The survey obtained information on the extent of use of agrochemicals and agricultural activities carried out in the two regions. Obtained data was analysed using descriptive statistics. One-Way ANOVA and t-test was used to compare agrochemicals usage in all agro-ecological zones. A total of 384 households were sampled in both regions and showed that farmers used different agricultural chemicals and fertilizers. In Uasin Gishu County 89.8% of farmers used herbicides to weed their farms whereas in Homa bay only a small percentage (28.4%) used herbicides. Other agronomic practices include, manual weeding at 10.2% in Uasin Gishu and 71.6% in Homa Bay county. Use of insecticides was 10.0% in Uasin Gishu County and 9.8% in Homa Bay County. The use of inorganic fertilizers indicated that in Uasin Gishu County, all of the sampled households (100%) used inorganic fertilizers in their farms. A small proportion of farmers (27.4%) in Homa Bay County used inorganic fertilizers. Most of the farmers in Homa Bay County used animal manure (54.2%) while a small number of farmers (19.2%) did not apply any fertilizers in their farms. There was a significant difference in usage of agrochemicals in both counties. These findings show that farmers in both regions use inorganic fertilizers, herbicides and pesticides in their farms and may lead to heavy metal contamination in the soils. Limited knowledge among the farming communities on use of agrochemicals could pose risk to the users and the environment. It is therefore necessary to sensitize farmers on use of organic fertilizers and integrated pest management (IPM).

Key Words: Agrochemicals, Agricultural Practices, IPM, GDP, Inorganic

Introduction

The Kenya agricultural sector is an important segment of the national economy generating employment, outputs and incomes. Currently, agriculture directly represents 26% of the gross domestic product (GDP) and another 25% indirectly through its linkages with manufacturing, distribution and service industries (GoK, 2010). It accounts for 65% of national exports and provides 70% of informal and approximately 18% of formal employment. Approximately 80% of the population, consisting of 3.5 million farm-family households, lives in rural areas and owns an average of 4 hectares (ha) of land. Seventy percent of cultivated land is cropped by smallholder farmers (Nyoro, Ayeko & Muyanga, 2007). Food crops (maize, sorghum, millet, wheat, etc.) make up 34% of agricultural GDP. Population pressure, poor weather and low input use have led to an increased focus on agriculture in order to raise production and contribute to increased access to food. Due to the significant contribution of the agricultural sector to the overall economic growth, it is important to invest commensurately in order to meet the targeted growth rate of 6 % per year.

In trying to expand the agricultural production, farmers face several challenges including inadequate farm inputs i.e. Agrochemicals such as fertilizers, fungicides, herbicides and pesticides. The term agrochemical is a common term encompassing various chemical products that are used in agricultural activities. In most cases, it refers to the wide range of pesticides including insecticides; herbicides; and fungicides (Larry, 2012; Gorell, Johnson, Rybicki, Peterson & Richardson, 1998; Garry *et al*., 2002). Aside from increased use of chemical fertilizers, occurrences of pests and diseases have lead to increased indiscriminate use of pesticide (Ajayi, 2000; Nonga, Mdegela, Lie, Sandvik & Skaare, 2011).

According to the statistics from China Customs, from January to November 2015, 192.3 kilo tonnes volume of pesticide were exported to Africa market (AGRO news, 2016).) In the year 2005, 371 886 metric tonnes of fertilizers were imported in Kenya and approximately 8 370 tonnes of pesticides were imported to Kenya (Birech, Freyer & Macharia, 2006). Salasya *et al*. (2005) reported that KARI's general fertilizer recommendation for Western Kenya was 60 kg/ha N and 26 kg/ha P to accommodate low nitrogen and phosphorous levels in soils but the total inorganic fertilizer use increased gradually from 879 tonnes in 1994 to 2,356 tonnes in 2000.

Agrochemicals are used to control pests' invasion and improve soil fertility for better crop and animals production (Bhanti & Taneja, 2007; Nonga *et al.*, 2011; Ware & Whitacre, 2004). However, agrochemicals have been associated with serious environmental and human health issues (USEPA, 2005; WHO, 2008), hence, their use is highly regulated globally, nationwide and region wide, with regulations and conventions (PAR, 2000; FAO/WHO, 2001). Pesticides and inorganic fertilizers could contain different levels of heavy metals among others. These products, when used during farming, could result in deposition of heavy metals to the soil environment (Heshmat, Aldesunguy, Abo & Abeer, 2012; Edlin, Golanty & Brown, 2000). Futhermore, pesticides have potential for various unintended negative consequences to human health ranging from respiratory issues, central nervous system impairment, developmental issues in babies and children, to types of cancer such as lymphoma (Bus & Hammond, 2007). Furthermore, many of these adverse effects have not yet been fully understood (Watson, 2014).

