TIMING OF WEED CONTROL AND HARVEST DATE EFFECTS ON POTATO CROP FIELD PERFORMANCE AND MINERAL CONTENT

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PREFACE

The research contained in this dissertation was completed by the candidate while based in the Discipline of Crop Science, School of Agricultural, Earth and Environmental Sciences, in the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Pietermaritzburg Campus, South Africa. The research was financially supported by Moses Kotane Institute

The contents of this work have not been submitted in any form to another university and, except where the work of others is acknowledged in the text, the results reported are due to investigations by the candidate.

Signed: Professor Albert T. Modi (Supervisor)

DECLARATION

I, Thobile Siphosethu Mdima declare that:

(i) the research reported in this dissertation, except where otherwise indicated or acknowledged, is my original work;

(ii) this dissertation has not been submitted in full or in part for any degree or examination to any other university;

(iii) this dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;

(iv) this dissertation does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been referenced;

b) where their exact words have been used, their writing has been placed inside quotation marks, and referenced;

(v) where I have used material for which publications followed, I have indicated in detail my role in the work;

(vi) this dissertation is primarily a collection of material, prepared by myself, published as journal articles or presented as a poster and oral presentations at conferences. In some cases, additional material has been included

[redacted]

Signed: Thobile MdimaDate: August 2020

ABSTRACT

Potato (*Solanum tuberosum*) is an important vegetable crop that is high on dietary minerals and vitamins that are needed by the human body but can be a weak competitor to weeds. The aim of the study was to determine the effect of weeds and harvest period on plant growth, yield and mineral content of tubers. The experiment was conducted at the University of KwaZulu-Natal's Ukulinga farm. The experiment had three weeding treatments namely control weed free, weed free till flowering stage then stop and no weeding. And two harvest periods which were early (90 days after planting) and late (120 days after planting). The crop was monitored from emergence using phenological (plant height and leaf number) and physiological (Leaf area index, Chlorophyll content index, photosynthetically active radiation, stomatal conductance) parameters during the growing stage prior to flowering. At harvest, the number of tubers, size of tubers and plant biomass were recorded to determine the yield. After yield determination the potato samples were taken to the laboratory for mineral content analysis. The results showed that there was a significant difference ($p<0.05$) in the weeding treatments with respect to the phenological parameters. The control weed free treatment had the highest plant growth and yield while the no weeding treatment had the lowest plant growth and yield. It was also observed that the early harvested tubers were smaller in size while the tubers harvested late were larger in size. This is because the tubers harvested late were given enough time to grow and mature. Harvesting early under the no weeding treatment resulted in significantly lower yields due to the decrease in tuber mass. There were significant effects of weed control and harvest timings with respect to mineral content in tubers. Potassium was found to be the dominant mineral element followed by phosphorus. These elements were found in levels that were up to 100 times higher than those of calcium, magnesium and sodium in potato tubers. It is concluded that delaying weed control reduces crop performance, yield and mineral content. However, delaying harvest time may provide an opportunity for the crop to accumulate more weight and mineral content in the tubers.

Keywords: Chlorophyll content index, Tubers, Biomass, Leaf area index, Photosynthetically active radiation, mineral content, yield

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Potato *(Solanum tuberosum)* is a vegetable crop belonging to the nightshade family (Solanaceae), including tomato and sweet pepper. In the world, potato is the most important non-grain food crop with over 365 million tonnes per year of total production ranking third (FAOSTAT, 2013), after wheat and rice. In the amount of protein/ha, potatoes are only second to soybean with patatin being the major protein storage and is the most balanced nutritionally protein known (Bradshaw and Ramsay, 2009). The recommended daily allowance of 45% of vitamin C and 10% of vitamin B6 can be provided by single tuber that weighs 150g as well as significant amounts of essential mineral nutrients required for human consumption (Liebman and Davis, 2000). Potato originated from the Andean region and later cultivated to other parts of the world. The crop thrives in soil temperatures higher than 7^{o}C, and soil temperatures lower than 21^{o}C. Soils should be moist and not wet at the time of planting (Bradshaw and Ramsay, 2009).

In the context of South Africa, the potato production gross value accounts for 15% of horticultural production, 43% of major vegetable and 4% of total agricultural production. Potato farmers harvest about R1.6 billion on average worth of potatoes annually. (DAFF, 2010).

The presence of weeds can seriously affect potato yields. Weeds should be managed within fields. Weeds can compete with potato plants for light, water, and nutrients (Anderson, 2015). Weeds may also act as hosts for diseases within the field. Weeds can also interfere with the harvest and ultimately the yield and quality of potato (Boydston and Vaughn, 2003).

1.2 Motivation

Potatoes are vegetable crops that are cultivated in most regions of the world, and are known for their importance as excellent sources of Vitamin A, C and E, minerals (such as calcium) and carotenoids (Anderson, 2015), which are required by the human body. Weed infestation can cause serious damage to potato yields. Potato yields can be seriously affected since they compete for essential resources that are required by the potato plant (Wortman *et al*., 2010).

Weed infestation can slow down operations by entangling equipment and lifting the crop, which ultimately affects the growers/farmers time and business (Ciuberkis *et al*., 2007). Weeds also boost the presence of pests and diseases such as slugs and rhizoctonia, this ultimately leads to less yields and poor quality of potatoes produced (Mukherjee *et al*., 2012). There is a need to study and understand how the duration of weed infestation, timing of weed control and the timing of harvesting of potato plants when subjected to weeding periods, can have an effect on potato production and how these factors can be addressed in obtaining higher yields.

1.3 Problem statement

Weed competition in potato production poses a serious problem as it competes for essential resources that are required by the potato plant. when it comes to weed infestation, potatoes are a weaker competitor (Mukherjee *et al*., 2012). Uncontrolled weed growth reduces the tuber yield by up to 55.7% depending on the types of weeds present, their intensity and duration of crop weed competition. The quality of produce is also reduced by weed infestation and diseases (Bailey *et al*, 2001). Weeds can act as hosts for insects such as Aphids (Anderson, 2015). Timing of weed control is also important in obtaining higher yields. The longer the weed infestation, the lower the quality and quantity of potato tubers produced (Wortman *et al*., 2010). Tall weeds such as oilseed rape and grasses can grow above the potato plant thus shading and strongly competing for resources (Liebman and Davis, 2000).

1.4 Aims and objectives

The aim was to determine the weeding effect on potato growth, nutrient content and yield capacity with respect to three weeding treatments(control weed free, weed free until flowering and no weeding) and two harvesting periods (90 days after planting and 120 days after planting) when subjected to the three weeding treatments. The null hypothesis in the study was that the variation in weeding treatments will have no effect on the plant growth, nutrient content of tubers and yield.

The objectives of the study were

- To determine the effect of weeding on potato plant yield with respect to three weeding treatments namely, weed free (CW), Weeding up until flowering then stop` (FW) and no weeding throughout the growing season (NW).
- To determine and compare crop response to the three weeding treatments in terms of growth phenology and physiology parameter.
- To determine the crop response to the three weeding treatments and two harvest periods on the quantity and yield of potato tubers.
- To determine nutritional content availability of potato plant when subjected to three different weeding treatments and two harvest periods under normal field conditions.

1.5 Chapter overview

In chapter 1, the research background, motivation, objectives, and the hypothesis were presented. In chapter 2, Literature on growth and development, managements practices, crop protection, weeds and yield determination of potato tubers were reviewed. Chapter 3 presents findings on the effect of three weeding treatments and two harvest periods on the growth and final yield of potato tubers. Chapter 4 presents findings on the mineral content of tubers in response to the different weeding treatments, two harvest periods and the interaction between the harvest period and weeding treatment. The conclusions, summary, and recommendations from the findings of the study were presented in Chapter 5.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Potato belongs to the perennial nightshade *Solanum tuberosum* and is a tuberous crop that contains starch (Bernet *et al*., 2006). In many parts of the world, potatoes are a staple food crop ranking fourth in being the largest food crop following maize, wheat and rice (FAO STAT, 2013. Potatoes originated in the Andes (Southern Peru and extreme North-western Bolivia (Bradshaw and Ramsay, 2009). Generally, potatoes are grown from seed potatoes. These are tubers specifically grown to be disease free and provide healthy plants (Naik and Naik, 2003).

Potato is an important cash crop which gives ready cash to farmers. It contains important nutrients such as carbohydrates, proteins, vitamins, and minerals that are needed by the human body. It is one of the major vegetable crops and it is the richest source of starch (Azadbakht *et al*., 2017). Just over two thirds of the global production are directly consumed by humans with the rest being used to produce starch or is fed to animals. This therefore means that the average global citizens annual diet in the first 10 years annual diet of an average of the 21st century included about 33kg of potato (Beukema and Van der Zaag, 1990).

Potato yields can be seriously damaged by the presence of weeds. Weeds compete with the crop for light, water and other essential resources that are needed by the plant. Weeds also act as hosts for pests and diseases, thus affecting potato production in the field (Azadbakht *et al*., 2017). The review was therefore undertaken to understand the relationship of yield and weeding of potato plant in obtaining maximum production and sustaining food production

2.2 Botany and Ecology

Table 2.1: Potato botany (Pati and Sundaresha, 2016).

Kingdom	Plantae
Subkingdom	Viridaeplantae
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Order	Solanales
Family	Solanaceae
Genus	Solanum
Species	*Solanum tuberosum*

2.2.1 Botanical features

The growth habit of the herbaceous potato plant varies within species. The enlarged portion of the underground steam /stolon is known as the tuber of the potato plant. The buds from which next seasons will emerge are known as tuber eyes. Eyes are situated near the apical end of the tuber, with fewer near the basal end or stolon (Pati and Sundaresha, 2016). Eye distribution and eye number are characteristic of the variety. During the early stages of growth, the stem is erect but becomes spreading and prostrate later. The leaves are compound and alternate. Rhizome which elongates fast and produce tubers are formed from buds in the axil of the leaves. (Cutter, 1978). Depending on the variety potato plants with senescence, fruiting and the formation of tubers, the crop can grow about 60cm high. Although a considerable amount of self-fertilizing occurs, the plants are mostly cross pollinated by insects such as bumble bees.

potato plants produce small green fruits after flowering that bear a resemblance to green cherry tomatoes, each containing about 300 seeds (Bernet *et al*., 2006).

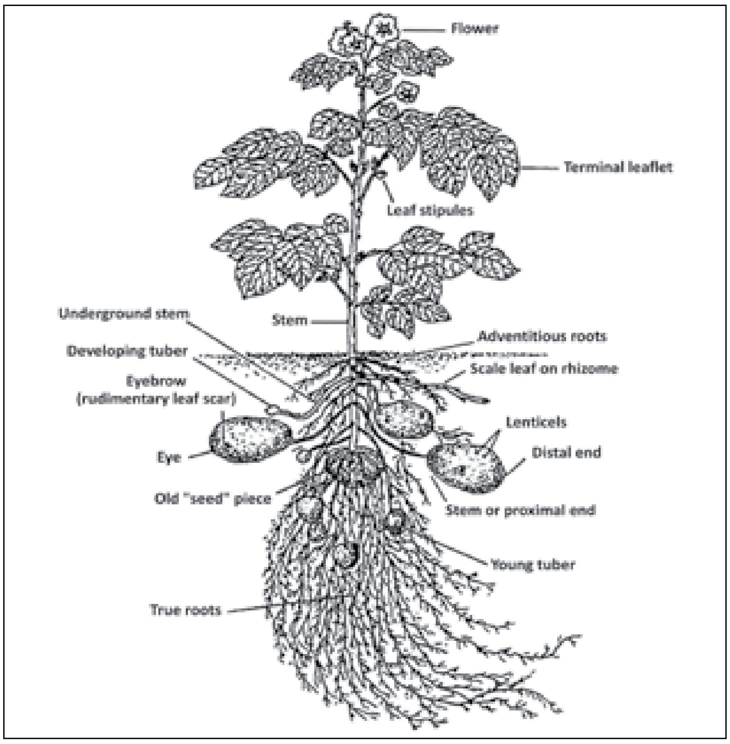

Figure 2.1: Potato plant (Bernet *et al*., 2006).

