EFFECT OF SELECTIVE HERBICIDE APPLICATION RATE ON THE YIELD AND GROWTH OF SOYBEANS (*Glycine max*) IN MUBI NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE NIGERIA

BY

ANUDATICHA CAROLYN TITUS
(SA/CP/HND/21/008)

OCTOBER, 2023

EFFECT OF SELECTIVE HERBICIDE APPLICATION RATE ON THE YIELD AND GROWTH OF SOYBEANS (*Glycine max*) IN MUBI NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE NIGERIA

BY

ANUDATICHA CAROLYN TITUS
(SA/CP/HND/21/008)

A PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL TECHNOLOGY FEDERAL POLYTECHNIC MUBI IN PARTIAL FULFILMENT FOR THE AWARD OF HIGHER NATIONAL DIPLOMA (HND) IN AGRICULTURAL TECHNOLOGY

OCTOBER, 2023

DECLARATION

I hereby declare that this work which is titled "Effect of Selective Herbicide Application Rate on the Yield and Growth of Soybeans **(*Glycine max*)** in Mubi North Local Government Area of Adamawa state". As a result of research effort and findings and to the best of my knowledge and belief that this work has never been submitted to any institution for the award of any certificate and various sources used has been duly acknowledged by the use of referencing.

………..……………......................   ……..………….....

ANUDATICHA CAROLYN TITUS   Date

DEDICATION

I dedicated this research work to my lovely parents for all their care, support and encouragement throughout my study.

APPROVAL PAGE

This project entitled "Effect of Selective Herbicide Application Rate on the Yield and Growth of Soybeans **(*Glycine max*)** in Mubi North Local Government Area of Adamawa state" meets the regulation governing the award of Higher National Diploma in Agricultural Technology of the Federal Polytechnic, Mubi and is approved for its contribution to knowledge and literary presentation.

…………..………….….	……..…………….….
Mr. Zakari Yusuf (Supervisor)	Date
…………..………….….	……..…………….….
Dr. Musa Benjamin Vimtim (Head of Department)	Date
…………..………….….	……..…………….….
Mr. Sunday Hamman External Examiner	Date

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty for his blessing and sparing my life up to this point, may he take all praise, honour, glory and adoration.

I am highly grateful to my supervisor Mr. Zakari Yusuf for his tireless effort in ensuring the success and completion of this research work.

I also acknowledge the Head of Department Dr. Musa Benjamin Vimtim and the entire staff of Agricultural Technology Department for their guidance during this experimental work.

My gratitude goes my beloved parent Mr. and Mrs. Rev. Titus Bitrus, my siblings, Mr. Yusuf Hussaini, Mr. Godwin Samaila Gadzama, Mr. Matthew Luka and all my friends for their moral and financial support in this experimental work may the almighty God bless you all abundantly. Amen.

ABSTRACT

The field experiment was conducted at the Teaching and Research Farm, Department of Agricultural Technology, Federal Polytechnic, Mubi (latitude 9º 26 and 10º 10'N and longitude 13º 10' and 13o 44' E, on latitude of 196m above sea level) in 2023 cropping season to study the effect of Selective Herbicide Application Rate on the Yield and Growth of Soybeans (Glycine max). The treatment comprised of four spray times of Herbicide (IMAZE-THAPYR-Legume force): H1 (control), H2 (Herbicide applied once), H3 (Herbicide applied twice), H4 (Herbicide applied thrice) using a randomized complete block design (RCBD) replicated four times, the growth and yield parameters measured include: plant height, number of leaves per plant, stem girth, number of branches, Days to first and 50% flowering, Days to 50% podding, number of pods per plants and 100 seed weight. The data collected were analysed using SAS (2010) and means with significant differences were separated using Least Significant Difference (LSD) at 0.05 level of probability. The results of this study revealed that effect of herbicide application rates on the growth and yield of soybean (Glycine max) had a significant effect on 50% flowering and days to first podding setting, number of pods per plant, 100 seed weight (g). Herbicide applied thrice (H4) gave earliest days to 50% flowering and days to first podding setting (67.67 and 72.04 days) produce highest stem girth at 4, 6, 8 WAS (3.46, 5.56 and 6.76mm).

TABLE OF CONTENT

Content Page No.

CHAPTER THREE: MATERIALS AND METHOD

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Herbicides are synthetic chemicals used to kill or suppress unwanted vegetation (Shobha *et al.*, 2010). The practice of killing the undesirable vegetation (that is weed) with herbicides is called chemical weed control management. Herbicides constitute the principal component of chemical weed management and are an integral part of the modem agriculture because they provide cost-effective increase in agricultural productivity (Rao, 2011). Herbicide has revolutionized the weed control methodology (Das, 2011). At global level, the usage of herbicide consumption is 43 as against 31 percent with insecticides, 21 percent with fungicides and 5 percent with other agrochemicals (Baishya *et al*., 2017).

Herbicide use in weed management has been the most important in the world agriculture because it destroys weeds on a large scale either before or at emergence of crop without disturbing the crop or soil and farmers don't depend heavily on human labour (Reddy, 2016).

According Singh *et al.* (2009), effectiveness of herbicide can be affected by environment, stage of maturity of target plant, type of plant, plant part sprayed, how herbicide move within the plant, concentration of herbicides and method of application.

Herbicides are one of the factors contributing to world food production. Advanced countries are almost depending on herbicide for their weed management because it is meeting their production challenges in agriculture and relatively ignoring other methods of weed control (Baishya *et al.,* 2017). Also, Rao (2011), reported that currently the most common method of managing weeds is through the use of herbicides.

The use of herbicides is increasing in worldwide crop production (Hossain, 2015). This is because the other alternative control measures do not provide an effective and economic substitute for herbicides in many situations (Labrada *et al.,* 1994). Herbicides are being rapidly accepted in developing countries that face shortages of hand weeding labor and the need to raise crop yields (Zhang, 2003). Improved weed control with herbicides has the potential to greatly improve crop yields in many developing countries in the near future (Hossain *et al*., 2015). Increased herbicide use promotes fertilizer use, which leads to even greater yield increases (Manda, 2011). In reality, crop fields are seldom adequately weeded by hand; weeding is tedious and time consuming. Laborers are not always available when needed (Holm *et al*., 2010). Weeding is often done late, causing drastic losses in yield (Rashid et al., 2012). Herbicide use is increasing in many countries where tillage and flooding for weed control are being reduced in order to conserve natural resources: soil, water and energy (Holm et al., 2010). Herbicide application has substituted for several tillage trips, and tillage equipment is also heavier than herbicide sprayers and needs more energy to pull steel implements through the soil. Using herbicide is more beneficial for controlling weeds and the world is rushing to adopt herbicide for the upcoming developed agriculture (Zhang, 2007).