Many farmers in Kenya and in many other developing countries are recently depending greatly on agrochemicals in order to increase their yield to sustain a growing population (Ecobichon, 2001; Scialabba, 2000; Amoah, Drechsel, Abaidoo & Ntow, 2006). It is frightening on the other hand that, herbicides such as Atrazine, Paraquat,

Alachlor, among others have been outlawed for years in the European Union (EU) and USA but are haphazardly used in Kenya (IUPAC, 2008; Wang'ombe, 2014). In addition, local farmers also have little or no knowledge on how, what, when and how often to apply agrochemicals on their crops; and its environmental and human consequence (Tilman, Cassman, Matson, Naylor & Polasky, 2002; Machipisa, 1996; Ntow, 2001). It is against this background that the study was conducted in Uasin Gishu County (UGC) and Homabay County (HBC) to determine the extent and reason for which farmers use agrochemicals on their crops and other food products, with a view to suggesting possible interventions to minimize overuse of agrochemicals. This study was conducted to assess farming practices, agrochemical usage and its potential impact on environment in Uasin Gishu and Homa Bay counties, Kenya.

Materials and Methods

Study Area

Uasin Gishu County

Uasin Gishu County lies between longitudes 34^0 50‟ east and 35^0 37‟ West and latitudes 0^0 03‟ South and 0^0 55‟ North (Chemei, 2015). It shares common borders with Trans Nzoia County to the North, Keiyo Marakwet County to the East, Baringo County to the South East, Kericho County to the South, Nandi County to the South West and Kakamega County to the North West. (Korir, 2011). The county covers a total area of 3327.8 km^2 with the population density of 232 per km^2 and approximately 2603.2 km^2 of arable land (Baraza, Chepkwony & Githae, 2008). The total number of maize farmers is approximately 166,635 (Wanjala, 2014). The County has an altitude of 1800 m above sea level (Lwayo, Okalebo, Muasya & Mongare, 2001). The average annual rainfall is between 900 to 1,200 mm per year with distinct peaks in April and August (Kibet *et al*., 2011).

The county is agricultural based with crops like, Maize, wheat, beans, potatoes and vegetables (CGUG, 2013; Government of Kenya, 2008). Maize, a staple food for most Kenyans, is produced in the county in large quantities, second to wheat (Lagat, Okemwa, Dimo, Kipkurui & Korir, 2007). The County is divided into six sub-counties: Turbo, Soy, Ainabkoi, Moiben, Kessess and Kapseret.

Homa Bay County

Homa Bay County is located between latitude 0^o15' South and 0^o52' South, and between longitudes 34^o East and 35^o East. The county boarders Migori County to the South, Kisumu and Siaya counties to the North, Kisii and Nyamira counties to the East, and Lake Victoria and the Republic of Uganda to the West. The county covers an area of 4,267.1 Km^2 inclusive of the water surface which on its own covers an area of 1,227 Km^2 (Homa Bay County Integrated Development Plan, 2013 – 2017). The altitude ranges between 1163 m and 1219 m above sea level. Most parts of the County receive 500–1000 mm mean annual rainfall, in a bimodal pattern falling between April to May and November to December. Temperatures range between 17.1°C and 34.8°C. Homa Hills is located about 50km north of Kendu Bay, lies on the Nyanzan Rift and covers an area of approximately 150km^2 (Antony, 2012; Lagat, 2010). Its top reaches an elevation of about 1571m above sea level or of 610 m above the level of Lake Victoria. The main economic activities include: fishing, agriculture, trade and livestock keeping. Major crops grown include sorghum, beans, maize and millet for domestic use and trade. The locals produce subsistence crops such as maize, sorghum, and beans among others (Lagat, 2010). Other activities done in the region include brick making.

Research Design

Primary and Secondary Data Collection

Both primary and secondary data sources were used in the research. Primary data were gathered directly from the participants while secondary data were collected from various documents including administrative documents such as government reports and online documents.

