PERFORMANCE OF SOYBEAN [*Glycine max* (L.) Merr.] VARIETIES AS INFLUENCED BY SOWING METHODS AND WEED CONTROL TREATMENTS IN THE NIGERIAN SAVANNA

BY

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DEPARTEMENT OF AGRONOMY,
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ZARIA

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A DISSERTATION SUBMITTED TO THE POST GRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN AGRONOMY

DEPARTEMENT OF AGROMOMY,
FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERITY,
ZARIA

JANUARY, 2018

DECLARATION

I hereby declared that this dissertation titled "Performance of Soybean (*glycine max* (l.) merr.) Variety as influenced by Sowing Methods and Weed Control Treatments in the Nigerian savannah" was written by me and it is a record of my own research work through the help of Allah and the guidance of my supervisors Professor N.C. Kuchinda and Dr.H.A Hamid . It has not being presented before in any previous application for a Master of Science degree in Agronomy. All references made to published literature have been duly acknowledged

……………………… ……………………..
Adebisi Isiaka Alimi Date
(Student)

The above declaration is confirmed by my supervisory team

………………………… ……………
Prof. N.C Kuchinda Dr. H.A Hamid
Chairman Supervisory Committee Member Supervisory
Committee

CERTIFICATION

This dissertation, titled "Performance of Soybean (*glycine max* (l.) merr.) Varieties as influenced by Sowing Methods and Weed Control Treatments in the Nigerian savannah" by Adebisi Isiaka Alimi meets the regulation governing the degree of Master of Science in Agronomy of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to ALLAH S.W.T the custodian of knowledge, Who has given me the opportunity to be alive to start this programme and complete it by His grace. And to my late sister, Mrs. Fadilat Mukila Adebisi, May her soul rest in perfect peace (Amen)

ACKNOWLEDGEMENT

All praises are due to Allah S.W.T who made it possible for me to start this programme at His own appointed time, today, the completion of the programme is to His Glory.

Special thanks to my team of supervisory committee lead by Professor N.C Kuchinda for all your assistance, guidance, suggestions, criticisms and recommendation throughout the course of this work. Your fatherly advice has contributed immensely to the successful completion of this research work.

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Finally, I am grateful to Allah the Almighty for sparing my life and seeing me through this period of my life. May Allah reward this effort and bless me with it (Amen)

ABSTRACT

A field trial was conducted during the wet season of 2016 at two locations, one at Samaru (11^o11'N, 7^o 38'E 686 meters above sea level) in the Northern Guinea savannah and the other at Bagauda (11'37N, $8^{\,o}$ 23'E, 500 meter above sea level) in the Sudan savannah of Nigeria, to study the performance of two soybean varieties as influenced by sowing method and weed control treatments. The experiment consisted of two varieties of soybean, (TGX 1448-2E and TGX 1987-10F), two sowing methods (Dibbling and drilling) and four weed control treatments.(Pendimethalin at 2.0 kg a.i. kg/ha applied as pre-emergence, fusillade 2.0 kg a.i. /ha applied as post emergence, hoe weeding at 3, 6 and 9 WAS and weedy check). The treatments were laid out in a split plot design with factorial combinations of weed control treatments and sowing method assigned to the main plot, while variety was assigned to the sub-plot. The results showed that variety TGX 1448-2E recorded lower weed dry weight and produced taller and more vigorous crops that had wider canopy and higher grain yield at both locations than TGX 1987-10F. Drilling method of sowing recorded lower weed dry weight, weed cover score, and produced more vigorous crop plants with wider canopy cover, higher total dry weight than the dibbling method of sowing. The weedy check plots recorded significantly higher weed dry weight, weed cover score and weed density than all the other weed control treatments. The treatments with fluazifop-butyl (fusillade) at 2.0 kg a.i.kg/ha resulted in significantly taller plants with wider canopy cover and more vigorous crops than Pendimethalin at the same rate. On the other hand, hoe weeding at 3, 6, and 9 WAS recorded higher seed yields than other weed control treatments. There was a positive and significant correlation among all the growth parameter and yield in both locations. While the correlation among weed parameters and yields are significant and negative. Shoot dry weight and haulm yield made the highest individual positive contribution of 38.7% and 20.4% to yield in both locations. Economic analysis of soybean production at both locations showed that variety TGX 1448-2E; drilling method of sowing and the application of fluazifop-butyl (fusillade) at 2.0 kg a.i.kg/ha gave the highest gross margin of ₦152098.00/ha and ₦124013.00/ha as well as gross margin per naira invested at Samaru and Bagauda respectively. Base on the results obtained from this study, it can be concluded that hoe weeding at 3, 6 and 9 WAS, fluazifop-butyl applied as post emergence at 2.0 kg a.i./ha and drilling method of sowing resulted in effective weed control and recorded the highest grain yield in both location. Variety TGX 1448-2E performed better than variety TGX 1987-10F during the trial.

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CHAPTER ONE

1.0 INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a member of the Leguminosae family and subfamily Papilinoideae. Soybean is an annual herbaceous legume that originated from North-eastern China and has been cultivated for the past three millennia (Simmond *et al.,* 1999). The crop is now cultivated throughout the world with the largest production in the United State of America, Brazil, China and Argentina (Javaheri and Baudoin, 2001).

Soybean which is popularly known as golden bean has become a miracle crop of the 21^{st} century because it is widely cultivated throughout the world. The world production figure for soybean as at 2013 was about 283 million tonne, while Nigeria production was 58 tonnes.

Soybean is an excellent health food crop, containing 40-44% protein, which is more than in other food crops and common vegetable sources in Nigeria (Thakare *et al., 2006*). The protein yield of soybean on dry matter basis is about twice that of meat and most beans and nuts and four times that of milk (Dalley *et al*., 2004). Soybean seed contains about 20% oils on dry matter basis and it is 85% unsaturated and cholesterol-free. It also contains 20% carbohydrate and 0.69% phosphorous (Oyekan, 1987). The seed is used in making soymilk (Kanase *et al*., 2006). The crop has been described as the world cheap source of edible vegetable oil and protein in livestock feeds (Dalley *et al.,* 2004). It is a primary source vegetable oil in local and international markets. It has the capability to fix 45-60 kg N /ha atmospheric nitrogen in the root nodules and adds about 0.5-1.5 t/ha organic matter through leaf fall (Khan and Asif, 2005). Soybean cultivation has expanded as a result of its nutritional and economic importance and diverse domestic uses.

The crop can be successfully grown in many states in Nigeria using low agricultural inputs (Dugje *et al.,* 2009). Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and the diverse domestic uses (Omoigui *et al.,* 2009). The crop is an excellent source of vegetable oil in the international market.

Soybean is an annual grain legume crop that provides about one –quarter of the world dietary protein. According to Ezedinma (1994) soybean and other leguminous crops are essential sources of plant protein for about 700 million people. About 35-40% of the total dry matter content of the whole soybean is protein. It compares favourably with animal protein sources and contains the most essential amino acids required by man. It has digestible nutrients of about 92%, which makes it a good source of energy (Mijindadi, 1987).

Soybean contributes to the improvement of soil fertility by fixing 60-70 kg-N-ha atmospheric nitrogen in the soil for the subsequent crop (Khan and Asif, 2005). The crop has an average protein content of 40% and is more protein –rich than any of the common vegetable crops or animal feed sources found in Nigeria (Dugje *et al.*, 2009). The crop can be used as soy-milk and vegetable oil. Soybean seed contains about 20% oil on a dry matter basis, which is 85% unsaturated and cholesterol- free (Kanase *et al.*, 2006)

1.1 Production Constrains of Soybean

Soybean was introduced into Nigeria in the early 20th century, the production of the crop is still localised to the Sudan and Guinean savannah agrological zones of Nigeria. The cultivation of soybean has not attained the level it should be in Nigeria, in view of it economics importance as a pulse crop. The low production was due to the following constraints that has hindered the cultivation of the crop among peasant farmers.

Inadequate awareness about the potential benefit of the crop; and low or poor seed viability that usually lead to seed dormancy. There is also availability of other pulse crop such as cowpea that is close substitute to soybean. The shattering and late maturity of some of the varieties of soybean is another constraint of note. The difficulty in cooking soybean like other pulse crop is also contributing to the low production of the crop. Another important constraint of soybean production is the disposal of the produced by the farmers at market level. This partly because soybean seeds are not like cowpea seeds, that can be bought and consumed directly. Some form of processing is required before soybean can be consumed. Also, processing is needed to incorporate soybean seeds into animal feed. Therefore, increased soybean cultivation will be depending on availability of processing plant to easy the utilization of the crop.

However, technological advancement and varietal improvement through genetic modification by crop breeder and improved extension activities is yielding fruit in raising the awareness about soybean production (Mijindadi, 1987).

1.2 Weed Infestation and Control in Soybean

Reduction in soybean yield due to weed infestation varies from 27-77% (Fletcher *et al*., 1992). Depending on the type of weeds and weed infestation intensity, soil type and rainfall pattern. It was reported that yield declined by as much as 84% as a result of weed infestation (Mijindadi, 1987). Weed infestation was reported to have removed 21.4 kg N and 3.4 kg P per hectare in soybean (Hailu *et al.*, 2010).

It was reported that two hand hoeing was very effective in suppressing weeds and increasing soybean seed yield (Ahmed *et al*., 2001). The conventional methods of weeding such as hoeing and hand pulling are expensive, laborious and the labour is not available during peak period of weeding (Khan and Asif, 2005). Presently, there is a great labour shortage and a rise in wages scale. Therefore, the use of herbicides in legumes to control weeds appears to be very useful (Dadari, 2003). The use of post emergence herbicides is not yet a popular practice among farmers in the Sudan Savanna of Nigeria. This may be due to lack of information on the benefits of using herbicides to control weeds, and the problem of availability and affordability (Mijindadi, 1987). Chemical weed control method may be necessary in reducing production cost and increasing soybean productivity. There is need to evaluate some of the available pre and post emergence herbicides in the study area, taking into consideration their effect on soybean plants, their efficiency in weed control and their profitability in relation to the farmers practice of manual weeding.

1.3 Justification

For so many years, the crop has been widely grown in the world. However, optimum yield has not been efficiently harnessed in Nigeria. This is due partly to non-adoption of improve varieties and lack of efficient weed control strategy (Dugel *et al*., 2009). Despite the satisfactory manual hoe weeding to control weeds, the method is associated with series of problem ranging from drudgery, cost implication, time wasting and unavailability of labour at the peak period of demand. Many questions remain unanswered on how weeds in soybean can be effectively controlled using the alternative herbicides so as to achieve the yield potential of the crop with reduced cost of production. Also, the use of recommended varieties for a given ecology to achieve weeds suppression and improve soybean performance remains unexplored.

There is also little information on the correct sowing method that will help to suppressed weeds and maximize crop productivity. Inadequate research in the above areas has been reported in the Northern Guinea savannah of Nigeria (Dugje *et al*., 2009). The knowledge of suitable varieties with efficient weed suppressing ability, as well as sowing method that can offer quick canopy development, smothering of understory weeds and enhancing seed yield must be explored. Integrating the two factors may go a long way in achieving effective and efficient weed control, which would in turn boost crop growth and yield.

1.4 Objectives of the Study

It is in view of the above limitations that this research work was conceived and proposed to achieve the following objectives:

(a) To evaluate the growth and yield performance of two varieties of soybeans and their weed suppression ability.

(b) to evaluate the effect of pre and post emergence herbicides on weeds growth and yield of two soybean varieties

(c) To determine the most appropriate sowing method for effective weed suppression and productivity of two soybean varieties.

(d) To determine economic profitability of soybean production in the Northern Guinea Savannah

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Performance of Soybean Varieties

Modern agriculture is concerned with yield and nutritional quality of crops, but environmental factors do not favour the manifestation of their potentials (Dugje *et al*., 2009). Crop varieties differ in terms of their genetic constitution, maturity period, morphology, yield potential and photo-period, among others. A large number of soybean cultivars are distinguished on the basis of maturity period, plant height, seed colour and size as well as oil and protein contents of the seeds (Dugje *et al*., 2009). Early maturing types take between 85-95 days to mature, and have plant heights of 30-70cm; they usually have homogeneous ripening, and their production is more reliable than the medium and the late maturing varieties (Ahmed and Kanded, 1993). Studies have shown that Soybean varieties exhibit variation in growth and development by various factors (Johson and Beaver, 1980). They studied the performance of determinate and indeterminate varieties of soybean and reported that both yielded equally. They also observed that average yield of both soybean varieties increased significantly as row width was reduced. Beuerlin (1988), on the other hand found that the yield of determinate variety increased with increased sowing rate, regardless of the sowing date or row spacing, while the indeterminate variety did not respond to sowing rate.

Parvez *et al*. (1989) reported that the number of nodes, pods number; leaf area index, total biomass and seed yield were significantly increased with increase in plant density, but no yield differences were observed between the determinate and the indeterminate cultivars.

2.2 Effect of Weeds on Soybean Performance

Weeds are a serious problem in soybean production, especially during the early growth stages (Dugje *et al*., 2009). They reported that a properly timed weed management program can minimize the effect of weeds on crop performance. In the Northern Guinea savannah of Nigeria, grain yield losses in soybean due to weeds have been observed to range from 30-75%, (Shebayan and Lagoke, 1986; Lagoke *et al*., 1991). Shebayan (1998) reported that initial weed infestation in soybean at three weeks after sowing (3WAS) did not significantly affect crop growth parameters and grain yield of soybean provided that weeds were subsequently removed. He also observed that at 6WAS, weeds significantly depressed crop vigour score, plant height, number of seed per pod, 1000 seed weight and grain yield. Singh *et al*. (1996) reported that the knowledge of the critical period of weed competition in soybean can help growers to implement effective and timely weed control strategy. Chhokar *et al.* (1995) reported that the critical period of weed control was found to be from 27 to 40 days after sowing (4-6 WAS) and controlling weeds during this period resulted in 95.7% increase in grain yield of soybean over the weedy check.

