# EVALUATION OF THE EXTENT AND LEVEL OF AWARENESS ON SAFE USE OF HERBICIDES BY TEA GROWERS IN BOMET COUNTY, KENYA

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# Evaluation of the extent and level of awareness on safe use of herbicides by Tea Growers in Bomet County, Kenya

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## DECLARATION

This is my original work and has not been presented for a degree in this or any other university.

Sign:_____ Date: _____

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This thesis has been submitted for examination with our approval as University supervisors.

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## DEDICATION

I dedicate this work to my mother Mrs. Esther Sang, on behalf of my late father Mr. Elijah Arap Sang who inspired and mentored me ,also to my children Chepkemoi and Kipkorir who encouraged me a lot .

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## LIST OF ABBREVIATIONS AND ACRONYMNS

| | |
|---|---|
| **EPA** | Environmental Protection Agency |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **G** | Grams |
| **GOK** | Government of Kenya |
| **IEET** | Institute of Energy and Environmental Technology |
| **ILO** | International Labour Organization |
| **IPM** | Integrated Pest Management |
| **ISO** | International Organization for Standardization |
| **KG** | Kilograms |
| **KIRDI** | Kenya Industrial Research and Development |
| **KTDA** | Kenya Tea Development Agency |
| **L** | Litres |
| **$LD_{50}$** | Lethal Dose required to kill 50% test population within 14 days |
| **MSDS** | Material Safety Data Sheet |
| **OELS** | Occupational Exposure Limits |
| **OSHA** | Occupational Safety and Health Act |
| **PCPB** | Pest Control Products Board |
| **PPE** | Personal protective equipment |
| **PVC** | Polyvinyl Chloride |
| **SHF** | Small Holder Farmer |
| **SPSS** | Statistical Package for the Social Sciences |
| **SSA** | Sub- Saharan Africa |
| **TESA** | Tea Extension Service Coordinators |
| **TRFK** | Tea Research Foundation of Kenya |
| **UNEP** | United Nations Environment Programme |
| **W.H.O** | World Health Organization |

## ABSTRACT

Herbicides are pesticides used to kill weeds. Herbicides play a major role in crop protection and control of vector borne diseases in all agricultural sectors. They are chemically active compounds designed in the most part to kill targeted organisms, but unfortunately, herbicides are dangerous when they are not used properly or as recommended in crops and the environment.

Weeds are unwanted plant since they compete with crop plants for sunlight, water and soil nutrients and hosts pests and diseases which can attack the crop. This study was carried to establish the extent and level of awareness on safe use of herbicides by tea growers of Kapkoros and Tirgaga tea factories in Bomet County, Kenya. The specific objectives were to determine the frequency of herbicide usage, the level of awareness on proper usage and handling of herbicides among tea growers and to determine the socioeconomic aspects of herbicide usage on household tea production. A Pre tested questionnaire was used to collect primary data from 363 respondents in all the six tea growing zones. Secondary data was collected from all the health centers in the study area and analyzed using descriptive and inferential statistic. Most of the tea growers (52%) preferred to use a herbicide with glyphosate formulation called round up in varying degrees.The use of preferred herbicides among tea growers aged between 26-40 years (54%) and those above 40 years (32%) was high. The high level of use and prolonged use by persons in the reproductive ages can be risky. There was statistical difference between the preferred herbicide and one's years of tea growing ($\chi 2=17.03$; $p<0.05$, $df=362$). The study shows that 80.2% of the respondents in the area read the herbicide labels before use. Majority of the tea growers (90.4%) use the Personal Protective Equipments (PPE) when handling herbicides. Before or after the use of herbicides, most respondents (96.6%) stored them in stores. On accidental contact with herbicide, 86.2% adopted to washing their bodies with water, while 13.2% visited a doctor and 0.06% just wiped their bodies. The study found that the main socioeconomic benefit from using herbicides was the reduction in workload which led to reduced overall cost of production therefore increasing the returns. There was significant statistical difference between the frequency of herbicides use and the socioeconomic benefits of using herbicide ($\chi 2 =$

64.869; p >0.05, df=362)**.** The study found that 77.1% of the tea growers had received general training with 55.1% of them being trained on safety while using herbicides. Most cases of intoxication were accidental (70%) and therefore first aid was administered before one was taken to the hospital. The level of intoxication was mild (80%) and mainly through inhalation (80%), ingestion (10%) and contact (10%). In most of the reported cases of intoxication, the victims (50%) did not know the dangers associated with improper use, whereas 30% were completely ignorant and a paltry 20% had some knowledge about intoxication. This study established that there exists a gap on the training on proper use of herbicide and associated dangers of improper use across all the areas. It is therefore recommended that training of tea growers in Bomet County on proper use of herbicide be improved by Kenya Tea Development Agency (KTDA) and other relevanst authorities so as to help minimize the negative impacts associated with improper use.

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background of the study

Herbicides are commonly known as a weed killer, is a type of pesticide that is used to kill unwanted plants. Selective herbicides kill specific targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often synthetic "imitations" of plant hormones. Herbicides play a major role in crop protection and control of vector borne diseases in all agricultural sectors. Herbicides are chemically active compounds designed in the most part to kill targeted organisms, but unfortunately, herbicides are dangerous when they are not used properly or as recommended in crops and the environment (www.edis.ifas.ufl.educ). Throughout the world herbicides are an effective, relatively simple and quick method of weed control. In many cases without chemical control man's crops would be ravaged by diseases, insect pests and weeds hence severe loss in food production. About fifty percent of global agricultural production is lost before or after harvest due to combined effects of disease, pest attacks and weeds. Use of herbicides in management of weeds is emphasized rather than their permanent removal. This is because it is good to maintain a balance of weeds in the plantation flora for sustainability by proving habitats for predators of insect pests and minimize soil erosion through anchoring effect of plant roots (George, 1980**).**

In Indonesia, rehabilitation of tea plant (*camellia sinensis*) was started in 1970 by the government tea estate and in 1974 by the smallholder and private tea estate where special attention was paid to up-keep young tea plants. Weeds played an important role as the upkeep cost is much higher compared to mature tea plants because they suppress tea growth and prolonged the non-productive period. Herbicides have been used in production fields since 1970 because it gives effective results. It was also used in larger tea plantation because mechanical weed control is difficult and labour intensive. Chemical weed control has been widely used but further research was recommended because continuous spraying changed the weed composition and enhanced growth of dominants weeds. Among the herbicides used are Paraquat,

Triazine, 2, 4-D, Diuron, Dalapon (2, 2 dichloro- propionic acid) and Glyphosate (Sasusi, 1977).

India has unique distinction of being the largest producer and consumer of tea in the world producing about 840 million kg tea annually. Being a perennial crop, tea needs to be fully protected from weed competition particularly in the young stage to allow the bushes develop its strong frame, obtain good harvest and prolonged productivity. Weed control is the second most expensive input in tea production. This is predicted to increase because of acute shortage of labour and escalating wages of labour with tea plantation alone using about 20% of the total quantities of herbicides used in India. A number of pre and post–emergence herbicides that have been recommended for controlling weeds in tea are simazine, diuron, glyphosate, 2,4-D and Dalapon. The selection of herbicides is very different due to variations of weeds species as well as their intensity of infestation (Rajkhowa *et al*, 2005).

In North East India where tea growing is a yearly duty, they spend up to two hundred million rupees annually on weed control. In general weed manifestation is severe in young tea in the years following light pruning, medium pruning and deep skipping. Grassy weeds reduce the productivity of tea by twenty one percent (21%) while broad-leaved weeds accounts for nine to twelve percent (9-12%).Weeds remove substantial amount of nutrients and moisture from the soil besides increasing the incidence of pest and diseases in crop by serving as alternate host (Rajkhowa *et al*, 2005).

In Kenya, weed control in tea bushes is unique in many ways such that pests and diseases management practices have focused on Integrated Pest and Disease Management (IPM) for the last 3 decades where pests, weeds and diseases constraints to tea production are managed through cultural practices, biological control and restrictive use of chemicals pesticides. No clear best practice have been adopted by the government or the farmers thus leaving the farmers to try any mode of weed control whichever suits them (Cheramgoi *et al*,2012).

Herbicides are not safe for use in the environment, improve crop production and protect human and plants life from disease, illness and annoyance when used as recommended. Chemical crop protection in most cases is effective and profitable in controlling weeds and diseases. But herbicides expose operators and consumers to

risks e.g. small amounts of herbicides and their degradation products –metabolites and residues end up in food supplies. Reports from experiments using rats, rabbits, guinea pigs or from observation on personnel exposed to pesticides in manufacturing firms shows that exposure to pesticides can lead to health problems which can range from mild skin irritation to birth defects, tumours, genetic changes, blood and nerve disorders, endocrine disruption and even coma or death (Green, 1976; Lorenz, 2009).

There are always risks with agricultural chemicals and care is needed to avoid accidental poisoning, irritation of eyes, nose and skin, allergies, chemical residues on food, environmental pollution, build up of resistance, fire, corrosion and problems with disposal (Kamrin, 1997). Exposure routes other than consuming food that contains residues include pesticide drift with potential hazards significant to the general public. Therefore safety measures have become a big concern worldwide when handling pesticides. Safety must be ensured for users of herbicides and the environment during application and disposal of left-over of spray mixtures, obsolete or unwanted chemicals and empty containers (Matthews, 1985).

### 1.2 Statement of the problem

Bomet County is a tea growing zone with roughly 24,868 households depending entirely on tea as main source of income. Most growers have dedicated up to sixty percent of their land to tea bushes with meaningful gain being expected out this source. However, majority of tea growers have recently been shifting to other farm diversification and uprooting their tea. This is attributed to low returns where, the 24,868 households in the county are still producing between 0.5 -1.0 kilogram per bush (kg/bush) compared to the KTDA production recommendation of 1.0-1.5 kg/bush for any meaningful returns to be achieved (**Table 3.1**).

The government's failure to restrict agrochemical stockists operations and to disseminate information on the approved list of pesticides to an extent that it can easily be reached at the rural villages where most farming is done in Kenya is also a challenge. With several stockiest the farmers are spoilt for choices and are unable to differentiate the user friendly herbicides from the cheap and very toxic ones. The use of herbicides by farmers, the trainings undertaken, the monitoring of stockists, the documentation on the types and frequency of herbicides used by the government is a

matter of interest in the study. The risk of exposure can cause chronic and acute illnesses which can lead to death of the users, animals and contamination of environment. Therefore, evaluating the extent and level of awareness on safe use of herbicides was important. Moreover, if production of this important crop is improved through the reduction of operation costs, it will become more profitable. This research therefore, aimed at answering the question; does on improving the level of awareness on safe use of herbicides among the tea growers at the same time increase their farm incomes given the same resource levels?

### 1.3 Justification of the study

The International Labour Organization (ILO) estimates that as much as 14 % of all occupational injuries are due to exposure to agrochemical constituents. 10 % of these are estimated to be around 17,000 per year are fatal. The World Health Organization (WHO) and the United Nations Environmental Programme (UNEP) estimated that one to five million cases of herbicide poisoning occur among agricultural workers each year with about 20,000 fatalities (ILO, 1991). Like in the rest of sub-Saharan Africa (SSA), farming in Kenya is mainly carried out by Small Holder Farmers (SHF). The health of the worker is an important component of human capital that affects the ability to do physical labour and to manage farm operations and therefore is a major factor in productivity especially in small holder enterprises. SHF in tea production rely 100% on human labour since no mechanization is utilized at any stage of production. Spraying herbicides to control weeds is one of the major activities. However, lack of demand driven and stringent regulatory herbicides standards in the local markets may contribute to the workers high exposure to herbicides and negative herbicides - environmental outcomes. The study is useful in coming up with information that will benefit the growers, the managing agent, and the other stakeholders on the appropriate methods of weeds control in the tea sector.

This study also contributed towards other studies that covered a wide range of topics on farmers' health, herbicides and other agrochemicals used in developing countries. These include health costs and acute toxicity symptom incidence related to pesticide exposure among cotton farmers (Maumbe and Swinton, 2003), and epidemiology of pesticide exposure among horticultural growers (Thrupp *et al.,* 1995; Ohayo-Mitoko

*et al*, 1999). However, none of these studies have addressed the extent and level of awareness on safe use of herbicides among tea growers in Bomet County, Kenya.

## 1.4 Hypothesis

$H_A$ The level of awareness on safe use of herbicides is high among tea growers.

## 1.5 Objectives

### 1.5.1 Main objective

To evaluate the extent and level of awareness on the safe use of herbicides by small scale tea growers.

### 1.5.2 Specific Objectives:

1. To establish the preferred herbicide used for weed control in tea plants among tea growers in Bomet County.
2. To determine the frequency of herbicides use when controlling weeds in Bomet County.
3. To establish the level of awareness on proper use and handling of herbicides among tea growers in Bomet County.
4. To determine the socioeconomic aspects of herbicides use on household tea production in Bomet County.

## 1.6 Research questions

In view of the problem and objectives, the following research questions were postulated.

1. Which type of herbicide is mostly used in weed control by tea growers in Bomet County?
2. How frequent do the tea growers in Bomet county spray their farms in a given season?
3. What is the level of awareness on proper use and handling of herbicides among growers in Bomet County?
4. What are the socioeconomic benefits on herbicides usage on tea production in Bomet County?

### 1.7 Scope of the study

The study was limited to Bomet County in Rift valley province with the sample drawn from those farmers who supply their tea to Tirgaga and Kapkoros tea factories and managed by KTDA.

### 1.8 Study Limitations

The limitation of this study was that it only focused on the extent and level of awareness on safe use of herbicide among the tea growers in the county of Bomet, but this may not be the only problem facing tea growers. There are also other critical problems that require research such as risk perception and assessment and the costs of adverse health effects among tea growers in Kenya. However, the exclusion of this area did not compromise the quality of this study.

### 1.9 Conceptual framework

The concept was developed to help understand the factors affecting man in a community set up while trying to improve his livelihood by increasing tea production while reducing the cost of production. In an effort to improve one's production, growers resort to use herbicides to kill weeds that act as the main competitor of nutrients with tea. This competition often lowers production of tea. Usage of herbicides is a matter of choice and preference because there are other methods that can be used which are equally suitable. There was an overall reduction in production costs associated with herbicides usage due to the massive reduction of labour required for weeding from an estimated 39 to 2 person-days per hectare (over field *et al.*,2001).

The government on the other hand, through the enactment of tea Act has enabled the tea sector to regulate itself. Tea board of Kenya has come up with several recommendations on crop husbandry in order to improve production while, other bodies like Pesticide Control Product Board (PCPB) have also been tasked with testing and recommending pesticides suitable for crops in Kenya. This has enabled growers to choose from a variety of pesticides. The government has also subscribed to several recognized international standards like ISO standards and thus the emphasis on safety assurance and hygiene of herbicides users. Being the main

exporter (95%) of its total production, KTDA has partnered with international tea buyers through sustainable agriculture, fair trade, rain forest alliance and tea ethical partnership with the main agreement mainly being the safety and wellbeing of the grower, environmental compliance and the safety of the end product.

Weeding has always been seen as women work, of little importance and does not receive priority attention. Weeds are also accepted naturally as consequences of crop production efforts and little input is given to improving their control (Mavudzi *et al*, 2001). The community in the area of study tends to value cattle keeping more than farming. Being mixed farmers weeding is mainly left to the farmhand where labour is becoming scarce while others prefer to graze their cows in the unattended tea farms. On the other hand, most researches that have been conducted in the past on herbicides use have not reached the growers. The safety concerns in not well understood by the growers leaving them to try any latest herbicides on the market. Training on reading of labels and understanding the meaning of signs is at its infancy stage. Training on proper use of PPE is also necessary so as to reduce the risk of exposure. Awareness on the dangers of continuous exposure/long use of herbicides needs to be established.

According to the 2009 national census, the community is largely populous with a birth rate of 6.8 .This means most household resources are strained to an extent that use of family labour is seen as cheaper option than use of herbicides and on the other hand it can also imply that they prefer to use herbicides to lessen the workload so to concentrate on other activities. Growers with large farms have no option but to use herbicide which eventually is cheaper and not labour intensive.

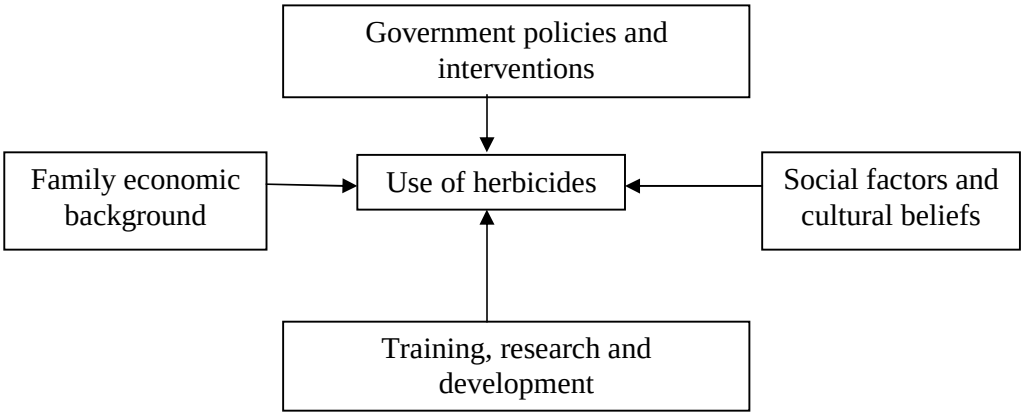


**Figure 1.1:** Conceptual Framework

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Introduction

Weeds are usually described as unwanted plants and they normally grow on arable land which is waiting to be planted, where a new flush of weed seedlings emerge with the crops. In perennial crops like fruit, vines, rubber and oil palm, weeds grow continuously with new growth prompted by the weather and changing seasons (www.edis.ifas.ufl.educ).

