EFFECTS OF VARIETY AND PRE-EMERGENCE HERBICIDES ON YIELD AND ECONOMIES OF GROUNDNUT (*Arachis hypogaea* L.) PRODUCTION IN YOLA, NORTHERN GUINEA SAVANNA OF NIGERIA

KOROMA, S.A.
Department of Agriculture and Natural Resources, Song Local Government Area, Adamawa State, Nigeria

ABSTRACT

Field trial was conducted during the 2017 and 2018 rainy seasons at the experimental farm site of the Department of Crop Production and Horticulture, Moddibo Adama University of Technology, Yola North Eastern, Nigeria to study the effects of varieties and weed control treatments on the yield of groundnut (*Arachis hypogaea* L.) crop and to determine the cost – benefit of controlling weeds in groundnut. The experiment consisted of two groundnut varieties (SAMNUT 23 and KAMPALA) and 11 weed control treatments comprising of 3 different pre-emergence herbicides (Metolachlor, Butachlor and Pendimethalin) at 0.75, 1.0 and 1.25 kg a.i./ha + Supplementary hoe weeding (SHW) at 6 weeks after sowing (WAS) while weed-free check (hoe weeding at 3 and 6 WAS) and weedy check were included as control. The treatments were laid out using split-plot in a randomized complete block design with variety designated to the main plot and pre-emergence herbicides rates applied in the sub-plots and replicated three times. Data were collected on some plant, yield, weed and economic analysis characters of groundnuts. The data collected were analyzed statistically using Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was used to separate their means at 5% level of probability. The results showed that SAMNUT 23 variety recorded significantly the tallest plants, the widest canopy spread, the highest weed control efficiency, kernel yield, production cost/ha, net return/ha and the largest cost-benefit ratio than "KAMPALA" while "KAMPALA" achieved significantly the highest number of branches and haulm yield compared to SAMNUT 23. Both varieties obtained CBR of greater than 1.0 value. Among the weed control treatments, weed free check performed tremendously on growth, yield, weed control and economic analysis characters while weedy check performed poorly. Among the pre-emergence herbicides rates, metolachlor at 0.75kg a.i/ha + SHW at 6WAS produced the highest number of branches, widest canopy spread and the highest haulm yield/ha, metolachlor at 1.0kg a.i/ha + SHW at 6WAS recorded the highest kernel yield/ha, net income and the highest cost-benefit ratio (CBR). All herbicides treated plots achieved CBR of greater than 1.0 value. In conclusion, both SAMNUT 23 and KAMPALA varieties are recommended for profitable groundnut production. Also, metolachlor at 0.75, 1.0, 1.25 and Pendimethalin at 1.0 kg a.i./ha + SHW at 6WAS are also recommended for use as an alternative to two-hoe weeding (weed free check) for higher haulm yield, kernel yield and net return/ha of groundnut production in Yola, Nigeria.

Key words: Economies, groundnut, pre-emergence herbicides, variety, yield
Correspondence: akeweta@gmail.com, 08085020704

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), also known as peanut is one of the world's most important oil seed crop [1] ranking the 13th most important food crop and the 4th oil seed crop in the world [2]. It is an ancient crop which is believed to have originated from Eastern Bolivia at the foothills of the Andes, where there is a very important Centre of variability for the subspecies - *hypogaea* [3]. According to Onwueme and Sinha [4], Portuguese navigators introduced groundnuts from South America to Africa, India, and possibly other areas. Today, the crop is being cultivated in more than 100 Countries of the World [5] and widely grown in the tropics and subtropics [6]. Ajeigbe *et al.* [7] reported that in 2012, the World total land area of 24.6 million hectares was cultivated with groundnuts producing 41.3 metric tons and productivity of 1676 kg/hectare. China, India, Nigeria, United States of America and Myanyar were the leading groundnut producing countries in the World. It further stated that Asia with 11.6 million hectares (47.15%) and Africa with 11.7 hectares (47.56%) hold maximum global area under groundnut cultivation. Developing countries in Asia, Africa and South America account for over 97% of World groundnut area and 95% of global total production. However, the productivity of Asia (2,217kg /ha) and Africa (929 kg/ha) is very poor as compared to America's 3,632 kg/ha [8]. Adekanmi *et al.* [9] reported that in 2014, the World groundnut production in shell basis in metric tons was more than 36.6 million. It explained that China was the main producer country with 13 million metric tons (36%) of World production), followed by India with 5 million metric tons (14%), Nigeria, 3 million metric tons (8%), U.S.A, 2.25 metric tons, Indonesia, 1.15 million metric tons, Argentina, 1.08 million metric tons and Senegal with 1.0 million tons. Groundnuts can be consumed raw, boiled, roasted, salted, or be processed into groundnut candy or peanut butter [10]. Apart from its direct consumption, groundnut is also used in processed food and snacks and approximately one third of its world production is used in the manufacture of confectioneries [11]. It is also used as feed for livestock [7] and in industries for manufacturing pharmaceuticals [12]. In developing countries such as Nigeria where the cost of animal protein is very high, groundnut serves as a good alternative source of animal protein [13]. In the farming system of Nigeria, groundnuts feature in intercrop with cereals as well as a rotation crop due to its ability to fix atmospheric nitrogen thereby improving soil fertility [14].

Despite the tremendous benefits of groundnuts to humans and the livestock, several factors such as weed infestation, pests and diseases, poor soil fertility, lack of high yielding varieties [7], poor market prices etc. affect its productivity. Among these problems, weed infestation have been reported to be the most important factor of production. Thamizhiyan *et al.* [15], noted that weed is one of the major concerns in the cultivation of groundnuts in India. It further reported that about 74-92% of groundnut yield is affected by weed infestation. Jat *et al.* [16] also stated that groundnut crop is highly susceptible to weed infestation because of its slow growth in the initial stages up to 40 days, short plant height and underground pod bearing habit. In addition, Singh and Osawalt [17] reported that 100% losses in groundnut yield at ICRISAT Center was caused by weeds and Zimdhal [18] observed that groundnut yield decreased with time of weeds interference and type of weeds species, therefore recommended that the crop should be weeded during its early crop growth stage.

In most developing countries, manual weeding is the major method for control of weeds. According to Adigun and Lagoke [19], the traditional method of weed control, namely, hoe weeding is the commonest method of weed control practiced by farmers in the Sudan savanna zone of Nigeria is labor intensive, expensive and strenuous and can also cause mechanical damage to growing branches and roots of plants, chemical weed control is a better supplement and forms an integral part of modern crop production. Zimdhal [18] stressed that the high loss in groundnut yield has created a wide scope of using herbicides in groundnut crop. He added that chemical weed control has revolutionized farmers approach to weed control in the world and stressed that the use of herbicides is more profitable in the production of various crops in Nigeria than hoe-weeding. However, the type and rates at which the herbicides are applied vary from one location to the other due to the variation in soil types, type of weed flora, prices and availability of the herbicides in the locality. In the study area, farmers do not follow the directives for use of the herbicides written on the labels. As a result of this, the cost of use of the herbicides in groundnut production may not be profitable and effective. It is therefore necessary that all groundnut production factors be managed in such a way that the output is at profit and not at loss taking into consideration, the current market prices for both the inputs and the resultant crop output. In view of this, the study seeks to determine (i) the performance of two groundnut varieties (SAMNUT 23 and “KAMPALA”) under three types of pre-emergence herbicides at three rates (ii) assess the profitability of the two varieties of groundnut and the three types of pre-emergence herbicides at three rates.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Research and Teaching farm of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola during 2017 and 2018 rainy seasons. The Experimental site lies between Latitude $12^0 30' 13.8''$ and $12^0 30' 14.0''$ and longitude $09^0 21' 14.3''$ and $09^0 21' 16.3''$ [21]. Yola is located at altitude 200m above sea level within the Sudan savanna ecological zone. It has an annual rainfall of 900 mm to 1100 mm [22].

