**EFFECT OF HERBICIDES ON THE GROWTH AND YIELD RESPONSE OF SWEET PEPPER *(Capsicum annuum L.)* IN OBIO AKPA, AKWA BIOM STATE.**

**A RESEARCH PROJECT**

**BY:**

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**JULY, 2023**

**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 Economic Importance of Sweet Pepper (*Capsicum annuum L.)***

*Capsicum annuum* L. is a major spice globally and it is used in diverse delicacies irrespective of culture nor religion (Cruz-Huerta *et al.* 2011). *Capsicum annuum* is a source of income to producers and store of wealth (Bradley, 2017). *Capsicum annuum* is an important crop not only because of its economic importance but also for the nutritional value of its fruits being a major source of natural colors and antioxidant compounds (Hwang *et al.,* 2014). The intake of these compounds I n food is an important health protecting factor, they have been recognized as being beneficial for prevention of widespread human diseases, including cancer and cardiovascular diseases when taken daily in adequate amounts (Bradley, 2017). These peppers are used either fresh or dried in preparation of traditional diets but they are commonly used fresh. Although pepper has been reportedly used as medicine in the management of arthritis pair, diabetic, neuropathy, post mastectomy and among others, there is paucity of information about the antioxidant capacity of the pepper varieties used as major condiments in the traditionally prepared diet in the South West of Nigeria (Hwang *et al.,* 2014). Hence, sweet pepper is important for both the producers, government and the consumers.

**1.3 Global Production Statistics of Sweet Pepper (*Capsicum annuum L.*)**

World pepper production has grown considerably over 20 years (1997–2017, www.fao.org/ faostat) from 2 to about 4.5 million tons of dry types and from over 17 to 36 million tons as fresh. The area harvested followed a similar trend, with an increase of the surface cultivated area of about 35% in the last 20 years, being today about 3.8 millions of hectares. Fresh pepper is cultivated in 126 countries of the world in all the continents. The world’s largest producer is China with over 18 million tons annually, followed by the Mexico with about 3.5 million tons (FAOSTAT, 2017). Dry pepper is cultivated in 70 countries and no relevant production is reported in Oceania. India is the largest producer with about 2.0 million tons, followed by Thailand (349.615 tons). Peppers are grown almost all over the world and are fairly easy to cultivate both in the ﬁeld and in the greenhouse in a wide range of climatic and environmental conditions. Africa, Europe, and America contribute in the same proportion to the total world production (about 10–12% each) for fresh pepper; while for dry pepper, Asia and Africa are the main producers contributing to the 70.3 and 21.2%, respectively. The economic value of pepper production has increased since 1991 becoming a good source of income for producers in many countries and giving an important role in international trading (FAOSTAT, 2017). The present worth of dry pepper is 3.8 billion dollars, while fresh pepper contributes with 30,208 billion dollars. For both, the increase observed over the past 25 years is four times higher in dry pepper and six times higher in fresh pepper. Around the genus Capsicum, there is an increasing interest and fascination due to the amazing diversity in many characteristics, such as plant architecture, ﬂower morphology, fruit typology, colors, pungency, and qualitative traits which make this crop extremely versatile and suitable for innumerable uses. As food, a variety of recipes are ensured thanks to the presence of sweet and hot types. The former is mainly widespread in temperate regions of Europe and North America where they are used freshly or cooked as vegetables (FAOSTAT, 2017). The latter are instead mainly spread in the tropical regions of America, Africa, and Asia, where they are mostly consumed fresh or dried as condiment as spice in powder or salsa in many dishes.

**1.4 Constraints of Sweet Pepper (*Capsicum annuum L.)* 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 eggplants and crop yields, hence the need for effective and sustainable herbicide (Shivalingappa *et al.,* 2014).

**1.5 Justification of the Study**

Where success of crop depends on many factors and effective weed management is one of most prior operation for a successful crop productivity. Favorable environmental conditions, spacing and liberal use of farmyard manure, chemical fertilizers and frequent irrigations encourage the weeds to grow vigorously and may lead to severe weed competition particularly during early stages of *Capsicum annuum* growth. It has been estimated that losses in yield due to weeds alone vary from 10 to 70% depending upon the extent of weed infestation (Mani *et al.,* 1968). It is difficult to control weed manually because of poor efficiency of the labour and the heavy cost involved in manual weeding. Therefore, the study is designed to investigate the effects of different types of herbicides and rates as a weed control approach considering the growth and yield response of pepper (*Capsicum annuum L.).*

**1.6 Objective of the Study**

The objective of this study will be;

