THE EFFECTS OF POTASSIUM CHLORIDE APPLICATION RATES ON POTATO GROWTH, WEIGHT AND YIELD IN SABOTI SUB COUNTY, KENYA

MARTIN SANGULA NGOMAT

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DECLARATION AND RECOMMENDATION

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

Signature: ……………… …………………… Date: …………………………………

Martin Sangula Ngomat

Reg. No. AGR-3-0475-2/2015

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

Signature: ……………… …………………… Date: …………………………………

Dr. Mworia Mugambi, PhD

Department of Agriculture and Natural Resources

Kenya Methodist University

Signature: ……………… …………………… Date: …………………………………

Professor Peter Kamau, PhD

Department of Agriculture and Natural Resources

Kenya Methodist University

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DEDICATION

To my beloved wife Eunice Ngomat and my children Luis Ndiwa, Innocent Rotich and Linda Cherusta who have been very patient and supportive throughout the study.

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ABSTRACT

Irish potato is one of the major staple food crops, only second after maize in Kenya. The low yield being realized in potato production is as a result of inadequate and wrong choices of fertilizers usage and application as well as the use of uncertified planting materials. The purpose of the study was to assess potato growth, weight and yield response to the application of potassium chloride in Milimani Location, Saboti Sub-County, Trans Nzoia County. The specific objectives were to assess the relationship between potassium chloride application rates to the growth of Irish potatoes, evaluate the relationship between potassium chloride application rates to the weight of different sizes of the three potato varieties-Markies, Kenya Mpya and Sherekea- and compare the relationship between potassium chloride application rates to the yield of the three potato varieties. A review of the related literature understudy as presented by various researchers, scholars and analysts was done. The location of the study was in Milimani location, Saboti Sub – County, Trans-Nzoia County. A randomized complete block design experiment with three replicates was conducted. Data from the measured variables were subject to analysis of variance (ANOVA) to determine whether there was a significant difference between the variable means. The means were separated at ($P<0.05$) significant level using SPSS version 21. It was found out that there was a significant difference in yield and yield attributes. However, there were no significant differences in mean yield between the two sites of production. It was therefore recommended that the fertilizer industry should change fertilizer formulation; establish fertilizer blending plants and the ministry of agriculture should establish a fertilizer advisory service for farmers to boost harvest and incomes. It was too recommended that the fertilizer rate of 250 kg/ha be applied and Sherekea variety be used in Milimani Location, Saboti Sub-County.

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ABBREVIATION AND ACRONYMS

ATP	Adenosine Triphosphate
Al	Aluminium
ASI	Asian Social Institute
ANOVA	Analysis of Variance
FAOSTAT	Food and agricultural organization statistics
KC1	Potassium Chloride
K_2SO_4	Potassium Sulphate
$KN0_3$	Potassium Sulphate
K	Elemental Potassium
N	Elemental Nitrogen
P	Elemental phosphorus
CPRS	Central Potato Research Station
IPC	International Potato Centre
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Inspectorate Service
RE	Recovery Efficiency
PLRV	Potato leafroll virus
PPI	Potash & Phosphate Institute
PVY	Potato virus y
PVX	Potato virus X
SSP	Single Superphosphate
TSP	Triple superphosphate
USD	US Dollars

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Potato (*Solanum tuberosum* L.) belongs to the family *Solanaceae* with more than 90 genera and nearly 3000 species distributed throughout the world. The tomato, eggplant, pepper, the nightshade and others belong to this family. The potato was first domesticated in the Andean region in southern America from it the spread to the rest of the world through the force of trade and colonialism. The greatest potato consumers are the Belarusians who consume 200 kg per capita per year more than anyone else in the world. China, India, Russia and Ukraine are the world-leading producers respectively (Gupta, Kushwaha & Chattopadhyaya, 2016).

Potato is one of the most significant plants in terms of the amounts generated and eaten globally, according to (Raigond, Mehta & Singh, 2018). They argue that potato is a key food source because it offers many individuals livelihoods. In their dry matter content, the potato offers protein, and the potato offers a high value of energy content. The fact that they are low energy products as opposed to other important foods, such as wheat, rice maize and sorghums, provides competitors with high-quality energy. As a consequent of the low energy, they get stored in the in form of glycogen in muscles and the liver, so the energy is available during strenuous exercise. On a fresh weight basis, the starch in potatoes contains 14% in which carbohydrates are found.

Raigond, Mehta and Singh (2018) add that potato proteins are high in biological food value because they have a balanced percentage of all the vital amino acids. They also claim that potato includes a greater protein percentage than in main cereals and milk and beef, and that potato protein supplements diets that are restricted in amino acid lysine. On a new weight basis, the fat content of potatoes is 0.1% smaller than that of rice, grain, corn and sorghum. Potatoes have elevated vitamin C amounts than any other crop such as carrots, tomatoes, and calves. Thiamine, niacin, pyridoxine, pantothenic acid, riboflavin and folic acid are a key cause of potatoes. The vitamins in vegetables are water-soluble and should therefore not be cleaned after cooking, in order to prevent loss of vitamin. The small percentage of the physical activity in potatoes that offers large components of pulp for the human body and allows greater calcium, iron and hydrogen supply is a helpful source of carbon as assimilable in other food crops. For this reason, potassium is not included in the diet of renal failure patients. Pommes deer have good food fibres which assist to reduce concentrations of cholesterol (Singh, Das & Das, 2016).

According to the International Potato Center (2018), Irish potato, in terms of human consumption, is the third most consumed food crop in the globe after rice and wheat. It is the world's leading food crop without grains. More than one billion individuals eat potatoes worldwide and over 365 million tons of the crop is produced annually. In sub-Saharan Africa, the potato has become a staple food crop and source of revenue in the highlands areas of Kenya, Malawi, Nigeria, Rwanda and South Africa (FAO, 2006).

According to Abd El-Latif (2011) potato in Lebanon which occupy an area of approximately 19,700 ha with production totalling about 460,000 tons, has a production yield averaging 23tonnes per hectare. This production is considered much below the crop’s likely productivity in Lebanon. Such low yield is associated with an imbalance in nutrients used for the agricultural production of this crop. This imbalance in nutrients is due to the current trend of rigorous cropping in Lebanon, the soils have developed nutrient deficiencies.

Farmers regularly diagnose as well as correct the lack of nitrogen along with phosphorus, but often abandon the effect of the shortage of other vital micronutrients such as potassium. Along with to Nitrogen and Phosphorous, potato is considered as a heavy remover of soil potassium with its response to potassium varying with source, variety and method of potassium fertilizer application.

Alberta (2004) found that K moves in the soil more readily compared to phosphorus, but for Potassium, fertilizers are utilized more efficiently when drilled or banded for annual crops unlike in broadcast application method that can use the rate that has been used in a drill-in application twice. According to Alberta (2002), potassium has more mobility in the soil than phosphorus one. According to Jacobsen (2009), the impact of potassium placement is anticipated to be more than with N and less than Phosphorus as mobility of potassium is in between the two.

According to Bizimana, Usengumukiza, Kalisa and Rwirahira (2012), potatoes are a priority crop in Rwanda. It was first by German missionaries in the nineteen century. The agro-ecological condition in Rwanda befits the potato growing conditions. It is currently a staple food and source of revenue for the populace. In Rwanda, potato is ranked fourth (4.38 %) after bananas 62.5 %, sweet potatoes 17.9 %, cassava 4.5 % and this underlie its role as one of the food security crops. Potatoes grow well at an elevation above 1800 m above sea level and some areas produce two or three crops in a year (Rwirahira, 2009). The average yield of 9 tons per hectare throughout the country puts Rwanda as one of potato producing counties in Africa however, yields in northern Rwanda is double the national average. The Rwandese yields compare to Uganda 25 tons/hectare on research station and 14.5 tons/hectare on farms, Egypt 25 tons/hectare, South Africa 34 tons/hectare, USA 36 tons/hectare and Germany 33tonshectare is quite low. This shows that there are gaps to be filled. The potential exists for enhanced productivity for small scale farmers and hence raised incomes (Funnekotter, Sortey, Bunn, Turner & Mancera, 2016).

Increased K uptake efficiency is achieved by K placement in close proximity to the roots as Roy, Finck, Blair and Tandon (2006) found out that movement of K+ diffusion to the roots is considered more rapid when K+ concentration in soil solution has been improved. Clay minerals do adsorb or fix fertilizer K, thereby rendering it unavailable to plants and K fertilizer placement in close proximity to the roots offers K fertilizer “protection” from such fate.

Potassium fertilization provides enhanced plant quality such as better management and storage. Potassium deficiency creates bad root growth and delayed plant growth. On both old and smaller leaves, the signs are easily evident because this component is translocated within the plant. Symptoms of chlorosis on the surfaces of reduced leaves that become stirring or stirring as there is no defect (George et al., 2002). The firing goes on to the inside until the whole leaf is gone. The capacity of the plant to generate carbohydrates is restricted and thus yields are reduced due to abandonment. The complete quantity for K in plants often exceeds 20,000 mg kg-1. This amount is unavailable to plant growth as it is not accessible due to the mineral structure of the soil (George et al., 2002). Due to the wide variances in soil properties and the weathering impacts of these products, the amount of potassium provided by plants differ. Three K shapes, accessible slowly or corrected, easily accessible and exchangeable, occur in the ground.

There are three key nutrients that are vital for crop growth and potassium is one of them. According to Lakudzala (2013), Potassium plays significant roles in the physiological processes of protein formation, water transportation, carbohydrates, nutrients photosynthesis, and N utilization, stimulation of early growth and in insect and disease resistance. In addition to promoting the transport of assimilates, the command of the opening of stomata, the activation of enzymes in crops, particularly those accountable for shifting energy and sugar, starch and protein, and promoting microbial operations and human food and cattle health (Yawson, Kwakye, Armah & Frimpong, 2011).

In view of population growth and hunger levels, potato is a critical food security crop. It is cultivated in 150 nations in both subtropical and temperate areas, from high altitudes of up to 4000 m (Jaarsma, de Vries & de Boer, 2013). In terms of nutrition, potato is the second most nutritionally balanced plant protein to be protein-heaped with a high level of retention being patatin. The largest energy output per hectare per day is one of the plants, and its protein and calorie proportion are also large.

In addition to the improved processing and storage characteristics of crops, potassium fertilization is often connected. Plants are developing bad root systems and stunted development with potassium deficiency. Older and lower plant leaves indicate the potassium deficiency symptoms as this component is translocated easily within the plant. Symptoms close the edges of the reduced leaves indicate interveinal chlorosis which, as the impairment progresses, subsequently grows into scorch. The spark extends to the inside until the whole concession falls and is thrown away.

The relative acidity or alkalinity of the soil is the soil pH. The 'ideal' soil pH is close to neutral or 7.0 on a pH scale of (0 – 14). The pH range of neutral soil is slightly alkaline of 7.5 (Römheld & Kirkby, 2010). Most plant nutrients are optimally available within 6.5 to 7.5 pH range. Plant root growth is generally good at this pH range. Below a pH of 5, the soils are considered acidic and very acidic below a pH of 4. Above a pH of 7.5, the soils are considered alkaline but very alkaline above a pH of 8. Plant nutrient availability is controlled by pH levels because the many chemical processes that take place in the soil are influenced by soil pH.

Potatoes are more tolerant of acidic soil circumstances than other plants, according to (Muthoni, 2016). Slightly acidic soils are preferred–pH 5. –6.0 but can grow in the 5.0 – 6.5 pH range. In soil pH below 4.8, impaired growth is witnessed. A widespread incidence of prevalent potato scab (Streptomyces scabies) arises when the soil pH is higher than 5.5 but is decreased in soil pH under 5.4. Despite the fact that potatoes tolerate acidic soil conditions, the advantage of increasing ground pH to 6.0–6.5 is that the appropriate soil pH is between 6 and 7 for most nutrients supply. Potato is cultivated in Kenya's elevated altitude where maize output is constrained by conditions are not conducive. The potato's dietary importance makes it a significant plant. Low soil fertility due to mono-cropping without appropriate replenishment of mined nutrient is one of the main limitations to high potato productivity in Kenya (Kiiya, Mureithi & Kiama, 2006). The absence of crop rotation and fallow cycle with small farm sizes that prefer food crops prevails over any other plant.

Another limiting factor for increased potato production in Kenya is soil acidity. Most of the potato-producing regions are acidic soils, and this is because the soils in these highland regions are formed from acidic volcanic rocks and are extremely leached by heavy rainfall. The extensive use of DAP (18-46-0) fertilizer for food crop production has led to enhanced soil acidity. It has been shown that this fertilizer increases soil acidity. It is quite probable that a poor soil pH has caused imbalances in nutrients that result in a further decrease in the yields of potato tuber yields (Jaetzold, Schmidt, Hornetz & Shisanya, 2006).

Characteristic of potato production in Kenya according to Muthoni (2016) are bimodal rainfall pattern that limits production to twice a year. Mono-cropping and absence of crop rotation because of reduced land sizes has caused soil degradation to extend of poor soil fertility. The use of farm-saved seed over time has resulted in increased diseases and pest alike. The poor choice and availability of suitable fertilizers and low application rates compound the challenges faced by potato farmers. Diammonium phosphate (DAP) 18-46-0 is the most popular fertilizer used in the county. As it is formed, this fertilizer does not comprise K nutrients. The need for this research stems from the reality that in the past there has been a decrease in potato output per unit acre in Trans-Nzoia County, which has subsequently impacted rural populations ' earnings, especially women and the youth, and has led to food insecurity in some families. The true aspects of improvement, according to Masood and Bano (2016), are the techniques of implementation of fertilizer use, including positioning and branding, side-dressing / top dressing, foliar feeding and transmitting. This study endeavoured to find out the effect of the application of the Basel application of potassium fertilizer on potato yield and growth.

