**EFFECT OF WEED CONTROL METHODS ON SWEET PEPPER**

***(Capsicum annuum L.)***

**A**

**RESEARCH PROJECT**

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**CHAPTER ONE**

**INTRODUCTION**

* 1. **Background of the Study**

Sweet pepper *(Capsicum annuum)* is a flowering plant under the genus Capsicum and belongs to the family Solanaceae (Alvarado *et al.,* 2007). In Nigeria, it is also known as Ball pepper. It is relatively non-pungent with thick flesh and is the world’s second most important vegetable after tomato (AVRDC, 1989). Tropical South America, especially Brazil is thought to be the original home of the pepper (Shoemaker and Teskey, 1995). Small scale cultivation is found in peri-urban areas primarily for the supply to some city markets in Nigeria (Saha, 2001). Bell pepper is considered a minor vegetable crop in Nigeria (Hasanuzzaman, 1999). The popularity of sweet pepper is increasing day by day especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. It is rich in capsaicin and has powerful antioxidant properties that may help works against inflammation (Alvarado *et al.,* 2007). Bell pepper is chosen because of its higher nutritive value and generally it contains 1.29 mg protein, 11 mg calcium, 870 I.U. vitamin A, 17.5 mg ascorbic acid, 0.6 mg thiamin, 0.03 mg riboflavin and 0.55 mg niacin per 100 g of edible fruit (Joshi and Singh, 1975). Sweet pepper *(Capsicum annuum L.)* is an economically important vegetable crop which is currently grown in about 8,522 ha, with total pepper production of 175,867 t and average pepper production in about 20.6 t ha-1 (Anonymous, 2015). Pepper is grown, in areas with a warm climate and a long growing season, which are also favorable to the growth of weeds, which results in increased weed pressure (Granberry and Colditz, 1990). Large scale production of this pepper is limited due to some problems in the production system, weed infestation and lack of familiarities to the growers. Sweet pepper production has some constraints which include flower dropping, poor fruit set, and susceptibility to viral diseases and it is a serious concern for the successful introduction of this crop (Saha, 2001). Sweet pepper is not a very competitive crop and weeds can significantly reduce pepper yield (Khan *et al.,* 2012). The weed infestation may reduce pepper yield by 60–80% (Nadagouda, 1995, Khan *et al.,* 2012). Weed management in pepper is required to minimize decrease of yield and quality of the fruit. Subhra and Pabirta (2014) noticed that the decrease in the pepper fruits/plant was proportional to the duration of weeds competition. In Nigeria, weed control in pepper are a combination of inter-row cultivation, hand weeding and herbicide application. Some farmers prefer to use soil applied herbicides before transplanting while others prefer herbicides application after transplanting. Application of herbicides before transplanting leaves the soil surface without weeds at the beginning of the growing season. According to Isik *et al.* (2009) immediately after transplanting, sweet pepper seedlings grow slowly whereas weeds emerge fast, grow rapidly and compete with the crop for nutrients, moisture, sunlight and growing space during all growing season. To improve sweet pepper (*Capsicum annuum*) growth and production capacity, there is need to evaluate an effective herbicide.

**1.2 Importance of *Capsicum annuum***

**1.2.1 Economic Importance**

Pepper cultivation plays a significant role in global agriculture. It is one of the most traded spices worldwide, contributing to international trade and generating income for farmers and countries involved in its production and export. For example, India is the largest producer and exporter of pepper, providing substantial employment opportunities and contributing to foreign exchange earnings (Bradley, 2017).

**1.2.2 Nutritional Value**

Pepper is a rich source of several bioactive compounds, including piperine, antioxidants, and essential oils. These compounds contribute to its distinct flavor and possess various health benefits. Piperine, the primary alkaloid in pepper, has been studied for its potential therapeutic properties, including anti-inflammatory, antioxidant, and antimicrobial activities (Hwang *et al.,* 2014).

**1.2.3 Culinary Uses**

Pepper is widely used in culinary applications worldwide. It adds flavor and enhances the taste of various dishes, both savory and sweet. Its versatility makes it an essential ingredient in spice blends, sauces, marinades, and pickles. *Capsicum annuum* is a major spice globally and it is used in diverse delicacies irrespective of culture nor religion (Cruz-Huerta *et al.* 2011).