* To determine the effect of Herbicides types on the growth and yield of pepper (*Capsicum annuum L.).*
* To assess the efficacy of rates of application of herbicides on growth and yield of pepper(*Capsicum annuum L.).*

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Origin and Distribution of Sweet Pepper (*Capsicum annuum L.)***

Sweet pepper *(Capsicum annuum L.),* also known as bell pepper, are a member of the Solanaceae family originating in South America and now an important food crop internationally. Domestication of capsicum occurred in two areas: in the Andean region and in Central America (Bosland and Votava 2012). In the Capsicum genus, about 30 species have been described, 5 of which were independently domesticated and cultivated for use as spice and vegetables (*C. annuum, C. pubescens, C. chinense, C. frutescens* and *C. baccatum*) (Yoshida *et al.,* 2014). Capsicums were introduced into Europe by the Spaniards following the expedition of Columbus in the fifteenth century and became widely cultivated (Yoshida *et al.,* 2014). In the eighteenth and nineteenth centuries, the sweet types (relatively large, nonpungent with fleshy fruit walls) became dominant in Western Europe and North America (Bonaccorsi *et al.,* 2016). Peppers are one of the most important vegetables worldwide due to their versatility for cuisine, medicine, and industry (Barboza *et al.,* 2019). The genesis of Capsicum apparently occurred in a broad area spanning Peru, Ecuador, and Colombia along the Andes in western–northwestern South America (Carrizo *et al.,* 2016). The subsequent expansion of the genus took place following a clockwise direction around the subcontinent, from Colombia to central– eastern Brazil, Paraguay, northern Argentina, Bolivia, and Peru, returning to northwestern South America. Within this migration, Bolivia and Peru emerged as particularly important centers of diversiﬁcation and origin of some cultivated species. Further spread of Andean peppers toward Central America gave rise to an *Annuum* clade including the *Capsicum annuum* species, which was presumably domesticated in Mexico from the wild bird pepper *C. annuum var.* Glabriusculum (Carrizo *et al.,* 2016). Following the voyages of Columbus in the late 15th century, peppers were introduced to Europe after their initial arrival in the Iberian Peninsula. Then, trade routes promoted their geographic dispersal toward the Mediterranean Basin, and thenceforth to Africa, India, and China (Andrews, 1984, 1994). Sweet pepper *(Capsicum annuum L.),* also known as bell pepper, are a member of the Solanaceae family was the most successful in this conquest, probably due to it being the ﬁrst Capsicum species to arrive in Europe rather than related to any superior agronomic trait (Andrews, 1993). Currently, this species holds the greatest economical recognition, being grown in most tropical, Mediterranean, and temperate regions of the world (Bosland and Votava, 2012). Contemporary *Capsicum annuum* has both sweet and hot types and encompasses some of the most widely consumed pepper varieties including bell pepper, jalapeno, cayenne, and poblano which is now used globally as a major spice.

**2.2 Botanical and Anatomical Description of Sweet Pepper *(Capsicum annuum L.)***

Sweet pepper *(Capsicum annuum L.),* also known as bell pepper, are a member of the Solanaceae family. In the Capsicum genus, about 30 species have been described, 5 of which were independently domesticated and cultivated for use as spice and vegetables (*C. annuum, C. pubescens, C. chinense, C. frutescens* and *C. baccatum*) (Yoshida *et al.,* 2014). *Capsicum annuum* fruit is classified as a berry (from a single flower, containing one ovary with numerous seeds (Zhigila *et al.,* 2014). The flesh of the fruit itself is the ovary wall, termed pericarp, which can vary in thickness. The interior of the fruit may be partially divided into three to four carpels, with the dividing tissue being fragile. So-called giant cells can be present close to the interior of the pericarp, giving rise to the roughness of the internal surface (Bosland and Votava, 2012). Numerous seeds are attached to the placenta. On the epidermis the cuticle coverage is abundant, while stomata are rare. The epidermal cells themselves are very thick (Whitaker, 1995). These features are typical plant mechanisms to prevent excessive water loss. However, the epidermis of the green tissue of the peduncle has numerous stomata, and there are large intercellular spaces within this tissue. Fruit shape trends from blocky (square/rectangular, with a thick pericarp wall) to elongated (extended and tapering, usually with a thinner wall). Consistent fruit size and shape are important quality factors for commerce. Non-ideal temperature during flowering can have an impact on ovary size and locule number, affecting fruit size and shape (Ali and Kelly 1993; Cruz-Huerta *et al.,* 2011). In *Capsicum annuum*, ripening is initiated when fruit have stopped enlarging, which can be contrasted with fruit such as strawberry whose fruit ripen as the fruit enlarge. Fruit that are ready to ripen are termed ‘horticulturally mature’. If fruit are harvested before the breaker stage they do not ripen fully (Cruz-Huerta *et al.* 2011; Aizat *et al.,* 2013). During ripening, capsicums lose chlorophyll and synthesise carotenoids, the timing of which can be affected by ethylene. Flavour and aroma also change. Ripening-related textural changes appear to be highly cultivar-dependent, and in many cases can be related to water loss after harvest (Aizat *et al.,* 2013).