2.3 Weed Control in Soybean

2.3.1 Conventional weed control in soybean

Soybean undergoes heavy weed competition, especially during the early growth stages. (Lagoke *et al*. 2001) reported that hoe weeding should be carried out two times, first at 2 weeks after sowing and the second at 5-6 after sowing, and that weeding should not be done immediately after rain fall, to avoid weeds being transplanted. Joy *et al*. (2006) reported that hoe weeding at 20 and 40 days after sowing (DAS) was found to be the best in reducing weed biomass over the other weed control systems evaluated.

Most weed in soybean can be effectively controlled with existing conventional herbicides in well- planned management system (Wilcut *et al.* 1996). Although there are many weed control options for soybean farmers, the main challenge of conventional herbicides program is the potential crop injuries which include stunted growth, yellowing of leaves, reddening of leaf veins and burning of leaves. While these symptoms do not always reduced yield, they sometimes delay canopy closure and increase weed competition with the crop (Padgett e*t al*. 1996).

2.3.2 Chemical weed control in soybean

This involves the use of herbicides to control undesirable plants. Herbicides could be selective or non-selective, contact or systemic, pre-emergence, post-emergence or pre sowing incorporated (Ado, 2007). Although chemical weed control in soybean is less developed in tropical Africa and Latin America than in S.E Asia, it however offers the most practical way of controlling weeds in the crop (Ado, 2007). It has been shown that appropriate herbicides used at the recommended rates offered good weed suppression and increased crop yield (Adekpe and Adigun, 2000). Abd-El Razik, 2006) reported that crop weed competition is minimized by pre-emergence herbicide, it also resulted to decrease in weed dry matter and increase in soybean yield. The factors that have made chemical weed control more popular than manual and mechanical weeding methods are that there is less drudgery in the chemical than cultural methods. Weed plants can be selectively controlled without injury on the crop plants. Pre-emergence application of herbicides protects crops from the adverse effects of early weed competition. The labour requirement in chemical weed control is lower than in mechanical and manual control methods, and there is little or no soil disturbance, which reduces the risk of soil erosion that is associated with the latter (Akobundu, 1987). In addition, it is simply a faster weed control method than the cultural measures, and is more effective against perennial weeds than the other methods if appropriate herbicides are used (Shebayan 1998). However, chemical weed control is not a panacea for all weed problems in agriculture. There are many weed problems and cropping systems where a combination of two or more methods of weed control is more economical and better than either chemical or cultural weed control alone (Akobundu, 1987). The indiscriminate use of herbicides and the total dependence on them have led to some of the adverse effect of herbicides use, such as development of resistance to some herbicides by certain weeds. There is potential for crop injury resulting from poor sprayer calibration, wrong dosage calculation, faulty spraying equipment or failure to follow label indication. Special skills are required to use herbicides successfully. Pre-emergence herbicides may fail to work because of the occurrence of sudden dry spell that follows the application of the herbicides (Peer, 2013). And chemical weed control requires special equipment that may not be readily available to farmers.

The chemical methods if used properly are safe and effective in controlling weeds in soybeans. The choice of herbicide depends on the predominant weed species and availability of herbicides. Herbicides such as Pendimethalin and fluazifop-butyl (fusillade) are used as pre and post emergence treatments to control weeds in soybean (Peer, 2013).

2.3.3 Effect of pendimethalin on weed, growth and yield of soybean

Pendimethalin [N-(1-ethlpropyl)-3, 4-dimetyl-2-6 dinitrobenzone-amine] is a selective and systemic herbicide belonging to the chemical family, chloroacetamide. The trade name is Machete, Butanex, (Wikipedia, 2012). The herbicide is absorbed primarily by germinating shoots and secondarily by the roots, and translocated throughout the plant, giving higher concentration in the vegetative than the reproductive part (Wikipedia, 2012). Pendimethalin is a pre-emergence herbicide for the control of annual grasses and certain broad leaved weeds. It inhibits cell division by blocking protein synthesis. The effective rate ranges from

1.0-4.5 kg a.i/ha. The activity of Pendimethalin depends on moisture availability through rainfall and irrigation.

Pendimethalin at a rate of 1 to 2 kg a.i/ha has been reported to significantly reduced the density and dry weight of *Phaiaris minor* and other weeds in wheat and soybean (Omoigui *et al*., 2009). pendimenthalin at a rate of 1.5kg a.i/ha, was reported to have produced a weedy mortality of 65-68% for *P.minor,* 92-94% for *Chenopodium album* and 80-87% for other weed species. Peer, (2013) has also reported an effective control of *P. minor* in wheat with the pre-emergence application of Pendimethalin at a rate of 1.5kg a.i/ha. The result of the trial carried out by Kenzevic *et al*. (2003) has shown a significant reduction in weed population and improved crop yield with pre emergence application of pendimethalin at 0.5 - 0.74kg a.i /ha. Pendimethalin at the rates of 1.0 to 1.5kg a.i /ha has been reported to cause significant increase in the yield of soybean with a corresponding reduction in weed dry weight (Kenzeviv *et al.*, 2003).

2.3.4 Effect of fluazifop-butyl (fusilade) on weeds and growth and yield of soybean.

Fluazitop-butyl (R-2-[4-[5-(trifluoromethyl)-2-pyridinyl]oxy] phenoxy]-propionate) belongs to the family of Aryloxyphenoxy-propionate. It inhibits root and shoot growth. Its mode of action is prevention of plant cell division and elongation in susceptible species (Wikipedia, 2012). The herbicide is marketed as fusillade and is recommended for weed control in soybean, potatoes, cabbage, pea, carrot, wheat. Fluazifop-butyl is formulated as emulsifiable concentrate for post-emergence weed control. The active ingredient is 150g Fluazifop-p-butyi per litre. It is systemic in action and controls annual and perennial weeds in broad leaved crops. It is absorbed mainly through the leaves, and is recommended for use after weed emergence (Wikipedia, 2012).

Fluazifop-p-butyl is a post-emergence 1.5 kg a.i. /ha, absorbed rapidly through leaf surfaces and quickly hydrolyzes to fluazifop acid. The acid is transported primarily in the phloem and accumulates in the meristems where it disrupts the synthesis of lipids in susceptible species. Fluazifop-p-butyl inhibits acetyl Co-enzymes carboxylase, an enzyme that catalyzes an early step in fatty acid synthesis. Lipids are important components of cell membranes, and when they cannot be produced in sufficient quantities, cell membrane integrity fails, especially in regions of active growth such as meristems. Drewit (2000), Nathanael *et al* reported an effective weed control of broad leaves weed with the application of Fluasifop-p-butyl in soybean and cowpea.

2.4 Effect of Sowing Method on Weeds and the Performance of Soybean

Soybean can be planted by drilling, dibbling or broadcast (Dugje *et al*, 2009). According to Kay (1979), the method used in sowing soybean depends on seriousness of the weeds problem and the method of control, either by manual or the uses of herbicides Ado, (2007). Other important factors that determine the method of sowing is the variety, moisture condition of the soil, the general productive capacity of the soil and the uses of the crop. If soybean is being grown for seed, it is planted by dibbling in rows. Soybeans are usually planted by dibbling the seed in rows (Sweeney, 2015). Dugje *et al*,(2009) reported that sowing soybean 3-4 seeds per hole at a spacing of 75cm between rows and 10cm between stand gave a better seed yields. He further reported that sowing soybean by dibbling in rows has the advantages of better weed suppression, higher yields and better seed quality, uniformity of stands and reduction in lodging. Soybean can also be planted in rows by drilling with a corn planter equipped with soybean plates (Sweeney, 2015). (Nathanael e*t al*., 2013) reported that soybean planted by drilling on a solid stand produce finer and more palatable hay than the dibbling sowing method.

(Madanzi ,2010) reported that there was no significant advantage using dibbling method of sowing, but the highest stand counts were obtained when the seed was planted in furrow opened by an ox-drawn plough. Opening furrows with hand hoe after harrowing and without harrowing also achieved high stand counts. He further reported that highest yield was achieved where furrows were opened by the plough and close with feet.

2.4.1 Effect of sowing by dibbling on growth and yield of soybean

Dibbling method of sowing soybean is the placing of seeds at cross marks made in the field with the help of marker. This sowing is done manually by hand dibbler. The method is suitable in crop like soybean, ground nut, castor and cotton etc. (Madanzi,2010) reported that sowing by dibbling ensure spacing between rows and stands is maintained, seeds can be dibbled at desired depth in the moisture zone, optimum plant population can be maintained, and the quantity of seed required is usually less than other methods. In addition an intercrop can be planted in the wider spaced crops. It is laborious and time consuming, requires more labour, thus it increases the cost of cultivation, and only high valued and bold seeds are sown by this method, under strict supervision (Madanzi, 2010).

2.4.2 Effect of sowing by drilling on the growth and yield of soybean

Drilling or line sowing is the dropping of seeds into the soil with the help of implement such as seed drill and then the seeds are covered to have contact with the soil. Crops like soybean and wheat can be sown by this method seeds are placed properly and in uniform depth along the rows, inter culturing can be practised uniform row to row spacing is maintained, seed requirement is less than in the broadcast method. (Madanzi, 2010). Sweeney (2015) reported that plant to plant intra row spacing is not maintained when using drilling, skilled person is required and there is need for implement for this sowing method.

2.5 Economic profitability of soybean production

Soybean is considered world- wide as an important leguminous crop for food and industrial used. The protein calories malnutrition which is common in many developing countries due to shortage of animal protein that is usually expensive when it is available for common man to purchase is what the utilization of soybean has help to solve. Soybean is rank very high among the leguminous crops that help to supply cheap plant protein which is as high as 40%. This has made the crop to gain special place in the nutritional programme of any countries of the world.

Dairy cattle also have a high demand for protein rich feed, which is met through supplementing forage with soybean meal. The haulm yield of soybean is usually helps in this regard. Commercial product like paints, soy protein, soybean glue for plywood, plastics, paper, fire fighting compound, fertilizer etc. can also be produced from soybean. All these are the economic profitability of soybean cultivation (Anos 1995).

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Experimental Sites

The experiment was conducted simultaneously during the wet season of 2016 at the Research farm of the Institute for Agricultural Research, Samaru ($11^0 11'$N,7^0 38′E; 686 m above sea level) in the Northern Guinea savannah and at the Irrigation Sub- station of the Research farm of the Horticultural Crops Research Institute of Nigeria, Bagauda, ($11^0$39` 08 02`E, 500m above the sea level) in the Sudan savannah zone of Nigeria.

3.2 Meteorological Data

During the experimental period, record of rainfall, temperature, sunshine hour and relative humidity at each location were collected from the Institute for Agriculture Research Meteorological Unit, Samaru and Horticultural Research Institute, Bagauda,

3.3 Soil Sampling and Analysis

Before land preparation in each site, soil samples were randomly taken at five points at the depth of 0-30cm using soil auger, and the samples were taken to the analytical laboratory in Agronomy Department, Ahmadu Bello University, Zaria for determination of soil Texture, pH, organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable bases such as potassium, magnesium,calcium and sodium, and cations exchangeable capacity (CEC), using standard procedures as described by Black (1965).

3.4 Treatments and Experimental Design

The treatments consisted of two varieties of soybean, TGX 1448-2E and TGX 1987-10F, and two sowing methods (Dibbling and drilling) four weed control treatments (Pendimethalin applied pre-emergence at 2 kg a.i./ha, fluazifop-butyl applied post-emergence at 2 kg a.i./ha at three weeks after sowing (WAS), hoe weeding at 3 and 6 WAS and a weedy check. The treatments were laid out in a split – plot design replicated three times. Factorial combinations of weed control treatments and sowing method were assigned to the main plots, and varieties to the sub plots.

3.5 Plot Size

The main plot size was 18m^2 (4.5m x 4m) consisting of 6 ridges, each 4m long and 0.75m apart and the sub plot size was 12m^2 consisting of the 4 inner ridges (3.0m x 4m).=12m^2. The spacing between the replicate was 1.5m while the spacing between the plots was 1.0m.

3.6. Varietal Description

3.6.1 Variety TGX 1448-2E is one of the recommended soybean varieties that were used in this experiment. It was released by IITA, Ibadan. It is a medium maturing variety and it is high yielding, and low shattering and high in oil content (Adigun, 1991). The morphological characteristics include erect growth, sturdy stem, with green based colouration. It has high oil content and good grain colour with potential yield of 1.5-2.0 tonnes per hectare. It is well adapted to the Southern and the Northern Guinea savannah. It also has good *Striga* control ability and is resistance to rust and *Cercospora* leaf spot. It required 90-100 days from sowing to maturity.

3.6.2 Variety TGX1987-10F is a new variety released in year 2010 by IITA Ibadan. The outstanding characteristics of this variety include early maturing, and high promiscuous nodulation, good resistance to rust, *Cercospora* leaf spot and bacterial pustule. Morphologically, it has erect, sturdy stem, with green-base coloration. It takes 75 to 90 days to mature. It is a low shattering, with high oil content and potential yield of 1.5-2.0 tonnes per hectare (Hailu *et al.*, 2010).

3.7 Cultural Practices

3.7.1 Land preparation

The experimental sites were ploughed and harrowed after one week to obtain a fine tilth. Six ridging was made at 75cm spacing and the field was marked into main and sub plots and replications. The space between the main and sub plots was 1m while the space between replications was 1.5m.

3.7.2 Sowing

Sowing was done according to treatment: Dibbling was done at10cm intra-row spacing on ridges, 75cm apart. Four seeds were sown per hole at the rate of 50kg/ha. The seedlings were thinned to 2 plants per stand at 2 WAS to give a population of 266, 66 plants/ha. Drilling was done by splitting crest of the ridge open and placing seed in drills at a spacing of 5cm apart at seed rate of 50kg/ha.

Sowing was done on 18th of June 2016. The seed were treated with Apron Star, using 1 sachet to dress 4kg of seed before sowing.

3.7.3 Weed control

The plots were treated according to treatment: Pendimethalin was applied pre- emergence using a CP15 Knapsack sprayer, fitted with a green deflector nozzle and set at pressure of 2.1kg cm^2 to deliver 250 litre spray liquid/ha. Similarly, fluazifop-butyl was applied post-emergence at 3 WAS, using the same applicator. The hoe weeded plots was achieved by hoe weeding at 3, 6 and 9 WAS.

