

**AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND
ENTREPRENEURIAL DEVELOPMENT**

FACULTY OF AGRICULTURE EDUCATION

**WEED CONTROL REGIME AND PLANT POPULATION DENSITY EFFECTS
ON THE GROWTH AND YIELD OF EARLY MATURING MAIZE (*Zea mays* L.)
VARIETY**

DOUGLAS APPIAH AGYEMAN

2025

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**A THESIS IN THE DEPARTMENT OF CROP AND SOIL SCIENCES
EDUCATION, FACULTY OF AGRICULTURE EDUCATION, SUBMITTED TO
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THE AWARD OF A DEGREE OF MASTER OF PHILOSOPHY IN CROP
SCIENCE (AGRONOMY)**

SEPTEMBER 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis, with the exception of quotations and references contained in published works which have been duly acknowledged; is the result of my own original work and that no part of it has been presented for another degree at this university or elsewhere.

Candidate Name: Douglas Appiah Agyeman

Signature: Date:

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

Principal Supervisor's Name: Prof. Harrison Kwame Dapaah

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Co-Supervisor's Name: Engr. Dr. Bernard Effah

Signature: Date:

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Lastly, to my family my wife, Madam Alice Pokuaa and Brother Agyeman Owusu, friends, especially my parents and other siblings, thank you for your continuous prayers, encouragement, and emotional support throughout this academic endeavour.

DEDICATION

This work is lovingly dedicated to my parents, Mr. David Okai Agyeman and Mrs. Monica Agyeman for their sacrifices, love, and belief in the power of education.

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LIST OF ACRONYMS/ABBREVIATIONS

CPWC	Critical periods for Weed Control
CSIR-CRI	Council for Scientific and Industrial Research - Crops Research Institute
DAP	Days after planting
FAO	Food and Agriculture Organization
GMO	Genetically Modified Organism
PP	Plant population
SSA	Sub-Saharan Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
WAP	Weeks after planting
WC	Weed control

ABSTRACT

This study was conducted to provide a comprehensive understanding of the impact of weed control strategies and plant population density on the growth and yield of early maturing maize variety. The experiment was conducted at the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Mampong Campus, Multipurpose Crop Nursery in two cropping seasons (major and minor) in the year 2023. The experimental design was Split-plot arranged in a Randomized Complete Block Design (RCBD) with three replications. The main plot factor was weed control which included (i) weed free (weed regularly at every 2 weeks), (ii) weed once at 4 weeks after planting (WAP), (iii) weed twice at 2 and 6 weeks after planting (WAP), and (iv) unweeded (control) and the sub plot factor was plant population density (PP) which also included (i) 80 cm x 30 cm (83,333 plants/ha), (ii) 80 cm x 40 cm (62,500 plants/ha) and (iii) 80 cm x 50 cm (50,000 plants/ha). The results showed that Weeding at 2 and 6 weeks after planting and 80 cm x 40 cm and the interaction significantly produced taller maize plant and greater number of leaves. Weeding once at 4 weeks after planting and 80 cm x 40 cm also produced higher plant dry matter. Weeding at every 2 weeks and 80 cm x 40 cm produced longer cobs, although the difference was not significant. Weeding regularly every 2 weeks significantly produced heavier stover and more grain yield during the minor season only. 80 cm x 30 cm (83,330 plants/ha) significantly produced heavier stover in both seasons and grain yield during the major season. All the treatment produced significant benefit to cost ratio. Weed once + 80 × 50 cm, weed twice + 80 × 40 cm, Weed twice + 80 × 30 cm and Weed free + 80 × 30 cm dominated over other treatments, where Weed twice + 80 × 40 cm had the highest marginal rate of return. Regular weeding every two weeks after planting or twice at two and six weeks after planting, along with a planting distance of 80 cm x 30 cm (83,333 plants/ha) or 80 cm x 40 cm (62,500 plants/ha), or a combination of weeding every two

weeks after planting and 80 cm x 30 cm (83,333 plants/ha), could result in higher maize productivity and higher economic returns.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Maize (*Zea mays* L.) is one of the most important cereal crop globally, serving as a staple food for millions of people and a valuable feedstock for livestock (Mandal *et al.*, 2023). It plays a critical role in meeting the high food demand and is globally one of the most widely cultivated crops (Haarhoff & Swanepoel, 2018). Globally, both the land area used for maize grain production and the amount of maize produced per unit area have been increasing in recent years (Haarhoff and Swanepoel, 2018). Achieving high yields and ensuring food security heavily relies on effective weed control strategies and optimizing plant population density. Weeds compete with crops for essential resources such as sunlight, water, nutrients, and space, leading to reduced growth and yield potential.

Early maturing maize varieties are particularly vulnerable to weed competition due to their shorter growth cycle and limited time for growth and development (Horvath *et al.*, 2023). Weeds not only hinder the growth of maize plants, but also impact the quality and quantity of harvested grains. According to Zargar *et al.* (2021), their presence can lead to yield losses ranging from 20% to 80%, depending on weed species, density, and the duration of competition. Thus, effective weed control is essential to minimize yield losses and maximize the economic returns for farmers. Various weed control methods are available, including chemical, cultural, and mechanical approaches (Monteiro & Santos, 2022). Chemical weed control involves the application of herbicides to selectively target and eliminate weeds while minimizing damage to the maize crop. Cultural weed control practices encompass techniques such as crop rotation, intercropping, mulching, and timely cultivation to suppress weed growth and propagation. Mechanical weed control involves physical methods like hoeing, hand weeding, and mechanical tillage to physically remove or disrupt weed growth.

In addition to weed control, optimizing plant population density is another critical factor for maximizing maize yield (Lacasa *et al.*, 2020). According to Ngoune Tandzi and Mutengwa (2019), plant population density refers to the number of plants per unit area. The appropriate plant density ensures efficient resource utilization, reduces intra-plant competition, and promotes optimal growth and development. However, determining the optimum plant population density is influenced by various factors, including soil fertility, climate conditions, genotype, and weed pressure.

Maize yield differs significantly under varying plant density levels due to difference in genetic potential (Hou *et al.*, 2019). Correspondingly maize also responds differently in quality parameters like crude starch, protein and oil contents in grains (Jahangirlou *et al.*, 2020). Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants. The grain yield per plant is decreased in response to decreasing light and other environmental resources available to each plant. Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production (Ayana, 2021). The use of high population densities increases interplant competition for light, water and nutrients, which may be detrimental to final yield because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Ayana, 2021).

1.2 Problem statement and Justification

Weeds are a critical factor in maize production, resulting in substantial yield losses on a global scale. The average yield loss is 12.8% when weed control is implemented, and 29.2% when it is not (Soltani *et al.*, 2016). The growth and yield of maize are significantly impacted by weed infestation, resulting in reduced productivity and economic losses (Fahad

et al., 2022). Weeds compete with maize plants for essential resources, including sunlight, water, nutrients, and space, which in turn impacts their growth and development (Kaur *et al.*, 2018). Furthermore, the vulnerability to weed competition is further exacerbated by the shortened growth cycle of early maturing maize varieties, as there is less time for crop establishment and growth (Dass *et al.*, 2017).

Maximizing the growth and yield of early maturing maize varieties necessitates optimizing plant population density (Assefa *et al.*, 2018). Optimal growth and development are promoted, intra-plant competition is minimized, and efficient resource utilization is guaranteed by adequate plant density (Gezahegn, 2019). Nevertheless, the optimal plant population density for early maturing maize varieties, in light of weed competition, is a challenge that necessitates additional research. Although individual studies have previously investigated the impact of weed control practices or plant population density on maize growth and yield (El-Gedwy, 2019), a comprehensive understanding of their combined effect on early maturing maize varieties is required (Zawada *et al.*, 2023; Idziak *et al.*, 2022; Mayerova *et al.*, 2018).

The most effective method of optimizing weed control applications is to control vegetation based on critical periods for weed control (CPWC). It is feasible to determine the necessity and timing of weed control with the assistance of CPWC, and to manage weeds only when they necessitate effective control (Idziak *et al.* (2022; Andert, 2021). Horvath *et al.* (2023) have discovered that the critical period occurred between 4 and 8 weeks after emergence, with the beginning of the period exhibiting greater variability than the end. Mechanical, cultural, and chemical vegetation control methods are frequently implemented in maize production systems. It is imperative to assess the comparative advantages and efficacy of these methods in order to create sustainable vegetation management strategies. It is equally

crucial to optimize the density of plants in order to optimize maize productivity. Efficient resource utilization, reduced intra-plant competition, and improved crop growth and development are all guaranteed by the appropriate plant density. Olaniyan (2015) underscored the importance of plant population density in relation to food security and yield potential, emphasizing the necessity of determining the optimal plant density for various maize varieties and agro-ecological conditions. Therefore, farmers fail to achieve optimal plant densities by failing to implement the appropriate recommended plant spacing. Once more, they are unable to procure the appropriate quantity of seed to achieve the highest possible plant densities. Optimization of plant density is a strategy that is employed to maximize yield and to reduce production as a result of the high cost of seed (Tokatlidi, 2017).

Furthermore, it is imperative to comprehend the relationship between plant population density and vegetation control practices in order to create integrated management strategies. Numerous studies have examined the combined impact of plant density and vegetation control on crop performance. Haug *et al.* (2023) investigated the impact of plant density on the growth and yield components of maize, offering a comprehensive understanding of the relationship between crop performance, herb competition, and plant densities.

1.3 Main Objective

The main objective was to provide a comprehensive understanding of the effect of weed control strategies and plant population density on the growth and yield of early maturing maize variety.

1.4 Specific Objectives

The specific objectives were to:

- i. Determine the effect of weed control and plant population density on phenology of maize.

- ii. Evaluate the effects of weed control and plant population density on yield and yield components of maize.
- iii. Evaluate the economic benefits or profitability of maize production as affected by weed control and plant population density.

CHAPTER TWO: LITERATURE REVIEW

2.1 Origin and Distribution

Maize, also known as corn (*Zea mays* L.), has its origin in the Americas. It was first domesticated by indigenous people in what is now modern-day Mexico over 7,000 years ago. Maize cultivation began around 9,000 to 10,000 years ago, making it one of the earliest cultivated crops in the world (Erenstein *et al.*, 2022). Indigenous peoples selectively bred wild grasses, transforming them into the maize we know today through a process called artificial selection. This process involved choosing and propagating plants with desirable traits such as larger kernels and more efficient growth. From its origins in Mexico, maize cultivation spread to various parts of the Americas. It became a staple food crop for many indigenous cultures (Tanumihardjo *et al.*, 2020). Maize played a crucial role in the diet and culture of these societies. The distribution of maize expanded even further when Europeans, including Christopher Columbus, brought maize back to Europe after their voyages to the Americas (Beding, 2016). Maize was then introduced to other parts of the world through global trade and exploration during the Columbian Exchange, which began in the late 15th century. Today, maize is one of the world's most widely cultivated crops and is grown on every continent except Antarctica. It has adapted to a wide range of climates and growing conditions, from tropical to temperate regions. According to Ranum *et al.* (2014), the largest producers of maize are the United States, China, Brazil, Argentina, and India. Maize is not only a vital food crop but also serves as animal feed, a source of biofuel, and a raw material for various industrial products. Its versatility and adaptability have made it a cornerstone of global agriculture.

2.2 Botany

Maize (*Zea mays*) is a plant belonging to the grass family, Poaceae (Dhoot *et al.*, 2017). It is an annual, monocotyledonous herbaceous plant with distinctive botanical features. Maize plants have sturdy, upright stems that can grow anywhere from 61.0 cm to 365.8 cm in height, depending on the variety and environmental conditions. The stem is typically cylindrical and often hollow. Maize leaves are arranged alternately along the stem. They are long, flat, and lance-shaped, with parallel venation. The leaves can vary in color from light green to darker shades, depending on the age of the plant. Maize plants have a fibrous root system, consisting of numerous thin, branching roots. These roots serve to anchor the plant and absorb water and nutrients from the soil.

The reproductive structure of maize is called the inflorescence, which is a complex structure known as a panicle. As stated by Mohapatra *et al.* (2022), the panicle consists of a central stalk called the rachis with numerous lateral branches called "spikes" or "spikelets." Each spikelet can produce a single maize kernel or grain. The flowers of maize are unisexual, meaning that a single plant has both male and female flowers. The male flowers are found in structures called tassels at the top of the plant, while the female flowers are located in the leaf axils and develop into ears of corn. Maize kernels, commonly referred to as corn, are the fruits of the plant. Each kernel represents a seed that can grow into a new maize plant (García-Lara *et al.*, 2019). Kernels are typically yellow, but they can come in various colors, depending on the maize variety. Maize is wind-pollinated, which means that pollen is dispersed by the wind to reach the female flowers on the same or neighboring plants. There is considerable diversity in maize cultivars, including variations in kernel size, shape, color, and plant size. Maize cultivars are categorized into 4 (dent, flint, flour, sweet, and popcorn types), each with distinct characteristics and uses. Maize is a C4 plant, which means it employs a specialized photosynthetic pathway that is highly efficient in warm,

sunny conditions (Ajao *et al.*, 2017). This adaptation allows maize to thrive in various climates and tolerate drought better than many other crops.

2.3 Varieties

Maize (*Zea mays*) is a highly diverse crop with numerous varieties and cultivars developed to suit different purposes and growing conditions (Revilla *et al.*, 2022). Some common varieties of maize are:

Dent Corn: Dent corn, also known as field corn, is one of the most widely grown varieties of maize. It is primarily used for animal feed and industrial purposes. According to Mboya (2020), Dent corn kernels have a dent or dimple on the crown of each kernel when they dry, hence the name "dent."

Flint Corn: Flint corn, also called Indian corn, is known for its hard, glassy kernels. It is often used decoratively in ornamental displays due to its colorful kernels (Mandal *et al.*, 2023). Some varieties of flint corn are suitable for making cornmeal and grits.

Flour Corn: Flour corn, as the name suggests, is primarily used for milling into cornmeal or corn flour. It has soft, starchy kernels that are easily ground into fine flour (Anderson and Almeida, 2019).

Sweet Corn: Sweet corn is a variety known for its high sugar content, making it a favorite for fresh consumption (Singh *et al.*, 2014). It is harvested when the kernels are still in the milk stage, which is when they are sweet and tender. Sweet corn is commonly found in grocery stores and farmers' markets.

Popcorn: Popcorn is a unique maize variety with kernels that have a hard, moisture-resistant outer shell and a starchy interior (Peyton, 2014). When heated, the moisture inside

the kernel turns to steam, causing the kernel to pop and expand. This variety is used for making popcorn snacks.

Waxy Corn: Waxy corn has a higher amylopectin content in its starch, making it suitable for various industrial applications, such as in the production of adhesives, textiles, and paper (Kumari and Sit, 2023).

Floury-Endosperm Corn: This type of maize has a high content of soft, floury endosperm, which is desirable for the production of corn starch and corn syrup (Singh *et al.*, 2019).

High-Oil Corn: High-oil maize varieties are bred for their elevated oil content. They are used in the production of corn oil and as a source of energy in animal feed (Kaul *et al.*, 2019).

High-Protein Corn: High-protein maize varieties are cultivated for their increased protein content, making them valuable for livestock feed and some food products (Henchion *et al.*, 2017).

Specialty Maize: In addition to the above varieties, there are specialty maize types developed for specific culinary or industrial purposes. These include heirloom varieties, organic maize, and GMO (genetically modified) maize with traits such as insect resistance or herbicide tolerance (Brookes and Barfoot, 2020).

2.4 Nutritional Value and Uses

The protein content found in maize plays a crucial role in various bodily functions, including tissue growth and maintenance, the formation of essential compounds, nutrient transportation, regulation of water balance, and more. The predominant component of maize grain is starch, which constitutes over 70% of its total weight (Wangmo *et al.*, 2020). As described by Amoako and Awika (2019) maize starch is comprised of two glucose

polymers, primarily amylose, contributing to 30% of its starch content, while the remaining 70% is composed of amylopectin. Waxy maize, on the other hand, consists entirely of amylopectin (Shi *et al.*, 2013). Maize's pectin content results in a branched structure, leading to the presence of glucose and fructose as monosaccharides and a small amount of sucrose as a disaccharide. Additionally, maize is a rich source of B-complex vitamins, which play pivotal roles in promoting growth, maintaining healthy skin, supporting heart health, nourishing hair, boosting brain function, and aiding digestion. Maize also contains fat-soluble vitamins, including provitamin A, carotenoids, and lutein, known for their unique abilities to combat aging and reduce the risk of cancer (Maria *et al.*, 2015). These fat-soluble vitamins (A, D, E, and K) act as antioxidants, providing protection against various types of cancer. The specific content of fat-soluble vitamins varies depending on the maize genotype. Yellow maize, for instance, boasts an abundance of carotenoid pigments due to its genotype, while white maize lacks these pigments due to the absence of the same genotype (Zhu *et al.*, 2021).

2.5 Economic Importance

Maize serves as a cornerstone for human nutrition, livestock feed, fermentation processes, and various industrial uses. Research conducted by Zhang *et al.* (2021) revealed that maize contains abundant starch (65%), with 35% of its production utilized for human consumption, 25% for poultry and cattle feed, and 15% in food processing. In the new millennium, maize has emerged as an alternative crop to rice and wheat. Its significance lies in being a rich source of essential minerals, vitamins, fiber, and oil, particularly in the embryo. Small-scale farmers are drawn to maize cultivation due to its high nutritional value, making it an affordable source of essential nutrients for rural people. Maize holds a prominent position as the primary cereal crop in the region, serving as a vital resource for more than 1.2 billion individuals in both Sub-Saharan Africa (SSA) and Latin America, as

outlined by Olaniyan (2015). Of particular note, over 300 million Africans rely heavily on maize as their primary staple food source (Olaniyan, 2015). In Africa, maize constitutes a significant portion of the household expenditures of low-income families, accounting for approximately 30-50% of their budgets. According to the findings by Smale *et al.* (2013), maize contributes to more than 20% of the total calorie intake in SSA. Consequently, numerous African countries regard maize as a fundamental staple food and have adopted agricultural policies aimed at ensuring a consistent supply by boosting production and productivity. Research conducted by Murdia *et al.* (2016) showed that maize boasts an abundant starch content, comprising 65% of its composition. Of this production, 35% is allocated for human consumption, 25% serves as feed for poultry and cattle, and 15% is used in food processing (Saeed *et al.*, 2021). In the modern era, maize has emerged as a viable alternative to traditional staples like rice and wheat. Its significance lies in its rich reservoir of essential minerals, vitamins, fiber, and oil, particularly concentrated in the embryo. This nutritional wealth makes maize an attractive and cost-effective source of vital nutrients for small-scale farmers and rural populations alike.