1.2 Problem Statement

Successful cultivation of any crop depends on several factors. Many farmers in Kenya may not be aware that potassium chloride is very important for their potato crops as they use more potassium than any other plant nutrient including nitrogen (Svenson & Aide, 2017). They claim that the demand for potassium in potato crops is greater compared to other plants. Potassium can be increased from 8 to 10 tons per acre at 272 kilograms to 318 kilograms per acre in their studies, as opposed to tests where potassium is not implemented. Despite the significance of potassium use on potatoes as postulated above, the productivity of potato in Kenya is very poor at about 7.7 t/ha as compared to more than 45 tons per hectare in developed regions such as Europe. The proper application rate has an effect on the growth weight and yield of potato, but the optimum levels have not been established for the farmers in Saboti, where excessive use of N and P fertilizers aggravate the situation in a mono-cropping system and nominal potassium use that accelerate the drainage of soil native potassium reserves. This research, therefore, was carried to evaluate the effects of potassium chloride application rates on potato growth, weight and yield in Saboti Sub County. For that reason, this study mainly established the effects of potassium chloride application rates on potato growth, weight and yield in Saboti Sub County, Kenya

1.3 Justification of the Study

It is projected that more than 10 million individuals are food insecure because maize has restricted the availability of alternative foods as a favoured food is in limited supply. The high cost of inputs associated with domestic food production, frequent drought occurrences and a big percentage of people residing below poverty lines with constrained purchasing power aggravate the condition of food insecurity. It was against this backdrop that research was carried out to explore how the implementation of potassium fertilizers could improve the output of potatoes. A favourable reaction would then have a far-reaching impact on enhanced food security, increased incomes and enhanced rural community standards.

1.4 Research Objectives

1.4.1 General Objective

The broad objective of the study was to assess potato growth and yield response to the application of potassium chloride in Milimani Location, Saboti Sub-county, Kenya.

1.4.2 Specific Objectives

i. To assess the effect of potassium chloride application rates on the growth of potatoes.

ii. To evaluate the effect of potassium chloride application rates on the weight of different sizes of the three potato varieties.

iii. To establish the effect of potassium chloride application rates on yields of three potato varieties.

1.5 Research Hypothesis

i. There is a significant relationship between the application of potassium chloride rates and the growth parameters of potato varieties.

ii. There is a significant relationship between potassium chloride application rates and weight of three Irish potato varieties.

iii. Application of potassium chloride fertilizer does significantly affect the yields of three potato varieties.

1.6 Definition of Terms

Potatoes	Starchy tuber and one of the main food crop of the world which belongs to Solanaceae family.
Potassium Chloride	Fertilizer material that contains 60 % k_20
Fertilizer Rates	A measure of the quantity of fertilizer applied in kilograms (0, 100, 150 and 250 kgs).
Yield	Measure in weight of the output in kilograms

CHAPTER TWO: LITERATURE REVIEW

This section provides a summary of the literature-related to the study as researched by different researchers and experts. The researcher reviewed different literature from various sources that were appropriate to the research objective. The literature will be reviewed on the basis of the following objectives: To assess the relationship between applications of potassium chloride to potato growth, size and yields, to compare the relationship between applications of potassium chloride and the yields of the three potato varieties.

2.1 Potassium Chloride Characteristics

Potassium is an essential nutrient required by crops, livestock and humans in large quantities as a significant component of all living cells. Most individuals get potassium through their diet directly or indirectly from crops. Potassium in the earth's crust is seventh in abundance. Slowly, potassium is produced with rock breakdowns, but the rate at which this essential nutrient is produced is often too limited to produce the big quantities that plants need (Franke, Steyn, Ranger & Haverkort, 2017).

The first to isolate potassium in 1807 was Sir Humphrey Davy. It is a smooth white substance that quickly combines with water, that the material is not produced in the environment. The sign of K is derived from potassium, the Latin Arabic name for alkaline. In agriculture, potassium is often described as the same. This is the ancient method by which potassium saltes are extracted by wood burning, and the ash recovered using water and putting the dried matter in steel containers. A combination of potassium salts, particularly potassium carbonate, chloride and sulfate, would be the possible outcomes (Bărăscu, Ianoşi, Duda & Donescu, 2015).

The crops are mainly derived nutrients from soil deposits, biological waste decomposition, aerial dispersal, bio-fixation of aerobic nitrogen and plant fertilizer. When the accessibility of soil biota is taken into consideration, the soil factors are included, for example, the absorption capacity of nutrients, acidity, redoc potential, temperature, synergy and anticipatory impacts of other components. The parent products they are obtained from and soil constitute the principal natural source of nutrients, which is, therefore, one of the major sources of soil components (Wang & Wu, 2017).

Potassium chloride is an excellent source of potassium that adds to great plant growth. Increase in plant vigour assists stem in plant formation. Potash Muriate is useful for crops such as root and tuber, as it promotes healthy root growth in crops such as carrots, beets and potatoes. The most prevalent source of potassium in cultivation is potassium chloride, accounting for about 95% of all global usage of potash fertilizers. Fertilizers with potassium (K) are used to treat plant deficiencies. If soils cannot provide the quantity K needed by plants, farmers need this vital plant nutrient to be supplemented. Potash is a common word for a variety of farm fertilizers with K content (Wibowo, Wijaya, Sumartono, & Pawelzik, 2014).

Potassium promotes crop metabolism and impacts the fluid concentration within and beyond plant cells. It is crucial for the good development of the root. For these reasons, potassium is crucial for the tolerance of plant stress. In small soil chloride concentrations, potassium chloride may also be helpful. Recent surveys have shown that chloride improves production by improving resistance to disease in crops. Unfortunately, in circumstances where water chloride or irrigation is on a large scale, the inclusion of extra chloride with potassium chloride may contribute to toxicity.

Potassium chloride, owing to its comparatively small price and far more K than most othe r sources, is the K fertilizer used often: 50 to 52% K (60 to 63% K_2 O) and 45% to 47% Cl-. Prior to labouring and planting, farmers distributed KCL on the soil surface. It can also be used in a focused group close to the seed. As the dissolution of fertilizer increases the soluble concentration of salt, banded KCl is put on the side of the seed to prevent the plant from becoming damaged.

2.2 The Importance of Potassium to Plants

In the modern era of industrial agriculture, extensive fertilizer usage is common as a prerequisite for maximizing output and therefore short-term profitability. Unfortunately, these inputs could unintendedly influence the composition of soil resources, physics, and biology, and the quality of air, water, and the diet for many generations. The soil fertility management concept is inherent in extensive K fertilization and shows the need for fertilizer input to at least substitute the plant harvesting. Originally, the handling of fertilizer K used the adequacy concept to predict an exchangeable of K13 per layer and gauge the output response. It is indirectly presumed that soil testing can adequately reflect a plant-available K profile availability, typically once in four years. This hypothesis, no less suitable for the basic cation saturation percentage 14-16, is highly doubtful because there is evidence that the replaceable portion of a big non-exchangeable and mineral K10 storage room has an exceptionally vibrant and temporally variable equilibrium (Singh, Das & Das, 2016).

In the activity of plant cells, potassium has two tasks. First, it plays an irreplaceable part in activating the different enzymes, which are crucial for metabolism, particularly protein and sugar manufacturing. This biochemical role requires only tiny quantities of potassium.

Secondly, potassium is a "plant-preferred" water argument and therefore a biophysical function (osmosis) (Svenson & Aide, 2017). Canada, the Russian Federation, Belarus, Germany, Israel and Jordan are the six principal potassium-producing nations. For example, the UK generates 0.6 metric tons in Europe and 0.5 metric tons in Spain, while robust mining techniques are used to mine underground deposits. In Israel and Jordan, potassium and other nutrients from the Dead Sea waters are gathered to allow saltwater to evaporate into tiny ponds. The salts are gathered when they crystallise, and they are refined. Potassium mining options differ and include a number of places between Canada and the US. Water is introduced and the nutrients are transmitted to the soil for extraction (Pervez, Ayyub, Shaheen & Noor, 2013).

Photosynthesis is the technique by which plants collect sunlight energy in sugar production. These sugars are produced of carbon dioxide, a tiny gap through the edge of the layer in the atmosphere. These tiny spaces have "garden bodies" and the potato are opened and only when they are turgid can carbon dioxide move through the leaf. However, when the stomata are open, the majority of the water transpired by the plant is wasted. If the plant has a water deficit, the stomata must be closed to retain the water. Potassium enables the plants while maintaining salt levels in cells to control the harmful effects of drying, frost, pest and disease. The quality of fruit and oil is also improved in many oil-producing plant products. The plant has access, through healthy fertilization, to a suitable quantity of each nutrient and is vital to optimize yields and reduce environmental hazards if needed (Jaetzold, Schmidt, Hornetz & Shisanya, 2006).

In addition, adequate potassium ensures the effectiveness of other inputs needed to achieve optimum economic results. Higher nitrogen yields are accompanied by greater nitrogen concentrations in crops with an appropriate supply of potassium, which implies that reduced concentrations of nitrate are at risk of damage to the soil when harvested. They take potassium from the water in the soil when the plant roots develop heavily. Rapid production of cereals requires 6 kg per hectare per day (ha, i.e. 10,000 m2) and even more up to 8 kg per hectare of sugar beet. To preserve this absorption level, potassium should be reused quickly within the soil structure which is only viable if the earth contains appropriate potassium stocks readily available to a plant from previous uses of fertilizers and preserved using potassium-containing manure and fertilizer (Ghiyal & Bhatia, 2017).

2.3 Potassium Deficiency

The most significant element in good potassium management is soil testing. In reaction to indications of impairment, the preservation of fertility, especially with perennials, is a futile undertaking. The addition of potassium chloride is not able to recover leaves that already demonstrate indications of deficiency. More importantly, when indications of defects emerge, the potential output was already reduced and the plant may become more susceptible to other conditions (Witold et al., 2017).

Consider a suggestion for 125 corn grain bushels, for instance, although a change is produced to include a winter rye cover in the peasants ' schemes taken as ryelage in summer and then as silage in the maize plant instead of grain. The expected withdrawal of K from the plant region would rise to about 230 lbs out of 35 lbs based on the suggestion of K_2O per hectare. While K is the same for a maize plant, grain harvest residues would bring about 115 lbs of K_2O into the soil but would be held in silage regardless of its harvest form. In the rye plant, additional K is drawn up (about 80 lbs K_2O) (Sarkar et al., 2018).

If insufficient K is available, during quickly increasing plants, typical indications of deficiency may be evident. First, symptoms happen on the decreased leaves because the plant's nutrient is elastic and K is separated from the previous leaves for the newly established tissues. Symptoms generally happen first and spread away at the bottom of the leaf on the sides. The indications in alfalfa begin to overlap along the spectrum of the leaves with an enhanced deficiency. In maize and tiny grains, the signs begin with yellowing of the edges of the leaves and proceed with the development of yellow, light tan and brown along the edges as the impairment remains until the demise of the leaf (Rhouma, Salem, Boughalleb-M'Hamdi & Ruiz, 2016).

2.3.1 Inputs of Potassium to Agriculture

Originally, wood ash was used to complement potassium-bearing minerals in the soil with a supplementary weathering. Nitrogen, phosphorus and potassium have been added to animal feed as animal production has increased. In the 1930s, Great Britain delivered about the same amount of oxygen and about 2/3 as sulfur as fertilizer in meat (Enujeke, 2013).

As at the time, a great deal of potassium and phosphoric was transmitted to the soil that was cultivated in the shape of farm manure on arable crops since most farms were mixed with cattle and arable crops. As agriculture is now more particular to plant or livestock farming, many do not have animals, and potassium fertilizers must be taken into account by arable producers. When cattle excrete dung and urine, they consume very little potassium. In the grasslands where lush development is occurring, this is obvious in urine fields. The soil may be more uniformly used for slurrings and organic manures of livestock, but only tiny quantities of potassium are always produced. The amount of potassium manure depends on the animal's diet and the way it is handled. The crop will have access to most of the potassium instantly, but it must be used at the right moment. This prevents any danger from manure-containing pathogens and environmental loss of nitrogen (Franke, Steyn, Ranger & Haverkort, 2017).

A potassium boost may be needed for plants that appear weary or unhealthy. Yellowing leaves may suggest an inherent root issue, speckled leaves may show a pest issue, and youthful crops need assistance laying fresh roots— all problems that can assist potassium. Potassium is one of the most helpful nutrients to include in the fertilizer of your garden, with all its advantages.

2.3.2 Plant Metabolism

Potassium (K) is the nutrient responsible for the metabolism of crops in N-P-K fertilizers. This makes it useful in any garden and serves as nutrient assistance for oxygen (N) and phosphorus (P). In particular, potassium helps crops retain water, controls the inner cation-anion equilibrium of crops— meaning that the beneficial and negative ions are in equilibrium— and helps the synthesis of proteins to energize crops for good development.

2.3.3 Root Development

Potassium is also needed for plant root growth, which is why it is particularly helpful for young crops to set up fresh root systems as they live in their fresh lives. Phosphorus, however, also contributes to root development. If your crops need assistance to grow a better root system, you should add both phosphorus and potassium to the soil and let them function in tandem; a 3-20-20 mix, which includes 3 per cent nitrogen, 20 per cent phosphorus and 20 per cent potassium, is an instance of a suitable root development fertilizer. Just be ready for the other impacts of phosphorus as well, such as enhanced plant blooming and fruiting.

2.3.4 Disease Resistance

Potassium also enhances the defence mechanisms of crops, rendering them less susceptible to disease. In particular, potassium thickens cell walls and strengthens stems, stalks and roots to create crops more disease resistant and more capable of tolerating stress. Potassium can decrease the seriousness of issues in crops that already have illnesses or infestations of insects. Dosing a potassium garden while neglecting other nutrients, however, can trigger an unhealthy dietary imbalance in your crops. You should also use nitrogen when applying elevated amounts of potassium, which promotes green growth.

2.4 Excess Potassium Levels

An issue with soil K concentrations beyond the optimal spectrum is the reality that adding k is either bad practice or a return-delayed investment. If manure is the source of K, its best effort will go to an industry that demands instantly all manure nutrients. Then all the nutrients of manure will return. On the farm, however, more manure is commonly available than required to provide each industry with the minimum quantity of nutrients required. In this scenario, the greatest use is to use manure to produce its most sensitive (loss) nutrient, N, at a velocity to meet the demands of agriculture. Excess levels of nutrients can trigger depressed yields as other nutrients are often affected in this scenario. Currently, no one really knows what adverse effects are detected above Soil Test K's upper limit. The best way to avoid unnecessary soil nutrient levels is to avoid any possible problems. Obviously, land K can only be reduced if it is continually mined, particularly when plants with elevated K demands are used.

The use of magnesium (Mg) from hot summer plants also leads to high soil concentrations of K. This may result in grass tissue necrosis, which could be fatal to ruminant animals. N fertilization, poor soil and animal physiology are connected with the effects of this. Grass accumulates K, especially on fertilized pastures, during luxuriant growth periods in May and early June, but soil temperatures below 60 ° F stop Mg from being absorbed. An elevated K diet raises your Mg need and people who need K trigger nutrient imbalances. Grass tetany is shielded by pasture and animal feed management.