3.7.4 Fertilizer application

Phosphorous fertilizer in the form of single super phosphate (18% P_2O_5) was applied at the rate of 13kg elemental P/ha at sowing in conjunction with 19.95 kg/ha elemental N, P and K of NPK 15:15:15.

3.7.5 Pests and disease control

Farm sanitation and the use of clean seed were adopted to avoid infections. Insect pests were controlled with Cypermenthrin+Dimethoate 10 EC, a broad spectrum insecticide at the rate of 1l/ha.Using knapsack sprayers at 2 and 4 WAS.

3.7.6 Harvesting

The crop was harvested at physiological maturity; that is when the leaves have turned brownish or yellowish in colour and the pods turn brown and have dried. Harvesting was done by cutting the plants at the ground level with sickles. The plants were stacked loosely on tarpaulin and allowed to further dry under the sun. They were beaten to release seeds from the pods, and the seeds were separated from the chaff by winnowing to obtain clean seeds.

3.8 Data Collection

3.8.0 Weed parameters

3.8 .1.Weed density

A1m x1m quadrant was used randomly in each plot at 3, 6, 9 and 12 WAS. Weeds were harvested and separated into grasses, sedges and broad weeds and they were counted to obtain the density of the individual weed species. The sum of the entire weed species were recorded at each sampling period as the total weed density

3.8.2 Weed covers score

Weed cover score was obtained by visual observation at 6 and 9 weeks after sowing using a scale of 1- 9, where scale1 represent no weed cover and scale 9 represents complete weed cover.

3.8.3 Cumulative weeds dry weight (g)

A quadrant of $1m^2$ was used randomly to collect samples of fresh weeds before weeding at 3, 6, 9 and 12 WAS. The weeds were cleaned of soil and oven dried at 70^oC to a constant weight and weighed using a Mettler digital balance (Metler Toledo, model SB 16001), which was made in Germany. The average weight were recorded for each plot the values at the various sampling periods were added to give the cumulative weed dry weight

3.9 Crop growth parameters

Ten soybean plants in each net plot were tagged for periodic observations during the crop growth period. The observations were made at 3, 6, 9, and 12 WAS as follows:

3.9.1 Crop injury Score

A scale of 1to 9 was used for the crop injury score where scale 9 represent the most vigorous plant and 1 represent completely dead plants, this was visually observed at 3, 6, 9 and 12 WAS. The greenness and canopy of shoot, plant height and ground cover by crop were considered for scoring the plants.

3.9.2Canopy spread (cm)

The spread of branches of five tagged plants were taken at random at different direction by using a meter rule during the vegetative growth at 3, 6, 9 and12 WAS. The averages of the tagged plants were expressed in cm/plant.

3.9.3 Stand count

Number of plants from each plot were counted at 3 and 12 WAS and recorded as per treatment.

3.9.4 Plant height (cm)

Plant heights of the ten tagged plants were measured from the base of plant to the highest leaf using a meter rule at 3, 6, 9 and 12 WAS. The average height of the sampled plants were computed and recorded for each plot.

3.9.5 Leaf area index (LAI)

Measurements were taken at 3, 6, 9 and 12 WAS. Leaf area index was obtained by dividing LA by the ground area subtended by the plant to obtain LAI as described by Watson (1958) in the formula:

$LAI = \frac{A}{G}$ Where A = leaf area per plant, G =ground area per plant

3.9.6 Shoot dry matter

Five plants outside each net plot were randomly taken at 3, 6, 9 and 12 WAS and cut at ground level. The samples were oven dried to a constant weight using Gallen-kamp oven at 70◦C. The dried samples were weighed using a Mettler balance (Metler Toledo, model SB 16001), which was made in Germany. The average weight per plant were computed and recorded in (g)

3.9.7 Number of days to first flowering

This was determined by counting going to the farm to get the number of days from seed sowing to the first flower opening in each plot and this was recorded for each plot.

3.9.8 Days to 50% Flowering

The numbers of days from seed sowing to when 50% of the plants had flowered were recorded in each plot.

3.9.9 Crop growth rate (g/wk.)

This was determined at 3, 6, 9 and 12 WAS from the five tagged sampled plants after being oven dried to a constant weight. The value was calculated from formula described by Radford (1964):

$$\text{CGR} = \frac{w_2 - w_1}{t_2 - t_1} \times \frac{1}{GA}\ g/m^2/\text{wk}$$

W1 and $W1_2$ are dry weights in grams per plant at times t_1 and t_2 in weeks, respectively, while; GA is the ground area (m^2)

3.9.10 Relative growth rate (g/g/wk)

This was carried out at 3, 6, 9 and12 WAS. It was determined after oven drying the five sampled plants to a constant weight using the formula describe by Radford (1964):

$$\text{RGR} = \frac{\log_e w2 - \log_e w1}{t_2 - t_1}\ (g/g/\text{wk.})$$

Where w_1 and w_2 are dry weights in grams per plant at times t_1 and t_2 in weeks, respectively, and $\log_e$ represent natural logarithm.

3.10 Yield and yield components

3.10.1 Seed weight per plant (g)

The seed from the dried pods of five tagged plants were harvested, threshed and weighed, and the average weight recorded for each plot.

3.10.2 100-seed weight (g)

One hundred seeds were randomly taken from each net plot yield and weighed. The weight was recorded as 100-seed weight for each plot

3.10.3 Grain yield (kg/ha)

Plants from each net plot were harvested, threshed, winnowed and the seeds were weighed. Seeds weight obtained from each net plot was extrapolated to seed yield in kg/ha and the value was recorded for each plot.

3.10.4 Haulms yield (kg/ha)

The haulms left after removing soybean seeds was air- dried under sun to constant weight. The haulms were weighed using Mettler weighing balance (Metler Toledo, model SB 16001). The values per net plots were extrapolated to kg/ha and recorded in each plot

3.10.5 Harvest index (HI)

This is the ratio of the seeds weight to the total dry matter per plant at harvest, which was calculated using the formula as follows:

$$HI = \frac{\text{Grain weight per plant}}{\text{Total dry matter per plant}} x100$$

3.11 Partial Economic Analysis

The partial economic analysis was done using the partial budget procedure to determine the treatment combinations that would give acceptable return at low risk to farmer (CIMMYT, s1988). Economic analysis of the data was done based on the prevailing farm gate prices of input, operations and outputs. The following concepts were used in the partial budget analysis are defined as follows: 1. Gross Revenue (GR) in ₦ per hectare is the product of average price of soybean and total yield for each treatment, 2. Total variable cost (TVC) in ₦ per hectare is the cost of labour and inputs which include seeds, fertilizer and chemicals. 3. Gross Margin (GM) in ₦ per hectare is the difference between gross revenue and total variable cost. The gross margin is given by the differences between the total revenue (TR) per hectare and total variable cost (TVC) per hectare.

$$GM = TR\ (\text{income/ha}) - TVC\ (\text{cost/ha})$$

It can be seen from the above equation that any increase in TR will result in increase in GM, provided TVC is constant

3.12 Statistical Analysis

The data collected was subjected to analysis of variance (ANOVA) using the F-test as described by Snedecor and Cochran (1969) to determine significance of differences between the treatment means. Differences among the treatment means were compared using the Duncan's multiple range test (DMRT) as described by Duncan (1955). The relationship between weed, crop growth and yield parameters were determined by correlation coefficient and path analysis as described by Little and Hills (1978)

CHAPTER FOUR

4.0 RESULTS

4.1 Soil Analysis

The physical and chemical properties of the soil of the experimental sites are shown in Table 4.1.The analysis showed that soil in Samaru site was loam. The soil was slightly acidic and relatively high in available phosphorous (10.34 mg kg^{-1}). While the soil in Bagauda was silty loam, slightly acidic and low in available phosphorous (2.75 mg kg^{-1}). The percentage of organic carbon (1.24, 1.12) and total nitrogen (0.21, 0.15) from both sites respectively were low. The exchangeable bases, Mg, K and Na were also low, except Ca, which was moderate at both locations. The cation exchanges capacity (CEC) was moderate at both locations.

4.2 Effects of Crop Variety, Sowing Methods and Weed Control Treatments on Weed Parameters

4.2.1 Weed cover score

The effects of crop variety, sowing method and weed control treatments on weed cover score at Samaru and Bagauda are presented in Tables 4.2. The effect of variety was only significant at 3WAS in Samaru, where TGX 1448-2E recorded low weed cover score than TGX 1987-10F. The effect of sowing method on weed cover score was significant at 3 and 9WAS at Samaru (Table 4. 2). Dibbling method of sowing recorded lower weed cover score compared with the drilling. The effect of weed control treatment on weed cover score in Samaru showed that at 6WAS the least weed cover score was recorded with hoe weeding followed by Pendimethalin at 2.0kg a.i/ha, which in turn gave lower weed cover than that of fluazifop-butyl at 2.0 kg a.i./ha and the weedy check. At 9 and 12WAS, fluazifop-butyl at 2.0kg a.i/ha

Table 4.1: Physical and chemical properties of soil at experimental fields during 2016 rainy season at Samaru and Bagauda

Location	Samaru	Bagauda
Soil depth (cm)	0-30	0-30
Soil characteristics		
Particle size distribution (g Kg^{-1})		
Sand	42.0	24.0
Silt	47.0	66.0
Clay	11.0	10.0
Textural class	loam	Silt loam
Chemical composition		
pH in H_2O (1:2.5)	6.30	6.22
pH in 0.01M $CaCl_2$ (1:2.5)	5.95	5.81
Organic carbon (g kg^{-1})	1.24	1.12
Available phosphorus (mg kg^{-1})	10.34	2.75
Total nitrogen (g kg^{-1})	0.21	0.15
Exchangeable bases (c mol kg^{-1})		
Calcium	3.9	3.4
Magnesium	0.801	0.721
Potassium	0.015	0.072
Sodium	0.086	0.134
CEC	4.701	4.281

Soil analysed in the Analytical laboratory of Agronomy Department, Ahmadu Bello University, Samaru, Zaira.

Table 4.2:Effects of variety, sowing method and weed control treatments on weed cover score in soybean during the rainy season of 2016 at Samaru and Bagauda

	Weed cover score[1]							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	2.4a	4.5	3.3	3.9	3.0	4.3	2.3	2.4b
TGX 1987-10F	3.1b	4.1	3.4	3.8	3.1	4.1	2.3	2.6a
SE±	0.23	0.43	0.22	0.20	0.14	0.35	0.16	0.14
Sowing (P)								
Dibbling	2.5b	4.2	3.6a	3.9	2.9	4.5a	2.6a	2.5
Drilling	3.0a	4.2	3.1b	3.8	3.3	3.8b	2.1b	2.5
SE±	0.23	1.14	0.22	0.20	0.38	0.35	0.16	0.14
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	2. 8	3.9b	4.2a	4.5a	2.7bc	3.4c	2.6a	2.9a
fluazifop-butyl at 2.0kg/ha	3.0	4.0a	3.0b	3.2b	3.7a	3.2c	2.3ab	2.5b
Hoe weeding at 3, 6 & 9 WAS	2.7	2.3c	2.1c	3.2b	2.4c	4.3b	2.1b	2.4
Weedy check	2.6	6.9a	4.2a	4.6a	3.5ab	5.8a	2.4ab	2.2
SE±	0.33	0.61	0.31	0.29	0.53	0.50	0.23	0.20
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	NS	NS
P X W	*	*	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

1. Weed covers score using a scale of 1-9, when scale 1 represented no weed cover, and scale 9 represented complete weed cover,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability, * = Significant at 5% level of probability

and hoe weeding at 3 and 6WAS reduced weed cover score compared to the highest (5.8) by the weedy check and Pendimethalin at 2.0kg a.i./ha.

At Bagauda, variety had significant effect on weed only at 12 WAS. Variety TGX 1448-2E recorded significantly lower weed cover score compared with variety TGX 1987-10F. Sowing method influenced weed cover score at 6 and 9WAS, drilling method of sowing recorded lower weed cover score compared to dibbling (Table 4.2). At 3 WAS in this location, hoe weeding reduced weed cover score over the untreated control (weedy check).

Treatment with Pendimethalin and fluazifop-butyl had similar weed cover score as the weedy check.

At 6 WAS, Pendimethalin and fluazifop-butyl at the same rates resulted in lower weed cover score than hoe weeding, which in turned was lower than the weedy check. At 9 WAS, hoe weeding resulted in lower weed cover score than Pendimethalin at 2.0 kg a.i/ha; while at 12 WAS, the treatment with Pendimethalin resulted in higher weed cover score than the other treatments, including the weedy check.

The interaction effect between sowing method and weed control treatments on weed cover score was significant at 3 and 6 WAS (Table 4.3). At 3 WAS dibbling method of sowing with the application of Pendimethalin at 2.0 kg a.i. /ha resulted in lower weed cover score than all other combinations except hoe weeding with dibbling and weedy check with dibbling and drilling respectively (Table 4.3). At 6 WAS, the combination of hoe weeding with dibbling and drilling gave significantly lower weed cover scores than Pendimethalin at 2.0 kg a.i./ha with dibbling and fluazifop-butyl at the same rates with drilling which are at par respectively.

Table 4.3: Interaction of sowing method and weed control treatments on weed cover score at 3 and 6 WAS in 2016 wet season at Samaru

	Sowing Methods	
Treatment	Dibbling	Drilling
	3WAS[1]	
Weed Control Treatments		
Pendimethalin at 2.0kg a.i./ha	2.0c	3.5a
fluazifop-butyl at 2.0kg a.i./ha	3.0ab	3.0ab
Hoe weeding at 3,6 and 9 WAS	2.3bc	3.0ab
Weedy check	2.7bc	2.5bc
SE±	0.27	
	6 WAS	
Pendimethalin at 2.0kg a.i/ha	3.2cd	4.7c
fluazifop-butyl at 2.0kg a.i/ha	4.7c	3.3cd
Hoe weeding at 3, 6 and 9 WAS	2.7d	2.0d
Weedy check	6.2b	7.7a
SE±	0.49	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT,

1. WAS = Weeks after sowing

4.2.2 Weed Density

The effects of crop variety, sowing method and weed control treatments on weed density at various sampling periods and locations are at Samaru and Bagauda are presented in Tables 4.4. At Samaru, the effect of variety on weed density was not significant throughout the sampling period. However, the effect of sowing method on weed density was significant at 6, 9 and 12WAS, where dibbling method of sowing recorded the highest weed density than drilling (Table 4.4). The effect of weed control treatments on weed density was significant throughout the sampling periods. At 3WAS Pendimethalin at 2.0kg a.i. /ha gave the lowest weed density than all the other weed control treatments, which were similar (Table 4.4). At 6 and 12 WAS, each weed control treatment resulted to lower weed density than the weedy check. At 9WAS the treatment with Pendimethalin and hoe weeding gave lower weed density than fluazifop-butyl at 2.0kg a.i/ha and the weedy check.