2.6 Production Estimate

In 2018, maize production in Africa reached approximately 75 million tons, constituting 7.5% of the global maize output. As of 2020, the global number of maize-farming operations was estimated at 216 million (216 M) (Erenstein *et al.*, 2022). Approximately 22% of global maize farms are located in Sub-Saharan Africa (SSA), and 12% in South Asia (SA). In total, 28 countries were estimated to have more than one million (1M) maize farms in 2020, with China contributing 60% of the global maize farm count (Erenstein *et al.*, 2022). Within Africa, maize occupies approximately 24% of the cultivated land, yielding an average production of 2 tons per hectare annually (Zhang *et al.*, 2021). Nigeria leads the continent in maize production, producing over 33 million tons, followed by South

Africa, Egypt, and Ethiopia (Aliyu *et al.*, 2018). Africa imports 28% of its maize grain requirements from non-African countries (Aliyu *et al.*, 2018) because a significant portion of maize production in Africa relies on rain-fed conditions, leaving the region vulnerable to shortages and famines during irregular rainfall and occasional droughts. According to Smale *et al.* (2013), the total maize cultivation area in Africa spans 40 million hectares, with Nigeria emerging as the top producer (16%), followed by Tanzania. Global maize consumption is estimated to exceed 116 million tons, with 30% of this consumption occurring worldwide and 21% in SSA (Sharma *et al.*, 2019). The processing and preparation of maize vary by country, with Eastern, Southern, and Western Africa commonly making porridge from ground maize. In times of grain shortages, fresh maize on the cob is boiled or roasted, serving as a crucial food source across the entire African continent.

2.7 Climatic and Soil Requirements

2.7.1 Climatic Requirements

The temperature range conducive for maize growth spans from 9°C to 46°C, with an optimal range hovering around 34°C (Singh *et al.*, 2019). Notably, maximum, minimum, and optimum are 4°C to 6°C higher compared to those suitable for wheat or barley. When mean daily temperatures dip below 20°C, the crop's growth duration extends by approximately 10-20 days, depending on the maize variety. Maize exhibits greater resilience to drought conditions, capable of recovering from early-season droughts. However, it is sensitive to freezing temperatures except during its very early stages, and can bounce back from the effects of frost if the plant is less than 15 cm in height. Very young seedlings are less susceptible to high temperatures. According to Rogers *et al.* (2013), maize's ability to recover from early adverse weather conditions during its initial growth

stages underscores the importance of early sowing, even in the face of potential early droughts due to late onset of regular rains.

During the reproductive phase, both temperatures exceeding 32°C and frost can negatively impact yield. Soil moisture stress before, during, and after the silking stage leads to reduced grain yield. The optimal temperature range for tasseling falls between 21 °C to 30 °C (Walne and Reddy, 2019). High temperatures promote respiration, and one significant effect of temperature is that elevated nighttime temperatures shorten the grain-filling period, consequently reducing yield. High temperatures accelerate grain filling but substantially curtail the duration of this critical period, while low temperatures yield the opposite effect. Maize, like other small grains, yields higher at lower temperatures due to an extended grain-filling period and increased allocation of photosynthesis to grain dry matter (Sun *et al.*, 2021).

2.7.2 Soil Requirements

Maize crops thrive in soils with a pH range of 5.5 to 7.3, with the optimal pH falling between 6.0 and 6.5. Within this pH range, essential nutrients such as nitrogen, potassium, phosphorus, calcium, and magnesium are readily available to support healthy growth. Nitrogen contributes to robust leaf development, phosphorus aids in root formation, and potassium supports fruiting. Soil testing is a valuable tool for assessing nutrient availability and identifying necessary remedial actions in case of deficiencies (Smale *et al.*, 2013). Preparing fertile soil is essential for successful sowing. Proper tillage methods ensure an adequate supply of plant nutrients, effective water retention, and reduced instances of pests and diseases.

Maize is adaptable to a pH range of 5.0 to 7.0, making it suitable for various soil types. However, for optimal yields, it is advisable to plant maize in deep, well-aerated, fine-textured loamy soils enriched with organic matter (Li *et al.*, 2022). Emamu and Wakgari (2021) emphasizes the importance of deep, well-drained silty loams with high to moderate organic matter and nutrient content, and a pH ranging from 5.5 to 8.0 for maximizing maize productivity. Since maize is vulnerable to waterlogging and primarily cultivated during the rainy season, it is crucial to prevent water from stagnating on the soil surface for more than 4-5 hours. Loamy or silty loam soils with reasonably permeable subsoil are ideal for maize cultivation. Research by Alkharabsheh *et al.* (2021) highlights maize plants' susceptibility to salinity, particularly during the seedling stage. Soil salinity can significantly affect nutrient uptake and decrease dry matter production, likely due to reduced soil moisture and increased sodium chloride and sulfate toxicity in the soil solution.

2.8 Agronomic Practices

2.8.1 Pest and Diseases Control

Maize faces threats from a range of pests, including stem borers, cutworms, grasshoppers, weevils, termites, fall armyworms, and larger grain borers (Shrestha, 2017). Additionally, common diseases affecting maize in the region encompass rust, smuts, bacterial blight, and maize streak. To effectively manage these challenges, it is crucial to identify the prevalent pests and diseases in the cultivation area and opt for maize varieties that exhibit resistance to them. A prudent approach to pest and disease management in maize involves monitoring the field for pest infestations shortly after seed emergence. Regular checks should be conducted to assess whether the pests are causing significant economic damage, justifying the implementation of management strategies. Furthermore, early planting can be an effective strategy to reduce the heavy insect pressure that late crops often encounter (Overton *et al.*, 2021).

2.8.2 Weed Management

Weeds pose a significant challenge to maize cultivation as they vie for space, nutrients, water, light, and soil resources, ultimately diminishing yields, compromising grain quality, and inflating production costs. Furthermore, weeds can serve as hosts for pests and diseases (Kumar *et al.*, 2021). It is crucial to prevent weeds from coexisting with maize plants, especially in the early growth stages, as maize is most vulnerable to weed competition during this period. According to Kumar *et al.* (2021), the critical window for effective weed management is within the first 2 to 4 weeks after planting. Timely weeding during this period not only fosters rapid maize growth but also enhances the competitive advantage of established maize plants. Initiating planting immediately after ground preparation can help reduce weed competition, and row planting facilitates more efficient weed control. In situations where weed pressure is high, and timely manual weeding may be challenging, judicious use of herbicides can be considered. Herbicides offer advantages over manual weed management due to their speed, cost-effectiveness, and reduced labor intensity. The choice of herbicide depends on whether broadleaved or grassy weeds predominate in the field (Kumar *et al.*, 2021).. Post-emergence herbicides like Glyphosate and Paraquat can be employed to eliminate weeds before preparing the planting area. Glyphosate (Round-up, Sunphosate, Sarosate) is typically applied 1-2 weeks before planting, while Paraquat can be used immediately after planting, often in combination with Pendimethalin to control pre-emergent weeds. Pendimethalin effectively targets pre-emerging weeds, while Paraquat eliminates any live weeds in the field.

2.8.3 Effect of weed control on the growth and yield of maize

Weed control plays a crucial role in the growth and yield of maize (*Zea mays*) crop. Unmanaged weed infestations can significantly reduce maize yields and overall crop quality (Rao, 2022). Weeds compete with maize plants for essential resources such as

nutrients, water, light, and space. They can quickly deplete these resources, leading to stunted growth and reduced yields for maize. Research by David (2023) stated that weeds can absorb and utilize nutrients from the soil, limiting the availability of essential elements for maize. This nutrient competition can result in nutrient deficiencies in maize plants, negatively affecting growth and development. It can consume a significant amount of soil moisture. In regions with limited water resources, excessive weed growth can lead to water stress in maize, reducing its ability to take up water for growth and transpiration.

Weeds can shade maize plants, reducing the amount of sunlight that reaches the maize canopy (Schmitt *et al.*, 2021). Reduced light interception can hinder photosynthesis and limit the production of carbohydrates needed for growth and grain formation. Weedy areas can serve as shelter and breeding grounds for pests and diseases that can also affect maize crops. Effective weed control can reduce the risk of pest and disease infestations. Weeds can make harvesting more challenging and time-consuming, potentially leading to losses during the harvest process. Clearing the field of weeds before harvest can improve efficiency and reduce grain losses. Maize is wind-pollinated, and excessive weed growth can interfere with the movement of pollen between maize plants (Jhala *et al.*, 2021). This can result in poor kernel formation and reduced yields.

2.9 Effect of plant population density on the growth and yield of maize

Plant population density, or the spacing and arrangement of maize plants within a field, can have a significant impact on the growth and yield of maize crops (Li *et al.*, 2021). The optimal plant population density depends on various factors, including climate, soil conditions, maize variety, and local farming practices. When maize plants are densely spaced, they compete more intensely for resources such as nutrients, water, and sunlight (Gezahegn, 2019). This competition can result in smaller individual plant size and limited

access to essential resources, potentially leading to lower yields per plant. Spacing maize plants too far apart can result in underutilization of available resources, leading to inefficiencies in resource use. Individual plants may grow larger but might not maximize their yield potential. In densely planted fields, there is a higher demand for resources. Adequate nutrient and water management becomes crucial to meet the needs of a larger number of plants (Gavrilescu, 2021). Proper fertilization and irrigation are essential to support higher populations.

Lower plant populations allow for more abundant resource availability per plant. However, it may be necessary to adjust fertilization and irrigation practices to ensure that resources are efficiently utilized. Densely planted maize can create a denser canopy that may provide better weed suppression due to reduced light penetration to the soil. However, it can also create a more favorable environment for certain pests and diseases, as air circulation may be limited. In fields with wider spacing, there may be more opportunity for weed growth between plants. Pest and disease pressure might be lower due to better air circulation and reduced humidity in the canopy. According to Chapepa *et al.* (2020), dense plant populations can result in a closed canopy, reducing the amount of sunlight that reaches lower leaves. This can affect photosynthesis in lower plant parts but may improve light interception in the upper canopy.

As stated by Chapepa *et al.* (2020), wider spacing allows for better light penetration throughout the canopy, benefiting lower leaves. However, it might reduce the overall efficiency of light interception. Harvesting in densely planted fields can be more efficient, as there are more plants per unit area to harvest. However, machinery and labor must be adapted to handle higher plant populations. Wider spacing can make harvesting easier, but it may result in a lower harvest efficiency, as fewer plants are concentrated in a given area.

The ideal plant population density for maximizing maize yield varies by region and specific growing conditions. Finding the right balance between too high and too low a density is crucial. It often involves conducting field trials and considering local factors (Gropper *et al.*, 2016).

2.10 Effects of weed control and plant population density on the growth and yield of maize

In a research carried out by Ababa *et al.* (2018) to evaluate effect of weeding frequency and plant densities on yield, and yield components of maize, the highest grain yields (7394.5 kg/ha, and 7273.6 kg/ha) were recorded for weed free and twice hand weeding, respectively and the lowest grain yield (918.9 kg/ha) from the weedy check. The highest grain yield (5485.8 kg/ha) was obtained at a plant density of 53,333 plants/ha and the lowest (4457.2 kg/ha) at a density of 31,250 plants/ha. A field experiment to determine the effect of plant population densities on maize was conducted by Abuzar *et al.* (2011) showed that plant population of 40000 plant/ ha produced maximum number of grains per row (32.33) and grains per ear (447.3). However, 60000 plants/ha produced the maximum number of ears per plant (1.33), number of grain rows per ear (15.44), biomass yield (16890 kg/ha) and grain yield (2604 kg/ha). In an experiment conducted by Mian *et al.* (2021) on hybrid maize with different plant population density, the highest grain yield (10.12-10.78 t/ha) was recorded by 100,000 plants/ha and the lowest (5.02-5.33 t/ha) was recorded by 166,666 plants/ha treatment.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of Experimental Site and Location

Two field experiments were carried out at the research field of the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Mampong Campus from March to July 2023 in the major rainy season and August to December 2023 in the minor rainy season. Asante Mampong is located in the Forest Savannah transitional zone of Ghana. The mean annual rainfall of Asante Mampong is approximately 1270 mm with a bimodal rainfall pattern. The major rains begin around early April and end in July whilst the minor rains start in September and end in November. There is a short dryness in mid-August but the main dry season (harmattan) begins in December and ends in March. The area experiences a mean temperature of about 27 °C per annum but this mean temperature normally varies from 22 °C to 30 °C (GSS, 2014). The soil at the experimental site is derived from the Voltaian sandstone and belongs to the Bedease Series of the Savannah Ochrosol class. It is deep red, sandy loam, and free from stones. It is well-drained and friable and also has good water-holding capacity, texture, and structure. It has a pH of about 6.5. It is classified as Chromic Luvisol in the FAO/UNESCO (2008) system of classification. The vegetation cover of Asante Mampong is the transitional type with a thick grass cover.

3.2 Experimental Design and Treatments

The experimental design used was a Split-plot arranged in a Randomized Complete Block Design (RCBD) with three replications.

The main plot factor was weed control (WC) made up of:

- i. Weed free (weed regularly at every 2 weeks)
- ii. Weed once at 4 weeks after planting (WAP)
- iii. Weed twice at 2 and 6 weeks after planting (WAP) and
- iv. Unweeded (control)

The sub plot factor was plant population density (PP) made up of:

- i. 80 cm x 30 cm (83,333 plants/ha)
- ii. 80 cm x 40 cm (62,500 plants/ha) and
- iii. 80 cm x 50 cm (50,000 plants/ha)

Each plot size was 4.6 m wide (consisted of six rows each) x 5 m long.

The Abontem variety of maize used for the research was developed and released by the Crops Research Institute of the Council for Scientific and Industrial Research (CSIR-CRI).

The maize variety is an early maturing variety with a maturity period 90 days. This variety of maize was selected for the study because it is drought and disease-resistant. It is a high-yielding maize variety.

3.3 Cultural Management Practices

3.3.1 Land Preparation and Planting

A land was ploughed and harrowed. Three seeds per hole were planted at a depth of 5 cm and spaced according to treatment and later thinned to 2 seedlings per stand two weeks after planting (WAP).

3.3.2 Fertilizer Application

A base application of Yara activa (23-10-5 NPK-2.5Mg-35-0.3Zn) at 247 kg/ha was done at 2 weeks after planting and sulphate of ammonia (23% N) was applied as top dress at 125 kg/ha at 4 weeks after planting.

3.3.3 Weed Control

Weed control was done carried out according to the levels of the main factor. Weed control was done manually by hand weeding with a hoe. There were four (4) weeding for the weedfree treatment.

3.3.4 Pest and Disease Control

A lot of visits were made to the field to observe the incidence of pests such as stem borers, corn leaf aphid rodents, and fall armyworm. Emaster (*Emamectin benzoate*) insecticide at a rate of 10-30 ml acre was applied to control fall armyworm infestation two weeks after seedling emergence any time the fall armyworm appeared on the field with the aid of a CP 15 litre knapsack sprayer.

3.4 Data Collection

3.4.1 Phenological Data

Days to 50% Emergence

The days to 50% emergence was estimated as the number of days after planting of seeds when 50% of the seedlings in the two central harvestable rows had emerged.

Percentage Plant Establishment

The percentage plant establishment was determined twenty-one (21) days after planting of seeds. This was done by counting the number of plants that had established within the two central harvestable rows and the percentage plant establishment was estimated.

Days to 50% Tasseling

Days to 50% tasseling was estimated as the number of days after planting when 50% of the plants in the two central harvestable rows had tasseled.

Days to 50% Silking

The days to 50% silking was determined as the number of days after planting when 50% of the plants in the two central harvestable rows had silked.

3.5 Vegetative Growth Data

Plant Height

The meter rule was used to determine the height of the plant from the plant's base to its apical bud. Plant height was measured from five randomly selected and tagged plants in the two central harvestable rows three (3) weeks after planting and every two weeks interval and their mean values were estimated.

Number of Leaves per plant

The number of leaves per plant from the five randomly selected and tagged plants in the two central harvestable rows was determined by counting the total number of leaves per plant for the tagged plants. This was done three (3) weeks after planting and every two weeks till tasseling and their mean values estimated.

Dry Matter Accumulation

The dry matter was determined at three (3) weeks after planting and every two weeks interval. Two plants were cut at the base of the plant at ground level were separated and oven dried at 75 °C for 48 hours.

Weed Dry Weight

The weight of weeds were determined by uprooting weeds within the four central rows and oven dried at 75 °C for 48 hours and weighed and recorded.

Crop Growth Rate (CGR)

This was measured in $\text{g m}^{-2} \text{ day}^{-1}$ using the formula below as adopted by Essilfie *et al.* (2023); $\text{CGR} = \left(\frac{1}{GA}\right) \times \left(\frac{W_2 - W_1}{T_2 - T_1}\right)$, Where CGR= Crop growth rate; W_1 =total dry matter at first harvest; W_2 = Total dry matter at second harvest; T_1 = Days of observation at first harvest; T_2 = Days of observation at second harvest.

Net Assimilation Rate (NAR)

This was measured in $\text{g m}^{-2} \text{ day}^{-1}$ using the formula; $\text{NAR} = \left(\frac{W_2 - W_1}{T_2 - T_1}\right) \times \frac{\ln LA_2 - \ln LA_1}{LA_2 - LA_1}$, Where; where (W_1) and (W_2) are the dry weights of the plant at time (T_2) and (T_1) , and (LA_1) and (LA_2) are the corresponding leaf areas.

Relative Growth Rate (RGR)

This was measured in $\text{g m}^{-2} \text{ day}^{-1}$ using the formula below as adopted by Essilfie *et al.* (2023); $\text{RGR} = \left(\frac{\ln W_2 - \ln W_1}{T_2 - T_1}\right)$, Where RGR = Relative growth rate; W_1 =Total dry matter at first harvest; W_2 = Total dry matter at second harvest; T_1 = Days of observation at first harvest; T_2 =Days of observation at second harvest; \ln =Natural log.

3.6 Yield and Yield Components

Number of Plants Harvested

The total number of plants harvested from the two central harvestable rows was counted to estimate the number of plants harvested per plot.