**2.3 Climatic and Edaphic Requirement of Sweet Pepper *(Capsicum annuum L.)***

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. A pepper crop requires very stable temperature ranges with minimums and maximums not being too far apart (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). This would also be the ideal temperatures for growing under protection. Long periods of overcast weather can also result in poor fruit set and loss of a crop (Starke, 2021). Sweet peppers cannot withstand higher temperatures (Starke, 2021). Also, for the development of the pepper plant, 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). Conversely, low relative humidity may cause infertility, due to pollen drying out before germination of the pollen on the stigma, which leads to small, deformed or flat fruit. At relatively low humidity and high temperature, evaporation rate from the leaves is rapid. If the root system is unable to supply the water volume required, it may lead to partial wilting of the growth tip and increase the incidence of blossom end rot (Horvitz and Cantalejo, 2014; Starke, 2021). In addition, high level of soil fertility is required for the profitable production of a successful pepper crop. The quality and quantity of pepper fruits are of crucial importance and are greatly influenced by the fertility and nutrient levels of the soil. Pepper plants do not perform too well in very high clay soils (Starke, 2021). They rather prefer sandy to loam soils; In fact, they will grow moderately well over a wide range of soil types, provided they are well drained to a depth of at least 600 mm (Granberry and Colditz, 1990). However certain criteria have to be satisfied in terms of the soil structure and content to make it 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. 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). Early root development should be encouraged, because nearly all root growth occurs before fruit set. The importance of organic matter cannot be over emphasized. Organic matter in the form of decayed leaves, compost, sawdust or animal manure is a source of plant nutrients and acts as a soil conditioner (Lownds *et al.,* 1993). It increases the capacity of the soil to retain water and nutrients. It also promotes root growth and the infiltration of water and air into the soil. Care should be taken to use, where applicable good quality organic matter known to be free of plant pathogens (Lownds *et al.,* 1993).

**2.4 Weed Management in Sweet Pepper *(Capsicum annuum L.)***

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. Good weed control in *Capsicum annuum* begins the same as any other crop, before the crop is planted. Knowing the weed species in the field is the first step in effective weed management. The use of cultural, mechanical, and chemical weed control techniques in a coordinated manor to reduce the risk of weed interference with the crop is necessary (Bradley, 2017). In choosing the right herbicides to control the weeds in the field, herbicides that provide proper soil texture and organic matter in the field, and minimizes the risk of crop injury and maximize weed control should be considered (Hembree, 2015). Several effective herbicides are registered for use in transplanted *Capsicum annuum* (Bradley, 2017). Effective weed management in *Capsicum annuum* also begins with proper field selection and identification of potential weed problems (Bradley, 2017). It involves pre-irrigation and cultivation, proper land and bed preparation, sanitation, and proper selection of herbicides (Hembree, 2015). When combined with good cultural practices, available herbicides can control many of the weed species that are found in pepper fields. The choice of herbicide depends upon the weed species that are present and the cultural practices followed thereafter (Hembree, 2015).

***2.4.1 Pre-Emergence Herbicides***

Pre-emergence herbicides are applied to the soil and mechanically mixed with the soil or are irrigated into the soil before weeds emerge (Hembree, 2015). They are effective against germinating seeds before they germinate; these materials usually give some residual control of 3-6 months. Herbicides work best if they are applied when soil moisture is adequate for plant growth. Pre-emergence herbicides are effective against germinating seeds, not dry seeds (Bradley, 2017). Pre-emergence herbicides are not to be applied on wet soils, as compaction can occur (Hembree, 2015).