At Bagauda, TGX1448-2E, variety resulted in higher weed density than TGX 1987-10F at 6WAS, but at 9WAS, the reverse was the case (Table 4.4).At 9 and 12WAS, drilling method of sowing resulted in significant lower weed density than dibbling method of sowing. Lower weed density than the hoe weeded and the weedy checks.

The influence of weed control treatments was significant throughout the sampling periods in this location. At 3 WAS treatment with Pendimethalin and fluazifop-butyl at 2.0kg a.i/ha gave lower weed density than the hoe weeded and the weedy check. At 6 and 9WAS, each weed control treatment gave lower weed density than the weedy check. At 12WAS, Pendimethalin and hoe weeding resulted in lower weed density than fluazifop-butyl at 2.0kg a.i/ha and weedy check (Table 4.4). However, the interaction of planting methods and weed control treatments was significant at 9 WAS at Samaru (Table 4.4).

Table 4.4:Effects of variety, sowing method and weed control treatments on weed density in soybean during the wet season of 2016 at Samaru and Bagauda

	Weed density[1]							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	66.5	87.4	86.5	88.9	46.1	69.2a	72.5b	81.8
TGX 1987-10F	66.1	82.0	92.7	84.5	49.4	56.1b	81.6a	82.2
SE±	4.31	5.63	6.07	3.52	8.73	6.90	3.99	3.25
Sowing (P)								
Dibbling	66.6	90.4a	97.3a	91.4a	54.9	67.3	83.9a	89.8a
Drilling	65.9	79.1b	81.9b	82.1b	40.6	58.1	70.3b	74.2b
SE±	4.31	5.63	6.07	3.52	8.73	6.90	3.99	3.25
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	48.8b	82.1c	76.9b	79.50c	34.8	43.8c	67.6c	69.1b
fluazifop-butyl at 2.0kg/ha	69.5a	87.0b	104.0a	94.6b	49.3	56.8bc	87.4b	93.7b
Hoe weeding at 3, 6 & 9 WAS	69.9a	56.9c	58.7c	66.1d	53.1	64.3b	55.0d	67.2c
Weedy check	76.9a	112.9a	118.8a	106.7a	53.8	85.8a	98.2a	98.0a
SE±	6.09	7.97	8.59	4.98	12.34	9.76	5.46	4.60
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	NS	NS
P X W	NS	NS	*	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

1. Weed covers score using a scale of 1-9, when scale 1 represented no weed cover, and scale 9 represented complete weed cover,
2. WAS = Week after sowing,
3. NS =Not significant at 5% level of probability,
4. * = Significant at 5% level of probability

Table 4.5 shows the interaction effect between sowing method and the weed control treatments at 9 WAS in Samaru. The combination of hoe weeding with all the sowing methods recorded significantly lower weed density than the other weed control treatments. Pendimethalin at 2.0 kg a.i./ha, combined with dibbling method of sowing resulted into higher weed density than fluazifop-butyl at 2.0 kg a.i./ha, which was at par with Pendimethalin at 2.0 kg a.i./ha, combined with drilling method of sowing. The combination of Weedy check and sowing methods did not influence weed density. The weedy check and the two sowing methods resulted in statistically similar but significantly higher weed density compared to other interactions except with fluazifop-butyl at 2.0 kg a.i./ha with dibbling. Pendimethalin at 2.0 kg a.i. /ha with drilling gave significantly least weed density but at par with Pendimethalin at 2.0 kg a.i. /ha with dibbling and hoe weeding with dibbling (Table 4.5).

4.2.3 Weed dry weight (g)

The effects of variety, sowing methods and weed control treatments on weed dry weight in soybean at Samaru and Bagauda are presented in Table 4.6. The effect of variety on weed dry weight was not significant throughout the sampling period in Samaru and Bagauda (Table 4.6). At Samaru, the effect of sowing method on weed dry weight was only significant at 9 WAS, in which the dibbling method of sowing produced more weed dry matter than drilling methods. The effect of weed control treatments on weed dry weight at 3, 6 and 9 WAS shows that the hoe weeded plots had the least weed dry weight, compared with all the other treatments (Table 4.6). Treatments with Pendimethalin at 2.0 kg a.i. /ha and fluazifop-butyl at 2.0 kg a.i. /ha resulted in similar weed dry matter production and each was higher than the weedy check.

Table 4.5: Interaction of weed control methods and sowing methods of soybean on weed density 9 WAS in 2016 wet season at Samaru

	Sowing methods[1]	
Treatments	Dibbling	Drilling
Weed Control (W)		
Pendimethalin at 2.0 kg a.i./ ha	80.0cd	73.8d
fluazifop-butyl at 2.0 kg a.i./ ha	112.5ab	95.5bc
Hoe weeding at 3, 6 & 9 WAS	80.5cd	36.8e
Weedy check	116.0a	121.7a
SE±	7.01	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

1. WAS =Weeks after sowing

Table 4.6:Effects of variety, sowing method and weed control treatments on weed dry weight in soybean during the wet season of 2016 at Samaru and Bagauda

	Weed dry weight[1]							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	54.4	62.2	99.9	150.3	38.7	61.9	96.5	178.4
TGX 1987-10F	53.2	57.7	99.0	155.1	35.1	64.9	8.5	172.8
SE±	7.85	6.65	6.83	15.93	8.32	6.32	4.12	22.16
Sowing (P)								
Dibbling	51.0	58.0	106.0a	163.9	37.3	57.9b	100.1	196.8a
Drilling	56.6	61.9	93.0b	141.4	36.6	68.9a	94.9	154.4b
SE±	7.85	6.65	6.83	15.93	8.32	6.32	4.12	22.16
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	42.2b	51.4	106.9b	150.7b	34.1	57.1	96.5b	112.3b
fluazifop-butyl at 2.0kg/ha	50.1ab	59.9	107.5b	165.1b	40.3	65.6	109.2a	144.7b
Hoe weeding at 3, 6 & 9 WAS	70.2a	62.1	58.3c	66.3c	41.8	60.1	65.9c	149.3b
Weedy check	52.8ab	66.5	125.2a	228.6a	31.5	70.9	118.3a	296.2a
SE±	11.10	9.41	9.65	22.53	11.78	8.94	5.84	31.33
Interactions								
V X P	*	NS[3]	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	NS	NS
P X W	NS	NS	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

1. Weed covers score using a scale of 1-9, when scale 1 represented no weed cover, and scale 9 represented complete weed cover,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability, * = Significant at 5% level of probability

At Bagauda, the effect of sowing method on weed dry weight was significant at 6 and 12 WAS (Table 4.6). At 9 WAS, drilling method of sowing resulted in higher weed dry weight than dibbling method of sowing. But at 12 WAS, dibbling method had higher weed dry weight than drilling method of sowing. At 9WAS in this location, Pendimethalin at 2.0kg a.i./ha and hoe weeding reduced weed dry matter production compared with the weedy check and the use of fluazifop-butyl at 2.0 kg a.i/ ha, both of which gave similar results (Table 4.6).

The interaction effect between sowing method and variety was significant at 3 WAS at Samaru (Table 4.7). The combination of TGX 1448-2E variety with dibbling method of sowing gave lower weeds dry weight than with drilling method (Table 4.7). With TGX 1987-10F variety, sowing method did not influence weed dry weight. Similarly, with each sowing method, variety did not affect weed dry weight (Table 4.7).

4.3 Effects of Crop Variety, Sowing Method and Weed Control Treatments, on Growth and Yield Parameters

4.3.1 Crop injury score

The effects of crop variety, sowing methods and weed control treatments on soybean crop injury score at 3WAS at Samaru and Bagauda are presented in Table 4.8. There was no significant influence of crop variety, sowing methods and weed control treatments on crop injury score at both Samaru and Bagauda.

The interactions effect between variety and sowing, variety and weed control methods, sowing methods and weed control methods as well as variety, sowing methods and weed control methods on crop injury score in both locations were not significant (Table 4.8).

Table 4.7: Interaction of weed control treatments and sowing methods of soybean on weed dry weight at 3WAS in 2019 wet season at Samaru

	Varieties	
Treatments	TGX1448-2E	TGX1987-10F
Sowing methods		
Dibbling	44.8b	57.2ab
Drilling	64.0a	49.3ab
SE±	6.41	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

Table 4.8: Effects of variety, sowing method and weed control treatments on crop injury score in soybean during the wet season of 2016 at Samaru and Bagauda

	Crop injury[1]	
	Samaru	Bagauda
Treatments	3WAS[2]	3WAS
Variety (V)		
TGX 1448-2E	1.42	1.54
TGX 1987-10F	1.58	1.83
SE±	0.12	0.17
Sowing Methods (P)		
Dibbling	1.54	1.67
Drilling	1.46	1.46
SE±	0.12	0.17
Weed Control Methods (W)		
Pendimethalin at 2.0 kg/ha	1.17	1.25
fluazifop-butyl at 2.0 kg/ha	2.75	3.00
Hoe weeding at 3,6 & 9 WAS	1.08	1.00
Weedy check	1.00	1.00
SE±	0.18	0.19
Interactions		
V *P	NS[3]	NS
V*W	NS	NS
P*W	NS	NS
V*P*W	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability

4.3.2 Stand Count

The effects of crop variety, sowing method and weed control treatments on stand count of soybean in both locations are presented in Table 4.9. Stand count was significantly affected by crop variety and sowing method throughout the sampling period in both locations. In both locations, TGX 1987-10F variety significantly had higher stand count than TGX 1448-2E variety at the two sampling periods and locations (Table 4.9). Similarly, drilling method of sowing had more plant stands than the dibbling method at both sampling periods and locations (Table 4.9). Weed control treatments on did not have any significant effect on stand count in both the sampling period and locations (Table 4.9).

The interactions effect between crop variety, sowing methods and weed control treatments on stand count were not significant throughout the sampling period in both locations (Table 4.9).

4.3.3 Crop Vigour Score

The effects of crop variety, sowing method and weed control treatments at Samaru and Bagauda are presented in Tables 4.10. In both locations, crop variety did not have any significant influenced on crop vigour score. The effect of sowing method on crop vigour shows that dibbling method of sowing soybeans produced more vigorous crop at 9 and 12 WAS in both locations. The effect of weed control treatments on crop vigour score shows that hoe weeded plots had the most vigorous plants at 6, 9 and 12 WAS at Samaru, although the values were similar to the application of fluazifop-butyl at 2.0kg a.i./ha and weedy check at 9 and 12 WAS (Table 4.10). At Bagauda, the weedy check resulted in greater crop vigour than a Pendimethalin-treated plot at 3 and 12 WAS. At 12 WAS, fluazifop-butyl at 2.0kg a.i. /ha resulted in more crop vigour than pendimethalin at 2.0 kg a.i/ha.

Table 4.9: Effects of variety, sowing method and weed control treatments on Stand count of soybean during the wet season of 2016 at Samaru and Bagauda

	Stand counts[1]			
	Samaru		Bagauda	
Treatments	3WAS[2]	12WAS	3WAS	12WAS
Variety (V)				
TGX 1448-2E	16.0	15.2b	18.8b	17.7b
TGX 1987-10F	18.9a	17.9a	23.5a	22.8a
SE±	1.53	1.40	2.41	2.16
Sowing Methods (P)				
Dibbling	13.5b	12.9b	14.8b	14.1b
Drilling	21.4a	20.1a	27.5a	26.4a
SE±	1.53	1.40	2.41	2.16
Weed control methods (W)				
Pendimethalin at 2.0kg/ha	16.9	16.1	24.0	23.1
fluazifop-butyl at 2.0kg/ha	18.9	17.8	19.2	18.3
Hoe weeding at 3,6 & 9 WAS	16.6	15.6	19.5	18.7
Weedy check	17.4	16.6	21.5	21.0
SE±	2.16	1.98	3.41	3.06
Interactions				
V X P	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS
P X W	NS	NS	NS	NS
V X P X W	NS	NS	NS	NS

1 Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

Table 4.10:Effects of variety, sowing method and weed control treatments on crop vigour score in soybean during the wet season of 2016 at Samaru and Bagauda

	Crop vigour score[1]							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	7.8a	6.8	8.0	8.2	7.1	7.6	8.3	8.5
TGX 1987-10F	7.4b	6.4	7.7	7.7	7.4	7.7	8.4	8.33
SE±	0.180	0.310	0.370	0.290	0.220	0.290	0.270	0.250
Sowing (P)								
Dibbling	7.5	6.4	7.4b	7.6b	6.8b	7.4	7.9b	8.2b
Drilling	7.6	6.8	8.3a	8.2a	7.7a	7.9	8.8a	8.6a
SE±	0.18	0.32	0.37	0.29	0.22	0.29	0.27	0.25
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	7.5	6.2b	7.1b	7.4b	6.9b	7.8	7.8b	7.9b
fluazifop-butyl at 2.0kg/ha	7.6	6.8b	8.0ab	8.2ab	7.2ab	7.8	8.8a	8.5ab
Hoe weeding at 3, 6 & 9 WAS	7.4	7.6a	8.6a	8.3a	7.2ab	7.5	8.4ab	8.5ab
Weedy check	7.8	6.7b	7.7ab	7.8ab	7.7a	7.4	8.4ab	8.7a
SE±	0.26	0.44	0.52	0.14	0.31	0.42	0.39	0.35
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	NS	NS
P X W	*	NS	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

1. Weed covers score using a scale of 1-9, when scale 1 represented no weed cover, and scale 9 represented complete weed cover,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

4. * = Significant at 5% level of probability

The interactions effect between sowing methods and weed control treatments on crop vigour score were significant at 3 WAS (Table 4.11). With dibbling method of sowing, weed control treatments did not affected crop vigour, but with drilling method combined with hoe weeding resulted in more vigorous plants than the weedy check. On the other hand, crop variety did not influenced crop vigour score at each level of weed control treatments (Table 4.11).