Number of lodged Plants Per Plot

The total number of plants from the two central harvestable rows that had lodged at the base or stem was counted and the mean was estimated.

Stover Weight Per Plant and Per Plot

The stalk of maize together with the cobs for the five tagged plants was harvested from the two central harvested rows and weighed in kilograms (kg) using the Westinghouse electronic weighing scale and recorded as the stover weight per plant whilst the remaining untagged plants from the harvestable area per plot were harvested and added to the tagged ones and weighed in kilograms (kg) using the Westinghouse electronic weighing scale and were recorded as the stover weight per plot.

Dry Matter Accumulation at Harvest

The dry matter accumulation at harvest was determined after the plants have been harvested. Harvested plants shoot per plot was chopped into pieces and weighed in kilogram (kg) using the Westinghouse electronic weighing scale and oven dried in the laboratory at 85 °C until the constant temperature was attained and the mean recorded.

Cob diameter

The diameter of five cobs that were randomly selected at harvest from the two central harvestable rows was measured from the widest part using the vernier caliper after de-husking and the mean estimated.

Cob length

The length of five cobs that were randomly selected at harvest from the two central harvestable rows was measured using the metre rule after de-husking and the mean estimated.

100-Seed weight

The 100 - seed weight was measured by randomly selecting 3 lots of hundred seeds from each plot after shelling and their weight taken using the Westinghouse electronic weighing scale and their means recorded.

Grain yield

The grain yield at 15% moisture content from the harvestable area per plot was calculated and the results were then used to compute the yield per hectare. The formula used as described below was adopted from Shabani & Sepaskhah (2019).

$$\text{Yield (kg/ha)} = \frac{\text{Seed yield (kg)}}{\text{Harvestable area (m}^2\text{)}} \times \frac{10,000 \text{ m}^2}{1000}$$

Harvest index

The shoots together with the cobs from the two central harvestable rows were weighed using a salter suspended weigher with model number 235. The cobs were then removed and weighed alone.

$$\text{Thus, Harvest index} = \frac{\text{Grain weight}}{\text{Above ground biomass(stover+grain)}}$$

3.7 Data Analysis

The data collected was analyzed using Genstat (11th edition) software package and analysis of variance (ANOVA) was performed on the experimental data. The Tukey's Honestly Significant Difference (HSD) was used to differentiate treatment means at a 5% level of probability. Correlation analysis among yield and yield components was carried out.

CHAPTER FOUR: RESULTS

4.1 Phenology

4.1.1 *Percent Plant Establishment*

The % plant establishment as affected by weed control regime, plant population and their interaction is shown in Table 4.1. Weed control did not significantly ($p > 0.05$) influence percentage plant establishment during both the major and minor seasons. However, there were differences among plant population densities in both seasons. On the average, 80×30 cm and 80×50 cm had 75-76% establishment compared with 63% for 80×50 cm in the major season. In the minor season, 80×30 cm had 83% plant establishment compared with 76% plant establishment for 80×40 cm and 80×50 cm. There were significant weed control \times plant population interaction on % plant establishment. In the major season, weeding twice $\times 80 \times 40$ cm had the highest % plant establishment (84%) while weed free $\times 80 \times 50$ cm had the least establishment (49%). In the minor season, weed free $\times 80 \times 30$ cm and weed free $\times 80 \times 40$ cm had the highest establishment (81-82%), while weeding twice $\times 80 \times 40$ cm had the least (72%). Between the seasons, minor season on the average had better establishment than the major season.

Table 4. 1: Weed Control Regime and Plant Population Density on Percentage Plant Establishment

Weed Control Regime (WC)	% Plant Establishment							
	Major Season				Minor Season			
	Plant population (PP)			Mean	Plant population (PP)			Mean
80×30	80×40	80×50	80×30		80×40	80×50		
Weed free	83.1	80.4	48.8	70.8	80.7	80.7	73.5	78.3
Weed once	77.1	72.5	68.8	72.8	79.3	76.0	80.3	78.6
Weed twice	71.8	84.2	66.7	74.2	81.3	71.7	68.7	73.9
Unweeded	66.7	66.7	67.7	67.0	81.7	77.3	79.7	79.6
Mean	74.7	75.9	63.0		80.8	76.4	75.5	
CV (%)				11.9				5.85
WC	HSD (p<0.05)=			NS				NS
PP	HSD (p<0.05)=			9.0**				4.7
Season (S)	HSD (p<0.05)=			4.1**				4.1**
WC × PP	HSD (p>0.05)=			NS				NS
WC × S	HSD (p>0.05)=			NS				NS
PP × S	HSD (p>0.05)=			NS				NS
WC × PP × S	HSD (p>0.05)=			NS				NS

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Turkey's honestly significant difference

4.1.2 Days to 50% Emergence

Table 4.2 shows the effect of weed control, plant population and their interaction on days to 50% emergence, days to 50% tasseling and days to 50% silking. Days to 50% emergence was not significantly affected by weed control, plant population nor their interaction in both seasons. The days to 50% emergence ranged from 5-7 (Table 4.2).

4.1.3 Days to 50% Tasseling

In the major season, the days to 50% tasseling differed only among weed control treatments, but not significantly different among plant population density and weed control × plant population density interaction (Table 4.2). The weeded twice (at 2 and 6 WAP) Tasseled earlier (52 days), while the unweeded (control) Tasseled latest (60 days). The days to tasseling among the interaction effects ranged from 51-61 days (Table 4.2). In the minor season, the days to 50% tasseling differed among the weed control and population density treatments, but was not significantly affected by weed control × plant population density

interaction. Similarly, in the major season the weeded twice treatment tasseling earlier (51 days), while the density Tasseled latest (60 days). The 80 × 40 cm density Tasseled earlier of 52 days, while the 80 × 30 cm Tasseled late at 58 days.

4.1.4 Days to 50% Silking

The days to 50% silking only differed among weed control treatments, but not among plant density nor weed control × plant density interaction in the major season (Table 4.2). The weeded twice (2 and 6 WAP) silked earlier (55 days), while the unweeded (Control) silked late at 63 days after planting. In the minor season, days to 50% silking was affected by weed control, plant population density and their interaction. The days to 50% silking among the interaction effect ranged from 47-62 days. Generally, 80 × 40 cm among the various weeding regimes silked earlier than the other plant population densities, while the 80 × 50 cm combined with the various weeding regimes silked latest (Table 4.2).

There were not significant difference between the major and minor seasons for the days to 50% emergence, tasseling or silking.

Table 4. 2: Weed Control Regime and Plant Population Density Effect on Days to 50% Emergence, Days to 50% Tasseling and Days to 50% Silking

Weed Control (WC)	Plant Population (PP)	Days to 50% Emergence		Days to 50% Tasseling		Days to 50% Silking	
		Major	Minor	Major	Minor	Major	Minor
Weed free	80×30	7	5	53	52	57	52
	80×40	6	7	54	50	57	50
	80×50	6	6	58	56	61	56
Weed once	80×30	5	6	56	56	59	56
	80×40	5	5	56	54	63	54
	80×50	5	5	56	58	59	58
Weed twice	80×30	5	7	52	49	56	49
	80×40	5	5	52	47	55	47
	80×50	6	6	51	56	54	56
Unweeded	80×30	5	6	61	62	64	62
	80×40	6	5	59	59	62	59
	80×50	7	6	56	60	55	60
CV (%)		17.6	21.7	6.7	7.2	7.7	7.3
WC	HSD (p>0.05)=	NS	NS	5.9	3.9	5.3	5.2
PP	HSD (p>0.05)=	NS	NS	NS	4.14	NS	5.3
WC × PP	HSD (p>0.05)=	NS	NS	NS	NS	NS	NS

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Turkey's honestly significant difference

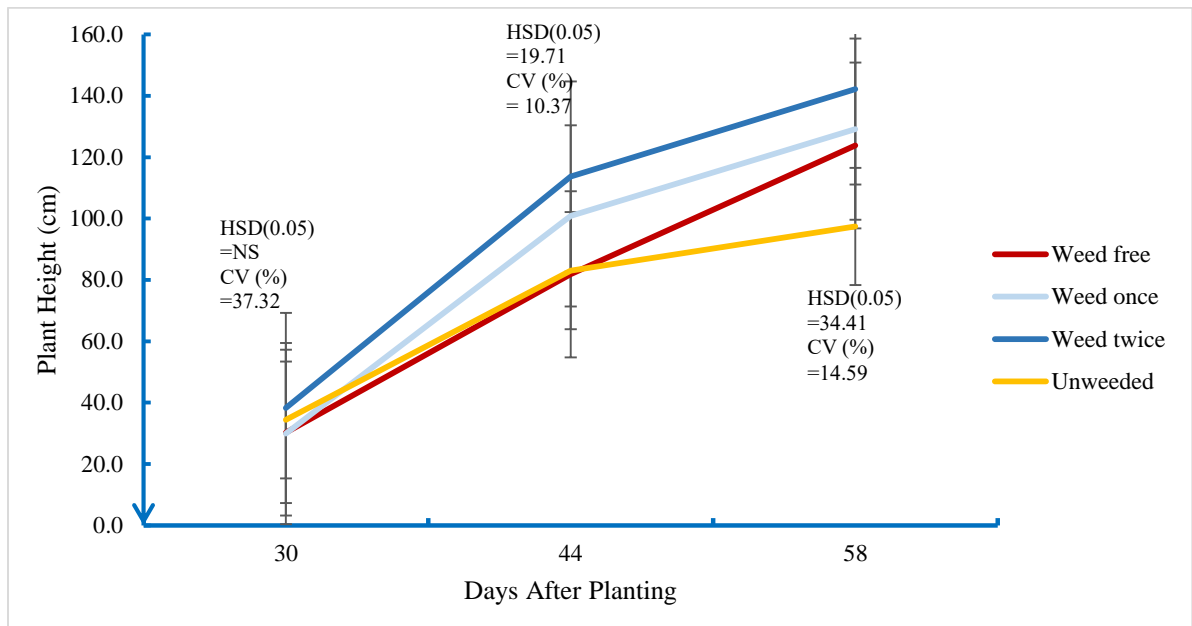
4.2 Vegetative Growth

4.2.1 Plant Height

Figures 4.1 and 4.2 show the individual effect of weed control regime and plant population respectively on plant heights of maize for both major and minor cropping seasons. There was no statistically significant ($p>0.05$) difference in plant height at 30 DAP as influenced by weed control, plant population and their interactions for both seasons. There was statistically significant ($p<0.05$) difference in plant height at 44 DAP and 58 DAP during both seasons (Figure 4.1 and Figure 4.2).

During both major and minor seasons, for weed control regime, weed twice at 2 and 6 weeks after planting recorded the tallest plant, followed by Weed once at 4 WAP, followed by unweeded plots and the shortest plant was recorded on 80 cm x 30 cm among the different weed control regimes (Figure 4.1). For plant population, during both major and minor cropping seasons, 80 cm x 50 cm had the tallest plants where 80 cm x 30 cm had the shortest plants (Figure 4.2).

(a) Major cropping Season, 2023



(b) Minor Cropping Season, 2023

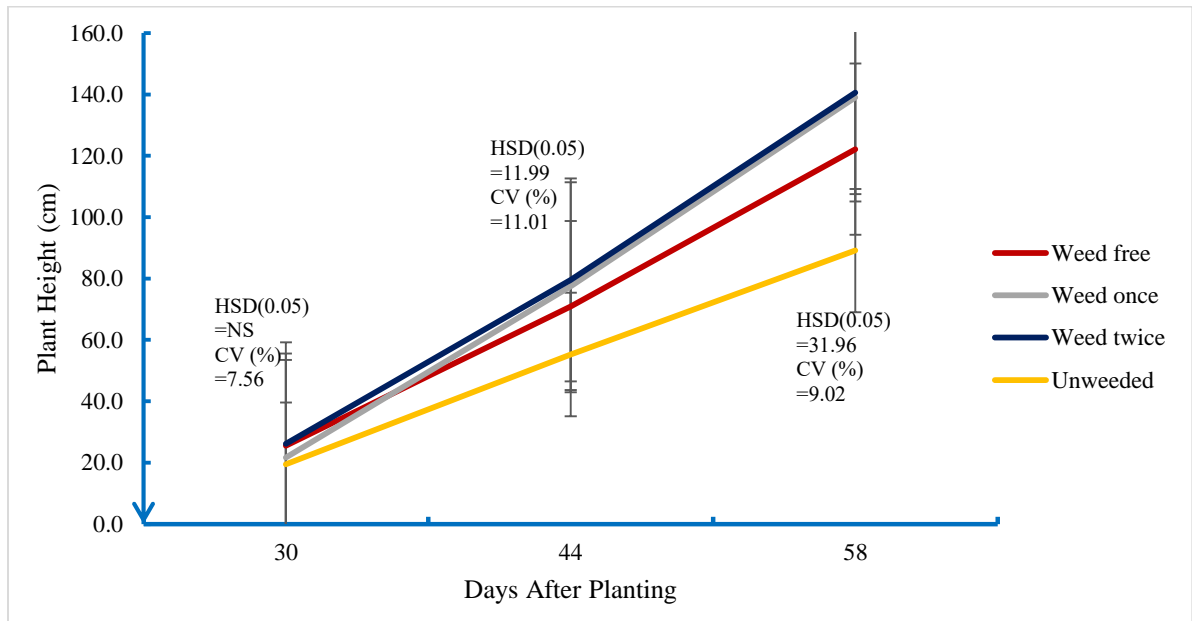
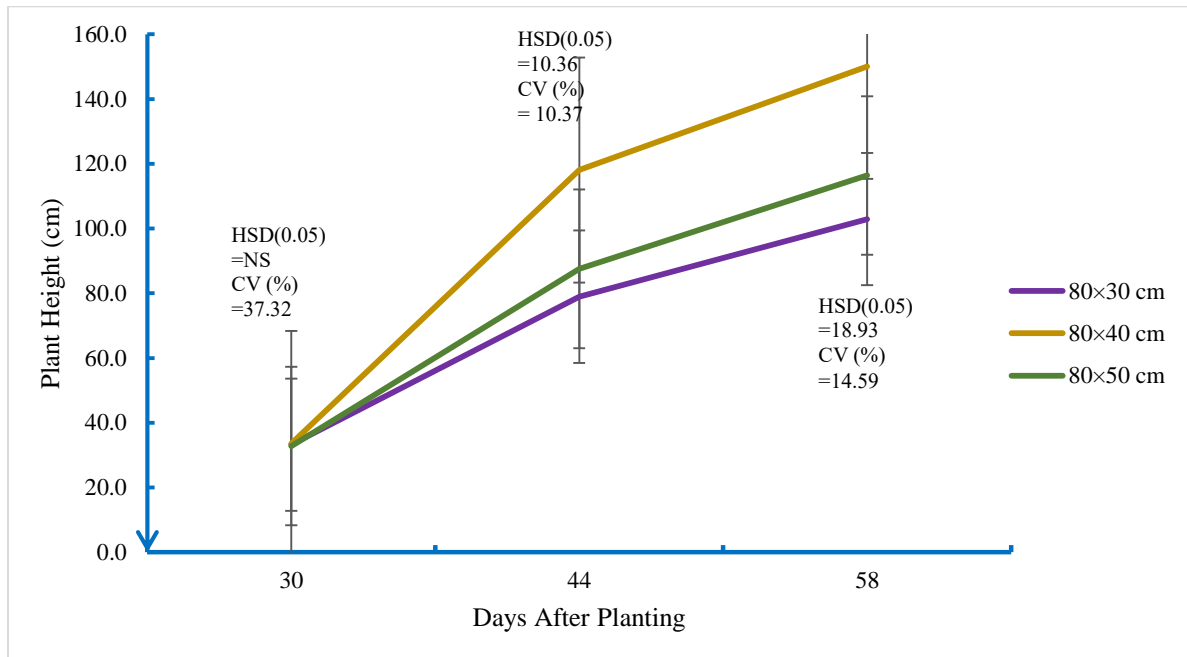


Figure 4. 1: Effect of Weed Control Regime on Plant height of Maize during both Major and Minor Cropping Seasons, 2023

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

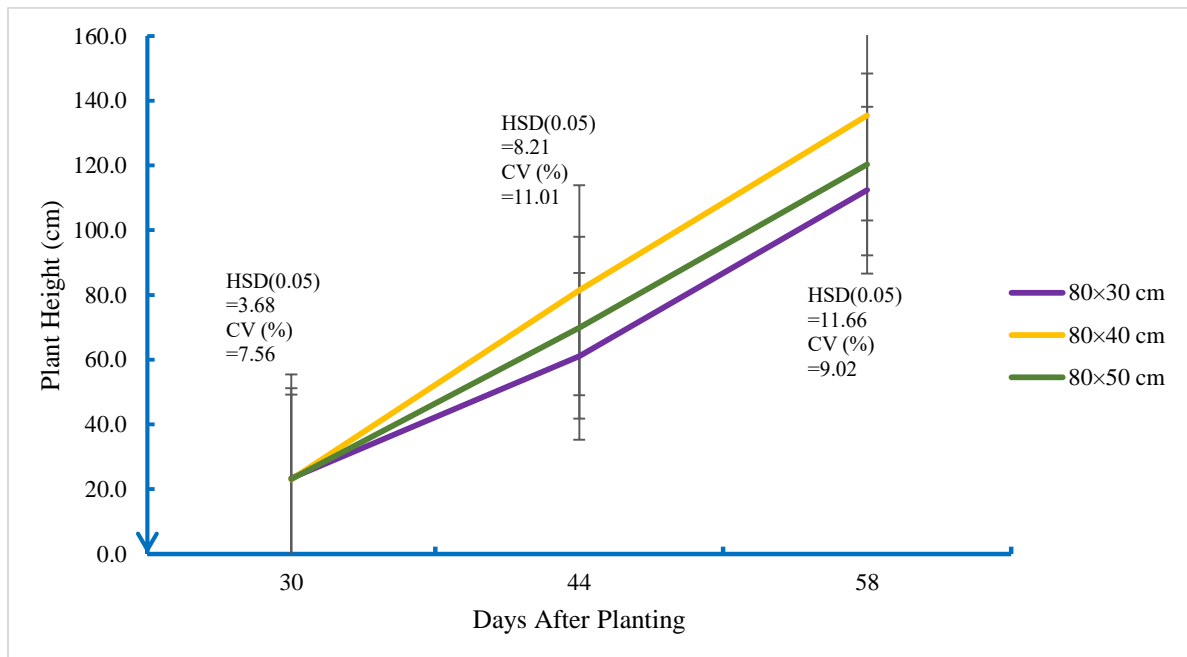


Figure 4. 2: Effect of Plant Population Density on Plant Height of Maize during both Major and Minor Cropping Seasons, 2023