Figure 2.2 : Botanical features of the potato plant (Taberna, 2007).

2.3 Growth and development

The growth stages of potatoes can be broken down into 5 distinct stages according to Taberna (2007).

Growth stage I: Sprout development

In the first phase, the root grow begins when the sprouts have emerged from the seed potatoes. This stage takes about 10-30 days.

Growth stage II: Vegetative growth

In the second phase, the plant develops leaves, stolons and branches during photosynthesis. This phase takes about 15-20days.

Growth stage III: Tuber initiation

In the third phase, from lower leaf axils on the stem the stolons develop and grow downwards into the ground and new tubers develop from these stolons as swellings of the stolon. This phase takes about 15-30 days.

Growth stage IV: Tuber bulking

This phase takes place when the resources of the plant are invested mainly the plants newly produced tubers. Several factors at this stage are crucial in obtaining high yields. These factors include temperature, soil moisture, soil nutrient availability and the resistance to the attacks from pests.

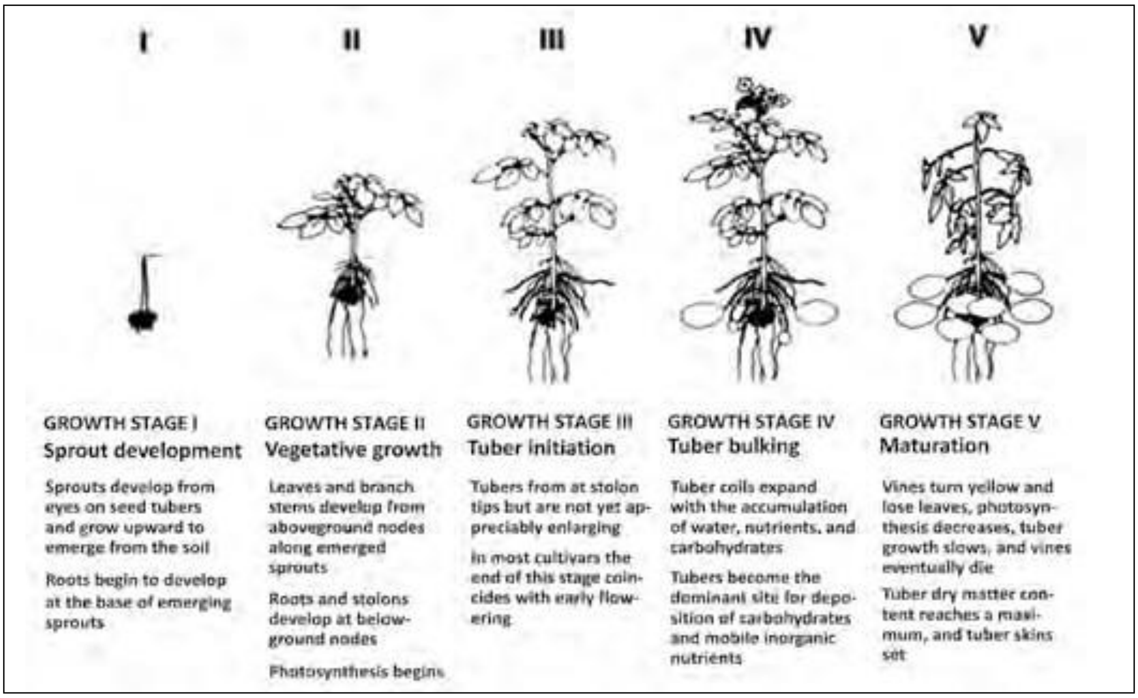

Figure 2.3: Growth stages of the potato plant (Taberna, 2007).

2.4 Environmental requirements

2.4.1 Rainfall

Potatoes require 500-700mm of rain or supplementary irrigation over 110 to 150 days of the growing season or a minimum of 800mm per annum under dryland conditions (Costa *et al*, 2008).

2.4.2 Temperature

Potatoes require cool temperatures with optimum between 16 and 18^{o}C being favourable. Tuber development stops at 30^{o}C. High temperatures promote foliage growth but retard tuber initiation. The crop is susceptible to frost (Costa *et al*., 2008).

Table 2.2 : The effect of different temperature on the growth and development of the potato plant (Pati and Sundaresha, 2016).

Temp. Cº	Effects
7-8	Slowly germination begins in the soil
10-12	After 23 days, buds start to appear in the soil
14-15	After 17-18 days, buds appear in the soil.
18-25	It is the perfect temperature for germination as buds appear after 12-13 days, above 25 Cº will cause delay in germination
20-25	It is the best temperature for development of leaves, photosynthesis and development of stems, and flowering for the plant.

2.4.3 Soil

Sandy loam soils are suitable the 25% clay present. pH range of 6 to 7 (Taberna, 2007).

2.5 Management Practices

2.5.1 Pre-planting

It is important to identify and review which diseases and pests have been the highest risk in the previous years in particular the soil-borne ones. This will help in determining which pests and diseases the crop may be exposed to and the most suitable method to use. Remove weeds and clean up the crop area. Avoid continuous cropping with potatoes. This reduces the growth of pests and diseases in the soil (Halseth, 2008).

2.5.2 Cultivar selection

Cultivar selection should be based on the soil type, cultural practices and intended market. The grower should then choose the variety that will work best with the farm resources and environmental requirements. No cultivar has all the desirable traits one would like, so one must choose what combinations that might work best (Halseth, 2008).

2.5.3 Fertility management

Soil tests and previous crop history of the field will help determine which fertilizers are required by the soil and at what rate. It is crucial to use suitable application rates as too little or too much can both cause significant quality and yield problems (Canali *et al*., 2012). One of the most important factors required in obtaining higher yields is proper nitrogen management. Prolonged plant maturity and proper skin set of potato tubers can be inhibited by excess nitrogen (N). Inhibited proper skin set makes tubers more prone to soft rot (Taberna, 2007). Potassium in the soil is required in large amounts by the potato since potassium plays an important role in the metabolic functions. Potassium (K) levels are important for tuber quality as low K levels are associated with smaller tuber size, brown and blackspot. (Laboski and Keilling, 2007).

2.5.4 Irrigation

It is important to provide a longer and less stressful growing environment. If the soil is too dry the plant roots cannot absorb nutrients in sufficient amounts and so plants will end up deficient in nutrients. Potatoes have no tolerance to water stress and so it is important to make sure that that plants are not under water stress (Halseth, 2008).

2.6 Crop protection

2.6.1 Hilling

Soil structure needs to be improved and maintained and create well drained hills. The development of diseases such as blackleg are favoured by soils that are poorly drained. It is important to maintain good soil cover throughout the growing season since good soil cover inhibits the exposure of tubers to potato moths and greening (Renner, 1992).

2.6.2 Diseases and control

Worldwide, Late blight is the most damaging disease of potatoes. It destroys stems, leaves, tubers, and it is caused by a water mould called *Phytophthora infestans*. (Beukema and Van der Zaag, 1990). Bacterial wilt is caused by the bacterial pathogen called *Ralstonia solanacearum*that leads to loses in yield. Blackleg in potatoes causes tubers to rot in the ground and in storage and is caused by a bacterial infection. Using tolerant varieties in rotation with non-susceptible crops and planting healthy seed in clean soil and other sanitary cultivation methods can help reduce the disease since there is no effective chemical control against Bacterial wilt (Bernet *et al*., 2006). Farmers use integrated pest management to reduce the need for chemical methods while increasing production (Halseth, 2008).

2.6.3 Harvesting

It is important to make sure that the tubers are mature before harvesting. Mature tubers have a protective skin which reduces the risk of infection. Potato tubers should be harvested as soon as they mature. Prolonged periods in the ground increases risk of exposure to pest and diseases (Taberna, 2007). Handling tubers with care during harvesting is important as damage to tubers creates an entry point for disease pathogenss. Harvesting in hot and dry conditions increases damage to tubers and runs the risk of rotting (Fuyi, 2010).

2.7 Weeds

Weeds are undesirable plants which compete with potato plants for light, water, and other essential nutrients that are needed by the potato plant. Weeds may also act as hosts for pests and diseases thus affecting tuber quality and yield (Ahmaduand *et al*., 2009).

2.7.1 Methods of weed control

2.7.1.1 Cultural weed control

The focal point of cultural weed control method is the prevention of the entry of new weeds into the field by managing weeds within the crop rotation and increasing the competitive ability of the crop with weeds by employing crop management decisions. (Ahmaduand *et al*., 2009).

Proper weed management of the potato plants starts with excellent weed management in previous years. Weeds such as sow thistle and night shades should be controlled by potato growers early since there a few control methods that are effective against these weeds (Azadbakht *et al*., 2017). Scouting the field regularly and can help identify the presence of new weeds. Preferably escaped weeds should not be allowed to set seed (Azadbakht *et al*., 2017).

2.7.1.2 Mechanical weed control

Annual weeds are effectively controlled with the use of mechanical weed control. Tillage practise can have a negative impact on yield, harvesting operations and quality if performed under wrong conditions. In post planting, hilling is the only required operation in potato production since hilling reduces the infection of diseases, minimizes frost damage, and prevents greening of the tuber (Costa *et al*., 2008).

2.7.1.3 Herbicide weed control

Potatoes have several herbicides that can be recommended in controlling weeds. Once the spray programme is planned based on the knowledge of the field, weed control can be achieved. Herbicides must be used responsibly. Roughly 15 to 30 days after planting, potato plants emerge and during this period a significant number of weeds germinate (Mukherjee, 2012).

Annual weeds can be controlled with the application of a non-selective herbicide just before the emergence of potato plants and this will also set back perennial weeds (Naik and Naik, 2003). If you begin with a pre-emergence herbicide treatment, you can apply post-emergence herbicide treatment if necessary. (Pramanick *et al,* 2004).

2.8 Timing of weed control

Weed control in potato plants needs to begin while the weeds are accessible to the treatment and the treatment should be able to control the weeds for up to 6-8 weeks after the crop has emerged (Ahmaduand *et al*., 2009).

In conventional farming systems, treatments are based on herbicide treatment. Depending on the soil type, dose and weather conditions, the application of the residual soil acting herbicide may be before crop and weed emergence which provides several weeks of control. Some residual herbicides can be used as the crop and weeds emerge since some have foliar as well as root activity (Anderson, 2015).

Thermal weed control systems and cultivations are used in organic farming systems. An alternative approach is however required since there is no residual effect from this treatment. Good kill of weeds can be achieved by planting under a low ridge which is built up by riding operations. This treatment works best while the weeds are at seedling stage. (Evans *et al*., 2003).

2.9 Effect of weeds

Weed infestation can cause serious damage to potato yields. Weed presence can slow down operations by entangling equipment and on lifting the crop. Weeds also boost the presence of some diseases and pests. Weeds also compete with the potato crop for water, nutrients, and (Ciuberkis *et al*., 2007. Weeds that entangle the crop such as knotgrass and bindweeds grow through the crop while tall weeds such as grasses can grow above the crop thus competing and shading for resources (Mukherjee *et al.*, 2012).

Weed presence can reduce potato yield and quality by causing a reduction in tuber size, quantity, and plant biomass. Interference of weed competition in potato plants can cause problems during harvest as more potatoes are left in the field (Costa *et al*., 2008). According to Mondani *et al*., (2011) if a mixed population of annual weeds can compete with potatoes all season, each 10% increase in dry weed biomass causes a 12% decrease in tuber yield. Roughly at four weeks after plant emergence, weed control should begin as this is the critical period of weed control in potato plants (Ahmaduand *et al*., 2009).

2.10 Yield and yield determination

The number of tubers per unit area and size of tubers are the two main yield components in potatoes. Maintaining a green leaf and achieving the highest number of tubers can contribute to increased yields (Anderson, 2015).

In the South African context, farmers who produce potatoes for processing aim at producing yields of 50tonnes per hectare at the lowest expense as possible. High yields can be achieved when cultivars are supplied with enough inputs and are grown in suitable conditions (Costa *et al*., 2008). The best quality of tubers depends on large tuber sizes, uniform and high dry mater content thus high yields produced don't always equate to quality (Costa *et al*, 2008). Weed control therefore one of the determining factors in both yield and quality of potato tubers. Many growers are interested in producing large tubers to market (Ahmaduand *et al*., 2009).