2.5 Fertilizers Which Contain Potassium

Now in a multitude of fertilizers potassium is accessible. Some of them have only potassium, while others have 2 nutrients or more. Manufacturers often generate a range of nitrogen, phosphorus and potassium fertilizers to satisfy particular crop requirements and to ensure distinct plant nutrient concentrations in the land. "complex" fertilizers are available, each comprising the fertilizer's nutrients. The compound fertilizer 15:15:15 includes 15% N, 15% P_2O_5 and 15% K_2O, for example, for all granules (Bărăscu, Ianoşi, Duda & Donescu, 2015).

It is vital in today's mechanized farming that fertilizer is uniformly applied by machine so that in a limited size range, the fertilizer sector generates specific fertilizer and granules that are capable of preventing disruption and dispersal. Muriate of Potash (MOP) is perhaps the most affordable manufacturing component for 95 per cent of all agricultural fertilizers. It can easily be integrated into granules as fine crystals or compacted into the proper device parts or used in different combination (Knowles & Knowles, 2016).

Potassium sulfate (potash sulfate, SOP) contains two components, sodium and sulfur, and is more expensive per ton than potassium muriate. It appears to be used for crops of high value and those where it is possible to demonstrate plant performance. Tobacco burning performance is improved and tuber starch levels are reduced. In arid and semi-arid (ASAL) areas where the soils may be saline, potassium sulfate can be used. Two nutrients, a plant-based nitrate and potassium nitrate are also included (Raigond, Mehta & Singh, 2018).

In the fertigation process, where nutrients are incorporated and implemented, both sodium nitrate and potassium sulfate are used. A certain number of manufacturers of fertilizers produce unique fertilizers where the proportion of potassium to other nutrients is adapted for specific plant demands or where fertilizers have some desirable physical features (Wang & Wu, 2017).

2.6 Factors Affecting Performance of Irish potato

The water content of fleshy storage tissues like tubers is affected because the water content of the plasma volume is influenced by potassium. Lower contents of dry matter and above normal water content is caused by elevated Potassium concentration in the tubers of above 2% DW. In the process of starch synthesis, the enzyme starch synmase which is responsible for synthesis, potassium is involved in its activation. The incorporation of glucose into long-chain starch molecules as argued by Mengel, Kirkby, Kosegarten and Appel (2001) involves potassium which is the most efficient cation that stimulates the activity of this enzyme.

Potassium may decrease starch content by increasing tuber water content and activating starch acids (Perrenoud, 1993). Potassium application increases the content of starch until Potassium undernutrition can be corrected, as high potassium doses can lower the content of starch. In order to obtain chips with the desirable light colour, the glucose-fructose of potato tuber should not exceed 0.25 per cent. Negative effects such as accumulation and decline in the starch content of soluble carbon are caused by modifications in carbohydrate metabolism caused by potassium deficiency (Mengel, Kirkby, Kosegarten & Appel, 2001). Unwanted brown potato chips that happen under poor K-nutrition are caused by the buildup in potato tubers and by a decline in starch. High potassium concentrations normally contribute to an increased amount of organic acid, which also benefits ascorbic acid levels. Some tests indicate that vitamin C and tubers are increasing (Perrenoud, 1993).

2.7 Application of Potassium Fertilizers

By removing carbon dioxide, wind energy, and groundwater and minerals from the atmosphere, plants are able to survive, grow and reproduce. The crops contain nearly all (92) recognized elements in nature, but obviously not all are essential to develop and operate these elements. 16 Components presently have a known role in plants, but considerably vary in the quantity required (Wibowo, Wijaya, Sumartono, & Pawelzik, 2014).

The application of potassium fertilizer peaked in Western Europe in 1979. Since then, it has fallen to K_2O 3.8 million tonnes each year by more than 40 per cent. For the Used Agricultural Area, the current average consumption of potash fertilizer on arable soil in the European Union amounts to about 42 kg K_2O / ha and 30 kg K_2O / ha. Knowing the links between soil nutrient resources, soil texture and root growth is vital in order to enhance the efficiency of fertilizers used in plant production (Franke, Steyn, Ranger & Haverkort, 2011).

2.7.1 Soil Physical Properties and Texture

Soil is a complicated mixture of particles of mineral, organic, water and air. Mineral particles move through rock breakdowns, of which there are two main types. The molten lava has dried and solidified beneath the ground of the earth, producing igneous rocks. Geologically weathering igneous rocks resulted in sedimentary rocks like sandstones. Due to rocks-like consistencies, the sediments placed under the sea were compressed and raised massively over sea level. Humus, an organic soil matter, plays a crucial part in retaining water, and plant-based nutrient sources, leading from the decomposition of organic new products lately added to the structure of earthworms and soil microbes. The mineral part is kept together in many soils by multiple aggregate and crumb processes. There are spaces (pores) and an organized soil inside and between the crumbs connected with pores of various dimensions. Water or air can be in the pores (Gao et al., 2017).

Water contains plant nutrients that can be consumed by roots instantly. The soil solution concentration reduces when crops obtain nutrients from the water, and either the root develops to the point where more nutrients exist or the nutrients are transmitted to the root using the dissemination method. As air and water are essential to the proper working of roots and soil microbes, pores must be crossed between the layers of the earth (Gao et al., 2017).

2.7.2 The Behavior of Potassium in Soil

When rocks fall into the sand, silt and clay parts of the ground, plants release potassium and other components. The potassium behaviour in the soil as influenced by clay and organic soil form and quantity. The kind of clay varies on the parent rock, whether abstract or sedimentary and the weathering of mineral items for thousands of years (Mahmoud & Hafez, 2010).

Tiles are visible as numerical layers of silicone and oxygen interconnected Soil and pores of separate soil texture. This shows that the proportion of strong and full pores in soils of various textures is not significant. However, there are significant differences in the ratios of strong traces and entire pores of soils with different textures (Masood & Bano, 2016). The powder can be kept at the edges of the clay layers in both kinds of clay. The layers also tend to open on the edges, enabling potassium to enter readily. Other positive ions are comparatively readily substituted for the positive potassium ions at the ends of the clay layers and towards the outside edge of any interlayer area. This results in releasing potassium into the soil solution from which plant roots take it. Deeper potassium can only be slowly exchanged in the interlayer room.

2.7.3 Potassium and Organic Farming

Organic agriculture is an essential component of animal agriculture and husbandry. It aims to focus on' natural' systems and use renewable resources as much as possible instead of non-renewable resources. Soil fertility is preserved or enhanced, as in traditional agriculture, and the recycling of animal manures is also a primary objective. The latter indicates that both livestock and crops are found in organic farms.

In agricultural products, they do not involve additional potassium for additional potassium. Most animal nutrients go back to the faeces and urine, but into small and excessively distributed areas to prevent the efficient use of plants with nutrients. Manure and slurry collected during livestock collection may be more consistently distributed in all areas, but it cannot be sufficient to guarantee that appropriate quantities of nutrients are present in all fields. When livestock are kept and bedding products are frequently transported into organic farms, additional potassium is acquired. Again, these exports are a disincentive and they should be mainly organic.

The latest study of European farms only shows significant favourable potassium balances for intensive dairy farms that buy big amounts of feed (Noor, 2010). Bio-farmers suggest less potassium due to the restricted nitrogen supply. This is accurate when returns are controlled by nitrogen rather than by some other nutrient. Some say that crops take it unnecessarily if there is too much potassium in the soil.

That's not the manner it is. Plants use powder to maintain their cells turgor. If water is available, an adequate amount of potassium will be drawn in. The extra potassium may not seem to serve any useful objective if there is no extra yield owing to the accessibility of ready water. There is another significant reason why appropriate concentrations of accessible potassium in the soil are maintained in all agricultural systems (Rens et al., 2016). A useful source of potassium for humans is many new fruits and greens, often the only natural source. If too much potassium is in the soil to fulfil the requirements of the plant, then the potassium content in the plant is lower and the human consumption in the food is not adequate to replace natural losses (Rens et al., 2016).

2.8 Potassium Chloride Application Rates and Growth of Potatoes

The effect was significant ($p<0.05$) on the application of K in each plant. The amount of plants leaves gradually increases to 150 kg K20/ha, with improved K. The K20/ha 150 kg plots had the greatest leaf per plant (4.17) and the test had the lowest leaf per plant (3.19). Abay and Shelane (2011) recorded having affected the number of leaves per plant by applying K fertilizer. The amount of the aerial roots of Ajiba per crop (6.23) is very significant ($p<0.05$), which is due to a variety of plant physiological techniques in meristematic tissue where the main tissue is split (Havlin, Tisdale, Nelson & Beaton, 2016). The genetic structure of the plants influenced the number of trunks so produced. The number of flowers per seed tuber used and the consistency of the seed tubers used did not affect stem numbers per crop. Compared to the other two variations, the form Ajiba had a mildly greater amount of eyes than Zafira or Picasso on seed tuber variation. Important impacts ($p<0.05$) have occurred (Abubaker, AbuRayyan, Amre, Alzu'bil & Hadidi, 2011).

In comparison to present findings by Pervez, Ayyub, Shaheen and Noor (2013), stated that the vegetative parameter, like plant height, has progressively and substantially risen by raising the application level of K up to 285 kg K20/ha. In the plant height reaction of various potato types, there was a substantial ($p<0.05$). The Picasso variety was the lowest (32.48 cm) and over the rest of the variations studied Ajiba was the highest (42.15 cm). This could be explained by the development personality of the plants affected by the genetic composition of the plant (Enujeke, 2013).

K application and varieties had a significant impact on plant height. A difference was obtained in K application, which resulted in Zafira and Picasso treating 150 kg K_20/ha respectively in the height of their highest plant of 43,33 cm and 34 cm. At 75 kg K_20/ha, Ajiba responded better. In a study of fertilizers and their impact on the output of sweets, Ali, Costa, Abedin, Sayed and Basak (2009) revealed considerably impacted plant height by interactions between variation and fertilizer.

2.9 Potassium Chloride Application Rates and Weight of Potatoes

Increased implementation of K from 0-300 Kg K_20, considerably enhanced the weight of tuber per plant. This could be ascribed to the reality that greater use of K makes it easier for the plant to have stronger nutrient concentrations and water absorption that will improve plant growth and consequently tuber weight development. A critical potato reaction to K implementation on tuber weight was created by (Adhikary & Karki, 2006).

Ajiba was inferior on tuber weight of the three variants followed by Zafira. According to the finding, Abubaker, AbuRayyan, Amre, Alzu'bil & Hadidi (2011) recorded important variations in their annual output and tuber output per crop between strains. Cultivars and different environmental conditions cause variation in nutrient usage, however, all varieties showed a steady increase in their tuber weight with an increase of K levels.

2.10 Potassium Chloride Application Rates and Yield

There was a gradual and significant ($p<0.05$) on potassium levels. The application of 300 kg K_20/ha produced the highest number of tubers per plant (9.08) while the lowest (6.92) was obtained from 0 kg (control). A study carried out by Svenson and Aide (2017) in the USA found that Potassium was the dominant plant essential nutrient taken into the plant mass. Concentrations of plant tissue indicate that consumption of potassium luxury is a widespread problem and fresh rules for potassium fertilization need to be developed. Leaching of soil potassium is not a method of sufficient importance to restrict plant output or profitability of producers.

In research by Witold, Pavel, Evan, Jarosław and György (2017) in Central Eastern Europe, it was shown that K fertilization plays a major beneficial part in potato plant manufacturing. In addition, the research shows the significant interactive impacts of N and K implementation on both nutrients ' evident effectiveness of use. K implementation has actually improved the effectiveness of N use and vice versa. Therefore, none of these nutrients should be ignored, particularly K, when nutrition policy for potato is considered.

The addition of sulphate to sodium increased the amount of tuber production according to (Wibowo, Wijaya, Sumartono & Pawelzik, 2014). This can be attributed to the position of K in photosynthesis, which promotes elevated energy, which helps to translocate the plant appropriately and efficiently and absorb water from radicals. This means that a number of tubers per plant will be available with more photosynthates. There was a considerable distinction between the potato types in producing tubers per plant.

Potassium fertilization is an important practice in improving growth and yield of crops. There are different fertilizer sources of potassium and based on their potassium content and kind of chemical formula they can be used in different soil conditions. Potassium is generally given sooner than nitrogen and phosphorus, and consumption rises quicker than the manufacturing of dry matter. This implies that in the increasing era potassium accumulates quickly and is then translocated to other components of the plant. There is much research on the impact of potassium fertilization on the productivity of distinct plants. This evaluation, however, focuses on plants such as sugar beet, corn and rice. The impact of potassium fertilizer on the manufacturing of sugar beet in separate areas of the globe has been investigated in various ways.

In Egypt, using 72 kg potassium fertilizer, K_2O / ha considerably increased output and output element, sucrose content, and sugar beet purity percentages (El-Sayed, Hassan & El-Mogy, 2015). Whereas in Turkey, according to Sarkar, Kakraliya, Bochalya and Choskit (2018), the largest plant reported weight/plant, fruit and fruit yields/ha were correlated with the application of 60 kg K_2O / ha oxygen fertilizer. In addition, potassium fertilizer implementation in Romania boosted the root output from 80 to 83 t / ha at a pace of 70 kg K_2O / ha and the sugar output from 9.2 to 10.0 t / ha (Bărăscu, Ianoşi, Duda & Donescu, 2015).

On the other hand, certain results indicated that contact between potassium fertilizer and nitrogen increased the output of sugar beet and the output. El-Sayed, Hassan and El-Mogy

(2015) found that for the optimal white sugar yield per unit area fertilizer of 90 kg N + 24 kg K_2O / ha can be suggested. In addition, the lowest amount of K (114 kg K_2O / ha) at various levels of N to considerably enhance sucrose content, recoverable sugar output and some performance characteristics were reported by Faridi-Myvan, Al Ahmadi, Eslami and Shojaei-Noferest (2018) in Iran. Moreover, the most effective way to improve yields, quality and nutritional status of potatoes grown in calcareous sandy soil was by adding N fertile with N / ha, at 285 kg accompanied by 114 kg K_2O / ha.