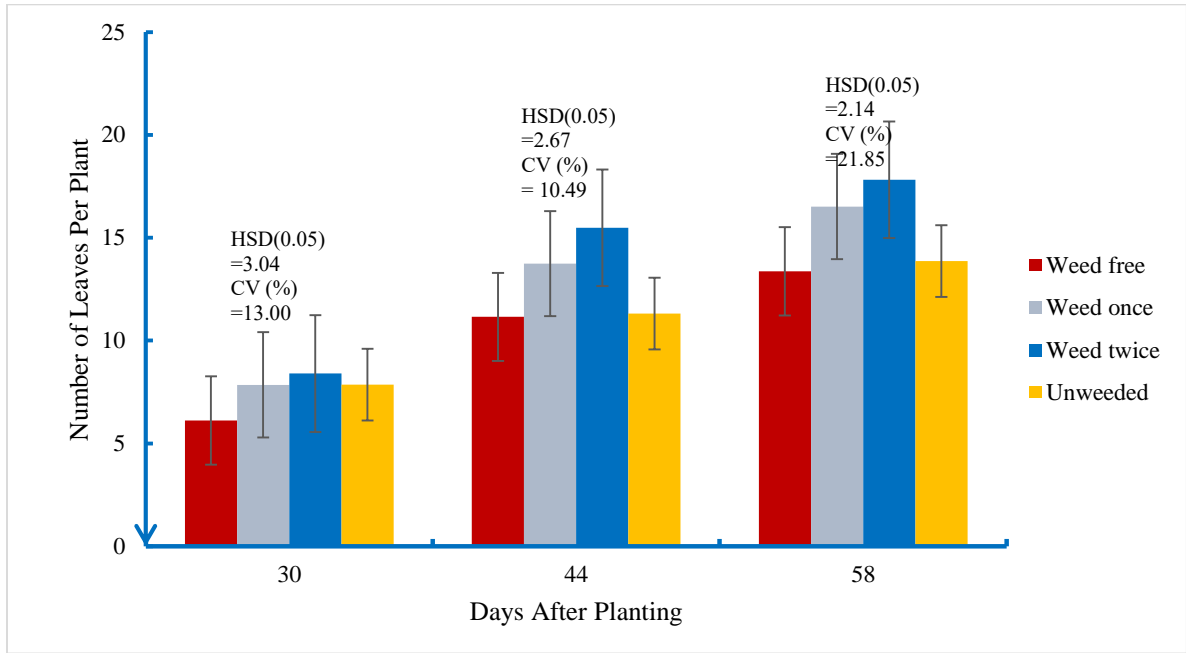
4.2.2 *Number of Leaves Per Plot*

Figures 4.3 and 4.4 show the individual effect of weed control regime and plant population density on number of leaves of maize for both major and minor cropping seasons.

Weed control significantly ($p < 0.05$) affected the number of leaves from 30 to 58 DAP for both seasons. At the major season, weed twice recorded the greatest number of leaves from 30 DAP through to 58 DAP, followed by weed once which had the next greatest number of leaves after weed twice, unweeded plots also recorded the next greatest number of leaves after weed once whereas weed free (no weeding) had the fewest number of leaves (Figure 4.3a). At the minor cropping season, similarly trend observed during the major season occurred, weed twice had the greatest number of leaves through from 30 DAP to 58 DAP, weed once had the next greatest, but this time weed free rather had the next greatest after weed once and unweeded plots rather had the fewest number of leaves (Figure 4.3b).

Plant Population density significantly ($p < 0.05$) affected the number of leaves from 30 to 58 DAP for both seasons (Figure 4.4). During the major season, 80 cm x 30 cm had the greatest number of leaves from at 30 DAP, but 80 cm x 50 cm rather had the greatest from 44 DAP to 58 DAP. At 30 DAP, the fewest number of leaves was recorded on 80 cm x 40 cm, but from 44 DAP to 58 DAP it was recorded on 80 cm x 30 cm (Figure 4.4a). During the minor season, similar trend as in the major season was observed, at 30 DAP, 80 cm x 30 cm had the greatest number of leaves, followed by 80 cm x 50 cm and then 80 cm x 40 cm had the fewest number of leaves. 80 cm x 40 cm rather had the greatest number of leaves from 44 DAP to 58 DAP while 80 cm x 30 cm had the fewest (Figure 4.4b).

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

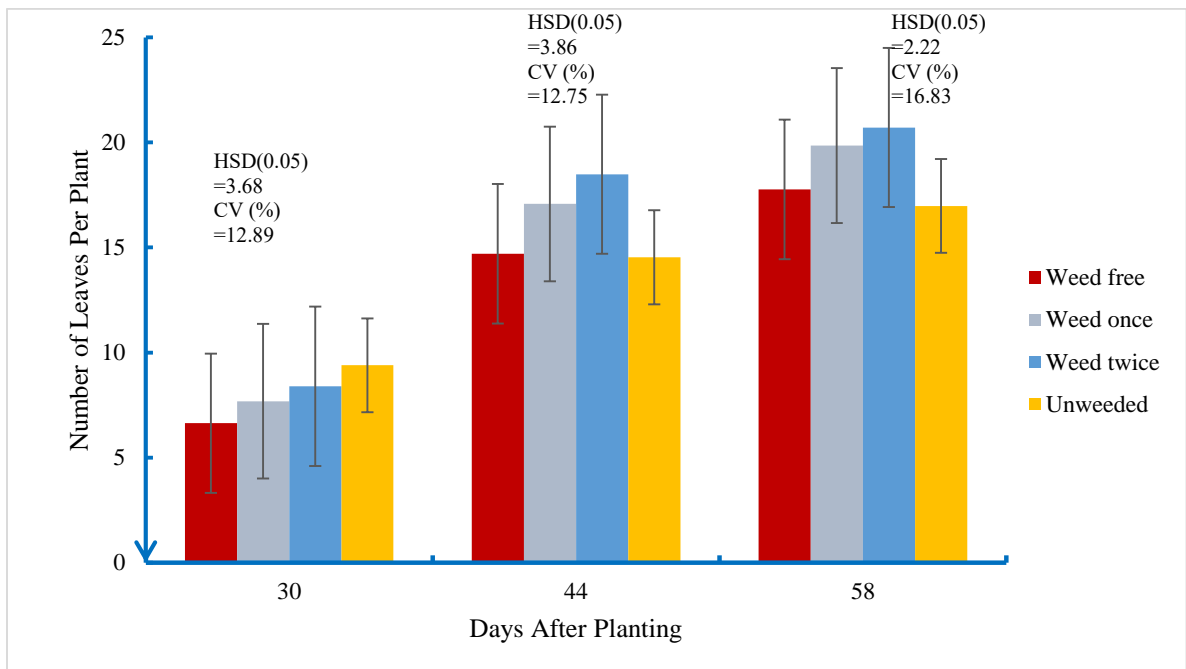
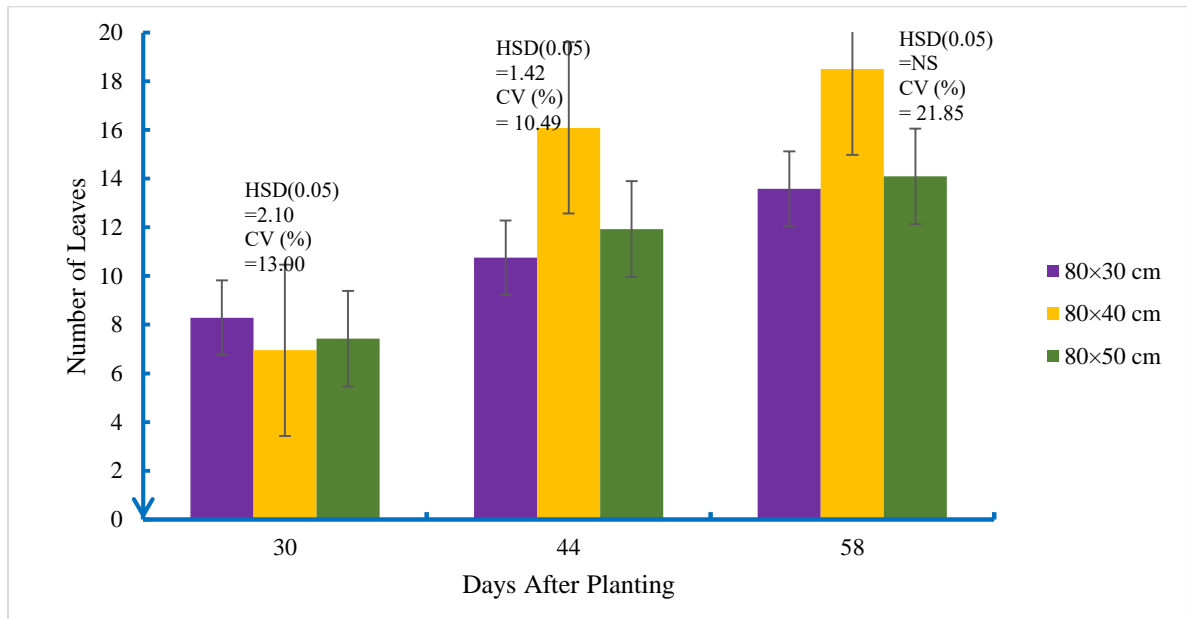


Figure 4. 3: Effect of Weed Control Regime on Number of Leaves of Maize during both Major and Minor Cropping Seasons, 2023

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

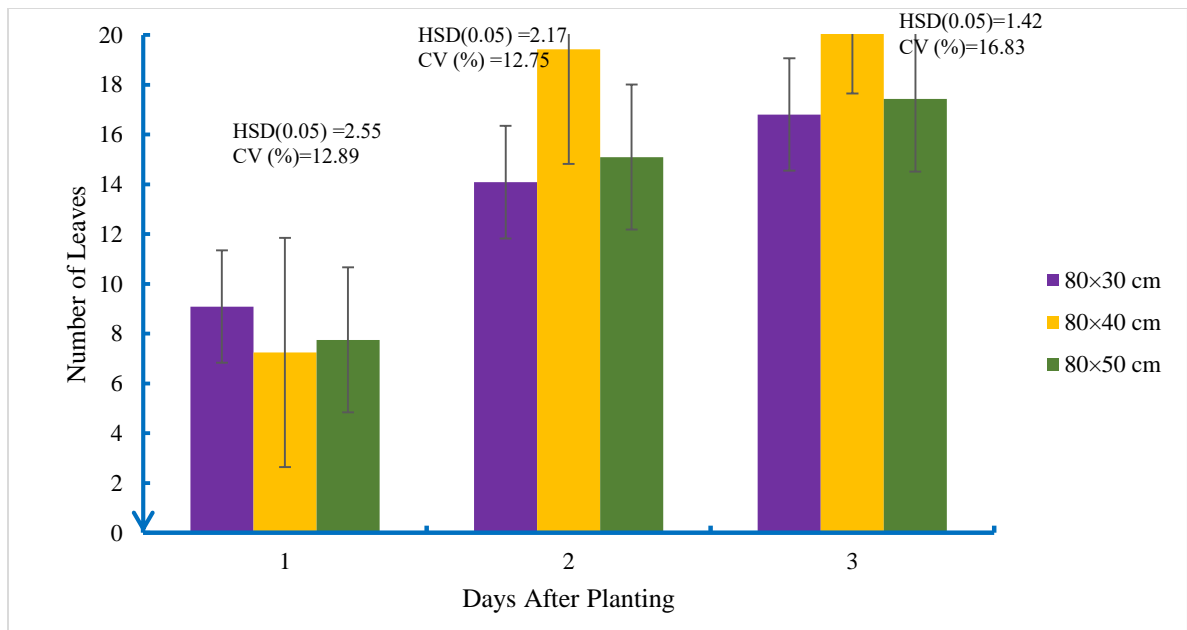


Figure 4. 4: Effect of Plant Population Density on Number of Leaves of Maize during both Major and Minor Cropping Seasons, 2023

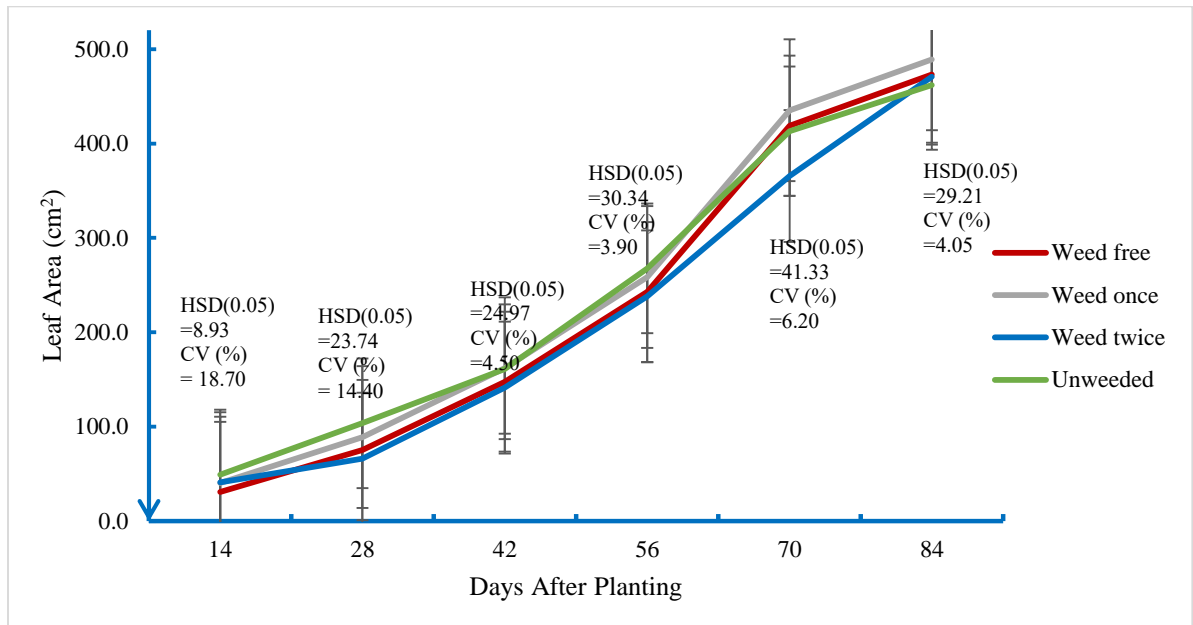
4.2.3 Leaf Area

Table 4.5 and 4.6 show the individual effect of weed control regime and plant population respectively on leaf area for both major and minor cropping seasons.

Weed control significantly ($p < 0.05$) affected the leaf area from 14 DAP to 84 DAP for both seasons. During the major season, the largest leaf area was recorded on unweeded plots from 14 DAP through to after 56 DAP and declined to have the least leaf area from 70 DAP to 84 DAP. However, weed once which also started recorded the least leaf area later increased significantly and recorded the greatest leaf area from 70 DAP to 84 DAP. Weed twice started with moderate leaf area compared to the other treatments and maintained throughout the period of sampling. The trend recorded during the minor season was similar to that of the major season for all the weed control treatments (Figure 4.5a).

Plant Population density significantly ($p < 0.05$) affected the leaf area from 14 to 84 DAP for both seasons (Figure 4.6). During the major season, 80 cm x 40 cm had the largest leaf from 28 DAP to 84 DAP, followed by 80 cm x 30 cm and 80 cm x 50 cm had the closest leaves throughout (Figure 4.6b). Similarly, during the minor season, the largest leaf started with 80 cm x 30 cm at 30 DAP, but was competed by 80 cm x 40 cm between 28 DAP and 56 DAP, the 80 cm x 40 cm took over the largest leaf from 70 to 84 DAP, but 80 cm x 50 cm started and remain as the closest leaf from 14 DAP to 84 DAP (Figure 4.6b).