Sampling Design and Technique

Uasin Gishu County

The sampling design involved purposive sampling where different agro-ecological zones were identified and household in these zones were randomly picked for questionnaires administration. Also, data collections were done through key information interview and focused group discussion. The first stage was purposive selection of Ainabkoi, Moiben and Turbo location. This was done in order to capture differences in agro-ecological zones LH_3, UH_4 and UH_2, soil types and weather conditions. A random sample of 2 locations in Ainabkoi, Moiben and Turbo constituencies were selected. There were Moiben and Kimumu ward in Moiben constituency, Kapkong and Tapsagoi ward in Turbo constituency, Kapkeno and Burnt Forest wards in Ainabkoi constituency. There are 166,635 farming households in the county out of which 20,139; 16, 876; and 19,694 are found in Ainabkoi, Moiben and Turbo Sub-counties respectively (Baraza *et al*., 2008).

Homa Bay County

The same procedure was followed in the Homa Bay County on selecting the two agro-ecological zones in Karachuonyo constituency, and Rachuonyo North Sub-County, where University of Eldoret research station lies. Two wards in the Sub-county were purposively selected. These are Kanam B location, where it falls under LM3 (Lower Midland 3) agro-ecological zone, where sorghum growing is pre-dorminant and Kokoth Kata, that falls under LM4 (Lower Midland 4) zone, where maize farming is extensively practised. Two sub-locations were randomly selected as well from each including; Kanyango and Rabuor Sub-locations in Kanam B; and Kokoth B and Koredo Sub-locations in Kokoth Kata. Rachuonyo North area has a population of about 230,000 people and approximately 11,056 and 15,078 are found at Kanam B and Kokoth B sub-location respectively (Antony, 2012; Lagat, 2010). In both areas, enumerators were trained to administer the farmers' questionnaires in the native dialect, i.e. *dholuo* language for better understanding by the locals. Key informants, consisting of agricultural extension officers were interviewed. They gave an overview of agricultural practices in the area. A total sample size of 384 households from the total population in the five agro-ecological zones was used during the survey. A simple random sampling approach was used to get the households that participated in the study.

Sample Size Determination

The sample sizes were determined using standard formulae (Andrew Fisher's Method, 1994): For Population> 10,000 Formula is

$$\mathrm{n} = \frac{Z^2(p)(\mathrm{q})}{\mathrm{d}^2}$$

Where n = Sample size; z = the standard normal deviate set at 1.96 and corresponding to 95% confidence level ±5; p= proportion of the population with desired attribute-estimate of farmers' agrochemicals usage in the study area at 50% as prior data is lacking; q= 1.0 – p and d= desired precision level or allowed standard error level ±5%

Thus required sample size;

$$\mathrm{n} = \frac{1.962(0.5)(0.5)}{0.052} = 384$$

Desired sample size determined and used was 384.

Data Analysis

Data was cleaned and analysed using statistical package of social scientist (SPSS version 16).

Results

Land Use and Farming Practices

Land Use

Uasin Gishu County

In Uasin Gishu County (UGC), the size of land under cultivation ranges between 2 to approximately 400 acres. It was established from the surveyed population that 85.5% of the farmers own 0-10 acres while 11.7% own between 10-50 acres and only (2.5 %) own above 50 acres.

Table 1. The Total Acreage under Cultivation in Uasin Gishu Agro-Ecological Zone

Acreages	**%**
0-10	85.8
10-50	11.7
Above 50	2.5
Total	100

Homa Bay County

The land use activities in Homa Bay County include fish farming, livestock keeping and crop growing. They practice intercropping and crop rotation to improve soil fertility. Most of the population also practises mixed farming so that the products serve as animal feeds hence nothing go to waste. Only a small proportion of farmers irrigate their land and the rest opt for crops like cassava and sweet potatoes which take longer period to produce yield.

In Homa Bay County, the size of the land the farmers own range between 1-15 acres as presented in table 2.

Table 2. The Total Acreage under Cultivation in Homa Bay Agro-Ecological Zone

Acreages	**%**
0-2 acres	40.0
2 and above	60.0
Total	100.0

Farming Practices

Uasin Gishu Agro-Ecological Zones

The study established that 66.6% of the farmers interviewed in Uasin Gishu agro-ecological zones are producing maize. From the research, it was found that out of the surveyed farmers from this region i.e. 23.1%, 8.1%, 0.4% and 2.4% are producing potatoes, beans, sorghum, and vegetable respectively.