Weed is plant growing at a place and time where it is not desired (Reddy, 2016) or as Siddagangamma *et al*. (2018) put it, weeds are unwanted and undesirable plants which interfere with the utilization of land and water resources and thus adversely affect human welfare. It is also a plant growing where it is not desired in such a way that constitutes a nuisance either to man, livestock or the crops (Das, 2011). Weeds tend to be more aggressive and troublesome than cultivated plants and have characteristics that enable them to survive unlikely very harsh conditions (Martin *et al.*, 2006).

Weeds are highly competitive and are highly adaptable under varied adverse conditions Reddy (2011). Reproductive mechanism is far superior to crop plants particularly under unfavorable side; therefore, weeds are constantly invading the field and try to succeed over less adapted crop plant (Yaduraju *et al*., 1997). Produces larger number of seeds compared to crop as reported by Reddy (2011). Also most of the weed seeds are small in size and contribute enormously to the seed reserves. Weed seed germinate earlier at their seedlings and grow faster (Das, 2011). They flower earlier and mature ahead of the crop they infest. They have the capacity to germinate under varied conditions (Reddy, 2016). Weed seeds possess the phenomenon of the dormancy, which is an intrinsic physiological power of the seed to resist germination even under favorable conditions. Weed seed do not lose their viability for years even under adverse conditions, (Baishya, 2017). They possess extensive root system, which go deeper as well as for creeping type (Chandrasekaran *et al*., 2010).

Weeds reduce the quantity of crop yield and quality by competing with crops for nutrients, water, light and space. Nutrients, soil moisture, light and space, which are the principal factors for crop production, if affected crop yield is also affected (Singh, et al, 2009). Reddy (2016) reported that losses caused by weeds exceed the losses from any category of agricultural produce from various pests, weeds account for 45%, insects 30%, disease 20% and other pests 5% (Rao, 2006). Also, Yaduraju (1997) reported that weed roughly account for 37%, insects for 29%, disease for 22% and other pests 12% of the total annual loss of agricultural produce. Generally, an increase in one kilogram of weed growth corresponds to a reduction in one kilogram of crop growth (Chandrasekaran et al., 2010). Weeds remove plant nutrients more efficiently than crop plants. When left undisturbed, some weeds can grow faster and taller than crop plants and inhibit tillering and branching (Vissoh, et al., 2004). They can curtail sunlight and adversely affect photosynthesis and plant productivity. The percentage range of yield loss due to weeds in some important crops is given in Table 1 as reported by Chandrasekaran, et al, (2010).

Table 1: Yield losses due to weeds in some important crops

Crop	Yield loss range (%)
Rice	9.1 – 51.4
Wheat	6.3 – 34.8
Maize	29.5 – 74.0
Millet	6.2 – 81.9
Groundnut	29.7 – 32.9
Sugarcane	14.1 -71.7
Soybean	30.9 – 39.1
Cotton	20.7 – 61.0
Carrot	70.2 – 78.0
Peas	25.3 – 35

Source: Chandrasekaran *et al.*, 2010.

Weeds also lead to loss in crop quantity and quality, the quantity of leafy and other vegetable crops suffers in the presence of weeds. Contamination of other noxious weed seeds greatly reduces the value of crop seed and grain and sometimes even renders them unusable Rao (2006).

1.2 Statement of the Problem

Most farmers cultivate soybean without proper knowledge on the appropriate dosage of herbicide to be applied to control weed for soybean production for optimum yield. Some farmers exceed the limit of recommended rates which kill or affect the yield of soybean and also affect the health of the farmer.

Furthermore, improper application of herbicide on soybean farm will make the weeds to invade the farm.

1.3 Justification of the Study

The findings of this research work will provide useful information on the appropriate dosage of herbicide application on the growth and yield of soybean which will boost the farmers yield, income and availability of soybean in the study area.

1.4 Objectives of the Study

The main objective of this research work was to evaluate the effect of herbicide application on the growth and yield of soybean, while the specific objectives was to determine the best application rate of herbicide on the growth and yield of soybean for optimum yield in the study area.

1.5 Scope of the Study

The research work was carried out to evaluate the effects of different application of herbicide rates on the growth and yield of soybean in 2023 rainy season at the students' demonstration and research farm Department of Agricultural Technology, Federal Polytechnic, Mubi.

1.6 Limitation

The limitation of the study is over and under-dose of herbicides can make a market difference between the success or failure of weed control. Certain herbicides because of their long residual effect limit the choice of next crop in the crop rotation. Herbicides drifts may harm the neighbouring crops. Herbicides use may cause environment pollution.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and Distribution of Soybean

Soybean is a temperate species found in East Asia north of the Tropic of Cancer, including China, Korea, Japan, and the far eastern regions of Russia (Wilson 2008; Zhou et al. 2015). Wild soybean is most widely distributed in China where it is present in all provinces except Qinghai, Xinjiang, and Hainan provinces (Li 1994; Dong *et al*., 2001). In China, the distribution area of wild soybean ranges from Yisiken (53° N) in Tahe County, Heilongjiang Province in the north, Xiangzhou (24° N) in Guangxi Province, and Yingde (24° 10′ N) in Guangdong Province in the south, Fuyuan (134° 20′ E) in Heilongjiang Province in the east, to Shangchayu District (97° E) in Zayu County, Tibet, in the west. The upper limit of the altitude distribution of wild soybean is 1300 m above sea level in Northeast China, 1500–1700 m above sea level in the Yellow River and Yangtze River valleys, and 2250 m above sea level in Tibet. The highest point of distribution of wild soybean in China is Ninglang County, Yunnan Province at 2650 m above sea level (Zhuang 1999; Dong *et al.*, 2001).