Weeds compete with crop plants for sunlight, water and soil nutrients, reducing yields and quality; they also provide a habitat for pests and diseases from which these can attack the crop. Large, climbing or spiny weeds can make it difficult to get into the crop for pest and disease control, fertilizer application, harvesting and other operations. Weeds are often unattractive, but they are not always a problem since they play an important role in reducing soil erosion, provide habitats for beneficial insects and wildlife and increasing biodiversity (www.paraquat.com). However, it is not only the effects on the current crop that count and weeds must be managed since they become a problem when they reach a critical size or number, and these will depend on how aggressive a particular species is. Weed management is part of any farmer's job and use of herbicides is a very economic, environmentally sound and flexible tool (Rajkhowa *et al.*, 1995).

Herbicides are called plant protection product, and are grouped together as pesticides with fungicides, insecticides and nematocides. They are made up of biologically active substances and as such, they can cause damage elsewhere than to the plants they were intended to eliminate and thus their use involves certain risks for humans, consumer, domestic or wild animals and the environment (www.edis.ifas.ufl.educ).

### 2.2 Tea Plant

Tea grows best in regions that enjoy a warm, humid tropical climate with rainfall measuring at least 1000 mm per annum and prefers deep, light, acidic and well drained soils. In such conditions tea will grow in areas from sea level up to altitudes

as high as 2100 m (Anon, 2002). Camellia sinensis plants are evergreen, medium sized woody shrubs growing to a height of 1.8m.

Tea plants are planted in the field at a spacing of 120 cm by 60 cm leaving a large area of soil surface open to full sunlight which is a condition that lasts for 2 years and is very favorable for weed growth before the canopy of tea bushes completely covers the soil. As in other crops, weeds in tea compete for nutrients, water in dry season and occasionally for light (Cheramgoi *et al*, 2012).

### 2.3 Types of tea weeds

Weed composition differs from one tea estate to another with perennial grasses creating the greatest problem in tea plantation due to the fact that these grasses propagate not only by seeds but often by ground runners and underground parts such as stolon, rhizomes, tubers, which make all these grasses difficult to eradicate. Grasses with shallow fibrous roots and soft broadleaf weeds appear to be less troublesome in comparison with the deep rooting perennial grasses. The eradication of deep rooting perennial grasses by mechanical weeding is often very difficult because pieces of rhizomes left in the soil can sprout and start a new plant. Insufficient weeding might also stimulate the growth of these weeds (www.weeds).

Weeds are classified on the basis of leaf shape, life-cycle and climate or seasonal preference. They have evolved to grow best in particular temperature and day lengths which tend to define the crops that are found in and the time at which they germinate, for instance, winter annuals or summer annuals. Also, in tropical climates with dry seasons and rainy seasons, some species tend to be more prevalent in one season than the other (www.weeds).

Annuals germinate, flower and set seed in a single season while, perennials have underground storage organs, often rhizomes, which enable them to grow for many years. They can reproduce both from seed and by extending their rhizomes from which daughter plants grow. Other types are biennial that germinates in one season and flowers in another by passing through winter prompts them to ‘bolt’ by elongating a tall flowering stem (www.paraquat.com). Broadleaved weeds have seeds with a pair of storage organs which after germination become the first leaves (the cotyledons) hence the other name often used: dicotyledons, or dicots. Grasses

are monocotyledonous (monocots). There are a few exceptions in that the odd monocot can have broad leaves, like the important tropical weeds in the Commelina genus. Sedges are grass-like class with relatively few members like purple nutsedge (*cyperus rotundus*). They are important because they are difficult to control hence has been called the world's worst weed (www.paraquat.com).

### 2.4 Effects of weeds on tea plants

Weeds are an under estimated crop pest, where government spending in Africa on training, research and education is minimal and appropriate weeds management technologies remain largely unavailable and or underdeveloped. Crop losses caused by weeds are invisible and are not as spectacular as those caused by any other pest organisms (Labrada, 1996; Sibuga, 1997).

Because weeds do no strike as violently as insects, there is a tendency to underestimate their economic importance even when a farmer is forced to abandon a crop to weed, such incidents do not attract attention. Consequently the lowest priority is assigned to weed science research in practically all of Africa (Sibuga, 1997).

There were indications showing that growth retardation of the young tea plant is related to nutrients uptake of weeds, but on the other hand it has been noted that production of organic matter by weeds should be in some way related to the extent of nutrients uptake (Soedarsan *et al.*, 1983).

Rao *et al.* (1977) established that weeds are the number one pest and can reduce the productivity of tea by 10-15% depending on the intensity of weed growth, extent of competition and the weeds species that have competitive ability of cloning. Besides reducing the yields, weeds also produce the following adverse effect on tea; restrict branching and frame development in young tea, harbor and serve as alternate host for many organisms including some important tea pest, reduce plucking efficiency, creepers like those of poaceae family contaminates plucked shoots and reduce water flow in the drains.

## 2.5 Weed management

Weed control plays an important role in tea plantation as the upkeep cost is much higher in young tea compared to mature tea due to the fact that that they suppress tea growth and prolong non-productive period in young (www.weeds).

According to the findings by Staal-duine (1993), he observed that chemical weed control had been used in producing fields since the 1970s and seems to give effective results. Due to the risk of damage and limited data, chemical control is not applied in young tea plants but on the other hand there is an insufficient mechanical weed control in many estates as well as small holder farms due to the effect of plant damage, loss of top soil to erosion and retardation of growth. In a large part of the young tea plantings, mechanical weed control is difficult to effect at the right time because the method of weeding is labour intensive and hence there is also need for more labour in the producing fields.

Past researches showed that certain herbicides if applied correctly give good weed control without affecting the tea plants especially in perennial plant crops such as tea, where emphasis is on the management of weeds rather than their permanent removal. This is because maintaining a particular balance of weeds in the plantation flora is important for sustainability by providing habitats for predators of insect pests and minimizing soil erosion though the anchoring effect of plant roots. It also interfere with the work of tea pluckers especially thorny or climbing weeds such as mimosa, day-flowers or lygolium (Soedarsan *et al.,* 1983).

## 2.6 Herbicide application, mode of action and its efficiency

Weeds are vulnerable to herbicides if their internal biochemical processes can be accessed. Once inside a plant cell, an effective herbicide will disrupt normal functioning leading to death. However to kill the plant itself, all the various growing points at shoot and root tips, and the buds on stems and rhizomes must be killed too. A number of pre- and post emergence herbicides have been recommended for controlling weeds in tea. However the choice of herbicides mainly depends on the weed flora present, type of herbicides, its availability, age of tea plantations and economic considerations (Rajkhowa *et al.,* 1995). The intensity of weed infestation and weed species preliminary are different from area to area or even from section to

section in the same estate. The number of herbicides application in a season depends on the efficiency of a particular herbicide and the type of weeds appearing after the initial application. Herbicides are classified according to their mode of action e.g. contact or systemic; action or effect on weed e.g. selective or non selective and time of application with respect to stage of weeds e.g. pre-emergence or post emergence. The benefits to be gained are evaluated against potential hazard due to their introduction. The general rule is, the herbicide should not affect tea yields, brew qualities, and not be phototoxic to crop or leave high residues on the final product of edible part of the plant.

Herbicide program vary with weed situations where a particular programmers may be used as long as the relevant weed spectrum changes over the years and the suitable programmes for the new weed situation should be used (Agarwala, 1973; www.communityipm.org).

Herbicides programmes for young and mature tea is also different due to variation in weed species as well as their intensity of their infestation. Pre-emergence herbicides are use after the early rains to prevent weed emergence and establishment.

Different types of herbicides can be used to control weed in a season, or on rotational programmes and it frequency of use or application depend on the extent and rate of new weed growth following initial application, the regenerative capacity of the weed species following initial application, the type of weed persisting following application of the herbicide and the efficiency of the initial spraying (Ohioline-state-educ). In mixed weed situations in tea, different herbicides combination and use of herbicide in rotation should be practiced in order to control broad spectrum weeds and to prevent resistant weeds from predominating an area. Herbicides mixture performs better in weed control due to their synergistic effects, reduces the overall cost of weed control and minimizes the possible phytotoxicity of chemicals. The major benefit of herbicide combinations in tea are; broad spectrum weed control, better control of weeds due synergism of two or more herbicides, dose of component herbicide could be reduced by mixing appropriate chemicals thereby reducing the phytotoxicity from the components. Low rates in combination will result in minimum residue in soil which will biograde in shorter time and combinations help to avoid

shift of resistant weed species due to their repeated use of same herbicide (Agarwala, 1973; Ohioline-state-educ).

Roots are obviously adapted to absorb water, so soil-acting soluble herbicides have an easy way in while plant shoots have a thick waxy cuticle to help retain moisture in which foliar herbicides have to cross this barrier to enter. Leaves have pores called stomata through which carbon dioxide, oxygen and water vapor diffuse, but these are generally too small for spray droplets to penetrate. Once inside, some systemic herbicides move extensively throughout the weed either in the transpiration stream of water as it is drawn from the roots to evaporate from leaf stomata, or with sugars produced by photosynthesis in the leaves translocation to the growing points (www.weeds). Among the herbicides identified for use in Kenya to control tea weeds are shown in *appendix VI.*

Young tea plant should be kept under manual weeding for a period of 2 years after which careful application of herbicides.For mature tea, herbicides like 2,4-D, Paraquat, Glyphosate, Simazine among others are useful for effective control of weeds (www.paraquat.com ).

Paraquat (grammaxone) is a broad-spectrum herbicide with a mode of action of inhibiting photosynthesis, an essential process in plants and hence paraquat destroys all green tissue. Although it is termed ‘non-selective’, paraquat is safe to tea crops due to the fact that, it is immobilized on contact with the soil meaning that it cannot move to roots and be taken up into plants. It is also sprayed around the tea plants, which are protected by bark which paraquat cannot penetrate. Finally, even if small amounts of paraquat lands on lower tea leaves there is little or no damage nor residues reaching the buds and young leaves because paraquat does not move through plants systemically like the alternative non-selective herbicide glyphosate. Paraquat is very fast-acting and therefore weeds sprayed with a paraquat solution in the morning will often show symptoms by the afternoon, making it easy for spray operators and plantation managers to see which areas have already been treated. This holds even if rain falls within 15-30 minutes, making it possible to spray before rain is expected. Paraquat has a very robust environmental profile since it does not leach because it is extremely tightly bound to soil particles immediately on contact, so it

cannot move into groundwater or surface waters by run-off and similarly cannot affect soil animals or microorganisms (Prematilake *et al.*, 2004).

Glyphosate (Round up) has been increasingly used because tea growers have been under pressure to simplify their systems and cut costs. However, unless used very carefully, glyphosate is a systemic herbicide and spray drifting on to tea can damage young leaves and buds, and cause longer-term reductions in plant vigor and hence decrease yields. Effectiveness of glyphosate has also been compromised by the pressure it puts on the weed flora to shift to more tolerant and competitive species (www.paraquat.com). Chemically, glyphosate is an organophosphate like many other pesticides but it does not affect the nervous system as other organophosphates do. It is a broad spectrum, non-selective herbicide which kills all plants, including grasses, broad leaf and woody plants. It is absorbed mainly through the leaves and is transported around the whole plant, killing all parts of it. It acts by inhibiting a biochemical pathway. At low levels of application it acts as a growth regulator (Prematilake *et al.*, 2004).

There are several disadvantages of using herbicides like the disruption of the ecosystem, weeds resistance thus requiring higher and higher doses since no herbicides can kill every weed. (www.paraquat.com).

Wholesale distribution and retail forms part of the supply chain of agrochemical products. Wholesalers are responsible for effective, efficient and safe handling, storage and distribution of herbicides. Sale of unregistered/unauthorized herbicides is illegal in Kenya. The herbicides being sold should be identified appropriately by giving details like trade name and their active ingredients in order to help growers make informed choices. Some of the herbicides found in use were Glyweed, Glycel, and Round up, Gramaxone, Wound out, and Wipe out, Mamba, Touchdown and Eraser (PCPB, 2010).

Eraser 360SL is a glyphosate distributed by Lachlan Company. It is used for control of broad-leaved weeds and grasses in tea, barley and coffee plantations. Glyweed SL is a systemic non-selective herbicide with glyphosate as the active ingredient for control of annual and perennial weeds in baby corn. It is distributed by Orbit Company. Gramaxone 20sl has paraquat dichloride as the active ingredients. It's a fast acting herbicide in crops such as coffee, tea, orchids, and maize and distributed

by Syngenta Company. Wipe out has glyphosate as the active ingredient used to control broad level weeds and grasses. It's distributed by Juanco ltd. Wound out is a systematic non selective herbicides for control of annual and perennial grasses with glyphosate IPA salt as the active ingredient. It's distributed by OSHO ltd. Touch Down has glyphosate trimesium as the active ingredient used for control of a wide range of weeds in coffee, bananas, tea, sisal (PCPB,2010).

### 2.7 Herbicides toxicity and mode of exposure

The toxicity of herbicides is based upon the lethal dose required to kill 50 % of the test population within 14 days after an exposure expressed as $LD_{50}$ ( *ILO, 1991).*

Glyphosate is the active ingredient in most of the herbicides .Glyphosate is a moderately toxic herbicide and carries the signal word WARNING on the label. Even though the $LD_{50}$ values show the compound to be relatively non-toxic it can cause significant eye irritation. The low acute toxicity of glyphosate can be attributed to its biochemical mode of action on a metabolic pathway in plants which does not exist in animals. However, glyphosate can also disrupt functions of enzymes in animals. In rats it was found to decrease the activity of some detoxification enzymes when injected into the abdomen. In general, controlled toxicity tests report adverse symptoms from exposure to glyphosate only at extremely high doses, i.e. several grammes per kg body weight (WHO, 2002).

While glyphosate itself may be relatively harmless, some of the products with which it is formulated have a rather less benign reputation. Marketed formulations of glyphosate generally contain a surfactant. The purpose of this is to prevent the chemical from forming into droplets and rolling off leaves which are sprayed. Some of these surfactants are serious irritants, toxic to fish, and can themselves contain contaminants which are carcinogenic to humans (EPA 987). It was noted that at spray strength, glyphosate formulations are of relatively low toxicity. It is classified as solid and with acute oral $LD^{50}$ for rats of 157 mg/kg which puts it into WHO as class II "Moderately hazardous" (EPA, 1987). Cheramgoi et al, (2012) noted that glyphosate formulations are normally used in Kenya to control weeds during the first years of establishment and in pruned tea.

Every pesticide must be labeled "Keep Out of Reach of Children." Additional information required on the label denotes environmental hazards and physical or chemical hazards. Toxicity to human health can be acute or chronic. Acute toxicity being the ability of biologically active chemical to cause an alteration of vital functions after absorption of a single dose while chronic toxicity occurs after repeated exposure to low doses over an extended period hence is typically a long term hazard due to repeated absorption of a substance in small amount (Norman *et al.*, 2005).

It was noted that before a pesticide can harm it must be taken into the body. Active ingredients reach sensitive tissue or organs before its biological action can take place and therefore has to penetrate somehow into the organism (Lorenz, 2009). Pesticides can enter the body orally (through the mouth and digestive system); dermally (through the skin) or by inhalation (through the nose and respiratory system). Oral exposure may occur because of an accident, but is more likely to occur as the result of carelessness, such as blowing out a plugged nozzle with one's mouth, smoking or eating without washing hands, splashing concentrate while mixing or eating fruit that has been recently sprayed with a pesticide containing residues (Kamotho, 2004). The main causes of oral ingestion include droplets of products accidentally entering the mouth or accidental ingestion due to improper storage but small amounts are absorbed when the operator's eats or smokes without washing his hand or use of recycled chemical containers among others Oral ingestion is a serious professional hazard which is more frequently as suicides, homicide or accidental. (Kamotho, 2004; Norman *et al*, 2005).

Dermal (skin) exposure accounts for about 90% of the exposure for pesticide users that may occur any time a pesticide is mixed, applied, or handled, and it often goes undetected (Kamotho, 2004). Dermal absorption is the primary route of penetration into the organisms for most pesticides through leaked or droplets coming into contact with the skin, drifting of the product during application, contact with the sprayed crops and or wearing of torn or contaminated clothing (Norman *et al*, 2005).

Inhalation exposure results from breathing pesticide vapors, dust, or spray particles. Depending on the physical properties of the active ingredient, its formulation and

application techniques, quantities absorbed via the respiratory tract will vary. Active ingredient in gas or vapour form will be absorbed rapidly by the blood stream. Fine particles produced by powdering, atomizing, fogging or spraying may deposit on the respiratory mucosa and end up in the lungs (Lorenz, 2009).

## 2.8 Proper handling, labelling, storage, application and safety precautions when using herbicides

When spraying weeds, the operator should receive appropriate training so as to be aware of the type of herbicides to be used, how to carry out the spraying safely and the precautions to be undertaken in case of a spill (Kamotho, 2004). Hand spraying should not be carried out during high winds and in very hot weather. The handling and use of herbicides supplied in soluble bags placed directly in a spray appliance must be in accordance with the manufacturing instruction. Due to that, the person in charge of spraying or operator must have specified personnel protective equipment PVC gloves, goggles among others and he/she must avoid smoking any time herbicides are being handled or sprayed (Norman *et al*,2005). Containers should be inspected to ensure they are not leaking and in the event of contamination of the skin or eyes by herbicides, it should be washed off immediately and medical advice sought. If herbicides are accidentally swallowed medical advice should be sought without delay (Mathews, 1985).

Herbicides must be stored away from food, drink and cleaning material with concentrated herbicides not stored in unmarked or incorrect containers. It must also be issued to staffs that received appropriate training. Up to 200 litre or 200 kg herbicides may be stored in a lockable metal container which is robust, dry, well ventilated and afford protection from frost. Any excess herbicides must be tipped on the ground while the empty containers must be thoroughly rinsed out and all used containers must be returned to store awaiting approval for disposal without any attempt to burn them (Cornell, 1992).

Personal protective equipment (PPE) is designed to reduce risk of contamination to pesticide handlers and must be correctly used and maintained to give maximum protection. The user must comply with label instructions such as “PPE required”

when using different pesticides. Some of the PPE commonly used are overall, coats, gloves, respirator, gumboots and aprons (Kamotho, 2004).

PPE should be used according to the instructions on the container label;when mixing, decanting or spraying.The PPE in use should be appropriate to the task,suitable for the wearer, readily availabe,clean and in full operational condition (FAO,2002). Sprayers should also be trained on proper use, seletion, maintenance i.e where appropriate and when to discard the disposable. Eye protection should be worn to protect one from chemical splash or flying objects either by using safety glasses, goggles, a face shield or full face respirator. Respiration protections are worn to avoid inhalation of spray, vapour or dust (FAO, 2002).