Experimental treatments and design

The experiment consisted of two groundnut varieties (SAMNUT 23 and KAMPALA) and 11 weed control treatments comprising of 3 different pre-emergence herbicides (Metolachlor, Butachlor and Pendimethalin) at 0.75, 1.0 and 1.25 kg a.i./ha + Supplementary hoe weeding (SHW) at 6 weeks after sowing (WAS) while weed-free check (hoe weeding at 3 and 6 WAS) and weedy check were included as control. The treatments were laid out using split-plot in a randomized complete block design with variety designated to the main plot and pre-emergence herbicides rates applied in the sub-plots and replicated three times. The plot size was 2 m x 3 m (1.875 m^2 net plot area) placed at the distances of 0.5 m between main and subplots and 1.0 m between replicated blocks

Cultural practices

Cultural practices were carried out on land preparation, fertilizer application, seed treatment, sowing and spacing, weeding, pests and diseases control, and harvesting

Data collection

Data were collected on the following:

Number of branches/plant: Number of groundnut branches per plant was obtained by counting the branches of randomly five sampled plants in the net plot and the average obtained to represent the plot at 4, 8 and 12 WAS.

Plant height /plant (cm): The groundnut main stem height per plant was obtained by measuring the height of randomly five sampled plants in net plot from the ground level to the tip of the stem and average obtained and recorded to represent the plot at 4, 8 and 12 WAS.

Canopy spread / plant (cm): The canopy spread of five randomly sampled plants were measured from the last leaf on one side to the last leaf on the other side in perpendicular directions using a measuring tape in centimeters at 4, 8, and 12 WAS, and the average canopy spread was determined and recorded.

Haulm yield (dry groundnut biomass) (kg/ha)

Groundnut plants were harvested from the net plot area, sun dried, weighed and used to compute the total haulms yield per hectare using the formula:

$$\text{Dry haulm yield} = \frac{\text{weight of haulm/net plot (kg)}}{\text{Net plot Area } (m2)} \text{ X } 10{,}000\text{m}^2$$

Kernel yield /ha

The kernel yield/ha was computed from seed yield per net plot area using the formula:

$$\text{Kernel yield (kg/ha)} = \frac{kernel \text{ weight } per\ net\ plot(kg)}{Net\ plot\ Area(m2)} X\ 10{,}000m^2$$

Weed control efficiency (WCE) (%)

The weed control efficiency of the treatment was calculated at harvest using the formula below

$$\text{WCE (\%)} = \frac{\text{DM of weeds in unweeded plot} - \text{DMof weeds in treated plot}}{DM\ of\ weeds\ in\ unweede\ plot} x\ 100$$

Where DM = Dry matter

Weed index

Weed index was calculated by using the following formula.

$$\text{Weed Index} = \frac{\text{Yield from the weed free check} - \text{Yield from the treated plot}}{\text{Yield from the weed free check}} x100$$

Production cost (N/ha)

The estimated cost of variable inputs obtained from field trial record and the farmer practice in the study area (Yola) in 2017 and 2018 rainy seasons was used for calculating production cost/ha for each treatment.

Net return (N/ha)

The net return/ha was estimated using the prices paid for kernel yield and haulm yield of groundnut at farm gate prices in 2017 and 2018. At harvest in 2017, the prices paid for grains and haulms at gate market price were N166.70/kg and N5000.00 /ton respectively while in 2018, the farm gate prices for these products were N166.70/kg and N6000.00/ton in the same order.

Cost- benefit - ratio (CBR)

Cost - benefit - ratio was calculated by using the formula given below.

$$\text{CBR} = \frac{\text{Net return (N/ha)}}{\text{Cost of production (N/ha)}}$$

Data analysis

Data collected from the experiment were subjected to analysis of variance (ANOVA) for split-plot design and Duncan's Multiple Range Test (DMRT) at 5% level of probability was used to separate between the treatment means [23].

RESULTS AND DISCUSSION

The data pertaining to the cost of variable inputs for the cultivation of groundnut in 2017 and 2018 rainy seasons in Yola is presented in Table 1. The cost of variable inputs used for computing the production of groundnut/hectare was higher in 2018 than 2017 rainy season. Several factors may be associated with annual variation in production cost. According to Jonathan [24] variable costs can be influenced by the production volumes, but "fixed" costs are generally the same each year regardless of volume.

The effect of variety on number of branches per plant was not significant but numerically differed in the two years of study with ''KAMPALA'' variety recording the highest number of branches per plant than SAMNUT 23 that had the lowest number of branches per plant (Table 2). This could possibly be due to differences in the genetic compositions of the varieties influenced by weather conditions of the two rainy seasons. The result is similar to the report by Stephen [25] who observed that there was no significant difference on number of branches per plants between Adepa, Azivivi Jenkaah and Nkosour varieties of groundnut in the major season.

Plant height was significantly affected by the variety in the early growth period (at 4WAS) (Table 2), but was not influenced in the later growth periods (at 8 and 12WAS) in the two seasons. SAMNUT 23 variety recorded taller plant heights than ''KAMPALA'' variety possibly due to variation in growth rate of the varieties at the early stage of crop growth, but was not influenced in the later growth periods (8 and 12WAS) in the two seasons. According to Sathya-Prya *et al.* [26], groundnut is highly susceptible to weed competition in the early crop growth stages due to its slow growth in the initial stage up to 40DAS. Bala *et al.* [14] also reported that SAMMNUT-23 obtained significantly higher crop growth rate (CGR) during 3-6 WAS than SAMMNUT-22 variety whereas during other two growth periods (6-9 and 9-12WAS), the two varieties did not differ in their CGR values. On the other hand, canopy spread was affected by the variety in the early growth period (4WAS), but was not influenced at that later growth period (8 and 12WAS) in the two seasons (Table 3). This could be attributed to the variation in canopy spread growth habit of the crop. In a similar study, Usman [27] reported that SAMNUT 11 produced the widest canopy spread at 6, 9 and 12WAS than SAMNUT 23 and SAMNUT 22 that was at par with each other in two rainy seasons. He attributed the differences in the growth habit to variation in genetic make-up and gene interaction with the environment.