Homa Bay Agro-Ecological Zones

Approximately 48.4% of the interviewed famers in Homa Bay agro-ecological zones are farming maize followed by sorghum represented by 31.8% of the respondents. Also, cassava, sweet potatoes, and vegetables were produced s presented by 10.8%, 5.0%, 2.0% and 2.0% of the respondents respectively.

Agrochemical Inputs

Herbicide, Fungicide and Pesticides Application in Uasin Gishu Zones

The results of this study revealed that in UG county's two major method of weed control were herbicide application and manual weeding. There is an extensive use of herbicides in maize farming in Uasin Gishu zones. The study sought to establish the level of Agrochemical use in weed and pest control by farmer's and descriptive statistics were used and the results are presented in table 3.

Table 3. Weed and Pest Control by Agrochemical Application in Uasin Gishu Agro-Ecological Zones

Active Ingredient	**Type of Pesticide**	**(%)**
Atrazine	Herbicide	65.0
Paraquat	Herbicide	10.0
2,4-D	Herbicide	3.0
Bromoxynil	Herbicide	1.8
Ridomil	Fungicide	3.0
Bulldock	Insecticide	4.5
Dimethoate	Insecticide	1.5
Endosulfan	Insecticide	1.0
Hand Weeding	Manual	10.2
Total		100.0

The study indicated that the usage of herbicides by farmers include; Atrazine (65 %), Paraqut (10%), 2,4-D (3%), Bromoxynil (1.8%), while 3.0% used fungicides (Ridomil). Insecticides used were; Bulldock (4.5%), Dimethoate (1.5%), and Carbofuran (Furadan) (1.0%). Those who practiced manual weeding were 10.2% of the households.

Comparisons of Use of Agrochemicals in Weed, Disease and Pest Control in LH_3, UH_4 and UH_2 Agro-Ecological Zone

To determine whether there existed significant differences in agrochemicals' use in LH_3, UH_4 and UH_2, One Way ANOVA was conducted. The results are presented in table 4.

Table 4. ANOVA Results Comparing Agrochemicals Use in LH3, Uh4 and UH2

Element	Df	Mean Square	F	P
Herbicides	2	4.24	2.92	0.042
Insecticides	2	2.13	1.53	0.084
Manual weeding	2	1.48	2.05	0.104

According to ANOVA results above, the p values of insecticide and manual weeding were 0.084 and 0.104 respectively and all were above 0.05 significance level, indicating that there was no significance at 95%. The p value of herbicides was 0.042 indicating significance in the usage of herbicides in all the three agro ecological zones.

Agrochemical Application in Homa Bay Zones

The findings on agrochemical application in Homa Bay County indicated that 71.6 % of the farmers in Homa Hills preferred manually weeding on their farms while 28.4% used various chemicals. This study established that 10.0% of the farmers used atrazine herbicides and 0.8% of them used 2,4-D for weeds control, 7.8% of the farmers used paraquat. While 5.3% used insecticides to control pests, 4.5% used fungicides to control diseases.

Table 5. Pesticide Application in Homa Bay Agro-Ecological Zone

Active ingredient	Type of pesticides used	(%)
Atrazine	Herbicide	10
Paraquat	Herbicide	7.8
2,4-D	Herbicide	0.8
Ridomil	Fungicide	4.5
Bulldock	Insecticide	3.8
Dimethoate	Insecticide	1.5
Weeding	Hand use	71.6
Total		100.0

Comparisons of Use of Agrochemicals in Weed, Disease and Pest Control in LM_3 and LM_4 Agro-Ecological Zone

To determine whether there existed significant differences in pesticides usage in LM_3 and LM_4 agro-ecological zone, a t-test was conducted. The results are presented below.

Table 5. T test Results Comparing of Use of Agrochemicals in LM_3 and LM_4 Agro-Ecological Zone

	T	Df	Sig. (2-tailed)
Herbicides	1.626	2	0.143
Insecticides	1.452	2	0.184
Weeding	1.02	2	0.128

The results of the table above shows no significant difference at 95% in the herbicides (p=0.143, df=2 t=1.626), insecticides (p=0.184, df=2, t=1.452) and weeding (p=0.128, df=2, t=1.02).