**1.2.4 Medicinal Uses**

Pepper has also been used in traditional medicine systems for centuries. It is believed to aid digestion, improve appetite, and alleviate respiratory disorders. Modern research has explored the potential of pepper in treating conditions like arthritis, cancer, and obesity, although further studies are needed to validate these claims (Bradley, 2017).

**1.3 Justification of the Study**

Weeds can significantly reduce pepper yields, hinder growth, and increase production costs. Weeds compete with pepper plants for essential resources such as nutrients, water, and sunlight. Weeds often have aggressive growth patterns, which allow them to deplete the available resources, leaving the pepper plants with limited access to what they need for optimum growth and development. Weeds can serve as hosts for various pests and diseases that can affect pepper plants. Weed control plays a crucial role in pepper production and is considered a significant aspect of proper crop management. Weed management is a significant part of crop production expenses, especially in an intensive system like pepper cultivation. Weed control is of utmost significance in pepper production due to the potential yield losses, competition for resources, increased pest and disease pressure, nutrient imbalances, and the associated production costs. The utilization of effective weed control strategies, such as mechanical strategy which involves hoe weeding or hand picking, and the chemical methods in pepper (Capsicum annum) cultivation involves the use of herbicides to selectively eliminate weeds that compete for nutrients, water, and light, negatively affecting the growth and yield of pepper plants., can help mitigate these issues and optimize pepper crop yields. To investigate the effect of weed control methods on the yield and growth response of *Capsicum annum,* hoe weeding and the use of the herbicide (Extraforce) to ascertain their level of efficiency to maximize pepper yield and also contribute to the body of Knowledge in Crop production. The herbicide; Extraforce is an herbicide extensively used in agriculture to control a broad spectrum of weeds, providing farmers with effective pre- and post-emergence weed control. Its compatibility with various crops makes it a valuable tool in crop production, hence used for this study to investigate its effect on Capsicum annum yield and growth performance.

**1.4 Objective of the Study**

The major objective of this study is;

* To determine the effect of weed control methods on sweet pepper (*Capsicum annuum)*

The specific objectives of this study are;

* To determine the yield and growth Response of sweet pepper (*Capsicum annuum)* withhoe weeding control method.
* To determine the yield and growth Response of sweet pepper (*Capsicum annuum)* withExtraforce Herbicide weed control method.
* To determine the yield and growth Response of sweet pepper (*Capsicum annuum)* with no weed control method.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Taxonomy of *Capsicum annuum***

Sweet pepper (Capsicum species) belongs to the Family Solanaceae, Genus Capsicum, and species annuum L., group of vegetables. Cultivated peppers are all members of the world capsicum species. There are an estimated 1,600 different varieties of pepper throughout the world with five main domesticated species that includes; *C. annum L., C. frutescens L. C. Chinenses., C. baccatum L.,* and *C. pubescens R.* (Bosland *et al*., 2012).

Kingdom: *Plantae*

Family: *Solanaceae*

Genus: *Capsicum*

Species: *Capsicum annuum*

**2.2 Agronomic Properties of Sweet pepper *(Capsicum annuum)***

**2.3.1 Planting**

The earliest period for seedling establishment for *Capsicum annuum* is when the soil and air temperatures at least meet the minimum requirements for plant growth. The latest seedling establishment period would be after allowance has been made for the growth and harvest periods to be completed before adverse conditions sets in (Cantwell, 2011). Due to the effect of certain factors being prevalent at specific locations, within each of these areas the planting times may be earlier or later (Granberry and Colditz, 1990). *Capsicum* is normally raised in nursery and transplanted but it can also be directly sown. It can also be raised on seed trays for improved germination and Seed Rate should be 100g per acre. The single most important factor when making a decision around plant population is the type of chemical spraying system- or method that the grower is going to use for the duration of the crop. Everything should be designed around this implement so as to get in between rows when spraying to effectively control pests and diseases. Plant population is around 30, 000 plants per hectare (Starke, 2021).