A critical review on effects of weed control treatments on growth parameters indicated that number of branches/plant (Table 2) and canopy spread/plant (Table 3) differed significantly while plant height/plant (Table 2) did not significantly differ, but numerically affected by the weed control treatments. In all cases, weed free check and the herbicides treated plots had the highest number of branches, widest canopy spread and tallest plant heights per plant compared to the weedy check. The probable reason for the weed free check and herbicides treated plots recording the higher growth values could be attributed to better weed control that allowed vigorous growth of the crop and the development of greater number of branches, canopy spread and plant heights while the low performance of weedy check in relation to the growth traits could be attributed to the effect of weeds due to crop-weed competition for growth resources including nutrients, moisture, sunlight and space. Several scholars reported similar observations. For instance, Jadhav *et al.* [28] studied the effects of weed control methods on growth and yield of groundnut and reported that the highest number of branches was recorded under weed free check and the lowest obtained from weedy control treatment. Similarly, Garko *et al.* [29] also studied the performance of groundnut varieties as influenced by weed control treatments and reported that weedy check treatment recorded the lowest canopy spread compared to weed free control and herbicides treated plots.

Among the effect of herbicide treatments on number of branches per plant (Table 2), despite the fact that metolachlor and Butachlor at 1.25 kg a.i./ha + SHW at 6WAS had the highest weed control efficiency at 4WAS in both years, metolachlor at 0.75 and 1.0 kg a.i./ha + SHW at 6WAS obtained the highest number of branches per plant in the two seasons; while the highest dose rate of 1.25 kg a.i./ha + SHW at 6WAS of the three herbicides recorded the lowest number of branches/plant at 4WAS and later at 8 and 12WAS, achieved the highest number of branches/plant indicating the recovery from phytotoxic effect of the dose rate. metolachlor at 0.75 and 1.0 kg a. i. /ha + SHW at 6WAS obtained the highest number of branches/plant at 4WAS possibly as a result of low phytotoxic effect of the rates at the crop growth stage. metolachlor at 0.75 kg a.i./ha was able to maintain the highest number of branches/plant possibly due to the crop vigor recorded by the treatment at the initial stage of development. According to Imoloame [30], phytotoxic effects of herbicides at higher rates might cause depressive effects on crop growth. The result is similar to that obtained by Jadhav *et al.* [28] who observed that Oxyfluorfen 23.5 EC + hoe weeding at 45DAS recorded significantly, the highest number of branches at 30 DAS while at 60 and 90DAS, Pendimethalin at 1.0 kg/ha at 2DAS + hoe weeding at 45DAS recorded the highest number of branches/plant of groundnut.

Similarly, among the effect of herbicide treatments on plant height and canopy spread/plant, the result indicated that plant height was not significantly affected, but numerically influenced. Plant height was not affected possibly due to the growth habit of the weed species found in the experimental site. The weed flora of the site was dominated by 70% broadleaf weeds whose growth habit were prostrate, spreading with semi upright stems that did not influence plant height of the groundnut crop. This is an indication that crop-weed competition for sunlight was minimal.

According to Mizra [31], plant height defines an effective component of competitive struggle for sunlight. Similar findings by Oyewole *et al.* [32] indicated that weeding regime did not translate into statistically significant plant height variation among the groundnut crop. Dauda, [33] also reported that the effects of herbicide levels on main stem height at 3, 6 and 9WAS of groundnut was not significant at Mubi and Yola in 2012 growing season. On the other hand, canopy spread was adversely affected by herbicide treatments. At most sampling periods, Metolachlor at 0.75 and 1.0 kg a. i./ha + SHW at 6WAS recorded the highest canopy spread per plant. This could be attributed to the low phytotoxic effects of the rates and their ability to manage crop-weed competition to moderate weed control efficiency. The prostrate and spreading growth habits of both the weed flora and the groundnut crop could have contributed to herbicides treatments achieving significant differences on canopy spread as both of them compete for space. Although the crop-weed competition will be less in fields that possesses higher percentage of broadleaf weeds than plots that compose of higher percent of grass weeds. According to Wilcut [34], annual and perennial grasses are more competitive and detrimental to groundnut than annual and perennial broadleaf weeds.

The result in this report is in conformity with the study on common ragweed interference in peanut by Clewis *et al.* [35] who noted that ragweed grew taller than peanut throughout the growing season and did not affect canopy diameter. They considered the competition between peanut and common ragweed for light to be primary and hence concluded that ragweed is very competitive in peanut production.

Haulm yield (Table 4) was significantly affected by the variety in 2017, but numerically differed in 2018. In all cases, ‘‘KAMPALA’’ variety recorded the higher values compared to SAMNUT 23 variety. This could be attributed to the highest number of branches recorded by ‘‘KAMPALA’’ throughout the sampling period in the two seasons. Harrison *et al.* [36] reported similar results in 2009 when they studied the phenological development and yield of three groundnut varieties as influenced by plant density in a Forest-savanna. They noted that Azivivi and Nkosour variety produced higher haulm yield of groundnut due to their higher number of branches than Shitaochi variety. Similarly, the haulm yield of groundnut was also affected significantly by weed control treatments in both 2017 and 2018 rainy seasons. The weed free check treatment recorded the highest haulm yield while weedy check treatment produced the lowest haulm yield. Among the herbicide rates in 2017, metazachlor at 1.0 kg a.i./ha + SHW at 6WAS which was significantly at par with all other rates except butachlor at 0.75 kg a.i./ha + SHW at 6WAS recorded the highest haulm yield next to weed free check treatment, while in 2018 rainy season, metazachlor at 0.75 kg a.i./ha + SHW at 6WAS produced the highest haulm yield next to weed free check treatment indicating that uncontrolled weeds suppressed the growth of the crop in weedy check plots. In a related study, Gunri *et al.* [37] reported that pre-emergence application of pendimethalin at 1.0 kg a.i./ha along with one hand weeding recorded the highest haulm yield as compared to post-emergence herbicides treatments and ascribed it to weed suppression by the pre-emergence application of pendimethalin at early crop growth stage which allowed the development and growth of the crop to obtain the highest haulm yield. Garko *et al.* [29] also reported that the application of metolachlor at 1.0 kg a.i./ha + fluafob-p-butyl at 1.0 kg a.i./ha produced the highest plant dry weight as weedy check recorded the lowest plant dry weight among other herbicides treatments.

The effect of variety on kernel yield (kg/ha) differed numerically in 2017, but significantly affected in 2018 (Table 4). In all cases, SAMNUT 23 variety had higher values compared to the ‘‘KAMPALA’’ variety. The outstanding performance of SAMNUT 23 variety over ‘‘KAMPALA’’ variety could be due to the genotypic variation between the two varieties. This result is similar to the report by Jadhav *et al.* [28] who observed that SAMNUT 23 variety had the highest mean grain yield in 2012 and 2013 compared to SAMNUT 22 variety and one improved local variety studied in transitional rain forest and savanna grassland agro-ecologies of Sierra Leone. They considered SAMNUT 23 variety to be high yielding than SAMNUT 22 variety and the improved local variety concluding that SAMNUT 23 variety is more efficient in manufacture of assimilates and partitioning of the reproductive sink. As per the effect of weed control treatment on kernel yield, it was observed that weed free check treatment recorded significantly the highest kernel yield (kg/ha) compared to the weedy check treatment, and all other herbicide rates in 2017 and 2018 rainy seasons. Among the herbicide rates, metazachlor at 1.0 kg a.i./ha + SHW at 6WAS which was at par with pendimethalin at 1.0 kg a.i./ha +SHW at 6WAS and metazachlor at 0.75 kg a.i./ha + SHW at 6WAS had the highest kernel yield (kg/ha) compared to the lowest yields obtained by these herbicides applied at the highest rates. The highest yields achieved by butachlor, metolachlor and pendimethalin at lower rates could be attributed to none or lesser phytotoxic effect while the reverse could be the case with higher herbicides rates recording lower kernel yields. According to Khan *et al.* [39] toxicological effects of various herbicides on legumes have been reported by different scholars and Almas *et al.* [40] added that the magnitude of toxic effects of herbicides depends primarily on the type and dose of compounds, duration of exposure, species and age of plants, and environmental factors. In the study of the effects of herbicides on growth, nodulation and nitrogen content of green gram, Almas *et al*. [40] also noted reported that kernel yield declined consistently with dose for all herbicides except fluchloralin. On the other hand, Yohanna *et al.* [41] applied different rates of pendimethalin (ranging between 0.5-3.0 kg/ha) and reported that there were no significant effects on Bambara groundnut.