4.3.4 Plant height (cm)

The effects of crop variety, sowing method and weed control treatments on soybean plant height at Samaru and Bagauda are presented in (Tables 4.12). In Samaru, the effect of crop variety on plant height was not significant at 3 and 6 WAS (Table 4.12). At 9 and 12WAS, TGX 1448-2E variety produced taller plants than TGX 1987-10F variety. Sowing method did not significantly influenced plant height at 3 WAS in this location. However, at 6-12 WAS, dibbled crop gave taller plants than the drilled plants. The effect of weed control treatments significantly influenced plant height at 6 and 9 WAS only. At 6 WAS, hoe weeded plot recorded taller plants than plots treated with Pendimethalin at 2.0 kg a.i. /ha. At 9 WAS, hoe weeding gave taller plants than Pendimethalin at 2.0 kg a.i. /ha, treated plants. In each case, the other treatments gave similar plant height to both the tallest and shortest. The effects of crop variety, sowing methods and weed control treatments on plant height were not significant throughout the sampling period in Bagauda (Table 4.12)

The interaction effect between sowing and weed control treatments on plant height was significant at 6 WAS (Table 4.13). Drilled seed resulted in taller plants than the dibbled ones when applied in conjunction with Pendimethalin at 2.0 kg a.i. /ha, fluazifop-butyl at 2.0 kg a.i. /ha or the weedy check. On the other hand, weed control treatments did not influence

Table 4.11: Interaction of weed control treatment and sowing method of soybean on crop vigour at 3WAS in 2016 wet season at Samaru.

	Sowing methods[1]	
Treatments	Dibbling	Drilling
Weed Control method (W)		
Pendimethalin at 2.0 kg a.i/ ha	7.3ab	7.7ab
fluazifop-butyl at 2.0kg/ha	7.5ab	7.7ab
Hoe weeding at 3, 6 & 9 WASS	7.8a	8.0a
Weedy check	7.5ab	7.0b
SE±	0.21	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

Table 4.12:Effects of variety, sowing method and weed control treatments on plant height in soybean during the wet season of 2016 at Samaru and Bagauda

	Plant height[1] (cm)							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	23.6	50.4	83.9a	93.3a	21.9	54.7	76.8	81.3
TGX 1987-10F	23.6	48.2	79.1b	87.3b	23.1	57.3	78.3	81.8
SE±	0.52	1.80	2.41	2.15	0.81	2.63	7.03	7.26
Sowing (P)								
Dibbling	23.3	47.3b	78.9b	92.6a	22.1	55.7	72.4	76.3
Drilling	23.6	51.3a	84.1a	87.9b	22.9	56.3	82.7	86.8
SE±	0.52	1.80	2.41	2.15	0.81	2.63	7.03	7.26
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	22.8	45.9b	77.6b	89.2	22.5	53.5	78.2	80.3
fluazifop-butyl at 2.0kg/ha	23.6	49.0ab	80.8ab	90.7	22.7	58.0	81.4	84.8
Hoe weeding at 3, 6 & 9 WAS	23.6	52.0a	84.4a	89.8	21.7	56.6	69.7	75.3
Weedy check	23.9	50.3ab	83.3ab	91.3	23.1	55.8	81.0	85.7
SE±	0.74	2.55	3.41	3.04	1.14	3.72	9.94	10.27
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	NS	NS
P X W	NS	*	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

1Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

4. * = Significant at 5% level of probability.

Table 4.13: Interaction between weed control and sowing methods of soybean on plant height 6 WAS at Samaru

	Sowing Methods	
Treatment	Dibbling	Drilling
Weed control method		
Pendimethalin at 2.0kg a.i/ha	48.2ab	43.7c
fluazifop-butyl at 2.0kg a.i/ha	44.8bc	53.2a
Hoe weeding	49.6ab	54.4a
Weedy check	46.5bc	54.1a
SE±	2.08	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

plant height in the dibbled crop, while in the drilled crop Pendimethalin gave shorter plants than all the other treatments, which were similar (Table 4.13).

4.3.5: Canopy spread

Table 4.14 shows the effect of crop variety, sowing method and weed control treatment on canopy spread at 6 and 9 WAS in Samaru and Bagauda. At Samaru, variety TGX 1448-2E had wider canopy than TGX 1987-10F at both sampling periods. However, the effect of variety was not significant on canopy cover at Bagauda. In both locations, sowing method did not influence canopy spread. The effect of weed control treatments on canopy spread was significant at 6 WAS in Samaru and 9 WAS in Bagauda. At Samaru, Pendimethalin at 2.0 kg a.i./ha gave lower canopy spread than all the other treatments, including the weedy check. In Bagauda, fluazifop-butyl at 2.0 kg a.i./ha gave wider canopy than all others except Pendimethalin at 2.0 kg a.i./ha, which in turn was greater than the weedy check.

The interactions effects among the treatment factors were not significant in both sampling periods and locations (Table 4.14).

4.3.6 Shoot dry weight

The effects of crop variety, sowing method and weed control treatments on shoot dry weight of soybean plant at Samaru and Bagauda are presented in Tables 4.15. The effect of crop variety on shoot dry weight was not significant at all the sampling periods in both locations. Similarly, effect of sowing method on shoot dry weight was not significant at Samaru. However, weed control treatments influenced shoot dry weight at 6 and 12 WAS in Samaru. In this location and at 6 WAS, hoe weeding at 3 and 6 WAS increased shoot dry weight over the other treatments, except fluazifop-butyl at 2.0 kg a.i/ha, which was similar to the least and highest values. At 9 and 12 WAS, higher shoot dry weight was achieved by hoe weeding,

Table 4.14: Effects of variety, sowing method and weed control treatments on canopy spread in soybean during the wet season of 2016 at Samaru and Bagauda

Treatments	Canopy spread[1]			
	Samaru		Bagauda	
	6WAS[2]	9WAS	6WAS	9WAS
Variety (V)				
TGX 1448-2E	38.4a	54.5a	35.9	57.7
TGX 1987-62F	35.3b	50.5b	35.4	54.8
SE±	1.60	2.07	1.29	3.75
Sowing Methods				
Dibbling	35.8	51.3	36.5	58.3
Drilling	37.9	53.7	34.8	54.2
SE±	1.64	2.07	1.29	3.75
Weed Control Method(W)				
Pendimethalin at 2.0kg/ha	33.0b	50.6	34.3	58.1ab
fluazifop-butyl at 2.0kg/ha	37.6a	51.8	36.8	65.9a
Hoe weeding at 3,6 & 9 WAS	39.4a	65.0	36.7	54.3bc
Weedy check	37.3a	52.5	34.8	46.7c
SE±	2.32	2.90	1.29	3.74
Interactions				
V X P	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS
P X W	NS	NS	NS	NS
V X P X W	NS	NS	NS	NS

Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

Table 4.15:Effects of variety, sowing method and weed control treatments on shoot dry weight in soybean during the wet season of 2016 at Samaru and Bagauda

	Shoot dry weightt[1] (g)							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	4.9	14.2	35.5	42.7	3.6	5.0	31.4	37.9
TGX 1987-10F	4.9	14.5	34.8	41.0	4.2	5.4	30.6	38.0
SE±	0.470	1.060	4.120	3.710	0.450	0.550	4.570	4.290
Sowing (P)								
Dibbling	5.3	15.4	35.1	41.9	4.5a	5.9a	32.4	39.6
Drilling	4.6	13.7	35.2	42.2	3.4b	4.4b	29.6	36.4
SE±	0.470	1.660	4.120	3.710	0.450	0.550	4.270	4.200
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	4.9	11.7b	29.8b	35.6c	3.6	5.1	29.9	37.2
fluazifop-butyl at 2.0kg/ha	4.9	15.1ab	28.7c	33.6c	3.6	4.8	29.1	35.9
Hoe weeding at 3, 6 & 9 WAS	5.2	19.1a	49.2a	55.9a	4.7	5.7	37.1	43.3
Weedy check	4.7	12.1b	32.9b	42.3b	3.8	5.0	28.0	35.4
SE±	0.660	2.340	5.830	5.250	0.640	0.780	6.470	6.070
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	*	NS
P X W	NS	NS	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

1 Means followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

* = Significant at 5% level of probability.

followed by Pendimethalin at 2.0 kg a.i/ha at 9WAS and the weedy check at both periods. The least shoot weight was obtained by fluazifop-butyl at 2.0 kg a.i. /ha. In Bagauda, sowing method influenced shoot dry weight at 3 and 6 WAS, and dibbling sowing method resulted in greater value than drilling sowing method. The effect of weed control treatments on shoot dry weight of soybean was not significant throughout the sampling period in this location.

The interaction effect between variety and weed control treatments was significant at 9 WAS at Bagauda (Table 4.16). Variety TGX 1448-2E, combined with hoe weeding resulted in higher shoot dry weight than all the other weed control treatments. However, the combination of varieties TGX 1987-10F and weed control treatments did not affect shoot dry weight. On the other hand, variety did not influence shoot dry weight of soybean when used in conjunction with Pendimethalin applied at 2.0 kg a.i. /ha and fluazifop-butyl at 2.0 kg a.i. /ha except hoe weeding at 3 and 6WAS in which TGX 1448-2E gave higher dry weight than the variety TGX 1987-10F (Table 4.16).

Table 4.16: Interaction between weed control methods and Varieties of soybean on shoot dry weight 9 WAS at Bagauda

	Varieties	
Treatment	TGX 1448-2E	TGX 1987-10F
Weed control (W)		
Pendimethalin at 2kg a.i/ha	27.3b	32.5b
Fluazifop-butyl at 2kg a.i/ha	24.4b	33.93ab
Hoe weeding 3&6WAS	48.2a	25.95b
Weedy check	25.9b	30.15b
SE±	5.28	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

4.3.7 Leave area index (LAI)

The effects of crop variety, sowing method and weed control treatments on leave area index (LAI) at Samaru and Bagauda are presented in Tables 4.17. At Samaru, the effect of variety was only significant at 9 and 12 WAS, in which variety TGX 1448-2E recorded higher LAI than variety TGX 1987-10F (Table 4.17). In this location, sowing method significantly influenced (LAI) throughout the sampling period and drilling method of sowing resulted in greater (LAI) than dibbling sowing method. The effect of weed control treatments shows that there was high significant difference in (LAI) among the treatments at 6 – 12 WAS Fluazifop-butyl at 2.0 kg a.i. /ha gave higher LAI than the other treatments at 6 WAS. Hoe weeding recorded higher leave area index at 9 and12WAS compared to other weed control treatments. The application of 2.0 kg a.i. /ha of fluazifop-butyl gave higher LAI than the weedy check at 12 WAS. At Bagauda, variety did not influence LAI, while sowing did throughout the sampling periods. Drilling sowing method gave higher LAI than dibbling sowing method at 3, 9 and 12 WAS, while the reverse was case at 6 WAS. At 9 WAS, all the weed control treatments gave similar LAI and each was higher than by the weedy check. Fluazifop-butyl at 2.0 kg a.i./ha gave higher LAI than Pendimethalin, which together with hoe weeding had an edge over the weedy check, being the least, while the weedy check constantly recorded the lowest leave area index.

The interaction effects between variety and weed control treatments were significant at Bagauda at 9 WAS (Table 4.18). Crop variety did not influence LAI under all the weed control treatments, except with hoe weeding at 3 and 6WAS. Variety TGX 1448-2E, combined with Pendimethalin applied at 2.0 kg a.i. /ha and Fluazifop-butyl at 2 .0 kg a.i. /ha as well as hoe weeding control gave similar LAI, and each was higher than the weedy check. Variety TGX 1087-10F, in combination with Pendimethalin at 2.0 kg a.i. /ha and Fluazifop-butyl at 2.0 kg

Table 4.17:Effects of variety, sowing method and weed control treatments on leave area index (LAI) in soybean during the wet season of 2016 at Samaru and Bagauda

	Leave area index[1]							
	Samaru				Bagauda			
Treatments	3WAS[2]	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety								
TGX 1448-2E	0.7	3.6	1.4a	1.6a	0.5		2.3	3.5
TGX 1987-10F	0.8	3.3	0.8b	1.4b	0.6	0.1	2.5	3.8
SE±	0.08	0.37	1.11	1.07	0.05	0.04	3.04	2.34
Sowing (P)								
Dibbling	0.3b	1.6b	5.3b	2.6a	0.3b	0.2a	1.5b	2.3b
Drilling	1.1a	5.3a	1.9a	1.3b	0.8a	0.1b	4.3a	4.9a
SE±	0.08	0.37	1.11	1.07	0.05	0.04	3.4	2.30
Weed Control (W)								
Pendimethalin at 2.0 kg a.i./ha	0.7	0.2b	3.1b	1.6bc	0.5	0.1	2.5a	3.6b
fluazifop-butyl at 2.0kg/ha	0.71	1.5a	1.4b	1.7b	0.5	0.2	3.4a	3.2a
sHoe weeding at 3, 6 & 9 WAS	0.8	1.2b	1.8a	1.8a	0.5	0.1	2.6a	3.3ab
Weedy check	0.8	2.8b	0.1b	0.7c	0.7	0.2	1.1b	2.4c
SE±	0.11	0.52	1.57	1.51	0.07	0.05	4.73	3.31
Interactions								
V X P	NS[3]	NS	NS	NS	NS[3]	NS	NS	NS
V X W	NS	NS	NS	NS	NS	NS	*	NS
P X W	NS	NS	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,
2. WAS = Week after sowing,
3. NS =Not significant at 5% level of probability,
4. * = Significant at 5% level of probability.