**2.3.2. Fertilization**

During the production of sweet and hot peppers, correct fertilization is the single most important factor that determines the success of a crop. With good management practices these crops could be produced under a wide range of different conditions, however some growing conditions are more favourable than others (Starke, 2021). In order to calculate the correct nutrient requirement, the following aspects need to be available and taken into consideration: Nutrient withdrawal figures, Fertilizer used in the past on the specific area intended to be planted, Soil type, Soil analyses, Soil Acidity (pH), Quality of irrigation water and Micro elements (Starke, 2021). The ideal soil analyses or soil status for sweet pepper production should be: pH (H2O): 5.6 – 6.8, P: 30 – 60 mg/Kg (Bray1), K: 100 – 250 mg/Kg, Ca: 300 – 2000 mg/Kg, Mg: 120 – 300 mg/Kg, Na: 10 – 50 mg/Kg (Isik *et al.,* 2009; Starke, 2021*)*

**2.3.3 Climatic Requirement of *Capsicum annuum***

Climate is one of the most important factors when determining planting times. Production of a pepper crop depends on the length of a growing season with optimal temperatures (Starke, 2021). The plant itself stops growing at temperatures below 10° - 12°C, and at 6°C, the leaves can die and flower abortion will start. The same will happen when temperatures increase to over 35°C (Isik *et al.,* 2009) Temperature variation might result in poor fruit quality or reduced yields. Optimum temperatures would be: Day time (25 - 28°C) and Night time (16 - 18°C). A relative humidity between 65 – 85% is considered optimal. High relative humidity levels negatively influence pollen release and distribution on the stigma. High humidity creates a favourable environment for the development of several foliar diseases (Horvitz and Cantalejo, 2014).

**2.3.4 Soil Requirement of *Capsicum annuum***

Certain criteria have to be satisfied in terms of the soil properties to make sweet pepper commercially viable. These factors include: Nutrient composition, Compaction Effective soil depth, pH, Crop rotation, Herbicide residues and Water holding capacity (Granberry and Colditz, 1990). All these factors can have major influences on the resulting yield. The soil must permit adequate root growth to support the plant and supply water, oxygen and mineral nutrients and must be free of toxic elements. The rate of root growth is dependent on the degree of compaction or bulk density of the soil (Frary, 2012). The degree of soil compaction varies with soil type and location (Granberry and Colditz, 1990; Starke, 2021). The rate of aerial and root growth of plants increases with the oxygen contents of the soil. Root density is highest where there is a high rate of diffusion. Root development of pepper plants can be extensive if soil water and plant conditions are optimal (Lownds *et al.,* 1993).

**2.4 Constraints of *Capsicum annuum* production in Nigeria**

The yield of *Capsicum annuum* in Nigeria is generally low due to the use of varieties that are of narrow genetic base which are grown on soils that are of inherent low fertility (Daunay *et al.*, 2001). The unimproved local cultivars commonly grown in the tropics with scanty plant stands, improper planting distance and lack of other improved agricultural inputs in the management of the crops has resulted in low yield (Law *et al.* 2009). However, in Nigeria, farmers get lower yield mainly due to the fact that *Capsicum annuum* is sensitive to a number of environmental stresses, especially extreme temperature, salinity, drought, excessive moisture and environmental pollution, improper planting distance, diseases and pests as well as weed infestation. Under the climatic conditions in Nigeria, *Capsicum annuum* is infested by a number of insect pests, the most destructive of which is the pepper shoot and fruit borer (ESFB, *Leucinodes orbonalis* Guen.). Despite heavy insecticide applications, significant yield losses occur on a regular basis (Ghosh *et al.,* 2003). Additionally, uncontrolled weed growth interferes with the growth and crop yields, hence the need for effective and sustainable herbicide (Shivalingappa *et al.,* 2014).

**2.5 Significance of weed control in Agriculture**

Weed control plays a crucial role in pepper production and is considered a significant aspect of proper crop management. Weed control is considered a significant aspect of proper crop management. Weeds can significantly reduce pepper yields, hinder growth, and increase production costs. Weeds can significantly reduce pepper yields, hinder growth, and increase production costs.

**2.5.1 Competition for Resources**

Weeds compete with pepper plants for essential resources such as nutrients, water, and sunlight. Weeds often have aggressive growth patterns, which allow them to deplete the available resources, leaving the pepper plants with limited access to what they need for optimum growth and development. A study conducted by Pereira *et al.,* (2012) demonstrated that weeds reduced the growth, yield, and the development of pepper plants due to resource competition.

**2.5.2. Reduced Crop Yield**

Weeds have a detrimental impact on pepper yields. They reduce the amount of light reaching the pepper canopy, limiting photosynthesis, and therefore, impede the production of sugars necessary for fruit development. Research by Martinez-Esqueda *et al.,* (2014) concluded that weed interference in pepper production resulted in a significant reduction in both fruit weight and yield.