The labels on herbicide are very important source of information to the farmer on how to use the product safely. However, it may look complicated but it is very important to read before using the herbicide since it warns the user of the toxicity and hazards associated with the product and the precaution which needs to be taken when handling and using it. Potential hazard is assessed on the formulation of product in the packed and therefore takes into account the properties of the solvents, diluents and other adjuvant in addition to the active ingredients. Rate of herbicides application is different due to variations of weeds species as well as their intensity of infestation (www.bvsde.paho.org ).

The purpose of labels is to provide the user with all essential information about the product and how to use it safely and effectively. Users should read labels which have information identifying the contents that appears as follows: Product or Trade name; associated product category (e.g. herbicide or fungicide); type of formulation-name and code; active ingredients name or other locally used common name; net contents of the pack expressed in metric units (e.g. litres, grams. kilograms abbreviated as l, g, kg. There should also be a clear warning on the label in relation to: reading safety instruction before opening the pack, handling, transport and storage warning symbols, hazard classification/symbol. In all labels; safety precautions, safety pictograms, warning, first aid advice and medical treatment should be indicated (FAO, 2002).

Chemicals should be stored in their original packages and if the package is damaged or leaking, transfer the contents into another correctly labeled package. All original

labels should remain legible on the package. Containers that are leaking or corroded should be secured by placing in another container or removed. Always use old stock first. Keep containers closed or the lids on while in storage. This helps to reduce dust and/or solvent vapours building up in the storage area. Liquids should not be stored above solids (www.ohioline.ag.ohio-state-educ).

Cole *et al.,* (2002) found that growers store pesticides poorly with majority of them storing in farmhouse while using wrong and unsafe disposal methods which contribute to health problems of the growers and their families.

Sprayers should be used according to the manufacturer's instructions and be the most appropriate for the task in hand. Depending on the type of sprayer, variables such as nozzle type, hydraulic pressure, height of delivery and the presence or absence of a directed airstream will affect the size and movement of droplets produced, and the efficiency with which they impact on the target. Application equipment needs to be set up to maximize pest control efficiency and to minimize spray drift. Spray volume should be controlled by changing nozzles and not by varying pressure. A higher pressure generally forms a finer spray that may drift excessively. Droplet drift before the pesticide hits the target is reduced if the release height is as low as possible (www.ohioline.ag.ohio-state-educ). Exposure of the operator is a very important risk which requires proper knowledge of product properties to ensure that treatment is effective. The operator is often at risk during the application phase of the mixture, the preparation of the mixture. The preparation of the mixture accounts for over 70% of the exposure risk which takes place when opening the package, rinsing the spray tank or when filling the sprayer. For these operations 90 to 98% of the exposure occurs through the hands that emphasizes the need to wear water proof gloves during operation (Kamotho, 2004).

Risk of exposure during application phase of the mixture will vary based upon nature and quality of the protective clothing, presence of wind over 12km/h, an excessively high temperature, volume of application, concentration of the spray mixture, the work duration, negligence and lack of personal hygiene and the spraying equipment. Secondary exposure risk occurs due to contamination after pesticides application occasioned by contamination to workers in the field before re-entry interval is over, from poorly washed PPEs and when washing the PPEs (Kamotho, 2004).

The re-entry period is the period in which a treated field must not be entered by unprotected persons after the application of a chemical on a crop. It is important to observe the re-entry period where contact between foliage and skin is unavoidable. The label should be checked to see if the re-entry period. Where no re-entry period is stated, a minimum of 24 hours should be observed or until the chemical has dried upon the crop. Caution should be exercised when entering wet crops where chemicals have previously been applied, irrespective of the time lapse between application and re-entry. Even after the re-entry period has been observed, some PPE may be necessary (Cornell, 1992).

Cornell, (1992) noted that herbicide must only be issued to staff who have appropriate training. The trained operators will be aware of the herbicide being used and are able to carry out spraying safely and takes precautions in case of a spill. It was noted that it must be stored away from food, drink and cleaning materials while concentrated herbicides must not be stored in unmarked containers.

### 2.9 Health, environmental and ecological effects of herbicides exposure

The encouraged use and misleading advertisement of agrochemicals, combined with their easy access in local markets means that pesticide misuse and illness are widespread throughout Kenya (Mwanthi and Kimani, 1993). The unsafe storage methods, inadequate protective clothing and ambiguous instructions contribute to the growing number of accidental poisonings of Kenya's farmers and their families (Mwanthi and Kimani, 1993).

Chronic occupational poisoning of Kenyan agricultural workers by pesticides and in particular, by organophosphate pesticides, has been documented (Mwanthi and Kimani, 1995; Ohayo-Mitoko *et al*, 1999).

Herbicides have widely variable toxicity with acute indirect toxicity from high exposures that results to problems like carcinogenicity as well as other long-term problems such as contributing to Parkinson's disease. Some herbicides cause a range of health effects ranging from skin rashes to death (www.ohioline.ag.ohio-state-educ). The pathway of attack can arise from intentional or un intentional direct consumption, improper application resulting in the herbicide coming into direct

contact with people or wildlife, inhalation of aerial sprays, or food consumption prior to the labelled pre-harvest interval. Under extreme conditions, herbicides can also be transported through surface runoff to contaminate distant water sources and on the other hand most herbicides decompose rapidly in soils through soil microbial decomposition, hydrolysis, or photolysis (www.ohioline.ag.ohio-state-edu).

When a plant protection product is used there is always the risk that some of the product will contaminate an area outside the targeted area, an accident caused by negligence or insufficient knowledge (Lorenz, 2009). Environmental contamination risks can be traced to water, air, birds, aquatic organisms, Bees, beneficial organisms and mammals. The fraction of the product reaching the soil before penetration can be carried off by runoff water which is the primary means of transport of herbicides and can lead to contamination of surface water or indirectly to the contamination of ground water (EPA, 1987). Birds are directly affected by feeding on seed plates or indirectly in their prey for insectivores, by product drift when spraying is done near the proximity of their nesting place while bees are affected when gathering pollen, or honey dews on the sprayed weeds and it can affect the larvae of bee thereafter affecting pollination of fruit trees. Non -selective pesticides destroy auxiliary insect and encourage the proliferation of their customary prey mammals, primary consumers, secondary consumers and other at the end of the food chain (Kamotho, 2004).

The health and environmental effects of many herbicides is unknown, and even within the scientific community there is often disagreement on the risk. For example, a 1995 panel of thirteen scientists reviewing studies on the carcinogenicity of 2,4-D had divided opinions on the likelihood that 2,4-D causes cancer in humans. As of 1992, there were too few studies on phenoxy herbicides to accurately assess the risk of many types of cancer from these herbicides, even though evidence was stronger that exposure to these herbicides is associated with increased risk of soft tissue sarcoma and non-Hodgkin lymphoma (www.bvsde.paho.org). In general, herbicides and fungicides are less toxic than many of the other types of pesticides. However, because of current concern about the possibilities of chronic health problems and environmental effects, including ground water contamination, many of those that

have been commonly used in the past are now under EPA review (EPA, 1987). Some herbicides such as the arsenicals are not particularly hazardous by skin contact, but are very toxic stomach poisons. Paraquat, which is a widely used herbicide in minimum tillage systems, must be considered highly toxic when ingested, with the potential of causing respiratory failure (www.paraquat.com)

## 2.10 Legislative and regulatory requirements when using pesticides

### 2.10.1 Pest Control Produce Board

Pest control products act CAP 346 was enacted in 1982 to regulate the import/export, manufacture, distribution and use of products which are used for the control of pests and of the organic function of plants and animals. It established the Pest Control and Produce Board (PCPB) whose mandate is to register pest control products. It requires that every person who desires to register a pest control product shall make an application to the board. The board may refuse to register the product if its use would lead to unacceptable risk or harm to users. Under the Act, 3 classes of pest control products namely; restricted, commercial and domestic class were established. Restricted class of products present significant environmental risks and these are products which are intended for use in aquatic and forestry situations. Commercial class has environmental effects which are limited to a specific region while Domestic class has no special precautions required before use and no irreversible effects from repeated exposure.

### 2.10.2 OSHA 2007

It is a legal requirement under Occupational Safety and Health Act 2007 (OSHA, 2007) that manufacturers, importers, suppliers and distributors of chemicals must avail to a buyer/user the Material Safety Data Sheets (MSDS) for chemicals and other hazardous substances. The MSDS contain crucial information, including the handling, use and precautions to take including advice on personal protective equipment. It also gives guidelines on emergency action in the event of fire, spillage, and first aid requirements.

### 2.10.3 Hazardous Substance Rules

The Occupational Exposure Limits (OELs) for people exposed to hazardous substances is indicated in the Factories and other Places of Work Act (Hazardous

Substance) Rules (2007). According to part (7) of the Hazardous Substance Rules, substances used as active ingredients in pesticides are listed under their chemical names and/or their common (ISO) names. These names may sometimes be used as parts of the names of proprietary pesticide formulations. In all cases the exposure limit applies to the specific active ingredients and not to the formulation as a whole.

### 2.11 Benefits of using herbicides

Herbicide usage has become very much popular and is being used widely due to their cost effectiveness, efficiency in controlling diverse weed flora and less labour intensive. Herbicides enter plants through directly into shoots and through the soil into seeds, roots or rhizomes. Post-emergence herbicides enter shoots and some also act through the soil where it affect the germinating seeds and have some degree of persistence in the soil to give a residual effect preventing further flushes of germination ( Rajkhowa *et al.*, 1995).

In a research trial done in Kenya, herbicides increased net benefits by 61% in a maize/bean intercrop and 46% in a maize monocrop (Kibata *et al.* 2002). Herbicides have been extensively studied in weed control research in Africa. However, there has been no mechanism to disseminate the technology to smallholders once the research process was over. This scenario has led to the non-adoption of the herbicide technologies on the small-scale farms even though the research has shown that the herbicide technologies were cost-effective and yielded higher returns than conventional methods (Mucheni *et al.*, 2001).

A study done in 2004 from the institute of biology and environmental sciences in German showed that DNA damage occurred in human connective tissues cells when they were exposed to glyphosate and hydrogen peroxide, a molecule that is commonly found in living things .The studies established that glyphosate exposure has been linked to increased risks of miscarriages and also caused a significant increase in the number of abnormal chromosomes (EPA, 1987). Farmers in participatory weed control trials in Kenya were all in favor of herbicide use and said that the saved labor is used in some other farm activities (Muthamia, 1995). The results of a research program in Kenya indicated that herbicides can improve the economic returns of smallholder farms (Kibata *et al.*, 2002).

The potential benefits of herbicide use include increased incomes, reduced drudgery, and improved food security and nutrition. These benefits accrue to women, young people and the very poor who often bear the brunt of weeding (Chikoye *et al.,* 2007). Chemical weed control has great potential and will become more widely-adopted by smallholders as solutions to the major constraints limiting herbicide use in Africa are found. These constraints include (a) inadequate knowledge of which herbicide to use in a given weed-crop situation, (b) poor timing of application (c) unavailability of herbicides in farmer-usable packages (d) uncertainty of availability of herbicides (e) limited knowledge of herbicides and their use (f) lack of extension services and (g) scarcity of trained personnel in weed science (Mavudzi *et al.*, 2001).

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# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 The study site

Bomet County was chosen for the study because it is one of the highest tea producers in Kenya. It produced a total of 45,023,957 million kilos of green tea leaf (9.4%) out of the total 480 million produced in the country by small scale tea growers (KTDA 2011).

**Table 3.1**: Tea production per zone

| **Zone** | **Total bushes** | **Total yields** | **Average production/Bush/yr** |
|---|---|---|---|
| Chesoen | 6,762,949 | 5,919,214.50 | 0.88 |
| Sibaiyan | 7,845,124 | 9,906,435.00 | 1.26 |
| Ndaraweta | 10,362,772 | 12,126,019.50 | 1.17 |
| Singoruwet | 5,664,832 | 5,646,057.00 | 0.95 |
| Tegat/Chemaner | 5,763,472 | 3,928,219.50 | 0.64 |
| Kiromwok/Mugango | 8,333,493 | 7,498,011.50 | 0.91 |
| | **44,732,642** | **45,023,957.00** | **0.96** |

Source: **KTDA July, 2011**

According to the Kenya National Bureau of statistics census results of 2009, Bomet County has a total of 142,361 households and a total population of 724,186. Small scale tea growers are spread across the three constituencies of Sotik, Konoin and Bomet Central within the county where a total number of 24,868 growers are involved in tea production with a total of 5,119 hectares of tea. The study was conducted in both catchments of Tirgaga and Kapkoros tea factories within Bomet County and is managed by Kenya Tea Development Agency (KTDA).The area lie between 35° E and 0° 45’ S, with an altitude of 1745- 2,200m above sea level. It is surrounded by Mau forest to the East and Maasai Mara to the South. It situated South East of Nairobi about 265Km from Nairobi.

**MAP OF K.T.D.A FACTORIES**

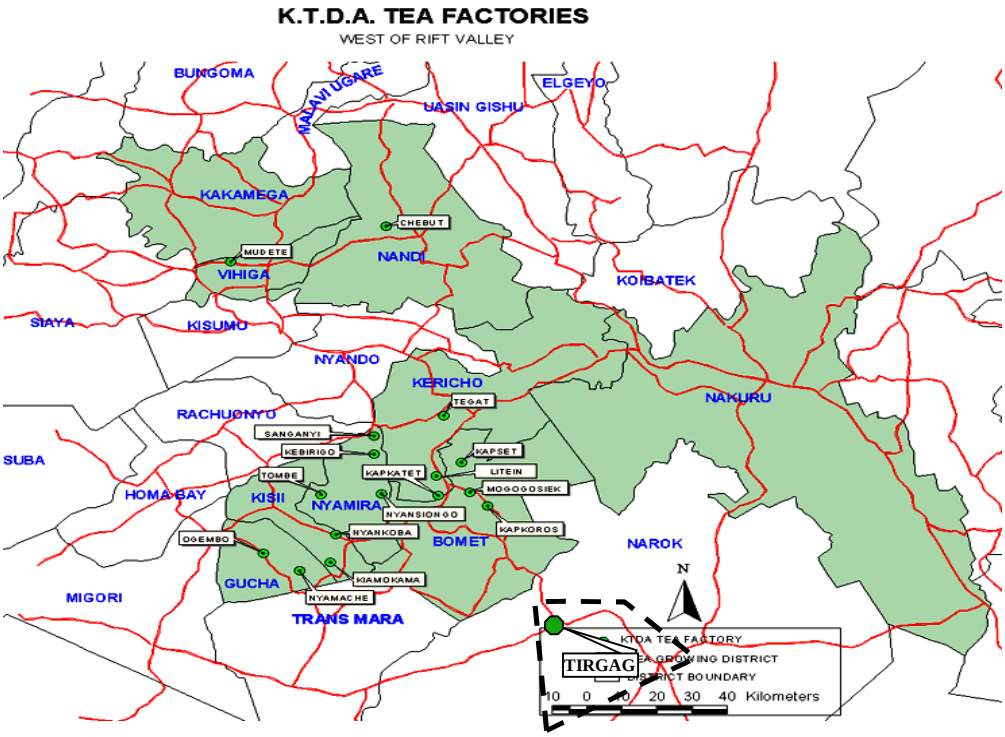


**Figure 2:** Map of KTDA tea factories-West of Rift valley

**KEY**

– – – KAPKOROS/TIRGAGA

Altitude and physical features influence the climatic conditions of this area where the area experience equatorial kind of climate which is generally warmer and receives a maximum amount of rainfall ranging between 1500 mm to 1750mm p.a. The area is dominated by the red volcanic soils that are deep and well drained with pH range of 4-6. The main crops grown in the area are tea, maize and horticultural crops. Plate 1 is a typical picture of a well maintain tea farm in the area of study.

**Plate 1:** A well maintain tea farm at Mugango zone taken during the study.

Special focus was Bomet Central Constituency where growers supply their tea to both Kapkoros and Tirgaga tea factories. The study area have a total of over seven hundred and forty six tea growers being representatives of households distributed into six administrative zones. The number of growers has been rising due to subdivision of land and the continued registration of new farmers.

The ten (10) clinics/dispensaries namely Kapkoros health centre, Ndaraweta, Nyongores, Sibaiyan, Singoruwet, Chesoen, Silibwet, Kitaima, Kitoben and Mugango were used to collect the secondary data on contact of chemicals and symptoms displayed.

### 3.2 The Study design

The study used descriptive research design in collecting data from respondents. The design was preferred because it answered questions such as who, how, what, which, when and how much. A descriptive research determines and answers how things are as it attempts to describe such issues as possible behaviour, attitudes and characteristics (Mugenda and Mugenda, 1999). In each selected zones, growers were randomly selected in the tea buying centres and issued with a structured questionnaire. The questionnaire was structured to give answers on socio-economic

and demographic factors such as age, gender, marital status, education and years in tea farming. For the study of level of awareness on safe use of herbicide, the questionnaire was structured to collect data on different types of herbicides being used, the most preferred and frequency of herbicide application. The level of awareness when using herbicides, handling, storage, usage and action taken in case of contamination was determined. A semi structured questionnaire was also used to collect secondary data from health centres and clinics concerning the magnitude of intoxication, causes, symptoms and treatment in case of herbicide contamination.

**3.3 Sampling method and sample size determination**

A sample is a smaller group or sub-group obtained from the accessible population. The sample size was proportional to the relative size of the strata as described by Mugenda and Mugenda (1999). During the study, Tea Extension Service Assistants (TESA) were used in getting the desired number of respondents from the area together with the identification of tea growers. Simple random sampling was employed where growers were allocated into six strata called zones. The six zones were Sibaiyan, Ndaraweta, Singoruwet, Chesoen, Tegat/Chemaner and Kiromwok/Mugango .All growers deliver tea to the nearest buying centers where they were recruited in a given zone hence all buying centers were represented in all the zones. All the 10 government run health facilities and clinics in the area were also sampled for reported cases of intoxications. .