2.11 Potassium Application

Manure Potassium

On most farms in Pennsylvania, manure is a K resource. Table 1 shows the median K of different animal fumes. The amount of K, however, depends on the amount of water and bedding. The only safe way to handle the quantities of added manure nutrients is through the fungal nutrients assessment. Potassium is nearly entirely submerged in animal manure in the liquid part and this part of the manure needs to be maintained. The processing of the ground or the embedded software shall not affect the material or accessibility of K unless the liquid is wasted. If a sample of soil is taken after the implementation of manure, the existing manure K is shown in the ground test stage and the suggestions. If nevertheless, manure is used after soil sampling, manure K should be removed from the soil test study guidelines. Manure K is available immediately and can be regarded as a 1:1 fertilizer substitute (El-Sayed, Hassan & El-Mogy, 2015).

Fertilizer Potassium

Potassium oxide (KCl), known as potash muriate, is the most prevalent type of fertilizer. This is an extremely water-soluble salt with a 60-62% K_2O assessment. Differences in processing, identified as red and white potash muriate, lead to two prevalent chemical properties. Since the plant has no distinction, the price per K unit varies on the application of the plant. The assessment K is provided as a K_2O (potash) in the material for the fertilizer product. There is no real K_2O fertilizer, but this type of communication is permitted and legal. The survey of the Penn State groundwater sample records recommendations of potassium as K_2O tons per acre. Potassium (K_2O) units can be converted with magnesium (K) multiplying 0.83 lbs in K_2O. To acquire lbs of K_2O for the reverse transformation, multiply K by 1.2 lbs. While KCl in fertilizers is the most common form of K, other forms are used in special cases. Chloride, other than tobacco, is usually thought to benefit crops. Chloride has negative impacts on performance with this crop and is preferred for the sulfate type of K. Potassium sulfate also provides sulfur with a 50% K_2O assessment. The KOH source may be used by solution fertilizers. Although KOH has an elevated K_2O test, the K is no longer accessible for the plant as KCl has been used. KCl may not provide clear fertilizers alternatives, but from a plant view, this is no disadvantage.

K can damage the origins of the herb, like salt. It relies on the velocity of fertilizer (or dung, in particular, poultry manure) used and its positioning when compared to plant roots it becomes an issue. Regeneration dilutes soil salts and leaches, which reduces the likelihood of damage. This exercise has the highest possibilities for damage due to the placement of the starter fertilizer near to growing roots by design. In addition to the low K soils, there was a little continuous advantage in banding K as part of the starting process, so it may be best not to include K in the starting fertilizer.

The Right Fertilizer Source

The prevalent source of P used in potato manufacturing differs more frequently (e.g. SSP, MAP, DAP, TSP and Calcium-magnesium sulphate) depending on agro-zone choice; KCL is the primary source of potassium relative to other sources such as K_2S0_4 and KNO_3.To preserve both tuber output and performance, elevated soil K consumption is essential and these, in turn, may be influenced by K source. The preferred sources are either potassium chloride or potassium sulfate depending on output information (Gao et al., 2017). There is proof suggesting the implementation of enhanced tuber starch and vitamin C content of KCL and reduced sugar content in tubers rather than potassium sulphate. Organic sources of nutrients such as manures on the farm are efficient sources of nutrients. However, healthy use of fertilizer in combination with organic manures typically results in stronger yields and excellent financial returns through the single implementation of either source (Brown, Hoshide & Gallandt, 2019).

In harvested tubers, very large quantities of K are removed by potatoes (90-180 kg/acre, but K is taken up by the plant in the cationic K+ form irrespective of the fertilizer material applied to the soil. Diminished yields and quality of the tuber result from inadequate supplies of K. Low percentages of dry matter in tubers are reported to be caused by heavy use of potassium chloride. There are soluble sources of K that are compatible with irrigation systems. In the root zone, adequate nutrient supplies have to be maintained considering that potato accumulates up to 6.4 kg K/acre/day during bulking. For fertigation, K can be solubilised from common K sources and applied (Brown, Hoshide & Gallandt, 2019).

Right Application Method

Since K nutrient is essential to metabolic tasks such as moving sugars from leaves to tubers and turning sugars into potato starch, potato needs a big quantity of K. Due to deficiencies in K, reduced output, size and quality of potato plant happens. Inadequate K. potatoes can weigh up to 6.4 kg/acre every day during peak period is linked with low specific gravity. As a consequence of the excessively elevated concentration of K in the tubers, elevated water content and reduced specific capacity. K application's prevalent procedure is to broadcast through the ground before planting. K can efficiently be supplied to the plants by band placement of a small fraction of K fertilizer in the beds or during row mark out. It is recommended that no more than 16.2 kg K_20/acre be applied in deficient soils in a band to prevent salt damage to young plants. In K deficient soils can be applied as a combination of broadcast and banded K. Potassium foliar feeding is practical and effective as the plant expands. In 10-24 hours, potassium will be taken into the plant and translocated throughout the plant. Foliar potassium feeding has a major effect on the increasing plant. A real solution can be coupled with potassium liquid formulation with post-emergence herbicides and insecticides (Gao et al., 2017).

The Right application Time

Knowing the complete season demand and daily uptake of nutrients offers advice for the proper timing of nutrient usage. During the bulking phase, rapid accumulation of nutrients happens. Daily nutrient uptake of irrigated potatoes occurs about 2 decades sooner than rain-fed potatoes, offering an early implementation of nutrients for an irrigated potato to meet the requirement. Lower tuber output happens when unnecessary N implementation takes place at or before tuber setting, which extends the span of vegetative growth and delays the development of tuber.

Later in the season, the use of N delays the tuber development, which reduces yields and performance. The division of N is suggested in order to satisfy the requirement for plant uptake, increase the effectiveness of nutrient use and offer broad flexibility in the leadership of nutrient fertilizers enabling farmers to alter the N leadership on climatic circumstances and plant growth. Use of N can be divided into 3 or 4 divides to enhance the effectiveness and output of nutrients. Split N is a very efficient implementation to reduce environmental N loss in irrigated sandy soils manufacturing. However, if the leaching danger is small, N must not be divided (Bizimana, Usengumukiza, Kalisa & Rwirahira, 2012).

Every implementation of K & P fertilizer is performed in pre-plants and blended before planting with the land. Micronutrients like Mn, Zn and Fe, pre-planting, are oxidized or precipitated to inaccessible types before plant uptake on calcareous soils with elevated soil alkalinity. Elemental S is performed before planting, enabling S oxidation to crop sulphate accessible in cold regions in particular and in soil with small capacity for the oxidation of sulphur (Abay & Sheleme, 2011).

A good supply of K should be retained at all moments in the root zone as a result of the elevated demand for potatoes. If K deliveries are brief, the tuber output and performance parameters are adversely impacted, particularly for tuber bulking. The tubers removed can comprise over 90% of the complete K of the factory. The most efficient way of supplying K is to apply before planting. If big quantities of K are needed to supply appropriate food, it is advisable to divide the request into two or more apps before creation. The tracking of the level of petiole K is helpful for anticipating the mid-season supplementation. K concentration continues to decrease constantly for the rest of the season after tuber initiation. The level of the petiole K cannot improve for 2 to 3 decades after K fertilizer implementation through an irrigation scheme and do not, therefore, continue until the petiole K level falls below critical concentrations before additional K can be applied. Monitoring the K decrease level of the petiole helps predict when extra K might be required. If the extra K request takes place in 1 month by the end of the growing season, the probability for a financial reaction (Cambouris et al., 2016).

The Right application Place

The fertilizer K must be placed in the near root zones to ensure quick consumption of K nutrient during peak demand. Since K cation takes place on a cation exchange place, it is a relatively small movement in the soil. K's motion is higher in poor exchange power sandy textured soils. If K is needed during manufacturing, roots must be present close to the bottom of the ground in order to obtain the nutrients that were introduced. Adequate ground humidity should be minimized close the ground floor to allow for the nutrient absorption by the bottom roots (Rens et al., 2016).

Application for broadcasting and inclusion of K soil is efficient when preparing the seedbed. The placing of K in advance of planting may also be adequate if implemented at the standard request rates to satisfy the demand K. Avoid elevated banded K levels close to the plant part. If the K request levels are large, a mixture of broadcasting and channel reference positioning can be better. K soon after plant development is also prevalent Broadcast implementation (Kempenaar et al., 2017).

Enhancing fertilizer use effectiveness and nutrient loss is the advantage of having nutrient in the correct location. Placing the nutrient below the ground is accomplished by broadcasting on the ground of the soil, then by tillage procedure, the product is integrated into the soil. However, with the implementation of zero-tillage or minimum tillage methods, by putting those in a tight, focused group close the plants or seedlings, breeders choose to group fertilizer request. The fertilizer is put on the floor below the seed furrow or a few inches. The implementation of the subsurface band has the benefit of putting the nutrients where they are easily accessible to the plant and the prospective loss decrease. The use of nutrient effectiveness is accomplished by applying a band because it reduces phosphorus and potassium fixation by restricting soil interaction. There is enough phosphorus in focused areas to overwhelm the clay, calcium and aluminium that could form stable compounds that decrease the accessibility of P to crops. The capacity of the plants to absorb those nutrients soon in the growing season is significantly enhanced when the nutrients are positioned in the root areas and close the seed. This is critical for P because many plants need to be developed soon. The small movement of potassium and phosphorus in the soil, which is not integrated into the soil, results in these nutrients being stratified and accumulated in the bottom 2 or 3 inches of soil.

The stratification leads to reduced uptake of P and K, particularly when the topsoil is dry (Rhouma, Salem, Boughalleb-M'Hamdi & Ruiz, 2016).

The Right Application Rate

A range of methods has been created to determine adequate fertilizer implementation prices in China's Agriculture. The method used in the suggestion for potato fertilizer was focused on soil testing and target output. A systematic method for ASI soil testing and nutrient recommendation has been observed to be an efficient and commonly used nutrient management instrument in China (Li et al., 2015).

More balanced optimum therapy (OPT) suggested by the ASAI method relative to cows practice (FP) improved tuber production by an average of 3 t / ha and farmers ' earnings by USD 200/ha. P application has peak solubility within a limited spectrum where iron and aluminium or calcium are not kept in low-solubility complexes (Davenport et al., 2005).To overcome the impacts of soil responses that decrease P solubility, a popular practice in China is to add P fertilizers in excess of plant suppression median demand of 1.3 kg 205 kg/t. Due to the much greater output capacity, greater implementation levels and nutrients are needed for irrigated potatoes than rain-fed locations (Ghiyal & Bhatia, 2017).

CHAPTER THREE: RESEARCH METHODOLOGY

This section reflects the techniques for conducting the study. The methodology is the data extraction method. The methodology provides the strategy to be followed by the student to perform the study. This section includes the research place, layout, climatology, method for data compilation, procedures, and layouts of the plot.

3.1 Site Description

The location of the study was in Milimani Location, Saboti Sub County, Trans Nzoia County. The county borders Elgeyo Marakwet, West Pokot, Bungoma, Uasin Gishu and Kakamega counties in Kenya and the Republic of Uganda on the North West. The research study was conducted in two field sites in Milimani location, Saboti sub-county.

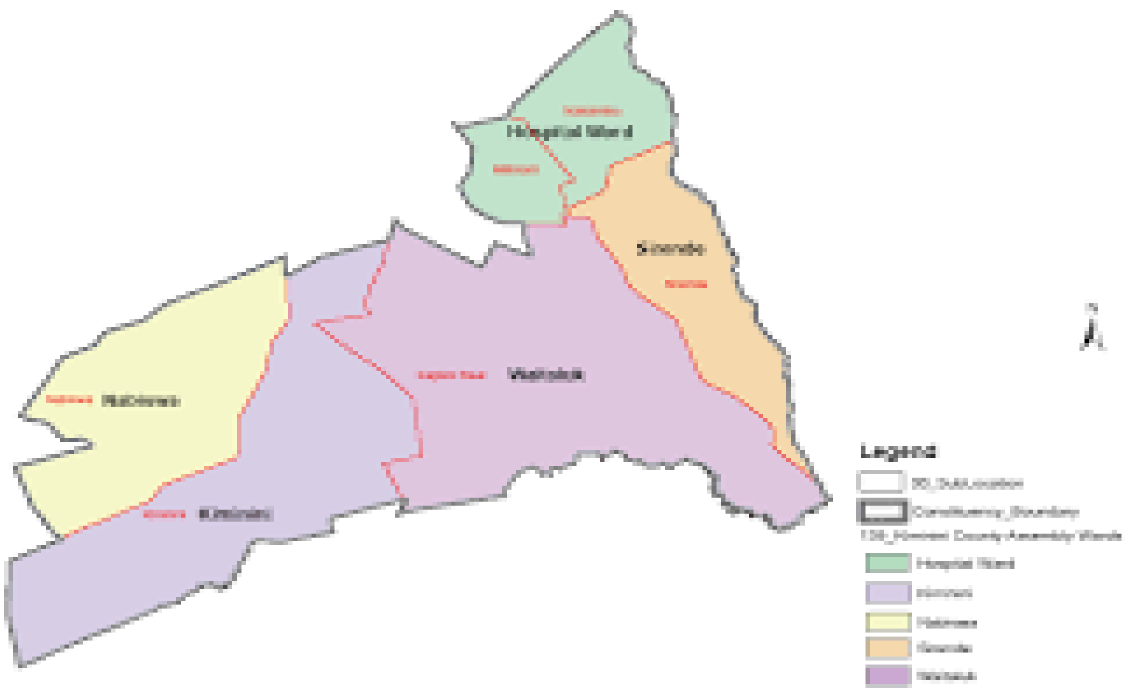

Figure 3.1 **Location of the Study**

Soils and Climatic Conditions

Soil evaluation on Physico-chemical characteristics showed that soil texture was reddish/brown clay loam with 0.29%, phosphorus,9 .64 ppm, m.e. 0.81% (Meru Site) but deficient (Milimani Site) 0.19%, organic material 1.00%, soil PH range 5.39-5.62, which was mildly acidic in both locations. The median temperature is 180c. Annual rainfall ranging from 1000 to 1,270 mm, with the wettest months between April and October. The altitude above sea level is 1,890 m.

3.2 Research Design

The research was a randomized complete block design (RCBD), Number of replications were three. The total number of plots per site was 36, Plot sizes 2m x 2m providing each an area of 4 square metres. Treatments were randomized within blocks as indicated in the layout below.

Table 3.1.