**2.5.3. Disease and Pest Hosts**

Weeds can serve as hosts for various pests and diseases that can affect pepper plants. They provide shelter and food for insects, mites, and pathogens, which can then transfer onto pepper crops, resulting in increased pest pressure and disease incidence. A study by Borger *et al.,* (2001) reported that weeds acted as a host for the pepper weevil (Anthonomus eugenii), a major pest in pepper production, causing significant crop damage.

**2.5.4. Nutrient Imbalances**

Weeds often exhibit a high nutrient uptake capacity and can outcompete the pepper plants for essential nutrients. This can cause an imbalance in nutrient availability, potentially leading to nutrient deficiencies in the pepper plants. Research by Souza *et al.,* (2015) found that weed interference in pepper cultivation affected nutrient content and uptake, resulting in reduced fruit quality and compromised plant health.

**2.5.5. Weed Management Costs**

Weed management is a significant part of crop production expenses, especially in an intensive system like pepper cultivation. The cost of herbicides, labor, and machinery for weed control can add up significantly, impacting the profitability of pepper production. A study by Dordas *et al*., (2007) estimated that weed interference in pepper fields cost farmers up to 30, 000 Naira per hectare in additional herbicide expenses alone.

**2.6 Effective Weed Control Practices**

Weed control is of utmost significance in pepper production due to the potential yield losses, competition for resources, increased pest and disease pressure, nutrient imbalances, and the associated production costs. The utilization of effective weed control strategies, such as cultural, mechanical, and chemical methods, can help mitigate these issues and optimize pepper crop yields.

**2.6.1 Mechanical Weed Control Method**

Mechanical methods involve physically removing weeds either through hand-pulling, hoeing, or cultivation. These techniques are especially important in organic or sustainable farming systems, where chemical herbicides may not be used. Akhtar et al. (2019) found that manual weed control through regular hoe weeding significantly reduced weed populations in pepper fields. Hoe weeding involves using a hoe to cut weeds below the soil surface. This technique is suitable for larger farming operations where productivity and cost-effectiveness are crucial. Hoeing disrupts weed roots, causing desiccation and subsequent death due to dehydration. The effectiveness of hoe weeding can be enhanced by adjusting its timing and angle (Chauhan *et al.,* 2008). Hoe weeding involves moving the hoe in a back-and-forth motion just below the soil surface. Different types of hoes, such as stirrup hoes or Dutch push hoes, can be used based on the field conditions. The angle and depth of hoeing should be adjusted to reach the weed roots while minimizing crop damage (O'Donovan & John, 2015). Hoeing covers a larger area making it more time-efficient and cost-effective for large-scale farming (Saini, 2016). Hoe weeding is effective against a wide range of weeds, including those with taproots or rhizomes, while reducing the weed population. Hoeing lightly disrupts the soil surface, promoting soil aeration and the breakdown of organic matter (O'Donovan & John, 2015). Although, how weeding has its own limitations; Improper use of the hoe or incorrect depth can damage crop roots or cut stems, affecting crop productivity and may lead to the survival and re-growth of cut weeds when it is done during rainy periods (O'Donovan & John, 2015).

**2.6.2 Chemical Weed Control Method**

Chemical weed control is commonly employed in large-scale pepper production. Herbicides are used to selectively control weeds and minimize damage to the pepper plants. Chemical weed control in pepper (Capsicum annum) cultivation involves the use of herbicides to selectively eliminate weeds that compete for nutrients, water, and light, negatively affecting the growth and yield of pepper plants. Chemical weed control, also known as herbicide use, is a common practice in agriculture to manage weed populations and increase crop yield. Research by Varanasi *et al.,* (2021) reported that appropriate herbicide application reduced weed biomass and increased pepper yield. These herbicides are primarily classified based on their mode of action, such as pre-emergent, post-emergent, or selective herbicides. For effective weed control, it is crucial to understand the specific weed species that infest the pepper crop, as well as select the appropriate herbicides with low toxicity to the peppers, considering their efficacy, crop safety, weed spectrum, and environmental impact (Varanasi *et al.,* 2021; FAO, 2020; USDA, 2020).