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

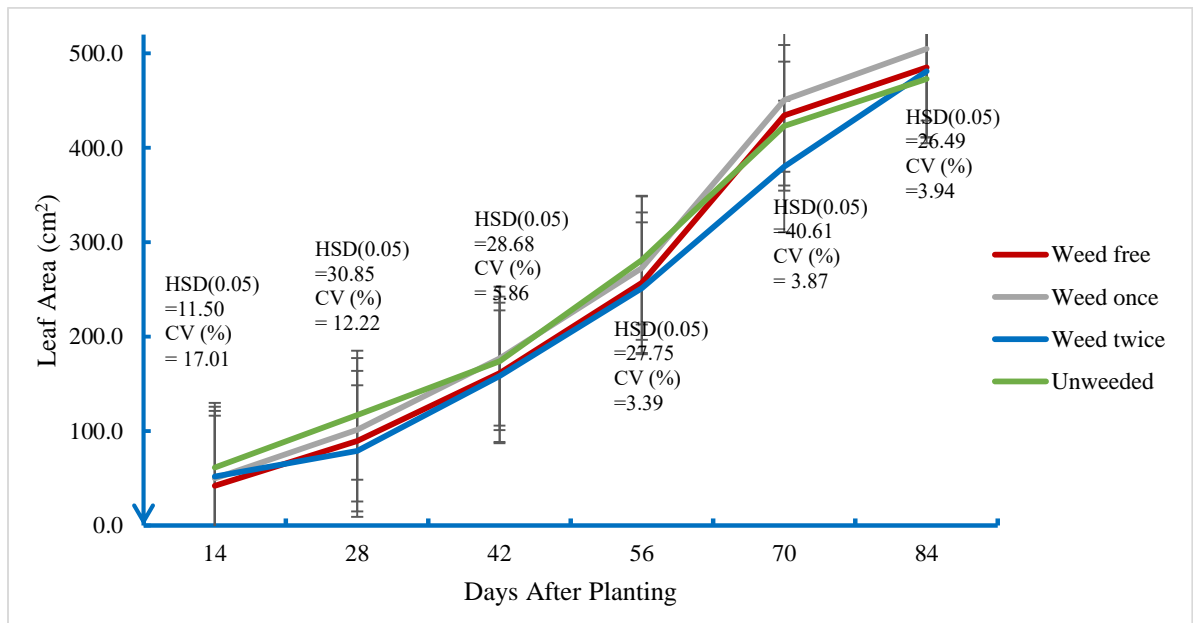
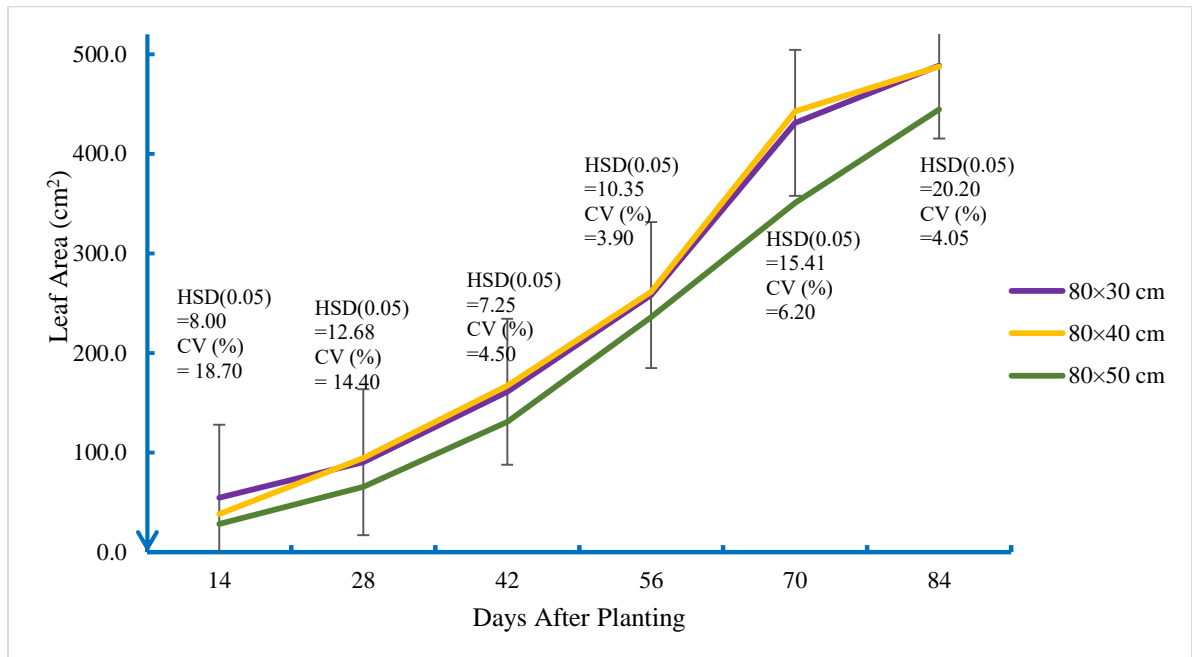


Figure 4. 5: Effect of Weed Control Regime on Leaf Area of Maize during both Major and Minor Cropping Seasons, 2023

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

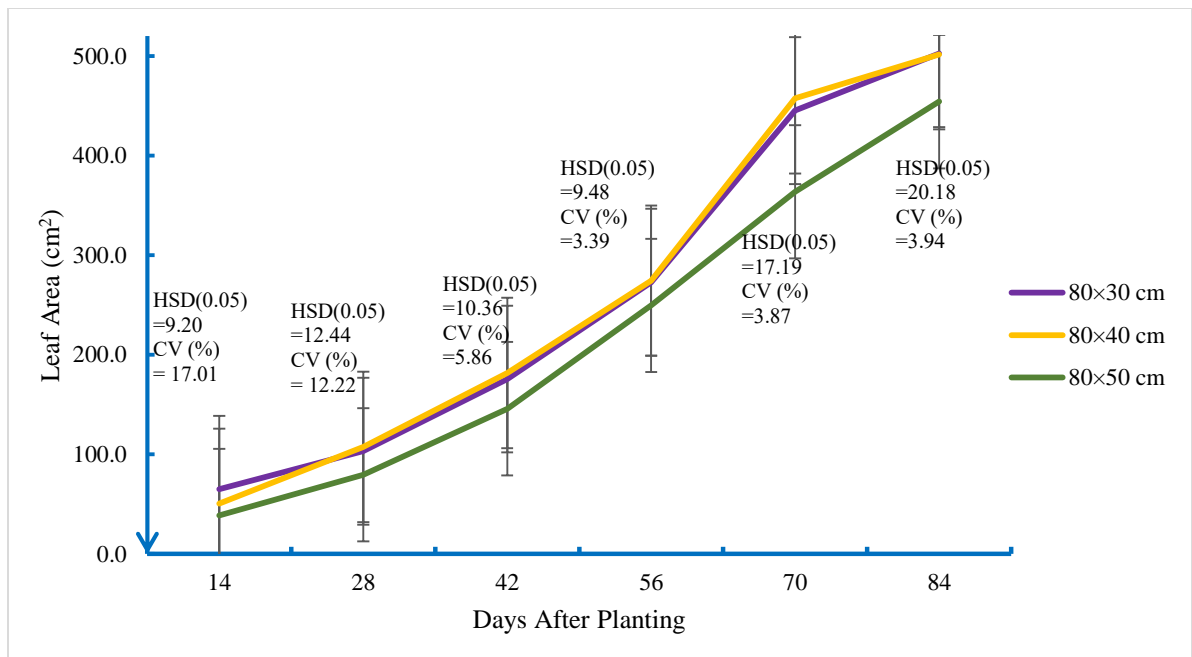


Figure 4. 6: Effect of Plant Population Density on Leaf Area of Maize during both Major and Minor Cropping Seasons, 2023

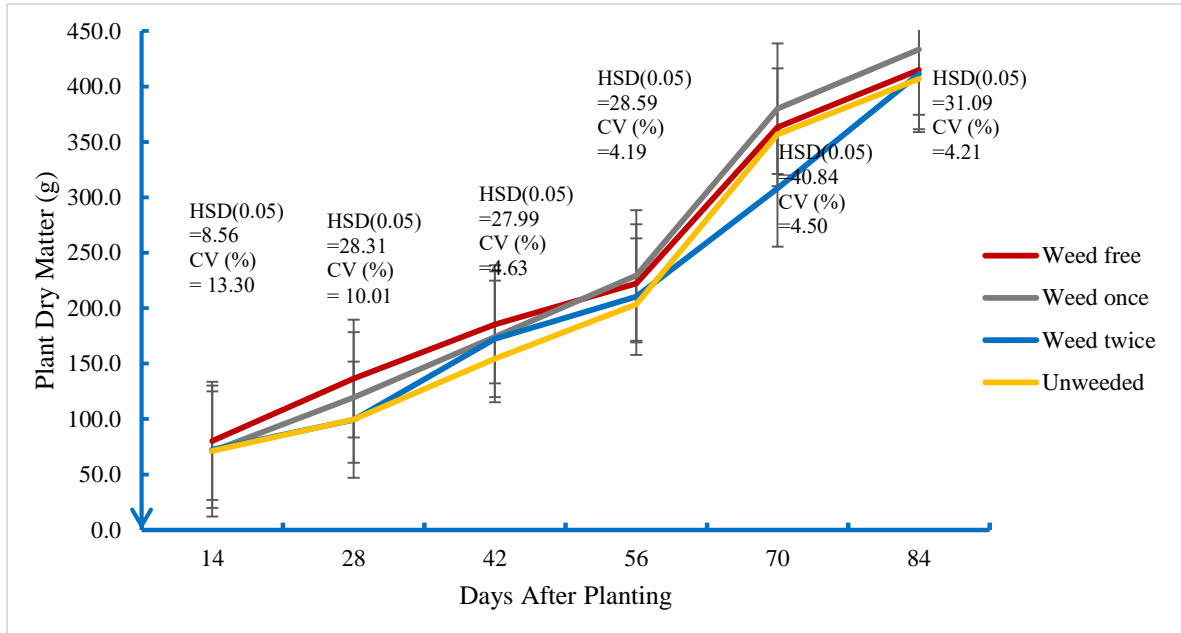
4.2.4 Plant Dry Matter

Figure 4.7 and 4.8 shows the individual effect of weed control regime and plants population density on plant dry matter from 14 to 84 DAP.

For individual effect of weed control regime on plant dry matter, there were statistically significant difference at 14 DAP to 84 DAP for both cropping seasons. At both major and minor seasons, weed free plots produced the heaviest plant dry matter at 14 DAP, 28 DAP and 56 DAP (Figure 4.7a). Weed once and Weed twice closely followed Weed free plots at the early stage and then later recorded the highest weight at 70 DAP and 84 DAP. Weed twice started producing higher weight than weed free but later dropped and had the lightest weight from 28 DAP through to 84 DAP.

For plant population density, during both major and minor seasons, similar trends were observed among the treatments. At 14 DAP and 84 DAP, the heaviest plant dry matter was recorded on 80 cm x 40 cm.

Major Season



Minor Season

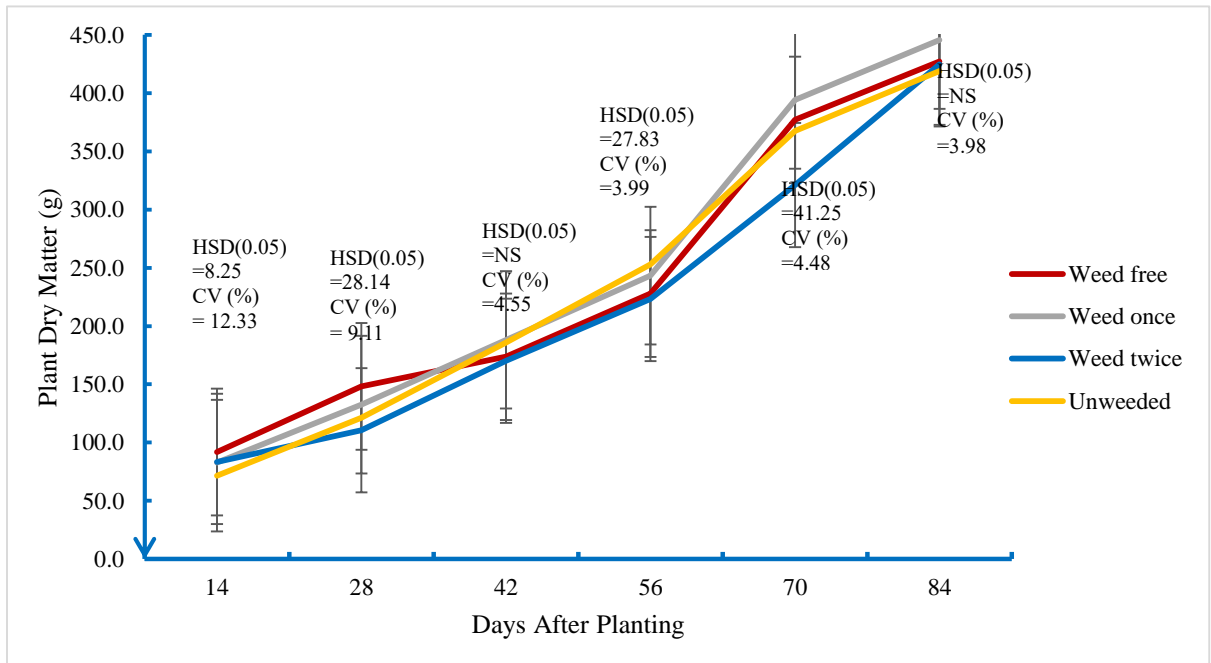
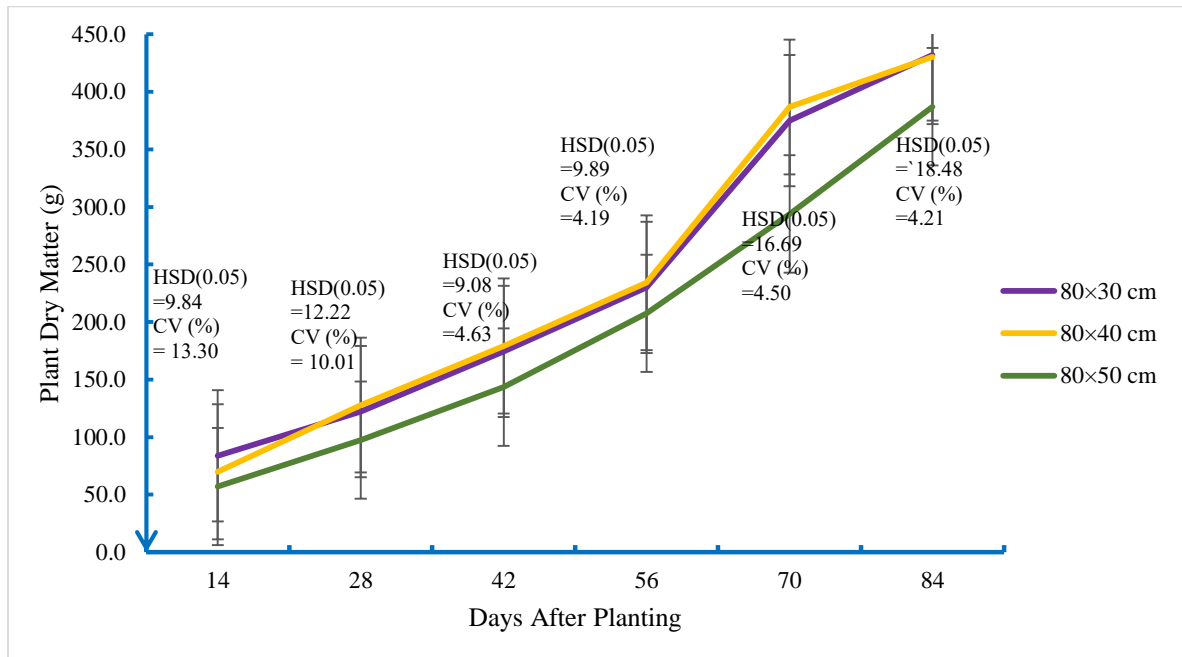


Figure 4. 7: Effect of Weed Control Regime on Maize Plant Dry Matter during both Major and Minor Cropping Seasons, 2023

Major Season



Minor Season

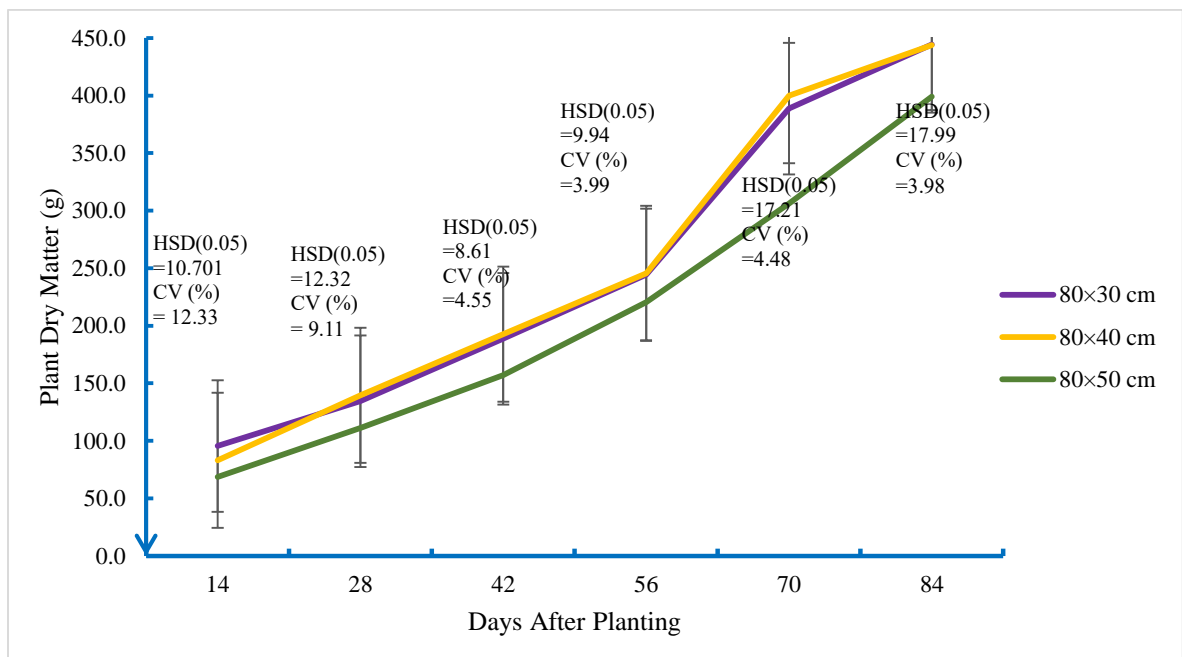


Figure 4. 8: Effect of Plant Population Density on Maize Plant Dry Matter during both Major and Minor Cropping Seasons, 2023

4.3 Crop Growth Analysis

4.3.1 Crop Growth Rate (CGR)

Table 4.3 and 4.4 show the individual effect of weed control regime, plants population and their interactions on crop growth rate (CGR) at 14 to 70 DAP for major and minor seasons respectively.

Generally, weed control regime, plant population density and weed control x plant population density significantly affected crop growth rate. Plots that were weeded had the highest crop growth rate throughout the sampling dates, but Unweeded (control) had the lowest during both seasons (Table 4.3 and Table 4.4).

Generally, among the different plant population densities, 80×40 cm had the greatest crop growth rate throughout the sampling dates, but 80×40 cm had the least during both seasons (Table 4.3 and Table 4.4).

Generally, in the interaction, Weed free × 80×40 cm had higher recorded higher crop growth rate at 0-14 DAP and at 42-56 DAP, but Weeded plots under all the different plant population densities produced greater crop growth rate than the Unweeded plot under all the plant population densities in the minor season (Table 4.4).