Experimental Lay Out

Block I	V_2L_2	V_1L_4	V_3L_3	V_1L_2	V_2L_3	V_3L_1	V_1L_1	V_2L_1	V_2L_3	V_1L_3	V_3L_2	V_2L_4
Block II	V_3L4	V_1L1	V_2L_4	V_3L_1	V_2L_1	V_1L_4	V_3L_3	V_1L_2	V_2L_2	V_3L_2	V_1L_3	V_2L_2
Block III	V_1L_1	V_3L_3	V_1L_3	V_2L_1	V_3L_1	V_2L_3	V_3L_4	V_2L_4	V_1L_2	V_1L_4	V_3L_2	V_2L_2

Variety	Symbol (V)	
V_1	Sherekea	
V_2	Markies	
V_3	Kenya Mpya	
Fertilizer	(Muriate of potash) levels Symbol (L)	
L_1	Nil application (control) 0 g/Plot	
L_2	100 kg/ha	67g/Plot
L_3	150 kg/ha	100g/Plot
L_4	250 kg/ha	167g/Plot

3.3 Experimental Set-Up

During the brief rainy season October / December 2016, a field experiment was performed under rainfed circumstances at Milimani Location. The soil on the experimental soil was randomly sampled on top and subsoil and exposed to soil analysis testing to determine the accessible essential nutrients, vegetation response and organic matter concentration.

Planting was done from 5^{th} – 6^{th} October 2016 using the following procedure. A spacing of60 x 15 cm was used and a V-shaped trench was then dug out about 5 -15cm deep. A uniform application rate of 250 kg/ha of D.A.P which translates to 100g per plot of size 2 x 2m. DAP was added to the bottom of the trench and incorporated into the soil. Chitted potato tubers of size 50 – 60g, shoots up (ears) was placed at the bottom of the trench at 15cm interval and then covered with 15cm of soil. Selection of the varieties to be planted was done randomly.

After 1 month of seed emergence(critical peak nutrient uptake) the crop was earthen up then band application of potassium chloride was carried out at following rates per 4metre squares (plot size);0 g (control), 67g (100 kg/ha), 100g (150 kg/ha), 167g (250 kg/ha).

3.4 Data Collection Methods

The Number of Stems per Plant

After 2 months of seed emergency, a count of the number of stems per plant was carried out through physical counting.

Stand Count

Each plot was planted with 52 pieces of potato tubers which were well chitted. After a period of 2 weeks of seedling emergence, the number of germinated seedlings were counted and expressed as a percentage of the total number of tubers planted. The results were recorded on a plot record sheet.

Plant Height

Each plant height was measured using a tape measure and the average height established per plot. This was done after 2 months after seed emergence just before flower set (bloom) i.e. at maximum vegetative stage.

Number of Leaves per Plant

This was done at the onset of the flowering stage after 2 months. The leaves were physically counted an average established.

Leaf Area Index (LAI)

This was done when the plant was at complete flower after 2 months of seed formation. A technique used by Charles Cudd. That's how it was done. A 1-centimetre grid graph paper has been used. A leaf still connected to the plant was placed on the graph paper sheet and a pencil was used to trace the shape of the leaf. The numbers on the graph paper of grid squares in the leaf outline were counted. A partial square if inside the outline at least half of the box was counted but those inside the outline were not counted. The area of the leaf stem was not included. The number of boxes was added up. This was the area in square centimetres. The importance of LAI is assessing growth and vigour of vegetation. It is a parameter in plant growth because it represents leaf material.

Aggregate and Grade Tuber Yield

Lifting of the potatoes was done per plot. The total harvest per plot was measured using a weighing scale and total weight per plot established. Then individual tubers were weighed and graded or categorized using the following schedules.

Table 3.2.

Aggregate and Grade Tuber Yield

Category	Size (grams)
Large	250+
Medium Large	170-250
Medium	100-170
Small	50-100
Cocktail pack	15-50

Lifting of the potato was done per plot. The total harvest per plot was measured using a weighing scale and the total weight per variety was determined. The weight per variety was taken as the total yield of the three varieties.

3.5 Data Analysis

The information from the selected variables was analyzed in an attempt to determine whether the distinction between the factors was significant using Analysis of Variance

(ANOVA). The means were separated at ($P \leq 0.05$) significance level using SPSS version 21.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This section of the study highlights the results of the study, analysis of results and the discussion of the findings based on the research objectives.

4.1 Fertilizer Rate on Growth

The researcher wanted to find out the relationship between fertilizer rate and growth of potatoes. The findings were as shown in figure 4.1.

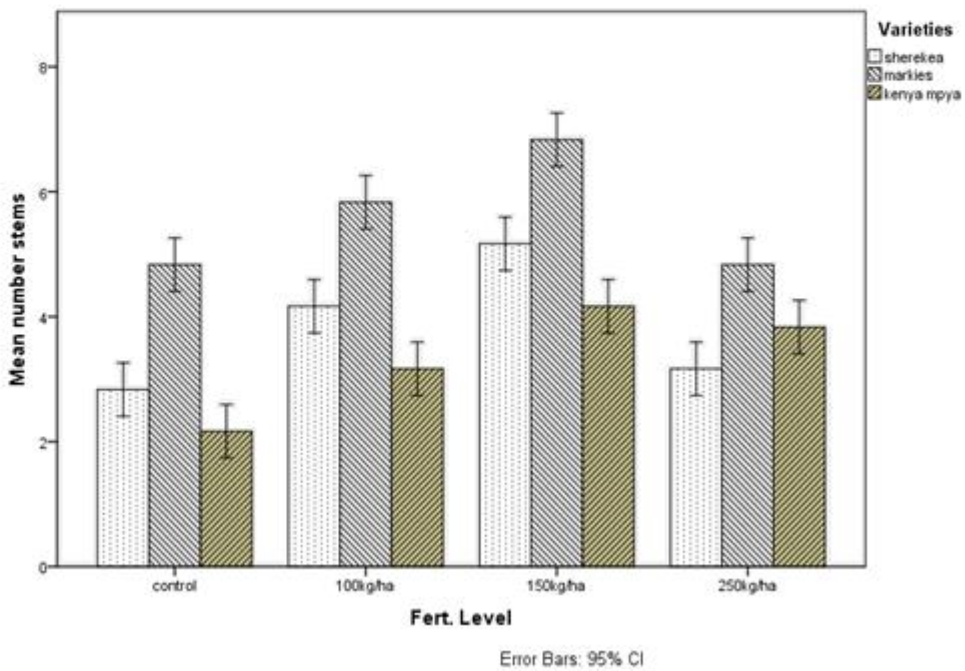

***Figure 4.1*: Fertilizer rate on Stem Number**

It was observed in figure 4.1, that there was a significant difference ($P<0.05$) between the different fertilizer rates. However, 100 kg /ha and 150 kg/ha was not significantly different in all varieties. It was also observed that fertilizer application of 150 kg/ha on Markies potato variety produced the highest stem number. Equally, the fertilizer application rate of either 100 kg/ha and 150 kg/ha on Kenya Mpya produced the high yet the same number of stems. All the varieties gave an average of 5 stems. The K implementation impact was important on aerial roots per crop ($p < 0.05$). With growing oxygen concentrations of 150 kg K_2O / ha, the amount of aerial roots per crop has gradually increased. In beds handled with 150 kg of K_2O / ha and with the smaller amount of flowers (2) per sample, the largest amount of soils was registered (7) was acquired by zero k implementation (control).

Table 4.1.

Number of Stem Number

Source	df	Mean Square	F	Sig.	
Corrected Model	11	10.682	64.091	.000	117.500[a]
Intercept	1	1300.500	7803.000	.000	1300.500
Varieties	2	33.500	201.000	.000	67.000
Fert. Level	3	14.130	84.778	.000	42.389
Varieties * Fert. Level	6	1.352	8.111	.000	8.111
Error	60	.167			10.000
Total	72				1428.000
Corrected Total	71				127.500
a. R Squared = .922 (Adjusted R Squared = .907)					

Table 4.2.

ANOVA of number of Stems

(I) Varieties	(J) Varieties	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sherekea	Markies	-1.75*	.118	.000	-1.99	-1.51
	Kenya Mpya	.50*	.118	.000	.26	.74
Markies	Sherekea	1.75*	.118	.000	1.51	1.99
	Kenya Mpya	2.25*	.118	.000	2.01	2.49
Kenya Mpya	Sherekea	-.50*	.118	.000	-.74	-.26
	Markies	-2.25*	.118	.000	-2.49	-2.01
*. The mean difference is significant at the 0.05 level.						

The results are consistent with Abay and Sheleme's (2011) findings which indicated that the potato stem amount was affected by K fertilizer implementation. This could be due to the crucial function of K in energy use, starch production, N absorption, and respiration in enzyme operations. The meristematic tissue, in which the cells divide and form the main tissue, contains abundant enzymes.

Contrary to Al-Moshileh & Errebi's (2004) results as well as Noor (2010), who reported no important impact on aerial stem counts per crop was discovered to occur on potassium therapy. The impact was also significantly important ($p < 0.05$) with regard to the amount of aerial stem per plant. Figure 4.4 information shows that from the varieties Markies and Kenya Mpya, the highest average aerial stalks amount were producing per plot. The variations in the number of aerial roots generated by the crops could depend on the genetic composition of the plants (Raigond, Mehta & Singh, 2018).

The amount of eyes per seed tuber used is influenced by the plant's stem and the number of seeds of seed tuber used in the present research was not consistent. The Markies seed tubers had a few eyes relative to the two other variants. As a consequence, several aerial roots per plant were generated, compared to the other two.

4.2 Fertilizer Rate on Plant Stand Count

The study wanted to investigate the relationship between fertilizer rate and plant count of Irish potatoes. From the study findings, the control experiment recorded a height of 95cm as shown in figure 4.2.

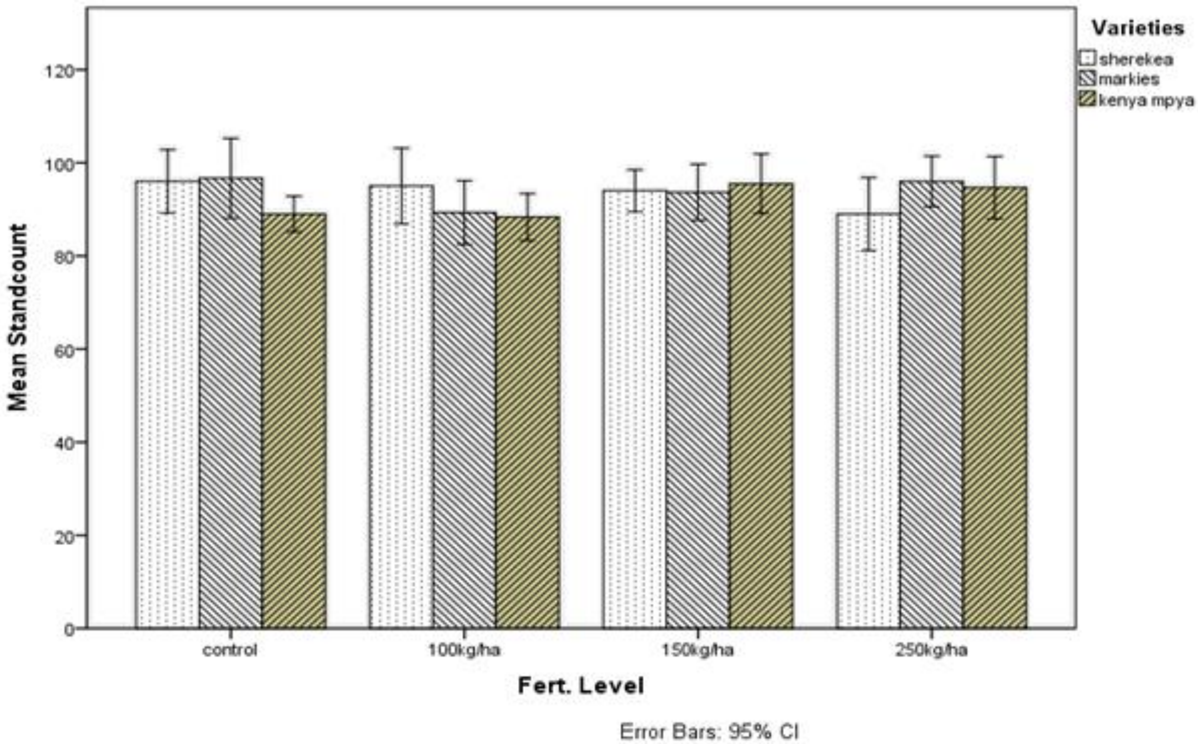

Figure 4.2: **Fertilizer rate on Plant Stand Count**

When different fertilizer rates were applied on potato varieties, it was observed that different Plant stand count was not significantly different (P>0.05) on fertilizer rates as observed in figure 4. It was observed that with an increase on K application from 100 kg/ha, to 150 kg/ha and 250 kg/ha on Sherekea, the stand count remained the same. It was also observed that the more the K application rate the less the stand count. Similarly, 100 kg/ha seemed to reduce the stand count on Kenya Mpya though, a 250 kg/ha, had no much difference in the stand count compared to the control.

Table 4.3.

Plant Stand Count

Source	df	Mean Square	F	Sig.
Corrected Model	11	84.064	2.041	.040
Intercept	1	619941.125	15052.189	.000
Varieties	2	15.167	.368	.693
Fert.Level	3	38.532	.936	.429
Varieties * Fert.Level	6	129.796	3.151	.009
Error	60	41.186		
Total	72			
Corrected Total	71			

Table 4.4
ANOVA on Plant Stand Count

(I) Varieties	(J) Varieties	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sherekea	Markies	-.08	2.016	.967	-4.11	3.94
	Kenya Mpya	1.33	2.016	.511	-2.69	5.36
Markies	Sherekea	.08	2.016	.967	-3.94	4.11
	Kenya Mpya	1.42	2.016	.485	-2.61	5.44
Kenya Mpya	Markies	-1.42	2.016	.485	-5.44	2.61
	Sherekea	-1.33	2.016	.511	-5.36	2.69

4.3 Fertilizer Rate on Plant Height

The study sought to find out the correlation between fertilizer application and plant height of Irish potatoes. The following was observed.