The weed parameters studied (Table 5) included weed control efficiency/m^2 at 12WAS and weed index at harvest of groundnut. Among the two parameters, none of them was affected by the variety in the two rainy seasons. Weed index was not affected by the variety in the two rainy seasons indicating that variety had neither contributed to increased nor decreased yield of groundnut due to herbicides treatments. On the other hand, the effect of pre-emergence herbicides treatments was significant on both weed control efficiency at 12WAS and weed index at harvest. In both cases, weedy check treatment recorded the lowest and highest weed control efficiency and weed index respectively. This indicates that weed free check was effective in reducing weed population and biomass which subsequently resulted into higher weed control efficiency and lower weed index. Among herbicides treatment rates, pendimethalin at 0.75 kg a.i./ha +SHW at 6WAS produced the highest weed index next to weedy check while pendimethalin at 1.25 kg a.i./ha + SHW at 6WAS, Metolachlor at 1.0 kg a.i./ha + SHW at 6WAS and Metolachlor at 0.75 kg a.i./ha + SHW at 6WAS got the lowest weed index. The lowest weed index recorded by these treatments could be attributed to their high weed control efficiency during crop growth. Weed index determines the reduction in yield due to weed infestation and it is an ideal parameter to judge the weed control effectiveness of the herbicides' treatments. In a similar study, Dzomeku [42] reported that lowest weed index was attained with farmer practice (weeding at 3 and 6 WAP).

The production cost of groundnut (Table 6) was not affected by the variety in 2017, but differed significantly in 2018 rainy season with SAMNUT 23 recording the highest production cost than ''KAMPALA'' variety whose production cost was lower. The differences in production cost was due to the higher cost incurred for harvesting SAMNUT 23 over ''KAMPALA.'' The amount paid for harvesting SAMNUT 23 was higher because of piece work rate that was adopted for payment of hired labor at harvest. Thus, the cost charged for picking, shelling, purchase of empty bags and bagging the produce depended on the unit output of each variety; and since SAMNUT 23 produced higher output, the labor charges was higher and hence higher cost of production. According to the Statistical Analysis of London [43], piece work is any type of employment in which a worker is paid a fixed piece rate for each unit produced or action performed regardless of time. This result conforms to the report by Semalulu *et al*. [44] that groundnut production costs were significantly ($P<0.05$) lower for Serenut 4 compared to Serenut 2, Serenut 3 and Red beauty varieties in the study of production costs as affected by difference in groundnut varieties and Phosphorus application. The production cost (Table 6) also varied significantly with pre-emergence herbicides treatments in the two rainy seasons. Weed free check recorded the highest production cost than weedy check that recorded the lowest production cost/ha. The weed free check treatment recorded the highest production cost due to the high charges paid for labor during hoe weeding operations. This result conforms to the observations made by Arun *et al.* [45] who reported that in weed management practices, the highest cost of cultivation was recorded under two hoe weeding plots due to higher cost of labor charges while the lowest production cost was recorded by weedy check. Similarly, weed free check recorded the highest cost of production as compared to the herbicides treated plots. Teli *et al.* [46] also reported that weeding at 3 and 6WAS proved to be the most expensive method of weed control as it resulted into the highest total cost of production in the two years of study and concluded that the report conforms to the observation by Adigun and Lagoke [19] that hoe weeding is expensive. Among herbicides treatments, metazachlor at 1.0 kg a.i./ha + SHW at 6WAS recorded the highest production cost than other herbicides treated plots followed by pendimethalin at 1.0 kg a.i./ha + SHW at 6WAS while pendimethalin at 0.75kg a.i./ha + SHW at 6WAS had the lowest production cost per hectare of groundnut. The variation in the production cost was as a result of the differences in the cost of quantity of herbicides applied based on the rates, labor paid for hoe weeding and harvesting (uprooting, picking and shelling dry pods) cost of empty bags and bagging the kernel yields of groundnut. Lesser charges were paid for hoe weeding, uprooting and picking groundnuts on lesser weed infested plots while higher charges were paid for hoe weeding, uprooting and picking groundnuts on higher weed infested plots. The dry pods and kernel yields per plot also determines the prices paid for picking, shelling and the cost of bags and bagging of groundnut. Arun *et al.* [45] also reported similar results that Pyrazosulfuron + one hoe weeding recorded the highest cost of cultivation as compared to other herbicides treated plots in rice. In a related study, Hossain and Mondal [47] also reported that Bispyribac + ethoxysulfuron recorded the highest cultivation cost among other herbicide treatments.

The net return (Table 6) recorded from the sale of kernel and haulm yields were not significantly affected by the varieties in 2017, but significantly differed in 2018 with SAMNUT 23 recording the highest net return than ‘‘KAMPALA’’ (Table 6). The highest net return recorded by SAMNUT 23 could be due to the variation in prices paid for the kernels and haulm yields of the varieties. The results are similar to that reported by Semalulu *et al*. [44] who observed that Red beauty realized significantly the highest income compared to other varieties and attributed it to overall higher yields obtained by the variety than other varieties while the lowest income was realized from Serenut 4 was due to the low kernel yield recorded by the variety and the low price paid for the kernel compared to the other varieties. As per the effect of pre-emergence herbicides on net return (Table 6), weed free check treatment recorded significantly the highest net return while weedy check produced the lowest net return/ha compared to other weed control treatments in both 2017 and 2018 rainy seasons (Table 6). Among pre-emergence herbicides treatments, Metolachlor at 1.0 kg a.i./ha + SHW at 6WAS which was at par with Metolachlor at 1.25 kg a.i./ha + SHW at 6WAS, Butachlor at 0.75 kg a.i./ha +SHW at 6WAS, Metolachlor at 0.75 kg a.i./ha + SHW at 6WAS and Pendimethalin at 1.0 kg a.i./ha + SHW at 6WAS achieved the highest net return/ha compared to other herbicides rates. These treatments recorded the highest net return/ha possibly due to their high shelling percentages and kernel yields whereas the lowest net returns were produced by the weedy check treatment and Pendimethalin at 0.75 kg a.i./ha + SHW at 6WAS as a result of their low dry pod yields/ha, shelling percentages and kernel yields/ha. The results conformed to the findings of Hassain and Mondal [48] who reported that the highest net income was recorded in weed free check followed by pre emergence application of Alachlor at 1.5 kg a.i. ha-^{1} + two inter-cultivation at 25 and 40 days after sowing followed by one hand weeding at 40 to 45 days after sowing which is at par with pre emergence application of Alachlor at 1.5 kg a.i. ha-^{1} followed by post emergence application of Imazethapyr at 100 g a.i. ha-^{1} at 30 to 35 days after sowing + one inter-cultivation at 40 to 45 days after sowing and pre emergence application of Alachlor at 1.5 kg a.i. ha-^{1} followed by post emergence application of Imazethapyr at 125 g. a.i. ha-^{1} at 30 to 35 days after sowing + one inter-cultivation at 40 to 45 days after sowing. He attributed it to a greater number of pods plant-^{1}, higher pod weight plant-^{1} that resulted into higher pod yield were recorded in these treatments. Whereas weedy check recorded the lowest net returns.