Adequate sample along with high quality data collection efforts results in more reliable, valid, and generalizable results and could also result in time saving and other resources (Bartlett, *et al.*, 2001). Using a population of 746, the table for determining minimum returned sample size for a given population size for continuous and categorical data was used as guided by Bartlett *et al.(*2001) giving a sample size of 363 (appendix **V**). The margin of error was set p>t 0.05, t=2.96.

**Table 3.2:** Number of growers selected per zone.

| **Zone** | **Total Growers** | **Proportion %** | **Sample Size** |
|---|---|---|---|
| Chesoen | 117 | 16 | **57** |
| Sibaiyan | 128 | 17 | **62** |
| Ndaraweta | 162 | 22 | **79** |
| Singoruwet | 94 | 13 | **46** |
| Tegat/Chemaner | 105 | 14 | **51** |
| Kiromwok/Mugango | 139 | 18 | **68** |
| **Total** | **746** | **100** | **363** |

### 3.4 Research instruments

Data was obtained from the respondents through face-to-face interviews using a semi-structured and pre-tested questionnaire with an aim of collecting primary quantitative data. The questionnaires are useful in reaching out to a large number of respondents within a short time and offer a sense of security (confidentiality) to the respondent. The questionnaire was divided into the main areas of investigation except the first part which captures the demographic characteristics of the respondents. Other sections were organized according to the major research objectives. Both qualitative and quantitative data were obtained. A total of 363 questionnaires were administered and all the 10 clinics were sampled. This involved descriptive statistics with the use of frequencies, pie charts, graphs, tables and percentages.

### 3.5 Data processing and analysis

This section entails the transformation of the data from all the 363 respondents (tea growers) together with the 10 respondents (health centers). Data analysis process involved systematically searching and arranging interview questions, data and other materials obtained from the field with an aim of understanding and presenting them to others. Data from the questionnaire were both qualitative and quantitative.

Qualitative analysis was done on some unstructured questions (open-ended) and coded to enable quantitative analysis. Quantitative data involved collecting data from the growers who represented the population, in a form that was easily converted to numerical indices. The data obtained from the study area was analysed through analytical computer software in order to make the necessary inferences as per the proposed objectives. The data analysis process involved the use of the Statistical Package for Social Sciences (SPSS) programme for MS windows to prepare code books, tabulations and drawing statistical inferences. Analysis through tabulations was based on computations of percentages, coefficients of correlation through application of descriptive statistics and inferential statistics.

Presentation was done in form of tables, figures and graphs. The study used frequencies and percentages as they easily communicated the research findings to a majority of readers. The frequencies were used to show the number of times a response occurred or the number of subjects in a given category. Percentages were used to compare sub- groups that differ in proportion and size. Secondary data from the health was categorized based on the questions asked.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

### 4.1 Overview of the data

The data enabled the evaluation on influence of the different factors to the use of herbicides in the study area such as the respondents' characteristics, preferred type of herbicides used, frequency of herbicide usage, level of awareness of proper use of herbicides and the associated benefits from the use of herbicides on tea production.

#### 4.1.1 Gender composition

The figure below indicates the gender composition of all the respondents in the 6 zones of study.

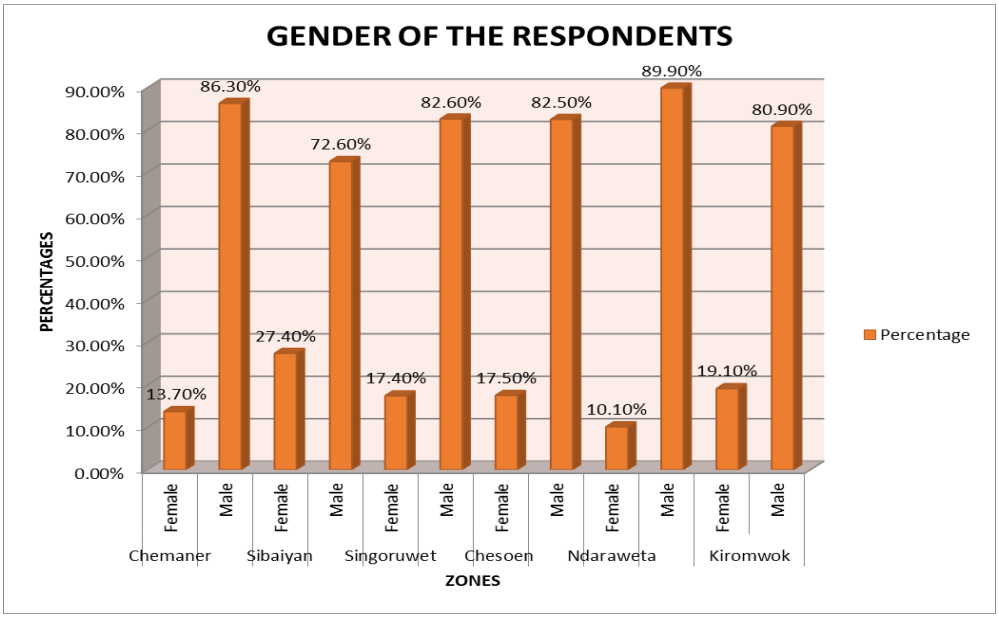


**Figure 4.1:** Gender distribution of the respondents

Majority of the respondents who participated in the study were males. Ndaraweta area had the highest male representation (89.9%) and the least being Singoruwet. In all the areas few females participated in tea growing with Sibaiyan, Kiromwok,

Chesoen, Singoruwet, Chemaner, Ndaraweta having 27.4%, 19.1%, 17.5%, 17.4%, 13.7% and 10.1% respectively an indication of gender parity (**Figure 4.1)**. The traditional african culture is still embedded in the area where male own the land and are the decision makers in the family hence the low participation of the female.

### 4.1.2 Marital status

Figure 4.12 shows the marital status of the respondents in the area of study.

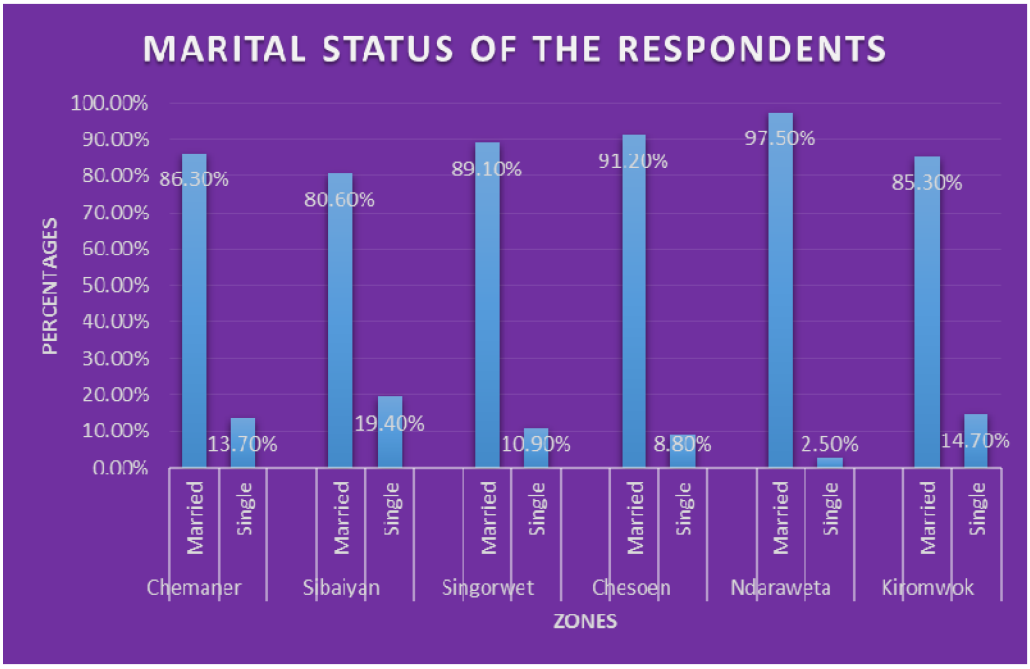


**Figure 4.2:** Marital status of respondents

Most of the respondents were married in the area of study. Ndaraweta Chesoen zone had the highest number of married respondents (91.2%) and Sibaiyan had the least (80.6%). These results indicate that tea growing in the study area was mainly done by households as a source of income. They work together in order to improve their live hoods.

### 4.1.3 Age categories of tea growers.

The figure below represent the age bracket of the tea growers in the area of study.

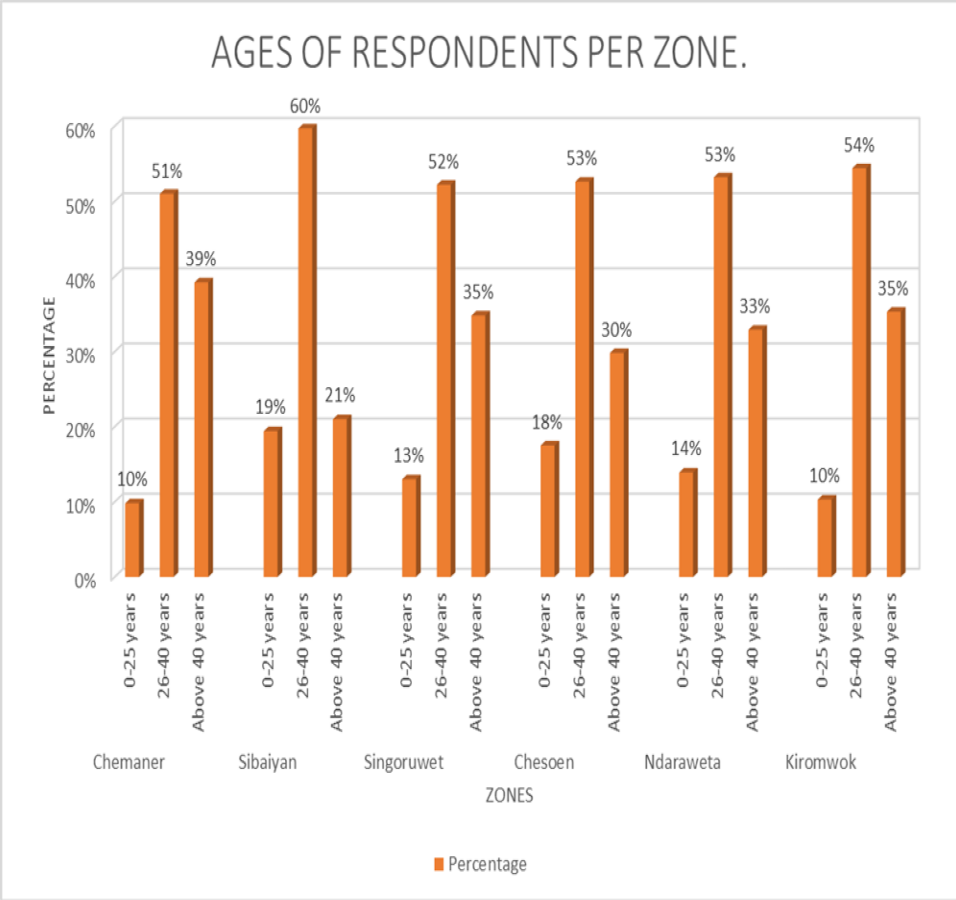


**Figure 3.3:** Age categories of the respondents

Majority of the tea growers (54%) in the area were between the ages of 26-40 years with 51%, 60%, 52%, 53%, 53% and 54% from Chemaner, Sibaiyan, Singoruwet, Chesoen, Ndaraweta and Kiromwok respectively. Tea growers below 25 years (14.1%) were the least in total meaning they are new while those above 40 years were 31.9% an indication that may be sub division of land has been undertaken.

### 4.1.4 Level of education

Majority of the respondents (61.2%) in all the zones attained secondary education while those with primary education were 26.9% and the rest (11.9%) being college/university. Singoruwet zone had the highest (67.4%) of those with secondary education while Chemaner, Ndaraweta and Kiromwok had no respondents with university education. The high percentage of growers who had secondary education

and above confirms that most of them can read and understand meanings of labels on proper use, misuse, overuse, signs, warnings, concentrations, First Aid. This improves the level of awareness among the growers.

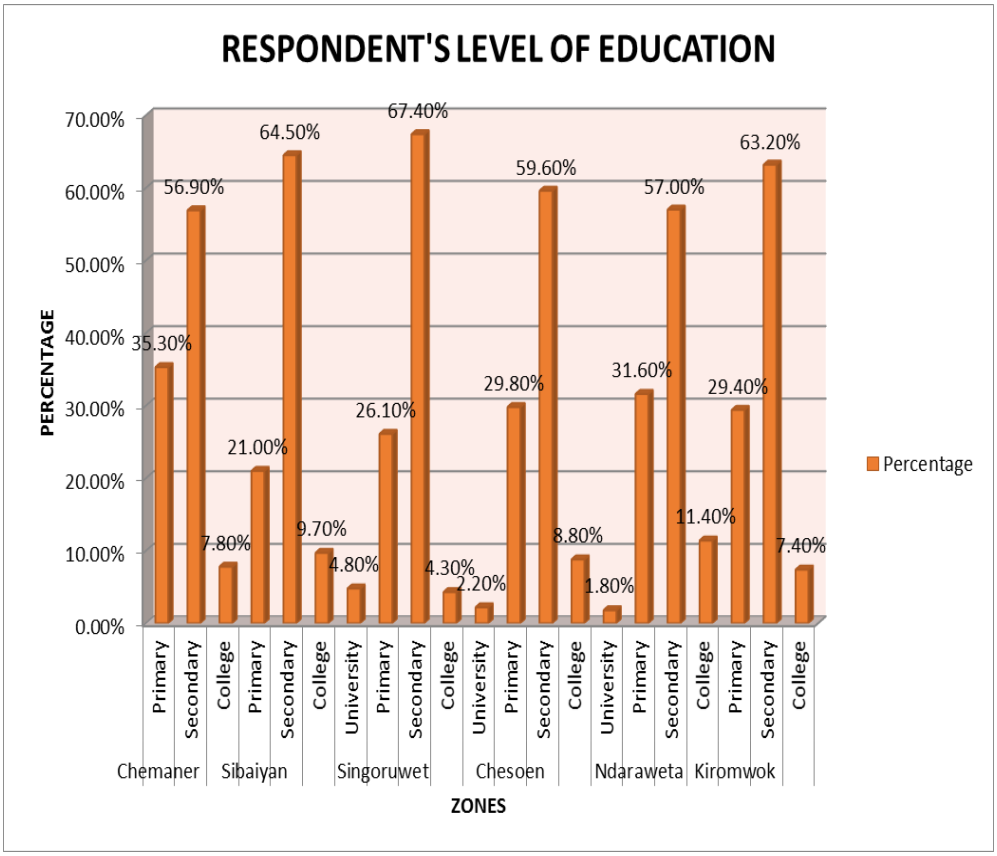


**Figure 4.4:** Level of education of the respondents

### 4.1.5 Experience in tea growing

Growers with 6-10 years experience (48%) and those above 10 years (30.3%) were the most an indication that tea farming has been undertaken in the area for along time. Respondents with 1-5 years of growing tea were the least in all areas of Chemaner, Sibaiyan, Singoruwet, Chesoen, Ndaraweta and Kiromwok with 21.6%, 25.8%, 26.1%, 10.5%, 24.1%, 22.1% respectively.

Figure 4.5 indicates the experience of the respondents in tea growing.

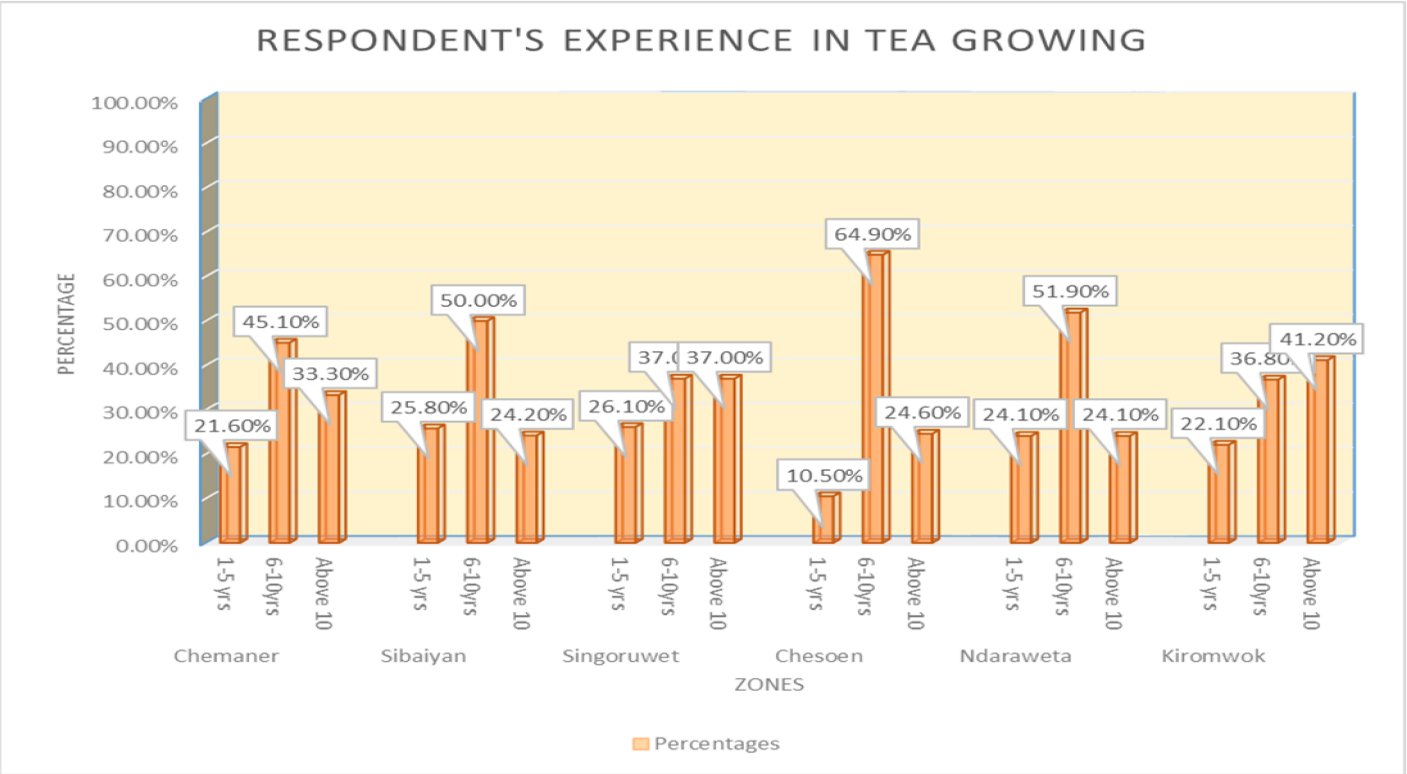


**Figure 4.5:** Respondents experience in Tea growing

### 4.2 Types of herbicide used by tea growers in Bomet County

Figure showing the different types of herbicides used by tea growers in the county.