It is generally accepted that the cultivated soybean was domesticated from its wild ancestor in the Huang-Huai-Hai region of China between 32° and 40° N, resulting in regional local landraces, and was further crossed and selected during breeding to generate modern cultivated soybean varieties (Hymowitz 1970; Carter *et al.*, 2004; Li *et al*., 2008; Wilson 2008). As China represents the origin of cultivated soybean, almost all soybeans grown in other regions of the world have directly or indirectly spread from China. Soybean may have been introduced to Korea, Japan, and South Asia approximately 2000 years ago, to Europe and North America in the middle of the eighteenth century, and to Central and South America in the first half of the twentieth century (Wilson, 2008).

The long history of domestication, cultivation, and breeding has narrowed the genetic basis of cultivated soybean and has restricted the further improvement of the yield and quality. By contrast, wild soybeans, which inhabit a wide geographical area in East Asia, show extensive genetic variation in pest and disease resistance genes and other useful agricultural and ecological characteristics. Understanding the origin of wild soybean could shed light on the mechanism of genetic penetration of wild soybean into cultivated soybean, provide theoretical guidance for the innovation and improvement of soybean germplasm, and clarify the basic laws of soybean variety improvement. However, to date, since few studies have focused on the origin and evolutionary pattern of wild soybean, the origin of wild soybean is still unresolved.

Soybeans are believed to have originated in East Asia, specifically in the regions encompassing China and Japan. The domestication and cultivation of soybeans date back thousands of years. Recent archaeological and genetic studies have shed light on the history of soybeans' domestication and their journey to becoming a globally significant crop. Recent genetic studies suggest that soybeans were first domesticated in northern China around 5,000 to 9,000 years ago (Lam *et al*., 2018). These studies have traced the genetic diversity of soybeans and identified several wild soybean ancestors in China. Historical records indicate that soybeans were cultivated in Japan as early as the Yayoi period (300 BC to 300 AD) (Nishida *et al*., 2020). Soybeans played a crucial role in Japanese agriculture and cuisine for centuries. Soybeans gradually spread to neighboring regions, including Korea and other parts of Southeast Asia, where they became integral to the local diets and agriculture (Lee *et al.*, 2021). Soybeans were introduced to the Americas by European explorers and traders. They arrived in the United States in the 18th century but didn't become a major crop until the 20th century (Duke, 1981). Soybeans have since become a global commodity, with the United States, Brazil, and Argentina being the leading producers (USDA, 2021). They are utilized for various purposes, including food products, livestock feed, and industrial applications.

2.2 Botanical Description of Soybean

Soybean (Glycine max (L.) Merrill) or soya bean is a legume crop belonging to the family Leguminosae or Fabaceae and sub-family Papilionaceae. The plant grows up to 1.5 meters tall, depending on variety. Erect stems are covered with thick brown hair. Leaves are compound, with 3 leaflets. They are alternate, trifoliate with ovate leaflets and short peduncle. The inconspicuous, stalkless white to purple flowers are borne singly or in small clusters in the axils (where leaf meets stem). The fruit is a broad, hairy, flattened legume or pod, around 10 cm (3 in) long, yellow to brown when fully mature and dried. The fruits are called pods measuring up to 7 centimeters long, containing 1 to 4 seeds which are colored yellow, black or green. Soybeans occur in various sizes, and in many hull or seed coat colors, including black, brown, blue, yellow, green and mottled. The hull of the mature bean is hard, water-resistant, and protects the cotyledon and hypocotyl (or "germ") from damage. If the seed coat is cracked, the seed will not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray and yellow) and at one end of the hilum is the micropyle, or small opening in the seed coat which can allow the absorption of water for sprouting.

2.2.1 Germination

The first stage of growth is germination, a method which first becomes apparent as a seed's radicle emerges. This is the first stage of root growth and occurs within the first 48 hours under ideal growing conditions. The first photosynthetic structures, the cotyledons, develop from the hypocotyl, the first plant structure to emerge from the soil. These cotyledons both act as leaves and as a source of nutrients for the immature plant, providing the seedling nutrition for its first 7 to 10 days.

2.2.2 Maturation

The first true leaves develop as a pair of single blades. Subsequent to this first pair, mature nodes form compound leaves with three blades. Mature trifoliolate leaves, having three to four leaflets per leaf, are often between 6 and 15 cm (2+1⁄2 and 6 in) long and 2 and 7 cm (1 and 3 in) broad.

Under ideal conditions, stem growth continues, producing new nodes every four days. Before flowering, roots can grow 2 cm (3⁄4 in) per day. If rhizobia are present, root nodulation begins by the time the third node appears. Nodulation typically continues for 8 weeks before the symbiotic infection process stabilizes. The final characteristics of a soybean plant are variable, with factors such as genetics, soil quality, and climate affecting its form; however, fully mature soybean plants are generally between 50 and 125 cm (20 and 50 in) in height and have rooting depths between 75 and 150 cm (30 and 60 in).

2.2.3 Flowering

Flowering is triggered by day length, often beginning once days become shorter than 12.8 hours. This trait is highly variable however, with different varieties reacting differently to changing day length. Soybeans form inconspicuous, self-fertile flowers which are borne in the axil of the leaf and are white, pink or purple. Though they do not require pollination, they are attractive to bees, because they produce nectar that is high in sugar content. Depending on the soybean variety, node growth may cease once flowering begins. Strains that continue nodal development after flowering are termed "indeterminates" and are best suited to climates with longer growing seasons. Often soybeans drop their leaves before the seeds are fully mature. The fruit is a hairy pod that grows in clusters of three to five, each pod is 3–8 cm (1–3 in) long and usually contains two to four (rarely more) seeds 5–11 mm in diameter. Soybean seeds come in a wide variety of sizes and hull colors such as black, brown, yellow, and green. Variegated and bicolored seed coats are also common.

2.2.4 Seed resilience

The hull of the mature bean is hard, water-resistant, and protects the cotyledon and hypocotyl (or "germ") from damage. If the seed coat is cracked, the seed will not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray and yellow) and at one end of the hilum is the micropyle, or small opening in the seed coat which can allow the absorption of water for sprouting.