Fertilizers Application in Uasin Gishu Agro-Ecological Zones

The declining soil fertility due to continuous tilling of the same land coupled with overuse of fertilizers and chemicals are among the key factors leading to low crop production in the County. From an interview with the Key informant, the farmers from Uasin Gishu agro-ecological zone applied fertilizers between 1 to 4 bags (DAP) per acre. Depending on their economical ability to purchase enough fertilizers required. The study established that the farmers who applied Di-ammonium Phosphate (DAP) fertilizers used between 1 and 4 bags DAP per acre. Others mix the DAP with Calcium ammonium phosphate (CAN) while others mix DAP with NPK fertilizer with proportion of either 1:1 ratio or 1:1.5 ratio. Those who mix CAN and NPK do it in a proportion of 1:1 or 1:2 proportions The survey indicated that, those who used DAP fertilizers were 36.0 %, NPK (44.0 %), CAN (0.8%), mixture of DAP and CAN were (10.0 %), DAP with NPK (5.0 %) and NPK and CAN (3.4 %) respectively as shown in Figure 1.

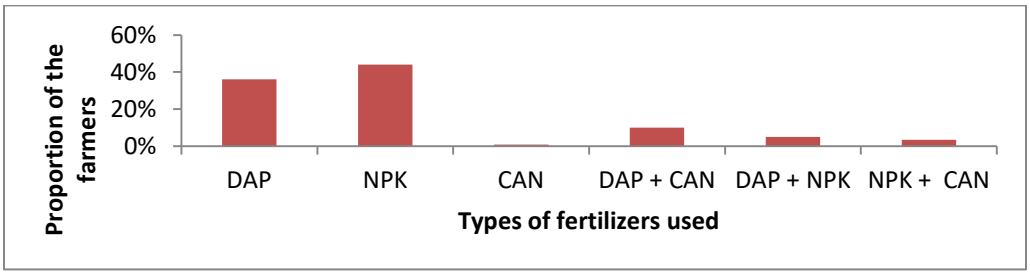

Figure 1. Fertilizers application in Uasin Gishu agro-ecological zone

Comparisons of Fertilizers Use in LH_3, UH_4 and UH_2 Agro-Ecological Zone

To determine whether there existed significant differences in fertilizers use in LH_3, UH_4 and UH_2 agro-ecological zone, One Way ANOVA was conducted. The results are presented in table 6.

According to ANOVA results, the p values of CAN and others (mixture of fertilizers) were 0.130 and 0.189 respectively which were above 0.05 significance level, indicating that there was no significance at 95%. p values of DAP and NPK were 0.035 and 0.020 respectively which were below 0.05 indicating that there was a significance at 95% limit.

Table 6. ANOVA Results Comparing Fertilizers Use in LH3, Uh4 and UH2

Element	Df	Mean Square	F	P
DAP	3	2.894	3.01	0.035
NPK	3	3.598	1.28	0.020
CAN	3	2.842	1.89	0.130
Others	3	3.247	1.01	0.189

Fertilizers Application in Homa Bay Agro-Ecological Zones

Out of sampled population in Homa Hills agro-ecological zone, 19.2% of the surveyed farmers did not use any fertilizers during maize planting while 80.8 % used different types of fertilizers both inorganic and organic. The farmers that used inorganic fertilizers were 27.4% while those who used organic fertilizers were 54.2%. Among farmers interviewed, 10.8% of the farmers used DAP during planting of maize, 36.7% used manures, 3.3 % used CAN, 17.5% used Urea, while 8.3% mixed DAP and CAN, while the rest of the farmers interviewed did not use any fertilizers.

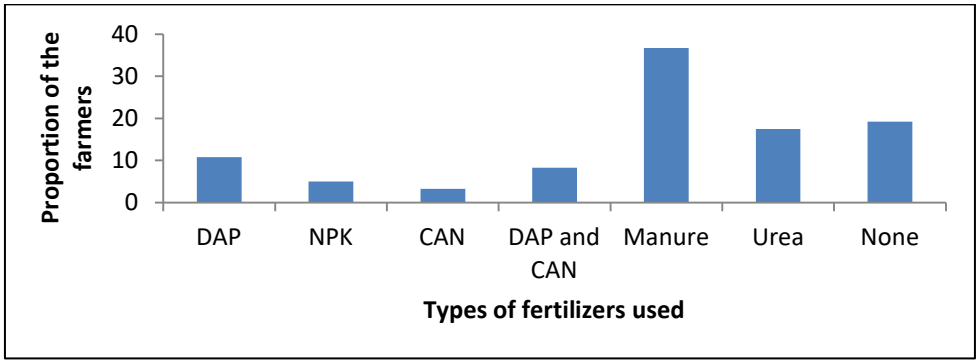

Figure 2. Fertilizers Application in Homa Bay Agro-Ecological Zone

Comparisons between Fertilizers Use in LM_3 and LM_4 Agro-Ecological Zone

To determine whether there existed significant differences in fertilizers usage in LM_3 and LM_4 agro-ecological zone, a t-test was conducted. According to t-test results, the p values of CAN and NPK were 0.782 and 0.083 respectively which were above 0.05 significance level indicating there was no significance at 95%. The p values of DAP and others (manure, urea, none) were 0.022 and 0.018 respectively which were below 0.05 indicating that there was a significance at 95% limit. The results are presented below.