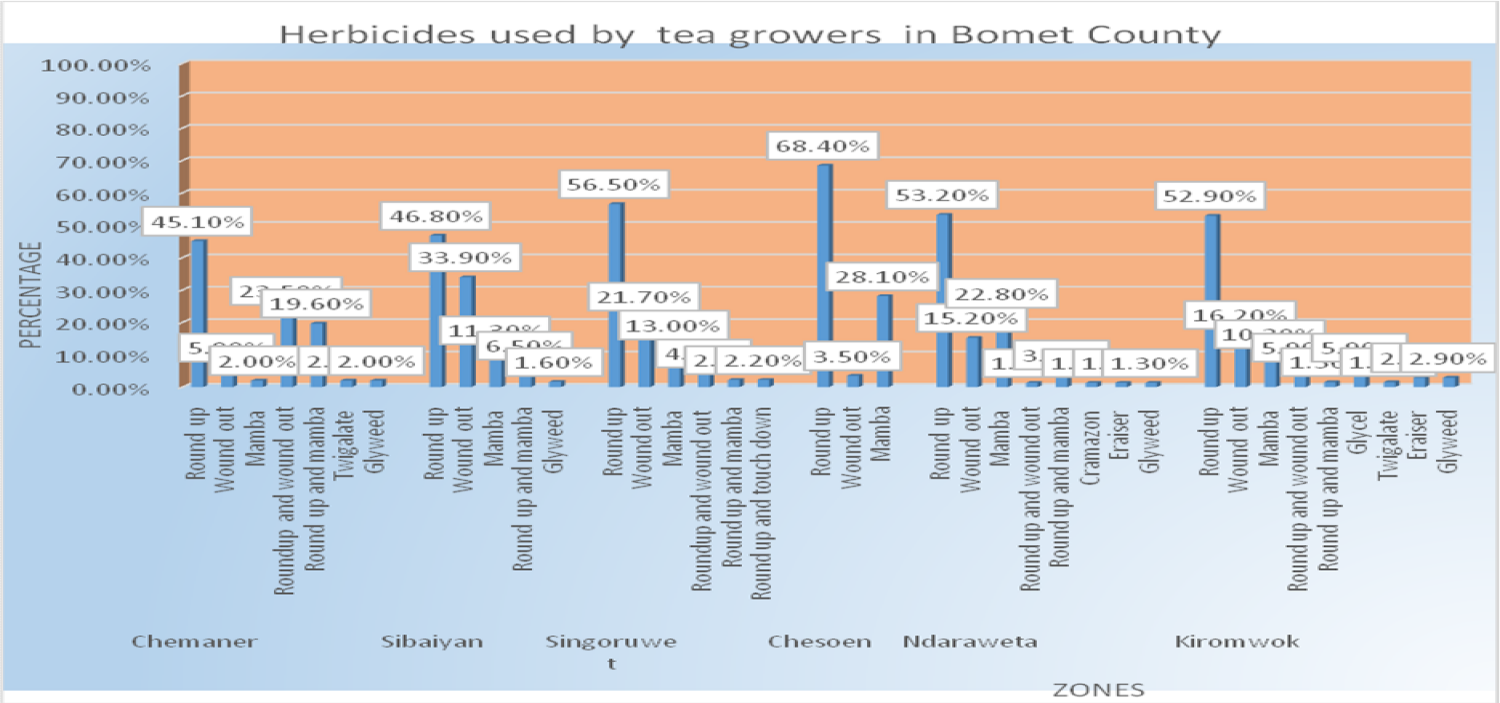


**Figure 4.6:** Herbicides used per zone

Herbicides in use were found to be glyphosate in different formulations sold under different trade names like Twigasate, Eraiser, Glyweed, Glycel, Touchdown, Wound out, Mamba and Round up.

It was noted that round up (53.7%) was the most preferred herbicide in all areas of the study followed by wound out and Mamba. The use of round up was 45.1%, 46.8%, 56.5%, 68.4%, 53.2% and 52.9% for Chemaner, Sibaiyan, and Singoruwet, Chesoen, Ndaraweta and Kiromwok zones respectively. Its significant use is attributed to its trade name only and availability because it is sold wildly in agro-vet stores and distributed by Monsanto. There are risks associated with over use of one type of herbicides like weed resistance and increased exposure of users. However pesticide usage in the study area seems to be highly influenced by manufacturers and their agents/distributors availability in the villages. This is a typical situation in many developing countries where the choice of pesticides to be used by farmers is influenced by the suppliers (Snoop *et. al.*, 1997).

Some growers indicated that they mix two herbicides when controlling weeds like Round up/Mamba (5.2%) and Round up/Wound out (5%). Most of these herbicides were manufactured by companies like Monsanto, Highchem, Twiga chemicals, Agriscope and Farmchem . All the herbicides used were found to have been registered by Pest Control and Produce Board (PCPB) among others and thus complied with standard requirements (PCPB, 2010). Some herbicides used like Mamba are not necessarily meant for weeds in tea but good results were reported. Agarwala, (1973) noted that the intensity of weed infestation and weed species are different from area to area or even from section to section in the estate. The researcher noted that the choice of herbicide mainly depended on weed flora present, type of herbicide, its availability, age of plantation and economic considerations.

The choice of herbicide among tea growers with 1-5 years experience was 22%, those between 6-10 years was 48% while those above 11years were 30% .Growers who had more experience tea growing used certain herbicides. There was significant statistical difference between the preferred herbicide and one's experience in tea growing ($\chi 2=17.03.$; $p < 0.05$, $df=362$). Use of herbicides was high (88.7%) among the married an indication that it was influenced by discussions in the family. There

was significant statistical difference between the preferred herbicide used and the marital status ($\chi 2=16.39.; p < 0.05, df=362$).

There was no significant statistical difference between the preferred herbicide and one's gender. The choice of herbicide was high (54%) among those aged between 26-40 years and those above 40 years (32%). The high level of preference is attributed to prolonged use of different types until a good result is achieved in a particular herbicide. However there are risks associated with prolonged exposure especially to persons who are still in the reproductive age.

The choice of herbicide was well spread among respondents with different level of education with secondary (47.6%) being highest, followed by primary (29%) and college/university (22%) being the least. There was no significant statistical difference between the preferred type of herbicide and one's level of education. At spray length herbicide is of relatively low acute toxicity thus classified by W.H.O as Class II 'moderately hazardous' (W.H.O, 1996).

(Cheramgoi *et al*, 2012) noted that glyphosate formulations are normally used in Kenya to control weeds during the first years of establishment and in pruned tea. The general rule is, the herbicide should not affect tea yields, brew qualities, and not be phototoxic to crop or leave high residues on the final product of edible part of the plant.

**Plate 2:** Tea farms infested by weeds taken at Singoruwet during the survey.

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**Plate 3**: A farm worker weeding at Chesoen area during the survey

It was established that in absence of herbicides, weeding was mostly done manually followed by uprooting. Some respondents indicated that they weed and uproot depending on the infestation. Studies done at Tea Foundation of Kenya (TRFK) indicated that deep weeding is discouraged in tea because it damages the tea feeder roots hence leads to poor growth. If weeding is to be done it should be by shearing where the weeds are just cut on the surface and alternated with chemical weed control.

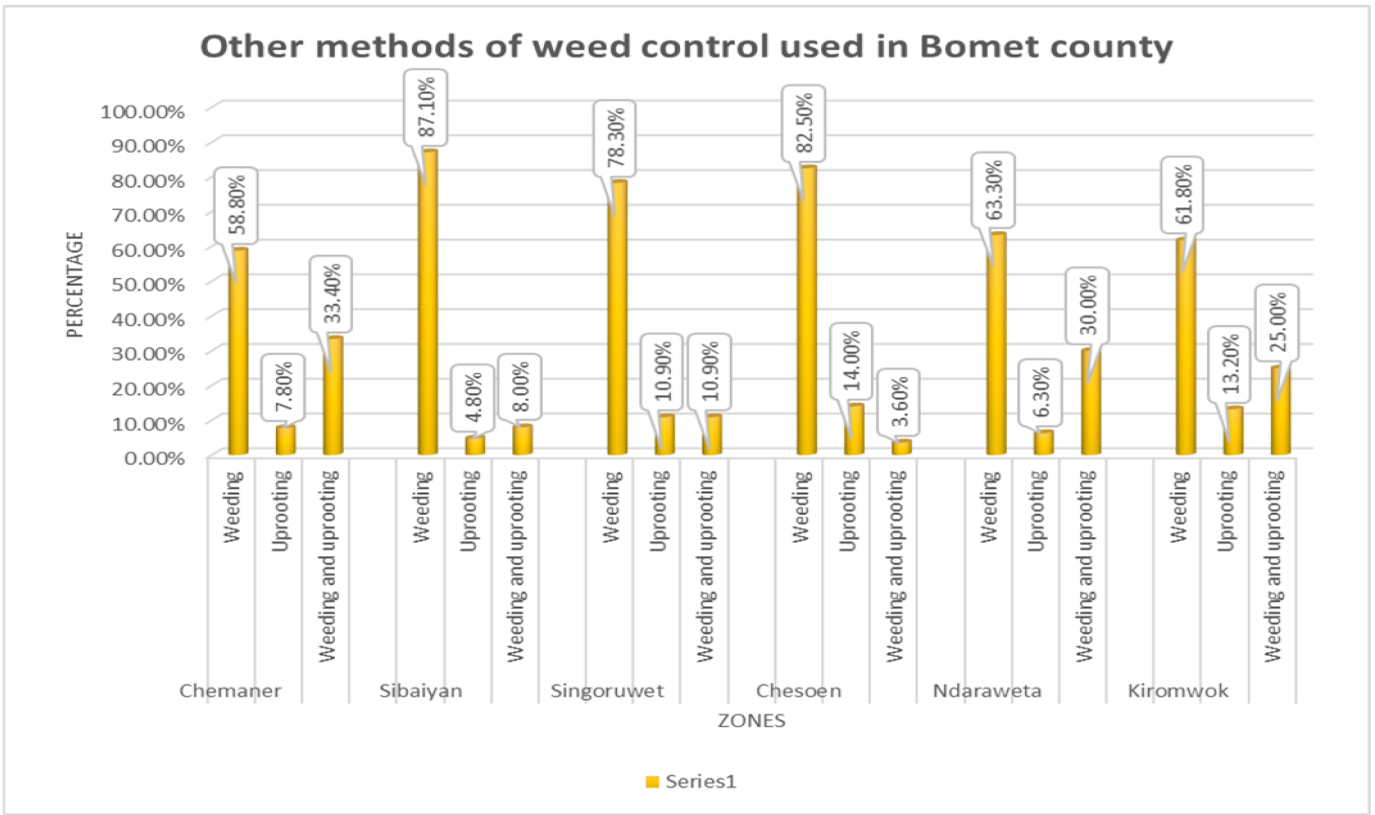


**Figure 4.7:** Alternative method of weed control used in Bomet County

### 4.3 Frequency of herbicide use by tea growers in Bomet County

The table below shows the frequency of herbicide use by tea growers in all the zones.

**Table 4.1:** Frequency of herbicide usage per zone

| Zone | Frequency of herbicide use | Frequency | Percentage (%) |
|---|---|---|---|
| Chemaner | Rarely | 31 | 60.8 |
| | Quite often | 10 | 19.6 |
| | Very often | 4 | 7.8 |
| | Always | 6 | 11.8 |
| | **N** | **51** | |
| Sibaiyan | Rarely | 37 | 59.7 |
| | Quite often | 14 | 22.6 |
| | Very often | 3 | 4.8 |
| | Always | 8 | 12.9 |
| | **N** | **62** | |
| Singoruwet | Rarely | 31 | 67.4 |
| | Quite often | 7 | 15.2 |
| | Always | 8 | 17.4 |
| | **N** | **46** | |
| Chesoen | Rarely | 30 | 52.6 |
| | Quite often | 19 | 33.3 |
| | Very often | 5 | 8.8 |
| | Always | 3 | 5.3 |
| | **N** | **57** | |
| Ndaraweta | Rarely | 47 | 59.5 |
| | Quite often | 23 | 29.1 |
| | Always | 9 | 11.4 |
| | **N** | **79** | |
| Kiromwok | Rarely | 39 | 57.4 |
| | Quite often | 15 | 22.1 |
| | Very often | 8 | 11.8 |
| | Always | 6 | 8.8 |
| | **N** | **68** | |

The decision to apply herbicides always, rarely, quite often or not varied among the tea growers. The study found that use of herbicides is minimal in tea production. Tea growers (40.8%) in the area used herbicides to control weeds in varying degrees as follows; Always use (11%), Very often (5.51%) and Quite often (24.2%). Twelve (12%), 13%, 17%, 5%, 11% and 9% of farmers always use herbicide to control weeds in Chemaner, Sibaiyan, Singoruwet, Chesoen, Ndaraweta and Kiromwok

respectively. Singoruwet zone (31.1%) showed a higher percentage of overall herbicide usage compared to others areas reason being it is strategically and centrally situated along the tarmac and upmarket centres. This increases the level of awareness among the growers. Generally use of herbicide is low due to the fact that tea forms a table when mature during plucking. This table forms a canopy which inhibits weeds from growing. The gaps in the farms that require infilling, edges and pathways along farm are the main source of weeds. This being the case, spraying for weeds is minimal. It is also well indicated that herbicides are used for annual and perennial crops meaning it will be applied only once. The area under study is also potentially rich in agriculture and growers also plant other crops like potatoes, rear cattle and when compared with tea, these other activities require weekly pesticides use. This justifies the response from growers where they rarely (59.2%) use herbicides when compared to other type of pesticides. Plate 4 shows a tea farm that is burnt out after being sprayed with herbicide while Plate 5 shows a person in the process of spraying weeds.

### 4.3.1 Reason for using herbicides

The table below show the responses of the tea growers on the reasons for using herbicides.

**Table 4.2:** Herbicide usage and timing intervals

| | **Time for herbicide use** | **N** | **%** |
|---|---|---|---|
| 1 | Regular interval throughout the season | 74 | **20.4** |
| 2 | Only when we see weeds in the field. | 183 | **50.4** |
| 3 | Only when recommended | 7 | **1.9** |
| 4 | Only when available | 8 | **2.2** |
| 5 | Only when other methods have failed | 91 | **25.1** |
| | **Total** | **363** | |

Many tea growers (50.4%) used herbicides only when there is weed infestations in the farm. Twenty point six percent (20.4%) of the growers preferred to apply

herbicides at given intervals within the calendar year in order to eliminate the weeds while 25.1% use herbicide when others methods had failed. Some growers (1.9%) used herbicides after recommendation by others while 2.2% would only use herbicides when available. Respondents aged between 25-40 years (54.6%) and those above 40 years (34%) would use herbicide when they see weeds. There was significant statistical difference between the frequency of herbicide usage when there is weed infestation and the ages of the growers ($\chi 2=26.7.$; $p < 0.05$, df=362).

Cheramgoi *et al,* (2012) noted that excellent results of herbicide weed management depends on applying at the right weed growth stage, type and diversity of target weed communities, correct rates of application and the season.

**Plate 4:** A sprayed tea farm (L) and spraying in progress (R)

### 4.3.2 Herbicide usage on gender basis

The study found that men (79%) prefer using herbicides than women. The cultural behaviour of the community under study is where the men are not encouraged to participate in domestic chores and therefore would prefer to control weeds by use of herbicides than to weed. It is also possible women in the area of study are not well educated and therefore are a source of labour for several households. Studies established that glyphosate exposure has been linked to increased risks of miscarriages (EPA, 1987).

The figure below shows herbicide use on gender basis.

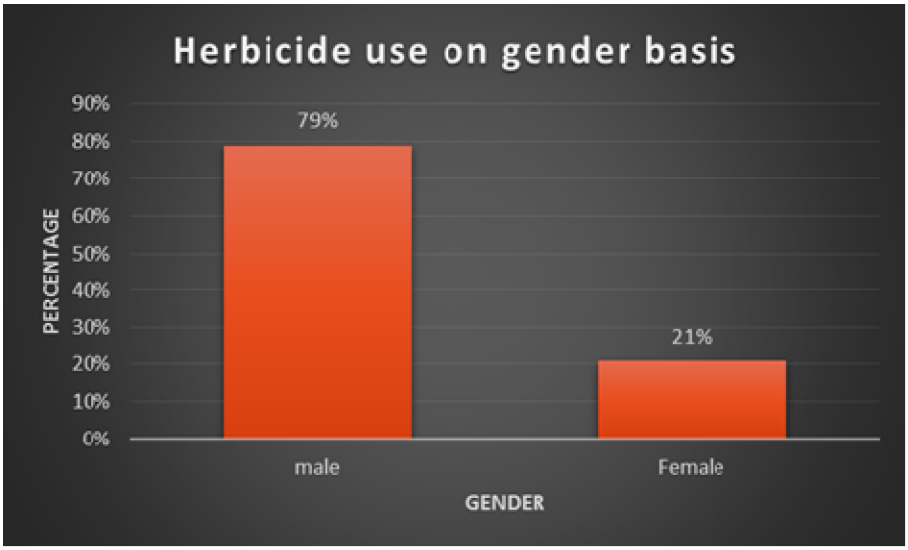


**Figure 4.8:** Herbicide use on gender basis

### 4.3.3 Herbicide use based on marital status

Figure indicating the extent of herbicide use on marital status.