The Cost-Benefit Ratio (CBR) (Table 7) did not significantly vary among varieties in both years (Table 6). However, both varieties produced CBR of greater than 1.0 indicating that both of them could be profitably produced. According to Gerald [49], if the CBR of a project exceeds one, then the project might be a good candidate for acceptance. The differences in the CBR could be attributed to kernel yield and haulm yield of groundnut as well as the prices paid for the produce of the varieties. The results are in close agreement with the findings of Sampson [50] who observed that Nkosuor and Nkapanieli varieties recorded the highest CBR at KNUST in 2006 and 2007 cropping seasons compared to Jenkaar Manipintar varieties that obtained the lowest CBR in the two seasons at KNUST. Similarly, Adepa and Manipintar varieties recorded the highest CBR than other varieties at Nyankpala in the two cropping seasons. He remarked that the differences in CBR among varieties were due to the differences in pods yield of the varieties of the groundnut. On the other hand, CBR varied significantly among weed control treatment in the two rainy seasons (Table 7). Weed free check recorded significantly the highest CBR followed by metolachlor at 0.75kg a.i./ha + SHW at 6WAS which was at par with all herbicides treatments except weedy check that recorded the lowest CBR. Despite the fact that weed free check recorded the highest cost of production, the treatment achieved the highest CBR. This could be attributed to the higher kernel yield and net return received by the treatment over other weed control treatments. Generally, all weed control treatments obtained CBR of greater than 1.0 except weedy check that had less than 1.0 indicating that all the treatments except the weedy check are profitable for groundnut production. Similar results were obtained by Samant et al. [51]. They reported that farmer practice of two hand weeding at 20 and 40DAS maize produced the maximum gross return, highest net return and maximum cost- benefit ratio with additional net return/ha compared to weedy check and other herbicides treatments due to the higher grain yield it achieved.

CONCLUSION

In conclusion, both SAMNUT 23 and KAMPALA varieties of groundnut could be recommended for profitable production. Metolachlor at 0.75, 1.0, 1.25kg a.i./ha and Pendimethalin at 1.0 kg a.i./ha are also recommended for use as an alternative to two-hoe weeding (weed free check) for higher haulm yield, kernel yield and net return/ha of groundnut production in Yola, Nigeria.

ACKNOWLEDGEMENTS

I would like to thank Professors A.B. Mustapha, B.B. Jakusko and S.Y. Simon for their immense contributions towards the success of the research work. I am also indebted to Dr. Kapsiya Joel for the assistance and moral support he rendered to me during the project work

Table 1: Cost of Variable Inputs for Groundnut Production in Yola in 2017 and 2018

Items	Production cost (N)	
	2017	2018
Land rent/ha	5000.00	5000.00
Land clearing /ha	-	-
Kernels (40 kg/ha)	8668.00	8000.00
Kernel treatment /(40 kg/ha)	2000.00	2000.00
Ploughing/ha	15000	10000.00
Levelling/ha	-	10000.00
Sowing (Labor)/ha	6668.00	6000.00
Herbicides/litre		
Butachlor	1800.00	1800.00
Metolachlor	3000.00	3000.00
Pendimethalin	2200.00	2200.00
N P K 15:15:15 60 kg/ha	7200.00	7200.00
Hoe weeding at 3WAS	15000.00	15000.00
Hoe weeding at 6WAS	10000.00	10000.00
Harvesting/ha		
Uprooting		
Weedy field	7000.00	7000.00
Weeded field	5000.00	5000.00
Picking/ha		
Weedy field	900.00	500.00
Weeded field	5000.00	650.00
Shelling/50 kg dry pods	500.00	500.00
Bags and bagging/100 kg kernel weight	150.00	150.00
Total	90, 586.00	94, 200.00

Field survey, 2017 and 2018

Table 2: Effect of Variety and Pre-Emergence Herbicides on Number of Branches and Plant Height/Plant at 12WAS of Groundnut in Yola in 2017 and 2018

	Number of branches/plant at 12 WAS			Plant height/plant (cm) at 12WAS		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety(V)						
SAMNUT 23	11.54	18.02	14.78	29.29	21.16	25.225
‘‘KAMPALA’’	12.21	18.80	15.51	30.31	21.04	25.23
SE (±)	0.760	0.690	0.725	1.456	0.896	1.18
Herbicide rate (H)						
Butachlor 0.75 kg a.i./ha + SHW@ 6WAS	10.93	18.80^{ab}	14.87	30.23	22.70	26.465
Butachlor 1.0 kg a.i./ha + SHW @ 6WAS	10.10	18.63^{ab}	14.37	31.27	23.33	27.3
Butachlor 1.25 kg a.i./ha + SHW @ 6WAS	9.67	19.80^{ab}	14.74	28.63	20.43	24.53
Metolachlor 0.75 kg a.i./ha + SHW@ 6WAS	14.20	18.00^{b}	16.1	31.53	21.27	26.4
Metolachlor 1.0 kg a.i./ha + SHW @ 6WAS	12.43	18.30^{b}	15.07	31.68	19.87	25.78
Metolachlor 1.25 kg a.i./ha + SHW @ 6WAS	13.83	19.40^{ab}	14.62	32.03	21.47	26.75

Pendimethalin 0.75 kg a.i./ha + SHW@ 6WAS	11.97	19.03^{ab}	15.5	29.47	20.43	24.93
Pendimethalin 1.0 kg a.i./ha + SHW @ 6WAS	12.48	18.43^{b}	15.46	28.72	18.67	23.695
Pendimethalin 1.25 kg a.i./ha + SHW @ 6WAS	12.17	19.07^{ab}	15.61	27.03	20.67	23.85
Weedy Check (No weeding)	7.70	12.23^{c}	9.97	26.23	18.93	22.58
Weed free Check (SHW @ 3 and 6WAS)	15.18	20.80^{a}	17.99	30.93	24.77	27.85
SE (±)	1.538	0.782	1.16	1.825	1.895	1.86
Interaction (V x H)	NS	*	NS	NS	NS	NS

SHW = Supplementary Hoe Weeding WAS= Weeks After Sowing NS= Not Significant
Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

Table 3: Effect of Variety and Pre-Emergence Herbicides on Canopy Spread/Plant at 12WAS of Groundnut in Yola in 2017 and 2018