Table 4.18: Interaction between weed control methods and sowing methods of soybean on Leave area index (LAI) at 9WAS in Bagauda

	Varieties	
Treatments	TGX 1448-2E	TGX 1987-10F
Weed Control (W)		
Pendimethalin at 2.0 kg a.i/ ha	31.2a	27.8a
Fluazifop-butyl at 2.0 kg a.i/ ha	28.8a	36.0a
Hoe weeding at 3, 6 & WAS	37.7a	19.5b
Weedy check	19.3b	18.8b
SE±	3.86	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT

a.i. /ha resulted in greater LAI than the hoe weeding control and the weedy check (Table 4.18).

4.3.8 Crop growth rate (CGR)

The effects of crop variety, sowing method and weed control treatment on crop growth rate (CGR) in Samaru and Bagauda are presented in (Tables 4.19). Throughout the sampling periods in both locations, there were no significant differences recorded due to crop variety, sowing method and weed control treatments on crop growth rate.

Similarly, the interactions of variety sowing and weed control methods were not significant throughout the period of sampling in both locations (Table 4.19).

4.3.9 Relative growth rate (RGR)

The effects of crop variety, sowing method and weed control treatment and on relative growth rate (RGR) of soybean in Samaru and Bagauda are presented in (Tables 4.20). There was no significant effect of crop variety, sowing methods and weed control treatment at all the sampling periods at both locations.

The interactions effect between variety, sowing method and weed control treatments on CGR were not significant throughout the sampling periods in both locations (Table 4.20).

4.3.10: Days to first flowering

The effects of crop variety, sowing methods and weed control treatments on number of days to first flowering in Samaru and Bagauda are presented in (Table 4.21). Days to first flowering was not significantly influenced by crop variety, sowing methods and weed control treatments in both locations.

Table 4.19:Effects of variety, sowing method and weed control treatments on crop growth rate in soybean during the wet season of 2016 at Samaru and Bagauda

	Crop growth rate[1]					
	Samaru			Bagauda		
Treatments	3-6WAS[2]	6-9WAS	9-12WAS	3-6WAS	6-9WAS	9-12WAS
Variety						
TGX 1448-2E	3.10	7.09	2.39	0.47	8.80	2.17
TGX 1987-10F	3.18	6.78	2.07	0.39	8.42	2.46
SE±	0.31	0.78	0.22	0.04	0.83	0.22
Sowing (P)						
Dibbling	3.26	6.69	2.12	0.51	8.82	2.38
Drilling	3.02	7.19	2.34	0.35	8.41	2.24
SE±	2.14	0.78	0.33	0.04	0.83	0.22
Weed Control (W)						
Pendimethalin at 2.0 kg a.i./ha	2.07	6.21	1.93	0.57	8.19	2.45
fluazifop-butyl at 2.0kg/ha	3.43	4.51	1.64	0.40	8.13	2.26
Hoe weeding at 3, 6 & 9 WAS	4.63	10.61	2.25	0.34	10.46	2.08
Weedy check	2.43	6.97	3.12	0.41	7.67	2.46
SE±	0.19	1.02	0.31	0.06	1.17	0.31
Interactions						
V X P	NS[2]	NS	NS	NS[2]	NS	NS
V X W	NS	NS	NS	NS	NS	NS
P X W	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT

, 2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

Table 4.20: Effects of variety, sowing method and weed control treatments on Relative growth rate in soybean during the wet season of 2016 at Samaru and Bagauda

	Relative growth rate[1]					
	Samaru			Bagauda		
Treatments	3-6WAS[2]	6-9WAS	9-12WAS	3-6WAS	6-9WAS	9-12WAS
Variety						
TGX 1448-2E	2.41	3.32	3. 38	1.26	3.25	3.25
TGX 1987-10F	2.46	3.24	3.33	3.29	3.26	3.29
SE±	0.08	0.08	0.05	0.07	0.08	0.05
Sowing (P)						
Dibbling	2.48	3.29	3.36	1.41	3.28	3.31
Drilling	2.39	3.26	3.35	1.13	3.22	3.23
SE±	0.08	0.08	0.05	0.07	0.08	0.05
Weed Control (W)						
Pendimethalin at 2.0 kg a.i./ha	2.15	3.09	3.19	1.31	3.23	3.27
fluazifop-butyl at 2.0kg/ha	2.52	3.12	3.16	1.21	3.15	3.19
Hoe weeding at 3, 6 & 9 WAS	2.78	3.64	3.64	1.27	3.42	3.38
Weedy check	2.29	3.26	3.43	1.29	3.21	3.24
SE±	0.12	0.12	0.17	0.10	0.11	0.08
Interactions						
V X P	NS[2]	NS	NS	NS[2]	NS	NS
V X W	NS	NS	NS	NS	NS	NS
P X W	NS	NS	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

Table 4.21: Effects of variety, sowing method and weed control treatments on Days to 1st flowering during in soybean the wet season of 2016 at Samaru and Bagauda

Treatments	Days to 1st flowering[1]	
Variety (V)	Samaru	Bagauda
TGX 1448-2E	49.63	50.4
TGX 1987-62F	50.8	50.1
SE±	0.43	0.16
Sowing Methods (P)		
Dibbling	50.2	49.9
Drilling	50.3	50.6
SE±	0.43	0.16
Weed Control Method (W)		
Pendimethalin at 2.0 kg a.i./ha	50.4	50.3
Fluazifop-butyl at 2.0 kg a.i./ha	51.3	49.3
Hoe weeding at 3,6 & 9 WAS	49.1	50.3
Weedy check	50.2	51.3
SE±	0.61	0.61
Interactions		
V X P	NS[2]	NS
V X W	NS	NS
P X W	NS	NS
V X P X W	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability

The Interaction effect of all the above factors on the number of days to first flowering was also not significant in these locations (Table 4.21).

4.3.11: Days to 50% Flowering

The influence of crop variety, sowing methods and weed control treatment on the number of days to 50% flowering of soybean at Samaru and Bagauda is shown in (Table 4.22). None of the above factors was observed to significantly influence the number of days to 50% flowering in the two locations.

Also, there was no significant interaction effect of factors on days to 50% flowering at both locations (Table 4.22).

4.3.12: Seed weight per plant (g)

The effects of crop variety, sowing method and weed control treatment on seed weight per plant at Samaru and Bagauda are presented in (Table 4.23). None of these factors was found to significantly influence seed weight per plant of soybean in both locations.

The interactions effect among variety, sowing method and weed control treatment were also not significant on seed weight in both locations (Table 4.23).

Table 4.22: Effects of variety, sowing method and weed control treatments on Days to 50% flowering in soybean during the wet season of 2016 at Samaru and Bagauda

Treatment	Days to 50% flowering[1]	
Variety (V)	Samaru	Bagauda
TGX 1448-2E	58.3	59.9
TGX 1987-62F	58.6	60.1
SE±	0.62	0.56
Sowing Methods (P)		
Dibbling	58.2	60.3
Drilling	58.7	59.7
SE±	0.62	0.56
Weed Control Method(W)		
Pendimethalin at 2.0kg a.i./ha	58.0	59.3
fluazifop-butyl at 2.0 kg a.i./ha	58.3	54.6
Hoe weeding at 3,6 & 9 WAS	59.6	60.7
Weedy check	58.0	60.3
SE±	0.88	0.79
Interactions		
V X P	NS[2]	NS
V X W	NS	NS
P X W	NS	NS
V X P X W	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability.

Table 4.23: Effects of variety, sowing method and weed control treatments on seed weight per plant in soybean during the wet season of 2016 at Samaru and Bagauda

	Seed weight per plant[1] (g)	
Variety (V)	Samaru	Bagauda
TGX 1448-2E	13.5	14.5
TGX 1987-62F	12.3	14.8
SE±	1.00	1.79
Sowing Methods (P)		
Dibbling	15.1	15.2
Drilling	10.7	14.1
SE±	1.00	1.26
Weed Control Method (W)		
Pendimethalin at 2.0kg a.i/ha	12.1	17.2
Fluazifop-butyl at 2.0 kg a.i/ha	11.3	13.9
Hoe weeding at 3,6 & 9 WAS	18.5	15.7
Weedy check	9.7	11.8
SE±	1.42	1.79
Interactions		
V X P	NS[2]	NS
V X W	NS	NS
P X W	NS	NS
V X P X W	NS	NS

1 Mean followed by same letter(s) within a treatment group in a column is statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

4.3.13: 100 Seed weight

Crop variety in both locations and weed control treatments in Bagauda significantly affected 100 – seed weight (Table 4.24). In both locations variety TGX 1987-10F gave heavier seeds than variety TGX 1448-2E in the two locations. Sowing methods did not significantly influenced 100 – seed weight in the two locations. At Bagauda, the hoe weeded plots gave higher 100 – seed weight than all the herbicide treatments and the weedy check, which are statistically similar.

The interaction effect between weed control treatments and sowing methods on 100 – seed weight was significant at Samaru (Table 4.25). Sowing by dibbling resulted in greater 100 – seed weight than by drilling sowing method when applied together with Pendimethalin at 2.0 kg a.i. /ha, Fluazifop-butyl at 2.0 kg a.i. /ha and the weed check . However, with the hoe weeding, sowing methods did not influence 100 – seed weight. On the other hand, Fluazifop-butyl at 2.0 kg a.i. /ha resulted to in lower 100 - seed weight than each of the other weed control treatment including weedy check. The combination of drilling sowing methods, hoe weeding at 3, 6 and 9 WAS and Fluazifop-butyl at 2.0 kg a.i. /ha resulted in higher 100 – seed weight than the weedy check (Table 4.25)

Table 4.24: Effects of variety, sowing method and weed control treatments on 100 seed weight in soybean during the wet season of 2016 at Samaru and Bagauda

	100 seed weight (g)	
Variety (V)	Samaru	Bagauda
TGX 1448-2E	14.5b	14.4b
TGX 1987-10F	15.7a	15.2a
SE±	0.29	0.29
Sowing Methods (P)		
Dibbling	15.3	14.9
Drilling	14.9	14.7
SE±	0.29	0.29
Weed Control Method (W)		
Pendimethalin at 2.0 kg a.i/ha	14.9	14.8b
Fluazifop-butyl at 2.0 kg a.i/ha	14.9	14.4b
Hoe weeding at 3,6 & 9 WAS	16.1	15.6a
Weedy check	14.5	14.4b
SE±	0.41	0.42
Interactions		
V X P	NS[2]	NS
V X W	NS	NS
P X W	*	NS
V X P X W	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability,

4 * = Significant at 5% level of probability.

Table 4.25: Interaction between weed control methods and sowing methods of soybean on 100 seed weight at Samaru

	Sowing methods[1]	
Treatments	Dibbling	Drilling
Weed Control (W) kg a.i/ha		
Pendimethalin at 2.0kg a.i/ha	15.3a	14.4bc
fluazifop-butyl at 2.0kg a.i/ha	13.8c	15.0ab
Hoe weeding at 3, 6 & 9 WAS	15.0a	15.4a
Weedy check	14.9ab	13.8c
SE±	0.35	

Means followed by same letter(s) are statistically similar at 5% level of probability using DMRT.

4.3.14: Grain yield (kg/ha)

The effects of crop variety, sowing method and weed control treatments at Samaru and Bagauda on soybean grain yield are presented in (Table 4.26). The effect of variety and sowing method in both locations were not significant at both locations. At Samaru, Hoe weeding at 3, 6, and 9 WAS significantly produced the highest grain yield (1166 kg/ha) than other weed control treatments (Table 4.26). While the least grain yield was obtained from the weed check (680). The effect of weed control treatment on grain yields was also significant at Bagauda, where the weeding treatments produced the highest grain yield (1034 kg/ha), which was comparable with the application of fluazifop-butyl at 2.0 kg a.i/ha (985 kg/ha) (Table 4.26). The least grain yield was obtained from the weed check (621kg/ha), followed by Pendimethalin applied at 2.0 kg a.i/ha (712kg/ha) at both locations (Table 4.26).

The interactions effect among crop variety, sowing method and weed control treatments on soybean grain yield were not significant in both Samaru and Bagauda (Table 4.26).

4.3.15: Haulm yield (g)

The effects of crop variety, sowing method and weed control treatments on soybean haulm yields are presented in (Table 4.26). None of the treatment factors showed any significant influence on haulm yield in both Samaru and Bagauda.

In the same vein, none of the treatments factors interactions had significant effect on this parameter in the two locations (Table 4.26).