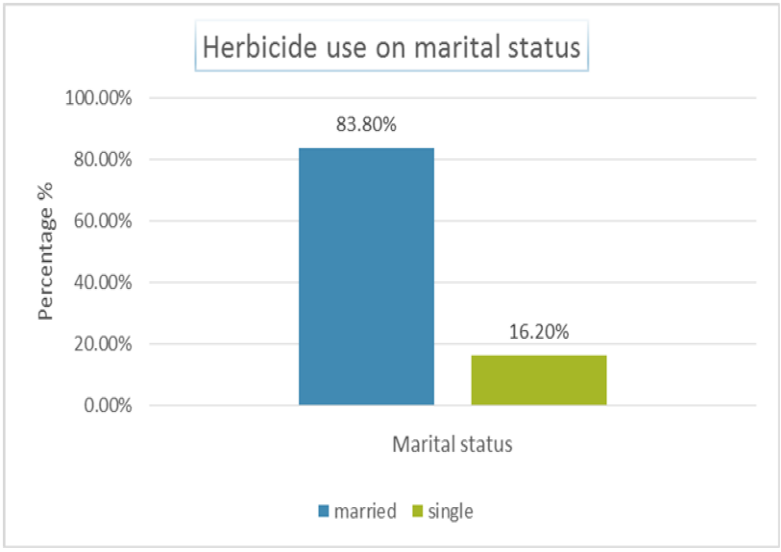


**Figure 4.9:** Marital status of respondents in Bomet County

The married persons (83.8%) preferred to use herbicide an indication that they have other family commitments to attend to.

From the study, there is significant statistical difference between marital status and the frequency of herbicide usage ($\chi 2=7.483.$; $p>0.01$, $df=362$, ).

Chikoye *et al., (*2007) noted that the potential benefits of herbicide use include increased incomes, reduced drudgery, and improved food security and nutrition. These benefits accrue to women, young people, and the very poor who often bear the brunt of weeding.

### 4.3.4 Herbicide use by respondents of different ages

Figure 4.10 indicates the frequency of herbicide usage per tea growers of different age groups.

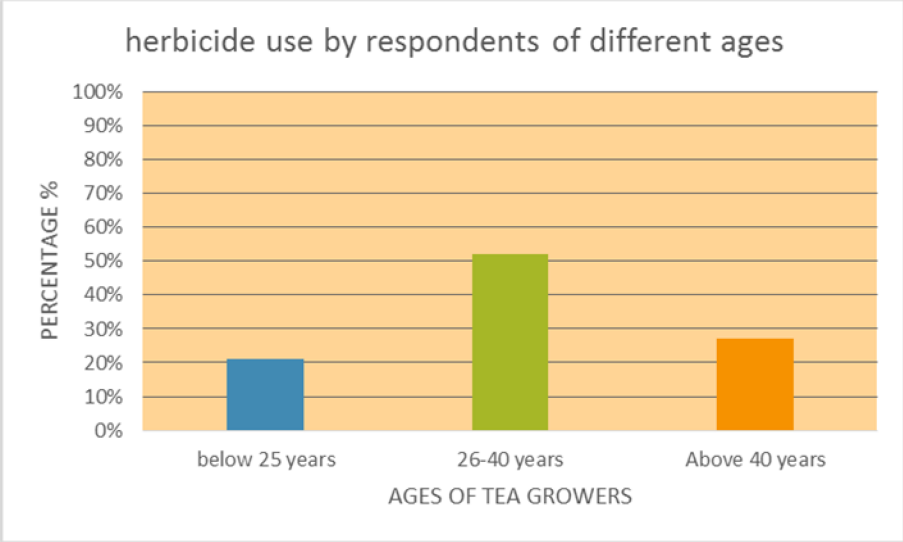


**Figure 4.10:** Frequency of herbicide use per age categories

The use of herbicides by respondents aged between 26-40 years (52%) was high while those below 25 years (21%) applied the least. Respondents aged between 26-40 years are in their prime and doing farming as their business. They are also the most productive group hence the high use of herbicide had a direct effect on their health because prolonged use of glyphosate can lead to chronic illnesses.

The study found that the ages of tea growers was significant with the frequency of herbicide usage ($\chi 2=18.97.$; $p < 0.05$, $df=362$).

### 4.3.5 Herbicide use by growers with different education levels

Figure 4.11 indicates the level of herbicides use by growers of different level of education.

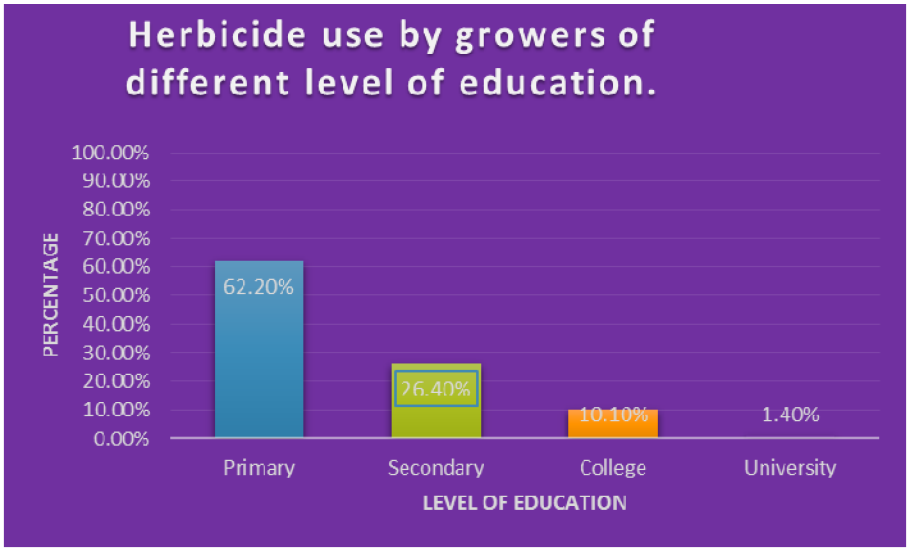


**Figure 4.11:** Herbicide usage in persons with different education levels

The use of herbicide was high (62.2%) among those with secondary level of education followed by those with primary level (26.4%) with those with college (10.14%) and university (1.35%) using the least. The low use by those with college and university is attributed to their low level of engagement in farming because most of them are employed elsewhere. The high percentage of educated persons is a good indicator that their level of understanding is high. The preferred method of weed control is not significant with the level of education but is having a positive effect on the level of education.

### 4.3.6 Herbicide use based on grower's experience in tea growing.

The figure below indicates the frequency of herbicides use by growers of different experience.

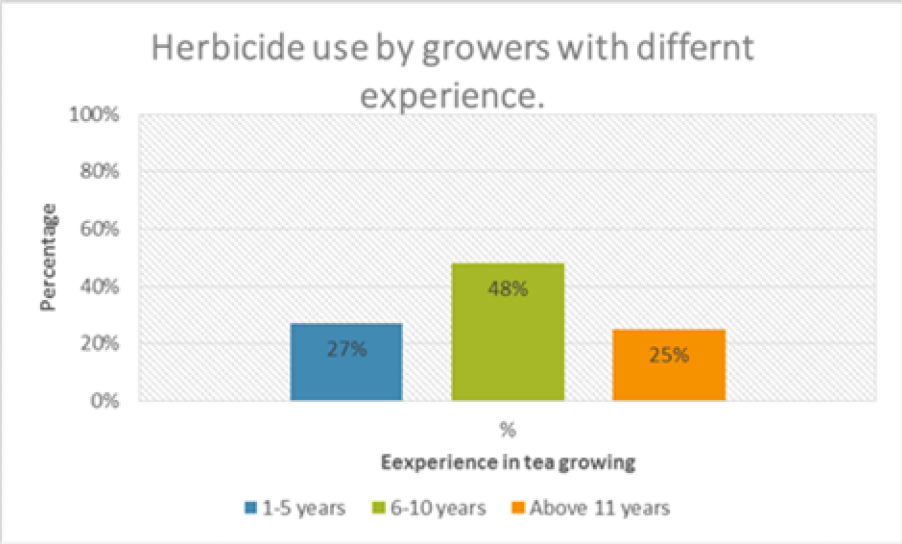


**Figure 4.12:** Rate of herbicide usage by growers with varying experience

The new growers of 1- 5 years (27%) use the herbicide quite often because they have young bushes and application is mainly restricted. Those of between 6-10 years (48%) use herbicide the most because they are at the peak of their production hence prefer to maximize their production while reducing their cost of production. The high rate of herbicide use by growers of 6-10 years will have a significant on their health. Those who have been growers for over 11 years (25%) have reduced uptake of herbicides. It is most likely that these groups have subdivided their land to their heirs or they are using the family labour to weed. The study concluded that one's experience as a tea grower will not have a direct impact on frequency of herbicide usage. Research by Agarwala (1973) supports the fact that the number of herbicide application depends on the efficiency of that particular herbicide in use and the type of weeds appearing after initial application. It was also noted that the frequency of herbicide usage depends on the extent of and rate of new weed growth following initial application, the regenerative capacity of weeds, the persistency of weed following initial application and efficiency of initial spraying.

### 4.4 Establishing the level of awareness on proper use and handling of herbicides

#### 4.4.1 Training

The table show training of the respondents and the areas of training.

**Table 4.3:** Training of respondents

| **Training** | | **Frequency** | **Percentage (%)** |
|---|---|---|---|
| Whether respondent have been trained. | Yes | **280** | 77.1 |
| | No | **83** | 22.9 |
| Weed control | Yes | **233** | 64.2 |
| | No | **130** | 35.8 |
| Herbicide usage | Yes | **200** | 55.1 |
| | No | **163** | 44.9 |
| Weed identification | Yes | **164** | 45.2 |
| | No | **199** | 54.8 |
| Green leaves quality | Yes | **176** | 48.5 |
| | No | **187** | 51.5 |
| When trained | 0 years(not trained) | **83** | 22.9 |
| | 1-5 years | **269** | 63.4 |
| | 6- 10 years | **8** | 2.4 |
| | Over 10 years | **3** | 0.6 |
| Who trained | Tea extension officers | **156** | 43.0 |
| | Rainforest Alliance | **112** | 30.9 |
| | Government Extension Officers. | **12** | 3.3 |
| | None (not trained) | **83** | 22.9 |

The study found that 77.1% of the growers had received general training with 55.1 % of them being trained specifically on safe use of herbicide. Sixty three (63%) of the respondents had been trained in the last 5 years on safe use of herbicides. Tea extension Service Assistants (TESA) trained 43% of the growers, Rain forest Alliance trained 30.9% while Government Extension Officers trained 3.3%.The results showed that the TESA were the most active in training farmers. The training by the TESA was high though they were not equipped with pesticides safety skills and health hazards thus making the training incomplete. Most of the trainers are not

specialist in health and safety field making the contents of their training to lack the technical aspects.

The low level of training by government is attributed to the fact the ministry of Agriculture had implemented “Mkulima-Driven Programme or Demand-Driven Programme” which requires the farmer to seek the assistance of their officers when need arises.

The study established that of the respondents trained 61.2% had secondary education, 26.9% primary, 10.6% college and 1.3% university. The high percentage of educated people meant that their overall understanding of proper use of herbicide was high. The ones with secondary education did farming after failing to proceed with education or to get employeed and opted for farming as a means of income. Those with college and university education were the least because they are professionals pursuing different careers. There was no significant statistical difference between the training of growers and the level of education.

The growers who were trained were mostly married (90.4%).The high percentage of married respondents confirms that tea growing was mainly done by households in area of study.There was no significant statistical difference between training and the marital status of a grower.

Most of the trained growers were between 25-40 yrs (54%), those above 40 yrs constituted 30% while those below 25 yrs (15%) were the least.The high percentage of the trained growers who are older meant thet training had been done routinely over a long period of time.The was no significant statistical difference between training and the ages of the growers.

The study found that 83.2% of the trained were males an indication that there was still gender parity in tea farming.There was a likehood that the females were provider of labour not necessarily the growers themselves.The was no significant statistical difference between training and gender.It was established that training was not biased to one’s experience as a tea grower. Twenty one point four percent(21.4%) of the trained had experience of between 1-5 years , 47.9% between 6-10 years while 30.7% were above 11 years an indication that training was well received by all the growers.The was no significant statistical difference between training and one’s experience in tea growing.

Total growers aged above 25 years (85.9%) had received training offered thus indicates high level of awareness. The mature growers who have been using herbicides for longer periods risk developing chronic illnesses that are associated with mild exposures over a long period of time.

Mavudzi *et al.*, (2001) concurs with the findings and noted that chemical weed control has great potential and will become more widely-adopted by smallholders as solutions to the major constraints like inadequate knowledge of which herbicide to use in a given weed-crop situation limiting herbicide use in Africa are found.

### 4.4.2 Use of PPE by Tea growers

The figure below indicates the percentage of tea growers who uses PPE.

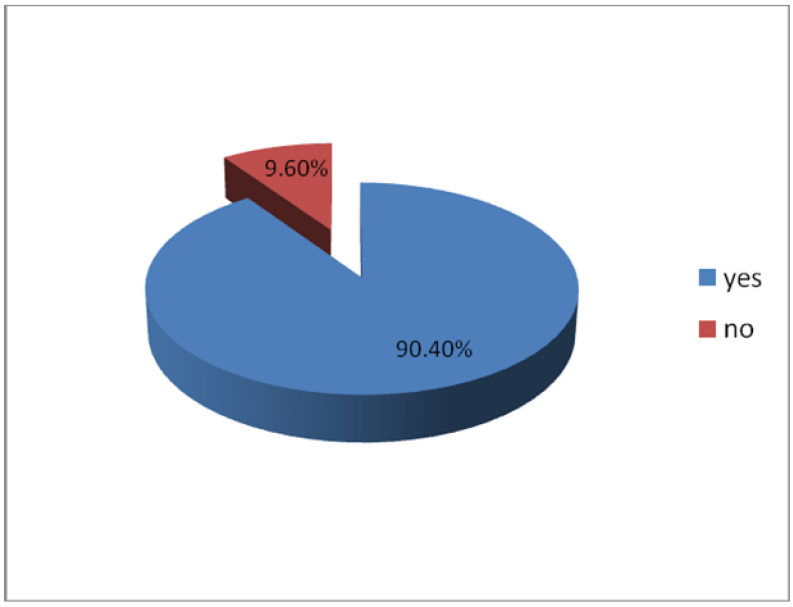


**Figure 4.13**: Use of PPE by tea growers

**Plate 5:** A sprayer with appropriate PPE found at a farm during the survey at Silibwet

The study found that 90.4% of the growers use PPE when applying herbicides showing that a larger part of growers in the area knew how to protect themselves from harmful effects of herbicides.

Table 4.4 indicates the use of PPE by tea growers of different age groups in the area of study.

**Table 4.4:** PPE use per different age categories

| AGE (yrs) | PPE use (n) | **%** | Didn't use (n) | % |
|---|---|---|---|---|
| Below 25 | 50 | **13.8** | 1 | **0.3** |
| 26-40 | 174 | **47.9** | 22 | **6.0** |
| Above 40 | 104 | **28.7** | 12 | **3.3** |

Forty seven point nine (47.9%) of those using PPE were aged between 26-40 years while 28.7% were above 40 years and 13.8% were below 25 years. The high

percentage of PPE usage by those aged above 26 years indicate that they were knowledgeable and able to make good judgement about personal safety and therefore use PPE.

**Table 4.5:** Use of PPE by growers with different experience in tea growing

| Experience (yrs) | PPE use (n) | **%** | Didn't use (n) | **%** |
|---|---|---|---|---|
| 1-5 | 71 | **19.6** | 8 | **2.2** |
| 6-10 | 153 | **42.1** | 21 | **5.8** |
| Above 10 | 104 | **28.7** | 6 | **1.6** |

The use of PPE was not biased on any category of growers with varying experience and was well distributed across all zones.The level of use was low at 19.6% in the 1-5years category, 42.1% among those with 6-10 years' experience and 28.7% in the above 10 years category.

**Table 4.6:** Use of PPE by growers of different level of education

| Level of education | Used PPE | **%** | Didn't use PPE | **%** |
|---|---|---|---|---|
| Primary | 96 | **26.5** | 9 | **2.4** |
| Secondary | 201 | **55.4** | 21 | **5.8** |
| College | 27 | **7.4** | 4 | **1.1** |
| University | 4 | **1.1** | 1 | **0.3** |
| Total | | **90.4** | | **9.6** |

The use of PPE was high (55.4%) among those with secondary level of education followed by those with primary (26.5%). This is attributed to the fact that this group

are the main people at home and doing farming. There was no statistical significance between the use of PPE and the level of education among the tea growers.

Married persons comprised 89% of those using PPE meaning its usage is well understood among family where sharing and discussion of ideas is well disseminated. This will reduce their risk of secondary exposure especially to the rest of the members who are not directly involved. There was no significant statistical difference between one's marital status and on use of PPE. The use of PPE was high (81.8%) among the male growers. There was statistical significance between one's gender and the use of PPE ($\chi 2 = 16.3.$; $p<0.005$, $n=328$). Plate 4.5 shows a person using PPE that is adequate and appropriate for spraying.

FAO (2002) concurs with the findings that PPE should be used according to the instructions on the container label,in open field;when mixing,decanting or spraying.The PPE in use should be appropriate to the task,suitable for the wearer,readily availabe,clean and in full operational condition.

### 4.4.3 PPE selection

**Table 4.7:** Types of PPE's used by tea growers.

| **Type of protective used by respondent.** | **Frequency** | **Percentage (%)** |
|---|---|---|
| Gumboots | 17 | 4.7 |
| Overall | 26 | 7.2 |
| Apron | 12 | 3.3 |
| Respirator | 5 | 1.4 |
| Hat/Cap | 49 | 13.5 |
| Gumboots, Overall and Respirator | 132 | 36.4 |
| Gumboots, Apron and Respirator | 119 | 32.8 |
| None | 3 | 0.8 |
| **Total** | **363** | **100** |

It was established that tea growers may not use all types of PPE during spraying but can combine. The use of one type of PPE was very minimal with those combining contributing to a high percentage like combination of gumboots, apron and respirators (32.8%) and combination of gumboots, overall and respirators (36.4%)

were the most preferred. This showed that the growers knew the risk of using herbicides without proper protection. Splashes are common when mixing, pouring and loading of chemical equipment and spraying therefore gumboots, aprons gloves, caps, and hats are worn to protect skin from corrosive effects of herbicides.