	Canopy spread/plant (cm) at 12WAS		
Variety (V)	**2017**	**2018**	**Mean**
SAMNUT 23	47.46	47.10^{a}	47.28
KAMPALA	45.70	45.90^{b}	45.8
SE (±)	1.106	0.115	0.615
Herbicide rate (H)			
Butachlor 0.75 kg a.i/ha + HW@ 6WAS	47.07^{abc}	46.33^{b}	46.7
Butachlor 1.0 kg a.i/ha + HW @ 6WAS	44.63^{c}	52.58^{ab}	48.61
Butachlor 1.25 kg a.i/ha + HW @ 6WAS	42.37^{c}	47.50^{b}	44.94
Metolachlor 0.75 kg a.i/ha + HW@ 6WAS	54.50^{ab}	47.73^{b}	51.12
Metolachlor 1.0 kg a.i/ha + HW @ 6WAS	50.10^{abc}	46.63^{b}	48.37
Metolachlor 1.25 kg a.i/ha + HW @ 6WAS	50.30^{abc}	50.63^{ab}	50.47
Pendimethalin 0.75 kg a.i/ha + HW@ 6WAS	44.27^{c}	43.87^{b}	44.07
Pendimethalin 1.0 kg a.i/ha + HW @ 6WAS	46.8^{abc}	46.73^{ab}	46.77
Pendimethalin1.25 kg a.i/ha + HW @ 6WAS	45.87^{bc}	44.37^{b}	45.12
Weedy Check (No weeding)	30.77^{d}	26.27^{c}	23.52
Weed free Check (HW @ 3 and 6WAS)	55.65^{a}	58.83^{a}	57.24
SE (±)	3.262	3.378	3.32
Interaction (V x H)	NS	NS	NS

SHW = Supplementary Hoe Weeding WAS= Weeks After Sowing NS= Not Significant
Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

Table 4: Effects of Variety and Pre-Emergence Herbicides on Haulm and Kernel Yield (kg//ha) of Groundnuts in Yola in 2017 and 2018

	Haulm yield (kg/ha)			Kernel yield (kg/ha)		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety(V)						
SAMNUT 23	3020.50^{b}	1737.30	2378.9^{b}	1409.00^{a}	593.120^{a}	1001.1^{a}
''KAMPALA''	4849.10^{a}	2020.20	3434.65^{a}	1158.20^{b}	405.21^{b}	781.7^{b}
SE (±)	201.990	173.650	375.64	96.386	27.907	62.14
Herbicide rate (H)						
Butachlor 0.75 kg a.i./ha + SHW@ 6WAS	3688.00^{ab}	2187.60^{bc}	2137.8^{e}	1380.50^{bcd}	524.1^{bcd}	952.3^{c}
Butachlor 1.0 kg a.i./ha + SHW @ 6WAS	3448.70^{b}	1916.00^{bc}	2682..35^{cd}	1342.40^{bcd}	421.90^{cd}	582.13^{ef}
Butachlor 1.25 kg a.i./ha + SHW @ 6WAS	3613.50^{ab}	1393.10cd	2503.3^{cd}	1465.80^{bc}	383.30^{d}	924.55^{cd}

Metolachlor 0.75 kg a.i./ha + SHW@ 6WAS	4257.80^{ab}	2304.60^{b}	3281.2^{b}	1376.50^{bcd}	487.10^{bcd}	931.8^{c}
Metolachlor 1.0 kg a.i./ha + SHW @ 6WAS	4870.30^{ab}	1453.10^{c}	3161..7^{c}	1480.50^{b}	498.60^{bcd}	989.55^{b}
Metolachlor 1.25 kg a.i./ha + SHW @ 6WAS	4464.10^{ab}	1838.70^{bc}	3131.4^{c}	1182.90^{bcd}	503.80^{bcd}	843.35^{d}
Pendimethalin 0.75 kg a.i./ha + SHW@ 6WAS	4301.50^{ab}	1666.70^{bc}	2984.1^{c}	1062.90^{d}	429.30^{cd}	746.1de
Pendimethalin 1.0 kg a.i./ha + SHW @ 6WAS	3664.50^{ab}	1909.90^{bc}	2787.2^{cd}	1271.50^{bcd}	631.60^{b}	951.55^{c}
Pendimethalin 1.25 kg a.i./ha + SHW @ 6WAS	4464.50^{ab}	2025.90^{bc}	3245.2^{b}	1120.90^{cd}	591.10^{bc}	856.0^{d}
Weedy Check (No weeding)	1322.20^{c}	605.90d	964.03^{ef}	519.00^{e}	151.60^{e}	335.3^{f}
Weed free Check (SHW @ 3 and 6WAS)	5187.80^{a}	3365.80^{a}	4276.8^{a}	1916.90^{a}	1009.60^{a}	1463.25^{a}
SE (±)	560.270	290.250	425.26^{f}	109.940	65.218	87.58
Interaction (V x H)	NS	NS	NS	NS	*	NS

SHW = Supplementary Hoe Weeding WAS= Weeks After Sowing NS= Not Significant
Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

Table 5: Effects of Variety and Pre-Emergence Herbicides on weed control efficiency and weed index of Groundnuts in Yola in 2017 and 2018

	Weed control efficiency (%)			**Weed index**		
Treatment	**2017**	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety(V)						
SAMNUT 23	84.72	88.06	86.04	29.6	54.19	41.90
''KAMPALA''	81.66	81.44	81.55	34.92	42.33	38.63
SE (±)	2.060	0.972	1.516	6.980	3.755	5.37
Herbicide rate (H)						
Butachlor 0.75 kg a.i./ha + SHW@ 6WAS	91.48^{ab}	92.78^{ab}	92.13^{c}	26.98^{bc}	48.85^{bc}	75.83^{b}
Butachlor 1.0 kg a.i./ha + SHW @ 6WAS	78.750^{b}	96.15^{ab}	87.45^{cd}	28.78^{bc}	53.27^{bc}	41.02^{e}
Butachlor 1.25 kg a.i./ha + SHW @ 6WAS	94.07^{a}	95.85^{ab}	94.96^{ab}	22.62^{c}	60.13^{b}	41.38^{e}
Metolachlor 0.75 kg a.i./ha + SHW@ 6WAS	92.050^{ab}	90.42^{ab}	92.24^{ab}	28.03^{bc}	47.10^{bc}	41.57^{e}
Metolachlor 1.0 kg a.i./ha + SHW @ 6WAS	94. 70^{a}	93.38^{ab}	94.04^{ab}	22.43^{c}	50.08^{bc}	36.26^{ef}
Metolachlor 1.25 kg a.i./ha + SHW @ 6WAS	96.40^{a}	94.65^{ab}	95.53^{ab}	38.13^{bc}	47.13^{bc}	42.63^{de}
Pendimethalin 0.75 kg a.i./ha + SHW@ 6WAS	83.93^{ab}	90.13^{b}	87.03^{cd}	45.15^{b}	52.63^{bc}	48.89^{c}
Pendimethalin 1.0 kg a.i./ha + SHW @ 6WAS	91.90^{ab}	90.45^{ab}	91.18^{c}	41.65^{b}	44.67^{bc}	43.16^{d}
Pendimethalin 1.25 kg a.i./ha + SHW @ 6WAS	93.32^{ab}	90.93^{ab}	91.42^{c}	28.58^{bc}	42.22^{c}	35.4^{ef}
Weedy Check (No weeding)	0.00^{c}	0.01^{c}	0.01^{d}	72.68^{a}	84.97^{a}	78.82^{a}
Weed free Check (SHW @ 3 and 6WAS)	98.53^{a}	97.47^{a}	98.0^{a}	0.00^{d}	0.01^{d}	0.01^{g}
SE (±)	5.319	2.884	4.10	6.567	5.771	6.17
Interaction (V x H)	NS	NS	NS	NS	NS	NS

SHW = Supplementary Hoe Weeding WAS= Weeks After Sowing NS= Not Significant
Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

Table 6: Effects of Variety and Pre-Emergence Herbicides on Production Cost/(N/ha) and Net Return (N/ha) of Groundnut in Yola in 2017 and 2018.