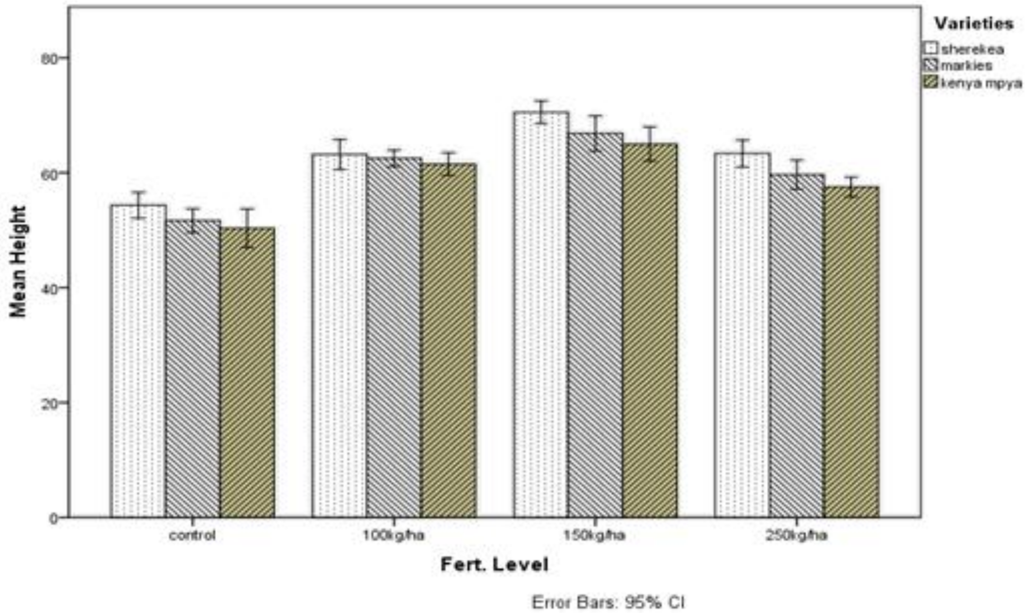

Figure 4.3**: Fertilizer Rate on Plant Height**

There was a weak significant difference ($P<0.05$) in terms of plant height. Generally, height increased with increase in fertilizer rate with 150 kg/ha giving the tallest (70 cm) plants in Sherekea variety. Generally, the heights of the potato plants were similar in all varieties. The average height was about 50 cm in both sites and variety. The findings show that the effect of potassium fertilizer rates, (Figure 4.3) shows that the 150 kg K_2O gave the highest significant values for plant height compared with other treatments in both sites as compared to control treatment (without K fertilizers). Increasing potassium fertilizer development of crops by improving the concentrations of implementation may be due to the position of potassium in plant nutrition, i.e. promoting the activities of enzymes and improving the translocation of assimilates and protein synthesis. The highest N, P and K content was caused by N, P and K fertilization according to Sarkar (2018), due to the fact that P and N were adequate in the soil even though it was not included in treatments. The vegetative development parameters according to Mahmoud and Hafez (2010) found that the growth if the plants rise gradually and markedly from 100 kg to 150 kg K_20/ha, improving the plant duration.

Table 4.5

Fertilizer on Plant Height

Source	df	Mean Square	F	Sig.
Corrected Model	11	223.419	41.848	.000
Intercept	1	263780.056	49407.294	.000
Varieties	2	110.722	20.739	.000
Fert.Level	3	733.648	137.416	.000
Varieties * Fert.Level	6	5.870	1.100	.373
Error	60	5.339		
Total	72			
Corrected Total	71			

Table 4.6

ANOVA on Plant Height

(I) Varieties	(J) Varieties	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sherekea	Markies	2.67*	.667	.000	1.33	4.00
	Kenya Mpya	4.25*	.667	.000	2.92	5.58
Markies	Sherekea	-2.67*	.667	.000	-4.00	-1.33
	Kenya Mpya	1.58*	.667	.021	.25	2.92
Kenya Mpya	Sherekea	-4.25*	.667	.000	-5.58	-2.92
	Markies	-1.58*	.667	.021	-2.92	-.25

The error term is Mean Square (Error) = 5.339.

*. The mean difference is significant at the .05 level.

In the same vegetative growing pattern, such as plant height in Irish patients, Jaetzold, Schmidt, Hornetz, and Shisanya (2006) reported that increased concentrations of N, P and K provided by inorganic fertilizers were gradually impacting on the available K available in the soil. By comparison, plant height was low for the 12-week checks and Gao et al. (2017) decided that nitrogen influences on the equilibrium between potato vegetative and reproductive development The parameters of vegetative growth such as the height and gradual rise in oxygen apps from up to 285 kg K_2O /ha were noted contrary to present conclusions by Abay and Sheleme (2011).

There were important variations ($p<0.05$) in crop height in various potato types. The largest crop height (70 cm) was discovered in Sherekea and the smallest (40 cm) of Markies was discovered over the remaining species tested. The distinction in its development personality affected by the plant's genetic make-up could be ascribed (Enujeke, 2013). K and varieties were interacting significantly on plant height. The three types showed differential reactions to potassium intake when the largest plant height of Sherekea and Kenya Mpya were at 70 and 60 cm and handled at 150 kg K_2O / ha respectively. At 100 kg k20/ha, Sherekea reacted better (Figure 4.3).

4.4 Fertilizer Rate on Number of Leaves per Plant

The study wanted to find out the relationship between fertilizer applications on the number of leaves per plant. The findings from the experiment were as below:

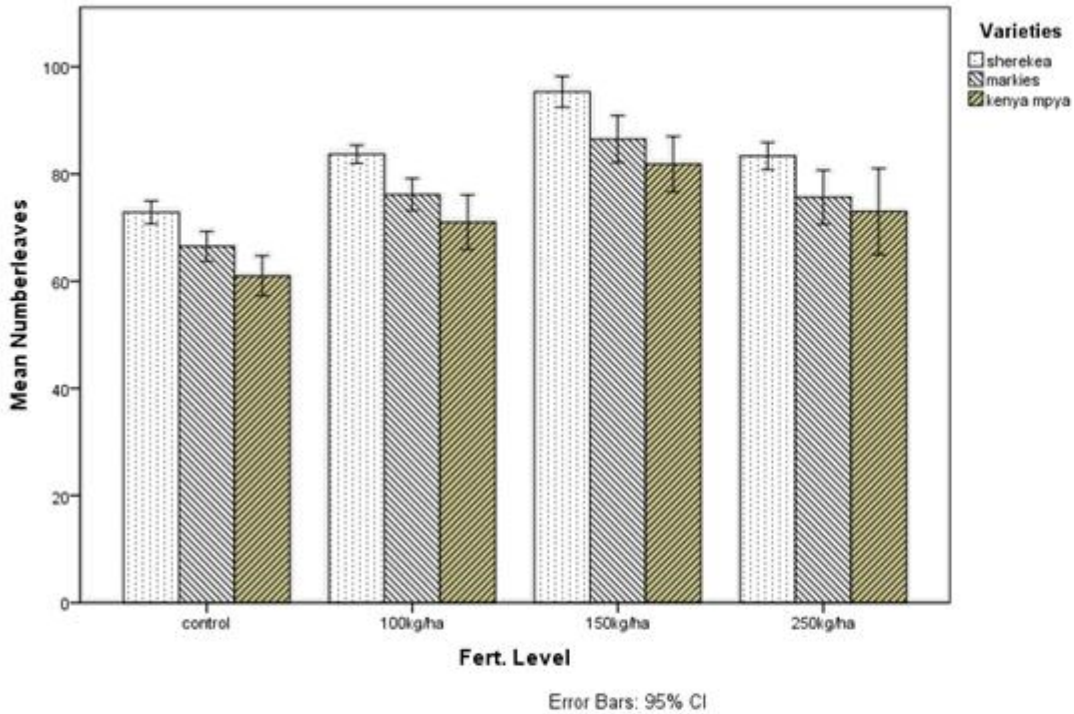

Figure 4.4**: Fertilizer Rate on Number of Leaves/ Plant**

From figure 4.4, it was noted that the number of leaves per plant was significantly different ($P<0.05$) in both fertilizer rate and variety. Sherekea variety was the best in terms of leaf number in both Meru and Milimani sites with an average 90 leaves/plant. However, there was no significant difference in leave number between two sites in terms of fertilizer level and varieties (Figure 4.4). This research is in agreement with a survey carried out by Li et al. (2015), which discovered the important impact of potassium implementation on the amount of plant leaves generated ($p<0.05$). The research, however, has stated that the amount of leaves per plant is 57.83, and the largest amount of leaves/plant was 95 in this research. This is in line with Noor's (2010) results that the largest leaves/plants were collected using 150 kg of K_2O / ha. The distinction between the three species was extremely important in the number of leaves per crop ($p<0.05$). The largest amount of leaves per plants (95) were generated by Sherekea, followed by Kenya Mpya (85) and Markies (64).

Growth differences in potatoes like the number of leaves are affected by the genetic composition of plants (Muthoni, 2016).

Table 4.7

Number of Leaves

Source	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	11	530.014	32.555	.000
Intercept	1	429510.014	26381.779	.000
Varieties	2	895.056	54.977	.000
Fert.Level	3	1337.718	82.167	.000
Varieties * Fert.Level	6	4.481	.275	.946
Error	60	16.281		
Total	72			

Table 4.8

ANOVA Number of Leaves

					Lower Bound	Upper Bound
Markies	Sherekea	-7.58*	1.165	.000	-9.91	-5.25
	Kenya Mpya	4.50*	1.165	.000	2.17	6.83
Kenya Mpya	Sherekea	-12.08*	1.165	.000	-14.41	-9.75
	Markies	-4.50*	1.165	.000	-6.83	-2.17
Sherekea	Markies	7.58*	1.165	.000	5.25	9.91
	Kenya Mpya	12.08*	1.165	.000	9.75	14.41

The error term is Mean Square(Error) = 16.281.

*. The mean difference is significant at the .05 level.

Species with more stems tend to grow more vegetative, leading to more leaves. However, the present research discovered that the Markies range (Figure 4.4), which generated the number of branches, produces fewer seeds per crop, which contradicts what Abubaker et al. (2011) have observed.

4.5 Fertilizer Rate on Leaf Area Index

The study wanted to find out the effect of fertilizer rate on leaf area index of Irish potatoes. Below were the findings from the experiment on this objective.

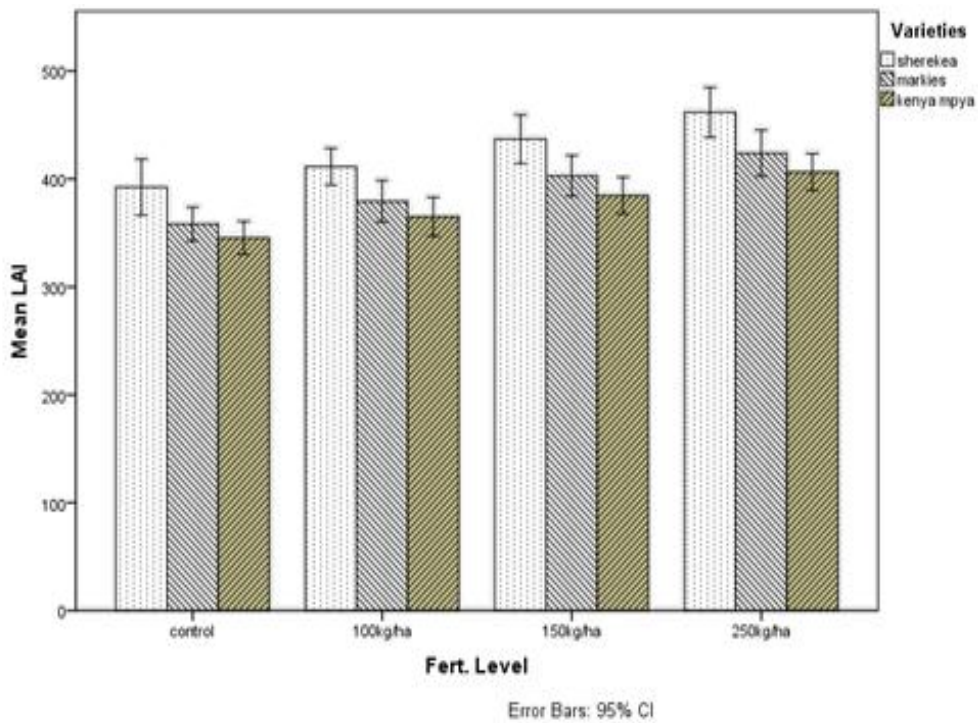

Figure 4.5. **Fertilizer rate on Leaf Area Index**

In terms of leaf area index (L.A.I), there was a significant difference between different fertilizer rates. 0 kg/ha produced plants with smaller L.A.I. The L.A.I increased with the increase in fertilizer rate. Varieties Sherekea and Markies were better in terms of L.A.I as compared to Kenya Mpya in both Meru and Milimani sites (Figure 4.5). Due to this relationship with potassium and potato species, variability in the anatomy, and development pattern thus results in the reaction of K plants to fertilizers may occur in L.A.I (Haile 2009).

Table 4.9.

Fertilizer on Leaf Area

Source	df	Mean Square	F	Sig.
Corrected Model	11	6820.620	19.678	.000
Intercept	1	11366117.347	32791.869	.000
Varieties	2	15809.556	45.611	.000
Fert.Level	3	14409.051	41.571	.000
Varieties * Fert.Level	6	30.093	.087	.997
Error	60	346.614		
Total	72			
Corrected Total	71			

Table 4.10.

ANOVA on Fertilizer and Leaf Area

(I) Varieties	(J) Varieties	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sherekea	Markies	34.50*	5.374	.000	23.75	45.25
	Kenya Mpya	50.17*	5.374	.000	39.42	60.92
Markies	Sherekea	-34.50*	5.374	.000	-45.25	-23.75
	Kenya Mpya	15.67*	5.374	.005	4.92	26.42
Kenya Mpya	Sherekea	-50.17*	5.374	.000	-60.92	-39.42
	Markies	-15.67*	5.374	.005	-26.42	-4.92

Based on observed means.
The error term is Mean Square (Error) = 346.614.

*. The mean difference is significant at the .05 level.

4.7 Fertilizer Rate on Weight/Sizes

The study sought to find out the effect of fertilizer rate application on the weight of the medium-large size of Irish potatoes. It was observed in figure 4.6, that with an increase of fertilizer application especially, for Sherekea variety, the medium-large weight increased. In markies variety, there was a significant increase in weight when 150 kg/acre was applied. Comparatively, There was no significant difference ($P<0.05$) between different fertilizer levels and potato varieties. Tuber development is improved by K and reduces the percentage of big tubers compared to smaller ones, as tuber water build-up rises and thus dry matter levels are reduced and special gravity is lowered.