The use of different types of PPE (81.8%) was high among males out of which 88.7% were married. There was significant statistical difference between the type of PPE used and one's gender ($\chi 2=16.3.$; $p < 0.05$, $df=362$ ).

The use of different type of PPE was well distributed among the different age groups with those aged between 25-40 years (53.6%) being the highest users followed by those aged above 40 (32.3%) and those aged below 25 years (14.2%) being the least.

The choice of different types of PPE was not affected by one's experience in tea growing with those between 6-10 years experience (47.5%) being highest, above 11 years (30.5%) while those below 5 years (22%) being the least.

The experience in tea growing did not affect the usage of different types of PPE with all age group properly using them. Growers of between 1-5 yrs formed 22%, those of between 6-10 yrs formed 47.5% while those of above 11 yrs formed 30.5% of the users.

The use of different types PPE was high among those with secondary education (61.4%), followed by those with primary (28.6%) then those with college (8.6%) and university (1.4%) being the least.

The use of PPE was generally high among all the age groups with different levels of education and experience meaning that growers are well aware of harmful effect of herbicides. It can also be attributed to proper reading of instructions on label therefore they are knowledgeable. The ability to combine different types of PPE is good indicator that growers know about the mode of entry of chemicals into the body.

### 4.4.4 Herbicide Labelling

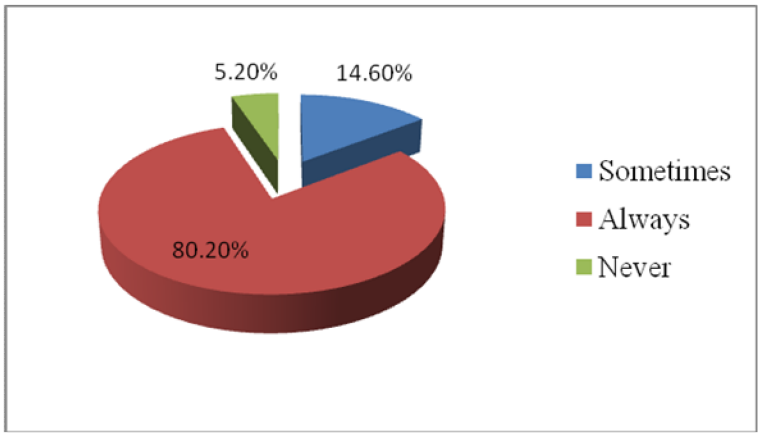


**Figure 4.14:** Frequency of reading herbicides labels by tea growers.

Majority (80.2 %) of the growers always read labels, 14.6 % sometimes read labels while 5.2 % never read labels before using herbicides. These showed that majority of farmers were cautious of the instruction given. Growers with secondary education (62 %) and primary level (28 %) always read labels more compared to those with college (9 %) and university (1 %) education. The high percentage of those reading labels confirmed that tea growers are interested in getting the right information before using the herbicides which is good in improving the level of awareness. The low level of reading labels by those with higher education might point to assumption of being literate enough to understand. Respondents aged between 25-40 years (55 %) read labels more followed by those above 40 years (31 %) and below 25 years (14 %) respectively. This showed that growers of all age groups read labels thus know the dangers associated with misuse. Married persons (89%) read labels out of which 83% were male. The low percentage of female who read labels meant that they can expose themselves to harmful effects of herbicide due to limited knowledge. Growers with 6-10 years experience (49%) read labels more compared to those with over 10 years experience (29%) while those below 5 years (22%) read the least. Experiences in tea growing made growers appreciate the need to read and understand labels. There was significant statistical difference between one's experience in tea growing and the reading of labels ($\chi 2=12.04$, $p<0.05$, $df=362$).

The study is supported by FAO (2002) findings that the purpose of labels is to provide the user with all essential information about the product and how to use it

safely and effectively. In all labels; safety precautions, safety pictograms, warning, First aid advice and medical treatment should be indicated.

Kamotho, (2004) noted that labels should be read as they are a very important source of information to growers on how to use the product safely.

### 4.4.5 Herbicide storage

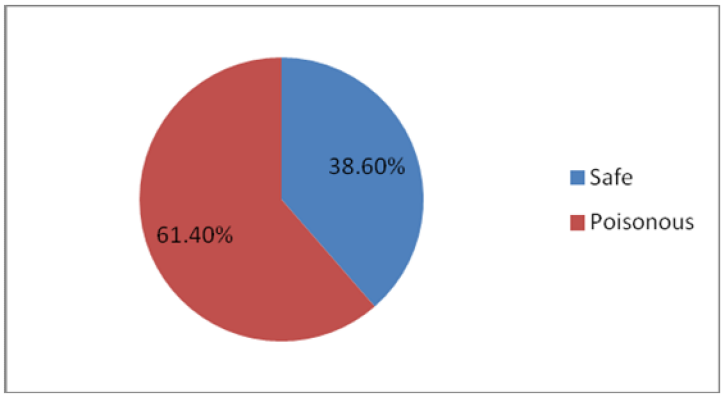


**Figure 4.15:** Reasons why respondents keep herbicides in stores

The study established that all respondents kept herbicides in stores. The ability to keep herbicides well showed that there was a possibility that they do not want to come into contact with it or it has some distinct smell or appearance that they are not sure of. The suitability of the stores being used could not be established. The respondents kept the herbicide in a safe place (61.4%) because they thought they are poisonous while 38.6% of the growers thought that herbicides are safe (Figure 4.11). The high percentage of those who think herbicides are safe indicates that there is a knowledge gap on the possible health effects on human.

The study concurs with Cole *et al.,* (2002) findings that growers poorly store pesticides with majority of them storing in farmhouse while using wrong and unsafe disposal methods which contribute to health problems of the growers and their families.

### 4.4.6 Preparing, mixing and handling of herbicides concentrates

It was established that most growers (92%) do not mix the herbicide with bare hands, while others sometimes mix with bare hands (8%). This is an indicator that the

growers knew that herbicides harm when one comes in contact with it. The mixing of herbicides properly varied in persons with different experience in tea growing with 6-10 years (48%), above 11 years (30%) and between 1-5 years (22%) respectively. Growers were able to do proper mixing considering there varying experience an indication that they read labels or they had been trained. There was significant statistical difference between proper mixing of herbicide and ones level of experience in tea growing ($\chi 2=9.47$, $p < 0.05$ df=362).

Growers between 25-40 years (54.2%) and those above 40 years (31.6%) were more careful while mixing the herbicides. There was a conscious effort by the growers to protect themselves when mixing herbicides in order to avoid contamination.

This is supported by Cornell, (1992) study that herbicide must only be issued to staffs who have appropriate training. The trained operators will be aware of the herbicide being used,is able to carry out spraying safely and takes preacutions in case of a spill.

### 4.4.7 Application of herbicide using a knapsack sprayer

Hand spraying was done by most growers (98.3%) an indication that they have small farms sizes which do not need aerial sprays. It is also possible that hand spraying is more reliable,faster and cost effective to a small grower however the sprayer can come into contact with herbicides in case of chemical drift if the weather suddenly turns windy.The use of a good hand sprayer acts as a control measure in avoiding herbicide contamination. Herbicide application was high among growers with 6-10 years (48%) experience and those with above 10 years (30%) an indicator that there are good reasons why growers prefer to chemical weed control to manual.

The use of a hand sprayer varied in persons with different level of education with primary (61%) being high, then secondary education (29%) while college/university (9%) being the least. The choice of hand sprayer among tea growers with varying experience, different levels of education points to the need to reduce workload or it is a cheaper option. Male tea growers (81%) use hand sprayers to apply herbicides in the farms to mean that they are trying to reduce the workload in the family or women do not know how to spray or are engaged in others chores. Most growers have their own knapsack sprayer (83.2%), others borrow (14.6%) while 2.2% rent it. Ownership

of the sprayer was high among growers of between 6-10 years (48%) and those above 10 years (31%).The growers owning the sprayer had varying education level with secondary leavers (62%) and primary (28%) being higher than those with college and university. The high ownership of sprayer by growers with varying experience, education and ages showed that the use of herbicide was high otherwise one cannot own a sprayer Growers aged between 25-40 years (52%) and above 40 years (34%) owned their sprayers as compared to those below 25 years (14%). Most sprayers are owned by males (84%) while 91% of the total growers owning sprayers are married. There was significant statistical difference between borrowing the sprayer and their marital status ($\chi 2=9.01$, $p<0.05$, $df=362$).

The level of education for those renting the sprayers varied in persons with primary education (38%) and secondary education (50%). There was significant statistical difference between those who rent it and their level of education ($\chi 2=8.42$, $p<0.05$, $df=362$).

The wide use of hand Sprayers among growers indicates that it is easier to use when spraying the tea plant and therefore concurs with FAO, (2002) findings that sprayers should be used according to the manufacturer's instructions and be the most appropriate for the task in hand.

### 4.4.8 Causes and level of intoxication

Intoxication caused by herbicides was lower (40%) as compared to fungicides (60%). It was noted that the magnitude of intoxication was mild (80%) and main cause being accidental (70%) as shown in Table 4.8.

The intoxication was mainly through inhalation (80%).The most displayed signs and symptoms of intoxication were rashes, headaches, fatigue, vomiting and nausea. It was evident that 50% of the reported cases of intoxication are not sure of the dangers associated with improper use whereas 30% were completely ignorant and a paltry 20% had some knowledge on intoxication.

Pesticides can enter the body orally (through the mouth and digestive system); dermally (through the skin) or by inhalation (through the nose and respiratory system) as stated by Norman *et al* (2005).

**Table 4.8:** Reports on cases of intoxication

| **Parameter** | | **Frequency** | **Percentage(%)** |
|---|---|---|---|
| Type of pesticides reported | Fungicides | **6** | 60.0 |
| | Herbicides | **4** | 40.0 |
| Signs and symptoms of intoxication | Rashes | **2** | 20.0 |
| | Vomiting | **1** | 10.0 |
| | Rashes, vomiting and Nausea | **7** | 70.0 |
| Causes of intoxication | Voluntary | **3** | 30.0 |
| | Accidental | **7** | 70.0 |
| Magnitude of toxicity | Severe | **1** | 10.0 |
| | Critical | **1** | 10.0 |
| | Mild | **8** | 80.0 |
| Common mode of entry | Inhalation | **8** | 80.0 |
| | Ingestion | **1** | 10.0 |
| | Contact | **1** | 10.0 |
| Whether patients know about dangers of improper handling | Yes | **2** | 20.0 |
| | No | **3** | 30.0 |
| | Not sure | **5** | 50.0 |
| Whether patients are administered first aid before seeking medical | Yes | **9** | 90.0 |
| | No | **1** | 10.0 |

### 4.4.9 First aid measures in case of herbicide contact

Ninety percent (90%) of the respondents indicated that in case of contact with herbicide they administer first aid before seeking medical attention**.** In cases of contact with herbicides majority of the respondents (86.2%) washed their bodies as a move to reduce the effects of the herbicides while 13.2% visited the doctors. These indicate that people are conscious about the effect of the chemicals to their well being. Mathews G.A. (1985) noted that if herbicides are accidentally swallowed medical advice should be sought without delay.

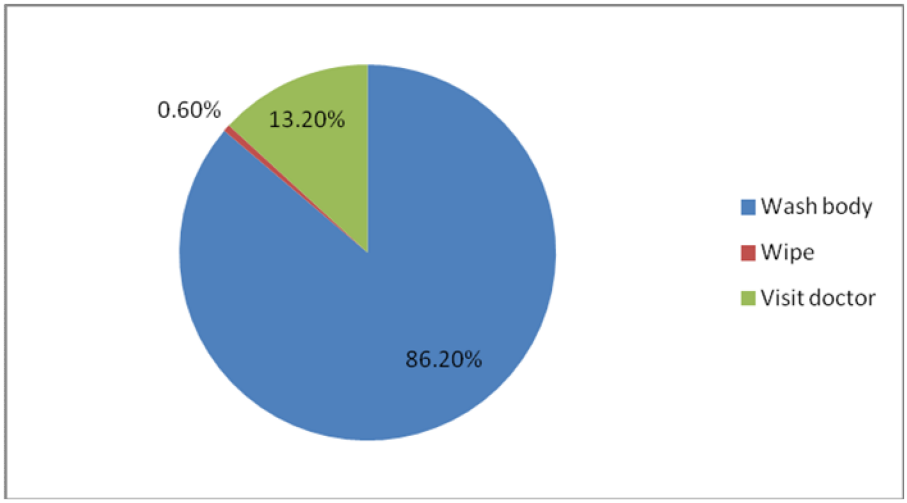


**Figure 4.16:** What the respondents do in case of contact with herbicides

### 4.4.10 Re-entry periods after spraying

Fifty seven point seven percent ( 57.5%) of the growers always waited for 12 hrs before entering the field, 29.5% sometimes waited while 13% never waited for 12 hrs. Out of those who waited for 12 hrs before entering the field 82.9% were males and 88.7% of them were married.It is important not to enter the field immediately after spraying to avoid coming into contact with the herbicide on the surface.The persons aged between 25-40 yrs (53.9%) and 32% those above 40 yrs ensured that they entered the field after 12 hrs of spraying. This indicates that some of the growers know the dangers of entering their farms before the chemical completely driers up. The was significant statistical difference between the enterance of field after 12 hrs and the age groups of the growers ($\chi 2=11.9, p<0.05$, df=362).

The fact that growers can still be come into with herbicides by entering the field early concurs with Kamotho,(2004) findings that secondary exposure risk occurs due to contamination after pesticides application occasioned by contamination to workers in the field before re-entry interval is over.

### 4.5 The socioeconomic aspects of herbicide use on household tea production

**Table 4.9:** Benefits of chemical weed control

| **Benefits of chemical weed control** | | **Frequency of herbicides use.** | | | | **Total** | **$X^2$** | **P value** |
|---|---|---|---|---|---|---|---|---|
| | | Rarely | Quite often | Very often | Always | | | |
| High tea production | **N** | 30 | 15 | 0 | 19 | **64** | | |
| | **%** | **14.0** | **17** | **0** | **47.5** | **17.6** | | |
| Reduced cost | **N** | 7 | 3 | 0 | 5 | **15** | | |
| | **%** | **3.3** | **3.4** | **0** | **12.5** | **4.1** | | |
| Reduced workload | **N** | 43 | 23 | 6 | 3 | **75** | | |
| | **%** | **20** | **26.1** | **30** | **7.5** | **20.7** | | |
| High tea production and reduced cost | **N** | 53 | 9 | 3 | 2 | **67** | | |
| | **%** | **24.7** | **10.2** | **15** | **5** | **18.5** | **64.869** | **0.001** |
| High tea production and reduced workload. | **N** | 26 | 3 | 4 | 3 | **36** | | |
| | **%** | **12.1** | **3.4** | **20** | **7.5** | **9.9** | | |
| Reduced cost and reduced workload | **N** | 33 | 17 | 3 | 4 | **57** | | |
| | **%** | **15.3** | **19.3** | **15** | **10** | **15.7** | | |
| | **N** | 23 | 18 | 4 | 4 | **49** | | |
| | **%** | **10.7** | **20.5** | **20** | **10** | **13.5** | | |
| High tea production, reduced cost and workload. | **N** | **215** | **88** | **20** | **40** | **363** | | |
| | **%** | **100** | **100** | **100** | **100** | **100** | | |
| **Total** | | | | | | | | |
| | | | | | | | | |

The study found that the benefit of using herbicide as method of weed control was highly significant. Respondents ( 20.7%) used herbicide in order to reduce workload, 18.5% believed that the method led to both high tea production and reduced cost, 17.6% thought that it leads to high tea production, 15.7% identified reduction in cost and workload while 13.5% identified high tea production , reduction in cost and workload as benefits associated with the use of herbicides. Four point one percent (4.1%) indicated that it reduced cost while 9.9% said it led to high tea production and

reduced workload. The frequency of herbicides use was statistically related with the benefits of herbicide as a method of weed control ($\chi 2 = 64.87$, $p<0.05$, $df=362$).

The benefits of herbicide use all indicates to the need to increase one's income concurs with the results of a research program in Kenya that herbicides can improve the economic returns of smallholder farms (Kibata *et al.*, 2002).

# CHAPTER FIVE

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusion

The study evaluated the extent and level of awareness on safe use of herbicides by the tea growers in the catchments of Tirgaga and Kapkoros Tea Factories in Bomet County. The following are the conclusions arrived at based on the specific objectives of the study.

**Preferred method used to control weeds**

It was observed that use of herbicides was not rampant and indication that other methods of weed control are also applied.

The study concludes that choice and preference of the herbicides to be used by the growers is mainly affected by its availability and its trade hence an herbicide called round up is the most preferred.

Farmers in the area have also adopted other methods of weed control other than the use of herbicides with weeding using hand tools taking the mainstay in all the zones.

**Frequency of herbicide use**

The frequency of using herbicides varied among the growers because of varied reason like lack of time for weeding, failure of other methods, upon being advised to and doing it routinely as a way of maintaining the farm.

Many tea growers will resort to herbicides only when there is weed infestations in the farm.

The use of herbicides by growers with 1-5years experience was low because the tea bushes are young and application of herbicides is restricted while those with experience of 6-10 years use the most.

**Level of awareness on proper use and handling of herbicides**

It was concluded that most respondents in the area with different experience, gender, varying ages and level of education read the herbicide labels before they use them.

Most tea growers in Bomet County used PPE with majority of them opting to combine various types of PPE when spraying. The use was well spread across all age groups, gender, level of education and experience.

The storage of herbicide was good with most of them keeping in store because they know they are poisonous.

A knapsack sprayer is used by most growers and contracted farmhands when spraying. This means that training on proper PPE use, mixing of herbicides, time of spraying, drifts and accidental contact should be done.

Most growers opt to wash their bodies as first aid measures when they come into contact with the chemicals but a high percent (38.6%) unaware of the dangers are associated with improper handling of herbicides.