Some seeds such as soybeans containing very high levels of protein can undergo desiccation, yet survive and revive after water absorption. A. Carl Leopold began studying this capability at the Boyce Thompson Institute for Plant Research at Cornell University in the mid-1980s. He found soybeans and corn to have a range of soluble carbohydrates protecting the seed's cell viability. Patents were awarded to him in the early 1990s on techniques for protecting biological membranes and proteins in the dry state.

2.3 Climatic and Soil Requirement of Soybean

The production, accumulation and degradation of organic matter are greatly dependent on climate. For example, when a thawing event occurs, the flux of soil gases with atmospheric gases is significantly influenced. Temperature, soil moisture and topography are the major factors affecting the accumulation of organic matter in soils. Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature or excess moisture which results in anaerobic conditions. Conversely, excessive rain and high temperatures of tropical climates enables rapid decomposition of organic matter and leaching of plant nutrients. Forest ecosystems on these soils rely on efficient recycling of nutrients and plant matter by the living plant and microbial biomass to maintain their productivity, a process which is disturbed by human activities.[181] Excessive slope, in particular in the presence of cultivation for the sake of agriculture, may encourage the erosion of the top layer of soil which holds most of the raw organic material that would otherwise eventually become humus. Cultivars are grouped into three: Early maturing- 125-130 days; Medium maturing- 140-150 days and Late maturing - 150-160 days cultivars though, the maturity length do increase with increased latitude, increased day light and cool conditions. Soybean is considered suitable for integration into the traditional intercropping systems (na Lampang, 1981) due to its outstanding features; its short growth duration (100 + 20 days), adaptability to short spells of moisture deficiency, high yield potentials, soil improving capacity as a benchmark nitrogen fixing legume second only to stem-nodule forming legumes (Ludwig, 1989), and its highly desirable nutritional profile. The major and specific objective of this study was therefore to evaluate the growth and yield responses of some twelve IITA bred promiscuous soybean varieties in the derived savanna zone of the South-Eastern agro-ecology of Nigeria.

The best soybean yields occur on well-drained, but not sandy, soils having a pH of 6.5 or above. The critical stage for soybean yield is in August and droughty soils that typically dry out in August will have disappointing yields. Soybeans have a very broad optimal planting date with optimum dates from about May 5-25 in the warmer regions in central and western New York. Soybeans can be successfully planted in late April or early May in these regions but final stands may be more erratic so an insecticide/fungicide seed treatment is recommended for late April and early May plantings. Mid to late Group II and early Group III varieties can be planted in these regions up until about May 20 and then just Group II varieties until June 1. If a wheat crop is to be planted after soybean harvest, then a late Group I vs. a Group II variety planted in late May will mature earlier and allow for a more timely wheat planting date. In the cooler regions in central and western New York and in Northern New York, optimum planting time is during the midlle two weeks of May. Early Group II and Group I soybean varieties should be planted at this time in these regions.

Although soybean yields decline with June plantings, high yields can still be achieved by planting early Group II or Group I varieties in central and western New York and early Group I and Group 0 varieties in Northern New York until about June 15. The earlier-maturing varieties, which tend to be short in stature, yield better at a row spacing of 15 inches or less. Soybean plantings after June 20 in central/western NY and after June 10 in NNY can be risky, even with Group 0 varieties, especially if the remaining part of the growing season is cool or if frost occurs before October 1.

It is important to place the soybean seed into the ground at a precise depth and in firm contact with the soil so choice of planting equipment is especially critical. A corn planter usually does a better job of planting than a grain drill, but soybeans typically yield about 5% less in 30-inch vs. 7.5 inch row spacing in New York even with lower final stands. In addition, modern drills have much better depth control than older grain drills.

Seeding rate depends on both row spacing and seed size. We recommend seeding rates, for seed not treated with insecticide or fungicide, of about 170,000 seeds per acre for 7.5 inch row spacing (~7.5 seeds per 3 ft.), 160,000 seeds/acre for 15-inch row spacing (about 14 seeds per 3 feet), and 150,000 plants per acre for 30-inch row spacing (~26 seeds per 3 ft.). If an insecticide/fungicide seed treatment is used, seeding rates can be reduced by 10,000 to 20,000 seeds per acre. Planting depth should be about 1.25 1 to 1.5 inches, depending on soil moisture conditions, and should not exceed 2 inches. Soybeans, however, can emerge reasonably well from a 2.5 inch depth, if soil crusting is not prevalent during actual emergence from the soil. Likewise, soybeans can be planted at the 1.0 inch depth, but the seed is susceptible to drying out, if conditions are dry after planting. We recommend the use of inoculum for soybean plantings in New York, especially on fields with a limited soybean history. On fields where soybeans have been grown for more than 20 years, however, inoculum may not be necessary. Likewise, the use of an insecticide/fungicide seed treatment is not necessary but can help stand establishment, especially on early-planted soybeans. Soybeans, however, can fill in the gaps very well and perfect stands are not required for maximum soybean yields.

2.4 Importance of Soybean

Soybean is renowned for its high-quality protein content, containing all essential amino acids required by humans. It is used to produce various food products such as tofu, tempeh, soy milk, and soy-based meat substitutes. These products serve as valuable sources of plant-based protein for vegetarians and vegans. Moreover, soy protein has been linked to potential health benefits, including cholesterol reduction and cardiovascular health (Cueva-Mestanza *et al*., 2021).

Soybean meal, a by-product of soybean oil extraction, is a critical component in livestock and poultry feed formulations. It provides an excellent source of protein for animal growth and is a cost-effective alternative to animal-based protein sources (Nguyen *et al*., 2021). Soybean oil is a major feedstock for the production of biodiesel, a renewable and environmentally friendly alternative to conventional fossil fuels. Biodiesel derived from soybean oil has been studied for its potential to reduce greenhouse gas emissions and reliance on fossil fuels (Motejlek *et al*., 2021).

Soybean oil is widely used in the food industry for cooking, frying, and as an ingredient in various food products due to its neutral flavor and high smoke point. Soybean oil is utilized in the production of biodegradable plastics and environmentally friendly lubricants. This application contributes to reducing the environmental impact of synthetic materials (Kaplan *et al.,* 2020). Soy-based ink and coatings are eco-friendly alternatives used in printing and packaging industries (Adeyemo *et al*., 2020). Soybeans have the unique ability to fix atmospheric nitrogen with the help of symbiotic nitrogen-fixing bacteria in their root nodules. This enriches the soil with nitrogen, benefiting subsequent crops in crop rotation systems (Crews & Peoples, 2004).