Treatment	**Production cost (N/ha**			**Net income (N/ha)**		
	2017	**2018**	**Mean**	**2017**	**2018**	**Mean**
Variety (V)						

SAMNUT 23	134854.0	97554.00^{a}	116204.0	250251.0	108873.0^{a}	179852.0
''KAMPALA''	135362.0	88786.00^{b}	112074.0	217007.0	80397.0^{b}	148702.0
SE (±)	4696.30	849.250	2772.775	16942.00	4414.40	10678.2
Herbicide rate (H)						
Butachlor 0.75 kg a.i./ha + SHW@ 6WAS	137952.0^{bc}	93236.0^{bcd}	115594.0	248400.0^{bc}	97515.0^{bc}	172957.5
Butachlor 1.0 kg a.i./ha + SHW @ 6WAS	133566.0^{bc}	90813.0^{cd}	112189.5	241021.0^{bc}	84663.0^{bc}	162842.0
Butachlor 1.25 kg a.i./ha + SHW @ 6WAS	139742.0^{bc}	88911.0^{d}	114326.5	262366.0^{b}	72672.0^{c}	167519.0
Metolachlor 0.75 kg a.i./ha + SHW@ 6WAS	131901.0^{bc}	95530.0^{bcd}	113715.5	250743.00^{bc}	94830.0^{bc}	172786.5
Metolachlor 1.0 kg a.i./ha + SHW @ 6WAS	143279.0^{b}	91295.0^{cd}	117287.0	271140.0^{b}	88863.0^{b}c	180001.0
Metolachlor 1.25 kg a.i./ha + SHW @ 6WAS	134006.0^{bc}	86661.0^{d}	110333.5	219504.0^{bc}	94999.0^{bc}	157251.5
Pendimethalin 0.75 kg a.i./ha + SHW@ 6WAS	127618.0^{c}	92703.0^{bcd}	110160.5	198698.0^{c}	82087.0^{bc}	140392.5
Pendimethalin 1.0 kg a.i./ha + SHW @ 6WAS	143143.0^{b}	101186.0^{b}	12164.0	234279.0^{bc}	110580.0^{b}	172429.5
Pendimethalin 1.25 kg a.i./ha + SHW @ 6WAS	132073.0^{bc}	98252.0^{bc}	115162.5	205172.0^{c}	100205.0^{bc}	152688.5
Weedy Check (No weeding)	92234.0^{d}	64782.0^{e}	78508.0	93106.00^{d}	25935.0^{d}	29520.5
Weed free Check (SHW @ 3 and 6WAS)	170672.0^{a}	121498.0^{a}	146085.0	345489.0^{a}	188637.0^{a}	267063.0
SE (±)	5074.800	3154.40	822.9	19522.00	10215.0	14868.5
Interaction (V x H)	NS	NS	NS	NS	*	NS

SHW = Supplementary Hoe Weeding WAS= Weeks after sowing *- Significant NS= Not Significant
Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

Table 7: Effects of Variety and Pre-Emergence Herbicides on Cost-Benefit Ratio of Groundnut in Yola in 2017 and 2018

Treatment	Cost-Benefit ratio		
	2017	2018	Mean
Variety (V)			
SAMNUT 23	1.82	1.06	1.44
''KAMPALA''	1.56	0.89	1.225
SE (±)	0.080	0.040	0.06
Herbicide rate (H)			
Butachlor 0.75 kg a.i./ha + SHW@ 6WAS	1.79^{ab}	1.03^{bc}	1.41^{ab}
Butachlor 1.0 kg a.i./ha + SHW @ 6WAS	1.78^{ab}	0.92^{bc}	1.35^{b}
Butachlor 1.25 kg a.i./ha + SHW @ 6WAS	1.89^{ab}	0.80^{c}	1.345^{b}
Metolachlor 0.75 kg a.i./ha + SHW@ 6WAS	1.86^{ab}	1.00^{bc}	1.43^{ab}
Metolachlor 1.0 kg a.i./ha + SHW @ 6WAS	1.88^{ab}	0.97^{bc}	1.425^{ab}
Metolachlor 1.25 kg a.i./ha + SHW @ 6WAS	1.63^{ab}	1.10^{b}	1.365^{b}
Pendimethalin 0.75 kg a.i./ha + SHW@ 6WAS	1.55^{b}	0.91^{bc}	1.23^{d}
Pendimethalin 1.0 kg a.i./ha + SHW @ 6WAS	1.60^{b}	1.06^{b}	1.33^{c}
Pendimethalin 1.25 kg a.i./ha + SHW @ 6WAS	1.56^{b}	1.01b^{c}	1.285^{c}
Weedy Check (No weeding)	1.02^{c}	0.40^{d}	0.71^{e}
Weed free Check (SHW @ 3 and 6WAS)	2.01^{a}	1.52^{a}	1.765^{a}
SE (±)	0.137	0.085	0.111
Interaction (V x H)	NS	NS	NS

SHW = Supplementary Hoe Weeding WAS= Weeks After Sowing NS= Not Significant

Means followed by the same letter (s) within the same treatment group are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT)