**Economic benefits of herbicide use**

Most growers agreed that use of herbicides led to reduction of the workload which in turn led to cost reduction and hence increased the returns.

Though most growers had been trained, most trainings did not cover any topic on safe use of herbicides.

### 5.2 Recommendations

From the study the following recommendations were made;

Efforts geared towards reducing the extent and over reliance of herbicides use should consider other alternative methods of weed control in order to reduce the chemical effect both to the human and the environment.

Availability of frequent training to the tea growers on which types of weeds and when they are suppose to apply the chemical method will help to reduce the frequent use of herbicides in controlling any type of weeds in the tea farm.

The use of experts in the field of safety is highly recommended.

Regular use of personal protective and proper storage of the herbicides should be enhanced in the study area. This will allow the tea farmers to reduce the harmful effect that are associated with the use of herbicides and enable them to operate under favourable conditions hence improving on their performance.

The government should ensure that there is regulation of the agrochemical stockiest operation with a mandate to disseminate information to user on effective use of herbicides in the study area. This will in turn limit the environmental and human impacts from the harmful effects of herbicides and also create flexibility in the use of different weed control methods.

The reduction of the workload and the associated benefit should not be seen as a score from the use of herbicides by the tea growers but they should reduce the use of herbicides due to the broader harm to their lives and the environment in general. This study therefore accepts the hypothesis that the level of awareness on safe use of herbicides is high among the growers.

### 5.3 Further research:

The main focus of the study was to evaluate the extent and level of awareness on safe use of herbicide by the tea growers in the study area so as to identify the policies that are likely to improve on proper use and handling and hence harmful effects reduction. However, the study proposes future research:

1. Assessment of risk perception and costs of adverse health effects in herbicide use among tea growers in Bomet County.
2. To assess effects of prolong herbicide exposure on tea growers health and productivity in Bomet county.

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## APPENDICES

### APPENDIX I: GROWERS QUESTIONNAIRE

**Informed consent**

My name is Florence Chepkirui Bett, a student at Jomo Kenyatta University of Agriculture and Technology, Kenya .I am conducting a study on the extent and awareness on safe use of herbicides by tea growers in fulfillment of masters' degree in occupational safety and health.

Your farm has been chosen among those to give a true representative picture in this study. I would appreciate if you participate in providing answers on the extent of use and level of awareness in safe use of herbicides. This information is for academic purposes and is expected to provide understanding of choice and preference growers make in an attempt to increase their production while ensuring they are safe.

Whatever information you provide will be treated with strict confidence and will not be shown to other participants, individuals or any company. Participation in this study is voluntary and you can choose not to answer any individual question or all the questions. However I hope that you will participate in this study since your answer as one of the identified grower is very important. At this time if you have any question regarding the survey please feel free to ask me.

May I begin the interview please?

Respondent Does Not Agree to be interviewed ……

Return questionnaire to the interviewer. End of interview.

Signature of the interviewer …… Date …….

Respondent Agrees to be interviewed ……

**APPENDIX II: QUESTIONAIRE FOR TIRGAGA/KAPKOROS TEA FACTORIES**

INTRODUCTION

The objective of this questionnaire is to enable the researcher to gather relevant information that is necessary to evaluate the extent and awareness on safe use of herbicides to control weeds by tea growers in Bomet County.

Information collected shall strictly be confidential and used only for the purpose of the study.

SECTION A. **PERSONAL PROFILE**

Kindly read and provide answers to the following questions by ticking in the box

1. What is your name?(OPTIONAL)
2. Gender

   Male ☐ Female ☐
3. Marital status?

   Married ☐ Single ☐
4. Which best describe your age?

   ☐ 0– 25 yrs ☐ 25 – 40 yrs ☐ Above 40 yrs
5. Level of education attained.

   Primary ☐ Secondary ☐ College ☐ University ☐
6. How many years have you been a tea grower?

   1– 5 yrs ☐ 6 – 10 yrs ☐ Above 11 yrs ☐
7. Which zone do you come from?

   .....

**SECTION B**

**Frequency of Herbicide Application**

1. How often do you use chemicals to control weeds

   Rarely ☐ Quite often ☐ Very often ☐ Always ☐

2. How do you decide to use the herbicides(tick all that apply)

   ☐ We use herbicides at regular intervals throughout the season (calendar)

   ☐ We use herbicides when we see weeds in the field (control)

   ☐ We use herbicides when told to apply (specify who)

   ☐ We use herbicides when we have them in store (purchase)

   ☐ We use herbicides when other methods have failed.

**Safety Precaution when Handling Herbicides**

3. Do you use a knapsack sprayer? Yes ☐ No ☐

| | Yes | No |
|---|---|---|
| If yes, do you- own | ☐ | ☐ |
| -rent it. | ☐ | ☐ |
| - borrow it … | ☐ | ☐ |

4. Do you use any personal protective equipment while applying or handling the herbicides?

   Yes ☐ No ☐

   If yes what kind? Hand Gloves ☐ Gumboots ☐ Overall ☐ Apron ☐ Respirator ☐ Face shield ☐ Hat/Cap ☐ All of the above ☐

5. Do you read labels on the herbicides containers before using?

   Sometimes ☐ Always ☐ Never ☐

6. Do you mix herbicides with your bare hands?

   Sometimes ☐ Always ☐ Never ☐

7. After spraying do you wait for 12 hours before entering the field?

   Sometimes ☐ Always ☐ Never ☐

8. Where do you store your herbicides?

   Store ☐ edroom ☐ chen ☐

Why do you store them there? ……

…….

9. Do you know if herbicides application affects your health or that of the person applying?

   Yes ☐ No ☐

10. What will you do if any of your body parts comes into contact with the chemicals?

    Wash body ☐ Wipe ☐ Visit a doctor ☐

**Preferred Method of Weed Control**

11. What kind of herbicide do you use to control weeds?

    Name them ……..

    If none …….. Why ……..

    If you use any herbicides above do you keep records of:

    Date of application Yes ☐ ☐

    Herbicide trade name Yes ☐ ☐

    If No, why? .....

12. From your experience are there any common effects of using herbicides?

    Yes ☐ No ☐

    If yes, kindly name them

    i. .....

    ii. ……..

13. Are you aware of other methods of weed control besides use of chemical (herbicides)?

    Yes ☐ No ☐

    If yes, describe these practices……

14. What are the benefits of chemical weed control?

i. High tea production ☐

ii. Reduced cost ☐

iii. Reduced workload ☐

iv. All of the above ☐

v. None of the above. ☐

15. Have you ever had training on the following topics?

| | Yes | No |
|---|---|---|
| Weed control | ☐ | ☐ |
| Herbicide usage | ☐ | ☐ |
| Weed identification | ☐ | ☐ |
| Quality aspect on green leaf production | ☐ | ☐ |

If yes to the above, when were you trained?

.....

Who trained you?

.....

Thank you for your participation and cooperation.

**APPENDIX III: HEALTH CENTRE'S QUESTIONNAIRE**

Informed consent

My name is Florence Chepkirui Bett, a student at Jomo Kenyatta University of Agriculture and Technology, Kenya .I am conducting a study on the extent and awareness on safe use of herbicides by tea growers in fulfillment of masters' degree in occupational safety and health.

Your health facility has been chosen among those to give a true representative picture in this study. It aims to understand whether improper handling of herbicides can lead to sickness. I would appreciate if you participate in providing answers on the numbers of patients treated due to herbicides misuse or improper handling. This information is for academic purposes and is expected to provide understanding of choice and preference growers make in an attempt to increase their production while ensuring they are safe.

Whatever information you provide, it will be treated with strict confidence and will not be shown to other participants, individuals or any company. Participation in this study is voluntary and you can choose not to answer any individual question or all the questions. However I hope that you will participate in this study since your answers as one of the identified grower is very important. At this time if you have any question regarding the survey please feel free to ask me.

May I begin the interview please?

Respondent Does Not Agree to be interviewed ……

Return questionnaire to the interviewer. End of interview.

Signature of the interviewer …… Date …….

Respondent Agrees to be interviewed …….

**B QUESTIONNAIRE 3**

Kindly provide answers to the following;

i. Name of health centre/dispensary/clinic
……...

ii. Contact person/Job title
……..

iii. What is the estimated number of patients you attend to every month?.....

iv. Do you at times attend to sick cases suspected to have been caused by agro chemical intoxication? Y☐ N☐

If yes to the above, which of these chemicals do you suspect: Insecticides ☐ Fungicides ☐ erbicides ☐ caricides ☐

Why is it so?.....

v. What are the most common displayed signs and symptoms of intoxication?.....
.....
.....

vi. What are the possible causes of intoxication? Voluntary ☐ Accidental ☐

vii. What is the magnitude of the toxicity? Severe ☐ Critical ☐ Mild ☐

viii. After examination, what is the possible common mode of entry into the body? Inhalation ☐ Ingestion ☐ ntact ☐ thers ☐

ix. Do these patients know about the dangers of improper handling of these chemicals? Yes ☐ No ☐ Not sure ☐

x. Do they administer the First Aid before seeking medication? Yes ☐ No ☐

Thank you for your participation and cooperation.

## APPENDIX IV: SAMPLE DETERMINATION TABLE

**Table 1: Table for Determining Minimum Returned Sample Size for a Given Population Size for Continuous and Categorical Data**

| Population size | Sample size | | | | | |
|---|---|---|---|---|---|---|
| | Continuous data (margin of error=.03) | | | Categorical data (margin of error=.05) | | |
| | alpha=.10 t=1.65 | alpha=.05 t=1.96 | alpha=.01 t=2.58 | p=.50 t=1.65 | p=.50 t=1.96 | p=.50 t=2.58 |
| 100 | 46 | 55 | 68 | 74 | 80 | 87 |
| 200 | 59 | 75 | 102 | 116 | 132 | 154 |
| 300 | 65 | 85 | 123 | 143 | 169 | 207 |
| 400 | 69 | 92 | 137 | 162 | 196 | 250 |
| 500 | 72 | 96 | 147 | 176 | 218 | 286 |
| 600 | 73 | 100 | 155 | 187 | 235 | 316 |
| 700 | 75 | 102 | 161 | 196 | 249 | 341 |
| 800 | 76 | 104 | 166 | 203 | 260 | 363 |
| 900 | 76 | 105 | 170 | 209 | 270 | 382 |
| 1,000 | 77 | 106 | 173 | 213 | 278 | 399 |
| 1,500 | 79 | 110 | 183 | 230 | 306 | 461 |
| 2,000 | 83 | 112 | 189 | 239 | 323 | 499 |
| 4,000 | 83 | 119 | 198 | 254 | 351 | 570 |
| 6,000 | 83 | 119 | 209 | 259 | 362 | 598 |
| 8,000 | 83 | 119 | 209 | 262 | 367 | 613 |
| 10,000 | 83 | 119 | 209 | 264 | 370 | 623 |

NOTE: The margins of error used in the table were .03 for continuous data and .05 for categorical data. Researchers may use this table if the margin of error shown is appropriate for their study; however, the appropriate sample size must be calculated if these error rates are not appropriate. Table developed by Bartlett, Kotrlik, & Higgins.

## APPENDIX V: PESTICIDES REGISTERED FOR USE ON TEA IN KENYA BY PEST CONTROL PRODUCTS BOARD (PCPB): CODEX RESIDUE LIMITS FOR TEA

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| RASER MAX 480 SL Soluble Concentrate | PCPB(CR)0513 | Glyphosate 480g/L | Makhkeshim Agan, Israe | Farmchem (K) Limited | A non-selective post emergence herbicide for control of broad leaf weeds |
| FAGILIA SL Soluble Concentrate | PCPB(CR)0684 | Glyphosate IPA Salt 480 g/L | Nantong Jiangshan Agrochemicals CO. Ltd, China | Biomedica Laboratories Ltd | Herbicide for the control of annual and perennial weeds in pastures, zero-minimum tillage |
| GALLANT SUPER EC Emulsifiable concentrate | PCPB(CR)0523 | Haloxyfop-RMethyl Ester 103g/L | Dow Agrosciences, S.A. | Lachlan Kenya Ltd | Post-emergence herbicide for the control of annual and perennial grasses in French beans and tomato fields. |
| GLYCEL 480 SL Soluble concentrate | PCPB(CR)0979 | Glyphosate 480g/L (as Isopropylamine salt 40.60% w/w, | Excel Crop Care, India. | Prestige Packaging Ltd. | A post emergence, non selective herbicide for the control of annual and perennial weeds in tea plantations and for |

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| | | | | | minimum tillage in carnations. WHO U- Products unlikely to present acute hazard under normal use. |
| GLYWEED 41%SL Soluble Concentrate | PCPB(CR)0583 | Glyphosate acid 360g | Sabero Organics Gujarat Limited, Mumbai-India | Orbit Chemical Industries Ltd | A systemic non-selective herbicide for the control of annual biennial & perennial weeds in baby corn. |
| GRAMOXONE 20 Aqueous solution | PCPB(CR)0029 | Paraquat Dichloride, 200g/L as paraquation | Syngenta Ltd UK *Distributor;* Twiga Chemical Industries Ltd., P.O. Box 30172, Nairobi, Kenya | Syngenta E.A. Ltd. | Herbicide for use on coffee, tea, bananas, citrus, mango plantations, cereals, sugarcane, cotton, row crops, and maize - minimum cultivation |
| GRASP 25 EC Suspension Concentrate (Twin pack with ATPLUS 463 | PCPB(CR)0257 | Tralkoxydim 250g/L | Syngenta Ltd UK / Syngenta E Africa. | Twiga Chemical Industries Ltd P.O. Box 30172, Nairobi. | post emergence cereal selective herbicide, used with wetter ATPLUS 463 |
| HERBIKILL | PCPB(CR)0480 | Paraquat dichloride 20% | Bao Feng Chemical Co. Ltd., | Osho Chemical Industries | Herbicide to control annual |

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| | | w/v | Taipei / Vapco, Jordan. | Ltd. | and perennial weeds in orchards, plantation crops, forests, in vegetable fields and in pasture renovation |
| KLIN SWIP 360 SL Soluble Concentrate | PCPB(CR)0514 | Glyphosate 360g/L (as free acid); equivalent to 480g/L Glyphosate Isopropylamine Salt | Cheminova A/S, Denmark | Worlwide Agrosupplies Ltd. | A non-selective post emergence herbicide for the control of broad leaved weeds, annual & perennial weeds in Coffee. |
| MAMBA 480 HIGH LOAD SL Soluble Concentrate | PCPB(CR)0859 | 480g/L Glyphosate equivalent to 647.8g/L IPA salt | Dow Agrosciences, South Africa & *Registrant:* Dow | Lachlan Ltd. | Herbicide to control Annual & perennial weeds in wheat as minimum tillage. Application rate 3.0l/ha |
| MANIFEST 360 SL Soluble Concentrate | PCPB(CR)0327 | Glyphosate 360gG/L (as free acid) – Equivalent to 480g/L Glyphosate Isopropylamine Salt. | Cheminova A/S, Denmark | Anset International | Post emergence non-selective herbicide for the control of annual and perennial weeds in wheat, sugarcane |

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| | | | | | coffee and tea. |
| ROUND UP TURBO | PCPB(CR)0328 | Glyphosate acid 450g/L | Monsanto, Belgium | Monsanto Kenya Ltd. | A herbicide for use in noncrop areas, zero/minimum tillage; control of broad leaved weeds, annual and perennial weeds in tea plantations and coffee |
| TOUCHDOWN FORTE 500 SL Soluble Concentrate | PCPB(CR)0417 | Glyphosate 500g/L | Syngenta Ltd, UK. | Syngenta E.A. P.O. Box 30393, Nairobi | Herbicide for control of annual perennial grasses and broadleaf weeds in tea, nontillage in wheat & barley |
| TWIGASATE SL Soluble Concentrate | PCPB(CR)0743 | Glyphosate 480g/L | Agrochem, Egypt | Twiga Chemical Industries Ltd. | Non-selective systemic herbicide for the control of annual & perennial grasses & broad leaved weeds in Tea & baby corn; and for the control of annual & perennial weeds in |

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| | | | | | weeds in barley; control of weeds in zero tillage in wheat; annual & perennial grasses and broad leaved weeds in sugarcane |
| WIPEOUT 360 SL Soluble Concentrate | PCPB(CR)0414 | Glyphosate 360 g/L | Almandine Corporations, Switzerland | Juanco SPS Ltd | A herbicide to control broad leaved weeds and grasses (for seed bed preparation) for Barley fields. |
| WIPER SUPER 360 SL Soluble Concentrate | PCPB(CR)0562 | Glyphosate 360g/L | Cheminova A/S, Denmark | Murphy Chemical (E.A.) Ltd. | Post emergence nonselective herbicide for the control of annual and perennial weed in Tea |
| WOUNDOUT 480 SL Soluble Concentrate | PCPB(CR)0584 | Glyphosate IPA salt 480g/L | Vapco Limited, Jordan. | Osho Chemical Industries Ltd. | A systemic non-selective herbicide for control of annual, and perennial grasses, herbaceous plants including deep-rooted perennial |

| Trade name and type of formulation | Registration Number | Active ingredients (Common names) | Manufacturer/ Registrant | Agent | Uses |
|---|---|---|---|---|---|
| | | | | | weeds on French beans, tea, and for use in minimum tillage system |

**Source-PCPB 2010**

**APPENDIX VI: WORLD HEALTH ORGANIZATION (WHO) TOXICITY CLASSIFICATION**

| CLASS | TOXIC RING COLOUR | ACUTE LD50 (RAT) mg/kg body weight | | | |
|---|---|---|---|---|---|
| | | ORAL | | DERMAL | |
| | | SOLID | LIQUID | SOLID | LIQUID |
| 1a Extremely Hazardous | RED | 5 OR LESS | 20 OR LESS | 10 OR LESS | 40 OR LESS |
| 1b Highly Hazardous | BLUE | 5-50 | 20-200 | 10-100 | 40-400 |
| II Moderately Hazardous | YELLOW | 50-500 | 200-2000 | 100-1000 | 400-4000 |
| III Slightly Hazardous | BROWN | OVER 500 | OVER 2000 | OVER 1000 | OVER 4000 |