Soybean and soy-derived products are promoted for their potential health benefits, including reducing the risk of chronic diseases such as heart disease and certain cancers. They are rich in phytochemicals like isoflavones, which have antioxidant properties (Setchell *et al*., 2021). Soybean exhibits considerable genetic diversity, which is a valuable resource for breeding programs aimed at developing improved cultivars with traits such as higher yield, pest resistance, and nutritional quality. Genomic research on soybean continues to advance, offering insights into its genetics and potential for crop improvement (Song *et al*., 2021).

2.5 Effects of Herbicide on the growth of soybean

Herbicides usage is more beneficial for controlling weeds and is getting more acceptability in the world for sustainable crop production (Hossain, 2015). In the United States, herbicide use accounted for 20% of crop yields. In the Philippines, the proportion of the farmers using herbicides is 96-98 %. Also, economic analysis of rice production in Bangladesh revealed that net income from herbicide application was 116% higher than hand weeding due to increased yield and lower cost (Rashid et al., 2012). In India, research demonstrated that herbicides treatments in maize produced 83 % more yields in comparison with. practice of plowing the field to control weeds (Tareen et al., 1991). Similarly, in Russia, herbicides use led to a 50% increase in cereal yield on the farms. The spraying of herbicides to control weeds in crop fields is an alternative to hand weeding in Africa. In Nigeria, maize yields doubled when atrazine was used. In Zimbabwe, research with herbicides resulted in maize yield increased of up to 50%. Furthermore, in Kenya the use of herbicides resulted in 33 % higher maize yields than with the farmer using hand weeding (Baishya *et al.,* 2017). Also, Hossain (2015) observed that without herbicides the world would have been lacking a good many tons of grain and also that the same varieties of wheat under the same climatic conditions yielded 600-900kg ha' simply due to weed control. He further observed that wheat could not be produced in a large acreage which was heavily infested with weeds. Within a year or two of the availability of 2,4-D, this acreage was released for wheat production, something that had not been achieved in almost 15 years of cultivation using cultural/mechanical practices. Thus, herbicides have made a significant contribution in the world's agriculture.

Das (2011), reported significant increases in the yield of soybean through the application of herbicide over the unwanted treatments. The increase due to herbicide treatments was approximately equivalent to two hand weeding. Rao (20011), observed that in tea, chemical weed management gave significantly higher yield over manual weed control methods. In cotton and rice production, the use of herbicides improved the yield by 13% in cotton and 24% in rice (over what was obtained by manual methods) was 19.3%.

Shobha, (2010) found that weed control cost in transplanted rice was far higher when hand labour was used instead of herbicides and that high amount of savings could be affected when the herbicide was used instead of hand labour. These and other numerous reports across the globe indicate that agriculture is more profitable when chemical weed management technology is adopted. Even in developing countries where the use of herbicide in weed management is not fully adopted, the person with the hoe has been replaced by the person with the chemical herbicides. The Crop yield response to herbicides weed control using herbicides increase the crop yield over manual weeding (Hussain *et al*., 2010). Different Researchers worldwide opined the beneficial effect of herbicides on crop yield resulted not only in reduced competition from weeds but also in better seedbed moisture because less cultivation was needed consequently through improving the soil nutrient status, nutrient uptake by the plants (Manda, 2011). Adoption of herbicide usage by the farmers in both the developed and developing countries gave a new direction to the farmer to realize the maximum yield potential of the crop at lower production cost which was never possible before.

Due to rapid increase in population which led to high demand of food and changes in agricultural production from primitive to modern agriculture has initiated an alternative means of weed management by the use of herbicides (Baishya, *et al.*, 2017).

Therefore, chemical weed management stands crucial in crop production. Employing efficient method of weed management (herbicides) will definitely be in good stead towards enhancement in crop's yield and farmers' income through concurrent reduction in weed competition (Siddagangamma *et al.*, 2018).

CHAPTER THREE

MATERIALS AND METHOD

3.1 Experimental Site

The field experiment was conducted during rainy season in 2023 at the teaching and research farm department of Agricultural Technology, Federal Polytechnic, Mubi to assess the effects of herbicide application rates on the growth and yield of Soybean. Mubi is located in the North Eastern part of Adamawa State between latitude 9^{o} 26 and 10^{o} 10’N and longitude 13^{o} 10’ and 13o 44’ E, on latitude of 196m above sea level. It bordered by the mountain range of the Mandara of the Republic of Cameroun to the East, Michika Local Government Area to the North, Hong Local Government Area to the South and Askira-Uba to the West. It is occupies a land mass of about 506,440 square kilometres (Nwagboso & Ugonga, 2016). The soil is largely of sandy clay loam, sandy loam or loam textured. The annual mean rainfall in Mubi is about 900mm and the minimum temperature is 18^{o}C during the harmattan period and 40^{o}C maximum as in April (Adebayo *et al.*, 2020).

3.2 Treatments and Experimental Design

The treatments comprised of four levels of herbicides application rates: 0 (control), applied once, applied twice and applied thrice laid out in a randomized complete block design (RCBD) replicated three times. The total land area used for the research work was 3m x 2m ($6m^2$). There was 1m pathway between replications and 0.5m between plots. The field layout of the experiment is shown in Figure 1.