4.3.16: Correlation among weed, growth, yield component and grain yield of soybean

The correlation matrix among weed parameters, crop growth and yield components and grain yield of soybean at Samaru and Bagauda are presented in Tables 4.27 and 4.28 respectively. At Samaru, soybean grain yield was highly significant and positively correlated to crop plant

Table 4.26: Effects of variety, sowing method and weed control treatments on Grain yield and Haulm yield in soybean during the wet season of 2016 at Samaru and Bagauda

	Yields			
	Samaru		Bagauda	
Treatments	Grain yield (kg)	Haulm yield(g)	Grain yield (kg)	Haulm yield (g)
Variety				
TGX 1448-2E	870	1525.0	910	1392
TGX 1987-10F	888	1373.9	766	1171
SE±	83.7	126.85	89.2	63.0
Sowing (P)				
Dibbling	837	1300	798	1418
Drilling	921	1599	879	1146
SE±	84.9	126.9	89.2	63.0
Weed Control (W)				
Pendimethalin at 2.0 kg a.i./ha	730c	1164	712b	1111
fluazifop-butyl at 2.0kg/ha	940b	1531	985a	1417
Hoe weeding at 3, 6 & 9 WAS	1166a	1842	1034a	1433
Weedy check	680c	1261.2	621b	1167
SE±	120.0	126.85	126.2	89.0
Interactions				
V X P	NS[2]	NS[2]	NS	NS
V X W	NS	NS	NS	NS
P X W	NS	NS	NS	NS
V X PX W	NS	NS	NS	NS

1 Mean followed by same letter(s) within a treatment group of any column are statistically similar at 5% level of probability using DMRT,

2. WAS = Week after sowing,

3. NS =Not significant at 5% level of probability.

Table 4.27: Simple correlation matrix among weed, crop growth, yield indices and grain yield parameter at Samaru during the 2016 wet season

	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.274*	1.00									
3	-0.502**	-0.164	1.00								
4	-0.497**	-0.153	0.011	1.00							
5	0.324*	0.142	-0.263*	0.022	1.00						
6	0.283*	0.228	-0.189	-0.155	0.916**	1.00					
7	0.336*	0.248	-0.275	-0.234	0.908**	0.924**	1.000				
8	0.361*	0.353*	-0.434**	-0.228	0.589**	0.494**	0.494**	1.00			
9	-0.487**	-0.178	0.564**	0.239	-0.352	-0.313*	-0.283	-0.537**	1.00		
10	0.143	0.012	-0.344*	-0.168	0.443**	0.425**	0.496**	0.237	-0.242	1.00	
11	0.414**	-0097	-0.403**	-0.245	0.295	0.201	0.233	0.029	-0.439**	0.278	1.00

*Significant at 5% level of probability (r = 0.282)

** Significant at 1% level of probability (r = 0.365)

1 Grain yield/kg/ha 5 Total dry matter 9 Weed density

2 Plant height 6 Crop growth weight 10 Grain weight/plot

3 Weed dry matter 7 Relative growth rate 11 100 grain weight

4 Weed cover score 8 Leave area index

Table 4.28: Simple correlation matrix among weed, crop growth, yield indices and grain yield parameter at Bagauda during the 2016 wet seasons

	1	2	3	4	5	6	7	8	9	10	11
1	1.00										
2	0.073	1.00									
3	-0.006	-0.191	1.00								
4	-0.030	-0.029	-0.273	1.00							
5	-0.175	0.042	-0.211	0.184	1.00						
6	-0.084	0.107	-0.247	0.139	0.954**	1.00					
7	-0.166	0.033	-0.253	0.159	0.905**	0.926**	1.00				
8	0.271	0.256	-0.484**	0.068	0.271	-0.395**	0.387**	1.00			
9	-0.302*	0.137	0.252	0.027	0.049	-0.007	0.091	-0.484**	1.00		
10	0.108	0.300*	-0.429**	0.046	0.195	0.196	0.061	0.098	-0.129	1.00	
11	0.038	-0.061	-0.012	0.057	0.020	0.010	-0.302*	-0.137	-0.400**	0.06	1.00

*Significant at 5% level of probability (r = 0.282)

** Significant at 1% level of probability (r = 0.365)

1 Grain yield/kg/ha	5 Total dry matter	9 Weed density
2 Plant height	6 Crop growth weight	10 Grain weight/plot
3 Weed dry matter	7 Relative growth rate	11 100 grain weight
4 Weed cover score	8 Leave area index	

height, shoot dry weight and 100 grain weight (Table 4.27) .The association between grain yield and 100 seed weight was positive but not highly significant and negatively correlated with weed cover score, weed density and weed dry matter at both locations (Tables 4.27 & 4.28). Weed density, weed dry weight and weed cover score were highly significant and positively associated with each other at both locations (Tables 4.27 & 4.28). At Bagauda, there was a positive correlation among the grain yield and crop vigour, plant height, canopy spread but none of the association was negative. 100 seed weight was positively and significantly correlated with grain yield. In both locations, it was observed that weed density, weed dry matter and weed cover score were significant and negatively correlated to other growth and yield parameters such as plant height canopy spread and crop vigour (Tables 4.27 & 4.28).

4.4 paths Analysis

4.4.1 Direct and indirect effect of some soybean growth and yield character to grain yield

A study of direct and indirect effect of the different growth and yield characters of soybean to grain yield in 2016 wet season at Samaru and Bagauda are shown in (Tables 4.29). The highest direct effect on yield was by 100-seed weight, followed by haulm yield at Samaru (Table 4.29). The least direct effect was by shoot dry weight (sdwt), which had a negative value. The highest indirect effect was by shoot dry weight via crop growth rate (CGR), followed by haulm yield via 100-seed weight, while the least was by CGR via shoot dry weight. All the indirect effect via shoot dry weight was negative.

In Bagauda (Table 4.30), the highest direct effect on yield was by 100-seed weight, followed by haulm yield at Samaru (Table 4.29). The least direct effect was by shoot dry weight (sdwt), which had a negative value. Also, the highest indirect effect was by shoot dry weight via crop growth rate (CGR), followed by haulm yield via 100-seed weight, while the least was by CGR via shoot dry weight. All the indirect effect via shoot dry weight was negative (Table 4.30).

The highest individual contribution to seed yield in Samaru was 100-seed weight, followed by shoot dry weight (Table 4.31). The least contribution was by plant height. The highest joint contribution to yield was by 100-seed weight plus CGR. The least joint contribution was by CGR and plant height followed by 100-seed weight and shoot dry weight, which had negative values (Table 4.31).

In Bagauda, the highest individual contribution to seed yield was shoot dry weight, followed by haulm yield (Table 4.32). The least individual contribution to yield was by LAI. The

Table 4.29: Direct and indirect effects of different yield characters to yield of soybean during **the wet season of 2016 at Samaru**

	Direct and Indirect contributions						
	100-seed weight	Haulm yield	CGR	Dry matter	Plant height	LAI	Total corr
100-seed weight	0.6777	0.1320	0.0741	-0.1425	-0.0063	0.0079	0.743O
Haulm	0.2155	0.4152	0.0616	-0.1198	0.0255	0.0958	0.6940
CGR	0.1362	0.0693	0.3688	-0.4425	0.0150	0.1360	0.2830
Shoot dry weight	0.1999	0.1029	0.3378	-0.4831	0.0093	0.1619	0.3290
Pltht	-0.0657	0.1611	0.0841	-0.0686	0.0658	0.0972	0.2740
LAI	0.0196	0.1445	0.1822	-0.2840	0.0232	0.2754	0.3610

Table 4.30: Direct and indirect effects of different yield characters to yield of soybean during the wet season of 2016 at Bagauda

	Direct and Indirect contributions						
	100gw	Haulm	CGR	Dry matter	Plant height	LAI	Total correlation
100-seed weight	0.085657	-0.03124	0.004493	-0.01245	-0.00726	-0.00119	0.038
Haulm yield	-0.00591	0.452766	0.012582	0.015567	0.003928	0.028067	0.507
CGR	0.000857	0.012677	0.449345	-0.59405	0.012738	0.034431	-0.084
Shoot dry matter	0.001713	-0.01132	0.428675	-0.62269	0.005	0.023622	-0.175
Pltht	-0.00523	0.014941	0.04808	-0.02615	0.119042	0.022315	0.173
LAI	-0.00117	0.14579	0.177491	-0.16875	0.030475	0.087166	0.271

Table 4.31: Percentage contribution of different growth character to yield of soybean during the 2016 wet season at Samaru

Parameters	%Contribution
Individual contribution	
s100-seed weight	35.9
Haulm	17.2
CGR	13.6
Dry matter	23.3
Plant height	0.4
LAI	17.5
Combined Contributions	
100 seed weight and Haulm yield	17.9
100 seed weight and CGR	10.0
100 seed weight and dry matter	-19.3
100 seed weight and plant height	-0.8
100 seed weight and LAI	1.0
Haulm yield and CGR	5.1
Haulm yield and Dry matter	-9.9
Haulm yield and plant height	2.1
Haulm yield and LAI	7.9
CGR and dry matter	-32.6
CGR and plant height	1.1
CGR and LAI	7.0
Dry matter and plant height	-0.9
Dry matter and LAI	-15.6
plant height and LAI	1.2
Residual	17.4
Total	100

Table 4.32: Percentage contributions of different growth characters to yield of soybean during the wet season of 2016 at Bagauda

Parameters Individual contribution	%Contribution
100gw	0.7
Haulm	20.4
CGR	20.1
Dry matter	38.7
Plant height	1.4
LAI	0.7
<u>Combined</u>	
100 seed weight and haulm yield	-0.5352
100 seed weight and CGR	0.076979
100 seed weight and dry matter	-0.21335
100 seed weight and plant height	-0.1244
100 seed weight and LAI	-0.02046
Haulm yield and CGR	1.139308
Haulm yield and dry matter	1.409665
Haulm yield and plant height	0.355729
Haulm yield and LAI	2.541599
CGR and dry matter	-53.3864
CGR and plant height	1.144709
CGR and LAI	2.522397
Dry matter and plant height	-0.62266
Dry matter and LAI	-2.94184
Plant height and LAI	0.531275
Residual	15.74691
Total	100

Highest joint contribution was by haulm yield plus LAI, The least joint contribution was by 100-seed weight plus haulm yield, followed by CGR plus LAI

4.5 Gross Margin Analysis

The results of Gross Margin (GM) analysis shows that the highest gross returns of ₦152098.00 was achieved by sowing soybean TGX 1978-10F variety at 266, 666 plants/ha using drilling method of sowing and hoe weeding at 3, 6 and 9 WAS. While the least gross margin of ₦81130 was achieved by sowing variety TGX 1987-10F, at Samaru (Table 4.33).

Also, at Bagauda, the study showed that production of soybean variety TGX 1448-2E under dibbling method of sowing and hoe weeding at 3, 6 and 9 WAS resulted to gross margin of ₦ 124013.00. While the least gross margin of ₦ 39400.00 with soybean variety TGX 1987-10F in the weedy check and drilling method of sowing (Table 4.34).

Table 4.33: Cost benefit ratio of soybean cultivation under rain feed at Samaru

Treatments	Yields (kg/ha)	Yields per bag	Average Price / bag (₦)	Total variable cost (TVC) (₦)	Gross Revenue (₦/ha)	Gross margin (GR -TVC) ₦/ha
W1P1V1	1080	10	11000	28870	110000	81130
WIPIV2	1008	10	11000	28870	110000	81130
W1P2V1	1029	10	11000	28870	110000	81130
W1P2V2	1010	10	11000	28870	110000	81130
W2P1V1	1109	11	11000	28870	121000	92130
W2P1V2	1032	10	11000	28870	110000	81130
W2P2V1	1282	12	11000	28870	132000	103130
W2P2V2	1240	12	11000	28870	132000	103130
W3P1V1	1265	13	11000	29622	143000	113378
W3P1V2	1270	13	11000	29622	143000	113378
W3P2V1	1425	14	11000	29622	156750	127128
W3P2V2	1652	16	11000	29622	181720	152098
W4P1V1	935	9	11000	24121	99000	74879
W4P1V2	876	9	11000	24121	99000	74879
W4P2V1	873	9	11000	24121	99000	74879
W4P2V2	900	9	11000	24121	99000	74879

W1 = Pendimethalin at 2.0 kg a.i./ha,

W2 = Fluazifop-butyl at 2.0 kg a.i. /ha,

W3 = hoe weeding at 3, 6, & 9 WAS

W4 = weedy check,

P1= dibbling sowing method,

P2 = drilling sowing method,

V1= TGX 1448-2E variety,

V2 = TGX 1987 -10F.

Table 4.34: Cost benefit ratio of soybean cultivation under rain feed at Bagauda

Treatments	Yields (kg/ha)	Yields per bag	Average Price / bag (₦)	Total variable cost (TVC) (₦)	Gross Revenue (₦/ha)	Gross margin (GR -TVC) ₦/ha
W1P1V1	10461	10	11000	28500	110000	81500
WIPIV2	1007	10	11000	28500	110000	81500
W1P2V1	1009	10	11000	28500	110000	81500
W1P2V2	1011	10	11000	28500	110000	81500
W2P1V1	1107	11	11000	28500	121000	81500
W2P1V2	1030	10	11000	28500	110000	81500
W2P2V1	1241	12	11000	28500	132000	103500
W2P2V2	1221	12	11000	28500	132000	103500
W3P1V1	1251	13	11000	29987	143000	113013
W3P1V2	1262	13	11000	29987	143000	113013
W3P2V1	1256	13	11000	29987	143000	113013
W3P2V2	1364	14	11000	29987	154000	124013
W4P1V1	6286	6	11000	26600	66000	39400
W4P1V2	7120	7	11000	26600	77000	50400
W4P2V1	6340	6	11000	26600	66000	39400
W4P2V2	8410	8	11000	26600	88000	61400

W1 = Pendimethalin at 2.0 kg a.i. /ha,

W2 = Fluazifop-butyl at 2.0 kg a.i. /ha,

W3 = hoe weeding at 3, 6, & 9 WAS

W4 = weedy check,

P1= dibbling sowing method,

P2 = drilling sowing method,

V1= TGX 1448-2E variety,

V2 = TGX 1987 -10F.

CHAPTER FIVE

5.1 DISCUSSION

To achieve high yield in soybean production requires good agronomic practices. The essential aspects of soybean production practices that need attention include; good varietal selection, correct sowing method, and effective and timely weed control among others. The better performance of soybean observed during the cropping season of 2016 in Samaru compared to Bagauda in the same cropping season can be attributed to the differences in climatic and soil conditions in the two sites.

The early rains recorded in Samaru (Appendix) allowed early sowing and encouraged early crop establishment and also the development of critical phases of the crop before the rain stopped. This really improved better growth and yield performance at Samaru than at Bagauda. Soybean is a worm weather crop that does well in a well-drained soil which has adequate moisture and temperature within the range of 18-35^{0c} (Odeleye *et al*. 2007). The relative humidity that was moderately high in Samaru (75.0-80.4%) was another important climatic factor that might be counted in favour of better performance of soybean at Samaru compared to what was obtained at Bagauda, where the condition was drier and the relative humidity lower with average of 10.0-46.8%. In addition to this, the better crop performance at Samaru could also be due to the higher available phosphorous content of the experimental site at Samaru (10.34mgkg^{-1}) compared to Bagauda with (2.75mgkg-^{1}) (Table 4.1).

Phosphorus is an important nutrient that is required in large quantity, especially for leguminous crops such as soybean (Dozomeku *et al.2006*). The lack or inadequate phosphorus may lead to stunted growth, suppression of pod formation and grain filling. This assertion corroborates the findings of (Khan and Asif, 2005). Who reported that low levels of soil nutrients such as available P, total N could make crops unable to optimally utilise the nutrient elements thereby, leading to reduction in growth and yield of soybean.