2.11 Conclusion

In the world's food supply, potatoes have become a staple crop. Weed presence reduces both the quantity and quality of tubers obtained during harvesting. It is therefore important the weeds be controlled at least four weeks after plant emergence as the crop as known to be a weak competitor to weeds. Tall weeds such as grasses shade the leaf canopy from receiving essential resources which therefore leads to lower yields.

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CHAPTER 3

THE EFFECT OF WEED CONTROL STARTEGY ON POTATO GROWTH, TUBER SIZE AND YIELD

3.1 Introduction

Potato is an annual staple crop in many parts of the world. It plays an important role in human's source of food. Potato tubers have various nutrients such as proteins and carbohydrates which are needed by the human body (Mondani et al., 2011). Tubers are the richest source of starch. Weeds play a critical role in the growth phases of potatoes. Weeds compete with the potato plants for water, nutrients, and sunlight (Ahmaduand *et al*., 2009). Weeds therefore decrease the quality and quantity of tubers produced through the reduction of size, weight, and the number of tubers. (Arnold *et al*.,1997) Competition affects the shape, size, and the proper function of the potato plants. According to Bukun (2004) growth analysis of competing species is the realization of the source of limitation and its effect on plant populations. According to Williams (2006) crop biomass is the most simple and rapid measure of species competition. John and frank (2010) believed that the factors affecting competition are somehow reflected in canopy development. Baziramakenga *et al*., (1994) stated that crop growth rate, leaf area index and dry matter accumulation are suitable scales of crop function which can influence the competing species. Light is one of the important factors affecting how the crop responds to weed competition and is related to the leaf are index (Mondani *et al*., 2011).

The aim of the present study was to evaluate the effect of three weeding treatments namely control weed free(CW), weed free till flowering stage then stop (FW) and No weeding (NW) and Two harvest periods (Two weeks after flowering and senescence) on plant growth, physiology and yield.

3.2 Materials and method

3.2.1 Field trial

A set of trials were conducted to determine the effect of weeds on potato plant growth, development, and yield.

3.2.1.1 Description of experimental site and management

The field experiment took place at the University of KwaZulu-Natal farm named Ukulinga farm on the 20th of December 2017 and were harvested on the 15th of March 2018. GPS Co-Ordinates S29°37’45’’ E30°24’17’prior to planting, soil samples were taken from the field for soil testing. The soil samples were analyzed in Cedara Laboratory. For land preparation (Table 3). Disc and ripper were used to fine the soil and weeding was done manually with the use of a hand hoe tool.

Table 3.1: Physical and chemical characteristics of soil in the field

Clay	N	Organic C	pH	P	K	Ca	Mg	Zn	Mn	Cu
——% ——			(KCl)	——(g kg^{-1}) ——						
31	0.15	1.8	3.99	25	160	857	304	40	50	8.0

3.2.1.2 Experimental design

The experimental design used was a split-plot design in a randomized complete block replicated three times. There were three weeding treatments used namely; Weed free all the time until harvest time (CW = control) ,weeding until flowering then stop (FW) and no weeding throughout the growing season (NW=None) and there were two harvesting period treatments namely early harvesting (90 days after planting) and late harvesting (120 days after planting) . Only one cultivar of potato (Mondial) was used in the experiment. The field in total had 18plots. Total area was 14m long x 9m wide with 3m by 2m long plots. The spacing was 1m between 0.5m within rows. There were four rows per plot. Each row was 2m long and 1m between plots. The potatoes were 50cm apart.

3.2.1.3 Weed management

Weed free control (CW) treatment plot was weed free throughout the potato plant growth till harvest and weed removal was done by hand on a weekly basis. The weed free till flowering stage then stop (FW) treatment plot was weed free only up until the flowering stage after which the plot was left with weed infestation. The no weeding (NW) plot was weed infested throughout the potato plant growth up until harvest. Weed specie composition were assessed by categorizing and counting weeds from 1m quadrant in each plot. A sample of the most abundant weed species was oven dried at 80^{o}C for two days to determine the dry matter content.

3.2.2 Data collection

The physiology and plant growth parameters were only taken after the emergence of the potato plants. Five plants per plot were taken randomly from the two middle rows excluding the boarder rows were selected and measured for plant growth.

3.2.2.1 Seedling emergence and total

Seedling emergence percentage was taken 3 weeks after planting

3.2.2.2 Seedling growth (height, leaf number, leaf area)

The plant height and leaf number were measured 3 weeks after planting. The height was measured with a ruler from ground level to the tip of the leaf while the leaf numbers were counted and recorded

3.2.2.3 Stomatal conductance

The stomatal conductance was measured with a Model SC-1 steady staeleaf porometer. Four potato plant leaves from the two middle rows excluding the border rows were selected randomly and the average figure was recorded. The stomatal conductance was taken from the adaxial leaf surface.

3.2.2.4 Chlorophyll content index

A portable chlorophyll meter, the SPAD-502 Plus (Konica Minolta, Japan) was used to measure chlorophyll content index (CCI). Four potato leaves were taken from the two middle rows excluding the border rows were selected randomly and the meter was placed on a fully expanded leaf and the average figure was recorded.

3.2.2.5 Leaf Area Index and Photosynthetically active radiation

Leaf area index (LAI) and photosynthetically active radiation (PAR Above and below) were measured using the AccuPAR LP80 Ceptometer (Decagon Devices, USA).

3.2.3 Yield parameters

3.2.3.1 Harvest

The process of harvesting was not done at the same time. The first nine plots of the three weeding treatments was harvested early (90 days after planting) while the remainder of the plots were harvested late (120 days after planting). Red sacks were labelled according to the three different treatments. With the use of a folk, the whole plant plus the potato tubers were dug up and carefully placed into the labelled sacks, this process was done in all 18 plots, the four potato plants were harvested from the two middle rows excluding the border rows.

3.2.3.2 Number of tubers

Four plants were randomly selected from the two middle rows excluding the border rows. The number of tubers present per plant was counted and recorded.

3.2.3.3 Mass of tubers

Once the tubers were counted, they were weighed with the use of a scale to obtain economic yield after which they were graded according to how much each tuber weighed. Tubers that weighed between 5-120g were graded as small, 140-225g were graded as medium and lastly 250-3505g were graded as large. Anything above was graded as large.

3.2.3.4 Mass of plant and tubers

The whole plant was weighed with the use of a scale. After this measurement, the mass of the tuber was added to the mass of the plant in order to obtain the total biomass of the plant,

3.3 Statistical analysis

Data collected were subjected to analyses of variance (ANOVA) using GenStat® Version (VSN International, United Kingdom) at the 5% probability level. Duncan's test on GenStat® at the probability level of 5% was used to compare means.

3.4 Results

3.4.1 Weed Composition

According to table 3.2 the control weed free treatment (CW) had the lowest weed dry weight of 234.18 g m^{-2} while the no weeding (NW) treatment had the highest weed dry weight of 418.19 g m^{-2}. Blackjack (*Bidens pilosa*) in all the three weeding treatments had the highest dry weight which made it the most dominant weed, followed by the field bindweeds (*Convolvulus arvensis*). Crabgrass (*Digitaria sanguinalis*) had the lowest dry weight which made it the least dominant weed in all the three weeding treatments.

Table 3.2: Weed composition and average dry weight (g m^{-2}) in all the three weeding treatments measured at crop harvest and averaged over the two harvest periods.

Treatment	**Common Name**	**Scientific name**	**Dry weight** (g m^{-2})
CW (Control weed free)	Black jack	*Bidens pilosa*	90.43
	Field bindweeds	*Convolvulus arvensis*	25.30
	Bermuda grass	*Cynodon dactylon*	3.67
	White clover	*Trifolium repens*	50.5
	Pigweed	*Amaranthus retroflexus*	61.3
	Crabgrass	*Digitaria sanguinalis*	2.98
			Total dry weight 234.18
FW (Weeding until flowering stage)	Black jack	*Bidens pilosa*	134.52
	Field bindweeds	*Convolvulus arvensis*	45.94
	Bermuda grass	*Cynodon dactylon*	6.42
	White clover	*Trifolium repens*	68.98
	Pigweed	*Amaranthus retroflexus*	71.76
	Crabgrass	*Digitaria sanguinalis*	4.67

			Total dry weight 332.29
NW (No weeding)	Black jack	*Bidens pilosa*	192.69
	Field bindweeds	*Convolvulus arvensis*	51.2
	Bermuda grass	*Cynodon dactylon*	9.6
	White clover	*Trifolium repens*	76.3
	Pigweed	*Amaranthus retroflexus*	82.5
	Crabgrass	*Digitaria sanguinalis*	5.9
			Total dry weight 418.19

3.4.2 Crop growth

3.4.2.1 Field Emergence

There were significant differences on the percentage of potato plant emergence with P=0.004 in respect to the three different weeding treatments as shown in figure 3.1. The CW (control weed free) treatment had the highest emergence of 77.9%, followed by FW (Weeding until flowering stage then stop) with emergence percentage of 66.7% while NW (No weeding) had the lowest field emergence of 47.5%.There was no significant difference among the three weeding treatments over the period of week 2 and 3 after emergence , this was shown in figure 3.2.

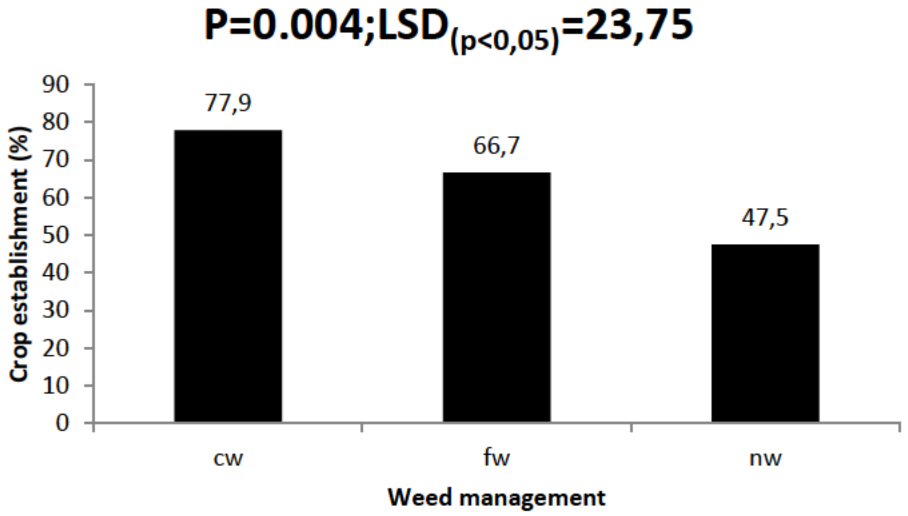

Figure 3.1: Potato plant emergence with respect to the three weeding treatments control weed free (CW), weeding until flowering (FW) and no weeding (NW).

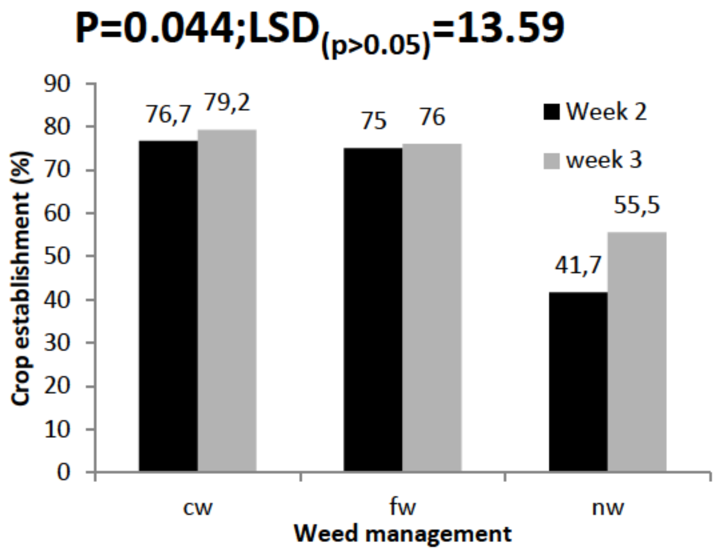

Figure 3.2: Potato plant emergence with the effect of three weeding treatments namely CW (control weed free), FW (weeding until flowering) and NW (no weeding) over the period of week 2 and week 3 after planting.