**2.6.2.1. Pre-emergent herbicides**

These herbicides are applied before weed seed germination, creating a chemical barrier that prevents weed growth while allowing pepper seeds to grow unharmed. Some commonly used pre-emergent herbicides for pepper cultivation include:

**a. Pendimethalin:** Effective against broadleaf and grassy weeds, Pendimethalin provides good control of annual grasses and several broadleaf weeds in pepper fields. It should be applied after sowing or transplanting, followed by irrigation or a light rain to activate its properties (Stansly*,* 2010).

**b. Oxyfluorfen:** Providing control against both broadleaf and grassy weeds, Oxyfluorfen is another pre-emergent herbicide used in pepper cultivation. It is essential to apply this herbicide soon after planting or transplanting peppers (USDA, 2020).

**c. Oryzalin:** This pre-emergent herbicide has been found effective against various annual grasses and broadleaf weeds in peppers (Fernandez*,* 2007). Proper application and dosage are critical to avoid potential crop injury.

**d. S-metolachlor:** Known for its pre-emergent activity, S-metolachlor can control many grasses and broadleaf weeds in pepper fields (Webster*,* 2018). It requires incorporation into the soil before weed germination for optimal results.

**2.6.2.2. Post-emergent herbicides**

These herbicides are applied after weed emergence and are effective against already established weeds. Some commonly used post-emergent herbicides in pepper cultivation include:

**a. Glyphosate:** A non-selective systemic herbicide, Glyphosate is widely used to control a broad spectrum of weeds present in pepper fields. It is crucial to apply Glyphosate carefully, ensuring it does not come in contact with pepper plants, as it can cause damage if applied directly.

**b. Bentazon:** It is a contact post-emergent herbicide effective against many broadleaf weeds, including nightshades and pigweeds (Stapleton, 2012). Bentazon is selective to peppers and can be sprayed directly on the crop foliage.

**c. 2,4-D:** This selective post-emergent herbicide controls many broadleaf weeds but is known to cause phytotoxicity in sensitive crops. Proper timing and application method are essential to prevent crop injury.

**2.6.2.3. Selective herbicides**

Selective herbicides specifically target certain weed species while causing minimal damage to the crop. These herbicides are commonly used in row-crop scenarios and may require tank-mixing or sequential applications to provide effective weed control without harming the pepper plants.

**a. Flumioxazin:** With selective control against several broadleaf and grassy weeds, flumioxazin is suitable for use in peppers (Grichar, 2007). It is typically applied as a pre-emergent or early post-emergent herbicide.

**b. Dicamba:** Dicamba is widely used to control broadleaf weeds in various crops. It is known for its effectiveness against tough-to-control weeds like Palmer amaranth and velvetleaf. However, dicamba can cause crop injury in sensitive crops through drift, so careful application is necessary (Norsworthy, 2012).

**c. Quizalofop-p-ethyl:** This selective herbicide is effective against grassy weeds, providing control without harming the pepper crop. It should be applied carefully, avoiding contact with the peppers, as it can cause injury.

**d. Clethodim:** Another selective herbicide for grassy weed control, Clethodim is used in pepper fields. It is vital to avoid spray drift onto the pepper plants during application, as it can cause damage.

**2.6.2.4. Contact herbicides**

These herbicides kill weeds upon contact, primarily targeting foliage and green tissue. They are generally non-selective and not recommended for use in pepper cultivation due to the potential for crop damage. However, if spot treatments are needed in specific situations, some contact herbicides might be considered.

**a. Diquat**: A non-selective contact herbicide, Diquat is used for quick burndown of weed foliage. However, caution should be exercised as it can cause injury to pepper plants (Fernandez, 2007).

**2.6.3 Alternative Weed Control Methods**

There are several alternative methods of weed control aside from chemical and mechanical approaches. These methods typically focus on preventing or inhibiting weed growth each categorically belongs to the cultural, biological, organic, and thermal techniques of weed control.

**2.6.3.1 Crop Rotation**

Crop rotation involves alternating different crops in a specific order to interrupt the life cycle of weeds. It reduces weed pressure by altering the environment and making it less favorable for weed growth. Crop rotation practices have been found to be effective against several weed species (Fageria *et al*., 2011).

**2.6.3.2 Mulching**

Mulching involves covering the soil around plants with a layer of organic or inorganic material, such as wood chips, straw, or plastic. Mulch suppresses weed growth by blocking sunlight and preventing germination. Several studies have demonstrated the effectiveness of mulching in reducing weed emergence and growth (Abbas *et al.,* 2018; Baumann *et al.,* 2019). Research by Martins *et al.,* (2020) suggested that a combination of mulching and proper irrigation scheduling significantly reduced weed infestation in pepper production.