Table 4. 3: Effect of Weed Control and Plant Population Density on Crop Growth Rate during the Major Season

Treatment	Crop Growth Rate (CGR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	4.0	3.7	3.9	10.6	3.7
Weed once	3.5	3.9	4.0	10.7	3.8
Weed twice	3.1	4.0	3.9	7.0	7.4
Unweeded	1.9	2.6	3.8	8.3	3.6
HSD (0.05)	1.89	0.83	0.17	2.14	3.04
Plant Population Density (PPD)					
80×30	2.7	3.7	4.0	10.4	4.1
80×40	4.1	3.7	3.9	10.9	3.1
80×50	2.9	3.3	4.6	6.2	6.7
HSD (0.05)	0.88	NS	0.24	1.08	1.22
WC × PPD					
Weed free × 80×30	5.4	3.7	3.9	10.5	4.2
Weed free × 80×40	4.6	3.7	4.0	11.6	2.5
Weed free × 80×50	2.9	3.8	3.9	9.5	4.3
Weed once × 80×30	3.5	4.0	4.0	10.4	4.4
Weed once × 80×40	3.5	3.9	3.9	11.3	3.7
Weed once × 80×50	3.4	3.8	3.9	10.6	3.3
Weed twice × 80×30	0.7	3.4	3.9	9.6	4.6
Weed twice × 80×40	3.4	3.7	4.0	10.5	3.4
Weed twice × 80×50	1.7	4.9	3.8	0.8	14.2
Unweeded × 80×30	3.4	3.8	4.0	6.5.0	1.1
Unweeded × 80×40	2.1	3.4	3.8	0.2	2.8
Unweeded × 80×50	3.5	0.6	6.7	3.7	1.9
HSD (p<0.05)	NS	1.71	0.63	3.91	5.10
CV (%)	25.72	14.25	5.63	11.24	25.28

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Tukey's honestly significant difference

Table 4. 4: Effect of Weed Control and Plant Population Density on Crop Growth Rate during the Minor Season

Treatment	Crop Growth Rate (CGR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	3.6	3.7	4.9	10.7	6.6
Weed once	3.5	4.0	3.9	10.8	3.7
Weed twice	2.0	4.3	3.8	8.0	7.4
Unweeded	1.7	2.6	3.4	7.2	3.7
HSD (0.05)	2.00	1.04	0.43	1.90	2.96
Plant Population Density (PPD)					
80×30	2.8	3.9	4.0	10.3	4.0
80×40	4.0	3.8	3.8	11.0	3.1
80×50	3.0	3.3	4.5	6.1	6.6
HSD (0.05)	0.92	0.48	0.38	1.07	1.14
WC × PPD					
Weed free × 80×30	5.3	3.8	3.8	10.7	3.9
Weed free × 80×40	4.4	5.7	4.0	11.7	9.6
Weed free × 80×50	3.0	3.8	4.8	9.6	4.3
Weed once × 80×30	3.6	3.9	4.4	10.2	4.3
Weed once × 80×40	3.4	4.2	3.7	11.5	3.6
Weed once × 80×50	3.7	3.8	3.8	10.6	3.1
Weed twice × 80×30	0.6	3.8	3.9	9.5	4.6
Weed twice × 80×40	3.4	3.9	3.9	10.7	3.3
Weed twice × 80×50	1.9	2.1	3.6	0.7	14.3
Unweeded × 80×30	3.6	3.1	3.1	10.8	3.2
Unweeded × 80×40	2.4.0	3.4	3.5	10.2	3.0
Unweeded × 80×50	3.7	0.4	2.9	3.5	2.9
HSD (p<0.05)	NS	1.83	1.10	3.66	4.91
CV (%)	26.64	12.50	8.97	11.18	23.78

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Tukey's honestly significant difference

4.3.2 Relative Growth Rate

Table 4.5 and 4.6 shows the individual effect of weed control regime, plants population density and their interactions on relative growth rate (RGR) at 14 to 70 DAP for major and minor seasons respectively.

Generally, weed control regime, plant population density and weed control regime x plant population density significantly affected crop growth rate, except at 14-28 DAP for plant population density and weed x plant population density interactions at 0-14 DAP. Although, Weed twice treatments had the greatest relative growth rate throughout the sampling dates, followed by weed once and by weed free had the greatest at 42-56 DAP, then 56-70 DAP Unweeded (control) had the least during both major and minor seasons (Table 4.5 and Table 4.6). 80 x 30 cm plant population density had the least relative growth rate at 0-56 DAP but 80 x 40 cm had the least between 56-70 DAP DAP.

Generally, the weed control regime x plant population density interactions were significant, relative growth rate ranged from 1.7 at 0-14 DAP to 38.9 at 56-70 DAP. Weed twice × 80×50 cm treatment generally had greatest relative growth rate throughout during both seasons but had the least was recorded by the Unweeded plot under all the plant population densities (Table 4.5 and Table 4.6).

Table 4. 5: Effect of Weed Control Regime and Plant Population Density on Relative Growth Rate during the Major Season

Treatment	Relative Growth Rate (RGR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	9.7	10.1	10.5	29.0	9.7
Weed once	9.6	10.8	10.7	29.3	10.0
Weed twice	5.3	11.6	10.3	19.0	20.1
Unweeded	1.1	7.2	3.0	12.3	9.0
HSD (0.05)	5.10	2.32	0.55	5.90	8.27
Plant Population Density (PPD)					
80×30	7.6	10.5	10.8	28.0	10.8
80×40	10.9	10.3	10.3	30.0	8.5
80×50	8.3	8.9	12.3	16.7	18.0
HSD (0.05)	2.43	NS	0.67	2.95	3.32
WC × PPD					
Weed free × 80×30	9.1	10.2	10.3	29.0	10.5
Weed free × 80×40	11.9	10.0	18.9	31.8	7.1
Weed free × 80×50	8.1	10.3	10.3	26.2	11.6
Weed once × 80×30	9.8	10.6	11.9	27.6	11.6
Weed once × 80×40	9.2	11.4	10.0	31.3	9.9
Weed once × 80×50	10.0	10.3	10.2	28.9	8.5
Weed twice × 80×30	1.7	10.2	10.5	25.9	12.6
Weed twice × 80×40	9.2	10.6	10.5	29.1	8.9
Weed twice × 80×50	5.0	13.9	9.8	2.0	38.9
Unweeded × 80×30	9.7	4.1	3.5	9.5	8.6
Unweeded × 80×40	3.5	9.3	9.6	7.8	8.1
Unweeded × 80×50	10.1	1.2	4.9	9.5	13.3
HSD (p<0.05)	NS	1.44	1.77	10.74	13.86
CV (%)	26.13	14.14	5.64	11.28	25.19

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Tukey's honestly significant difference

Table 4. 6: Effect of Weed Control and Plant Population Density on Relative Growth Rate during the Minor Season

Treatment	Relative Growth Rate (RGR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	9.8	10.1	10.7	28.7	10.0
Weed once	9.4	10.6	13.8	29.2	10.4
Weed twice	5.2	10.9	10.6	18.9	20.1
Unweeded	2.7	7.1	9.1	12.6	9.7
HSD (0.05)	5.40	2.83	1.14	5.09	8.04
Plant Population Density (PPD)					
80×30	7.5	10.2	10.8	28.2	11.1
80×40	11.3	10.0	10.7	29.6	8.5
80×50	7.8	8.9	12.4	16.8	18.1
HSD (0.05)	2.52	1.31	1.08	2.93	3.12
WC × PPD					
Weed free × 80×30	9.2	10.1	15.7	28.6	11.4
Weed free × 80×40	12.5	10.0	12.9	31.6	6.9
Weed free × 80×50	7.8	10.3	10.5	25.9	11.8
Weed once × 80×30	9.5	10.8	11.0	28.2	12.0
Weed once × 80×40	9.5	10.7	10.7	30.7	10.2
Weed once × 80×50	9.3	10.3	10.6	28.8	8.9
Weed twice × 80×30	1.9	9.3	10.7	26.1	12.4
Weed twice × 80×40	9.2	10.1	10.9	28.5	9.3
Weed twice × 80×50	4.6	13.4	10.3	2.2	38.5
Unweeded × 80×30	9.3	10.4	10.8	19.8	8.4
Unweeded × 80×40	4.0	9.2	10.2	17.8	7.6
Unweeded × 80×50	2.6	1.7	18.3	10.2	13.2
HSD (p<0.05)	NS	5.00	3.03	9.89	13.33
CV (%)	2.78	12.59	9.28	11.18	23.80

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Tukey's honestly significant difference

4.3.3 Net Assimilation Rate

Table 4.7 and Table 4.8 show the individual effect of weed control regime, plants population density and their interactions on net assimilation rate (NAR) at 14 to 70 DAP for major and minor seasons respectively.

There were significant differences in net assimilation are affected by weed control regime, plant population density and weed control x plant population interactions during both major

and minor seasons. In both major and minor seasons, weed control, plant population density and weed control x plant population interactions recorded an increase in net assimilation from 0-28 DAP, declined at 28-42 DAP and increased again between 42-70 DAP.

Generally, Weed twice treatments had the greatest relative growth rate throughout the sampling dates, followed by weed once and by weed free had the greatest at 42-56 DAP, then 56-70 DAP Unweeded (control) had the least during both major and minor seasons (Table 4.5 and Table 4.6). 80 x 30 cm plant population density had the least relative growth rate at 0-56 DAP but 80 x 40 cm had the least between 56-70 DAP DAP.

Generally, the weeded plots under plant population density and the interactions of all weeded plots under plant population densities significantly recorded the greatest (Table 4.7 and Table 4.8). Weed plot treatments generally had net assimilation rate throughout during both seasons but had the least was recorded by the Unweeded plot under all the plant population densities (Table 4.7 and Table 4.8).

Table 4. 7: Effect of Weed Control Regime and Plant Population Density on Relative Growth Rate during the Major Season

Treatment	Net Assimilation Rate (NAR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	38.4	51.5	27.5	43.8	56.6
Weed once	33.2	46.0	24.6	41.8	54.8
Weed twice	44.8	57.7	28.0	40.5	53.3
Unweeded	18.7	32.0	15.2	30.6	17.6
HSD (0.05)	13.25	12.81	4.48	9.55	9.27
Plant Population Density (PPD)					
80×30	30.4	43.5	25.2	40.3	53.5
80×40	27.0	40.0	23.6	41.8	54.4
80×50	43.9	56.8	36.0	35.5	48.2
HSD (0.05)	12.46	12.27	1.69	5.69	5.84
WC × PPD					
Weed free × 80×30	27.6	40.8	23.9	40.4	53.6
Weed free × 80×40	27.6	40.8	54.7	44.8	57.1
Weed free × 80×50	60.0	72.8	33.9	46.1	59.0
Weed once × 80×30	26.7	39.2	23.3	38.1	51.0
Weed once × 80×40	29.5	42.6	23.2	42.8	55.8
Weed once × 80×50	43.4	56.1	27.3	44.6	57.4
Weed twice × 80×30	45.4	58.7	32.2	43.6	56.9
Weed twice × 80×40	33.4	46.0	25.8	41.9	54.5
Weed twice × 80×50	55.6	68.3	26.0	35.9	48.6
Unweeded × 80×30	21.8	35.3	21.6	39.1	12.3
Unweeded × 80×40	17.5	15.6	20.9	17.6	20.3
Unweeded × 80×50	16.7	12.0	17.0	15.2	28.0
HSD (p<0.05)	NS	NS	7.83	8.86	18.87
CV (%)	35.03	24.	5.67	13.78	10.66

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Tukey's honestly significant difference

Table 4. 8: Effect of Weed Control and Plant Population Density on Relative Growth Rate during the Minor Season

Treatment	Net Assimilation Rate (NAR)				
	0-14 DAP	14-28 DAP	28-42 DAP	42-56 DAP	56-70 DAP
Weed Control (WC)					
Weed free	29.1	42.0	24.6	41.6	54.8
Weed once	27.0	40.5	22.5	39.7	52.9
Weed twice	42.4	55.4	24.2	33.5	46.5
Unweeded	14.2	27.4	14.3	32.4	25.5
HSD (0.05)	10.69	10.79	5.11	6.34	6.65
Plant Population Density (PPD)					
80×30	26.6	39.7	23.1	37.9	50.9
80×40	23.2	36.4	20.9	40.2	53.3
80×50	34.7	47.8	32.2	32.3	45.5
HSD (0.05)	6.69	6.66	3.10	5.24	5.30
WC × PPD					
Weed free × 80×30	22.6	35.2	20.9	38.9	52.1
Weed free × 80×40	22.3	35.5	23.2	42.5	56.0
Weed free × 80×50	42.4	55.2	29.7	43.6	56.3
Weed once × 80×30	20.3	33.7	23.8	35.0	47.7
Weed once × 80×40	27.1	40.6	19.7	41.7	54.9
Weed once × 80×50	33.6	47.0	24.2	42.5	56.1
Weed twice × 80×30	43.4	56.4	28.2	41.0	53.9
Weed twice × 80×40	29.4	42.4	22.5	40.3	53.3
Weed twice × 80×50	54.5	67.5	21.8	19.2	32.5
Unweeded × 80×30	10.2	13.6	9.6	36.9	10.1
Unweeded × 80×40	14.1	27.2	18.4	36.3	19.3
Unweeded × 80×50	8.4	21.3	13.0	23.9	13.1
HSD (p<0.05)	21.68	21.72	10.19	15.24	15.60
CV (%)	22.54	15.31	11.59	13.53	10.09

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD= Turkey's honestly significant difference

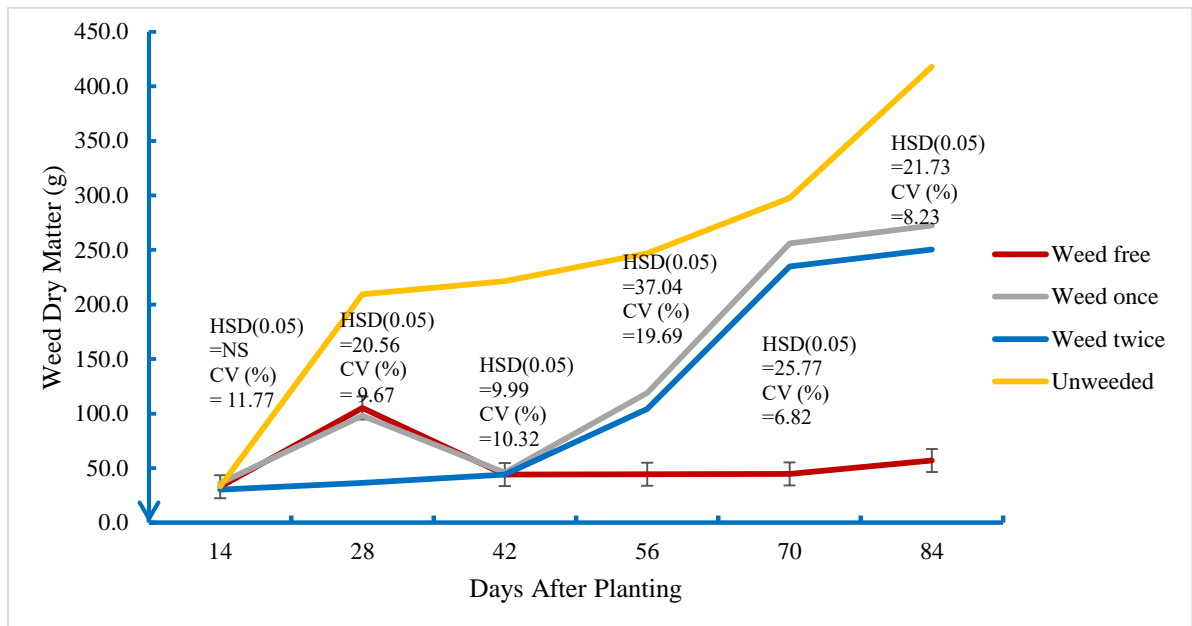
4.3.4 Weed Dry Matter

Figures 4.9 and 4.10 show the individual, interactive and seasonal effect of weed control regime and plant population on weed dry matter for both major and minor cropping seasons.

Weed control and weed control x plant population density interactions significantly influenced weed dry matter throughout the experiment. Plant population density also significantly influenced weed dry matter from 28 DAP to 42 DAP and at 70 DAP.

Generally, Unweeded treatment (control) had the greatest weed dry matter throughout and Weed free had the least in both seasons. There were declines in weed dry matter after 28 DAP, and an increase in weed dry matter was obtained from 42 DAP to 84 DAP for both weed control and plant population density and weed control x plant population interactions. 80 cm x 40 cm had the highest weed dry matter throughout and 80 cm x 50 cm had the lowest weed dry matter from 42 DAP to 84 DAP. All plant densities under Unweeded treatment (control) had the highest weed dry matter and all plant densities under Weedfree treatment had the lowest weed dry matter in both seasons.