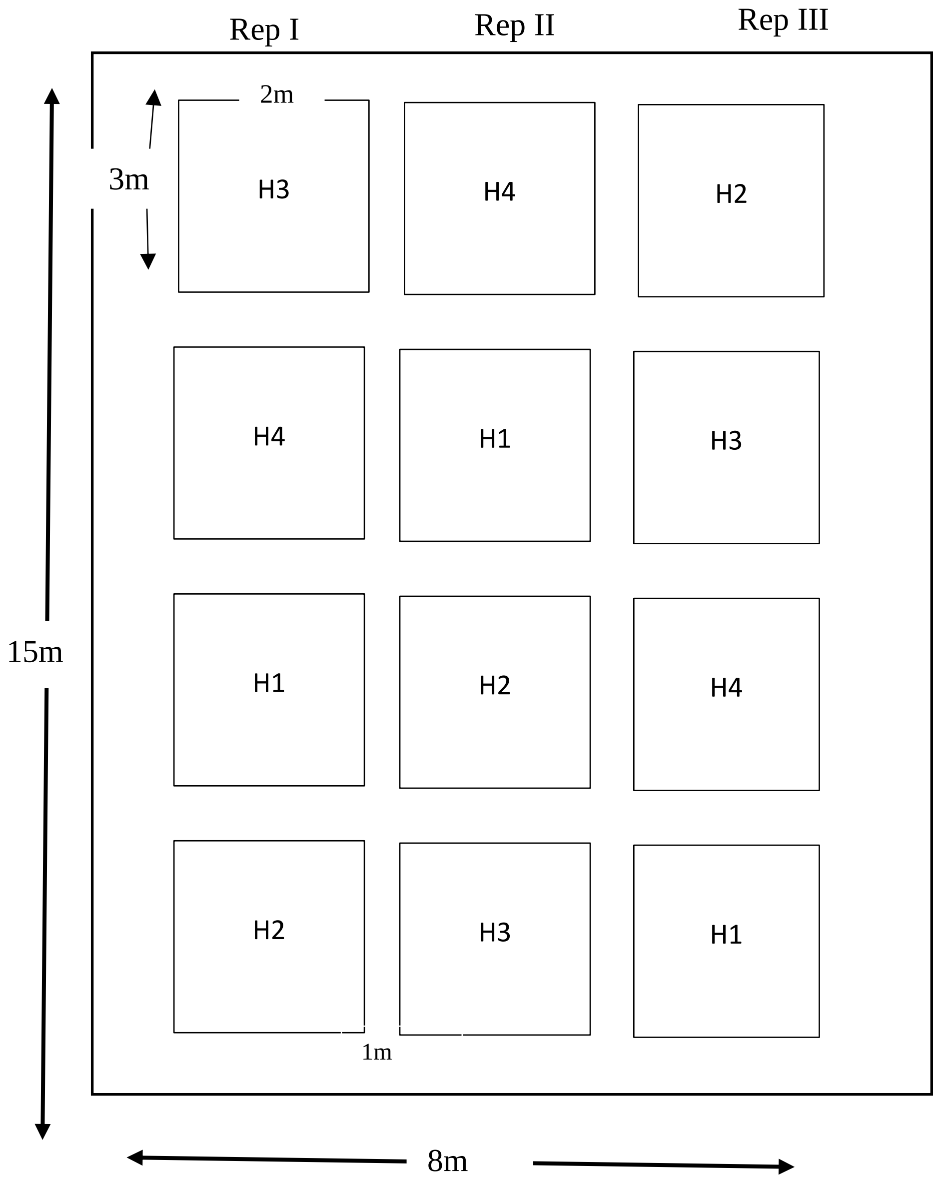

Figure 1: Field layout of the experiment

Key:
Rep = Replication
H1 = 0 (control)
H2 = Herbicide applied once
H3 = Herbicide applied twice
H4 = Herbicide applied thrice

3.3 Source of Seed

Soybeans seed for this research work were bought from the farmers in Mubi Market.

3.4 Cultural Practice

3.4.1 Land Preparation

The land was manually cleared using rake and hoe, tilt, levelled and the land was laid out into plots based on the experimental design.

3.4.2 Seed treatment and sowing

The seeds were dressed with Apron-plus 50 DS before sowing in order to protect the seeds from soil borne diseases and pests. Two seeds were sown per hole at a depth of 2 – 3m and were later thinned to one per seedling per stand at one week after seedling emergence.

3.4.3 Herbicide application

A selective herbicide legume force 10gram was diluted with 10 liter of water into a knap sack sprayer. The diluted herbicide was directly sprayed on the soybean plants using the 20 liter knap sack sprayer as per the treatments one week interval after seedling emergence.

3.5 Data collection

Data were collected from each plot and five plants from the centre of each plant were randomly selected and tagged as sampling plants for data collection.

3.5.1 Plant height (cm)

The plant height was measured from the base of the plants to the terminal bud at 2, 4, 6 and 8 weeks after sowing (WAS) using a groundnut meter rule and their mean was computed.

3.5.2 Number of Leaves per plant

The fully expanded leaves were counted at 2, 4, 6 and 8 WAS and their average taken and recorded.

3.5.3 Stem girth (mm)

The stem girth of five tagged plants in each plot were measured using a digital Vernier calliper in milometers at 2, 4, 6 and 8 WAS and their mean was calculated and recorded.

3.5.4 Number of branches per plant

The number of branches of five tagged plants from each plot was counted and their mean was computed and recorded.

3.5.5 Days to first flowering and days to 50% flowering.

The number of days when days to first flowering and days to 50% of the plant in each plot flowered were recorded.

3.5.6 Days to first podding and 50% podding

The number of days taken when first and 50% podding observed were recorded.

3.5.7 Number of pods per plant

This was determined by counting the number of pods 5 plants from each plot and their mean were recorded.

3.5.8 100 seeds weight (g)

100 seeds weight were determined by counting the seeds physically and the weight measured using an electrical weighing balance.

3.6 Data Analysis

The data collected were analysed using analysis of variance (ANOVA) and treatment means with significant differences were separated using least significant difference (LSD) at 1% and 5% level of probability.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Effect of Herbicide Application on Plant Height (cm^3)

Table 1 presents the effect of herbicide application on plant height of soybean. The result shows that there was no significant difference (P>0.05) of herbicide application on plant height at WAS and significant effect (P>0.05) of herbicide application on plant height at 4 WAS, 6WAS and 8WAS.

Application of herbicide thrice (H4) at 4WAS, 6WAS and 8WAS recorded the highest plant height (26.09cm, 30.10cm and 45.76cm respectively), and the shortest plant height was observed at control (20.10cm, 24.99cm and 39.00cm respectively). The non-significant effect of herbicide application on plant height at 2WAS could be attributed to the nature of plant that was not develop fully to respond to the treatment. The significant effect of herbicide application on plant height at 4WAS, 6WAS and 8WAS was due to the variation in the herbicide application which resulted to the differences in plant height. The result of this work is in agreement with the findings of Pacanoski (2007).