**2.6.3.3 Cover Crops**

Planting cover crops or green manure can help reduce weed populations by competing for resources and space. Cover crops provide living mulch and reduce weed germination and growth. Studies have shown that cover crop integration can significantly suppress weeds in different cropping systems (Liebman and Mohler, 2001; Heggenstaller *et al.,* 2010).

**2.6.3.4 Biological Control Agents (BCAs)**

BCAs include insects or microbial organisms that directly attack and weaken weeds. Examples include insects like weevils and thrips or pathogens like fungi and bacteria. For example, the use of the rust fungus Puccinia chondrillina has shown promise as a biocontrol agent against the weed rush skeletonweed (Gassmann *et al.,* 2019).

**2.6.3.5 Grazing Animals**

Well-managed grazing by herbivores, such as sheep or goats, can help control weeds through constant defoliation and competition for resources. Proper timing and stocking rates are crucial for successful weed suppression through this method (Nyamangara *et al.,* 2002).

**2.6.3.6 Flame & Thermal Weeding**

Flame weeding utilizes heat to kill weed seedlings by exposing them to high temperatures. This technique is effective for controlling small, annual weed species and has shown promise in organic vegetable production systems (Franke-Whittle *et al.,* 2014). Thermal weed control employs extreme heat or steam to control weeds. The two main techniques used are:

**a. Steam Weeding:** Steam weed control involves applying steam to weed-infested areas. Steam penetration can kill weeds by rupturing plant cells or causing thermal shock. Several studies have indicated the effectiveness of steam weeding in both agricultural and horticultural settings (Arancon *et al.,* 2015; Luvisi *et al.,* 2020).

**b. Thermal Soil Sterilization:** Thermal soil sterilization uses heat to eliminate weed seeds and pathogens in the soil before planting. This technique involves heating the soil to temperatures that kill unwanted organisms. Research has demonstrated the effectiveness of soil sterilization in reducing weed pressure and promoting plant growth (Simmonds *et al.,* 2019).

**2.7 EFFECT OF WEEDING CONTROL METHODS ON SWEET PEPPER (*Capsicum annum L.)***

Numerous studies have evaluated the efficacy and impact of various weed control strategies in pepper production. For instance, Research by Varanasi *et al.,* (2021) reported that appropriate herbicide application reduced weed biomass and increased pepper yield. Johnson *et al.* (2018) also found that the application of herbicide paraquat effectively controlled common weeds in pepper fields, resulting in improved growth parameters and increased yield. Similarly, Smith and Brown (2019) investigated the impact of herbicide bentazon on pepper growth, observing significant differences in plant height, leaf area, and fruit yield compared to the untreated control. Wang, (2020) investigated the effects of different mechanical weed control techniques on pepper growth, finding that hand weeding positively influenced growth parameters, including plant height, fruit weight, and marketable yield.

Zaman *et al.,* (2018) compared the efficacy of different herbicides on weed control in pepper fields. They reported that selective herbicides positively impacted pepper growth by controlling weeds without causing significant phytotoxicity.

Furthermore, Li *et al.,* (2019) evaluated the impact of pre-emergent herbicides on pepper growth and found that herbicide-treated plots exhibited superior plant height, fruit weight, and fruit yield compared to untreated plots.

Smith*,* (2020) evaluated the impact of weed control methods (use of buctalor and hand picking) on pepper yield and observed a positive correlation between weed suppression and increased marketable fruit yield.

However, Gudeta *et al.,* (2020) carried out an experiment comparing no weeding with manual weeding methods. The results indicated that the unweeded plots experienced severe weed competition, leading to stunted growth and reduced pepper yield compared to the manually weeded plots. Campos *et al.,* (2019) conducted a field experiment comparing manual weeding with unweeded control plots. They found that manual weeding significantly reduced weed competition, resulting in improved pepper growth and yield.

Moreover, Adeghe and Agbaji (2017) examined the frequency of manual weeding on pepper growth in Nigeria. The study concluded that regular manual weeding significantly increased pepper plant height, leaf area, and fruit yield.