3.4.2.2 Plant height

The three weeding treatments had a significant difference over a period of nine weeks with P=0.018 as shown in figure 3.3. CW (control weed free) had the highest plant height at week 9 of 77.58cm, closely followed by FW (weeding until flowering stage then stop) with the plant height of 75cm while NW (no weeding) had the lowest plant height of 71cm.

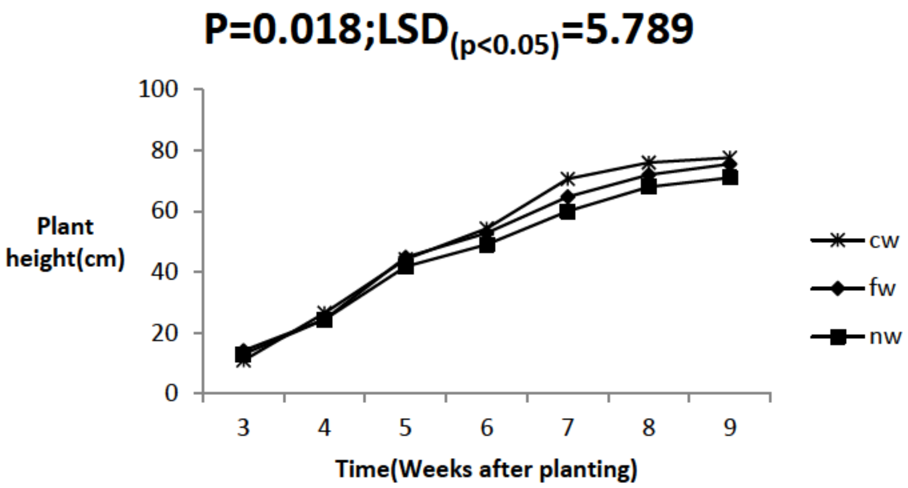

Figure 3.3: Weekly plant height of potato plant with the effect of the three weeding treatments namely CW (control weed free), FW (weeding until flowering) and NW (no weeding).

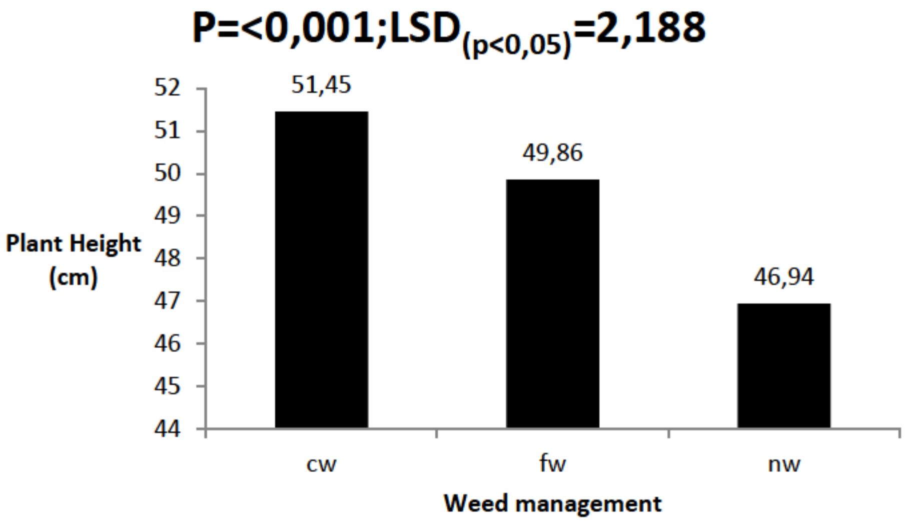

Figure 3.4: The comparison of plant height in potato plants subjected to three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding)

3.4.2.3 Leaf number

The weeding treatments had a significant difference over a period of nine weeks with p=<0.001. This is shown in figure 3.5. Overall, the CW (control weed free) treatment had the highest leaf number of 117 while NW (no weeding) treatment had the lowest leaf number of 97. This is shown in figure 3.6.

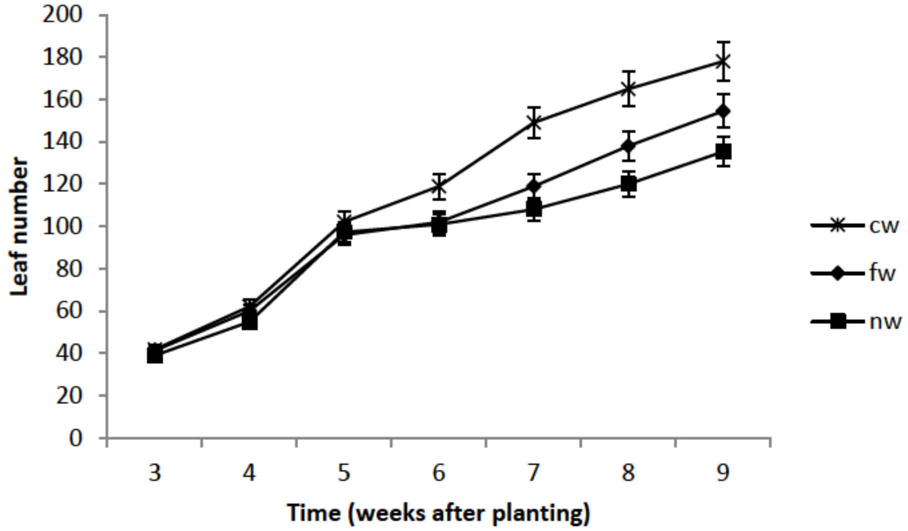

Figure 3.5: Weekly leaf number of potato plants with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding)

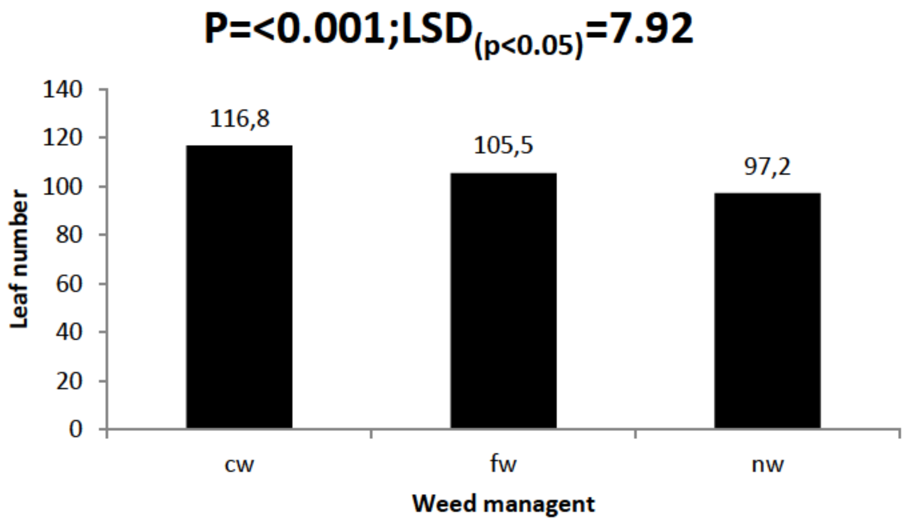

Figure 3.6: Comparison of leaf number in response to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

3.4.2.4 Intercepted photosynthetically active radiation

There were significant differences with the three different weeding treatments for PAR below with $p<0.001$ as shown in figure 3.7. The CW (control weed free) weeding treatment had the highest PAR at week 9 after planting of 1150Wm^{-2} while the NW (no weeding) treatment had the lowest PAR of 810Wm^{-2}. There were also significant differences with the three different weeding treatments for PAR above with $p=0.0048$ as shown in figure 3.8. The CW (control weed free) treatment had the highest PAR above at week 9 after planting of 1910Wm^{-2} while the NW (no weeding) weeding treatment had the lowest PAR above of 1610Wm^{-2}.

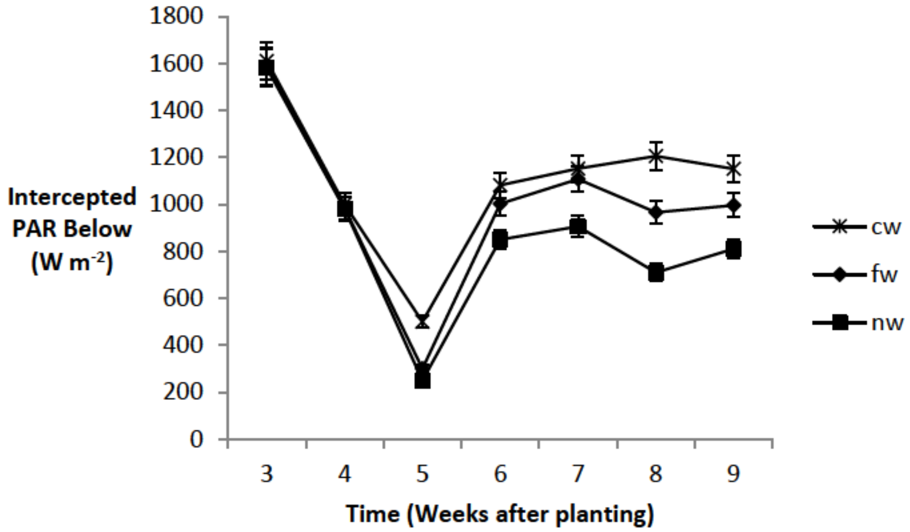

Figure 3.7: Weekly intercepted photosynthetic active radiation (PAR) below with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

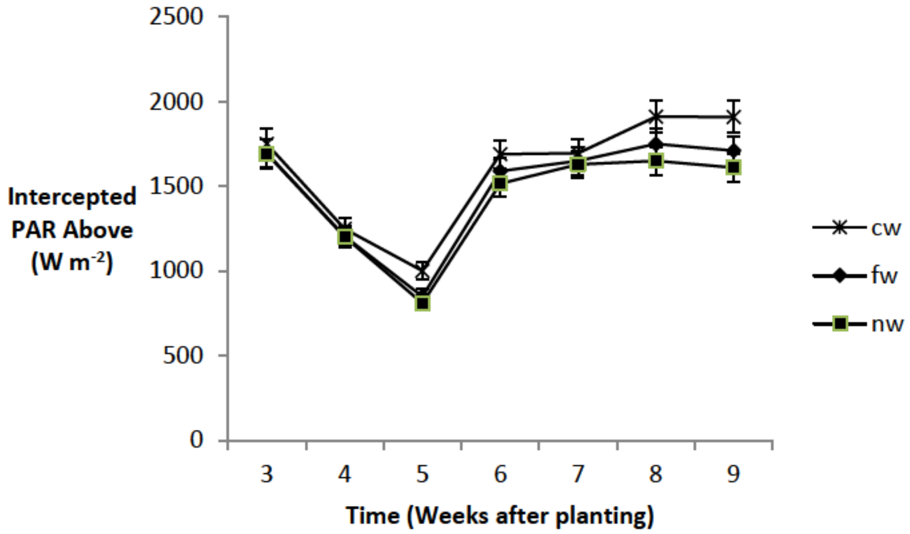

Figure 3.8: Weekly intercepted photosynthetic active radiation (PAR) Above with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

3.4.2.5 Leaf area index

There were significant differences in the weekly leaf area index (LAI) as affected by the three weeding treatments with P=0.007 as shown in figure 3.10. Week 9 after planting the CW (control weed free) treatment had the highest leaf area index of 2.55 while NW (no weeding) had the lowest LAI at week 9 after planting of 1.478. Overall, the CW weeding treatment had the highest LAI as shown in figure 3.9.