Table 1: Effect of Herbicide application on plant height (cm)

Treatment	2WAS	4WAS	6WAS	8WAS
H1 (control)	9.02	20.10	24.99	39.00
H2 (Herbicide applied once)	9.00	21.99	24.30	42.03
H3 (Herbicide applied twice)	9.31	24.10	29.06	43.90
H4 (Herbicide applied thrice)	9.22	26.09	30.10	45.76
Level of significant	NS	*	*	*
LSD	-	0.09	1.05	1.03

* = significant at 0.05, NS = Not significant using Least Significant Difference, WAS = Weeks After Sowing.

4.2 Effect of Herbicide Application on Number of Leaves of Soybean

The effect of herbicide application on number of leaves of soybean is presented on Table 2. The result revealed that there was no significant difference (P>.0.05) of herbicide application at 2WAS, while there was a significant effect (P<=0.05) of herbicide application at 4WAS, 6WAS and 8WAS. At 4WAS. 6WAS and 8WAS herbicide application thrice (H4) produced the maximum number of leaves (20.66, 30.29 and 45.60 respectively), while the control (H1) recorded the lowest number of leaves (17.40, 22.30 and 33.40 respectively). The significant effect of herbicide application on number of leaves at 4WAS, 6WAS and 8WAS could be due to the treatment effects which resulted to variation in the number of herbicide application. The result of this study is in conformity with the findings of Das (2011).

Table 2: Effect of Herbicide application on plant height (cm)

Treatment	2WAS	4WAS	6WAS	8WAS
H1 (control)	8.10	17.40	22.30	33.40
H2 (Herbicide applied once)	8.09	19.86	23.09	36.22
H3 (Herbicide applied twice)	8.90	19.90	26.88	40.34
H4 (Herbicide applied thrice)	9.00	20.66	30.29	45.60
Level of significant	NS	*	*	*
LSD	-	1.08	2.90	2.06

* = significant at 0.05, NS = Not significant using Least Significant Difference, WAS = Weeks After Sowing.

4.3 Effect of Herbicide Application on Stem Girth (mm) of Soybean.

The result of the effect of herbicide application on stem girth is shown on Table 3. The result indicated that there was no significant difference ($P \geq 0.05$) at 2WAS and 4WAS and had significant difference ($P \leq 0.05$) at 6WAS and 8WAS a mean value of 5.56mm and 6.76mm and the control gave a stem girth of 3.90mm and 3.99mm respectively.

The non-significant effect of herbicide application on stem girth at 2WAS and 4WAS could be due to the non-response of soybean to the treatments. The significant effect of herbicide application on stem girth at 6WAS and 8WAS probably due to the increase in the application of herbicide which resulted in the variation of stem girth. This result is similar to the work of Vissor *et al.* (2004).

Table 3: Effect of Herbicide Application on Stem Cirth (MM) of Soyabean

Treatment	**2WAS**	**4 WAS**	**6 WAS**	**8 WAS**
H1 (control)	2.02	3.09	3.90	3.99
H2 (Herbicide Applied once)	2.00	3.20	4.60	4.93
H3 (Herbicide Applied twice)	2.33	3.40	5.44	6.00
H4 (Herbicide Applied Thrice)	2.09	3.46	5.56	6.76
Level of Significant	N5	N5		
L S D	-	-	2.08	1.90

= Significant at 0.05, N5= Not significant using least significant Difference and WAS=weeks after sowing.

4.4 Effect of Herbicide Application on Number of Branches (NB) Days to first flowering (DFF), Days to 50% flowering (DS50%F).

This result on the effect of Herbicide Application on Number of Branches (NB), Days to first flowering (DFF), Days to 50% flowering (D50%F) is shown on Table 4. The result indicates that there were no significant differences on the number of branches (NB), Days to first flowering (DFF) and Days to 50% flowering (D50%F) with the mean values of 6.399 and 67.67. the non-significant effect of herbicide application on the NB, DFF and D50%F could be attributed to the nature of plant that was not develop fully to respond to the treatment. This result is similar to the work of Yaduraju *et al.* (1997).

Table 4: Effect of Application on number of branches (NB), Days to first flowering (DFF), Days to 50% flowering (D50%F).

Treatment	**NB**	**DFF**	**D50%F**
H1 (control)	3.04	63.04	67.02
H2 (Herbicide Applied once)	4.00	64.00	67.00
H3 (Herbicide Applied twice)	4.03	64.03	66.98
H4 (Herbicide Applied Thrice)	3.99	63.99	67.67
Level of Significant	N5	N5	N5
L S D	-	-	-

NS = Not significant using least Significant Difference and WAS = Weeks After Sowing.

4.5 Effect of Herbicide Application on days to first podding, Days to 50% podding, number of pods per plants and 100 seeds weight (g).

The result of the effect of herbicide application on days to first podding, days to 50% number of pods per plants and 100 seeds weight (g) is identified on Table 5. The result shows that there was no significant difference (P≥=0.05) at days to first podding (DFP) and days to 50% podding (D50%P) and had significant difference (P≤=0.05) at number of pods per plant (NPP) and 100 seed weight (g) (100 SWg) with a mean value of 20.30mm and 8.92mm. the non-significance of herbicide application on the days to first podding (DFP) and days to 50% podding (D50%P) could be due to the non-response of soybean to the treatments the significant effect of herbicide application for number of pods per plants (NPP) and 100 seed weight (g) (100SW) was probably due to the increase in the application of herbicide. This result is in line with the work of Hussain *et al.* (2010).

Table 5: Effect of Herbiceide application on days to first podding (DFP) days to 50% podding (D50%), number of pods p8 plant (NPP)and 100 seeds weight (1005w).