This merely implies that crops provided with more K-rich and chloride-enriched compound fertilizer can generate tubers bigger than crops provided with less. Nutrients improve the value and marketability of tubers. Increased implementation of potassium from 0 to 250 kg/ha considerably enhanced tuber weight per crop ($p<0.05$). The greater implementation of K makes it easier for the plant to have stronger nutrients and water absorption that enhance productivity and the growth of the plant.

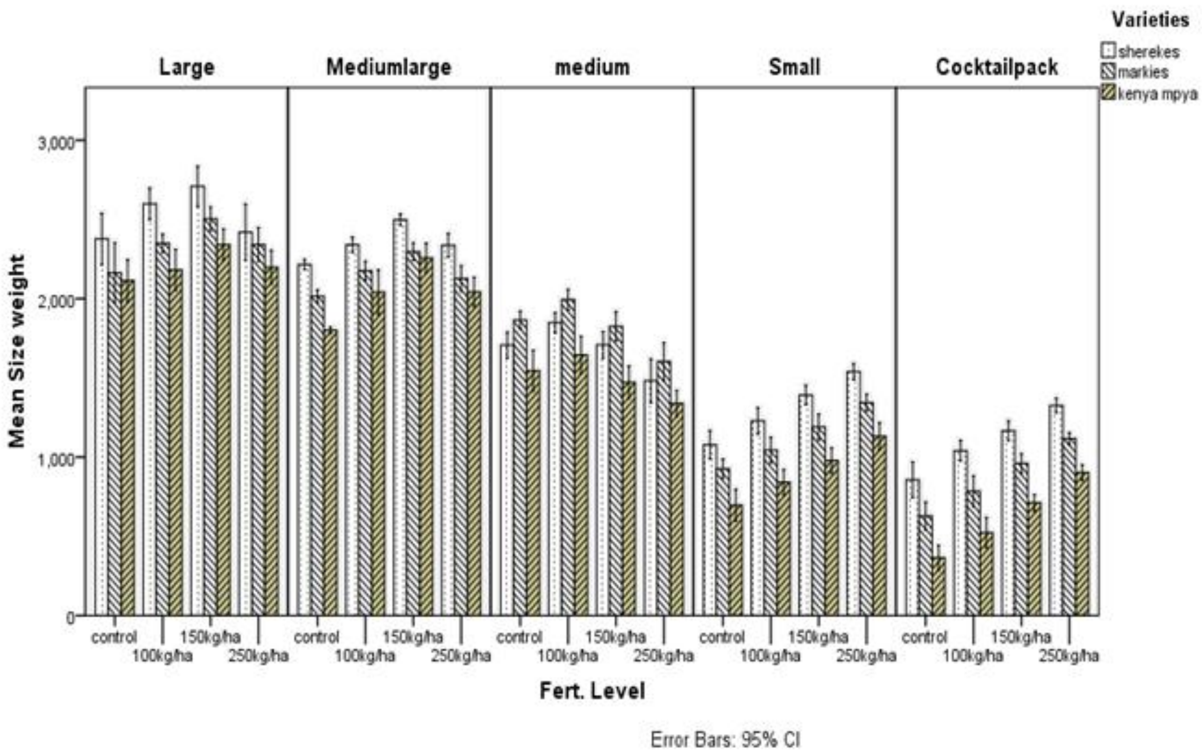

Figure 4.6: **Fertilizer Rate on Weight/Sizes**

A sharp response from potato to a tuber weight application was identified by El-Sayed, Hassan and El-Mogy (2015). Figure 4.6 illustrates further that tuber weight per plant was considerably ($p < 0.05$). Markies was higher than the three types assessed and Sherekea was pursued. Abubaker et al. (2011) have noted that important variances in their annual output and tuber manufacturing by the plant have been recorded in accordance with that finding. The fact that potato's use of nutrients differs between cultivars and distinct economic circumstances is attributed to this variability. However, with a rise in K concentrations, all the types showed steady growth in their tuber weight.

Table 4.11.

Fertilizer rate and Weight

Source	df	Mean Square	F	Sig.
Corrected Model	11	851203.838	2.275	.011
Intercept	1	964062151.111	2576.744	.000
Varieties	2	3458141.944	9.243	.000
Fert.Level	3	807308.889	2.158	.093
Varieties * Fert.Level	6	4171.944	.011	1.000
Error	348	374139.674		
Total	360			
Corrected Total	359			

Table 4.12

ANOVA on Fertilizer rate and Weight

(I) Varieties	(J) Varieties	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sherekea	Markies	130.92	78.966	.098	-24.39	286.23
	Kenya Mpya	336.75*	78.966	.000	181.44	492.06
Markies	Sherekea	-130.92	78.966	.098	-286.23	24.39
	Kenya Mpya	205.83*	78.966	.010	50.52	361.14
Kenya Mpya	Sherekea	-336.75*	78.966	.000	-492.06	-181.44
	Markies	-205.83*	78.966	.010	-361.14	-50.52

Based on observed means.
The error term is Mean Square(Error) = 374139.674.

*. The mean difference is significant at the .05 level.

4.9 Fertilizer Rate on Yield

The study sought to find out the correlation between the fertilizer rates application on the yields and three varieties of potatoes. The findings were recorded in figure 4.7.

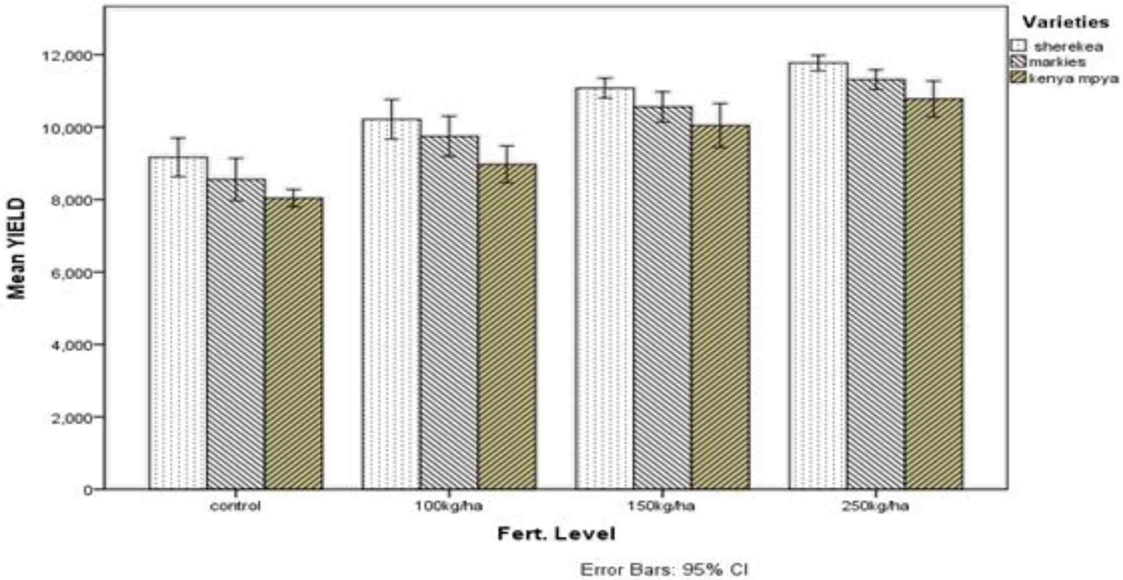

Figure 4.7**: Fertilizer Rate on Yield**

The finding from figure 4.7 indicates that there was a significant difference ($P<0.05$) between fertilizer level and variety. The yield increased with increase in fertilizer rate. Generally, 150 kg/ha produced the highest yield. Variety Sherekea recorded the highest yield of 12 t/ha compared with variety Kenya Mpya which recorded the lowest yield of 8 t/haThe impact of potassium concentrations on the potato output tuber was assessed in kg, with the plant handled 250 kg K20/ha being achieved the largest important numbers relative to other K fertilizer procedures, while controlled (without adding K fertilizers) were reported in the smallest doses. Weight of the tuber improved by the addition of up to 250 kg/ha of elevated class K fertilizers. Faridi-Myvan et al. (2018) also achieved this trend, finding that complete tuber output has been improved gradually and substantially, with the increase in the amount of potassium applied in both growing seasons. They also found that potassium applications from (100, 150 to 250 kg) considerably influenced the nutrient concentrations of potato tubers.

Average potato returns, ranging between 24-28 tons/ha or 0.648-0.756 kg per crop unit, were achieved for potato output in kg due to the accessibility of phosphorus, magnesium and mineral nutrients in the land. The findings also correspond with the outcomes reported on by Franke et al. (2014), which stated that plant exposures to nutrients result in a rise in overall tuber yield/ha for inorganic fertilizers. Furthermore, the significance of phosphorus in potato manufacturing and its absence in development was shown by Ghiyal and Bhatia (2017) to have significantly decreased yields. The effect of potassium on the physiological tuberization process in potato plants is seen as one of the most significant factors that affect potato growth and return.

Results in (Figure 4.7) showed the increase in potassium output of potato tuber and that the difference between the potato and all types was important ($p<0.05$). Application of 250 kg of K_2O / ha produced the highest tuber output (12 t / ha). Haile (2009) revealed that the complete tuber output was increasing gradually and substantially as a consequence of the enhanced rate K. Consistent with its recent outcomes. They noted that with the use of 285 kg K_2O / ha, the production reached its highest level. K was essential in carbohydrate production and handling. Significant variations were also observed ($p<0.05$). Sherekea yielded the largest tuber output of 16.7% against Markies and 33.3% over Kenya Mpya. The variety is grown considerably influenced the potato response to applied K. The capability of utilizing more k from the soil source in some potato varieties is the cause of low response to K application. A variety yield potential and the number of large-sized tubers it can produce is often related to its response to applied K.

Small tubers of variants react less than those with the quick bulking capability to apply K because tuber size is boosted with the application of K (Knowles & Knowles, 2016). The results of the Central Potato research station in Jalandhar, Punjab showed a wide variety in the potassium effectiveness of various potato varieties. The results of this experiment Varieties with a greater potassium efficiency yielded fewer doses of K fertiliser than those of less effective crops. Gupta, Kushwaha, and Chattopadhyaya (2016) have, contrary to the present findings, observed that the cultivar does not have any important impact on tuber yields by unit area.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The research found that the usage of K fertilizer affected the stem quantity of the potato. This might be due to the essential function of K in energy usage, starch synthesis, N metabolism and respiration in enzymatic operations. In the meristematic tissue, these proteins are abundant, where cells divide and main tissues development takes place. It was also concluded that different fertilizer rates applied to different potato varieties, the different plant stand count was not significantly different on fertilizer rates.

The research further found that the increased vegetative development for potato crops can be due to the position that potassium plays in plant nutrition through increased utilization of potassium fertilizer, that is to say, the advancement of enzyme activities and the improvement of the translocation of assimilates and protein synthesis influencing plant height. It was also found that the amount of leave from the two locations in terms of potato plants and fertilizer was not significant.

It was further noted that the LAI witnessed an increase proportionately with the rate of applied potassium due to changes in the physiology, morphology and habit of growth of the crop varieties, and also to their response to the fertilizer application. In conclusion, the study concluded that K enhances tuber growth and increases the proportion of large tubers compared to large ones by increasing the accumulation of water in tubers which reduces dry matter content and specific gravity. This just makes it easy for plants with more K rich and chloride enriched compound fertilizers can produce larger tubers compared to plants with less chloride.

From the study findings, it was concluded that there was a significant relationship between various rates of potassium application rate on the three potato varieties. For instance, Potassium chloride application of 150 kg/ha on the three varieties produced the largest potato weights. Tuber growth was enhanced by the application of potassium nutrient as it increased proportion of large tubers relative to small ones It was also concluded that optimal yields as per variety basis were realized at application rate of 250 kg/ha on Sherekea variety, 150 kg/ha on Markies and 100 kg/ha on Kenya Mpya.

5.2 Recommendations

From the study findings, it was recommended that farmers who are producing potatoes for the warehouse market apply 150 kg/ha on varieties Markies and Kenya Mpya but 250 kg/ha on variety Sherekea on account of their yield performances respectively. It was also recommended that potato seed growers use application rate of 100 kg/ha in any of the three varieties as it yielded tuber sizes suitable for seed use. Overall Sherekea variety was well recommended for Milimani location Saboti Sub County Trans Nzoia County on account of this research study.

5.3 Suggestion for Further Research

Studies are recommended to be done on the relationship between soil pH and potassium chloride application on the productivity of potatoes in all parts of Kenya where Potatoes are produced or where potential exists (above 250 k/a).

Further research needs to be done on the effect of potassium foliar fertilizer on potato yields. More researches need to be conducted to find out the influence of the combination of basal and foliar application of potash fertilizer on potato yield and quality.

REFERENCES

Abay, A., & Sheleme, B. (2011). The influence of potassium fertilizer on the production of potato (Solanum tuberosumL.) at Kembata in Southern Ethiopia. *Journal of Biology, Agriculture and Healthcare, Vol, 5*(1), 1-12. Retrieved from https://www.iiste.org › Journals › index.php › JBAH › article › view

Abubaker, S., AbuRayyan, A., Amre, A., Alzu'bil, Y., & Hadidi, N. (2011) Impact of cultivar and growing season on potato under centre pivot irrigation system. *World Journal of Agricultural Science*, Vol *7*(6), 718-721. Retrieved from https://www.scirp.org › pdf › ajps_2016082314224851

Al-Moshileh, A. M., & Errebi, M. A. (2004). Effect of various potassium sulfate rates on growth, yield and quality of potato grown under sandy soil and arid conditions. In *International Potash Institute. Regional workshop on Potassium and Fertigation development in West Asia and North Africa, Rabat, Morocco* (24-28). Retrieved from https://www.researchgate.net › publication › 329414830_Effect_of_Potassiu.

Ali, M.R., Costa, D.J., Abedin, M.J., Sayed, M.A. & Basak, N.C. (2009) Effect of fertilizer and variety on the yield of sweet potato. *Bangladesh Journal of Agricultural Research*, *34*(3), 473-480.Retrieved from https://www.banglajol.info/index.php/BJAR/article/viewFile/3974/3250/

Bărăscu, N., Ianoşi, M., Duda, M. M., & Donescu, V. (2015). The effect of high NPK levels on potato yield size structure and tubers starch content. *Scientific Papers-Series A, Agronomy, 8(2)*, 136-142. Retrieved from https://www.cabdirect.org › cabdirect › abstract › 20153325223

Bizimana, C., Usengumukiza, F., Kalisa, J., & Rwirahira, J. (2012). Trends in key agricultural and rural development indicators in Rwanda. *The Rwanda Strategic Analysis and Knowledge Support System (SAKSS), Ministry of Agriculture and Animal Resources (MINAGRI), Kigali*. Retrieved from www.resakss.org › sites › default › files › pdfs › trends-in-key-agricultural...