Hence, the empirical evidence suggests that weeding significantly improves pepper growth and yield by reducing weed competition. On the other hand, it is imperative to investigate the use of other herbicides (such as; extraforce) against mechanical weed control method (hoe weeding to ascertain it effects on the yield and growth parameters of sweet pepper (*Capsicum annum)*.

**CHAPTER THREE**

**MATERIALS AND METHODS**

**3.1 Study Area**

This study was carried out at the Teaching and Research farm of Faculty of Agriculture, Akwa Ibom State University. Obio Akpa Campus, Oruk Anam Local Government Area, Akwa Ibom State. The area lies between latitude 4030’N and 50 00’N and longitudes 700 30’E and 800 00’E (SLUS-AK, 1989). It records annual rainfall of about 2500mm. the rainfall lasts between April and November usually with a break in august which last for about 2 weeks (termed August break). Temperature range is between 22.5-30.7OC. The relative humidity is about 78%. The soil is sandy loam (SLUS-AK, 1989).

**3.2 Experimental Design and Treatments**

The experiment was laid out in a randomized complete block design (RCBD) with three treatments and three replications. Each sub-plot measured of 2m x 1m and consisted of 3 rows as shown in figure 1, having a net plot of 9m x 7.5m. There was no weeding in the first treatment and it serve as the control. In the second treatment, manual or hoe weeding control method was employed, whereas the herbicide used in the third treatment was Extraforce which was applied at the rates of 1.5 kga.iha-1

**7.5m**

**Control (No wedding) Hoe Weeding Herbicide (Extraforce)**

**1.5m**

**2m**

**1m**

**9m 2m**

**1m**

**2m**

**Figure 1: The Layout of the Experimental Treatments and Design**

**3.3 Soil Sampling**

Prior to planting the soil was randomly sampled at the depth of 0.15cm at three different location or spots in the area. The soil samples were bulked together to obtain a representative sample, the representative sample was air dried and sieved with 2mm sieve before being taken to the laboratory for analysis.

**3.4 Agronomic Practices**

**3.4.1 Land Preparation**

The field was cleared manually using cutlass and tilled with spade. Stumping (if any) and beds making was done manually through the use of spade.

**3.4.2 Planting**

Planting material was done using *Capsicum annuum* seeds purchased from a reputable seed vendor. The seeds were first planted in the nursery boxes and the seedlings were later transplanted to the field after 4 weeks in the nursery.

**3.4.3 Fertilizer application**

Organic manure in the form of poultry dung was used alongside Compound Fertilizer (N: P: K 15:15:20) was applied at the rate of 500 kg/ha by ring application, 4 weeks after planting.

**3.4.4 Weeding**

Removal of unwanted plants or weed was not done in the control but manual or hoe weeding and the application of the herbicide (Extraforce) was done in treatments two (2) and three (3) respectively 14 days after transplanting at 2 weeks (14 days) intervals.

**3.4.5 Harvesting**

At maturity, harvesting *Capsicum annum* was done manually using sharp knife at 30, 45 and 60 day intervals for a period of 2 to 3 months.

**3.5 Data collection**

**3.5.1 Growth Parameters**

* **Plant height (cm)**

The plant height was measured from the base of the plant to the terminal growing point of the main stem at 14, 30, 60 and 90 days after transplant. The average plant height was worked out and expressed in centimeters.

* **Number of leaves per plant**

The number of leaves per plant was measured at 14, 30, 60 and 90 days after transplant for three rows plants and then mean was worked out.

* **Leaf Area:** The leaf area of the plants per treatment were taken and worked out
* **Number of branches per plant**

The number of branches per plant at 14, 30, 60 and 90 days after transplant was counted for three rows plants and then mean calculated.

**3.5.2 Yield Parameters**

* **Total number of fruits**

The total numbers of fruits from three tagged plants was counted in all the pickings and the average total numbers of fruits per plant for each treatment was worked out.

* **Fruit weight (g /fruit)**

Five numbers of fruits from each treatment was weighed and worked out for single fruit weight and expressed in grams.

* **Length of fruit:** The length of the fruits for all the treatments were measured using a ruler and the single unit worked out.
* **Fruit yield (t/ha)**

The fresh fruit yield from the net plot area was taken to calculate the unit yield per hectare.

**3.6 Data Analysis**

All the data obtain were analyzed using One Way Analysis of Variance (ANOVA). Significant means was separated by applying Duncan multiple range at a probability level of 0.05 as outlined by Duncan (1955).

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