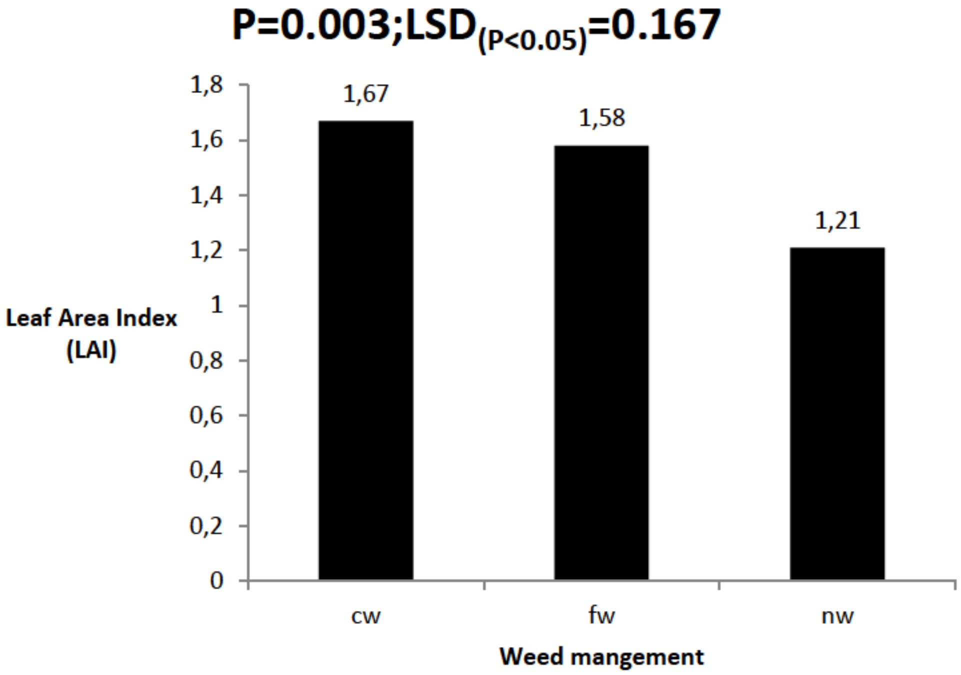

Figure 3.9: The comparison of leaf area index (LAI) of the potato plant with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

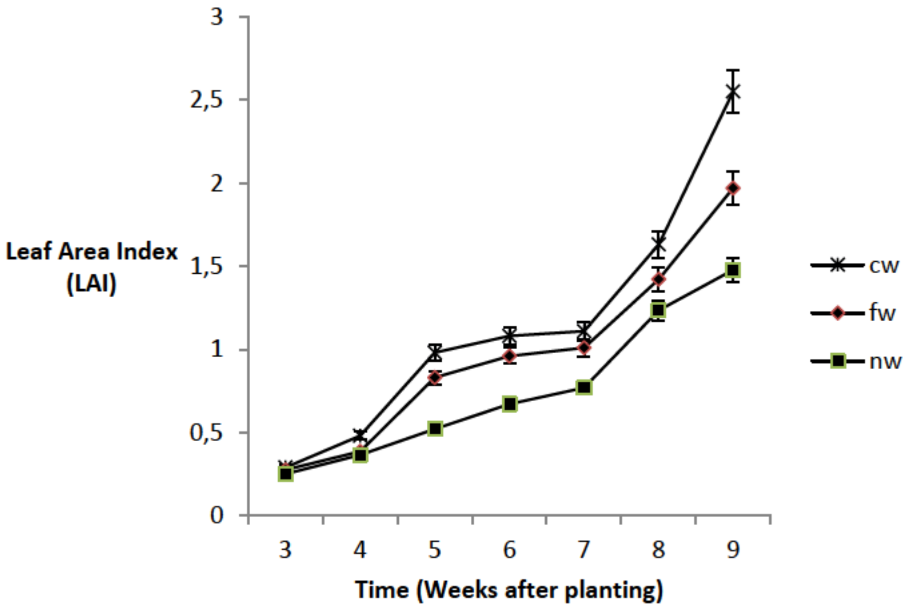

Figure 3.10: Weekly leaf area index (LAI) of the potato plants in response to the different weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

3.4.3 Crop physiology

3.4.3.1 Chlorophyll content index

There were significant differences with the chlorophyll content index as affected by the three weeding treatment with p=0.004 as shown in figure 3.11. The CW (control weed free) treatment at week 9 after planting had the highest chlorophyll content of 45.38 while NW (no weeding) had the lowest chlorophyll content of 40.17 this was shown in figure 3.12.

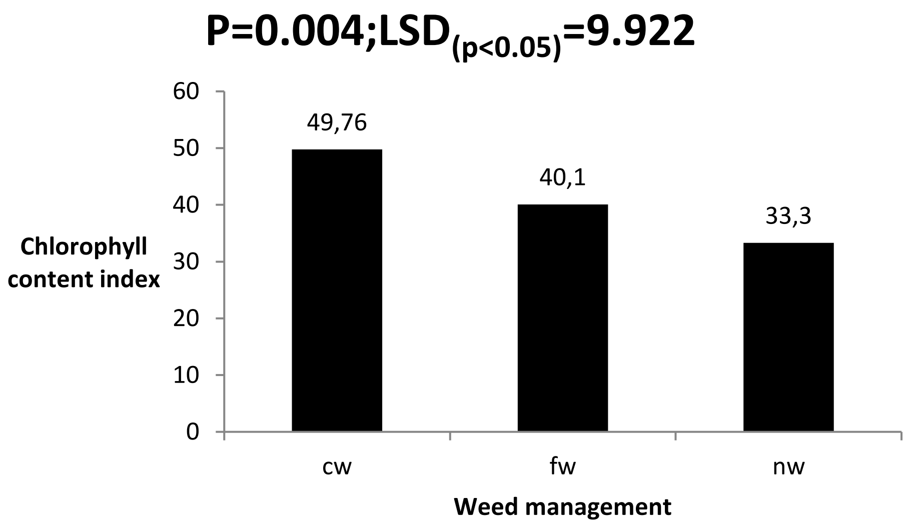

Figure 3.11: The comparison of the chlorophyll content index of the potato plant in response to the different weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

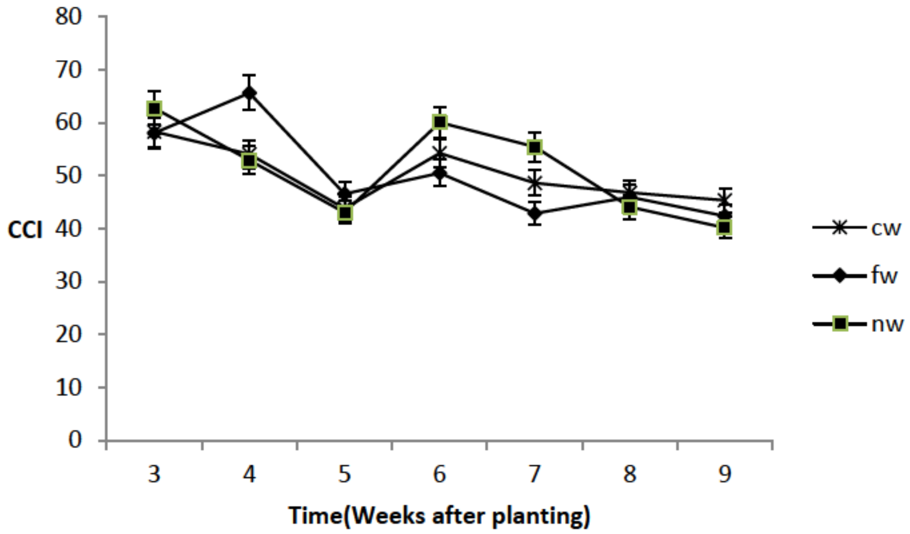

Figure 3.12: Weekly chlorophyll content index of the potato plant in response to the different weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

3.4.4 Yield and Yield Parameters

3.4.4.1 Harvest

There were significant differences with number of tubers per plant as affected by the three weeding treatments with p=0.041 as shown in figure 3.13. The CW (control weed free) treatment had the highest number of tubers while the NW (no weeding) treatment had the lowest number of potato tubers. There was a significant difference with the mass of tubers in response to the harvest period. Potato tubers harvested early (90 days after planting) had a lower mass while tubers harvested late (120 days after planting) had a lower mass as shown in figure 3.15. There was also a significant difference with the interaction between weeding treatment and harvest period when it came to tuber mass as shown in figure 3.16. There were also significant differences with the mass of tubers with respect to the three weeding treatments. The CW (control weed free) treatment had the highest average tuber mass of 320g while the NW (no weeding treatment) treatment had the lowest average mass of 120g. This is shown in figure 3.14.

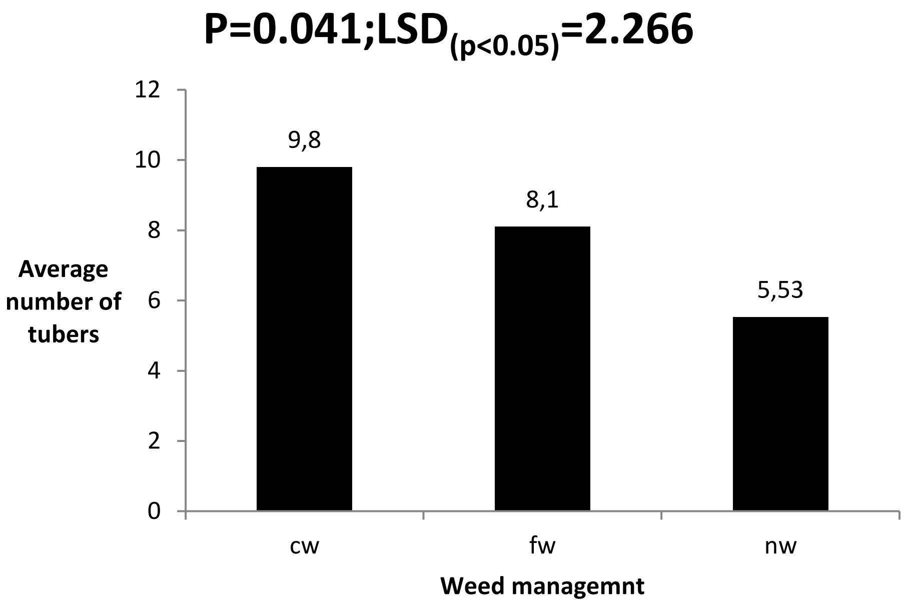

Figure 3.13: Number of potato plant tubers with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

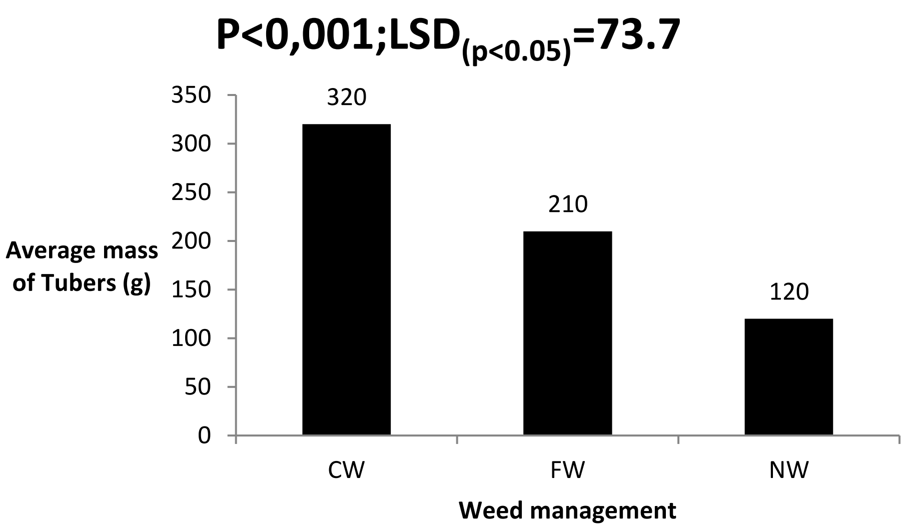

Figure 3.14: Average mass of potato tubers with respect to the three weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