***2.4.2 Post-Emergence Herbicides***

Post-emergence herbicides are sprayed onto the foliage of the weeds after they have emerged (Hembree, 2015). Certain post-emergence herbicides are systemic, selective and are absorbed by the leaves and stems of the weeds and translocated in the plant. Other post-emergence herbicides are strictly contact and only kill the leaves/plants they come in contact with (Bradley, 2017). Post-emergence herbicides work best on non-stressed plants, which absorb and translocate the material more readily than stressed plants (Hembree, 2015). Some common examples of post-emergence and it trade name include:

* Sethoxydim - *Trade name: Poast®,*
* Clethodim - *Trade name: SelectMax®*
* Halosulfuron - *Trade name: Sandea®*
* Bentazon - *Trade name: Basagran®*

*Source; Greg and Beth (2019).*

**2.5 Effect of Herbicides and Rates on Sweet Pepper Yield and Growth**

The productivity of any crop depends on many factors and effective weed management is one of most prior operation for a successful crop. Favorable environmental conditions, proper spacing and liberal use of farmyard manure, chemical fertilizers and frequent irrigations encourage the weeds to grow vigorously and lead to severe weed competition particularly during early stages of its growth (Hembree, 2015). It has been estimated that losses in yield due to weeds alone vary from 10 to 70% depending upon the extent of weed infestation (Mani *et al.,* 1968). It is difficult to control manually because of poor efficiency of the labour in summer and rainy season besides heavy cost of manual weeding. There seems to be good scope to make use of selective chemical and cultural control to attain season long control (Hembree, 2015). According to Marque *et al.,* (2017), in his study with major weeds found in the eggplant cultivar were; *Eleusine indica*, *Portulaca oleracea,* and *Cyperus rotundus*. And he reported that coexistence between the weed community and the eggplant throughout the entire crop production cycle reduced eggplant fruit yield by 78%. Sumeet *et al.,* (2017) reported that the treatment comprising with post-emergence application of paraquat @ 0.15 kg/ha at 45 days after transplanting (DAT) showed better result than other treatment (mulching) with yield of 96.72% and these findings was similar to Nadagouda, (1995). Shivalingappa *et al.,* (2014) also revealed that pendimethalin @ 1.5 kg a.i. ha-1 had more significant effect among treatments which results less number of weeds, less dry weight (g), high weed control efficiency (WCE %), and increased in morphological, biochemical parameters, yield attributes while comparing with all the treatments at 30, 60, 90, 120 DAT followed by pendimethalin @ 1.0 kg a.i. ha-1

**CHAPTER THREE**

**MATERIALS AND METHODS**

**3.1 Experimental Site and Cropping History**

This study will be 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 Soil Analysis**

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

**3.3 Experimental Design and Treatments**

The experiment will be laid out in a randomized complete block design (RCBD) with split plot arrangement and replicated three times. The main treatment will be types of herbicides (primextra, pendimethalin and butachlor) while the sub-treatment will be rates of application of herbicides (1.0, 2.0, 3.0 kga.i/ha) and a control plot of no herbicide application. Each sub-plot will measure 2m x 1m and main plot 2m x 4m. the total plot will be 9m x 12m as shown in figure 1.

**12m**

**Primextra Pendimethalin Butachlor**

**4m**

**2m**

**1m**

**9m 2m**

**1m**

**2m**

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

**3.4 Source of planting material**

The pepper seeds will be purchased from a reputable seed vendor in Abak while the herbicides(primextra, pendimethalin and butachlor) will be purchased from a reputable agro enterprise in Uyo vicinity.

**3.5 Agronomic Practices**

**3.5.1 Land Preparation**

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

**3.5.2 Planting**

**3.5.2.1 Nursery Establishment and Planting**

**3.5.2.2 Field Capacity**

**3.5.3 Herbicide Application**

**3.5.4 Fertilizer Application**

Organic manure will be used alongside agzyme three times which will be applied at the rate of 50 g/vine (500 kg/ha) by ring application, 4 weeks after planting.

**3.5.4 Weeding**

Weeding will be done by application of the treatments which are pre-emergence herbicides (primextra, Pendimethali and Butachlor).

**3.5.5 Harvesting**

Harvesting will be done manually using sharp knife at 30, 45 and 60 day intervals.

**3.6 Data collection**

**3.6.1 Growth Parameters**

* **Plant height (cm)**

The plant height will be measured from the base of the plant to the terminal growing point of the main stem at 30, 60, 90, 120 days after transplant. The average plant height will be determined and expressed in centimeters.

* **Number of leaves per plant**

The number of leaves per plant will be measured at 30, 60, 90, 120 days after transplant for three rows plants and then mean will be determined.

* **Number of branches per plant**

The number of branches per plant at 30, 60, 90, 120 days after transplant will be counted for three rows plants and then mean calculated.

**3.6.2 Yield Parameters**

* **Total number of fruits**

The total numbers of fruits from three tagged plants will be counted in all the pickings and the average total numbers of fruits per plant-3 for each treatment will be calculated.

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

Fruits per plant will be weighed in grams and the mean calculated.

* **Fruit yield (t/ha)**

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

**3.7 Statistical Analysis**

All data will be subjected to analysis of variance and the means compared at 5% (p<0.05) probability level (Wahua, 1999).

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