Treatment	DFP	D50%F	NPP	100SW(g)
H1 (control)	71.99	75.88	12.36	6.32
H2 (Herbicide Applied once)	70.86	76.04	14.03	6.99
H3 (Herbicide Applied twice)	71.20	75.92	19.25	8.00
H4 (Herbicide Applied Thrice)	72.04	75.53	20.30	8.92
Level of Significant	NS	NS	*	*
L S D	-	-	2.06	1.99

* = Significant at 0.05 level of probability, NS = Not significant using least Significant Difference and WAS = Weeks After Sowing.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The filed experiment was conducted at the Students' Research Farm, Department of Agricultural Technology, Federal Polytechnic, Mubi (latitude 9^o 26 and 10^o 10'N and longitude 13^o 10' and 13o 44' E, on latitude of 196m above sea level) in 2023 rainy season to assess the effects of herbicide application rates on the growth ad yield of soybean. The treatments consisted of four application rates of herbicide H1 (control), i.e. no herbicide application H2 (herbicide applied once), H3 (Herbicide applied twice) and H4 (Herbicide applied thrice) using a Randomised Complete Block Design (RCBD) replicated three times. The data collected were on plant height (cm), number of leaves, stem to first and 50% flowering, days to first and 50% podding, number of pods and 100 seed weight (g). The collected were subjected to analysis of variance (ANOVA) and means with significant differences were separated using least significant differences (LSD) at 0.05 level of probability. The results of this study indicated that herbicides application had a significant effect on plant height and number of leaves at 4WAS, 6WAS and 8WAS stem girth at 6WAS and 8WAS number of pods and 100 seed weight.

5.2 Conclusion

From the result of this research work, it proved that the more the application of herbicide, the higher the plant height, number of leaves, stem girth, number of branches, number of pods and 100 seeds weight. With these findings it could be concluded that herbicide application thrice proved to be most yielding than other applications.

5.3 Recommendations

Based on the findings of this research work, it is recommended that farmers in the study area should adopt herbicide application thrice for the improvement of growth and yield of soybean. However, further research needs to be conducted to ascertain this finding.

REFERENCES

Acqusah, G. (2002). Horticulture. Principles and practices. 2 Edition. Pp240-241.

Adebayo, A. A., Tukur, A. L. and Zemba, A. A. (2020). Adamawa State in Maps. (2nd Edn). Praclete publishers, Yola, Nigeria. Pp.: 31-35.

Baishya, I.K., Walling L, and Rajkhowa DJ. (2017). Chemical method of weed-control: an option for weed management. Chandrasekaran, B., Annadurai, K., and Somasundaram, E. (2010). A Textbook of Agronomy. Edition PP 300-311, 318-321.

Das. T.K. (2011). Weed Science. Basic and Applications. 2 Edition. PP 152, 158-174.

Hakansson, (2003). Weeds and weed management on arable land. An ecological approach. Pp200-203.

Holm, F and Johnson, E. (2010). A brief history of herbicide use in Western Canada. 17 Weed Sci. Conference.26-30 September, 2010. Christchurch, New Zealand.

Hossain, M.M. (2015). Recent perspective in herbicide: Review of demand and adoption in Agriculture. J. Bangladesh Agril. Univ. 13(11): 19-30,

Hussain, M., Ali, A., Tahir., Waseem, M., Nadeem, M.A. and Butt, A. (2010). Comparative efficacy of new herbicides for weed control in maize (Zea mays L.). Int. J. Trop. Agric.28 (2):17-23.

Labrada, J.C, Caseley and Parker, C (1994). Weed management for developing countries. Pp 90-92

Manda, P (2011). Results on the impact of spray service uptake on small-scale farmer livelihood in Zambia. CARE, Zambia.

Martin, J.H., Waldren, R.P. and Stamp, D.L (2006). Principle of field crop production.4"h Edition. PP 274-277.

Nwagboso, N. J. & Uyanga, J. (2016). Population in Adebayo, A. A. and Tukur, A. L. (Edn). Adamawa State in Maps, Yola, Praclete Publishers, pp. 23-34.

Pacanoski, Z (2007). Herbicide: Benefits for society as whole- a review. Pak. J. Weed Sci. Res.13 (1-2):134-148.

Rao, V.S (2011). Principles of Weed Science 2nd Edition PP 1-2

Rashid, 11.M., Alam, M.M. and Ladla, JK (2012) Comparative efficacy of pretilachlor and hand weeding in managing weed and improving the productivity and net income of wet-seeded rice in Bangladesh Field crops Res 125.16.26.

Reddy, S.R. (2011). Principles of Agronomy. Pp 574-575.

Reddy, SR (2016) Principles of Agroney, Firm Revised Edition PP 584-58 595-596 India

Shobha, S., and Varshney, J. G (2010) Herbicides Pp 97 98 Singh, S.S. Gupta, P and Gupta, A.K. (2009), Hand Book of Agricultural Science Second Revised and Enlarged Edition. PP 203-206.

Siddaganganna, R.R., and Channabasavanna. AS (2018). A review on weed management in Bt-cotton. International journal of current microbiology and applied sciences. Pp 908-911.

Streibig, J (2003). Assessment of Herbicides effects. Pp 102-104.

Tareen, M.A.K., Chatha,M.Q. Malik, H.N. and Javed, HI(1991). Effect of primextra herbicides on the productivity of maize grown under medium rain fed conditions. Pak J.Agric.Res., 12 (4):257-263.

Vissoh, P.V., Gbehounou, G., Ahanchede, A., Kuyper, T.W., and Rolling, N.G. (2004). Weeds As an agricultural constraint to farmers in Benin: Results of diagnostic study. Nigerian Journal of Applied Science (NJAS) 52-314 PP 305-329.

Yaduraju, N.T and Ahuja, K.N. (1997). Grass weed competition in wheat in relation to its time of planting and weed emergence. Indian Journal of weed Science. 29 (3&4).167-169.

Yahaya, A.T., Baba, K.M., Kyiogwom, U.B., Singh, A. (2008). Effects of weed on profitability of millet (Pennisetum glaucum) and groundnut (Arachishypogaea) crops in mixed cropping systems. Nigerian Journal of Basic and Applied Science (NJBAS). Vol. 16 no 2 PP 213-220.

Zhang, C.X. Liu, Y., Cuil, H. L., Wei, S. H. and Huang, H.J. (2007) Herbicide usage and sassociated problems in China. XVI Int. plant protection cong, " Glasgow, UK.

Zhang, Z. P (2003). Development of chemical weed control and integrated weed management in China. Weed Biol. Manag. 3:197-203.

APPENDIX