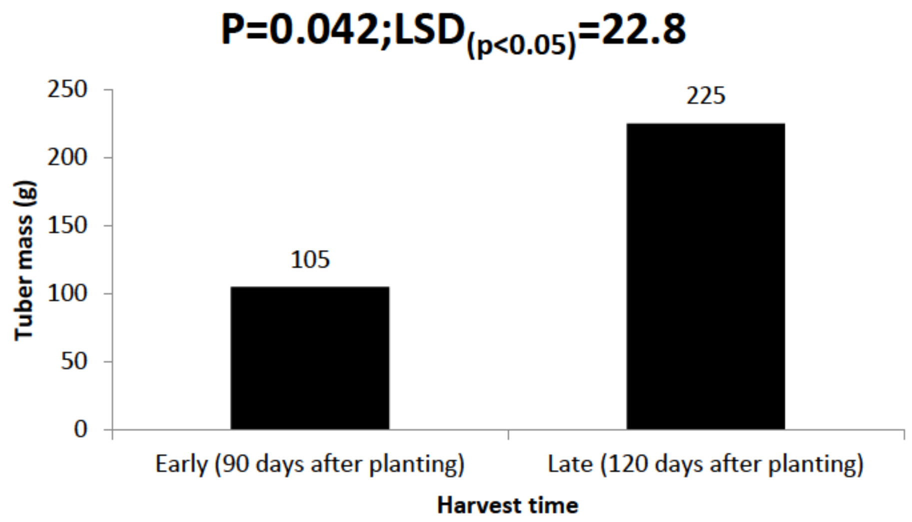

Figure 3.15: Mass of tubers in response to the three different harvest periods

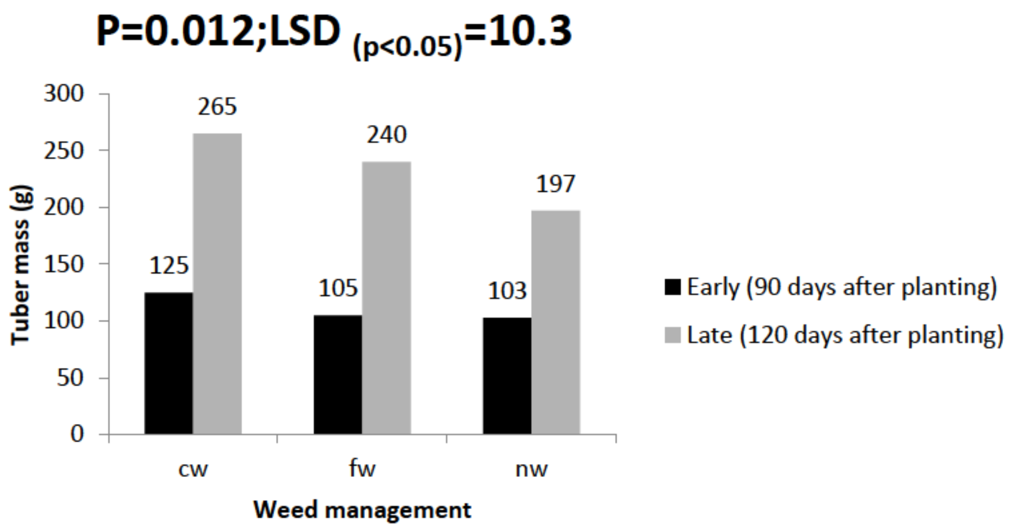

Figure 3.16: The mass of potato tubers in response to the different weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding) under two harvest periods.

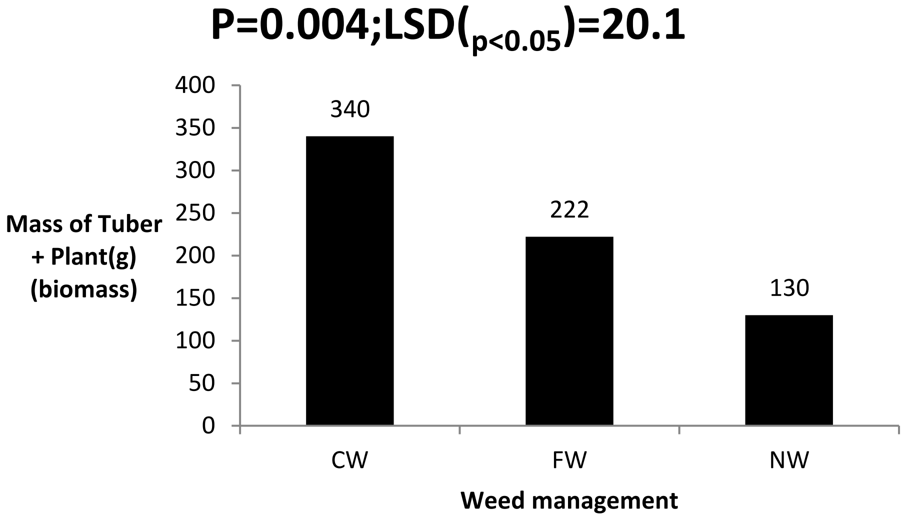

Figure 3.17: Mass of potato tuber and plant (Biomass) with respect to the different weeding treatments namely CW (control weed free), FW (weeding until flowering and NW (no weeding).

According to table 3.3 the control weed free (CW) treatment had the highest average number of potato tubers of 8, however the tubers that were harvested early (90 days after planting) were smaller in size compared to the tubers harvested late (120 days after planting) for the same weeding treatment. Tubers harvested early for this treatment fell in-between the small category of (5-120g) while those harvested late fell in-between the medium to large category. Weeding until flowering (FW) then stop treatment had the second highest average number of tubers per plant and it showed the same trend where tubers harvested early were smaller in size compared to those harvested late. The no weeding (NW) treatment had the lowest average number of tubers per plant of 5. This weeding treatment also had the same trend of tubers harvested early being smaller than those that were harvested at a later stage.

Table 3.3: Average number of tubers per potato plant graded according to their sizes per treatment

Treatment	**Number of Tubers (Average/Plant)**	**Small (5-120g)**	**Medium (140-225g)**	**Large (250-350g)**
CW (Early)	8	6	2	0

CW (Late)	8	2	3	3
FW (Early)	7	6	1	0
FW (Late)	7	2	3	2
NW (Early)	5	4	1	0
NW (Late)	5	3	2	0

CW-control weed free, FW-weeding until flowering stage, NW-no weeding, Early-harvest two weeks after flowering, Late-harvest at senescence

3.5 Discussion

The results of the experiment showed that there were six most abundant weed species as shown in Table 3.2. The weed free control treatment had the lowest dry weight of all the most abundant weed species combined of 234.18 g m^{-2} followed by the weed free treatment until flowering of 332.29 g m^{-2} and the weed infested treatment had the highest dry weight of 418.19 g m^{-2}. According to Mondani *et al*., (2011) the total dry weight and number of weeds in potato plants is the highest in none weeded treatments. *Bidens pilosa* had the highest dry weight of 192.69 in the none weeded treatment which therefore means it had the highest effect on the potato growth and final yield of potato. *Bidens pilosa* and *Trifolium repens* are tall weeds which can cause shading and prevent light absorption by the potato plant canopy (Amador-Ramairez, 2002). This therefore leads to lower yields. (Elkoca *et al*., 2005) stated that the increase in weed free periods on potato plants will result in decreased dry weight of weed species. The overall emergent percentage was the highest for the weed free treatment, closely followed by the weeding until flowering treatment while the none weeding treatment had the least emergent percentage. According to Bukun (2004) it is critical for potato growth and emergence to remove weeds at least three to four weeks after planting.

There were significant differences with plant height and leaf number in response to the weeding treatments. The weed free treatment had the highest plant height while the none weeded treatment had the lowest plant height and leaf number. There was a significant difference with plant height and leaf number in relation to weeks after planting. Initially at three weeks after planting , there was not much difference in plant height and leaf number ,however as the weeks progressed the weed free treatment and the weed free treatment till flowering had a high plant height and leaf number while the no weeding treatment had the lowest plant height by week 9. According to Croster and Witt (2000) the slowdown in potato plant growth in weed infested areas could be due to more falling rate of leaves at down of canopy because of weed interference, light competition, and weed shading on potato plants. A study done by (Mondani *et al*., 2011) indicated that with increasing the duration of weed free periods the rate at which the potato plants grow is also increased.

Leaf area index is an important plant parameter in interception of solar radiation which determines the final yield and photosynthesis (Croster and Witt, 2000).The weed free control method and the weed infested treatment had significant differences ($p<0.05$).The weed free control treatment had the highest LAI at week 9 after planting of 2.55, followed closely by the weeding until flowering stage treatment with the LAI of 1.97 and the weed infested treatment at week 9 after planting had the lowest LAI of 1.478. A study done by Cox *et al*.,(2006) showed that with increasing the duration of the weed infested periods, LAI was reduced. According to Stagnari and Pisante (2011) controlling weeds between week 3 and week 9 after planting is effective increasing the leaf area index. According to Mondani et al., (2011)) potato plants roughly flower 9 to 10 weeks after planting, this therefore means that the weeding until flowering stage treatment fell in between the critical period of weeding and hence the treatment also had a high leaf area index in comparison to the weed infested treatment.

There were significance differences with photosynthetic active radiation in response to the weed free control and weed infested treatment. There was also a significant difference with PAR in response to the weeding treatments over a period of 3 to 9 weeks after planting. PAR showed the same trend as LAI. PAR was the highest in the weed free treatment and it was the least in the weed infested treatment. According to Petroviene (2002) weeds compete for natural resources thus decreasing photosynthesis and dry matter accumulation. A study done by Mondani *et al*., (2011) showed that at week 4 to week 8 of weed control after emergence on potato plants had the most positive effect in PAR. This is due to the critical period of weed control in potato plants.

The results showed a significant difference in the final tuber yield of potato plants. The weed free treatment had the highest average number of tubers per plant and the highest average tuber mass. The tubers were categorized into small (5-120g), medium (140-225g) and large (250-350g) with respect to the different treatments. There was a significant difference with harvest time ($p<0.05$). Tubers that were harvested early (90 days after planting) showed to have a smaller mass while tubers that were harvested late (120 days after planting) had a high average mass. According to Petroviene (2002) potato plants are ready to be harvested two to three weeks after flowering, but they are smaller in size. This was shown in table 3.3 and figure 3.15. There was a significant difference with the interaction between the harvest period and weeding treatment when it came to the mass of tubers. Tubers harvested two weeks after flowering while subjected to no weeding treatment had a smaller mass compared to the tubers harvested at senescence but subjected to the same no weeding treatment. The weed free treatment had the majority of medium to large tubers. The weed free until flowering stage treatment had not much difference in comparison to the weed free control method. The weed infested treatment had the lowest average number of tubers per plant and the lowest tuber mass. Most tubers in this treatment fell in between medium and small when it came to tuber size. A study done by Bukan (2004) showed the same trend where final tuber yield was the lowest in the weed infested treatment due to the increase in weed infestation period. According to Morin *et al*.,(2009) weeds intensify inter competition and pressure of weed biomass which therefore results in the reduction of potato yields According to Ford and Pleasant (1994) inadequate weed control in potato plants causes 20% to 80% tuber yield loss. The reduction in tuber yield could also be a result of weed shading and competition for light absorption and other crucial resources that are needed by the potato plant. Competition affects the size of tubers, final yield, and function of the potato plants (Mondani *et al*., 2011).

3.6 Conclusion

Weed competition in potato tubers considerably affects the plant growth, tuber size and final tuber yield. Weed invasions reduce the quantity of potato tubers through the decrease in weight, size and the number of tubers. Weed management is therefore critical between week three and week nine after sowing of potato plants to increase crop growth and final yield.