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

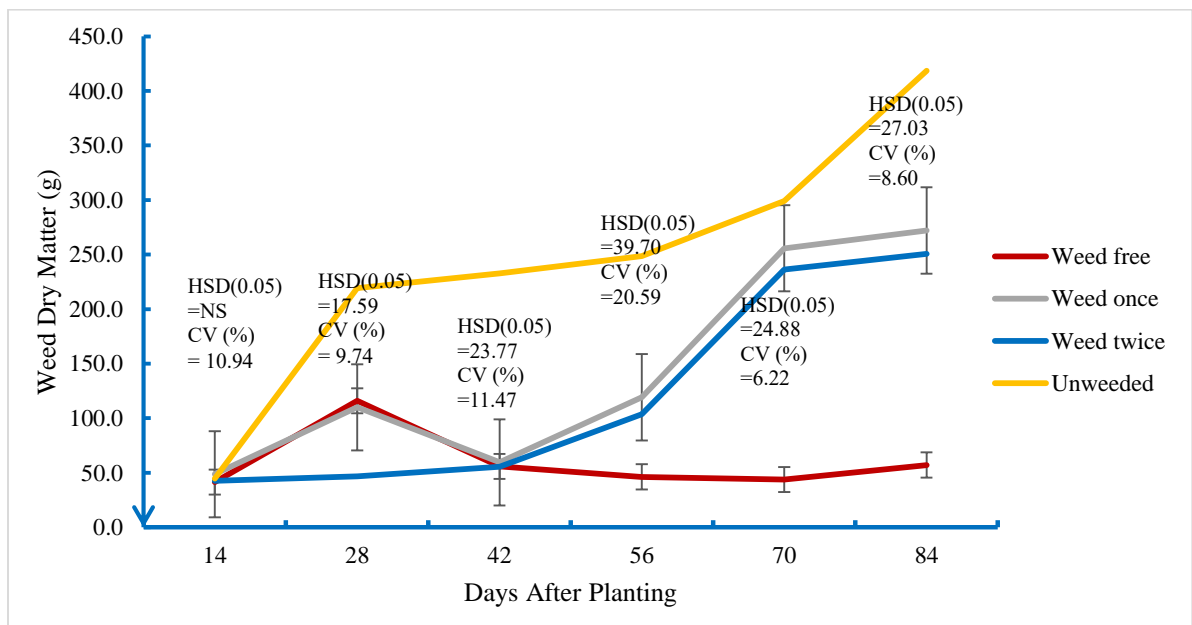
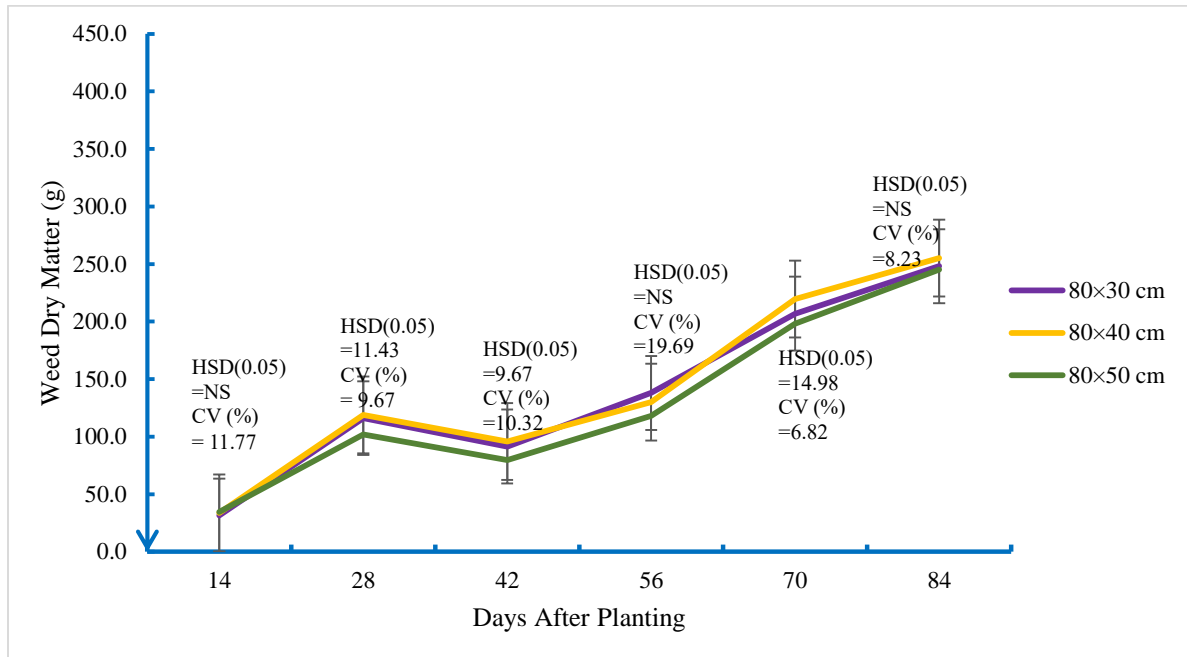


Figure 4. 9: Effect of Weed Control on Weed Dry Matter during both Major and Minor Cropping Seasons, 2023

(a) Major Cropping Season, 2023



(b) Minor Cropping Season, 2023

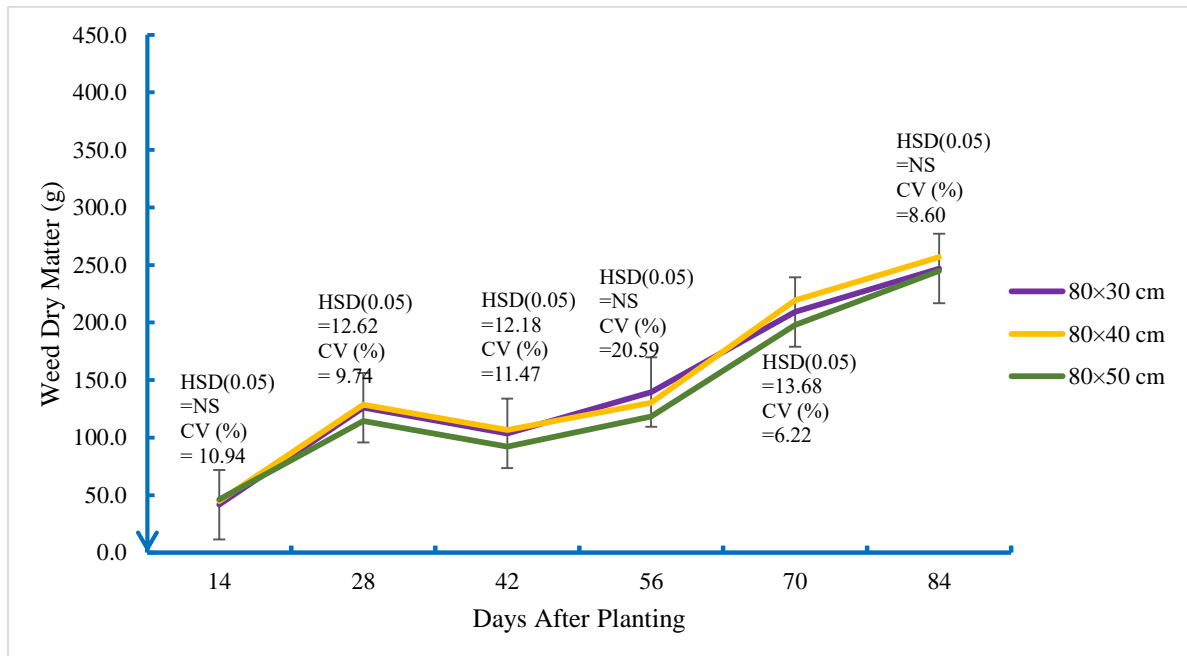


Figure 4. 10: Effect of Plant Population Density on Weed Dry Matter during both Major and Minor Cropping Seasons, 2023

4.4 Yield and Yield Components

4.4.1 Cob Diameter

The effects of weed control, plant population and their interaction on cob diameter are shown in Table 4.9.

During the major cropping season, weed control regime and plant population as well as their interactive effects significantly influenced cob diameter. The unweeded (control) had the smallest cob diameter, while the weedfree treatment had the largest cob diameter. The 80 cm x 40 cm had the smallest cob diameter, whereas 80 cm x 30 cm had the largest cob diameter. Generally, 80 cm x 40 cm under the various weed regime had the smallest cob diameter, except for weeding once (at 4 WAP) where 80 cm x 50 cm the smallest cob diameter (Table 4.9) had.

In the major season, plant population and weed control x plant population density interaction significantly affected cob diameter (Table 4.9). Weed control did not significantly influence cob diameter in the minor season (Table 4.9). The 80 cm x 50 cm density had the largest cob diameter. Cob diameter among the among the plant population densities under weedfree were similar. However, among the other three weed control regimes, 80 cm x 50 cm generally produced the smallest cob diameter, while the 80 cm x 30 cm produced the largest cob diameter (Table 4.9). Cob diameter was similar for both seasons.

4.4.2 Cob Length

The effects of weed control regime, plant population and their interaction on cob length are shown in Table 4.9.

In both major and minor seasons, weed control and weed control x plant population density interaction significantly affected cob length. However, plant population density did not significantly influence cob length in both seasons. The weedfree treatment had the largest cob length, which the unweeded (control) treatment had the shortest cob length in both seasons (Table 4.9). In general, the 80 cm x 30 cm plant density among all the weeding regimes had the longest cob length, while the 80 cm x 50 cm density among the regimes had the shortest cob length. On the average, cob length ranged from 7.3cm to 15.3 cm and 8.8 cm to 17.0 cm for the major and minor seasons, respectively.

4.4.3 100 -Seed Weight

The effects of weed control, plant population density and their interaction on 100-seed weight are shown in Table 4.9.

The 100-seed weight differed significantly among weed control regimes, plant population densities and the weed x plant population density interaction for both the major and minor seasons (Table 4.9). In both seasons, the weedfree treatment had the highest 100-seed weight, while the weeded twice (at 2 and 6 WAP) had the least 100-seed weight in both seasons (Table 4.9).

Generally, the 80 cm x 30 cm plant population density under the various plant regimes had the highest 100-seed weight while the 80 cm x 50 cm plant population density under the various weeding regimes had the lowest 100-seed weight, except under weedfree where it produced similar 100-seed weight did not differ between the two seasons.

Table 4. 9: Effect of Weed Control and Plant Population Density on Days to 50% Emergence, Days to 50% Tasseling and Days to 50% Silking

Weed Control (WC)	Plant Population (PP)	Cob Diameter (cm)		Cob Length (cm)		100 Seed Weight (g)	
		Major	Minor	Major	Minor	Major	Minor
Weed free	80×30	2.4	4.1	14.1	15.4	25.3	24.4
	80×40	1.7	4.1	9.7	12.6	21.2	21.1
	80×50	6.4	4.2	7.3	10.2	21.8	20.9
Weed once	80×30	4.4	4.2	15.1	17.4	21.2	21.0
	80×40	2.6	3.1	11.1	13.0	20.3	18.9
	80×50	1.9	1.6	6.1	8.8	19.5	18.2
Weed twice	80×30	4.2	4.0	12.1	14.8	20.6	19.7
	80×40	2.3	3.0	10.1	12.4	19.6	18.3
	80×50	4.6	1.7	9.3	11.9	19.3	17.6
Unweeded	80×30	5.6	3.9	15.3	16.6	21.4	19.9
	80×40	4.6	3.6	15.1	17.0	20.3	18.7
	80×50	5.6	2.1	7.9	9.8	18.8	18.3
HSD (0.05)		3.17	1.40	4.44	4.86	4.14	4.48
CV (%)		24.51	20.13	13.52	11.87	6.47	7.34
Season (S)		HSD (p<0.05)=0.78		HSD (p<0.05)=1.57		HSD (p<0.05)=1.0	
WC x S		HSD (p<0.05)= 1.38		HSD (p<0.05)= NS		HSD (p>0.05)= NS	
PP x S		HSD (p<0.05)= 1.12		HSD (p>0.05)= NS		HSD (p>0.05)= NS	
WC x PP x S		HSD (p>0.05)= NS		HSD (p>0.05)= NS		HSD (p>0.05)= NS	

4.4.4 Grain yield

The effects of weed control regime, plant population density and their interaction on Grain yield (t/ha) are shown in Table 4.10.

In the major season, grain yield was significantly affected by weed control, plant population density and weed control x plant population density interaction. Grain yield generally ranged from 2.11-2.71 t/ha. The weedfree treatment had the highest grain yield, while the treatment had similar grain yield. The 80 cm x 30 cm had greater yield than 80 cm x 40 cm and 80 cm x 50 cm among the weed control regimes yielded the lowest.

In the minor season, grain yield was not significantly affected by weed control, plant population density nor weed control x plant population density interaction. Grain yield, ranged from 4.38 to 5.35 t/ha. Between the two seasons, the minor seasons had grain yields almost twice the yield of the major season.

4.4.5 Harvest Index

The effects of weed control regime, plant population density and their interaction on harvest index are shown in Table 4.10.

Although weed control, plant population and weed control x plant population interactions did not significantly influence harvest index during both major and minor cropping seasons, the harvest at the minor season was higher than in the major season. Harvest index generally ranged from 0.40 to 0.43 in the major season, and from 0.64 to 0.80 in the minor season.

Table 4. 10: Effect of Weed Control Regime and Plant Population Density on Grain yield and Harvest Index

Treatment	Grain Yield (t/ha)		Harvest Index	
	Major Season	Minor Season	Major Season	Minor Season
Weed Control (WC)				
Weed free	2.54	5.09	0.41	0.71
Weed once	2.22	4.61	0.41	0.69
Weed twice	2.26	4.69	0.41	0.71
Unweeded	2.28	4.74	0.42	0.73
HSD (0.05)	0.26	NS	NS	NS
Plant Population Density (PPD)				
80×30	2.45	4.95	0.41	0.69
80×40	2.28	4.73	0.41	0.71
80×50	2.25	4.67	0.42	0.73
HSD (0.05)	0.18	NS	NS	NS
WC × PPD				
Weed free × 80×30	2.71	5.09	0.39	0.64
Weed free × 80×40	2.33	4.84	0.40	0.70
Weed free × 80×50	2.58	5.35	0.43	0.80
Weed once × 80×30	2.28	4.73	0.41	0.67
Weed once × 80×40	2.24	4.65	0.42	0.72
Weed once × 80×50	2.15	4.46	0.41	0.67
Weed twice × 80×30	2.41	5.01	0.42	0.72
Weed twice × 80×40	2.25	4.67	0.41	0.72
Weed twice × 80×50	2.11	4.38	0.40	0.70
Unweeded × 80×30	2.39	4.95	0.41	0.73
Unweeded × 80×40	2.29	4.76	0.42	0.71
Unweeded × 80×50	2.17	4.50	0.43	0.75
LSD (0.05)	0.53	NS	NS	NS
CV (%)	7.45	11.02	9.71	14.04

Season	HSD= 0.18	2.91
Weed Control × Season (HSD= p>0.05)=)	NS	NS
Plant Population × Season (HSD= p>0.05)=)	NS	NS
Weed Control × Plant Population × Season	= p>0.05)=NS	NS

CV= Coefficient of variation, NS= not significant at a probability of 95%, HSD (0.05) = Turkey's honestly significant difference

4.5 Correlation Analysis of Yield and Yield Components

Table 4.11 and 4.12 show correlation matrix analysis among some yield and yield components during the major and minor cropping seasons respectively. During the major

cropping season, grain yield and harvest index were moderately and positively correlated (0.35*). There were strong positively correlation between grain yield and 100 seed weight (0.70***), and a positive correlation between cob diameter and cob length (0.41*) and between negative moderate correlation between harvest index and 100 seed weight (Table 4.11).

During the minor cropping season, grain yield and harvest index were moderately and positively correlated (0.58*), grain yield and 100 seed weight were also moderately positively correlated (0.48**). 100 seed weight moderately correlated with both cob length and cob diameter (0.37*) and there was a strong positive correlation between cob diameter and cob length (Table 4.12).

Table 4. 11: Correlation Matrix Analysis of Yield and Yield Component Parameters during the Major Season

	1	2	3	4	5
1. Cob Length	1	0.41*	0.32ns	-0.13**	0.19ns
2. Cob Diameter		1	0.10ns	0.00ns	0.15ns
3. 100 Seed Weight			1	-0.35*	0.70***
4. Harvest Index				1	0.35*
5. Grain Yield					1

ns= $p \geq 0.05$, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$

Table 4. 12: Correlation Matrix Analysis of Yield and Yield Component Parameters during the Minor Season

	1	2	3	4	5
1. Cob Length	1	0.72***	0.37*	-0.15ns	0.19ns
2. Cob Diameter		1	0.37*	-0.21ns	0.16ns
3. 100 Seed Weight			1	-0.25ns	0.48**
4. Harvest Index				1	0.58***
5. Grain Yield					1

ns= $p \geq 0.05$, *= $p < 0.05$, **= $p < 0.01$ and ***= $p < 0.001$

4.6 Partial Budget Analysis

A partial budget analysis was done for both major and minor cropping seasons and the results are shown in Tables 4.13 and Table 4.14. The adjusted grain yield was obtained by deducting 10% of the grain yield from the total grain yield and then used to calculate the gross farm gate benefits.

The benefit to cost ratio showed that all the different plant population under Unweeded plots recorded the highest ratio of during both major and minor seasons, followed by plots that received Weed once, then by Weed twice and Weed free had the lowest benefit to cost ratio (Table 4.13 and Table 4.14).

The marginal rate of returns indicated all the treatment were dominated by the Unweeded + 80 × 50 cm, except the Weed once + 80 × 40 cm, Weed once + 80 × 30 cm, Weed twice + 80 × 40 cm, Weed twice + 80 × 30 cm, Weed free + 80 × 50 cm and Weed free + 80 × 50 cm. The MRR of Weed twice + 80×40 cm over the Unweeded + 80 Weed × 40 cm was GHS 463.70 and GHS 963.50 for major and minor seasons respectively indicating that in adapting the Weed twice + 80 × 40 cm over the c Unweeded + 80 Weed × 40 cm, for every one (1) cedi cost incurred, the farmer gains an additional (extra) GHS 463.70 and GHS 963.50 for major and minor seasons respectively (Table 4.13 and Table 4.14).