Brown, B., Hoshide, A. K., & Gallandt, E. R. (2019). An economic comparison of weed management systems used in small-scale organic vegetable production. *Organic Agriculture*, *9*(1), 53-63. Retrieved from https://www.semanticscholar.org › paper › An-economic-comparison-of-wee...

Cambouris, A. N., St Luce, M., Zebarth, B. J., Ziadi, N., Grant, C. A., & Perron, I. (2016). Potato response to nitrogen sources and rates in an irrigated sandy soil. *Agronomy Journal*, *108*(1), 391-401. Retrieved from agr.gc.ca › science-and-innovation › Quebec › scientific-staff-and-expertise

El-Sayed, S. F., Hassan, H. A., & El-Mogy, M. M. (2015). Impact of bio-and organic fertilizers on potato yield, quality and tuber weight loss after harvest. *Potato Research*, *58*(1), 67-81. Retrieved from https://www.semanticscholar.org › paper › Impact-of-Bio-and-Organic-Fertil.

Enujeke, E. C. (2013). Effects of variety and spacing on growth characters of hybrid maize.*Asian Journal of Agriculture and Rural Development*, *3*(5), 296. Retrieved from http://www.academia.edu/download/31570235/6-234-

Faridi Myvan, F., Jami Al-Ahmadi, M., Eslami, S. V., & Shojaei Noferest, K. (2018).*Studying the effect of planting pattern and potassium fertilizer levels on some physiological characteristics and yield of potatoes (Solanum tubers Lycopersicon .) under different irrigation levels*. Retrieved from agris.fao.org › agris-search › search › recordID=IR2018700050

Franke, A. C., Steyn, J. M., Ranger, K. S., & Haverkort, A. J. (2011). Developing environmental principles, criteria, indicators and norms for potato production in South Africa through field surveys and modelling. *Agricultural systems*, *104*(4), 297-306. Retrieved from https://research.wur.nl › publications › developing-environmental-principal...

Funnekotter, B., Sortey, A., Bunn, E., Turner, S. R., & Mancera, R. L. (2016). Influence of abiotic stress preconditioning on antioxidant enzymes in shoot tips of Lomandra sonder (Asparagaceae) prior to cryostorage. *Australian Journal of Botany*, *64*(3), 260-268. Retrieved from https://www.publish.csiro.au ›

Gao, X., Parsonage, S., Tenuta, M., Baron, K., Hanis-Gervais, K., Nelson, A. & Mohr, R. (2017). Nitrogen fertilizer management practices to reduce N 2 O emissions from irrigated processing potato in Manitoba. *American Journal of Potato Research*, *94*(4), 390-402. Retrieved from https://www.nrcresearchpress.com › doi › abs › cjss2012-057

Ghiyal, V., & Bhatia, A. K. (2017). Influence of Nitrogen Application Frequency on Yield and Economics of Drip Irrigated Potato (Solanum tuberosum *Lycopersicon* .) Cv. Kufri Bahar. *Int. J. Curr. Microbiol. App. Sci*, *6*(5), 753-758. Retrieved from www.ijpab.com › 2017 Volume 5, issue 1 › IJPAB-2017-5-1-484-488

Gupta, N., Kushwaha, A. K., & Chattopadhyaya, M. C. (2016). Application of potato (Solanum tuberosum) plant wastes for the removal of methylene blue and malachite green dye from aqueous solution. *Arabian Journal of Chemistry*, *6*(3), 295-305. Retrieved from https://core.ac.uk › download › pdf

Haile, W. (2009).Onfarm verification of potassium fertilizer effect on the yield of Irish potato grown on acidic soils of Hagere Selam, southern Ethiopia. *Ethiopian Journal of Natural Resources*, *11*(2), 207-221. Retrieved from https://www.researchgate.net › publication › 235976802_onfarm_veri..

Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2016). *Soil fertility and fertilizers*.India; Pearson Education.

Jaarsma, R., de Vries, R. S., & de Boer, A. H. (2013). Effect of salt stress on growth, Na+ accumulation and proline metabolism in potato (Solanum tuberosum) cultivars. *PLoS One*, *8*(3), 60183. Retrieved from https://www.ncbi.nlm.nih.gov › PubMed

Jaetzold, R., Schmidt, H., Hornetz, B., & Shisanya, C. (2006). Farm management handbook of Kenya Vol. II: Natural conditions and farm management information Part C East Kenya Subpart C1 Eastern Province. *Cooperation with the German Agency for Technical Cooperation (GTZ)*. Retrieved from library.wur.nl › Osric › Fulltext › isricu_i00023897_001

Kempenaar, C., Been, T., Booij, J., Van Evert, F., Michielsen, J. M., & Kocks, C. (2017). Advances in variable rate technology application in potato in The Netherlands. *Potato research*, *60*(3-4), 295-305. Retrieved from https://link.springer.com › article

Kiiya, W. W., Mureithi, J. G., & Kiama, J. M. (2006). Improving the production of Irish potato (Solanum tuberosum, L.) in Kenya: The use of green manure legumes for soil fertility improvement. *Development and upscaling of green manure legumes technologies in Kenya. 1*(7), 98-102. Retrieved from *www.academicjournals.org › app › webroot › article*

Knowles, L. O., & Knowles, N. R. (2016). Optimizing tuber set and size distribution for potato seed (Solanum tuberosum Lycopersicon .) expressing varying degrees of apical dominance. *Journal of plant growth regulation*, *35*(2), 574-585. Retrieved from https://app.dimensions.ai › details › publication › pub.1041356468 › or_fa

Li, S., Duan, Y., Guo, T., Zhang, P., He, P., Johnston, A., & Shcherbakov, A. (2015). Potassium management in potato production in the Northwest region of China. *Field Crops Research*, *1(4)*, 48-54. Retrieved from china-zh.ipni.net › beagle › CZH-3055&f=Potassium management is potato

Mahmoud, A. R., & Hafez, M. M. (2010). Increasing productivity of potato plants (solanum tuberosum, l.) by using potassium fertilizer and humic acid application. *International Journal of Academic Research*, *2*(2), 12-32. Retrieved from article.sciencepublishinggroup.com › 10.11648.j.ajaf.20150305.20.pdf

Masood, S., & Bano, A. (2016). Mechanism of potassium solubilization in the agricultural soils by the help of soil microorganisms. In *Potassium solubilizing microorganisms for sustainable agriculture, 5*(4), 1762-1765. Retrieved from https://scielo.conicyt.cl › pdf › jsspn › art05

Mengel, K., Kirkby, E. A., Kosegarten, H., & Appel, T. (2001). *Nitrogen; In Principles of plant nutrition* (pp. 397-434). Springer: Dordrecht.

Muthoni, J. (2016). Soil fertility situation in potato producing Kenyan highlands case of KALRO-Tigoni. *International Journal of Horticulture*. Retrieved from biopublisher.ca › index.php › ijh › article › view

Noor, M. A. (2010). *Physiomorphological determination of potato crop regulated by potassium management* (Doctoral dissertation, Doctoral thesis) submitted to Institute of Horticultural Sciences University of Agriculture, Faisalabad, Pakistan. Retrieved from *https://www.pakjas.com.pk › papers*

Perrenoud, P. (1993). *Le métier d'enseignant entre prolétarisation et professionnalisation: deux modèles du changement*. Faculté de psychologie et de sciences de l'éducation: Service de la recherche sociologique. Retrieved from https://www.unige.ch › teachers › php_main › php_1996

Pervez, M. A., Ayyub, C. M., Shaheen, M. R., & Noor, M. A. (2013).Determination of physiomorphological characteristics of potato crop regulated by potassium management.*Pakistan Journal of Agricultural Sciences*, *50*(4), 611-615. Retrieved from https://pakjas.com.pk/papers/2194.pdf

Raigond, P., Mehta, A., & Singh, B. (2018). Sweetening during low-temperature and long-term storage of Indian potatoes. *Potato research*, *61*(3), 207-217. Retrieved from https://pubag.nal.usda.gov › catalogue › 6135217

Rens, L., Zotarelli, L., Alva, A., Rowland, D., Liu, G., & Morgan, K. (2016). Fertilizer nitrogen uptake efficiencies for potato as influenced by application timing. *Nutrient cycling in agroecosystems*, *104*(2), 175-185. Retrieved from europepmc.org › abstract › AGR › IND605151986

Rhouma, A., Salem, I. B., Boughalleb-M'Hamdi, N., & Ruiz, J. I. (2016). Efficacy of two fungicides for the management of Phytophthora infestans on potato through different applications methods adopted in controlled conditions. *International Journal of Applied and Pure Science and Agriculture*, *2*(12), 39-45. Retrieved from www.journalcjast.com › index.php › CJAST › article › download

Sarkar, K., Gupta, R. K., Kakraliya, S. S., Kumar, A., Bochalya, R. S., & Choskit, D. (2018). Comparative studies of conventional and minitubers of potato (Solanum Tuberosum L.) Varieties As Influenced By Potassium Levels. *Journal of Global Biosciences*, *7*(8), 5550-5561. Retrieved from https://www.mutagens.co.in › job › vol.07

Singh, V., Das, M., & Das, S. K. (2016). Effect of varying knife speed and contact area on peak cutting force during slicing of peeled potato (Solanum tuberosum). *International Food Research Journal*, *23*(6), 2513. Retrieved from www.ifrj.upm.edu.my › 23 (06) 2016

Svenson, S., & Aide, M. (2017).Evaluation of potato potassium, phosphorus, and sulfur uptake and leaching under centre pivot irrigation in Southeastern Missouri. International Journal of Applied Agricultural Research, *12*, 309-319. Retrieved from https://www.ripublication.com › ijaar17

Wang, Y., & Wu, W. H. (2017).Regulation of potassium transport and signaling in plants. *Current opinion in plant biology*, *39*, 123-128. Retrieved from sklppb.cau.edu.cn › upload › editorfiles › 2017.9.19_9.21.36_6653.pdf

Wibowo, C., Wijaya, K., Sumartono, G. H., & Pawelzik, E. (2014). Effect of potassium level on quality traits of Indonesian potato tubers. *Asia Pacific Journal of Sustainable Agriculture, Food and Energy*, *2*(1), 11-16. Retrieved from http://journal.bakrie.ac.id/index.php/APJSAFE/article/view/424-1655-1-PB

Witold, G., Pavel, Č., Evan, R., Witold, S., Jarosław, P., & György, F. (2017). Potassium impact on nitrogen use efficiency in potato–a case study from Central-East Europe. *Plant, Soil and Environment*, *63*(9), 422-427. Retrieved from https://www.agriculturejournals.cz › public files › 344_2017-PSE

APPENDICES

Appendix I: Soil Analysis

The following was the report of the soil sample submitted to KEPHIS analytical laboratory on 23rd March 2016 for fertility. Soil PH range from 5.39 to 5.62 which was moderately acidic in both sites. Phosphorus was marginal in site A (Meru farm) and deficient in site B i.e available phosphorous (p) parts per, millimetre was 9.64ppm at site B which was less than 20 which was the deficiency level and 23.84ppm.

Report of analysis.

Analytical Laboratory for fertility evaluation analysis

Client's sample Identification code	**Milimani Farm**	**Meru Farm (Top-Soil)**	**Meru Farm (Sub-Soil)**
Laboratory code	KS16020	KS16021	KS16022
pH (H_20) 1:2.5	5.62	5.39	5.61
Sodium (Na) m.e. %	0.40	0.30	0.44
Potassium (K) m.e. %	0.19	0.81	0.41
Calcium (Ca) m.e. %	2.89	4.00	3.56
Magnesium (Mg) m.e. %	2.12	1.92	2.20
Manganese (Mn) m.e. %	1.14	1.03	0.92
Available Phosphorus (P) ppm	9.64	23.84	11.44
Total Nitrogen (N %)	0.29	0.28	0.24
Carbon (C) %	1.00	1.06	0.97
Copper (ppm)	1.98	1.35	0.56
Iron (ppm)	24.39	34.89	21.75
Zinc (ppm)	8.91	8.14	5.61

Source: (KEPHIS)

The soils are moderately acidic. Site of Milimani was deficient of K

Table 1 Nutrients levels of the soil sample

Sample Identification Code **Laboratory Code**	**SITE B KS16020**	**SITE A KS16021**	**A SUBSOIL KS16022**	**REMARKS**
PH(H_2O) 1:2.5	5.62	5.39	5.61	Moderately Acidic
Sodium (Na)M.E%	0.40	0.30	0.44	Adequate levels – between 0.0-2.0
Potassium (K)M.E%	0.19	0.81	0.41	Site B-has deficiency of K less than 2.0. Site A has adequate levels of more than 2.0.
Calcium (Ca)M.E%	2.89	4.00	3.56	Adequate levels i.e. 2.0 – 15.0
Manganese (MN) M.E %	1.14	1.03	0.92	Site A- deficient less than 0.11 Site B- adequate levels – between 0.11-2.0
Available phosphorus (P)PPM	9.64	23.84	11.44	Site A- Deficient less than 2.0 Site B-Deficient less than 2.0

Total Nitrogen (N)%	0.29	0.28	0.24	Adequate levels.
Carbon (C) %	1000	1.06	0.97	Adequate levels
Copper (PPM)	1.98	1.35	0.56	Adequate in site B but deficient in site A it is below 1.0.
Iron (PPM)	24.39	34.89	21.75	It has an adequate level of levels of above 10.0
Zinc (PPM)	8.91	8.14	5.61	Adequate levels as it is above 5.0

Source: (KEPHIS)

Analytical Laboratory for fertility evaluation analysis

Client's sample Identification code	**Milimani Farm**	**Meru Farm**
Laboratory code	KS 16065	KS16066
pH(H_20) 1:2.5	5.24	5.32
Sodium (Na) m.e. %	0.61	0.41
Potassium (K.) m.e. %	0.57	0.94
Calcium (Ca) m.e. %	3.25	4.31
Magnesium (Mg) m.e. %	ND	0.26
Manganese (Mn) m.e. %	1.16	0.28
Available Phosphorus (P) ppm	ND	14.55
~otal Nitrogen (N %)	0.33	0.42
Carbon (C) %	1.43	1.39
Copper (ppm)	ND	ND
ron (ppm)	21.98	15.05
3nc (ppm)	2.37	0.29

Source: (KEPHIS)