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CHAPTER 4

THE EFFECT OF WEED CONTROL OPTIONS ON MINERAL CONTENT OF POTATO TUBERS

4.1 Introduction

Potato is an important food crop in the world that produces calories and more weight percentage when compared to all other field crops (Morris *et al.*,2004). Potato tubers accumulate high volumes of proteins, starch, vitamin c and are an important source of dietary minerals. Potato tubers contain 1 to 1.2% mineral compounds, the most basic of those being magnesium, phosphorus calcium, and potassium (Morris *et al.*,2004). Nutritional essential minor and trace minerals in potato tubers include iron, copper, nickel and boron. Micro and macro elements play an important role in building functions that are part of enzymes that play an important part in regulating metabolic processes (Brzozowska, 2008). Mineral content in potatoes can be affected by a variety of factors which include soil, weather conditions during the plant growth, weed control, irrigation, and fertilization (Gugala and Zarzeck, 2009).

Potato is well known as an important source of dietary potassium in terms of mineral content. For the best functioning of the kidneys, heart and digestive system, potassium plays a key role in maintaining those functions in the human body (Brzozowska, 2008). Phosphorus after potassium is also one of the main minerals found in potato tubers. It plays an important role in healthy bones, cells and teeth in the human body Potato tubers are also an important source of calcium (Gugala and Zarzeck, 2009). Depending on the point of view, quality of tubers can be categorized into nutritional, sensory and market attributes. nutritional parameters include phytonutrients and phytochemicals that have an effect in human health such as vitamins, antioxidants, minerals, and secondary metabolites (Monteiro *et al*., 2007). However, no studies showing the relationship of timing of both weed control and harvesting were found, for comparison with the current study.

The aim of the study was to determine the effect of three weeding treatments namely control weed free (CW), weeding until flowering then stop (FW) and no weeding (NW) when subjected to harvest periods on the mineral content of potato tubers.

4.2 Materials and methods

4.2.1 Mineral nutrient content analysis

To preserve the nutrients of the potato tubers after yield determination, the tubers were peeled and chopped into small pieces and placed separately into small plastic bags according to each of the three different weeding treatments and two harvest periods. To avoid further metabolic reactions, the chopped potato tubers were freeze dried for a period of 48 hours using a model RV3 vacuum freeze drier (Edwards, United States of America). After being freeze dried the 18 samples were grinded with the use of a mortar and pestle. Once the samples were thoroughly grinded, they were subjected to standard mineral analysis process of ash, digested in hydrochloric acid (HCl) using Agilent 4100 Mircrowave-Plasma Atomic Emission spectrometer. Analysis of variance (ANOVA) was used for data were analysis (Genstat Statistical package) to determine statistical differences ($P \leq 0.05$).

4.3 Results

Overall, potassium was found to occur in the highest level in potato tubers compared with other mineral elements determined in this study, followed by P, Mg, Ca and Na, respectively (Figure 4.1). This observation agrees with the previous findings (Wekesa *et al*., 2014; White *et al*., 2009). Timing of weed control and harvesting showed a significant effect on mineral tuber content (Figure 4.1). Weed control (CW) improved mineral content compared to weeding late, at flowering (FW), and the lack of weeding (NW) showed the lowest levels of all mineral elements measured (Figure 4.1). Harvesting the crop late had an effect of improving the amount of mineral content in the tubers, irrespective of mineral type (Figure 4.1). Although the general trend of occurrence for the five mineral elements was a decrease in response to both early harvest and increased weed competition, the extent of this effect differed with type of mineral element.

Potassium showed the highest and most consistent negative correlation with the level of weed control (R^2 = 0.79) (Figure 4.2). This was followed by Ca (R^2 = 0.63), Na (R^2 = 0.51), Mg (R^2 = 0.45) and P (R^2 = 0.38) (Figures 4.3, 4.4, 4.5 and 4.6). The results show that K, the element of highest concentration in tubers was least affected by delayed harvest when the crop was weed free, compared to other mineral elements (Figure 4.2). On the other hand, Mg was highly responsive and positively affected by delayed harvest time compared to all other mineral elements (Figure 4.5).

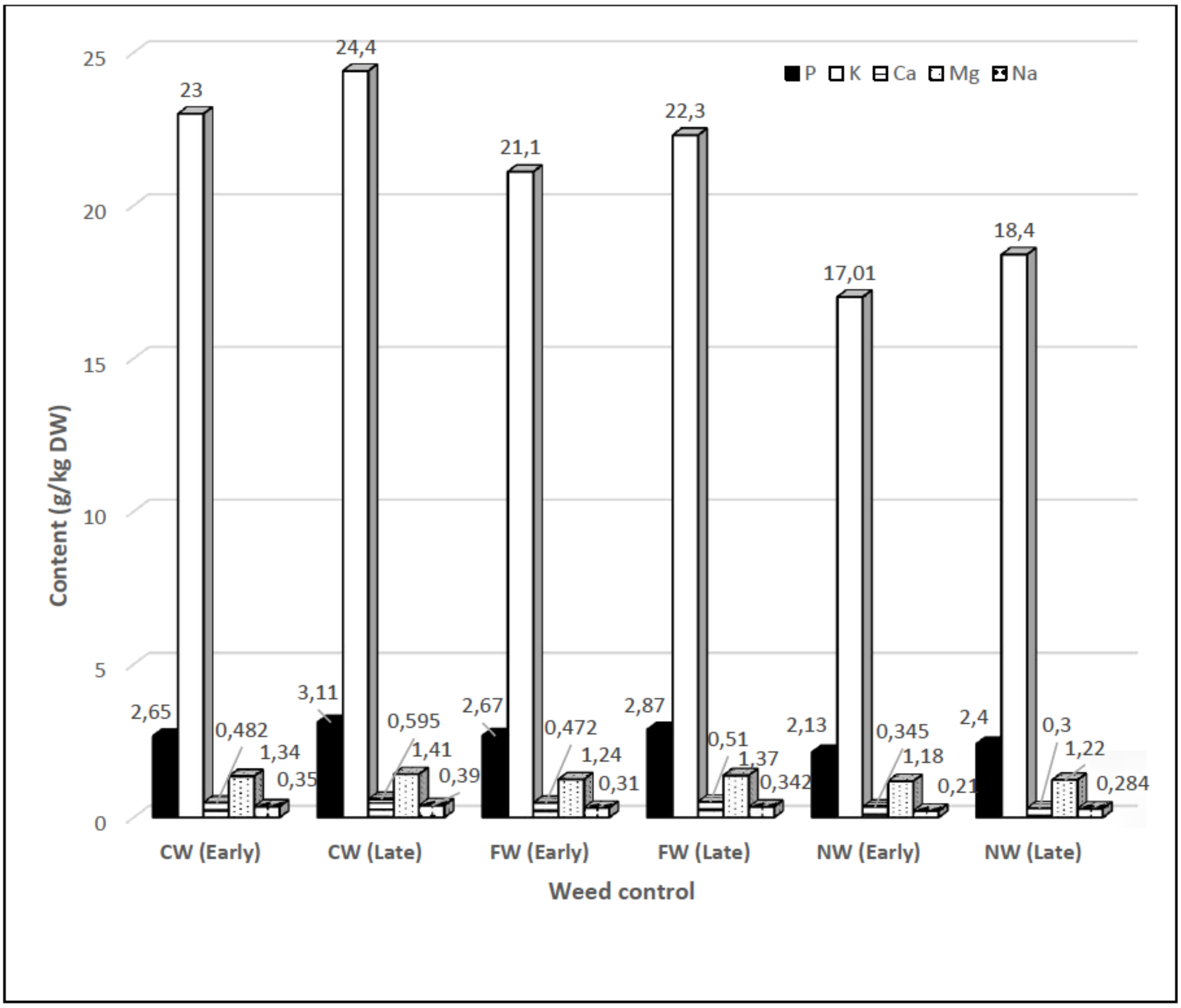

Figure 4.1: Changes in mineral (P,K, Ca, Mg and Na) levels of potato tuber in response to weed control (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

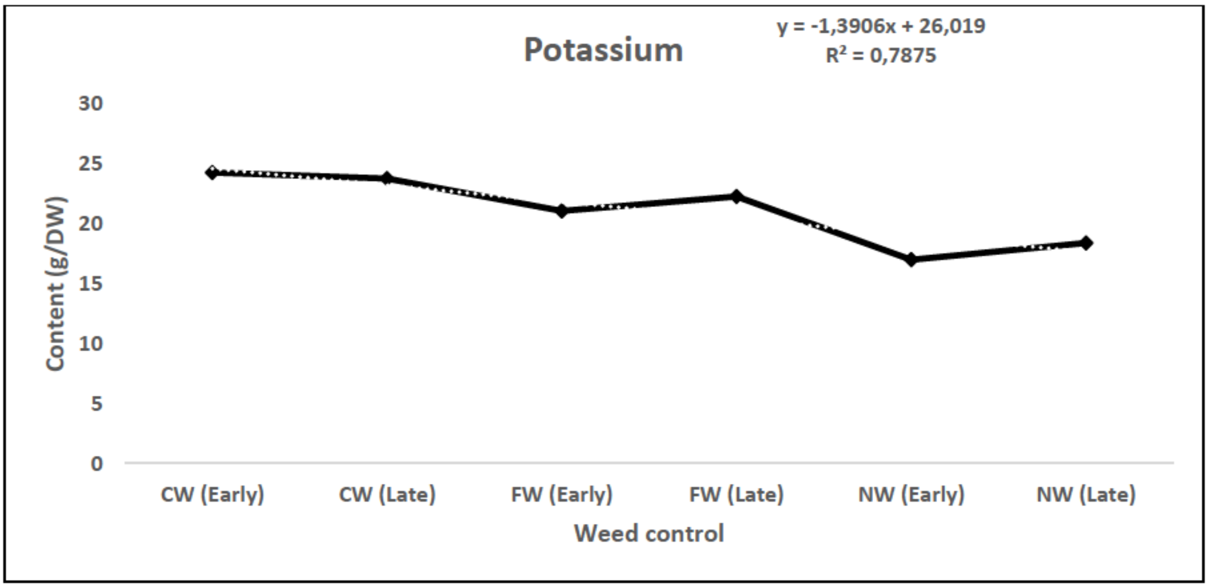

Figure 4.2: Correlation of potassium mineral content of potato tubers with weed control and crop harvest timing (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

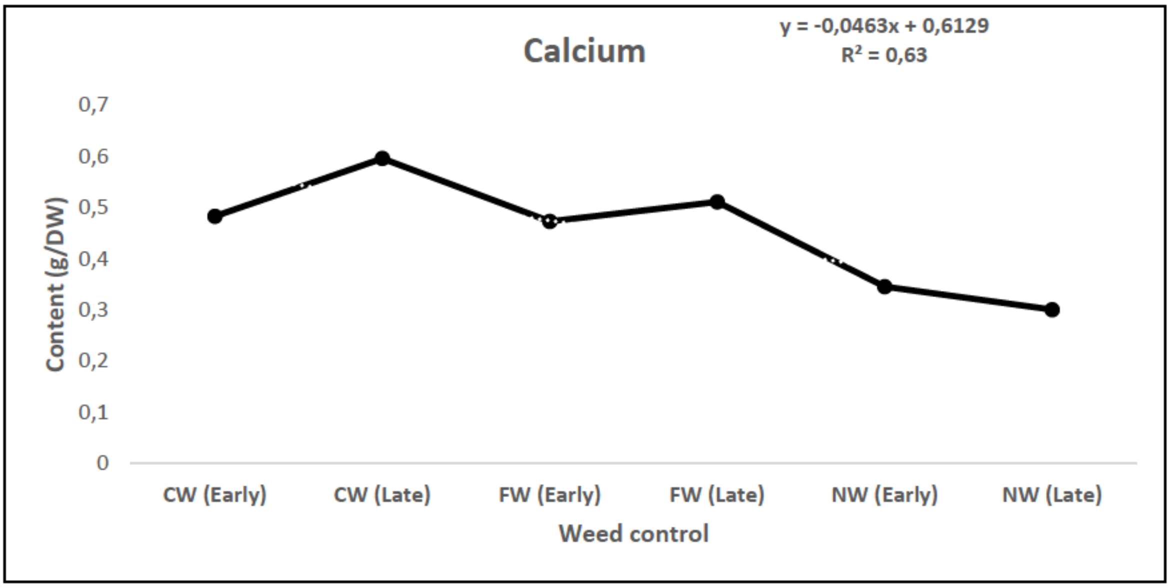

Figure 4.3: Correlation of calcium mineral content of potato tubers with weed control and crop harvest timing (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