Higher weed cover score and weed density were recorded in Samaru compared to Bagauda. This may be due to high rain that fall less than an hour after glyphosate was applied during land preparation at Bagauda. The rain might have leached the herbicide beyond the action zone of the soil, which might reduce the efficiency and efficacy of the herbicide on weeds. This is in support of the report by Das (2008), who observed that heavy rain fall washed away both foliar and soil- active herbicides and reduced their efficacy and efficiency. Moderately good grain yield and yield attributes were achieved at both locations. This may be as a result of adequate moisture and longer and high light intensity during the critical growth stages of the crop plants.

5.2 Effects of Variety on Weeds and Crop Growth and Yield

All the weed control treatments generally reduced weed cover score and weed dry weight throughout the cropping period, compared to the weedy check in both locations. The variety TGX 1448-2E produced taller crops with more number of leaves and wider canopy cover, which could help to supressed weeds and enhance more assimilate production for pod formation than variety TGX 1987 -10F. This can therefore, be attributed to the inherent genetic make-up of the variety, which was expressed during growth. This collaborate the findings of (Wicut et al., 1996), who reported that soybean varieties had varying genetic and phenotypic traits. At Samaru and Bagauda, weedy check had significant higher weed cover scores and weed dry matter than all other weed control treatments. The effect of weed control treatment was significant at 2WAS at Samaru and 12WAS at Bagauda .At Samaru variety TGX 1987-10F recorded higher weed cover score and produces more weed dry matter than variety TGX 11448-2E. This may be due to the fact that variety TGX 1987-10F has a slender stem and it is less robust, features that can inhibit early canopy formation and prevent closure to smother weeds. This observation agreed with the finding of Harder *et al*. (2007), who reported that crop growth attributes such leave area index; plant height, canopy cover, among others, were superior characters that can help to supress weed growth and reduce competition with crop.

The response of variety to canopy spread was significant in both Samaru and Bagauda in which TGX 1448-2E significantly had more canopy cover at 6 and 9 WAS. This fact buttressed the findings of (Joshi *et al.,* 2013), who reported that significant differences exist among soybean genetic make-up, which are exhibited in their phenotypic expression. Also, variety has significant effect on the plant height, canopy spread, LAI and 100 grain weight. But at Bagauda, the effect of variety was not pronounced with respect to plant height, LAI and canopy spread. At Samaru and Bagauda, variety TGX 1987-10F produced the heaviest 100 seed weight and highest grain yield compared to TGX 1448-2E.

5.3 Effects of Sowing Method on Weed, Crop Growth and Yield

The effect of sowing methods on weed was significant in both locations. It was observed that dibbling method of sowing soybean had highest weed dry weight and weed cover score at both locations especially at 9WAS sampling period. Drilling method of sowing produced less weed dry weight and weed cover score which revealed that sowing soybean by drilling method, help to stimulate early and effective canopy formation as well as closure for weed control. This collaborate the findings of (Dzomeku *et al*., 2006), who reported that shading of weed by early formation of canopy by soybean planted by drilling method helps to control weed and improved yield of crop plant.

The result of this research showed that the drilling method of sowing soybean gave significantly the highest dry biomass and increase yield in both Samaru and Bagauda. The biomass was more in drilled soybean because there were more plants on the ridges which result to more yield and increase dry biomass. This is in line with the findings of Olufajo

(1990), who reported that yield and yield attributes of soybeans increase with increase in plant population per unit area. Drilled soybeans can out-yield dibbled soybean, but care need to be taken to ensure that the seeds are placed at a uniform sowing depth. Some potential gains from drilling may be offset by inconsistent sowing depth Chiezey (1999).

5.4 The Effect of Weed Control Treatments on Weeds, Crop Growth and Yield

Hoe weeded plots gave significantly lower weeds cover scores and weed dry matter than other weed control treatments. This may be due to complete uprooting of the weed during hoe weeding periods. This corroborates the findings of Das (2008), who reported that soybean yields were low under weed infestation. Weed at the critical growth period such as pod filling is detrimental and it can cause competitions for environmental factors such as nutrient, sunlight, water and space, leading to high yield reduction in soybean. In both locations, Pendimethalin at 2.0 kg a.i/ha resulted in lower weed cover score and weed dry weight than fluazifop-butyl at 2.0 kg a.i./ha. This may be due to the suppressive effect of Pendimethalin on noxious and aggressive annual weeds like *Rottboellia cochinchinensis* and *Ancathuspermum hispidium*, which were dominant during the trial. This collaborate the findings of Anon (1995) who reported that Pendimethalin at 1.5 – 2.0 kg a.i./ha gave total control of grass weed seedlings. Many researchers have reported reduction in weed dry matter production due to herbicide applications in various leguminous crop (Reddy, 2002; Ishaya, 2004). Growth parameters of varieties of soybean such as stand count, plant height, crop vigour scores, shoot dry weight, leaf area index (LAI) crop growth rate (CGR), relative growth rate (RGR), days to first flowering, and 50% flowering were not significantly influenced by weed control treatments. In both Samaru and Bagauda, hoe weeding, plot treated with the application of 2.0kg a.i./ha of fluazifop-butyl applied as post emergency at the same rate and weeding check had significantly higher crop emergence count or stand count at 3 WAS than the plots treated with 2.0kg a.i/ha of Pendimethalin Chiezey *et al.*, (2001). The canopy spread was significantly enhanced by all the weed control treatments compared to the weedy check in both locations. This is because growth factor such as nutrient, water, light and space are more available in a weed free farm, which encouraged good leave formation both in the number of leaves and the size of the leaves. This observation is in line with the findings of Conner *et al*. (2004), who reported more leaves in sesame crop resulting from application of Pendimethalin at 2.0kg a.i/ha plus metholachlor at 1.5kg a.i/ha. In both Samaru and Bagauda at 6 and 9 WAS, weedy check recorded more crop vigour than other weed control treatments. This is because of the phototoxic effect of the herbicide on the treated plots and root injury in hoe weeded plots. However, the weedy check recorded the least crop vigour score in all the sampling periods and in both locations. This was due to unchecked weed competition for resources that led to lower crop vigour. The yield parameters such as grain weight, grain yield were increased considerably under Pendimethalin herbicide and hoe weeding. The good performance of soybean under hoe weeding and herbicide as compared to the weedy check could be attributed to better weed control that was provided by the other treatments.

5.5 Interactions

The interaction place between the weed control treatments and sowing methods revealed that the combination of weed control treatment with sowing methods had significant influence on plant height in which higher plants were recorded when hoe weeding was combined with drilling method of sowing. This may be as a result of good weed control ability of hoe weeding couple with early canopy cover of the drilled crop that culminate into effective weed control. In this case, weed competition with crop plant was reduced. Thus, there was adequate growth and development. On the other hand, drilling method of sowing with each weed control treatment helped to reduce the weed and suppressed compared to weedy check. Close spacing help to reduce weed competition and increase effective use of growth factors. Grichar *et al*. (2004) reported that efficient weed control in a narrow spacing of soybean than the wider spacing.

Variety TGX 1448-2E planted by drilling method produced significantly wider canopy cover. This may be attributed to the fact that variety TGX 1448-2E is taller and robust when planted with drilling method which encourages canopy cover.

5.6 Correlations and Path Analysis

The correlation matrix shows a significant relationship between grain yield and growth parameters which include plant height, canopy cover, crop vigour, crop growth rate, relative growth rate, 100 seed weight, grain weight and total dry weight which influence the vegetative growth and photosynthetic ability of the crop in both Samaru and Bagauda shows the importance of these yield component to soybean yield. The result revealed that an increase in any of these parameters would invariably contribute to grain yield. The highly significant and positive correlation ($p \geq 0.01$) exhibited between soybean yield and growth characters such as leaf area index, canopy spread in both location was probably due to the fact that these vegetative attributes directly determine the extent of photosynthesis and the amount of assimilates that were available for crop plant growth and grain yield production (Chiezey *et al.*, 1992)

.The path analysis and the percentage contribution revealed that among the growth and yield characters selected, dry matter production and haulm weight made the highest positive contribution of 38.7% and 20.4% respectively to soybean yield. This shows that the characters were most critical determinants of yields in soybean. Thus, constitute important characters that should be considered by breeders during any breeding programmes. The other growth and yield parameters assessed made their highest indirect contribution through plant height and seed yield. This also buttresses their importance for yield in soybean production Olufajo (1990).

5.7 Economic Analysis

Economic analysis was carried out using the prevailing market prices for inputs at sowing and for outputs at the time the crop was harvested. All costs and benefits were calculated on hectare basis in naira. The following concepts used in the partial budget analysis are defined as Mean grain yield is the average yield (t/ha) of each treatment. The average yield was adjusted downwards by 10%. The adjusted yields represent the potential yield from the farmer's field using the same treatments. The gross field benefit was calculated by multiplying the field price by the adjusted yield. The net benefits were calculated by subtracting the total costs that vary from the gross field benefits for each treatment.

5.8 Cost Analysis

The main aims of cost analysis of the soybean production enterprise were to determine the cost and returns of operations and corresponding level of profit. The cost is made up of all the expenses incurred during the production processes. The revenue was the amount of money realised from the sales of soybean obtained per the treatment imposed. The outcome of the gross margin analysis indicated the range of ₦6, 930.00 – ₦270, 378.00. The lower profit achieved is attributed to the lower yield obtained from the combination of weed control treatment, sowing method and variety which was not adapted to the environment and as a result, did not performed very well. The result of the cost analysis (CA) in this work shows that soybean production in the study area is an economically profitable enterprise. The positive average gross margin (GM) obtained in this study is a clear pointer that a good input – output relationship exist for soybean cultivation under rain fed production. Additional profit can be obtained from the sales of dry haulms at a time when is values is very high due to scarcity and high demand.

CHAPTER SIX

6.0 Summary, Conclusion and Recommendations

Field experiment was conducted during rainy season of 2016 at Samaru located in latitude 11^{o} 11'N and longitude 07^{0} 38'E 686 metres above sea level in the Northern Guinea savannah and at Bagauda located 11' 37N, 8 ^{o} 23' E, 500 metres above sea level in the Sudan savannah ecological zone of Nigeria to study the performance of soybean varieties as influenced by sowing method and weed control treatments. The experiment consist of two varieties of soybean (TGX 1448-E and TGX 1987-10F), two sowing methods dibbling and drilling as well as four weed control treatments Pendimethalin at 2.0 kg a.i./ha, Fluazifop-butyl at 2.0 kg a.i./ha, hoe weeding and weedy check.

The treatments were laid out in a split plot design with sowing method and weed control treatments in the main plot while varieties were assigned to the sub-plot. The data collected are weed cover score, weed density, weed dry weight, crop injury, stand count, crop vigour score, plant height, canopy spread, shoot dry weight, leave area index, crop growth rate, relative growth rate, days to first flowering, 50% flowering, seed weight per plant,100 seed weight and grain yield. The result shows that weed density and weed dry weight were significantly decreased by the weed control treatments. The hoe weeded plot recorded higher crop vigour, plant height, canopy cover and crop growth rate.

The yield parameters such as total dry weight, 100 seed weight, and grain yield weight were significant. The hoe weeded control treatment was observed to significantly increase growth and yield parameters. The variety TGX 1448-2E recorded less weed cover and weed dry weight. It produces the tallest plant and most vigorous crop with wider canopy and had the highest grain yield at both locations. The drilling method of sowing recorded less weed dry weights, weed cover score and produced significant more vigorous crop with wider canopy and heaviest total dry weight.

There was positive and significant relationship between soybean yield and growth parameter such as height, crop vigour, canopy cover, total dry weight 100 seed weight as well as grain yield weight. However, there was negative and significant association between grain yield weight and weed cover scores and also weed dry weight.

In conclusion, the result from the study shows that hoe weeding at 3,6 and 9 WAS, fusillade applied as post emergence at 2.0 kg a.i/ha and drilling method of sowing resulted in effective weed control and recorded the highest grain yield in both locations. Variety TGX 1448-2E performed better than the TGX 1987-10F during the rainy season of 2016 at Samaru and Bagauda.

It is therefore recommended that:

- Post emergency application of Fluazifop-butyl at 2.0 kg a.i. /ha, is more effective in controlling weed in soybean in the Nigerian savannah.
- Drilling method of sowing soybean should be considered for better performance of soybean in the Nigerian savannah
- Soybean variety TGX 1448-2E is more adapted and has ability to produce more grain yields with better and efficient weed suppression ability for a season long weed control.

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APPENDICES

Appendix I: Mean rainfall (mm), mean temperature (^{0}C), mean sunshine hours, mean relative humidity (%) and number of rainy days in 2016 wet season at Samaru.

Month	Rain fall (mm)	Temperature ^{0}C Max	min	Relative humidity (%) 10.00am	4.00pm	Sunshine hours day^{-1}	Rainy days
June	4.4	31	23	76	65	7	14
July	7.1	31	23	80	71	5	10
August	8.7	31	22	82	74	6	16
September	11.5	NA	25	77	NA	6	15
October	00	33	18	58	53	8	00

NA= Not available

Source: IAR Metrological unit, Samaru-Zaria, Kaduna

APPENDIX II

Mean rainfall (mm), mean temperature (^0C), mean sunshine hours, mean relative humidity (%) and number of rainy days in 2016 wet season at Bagauda.

Month	Rain fall (mm)	Temperature ^0C Max	min	Relative humidity (%) 10.00am	4.00pm	Sunshine hours day^{-1}	Rainy days
June	5.0	29	30	49	36	00	11
July	6.2	28	28	56	47	00	11
August	7.5	30	21	60	52	4	10
September	3.5	35	30	50	38	5	4
October	0.6	36	29	43	34	5	2

Source: Bagauda metrological unit Kano

BIBLOGRAPHY

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Mount Carmel College Ilorin KW/ST	1990-1995	O'Level Certificate
Abubakar Tafawa Balewa University,	1998-2002	B.Tech. Agric. (ATBU) Bauchi
Ahmadu Bellow University, Zaira,	2015-to date	MSc. (in view)
Working Experience	Period	Rank
National Population Commission, FCT Abuja	2003-2005	Census facilitators
Osi Community high Sch., Osi Ekiti	2006-2012	Senior Tutor
FCT Secondary Education Board, Abuja.	2012-to date	Exams Officer 11
Hobbies		Swimming and Travelling
Year of Admission into Master Program		2015
Admission no:		P14AGAG8007

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