Table 7. T test Results Comparing Fertilizers Usage in LM_3 and LM_4 Agro-Ecological Zone

Fertilizers	t	Df	Sig. (2-tailed)
DAP	2.847	3	0.022
NPK	1.984	3	0.083
CAN	1.693	3	0.782
Others	2.246	3	0.018

Discussion

Continuous cultivation of farm lands in Kenya has lead to poor soil fertility. Therefore most of the farmers are using agrochemicals and may have little or no knowledge on the dangers associated with agrochemicals (Laary, 2012). Though there may be existing evidence of associated dangers of agrochemical misuse, such evidence is hardly believed to be associated with agrochemicals, because their effects are gradual and seldom noticed. As a result, farmers rarely take caution during handling, formulation and application of these agrochemicals, and these acts put the farmer's and the consumer's health at risk (Smith & Gooding, 1999**)**. In Uasin Gishu, most farmers use fertilizers such as DAP, CAN and NPK, pesticides, fungicides and herbicides in large quantities. A study done by Wang'ombe (2014) on the risk of agrochemicals on the environment and human health in Mukaro location, Nyeri

County, Kenya, found that there was high usage of fertilizer, with 92% applying DAP during planting with only 40% carrying out subsequent top dressing by use of CAN. Also Biwott (2014) indicated that majority of the farmers in Moiben Sub-county, Uasin Gishu County use DAP fertilizer during planting of maize as represented by 72.6% and 26.8% use NPK. Most farmers prefer use of DAP, because it has a high phosphorus content which is good for proper root development. Previous studies on fertilizer use in parts of the study area revealed that farmers applied fertilizers liberally without specified rates or due regard to soil testing to determine the appropriate fertilizer rates to use (Njuguna *et al*., 2010). On the other hand, in Homa Bay, usage of inorganic fertilizers is very low in the region, with majority preferring compost manure, because of poverty and fertile land.

In Uasin Gishu agro-ecological zones, the study indicated that there was high use of herbicides and insecticides. Some farmers mix the herbicides i.e. atrazine and 2,4 D for effective control of weeds without understanding the real impacts on human life. Studies in River Nyando catchment showed that more than 91% of the farmers applied pesticides in vegetable crops (Abong'o, *et al*), 2014). On the contrary, in Homa Bay County, usage of pesticides was minimal as most of the farmers preferred manual weeding. Mechanizations of the farming has resulted in dramatic fall in the proportion of the population working in agriculture, with farming enterprise resorting to less labour intensive practices like use of agrochemicals instead of weeding (Osano, Admiraal & Otieno, 2002). This practice indicates that the use of agricultural pesticides is on the rise and its impacts on the environment are also increasing, thus, there is need for preventive measures to be taken.

Conclusion and Recommendations

In Uasin Gishu zones, most farmers use agrochemicals such as fungicides, herbicides, pesticides and fertilizers (DAP, CAN and NPK) in large quantities. On the contrary, in Homa Bay County usage of pesticides is minimal as most of the farmers prefer manual weeding and use of organic manure.

Therefore it is recommended that efforts to minimize the use of agro-chemicals through training and educational campaigns among farmers in the two regions is needed. These efforts should focus on limiting the frequency of fungicides, pesticides and herbicides' use and safe use of agrochemicals by adherence to instructions on the labels. Alternatively, natural, biological, and physical methods for controlling weeds, diseases and pests should be advocated whenever possible. Pesticide legislation related to the storage and sale of agro-pesticides should be strictly enforced and monitored.

Promotion of alternative pest control strategies such as application of bio-pesticides and integrated pesticide management (IPM) is apparently inevitable. There also needs to be more interaction between agricultural extension officers and farmers for information sharing on best farming practices. It is suggested that further study should be done to determine pesticide and other agrochemicals residual levels in foodstuffs and levels in environmental matrices including soils, water and organisms at local level.

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