Table 4. 13: Partial Budget Analysis for Major Cropping Season

	Treatment											
	Weed free × 80×30	Weed free × 80×40	Weed free × 80×50	Weed once × 80×30	Weed once × 80×40	Weed once × 80×50	Weed twice × 80×30	Weed twice × 80×40	Weed twice × 80×50	Unweeded × 80×30	Unweeded × 80×40	Unweeded × 80×50
Gross Farm Benefits												
Fruit Yield (T/Ha)	2.71	2.33	2.58	2.28	2.24	2.15	2.41	2.25	2.11	2.39	2.29	2.17
Adjusted Yield (10%)	2.44	2.10	2.32	2.05	2.02	1.93	2.17	2.03	1.90	2.15	2.06	1.95
Farm Gate Price (GHS/T)	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250
Total Gross Benefit (GHS)	17663.5	15201.8	16816.7	14860.7	14621.1	14018.9	15753.0	14688.0	13758.7	15562.7	14966.8	14152.2
Total Variable Cost												
Cost of Weeding	2114	2114	2114	643.0	643.0	643.0	1170.0	1170.0	1170.0	0	0	0
Cost of planting material	27	22	20	27	22	20	27	22	20	27	22	20
Cost of planting	30	30	30	30	30	30	30	30	30	30	30	30
Total Variable Cost (GHS)	2171.0	2166.0	2164.0	700.0	695.0	693.0	1227.0	1222.0	1220.0	57.0	52.0	50.0
Net Benefit (GHS)	15492.5	13035.8	14652.7	14160.7	13926.1	13325.9	14526.0	13466.0	12538.7	15505.7	14914.8	14102.2
Benefit: Cost Ratio	7.1	6.0	6.8	20.2	20.0	19.2	11.8	11.0	10.3	272.0	286.8	282.0
Marginal Rate of Return (MRR)				Weed once × 80×50	Weed once × 80×40	Weed once × 80×30	Weed twice × 80×50	Weed twice × 80×40	Weed twice × 80×30	Weed free × 80×50	Weed free × 80×40	Weed free × 80×30
MRR	0.0	D*	D*	D*	300.1	46.9	D*	463.7	212.0	0.1	D*	491.3
Total Variable Cost (GHS)	50.0	52.0	57.0	693.0	695.0	700.0	1220.0	1222.0	1227.0	2164.0	2166.0	2171.0
Net Benefit (GHS)	14102.2	14914.8	15505.7	13325.9	13926.1	14160.7	12538.7	13466.0	14526.0	14652.7	13035.8	15492.2

Table 4. 14: Partial Budget Analysis for Minor Cropping Season

	Treatment											
	Weed free × 80×30	Weed free × 80×40	Weed free × 80×50	Weed once × 80×30	Weed once × 80×40	Weed once × 80×50	Weed twice × 80×30	Weed twice× 80×40	Weed twice × 80×50	Unweeded × 80×30	Unweeded × 80×40	Unweeded × 80×50
Gross Farm Benefits												
Fruit Yield (T/Ha)	5.09	4.84	5.35	4.73	4.65	4.46	5.01	4.67	4.38	4.95	4.76	4.50
Adjusted Yield (10%)	4.58	4.35	4.81	4.25	4.19	4.01	4.51	4.21	3.94	4.46	4.28	4.05
Farm Gate Price (GHS/T)	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250	7250
Total Gross Benefit (GHS)	33223.9	31553.7	34905.7	30845.8	30348.5	29098.4	32697.8	30487.2	28558.3	32302.8	31066.0	29375.1
Total Variable Cost												
Cost of Weeding	2114	2114	2114	643.0	643.0	643.0	1170.0	1170.0	1170.0	0	0	0
Cost of planting material	27	22	20	27	22	20	27	22	20	27	22	20
Cost of planting	30	30	30	30	30	30	30	30	30	30	30	30
Total Variable Cost (GHS)	2171.0	2166.0	2164.0	700.0	695.0	693.0	1227.0	1222.0	1220.0	57.0	52.0	50.0
Net Benefit (GHS)	31052.9	29387.7	32741.7	30145.8	29653.5	28405.4	31470.8	29265.2	27338.3	32245.8	31014.0	29325.1
Benefi: Cost Ratio	14.3	13.6	15.1	43.1	42.7	41.0	25.6	23.9	22.4	565.7	596.4	586.5
Marginal Rate of Return (MRR)	Unweeded × 80×50	Unweeded × 80×40	Unweeded × 80×30	Weed once × 80×50	Weed once × 80×40	Weed once × 80×30	Weed twice × 80×50	Weed twice× 80×40	Weed twice × 80×30	Weed free × 80×50	Weed free × 80×40	Weed free × 80×30
MRR	0.0	D*	D*	D*	624.0	98.5	D*	963.5	441.1	1.4	D*	333.0
Total Variable Cost (GHS)	50.0	52.0	57.0	693.0	695.0	700.0	1220.0	1222.0	1227.0	2164.0	2166.0	2171.0
Net Benefit (GHS)	29325.1	31014.0	32245.8	28405.4	29653.5	30145.8	27338.3	29265.2	31470.8	32741.7	29387.7	31052.9

CHAPTER FIVE: DISCUSSION

5.1 Phenology

Percent plant establishment and days to 50% emergence was not significantly influenced by weed control regime and plant population. Days to 50% tasseling and days to 50% silking were significantly affected by weed control regime and plant population, there were significant advancement in the phenological stages of maize due to the influence of plant population and weed management practices. Tasseling is a prerequisite of cob formation and finally the maturity of the crop. Various plant population significantly influenced the days taken for 50% tasseling. The plant population of 80 cm x 30 cm (83,333 plants/ha) delayed the process of tasseling and silking. Under the spacing of 80 cm x 30 cm, because of the insufficiency of source and transformation of reproductive phase, these treatments could not supply sufficient photosynthates for the developing sinks. In the treatments where the source was not limiting (80 cm x 40 cm [62,500 plants/ha] and 80 cm x 50 cm [50,000 plants/ha]), it was rather vice versa. These observations are in contradiction with Bhattacharya *et al.* (2022) and Basu *et al.* (2022), who observed that when plants were subjected to stress like drought, high temperature, competition between plants for resources etc., they readily entered into reproductive phase before putting forth sufficient vegetative growth. Also, the reports of Bhatt & Ghimire (2024) who observed delayed tasseling due to availability of nitrogen and phosphorus at adequate quantity lend support to the present finding. Among the weed management practices, all the weed control practices took shorter days except for unweeded plots which took longer days for tasseling and silking.

In all the weed control treatments where the source was not limiting, the availability of photosynthates might be sufficient to put forth more number of tassels and silks thereby the yielding better (Vijayakumar, 2024). Again, this result disagrees with the findings of Bhattacharya *et al.* (2022) and Basu *et al.* (2022), who observed that when plants were

subjected to stress like drought, high temperature, competition between plants for resources etc., they readily entered into reproductive phase before putting forth sufficient vegetative growth.

5.2 Growth

Results of experiment revealed that plant height of maize showed marked variation due to weed control and plant population. Height of maize plants was not significant, Weeding at 2 and 6 WAP and 80 cm x 40 cm which recorded the highest plant height values would probably be due to the effect of etiolation (shading). Height of maize plant significantly increased by weeding at 2 and 6 WAP for both the minor and major rainy seasons while the unweeded plots also produced shorter maize plants for both seasons. Weeding once at 4 WAP + 80 cm x 40 cm spacing also produced taller plants in both seasons. The superiority of weeding at 2 and 6 WAP in respect of plant height parameter can be discussed in light of the fact that this treatment providing better growing environment to crop ensuring more availability of light, moisture and nutrients than other crop establishment treatments (Gibson *et al.*, 2017). Similar finding was reported by Thiem *et al.* (2020).

The height of maize plants were significantly influenced by plant population. 62,500 plants/ha (80 cm x 40 cm) produced taller maize plants and 83,333 plants/ha (80 cm x 30 cm) produced shorter maize plants. This finding was in agreement to the outcome of a study conducted by Abuzar *et al.* (2011) where the highest plant population density produced short statured crops due to increased competition between plants for resources such as nutrients, light and water. also, the results was contrary to the studies conducted by Imran *et al.* (2015) and Testa *et al.* (2016) where the highest plant height values were associated with maximum plant population density. Also contradicts the report of Lashkari *et al.* (2011)

who reported that increasing population density trigger physiological events and leading to prioritization and allocation of assimilates to the main stem to increase plant height.

Number of leaves of maize were significantly influenced by weed control and plant population. Number of leaves of maize plant were significantly increased by weeding at 2 and every 6 weeks for both the minor and major rainy seasons while the unweeded plots also produced fewer number of leaves for both seasons. This finding contradicts a study conducted by Aswani *et al.* (2022) which indicated that number of leaves per plant is significantly affected by genotype and not by plant population density.

Plant density significantly influenced plant dry matter at 14 to 84 DAP in both cropping seasons. 80 cm x 30 cm (83,333 plants/ha) and 80 cm x 40 cm (62,500 plants/ha) produced heavier plant dry matter than 80cm x 50cm (50,000 plants/ha). This finding disagrees with the report of Haarhoff & Swanepoel (2022) who reported that narrow spacing may have little effect on either improving grain yield or increasing the optimum plant population density necessary to maximize dry matter and yield as well. However, it is also evident from the report of Saberali (2017) that high maize density produced higher total dry weight, when crop growth rate increased than low maize density throughout crop growth season. Weeding regularly at every 2 weeks and weeding once at 4 WAP significantly produced higher plant dry matter than the unweeded plot. Weeding generally has a positive effect on plant dry matter, meaning that by removing competing weeds, the crop has more access to resources like sunlight, water, and nutrients, leading to increased plant biomass and overall dry matter production compared to a situation with uncontrolled weeds (Ahmed *et al.*, 20220; Devi *et al.*, 2017). Suresh and Reddy (2010) reported that dry matter of plant was attributed to the decreased weed population and lesser dry weight of weeds which favoured more utilization of moisture, light, space and nutrients.

Weed dry matter was significantly influenced by weed control regime and plant population. For weed control, the unweeded plot had higher weed dry matter. Jadhav (2017) also observed that the the highest weed dry matter production was recorded in weedy check treatment (unweeded plot) and the lowest weed dry matter accumulation was found in weed-free treatment which is weeding regularly at every 2 weeks in the case of this study. Weed dry matter is a better parameter to measure the competition than the weed number. The results obtained in this study might be due to the fact that weeding regularly every 2 weeks provided effective control on all early and lately emerged weeds reduced the overall population of weeds in plots. These results are in analogy with Megersa & Fufa (2017) who reported that weeding significantly decreased weed density.

5.3 Yield and Yield Components

The interaction of weed control and plant population significantly affected number of plants harvested, number of cobs harvested and cob diameter. The greatest loss of yield was due to weed competition with the crop for light, space, nutrients, and moisture, etc. (Duke & Patterson, 2018). In this study, weeds affect the main plant dry matter accumulation and reduce the plant growth and development. So, this directly affects the number of plants harvested, number of cobs harvested and cob diameter of maize plants. In view of this, regular weeding (weeding every 2 weeks + 80 cm x 40 cm [62,500 plants/ha]) had the greatest number of plants harvested, number of cobs harvested cob diameter, and the least were recorded on treatment which received no weeding. This study shows that the intensity of the weed population affects the harvested plants, harvested cobs and cob diameter as well (Dereje, 2020). The results shows that, it is not suitable and economically viable to perform regular weeding operations and closer plant spacing (83,333 plant/ha) so to make the farming beneficial for the farmer, it is good to integrate regular weeding operation with at least plant spacing of 62,500 plant/ha (80 cm x 40 cm).

Cob length was significantly affected by weed control regime, weeding every 2 weeks had highest cob length in both seasons, but minor season recorded longer cobs than the major season. Deewan *et al.* (2017) stated that effective weed control generally leads to increased maize cob length, as weeds compete with the maize plants for nutrients, water, and sunlight, which can significantly limit the plant's ability to produce large cobs; therefore, by removing weeds, maize plants can allocate more resources towards cob development, resulting in longer cobs. The maximum number of cobs was obtained at the population of 83,333 plants/ha, while the minimum number of cobs was observed at the density of 50,000 plants/ha.

Therefore, increasing plant population increased the number of cobs, which then led to an increase in cob yield. In the major season, higher and medium plant population (83,333 plants/ha and 62,500 plants/ha) was not significantly different in number of cobs harvested compared to the lower plant density and medium plant density (62,500 plants/ha and 50,000 plants/ha), similar results were observed in the studies of Khan *et al.* (2017). This might be explained by the fact that corn yield can be attributed to planting population, however the excessive density/population can also cause yield loss due to intra-specific competition.

When a population becomes excessively dense, individuals of the same species begin to compete fiercely for limited resources like food, water, sunlight, and space, leading to a phenomenon called 'intra-specific competition' which ultimately results in reduced yield or crop loss due to decreased individual growth, reproduction, and overall plant health. (Ngairangbam *et al.*, 2024; Biswas *et al.*, 2024). In addition, Galon *et al.* (2023) reported that moderately high densities may be useful to minimize intraspecific competition between the crop plants and wisely suppress weeds to achieve higher grain production. Similar results in terms of the effects of weed control and plant population on cob length were

observed in 100 seed weight. Weeding regularly at every 2 weeks recorded the highest 100 seed weight and the lowest was recorded on unweeded or weeding once.

Stover weight and grain yield in minor season were statistically higher than major planting season, but significant difference was observed in the major season only. In weeding every 2 weeks, adequate weeding was carried out which resulted in highest stover weight and grain yield due to more total biomass, number of plants harvested and number of cobs harvested and unweeded plots had the lowest for both planting season.

Also, no weeding plot has the lowest yield components; it could be due to high weed infestation in the plot. Kaur *et al.* (2018) are of the view that weeds usually grow faster than associated crop plants and thus absorb the available nutrients in more amount and lead in the deficiency of nutrients to the crop plants. Competition begins when the root system of crop and weeds overlap in the exploring soil profile and showed the enhanced competition for nutrients. This result may be due to lower density and dry weight of weed, which reduces the dilution of nutrients. These results further indicated that increased in yield contributing characters and yields in raised regular weeding was due to better growing environment than other weed control treatment. The results are corroborated research findings of Singh *et al.* (2015) and Lakshmi and Luther, (2017). The possible reason for higher yield in these weed control practices may be as a result of improved physical condition of the soil due to reduced bulk density by means of allowing the crop roots to penetrate deeper and create more pore space in the soil, which in turn leads to a lower bulk density. Removing weeds results in the soil being less less compacted and has better aeration, resulting in a less dense structure, which favourably increased the uptake of nutrients by the crop and also reduced the state of crop-weed competition by lowering the weed population and dry biomass, leading to increase in values of yield contributing

characters (Little *et al.*, 2021; Adeux *et al.*, 2019). Ganapathi *et al.* (2022) reported higher yield under plots treated with pendimethalin 750 g ha⁻¹ followed by hand weeding than unweeded plots.

The highest plant population recorded the highest stover yield and subsequently grain yield. The difference in stover yield and grain yield of medium plant population (62,500 plants/ha) and lower plant population (50,000 plants/ha) was not significant. The results of this study disagree with the findings of Liu *et al.* (2021) who reported higher yield of maize under wider row spacing due to better availability of resources. The present finding corroborates with the findings of Egli *et al.* (2022) and Sharma & Rayamajhi (2022). According to Menendez *et al.* (2021), plant population is the prime factor for getting maximum yield.

Plant population is decided by the inter and intra row spacing of crops. Optimum plant population for any crop varies considerably due to environment under which it is grown (Li *et al.*, 2021). It might not be perfect to recommend a generalized plant population since the crop is grown in different seasons with different management practices under varied environment. Proper adjustment of plants in the field not only ensures optimum plant population, but also helpful for plants to utilize the land, light, input resources such as water and fertilizers more efficiently and resolutely towards growth, development and towards final yield (Ghadirnezhad *et al.*, 2024). Maize production is greatly affected by varying planting density than other members of the grass family because of its monoecious floral organization. A review by Postma *et al.* (2021) affirms the results of the current study, increasing the plant density, yield per plant decreases but grain yield per unit area increases. Exceeding beyond a certain limit of plant density, yield is lost due to increase in plant-to-plant unevenness and increase in plant infertility as high plant density above the certain

level elongate the duration between pollen shedding and silking resulting in more unproductive plants (Ali *et al.*, 2022).

5.4 Partial Budget Analysis

The scaling down of the fruit yield by 10% before the determination of partial budget was necessary to avoid overestimation of the returns that farmers are likely to get, since experimental yields are usually higher than farmers yield because of higher management levels, small plot size, better harvesting methods and precision in harvesting (Azumah *et al.*, 2020).

The benefit to cost ratio varied significantly among the different treatments in both cropping seasons. The combination of Weed twice + 80×40 cm yielded the maximum benefit to cost ratio in both cropping seasons. In addition, all treatment had significant benefit to cost ratio (more than 1). The study by Mir *et al.* (2024) and Iqbal *et al.* (2003) has found variations in benefit to cost ratio attributable to different weed management in crop cultivation. The increased benefit to cost ratio or net benefit from Weed twice + 80×40 cm may be attributed to differences in weed control effectiveness, crop yield response, labor costs, and the type and quantity of inputs used. More costly methods like repeated hand weeding might offer high yields but incur high labor expenses, resulting in a lower BCR compared to more efficient or chemical-based methods, which can offer a better economic return for certain crops and environments (Singh *et al.*, 2018; Wasnik *et al.*, 2022). Also, the increased grain production, which resulted in augmented revenue generation in respect to low production cost. In the dominance analysis, a treatment is dominated if it has a higher cost of production but a lower net benefit than another (Mutenje *et al.*, 2019).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The following conclusions are drawn from the results obtained in the present investigation:

- Weed control and plant population density interactions had no significant influence on the phenology of maize. Weed control regime had no significant influence on percent plant establishment and days to 50% emergence, but there were significant differences on days to 50% tasseling and days to 50% silking. Plant population density had no significant influence on days to 50% emergence, days to 50% tasseling and days to 50% silking but there was a significant influence on plant population density in percent plant establishment.
- Weeding at 2 and 6 weeks after planting and 80 cm x 40 cm and their interaction significantly produced taller maize plant and greater number of leaves per plant. Weeding once at 4 weeks after planting and 80 cm x 40 cm also produced higher plant dry matter.
- The interaction of Weeding at every 2 weeks and 80 cm x 50 cm significantly produced larger cob diameter. Weeding at every 2 weeks and 80 cm x 40 cm produced longer cobs, although the difference was not significant. Weeding regularly every 2 weeks significantly produced heavier stover and more grain yield during the minor season only. The 80 cm x 30 cm (83,330 plants/ha) significantly produced heavier stover in both seasons and grain yield during the major season.
- All the treatment produced significant benefit to cost ratio. Weed once + 80 × 50 cm, Weed twice + 80 × 40 cm, Weed twice + 80 × 30 cm and Weed free + 80 × 30 cm dominated over other treatments, where Weed twice + 80 × 40 cm had the highest marginal rate of return.

6.2 Recommendation

Higher productivity of maize with higher economic returns could be obtained with regular weeding every 2 weeks after planting or weeding twice at 2 and 6 weeks after planting, and choosing a planting distance of 80 cm x 30 cm (83,333 plants/ha) or 80 cm x 40 cm (62,500 plants/ha) or by choosing a combination of weeding every 2 weeks after planting and 80 cm x 30 cm (83,333 plants/ha).

Farmers should adopt:

- Weeding regularly every 2 weeks and use plant spacing of 80 cm x 40 cm for larger cob diameter and longer cobs.
- Weed every 2 weeks use planting space of 80 cm x 30 cm for optimise grain yield.

For the purpose of future studies, the integration of early post emergence herbicide for effective weed management may be studied.

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APPENDIX

Appendix 1: Climatic data for 2023 major rainy season at the experimental site

Month	Total Rainfall (mm)	Relative Humidity (%)		Mean Temperature (°C)	
		6:00 hrs	15:00hrs	Min	Max
March	57.8	88	55	23.1	33.8
April	258.8	91	59	22.7	33.3
May	71.3	90	60	23.2	32.8
June	198	92	70	23	30.3
July	198.9	91	71	21.8	28.4
Total	784				

Appendix 2: Climatic data for 2023 minor rainy season at the experimental site

Month	Total Rainfall (mm)	Relative Humidity (%)		Mean Temperature (°C)	
		6:00 hrs	15:00hrs	Min	Max
August	213.4	93	74	22.5	29.0
September	196	92	69	22.4	30.6
October	286.4	90	62	23.0	32.0
November	91.1	91	59	23.5	33.1
December	0	74	44	22.7	34.5
Total	786.9				