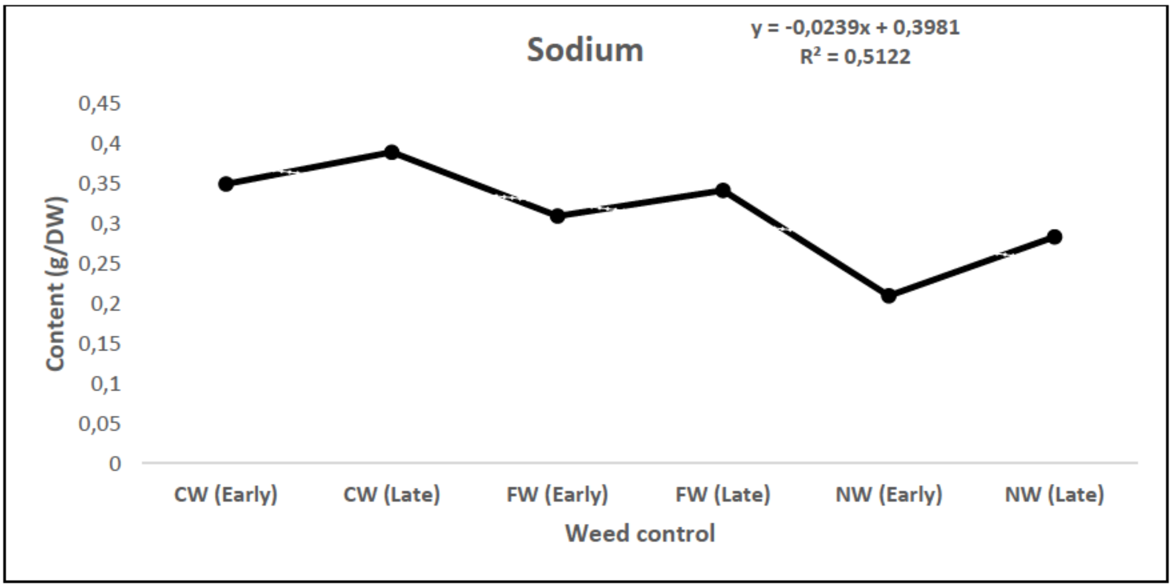

Figure 4.4: Correlation of sodium mineral content of potato tubers with weed control and crop harvest timing (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

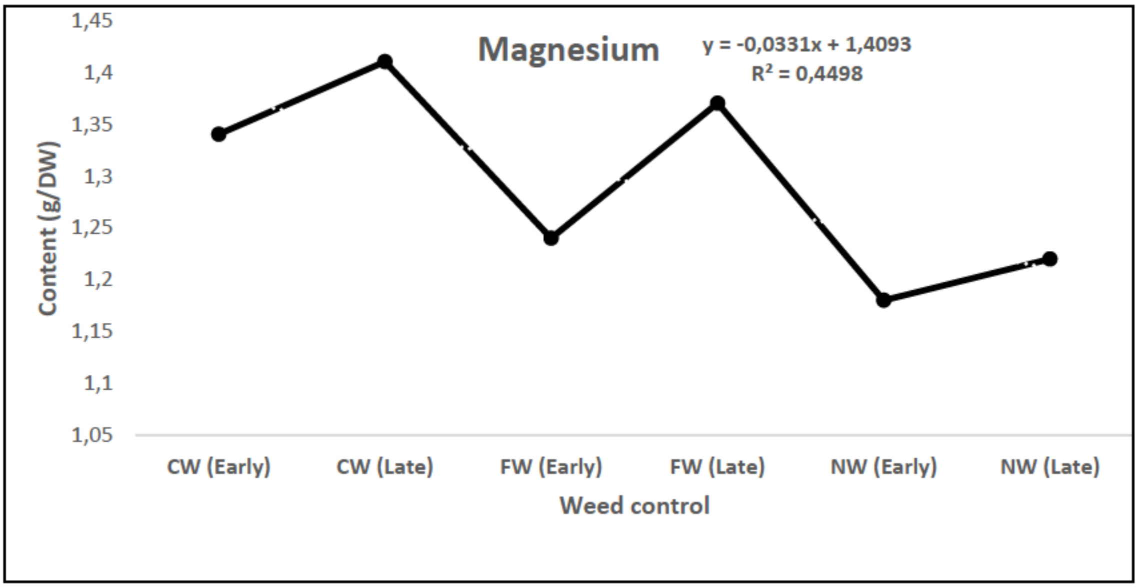

Figure 4.5: Correlation of magnesium mineral content of potato tubers with weed control and crop harvest timing (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

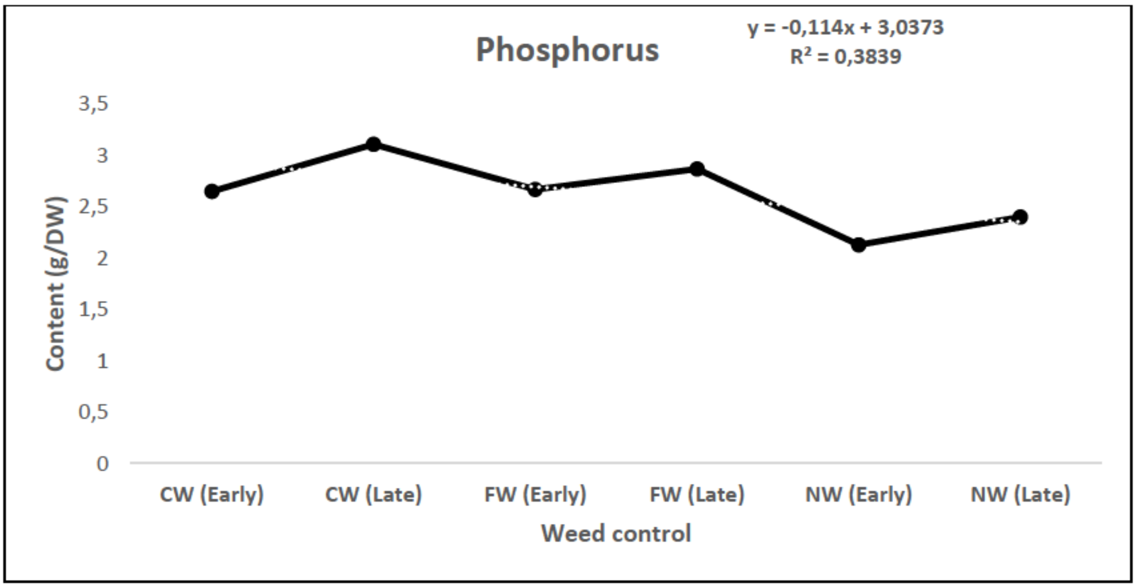

Figure 4.6: Correlation of phosphorus mineral content of potato tubers with weed control and crop harvest timing (CW = control weeding throughout season; FW = weeding until flowering; NW = no weed control) and harvest time (Early = 90 days after planting; Late = 120 days after planting).

4.4 Discussion

The effect of weed control on mineral content in potato tubers has been shown (Gugala *et al.,* 2012). In that study, Ca and Mg were found to increase in response to weed control using herbicides. The current study selected many mineral elements that have been previously shown to be important in agronomy and food science (Wekesa *et al*., 2014). The focus was on selected mineral composition of potato tubers. This study produced results about more elements. The findings showed that K is a predominant micromineral element in potato tubers. Previous studies (Nutrient Data Laboratory, undated) showed confirmed the results of this study in terms of relative concentrations of mineral the selected mineral elements in potato tubers (Figure 4.1). Thus, the highly significant (P<0/01) differences between levels of mineral elements and occurrence of Ca and Na at levels that are 10 to 20 times lower than P and K, respectively has been confirmed (White *et al*., 2009).

According to Rivero *et al.,* (2003), there were significant effects of cultivars, weed control methods and moisture on mineral element concentration of potato tubers. According to (Gugala *et al.,* 2012) potato tuber chemical composition is primarily affected by the genotype. In a study done by Kolbe and Stephan-Beckmann (1997) statistical analysis confirmed that calcium content in tubers significantly depends on weed control and weather conditions. It is easier for a crop plant to take up more individual nutrients and other essential resources where there is no competition of weeds which leads to better quality of potato tubers and mineral composition. This, therefore, can account for the significant differences in some of the minerals where the potatoes were subjected to weed infestation. According to a study done by Gugala *et al*., (2012) the genetic traits of the potato cultivars determined the amount of calcium content found in the tubers. According to Rivero *et al*., (2003) weather conditions significantly influenced the mineral content in potato tubers.

What is also significant in the current study is that both timing weed control and harvesting affect mineral content levels of potato tubers. Previous studies have shown that delayed harvest period affects yield (Akeley *et al*., 1955). However, no studies showing the relationship of timing of both weed control and harvesting were found, for comparison with the current study. What the literature shows is a general negative effect of delayed weed control on crop yield. In some many crops, delayed harvest time may decrease or improve quality, depending on crop type (Ahmed, *et al*., 2014; Gibson *et al*., 2002).

4.5 Conclusion

Timing of weed control is important for management of potato tuber quality in terms of mineral content at harvest. Delayed harvest improves the quantity of K, P, Ca, Mg and Na in potato tubers, regardless of weed control timing. These findings suggest that it is advisable to keep a potato crop weed free throughout the season, but the benefit of that is reduced after flowering. Also, keeping potatoes in the field may be an advantage in terms of mineral content quantity. This study did not investigate the relationship of improved mineral quantity to physiological and physical qualities of tubers. It would be useful to link these results with potato tuber quality parameters, including other nutritional qualities that are useful in the value of potato as a food crop.

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CHAPTER 5

GENERAL CONCLUSION AND RECOMMENDATIONS

The effect of weeds on crops has been known for a long time in agronomy and crop science. However, the major areas of focus, in the context competition, have been on how reduced availability of water and fertiliser nutrients affect vegetative growth and yield. Weeds reduce crop access to soil nutrients and this can be obvious in mineral deficiency symptoms, mainly during vegetative growth stages. Weeds reduce crop access to water and this can be visible in the crop being stunted during vegetative growth. In both cases, deficiency of nutrients and water, respectively, final yield is the important indicator of economic impact of weeds.

Published literature showed that potatoes are an important crop of high dietary importance with nutritional vitamins and minerals that are required by the human body. Potato growth and yield is highly affected by weed infestation. It is therefore important to control weeds three to nine weeks after emergence as this is the crucial stage in potato development. Weeds compete with plants for nutrients and other essential resources that are needed by the plant. Potato plants are weak competitors to weed infestation. This study showed a decrease in yield when weed control is delayed. Leaving the crop un-weeded throughout the season has the obvious results of limiting tuber number, size, yield and mineral content. It appears that some gains can be made in terms of potato yield and mineral content, if harvesting is delayed. The reduction in tuber yield could have been a result of weed shading and competition for light absorption and other important resources. Harvesting time also had in effect on tuber size. Potatoes that were harvested early (two weeks after flowering) were smaller in size while those harvested late (senescence) were much larger because they had enough time to grow and mature. There was an interaction between harvesting period and weeding treatment. Harvesting the tubers early with the effect of no weeding resulted in tubers weighing far more less compared to those harvested early but with the control weed free treatment. It is therefore important to control weeds during the growing stage of potatoes and allow them to mature by harvesting at late during senescence to obtain high yields. Mineral composition of potatoes can be affected by a variety of properties that include irrigation, weather conditions, and weed control methods. Weed control increases the quality of tubers produced thus making weed control important.

This study had limitations that may require further research using a combination of field trials and laboratory analysis.

a) Potato performance is influenced by both environment and genotype. The limitation of this study is that only one cultivar and one cropping season were used.
b) Distribution of minerals and other chemical compounds in potato tubers can vary with stage of maturity and location in the tuber (e.g., peel, cortex and pith). Determining mineral content in these different areas of the tuber may give interesting results that could be useful in terms of agronomy, postharvest handling and nutrition, especially if the findings include other bio-physiological aspects of crop quality.