REFERENCES

1. DWIVEDI, S.L., CROUCH, J.H., NIGAM, S. N., FERGUSON, M.E. & PATERSON, A.H. (2003). Molecular Breeding of Groundnut for Enhanced Productivity and Food Security in the Semi-Arid Tropics: Opportunities and Challenges. *Advanced Agronomy*, **80**: 153-221.
2. SURRENDRANATHA, E.C., SUDHAKAR, C. & ESWARA, N.P. (2011). Aflatoxin Contamination in Groundnuts Induced by Aspergillus Flavustype Fungi: A Critical Review. *International Journal of Applied Biology and Pharmaceutical Technology*, **2**: 2-9.
3. KRAPOVICKAS, A. (1968). The Origin, Variability and Spread of Groundnuts, in Peanut – Culture. and Uses: *American Peanut Research and Education Association*, 17-42pp.
4. ONWUEME, I.C. & SINHA, T.D. (1991). *Field Crop Production in Tropical Africa: Principles and Practice.* Published by C.T.A, Ede, The Netherlands. 324-336pp.
5. SHARMA, K.K, & MATHUR, B.P. (2006). Peanut (*Arachis hypogea* L.). *Methods in Molecular Biology* **343**: 347-358.
6. NIGAM, S.N., DWIVEDI, S.L. & GIBBONS, R.W. (1991). Groundnuts Breeding Constraints, achievements and Future Possibilities. *Plant Breeding Abstracts*, **61**(10): 1127-1136.
7. AJEIGBE, H.A., WALIYAR, F., ECHEKWU, C.A., AYUBA, K., MOTAGI, B.N., ENJAYEDU, D. & INUWA, A. (2014). *A farmer's Guide to Groundnut Production in Nigeria.* International Crops Research Institute for Semi-Arid Tropics. Patencheru 502324 Telangana India. 36pp.
8. FAO STAT (2014). FAO 2012 Data and Preliminary 2013 Data for 5 Major Commodity Aggregate. 8-10pp.
9. ADEKANMI, K.O. & KAZEEM, A.S. (2020). Effects of Groundnut (*Arachis hypogaea* L.) Varieties on the Flavour Profile and Consumer Acceptability of Dakuwa. (A Cereal-Groundnut Based Snack). *FUDMA Journal of Sciences* (FJS) ISSN online: 2616-1370 ISSN print: 2645 – 2944 **4(**3): 86 – 92. DOI: https://doi.org/10.33003/fjs-2020-0403-262.
10. NAUTIYAL, P.C. (2002). *GROUNDNUT: Post-harvest Operations*: Post Harvest Compendium. FAO. National Research Centre for Groundnut (ICAR) (www.icar.org.in).126pp.
11. STEPHANIE, A.L., YSUSHI, O., PAUL, T.J., SOHEILA, J.M., MARTIN, O.C., STEPHEN, A.T. GEORGE, D.T., MUSTAFA, S.S. & BRIAN, P.V. (2022). Manufacturing processes of peanut (*Arachis hypogaea* L.**)** Allergen Powder-dnfp. *Front Allergy*, **3**: 1004056. DOI:10.3389/FALGY.2022.1004056.
12. INTERNATIONAL NUTS AND DRIED FRUITS [INC (2015). *Global Statistical Review* 2014-2015. Care de la Fruits Seca,4 Poligon Tecnoparc 43204 REUS, Spain. http/www.nutfruit.org. 76pp.
13. ASIBUO, J.Y., AKROMAH, R., ADO-DAAPAH, H.K. & SAFO-KANTAKA, O. (2008). Evaluation of Nutritional Quality of Groundnuts (*Arachis hypogeal L*.) from Ghana. *African Journal of Agric. And Nutritional Development*, **8**(2): 133-150.
14. BALA, H.B.M., OGUNLELA, V.B., TANIMU, B. & KUCHINDA, N.C. (2011). Response of Two Groundnut (*Arachis hypogaea* L.) Varieties to Sowing Date and N.P.K. Fertilizer Rate in Semi-Arid Environment: Growth and Growth Attributes. *Asian Journal of Crop Science*, **3**(3): 141-150.
15. THAMIZHIYAN, D., VISHALKUMAR, L., ELANCHEZHIYAN, S. & INDIANRAJ, N. (2022). Weeds in Groundnut Cultivation and their management. *EPRA International Journal of Agriculture and Rural Economic Research (ARER)*-Peer Reviewed Journal **10(**11) November 2. DOI 10.36713/epra/impact Factor SJIF (2021):7.504/ISSN 2321-7847, 41-44. https//doi.org/10.36713/epra11838.
16. JAT, R.S., MEENA, H.N., SINGH, A.L., JAYA, N.S. & MISRA, R.S. (2011). Weed Management in Groundnuts (*Arachis hypogaea* L.) in India - A REVIEW. *Agricultural Reviews*, **32**(3): 155 - 171, www.arccjournals.com/indianjournals.comp er indianjournals.com.
17. SINGH, F. & OSWALT, D.L. (2005). Groundnut Production Practices. *Skill Development Number 3* ICRISAT Pantancheru, Andra Pradesh. 3pp.
18. ZIMDHAL, R.L. (2004). *Weed-Crop Competition: A Review*. Ames, IA: Blackwell Publishing Professional, 49-50pp.

19. ADIGUN, J.A. & LAGOKE, S.T.O. (2003). Weed Management with Various Herbicides Combinations in a Maize-Groundnut Intercrop. *Nigerian Journal of Plant Protection*, **20**: 12-23.
20. ADIEGUN, J.A., LAGOKE, ST.O., KUMAR, V. & ERINLE, I.D. (1993). Weed Management Studies in Transplanted Tomato in the Nigerian Savanna. *Samaru Journal of Agricultural Resources*, **10**: 29 – 39.
21. ANONYMOUS (2017). Etrex GPS Observation, Yola, Nigeria. 1p.
22. ADEBAYO, A.A. & TUKUR, A.L. (1999). *Mean Annual Rainfall of Adamawa State in Maps*. First Edition. Paraclete Publishers Yola, Nigeria. 23-26pp.
23. STATISTICAL ANALYSIS SYSTEM [SAS] (1999). SAS/Statistical Users Guide, Version 8, SAS Institute Inc, Cary NC USA.378pp.
24. JONATHAN L. (2020). Introduction to Cost of Production and its Uses Part 2. Michigan State University Extension. https//www.canr.msu.edu/outreach. 3pp.
25. STEPHEN, M. (2009). *Growth and Yield performance of Four Groundnut (Arachis hypogaea L.) Varieties in Response to Kernel Size*. A Thesis submitted to the Department of Crop and Soil Sciences, Kwame Nkuramah University of Technology, Kumasi Ghana 76pp.
26. SATHYA-PRIYA, C., CHINNUSAMY, C., MANICKASUNDARAM, P. & BABU, C. (2013). A Review of Weed Management in Groundnuts (*Arachis hypogeal L.*) Dept. of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu India. *International Journal of Agricultural Science and Research* (IJASR), **3**(1): 163-167.
27. USMAN, I. (2015). *Influence of Poultry Manure and Weed Control Methods on the performance of Groundnut (Arachis hypogaea L.) Varieties under Rain fed and Irrigated Conditions.* A Thesis submitted to the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria 176pp.
28. JADHAV, P.B. RAJESH, S. & KAMBLE, D.R. (2015). Effects of Weed Control Methods on Growth and Yield of Groundnuts *Advance Research Journal of Crop Improvement*, **6**(2): 151-157.
29. GARKO, M.S., MOHAMMED, I.B., YAKUBU, A.I. & MOHAMMED, Z.Y. (2016). Performance of Groundnuts (*Arachis hypogaea* L.) Varieties as Influenced by Weed Control Treatments in Kano State Nigeria. *International Journal of Scientific and Technology Research*, **5(**03) March, 2016 ISSN 2277-8616: 134-140pp.
30. IMOLOAME, E.O, JOSHUA, S.D. & GWORGWOR, N.A. (2011). Effects of Pre-Emergence Herbicides on Weeds Infestation and Productivity of Sesame (*Sesamum indicum* L.) in Sudan Savanna Zone of Nigeria. *Journal of Agricultural Biotechnology and Sustainable Development*, **3**(2): 19-27.
31. MIZRA (2015). *Weed Competition*. Department of Agronomy, Sher-e- Bangla Agricultural University. Retrieved from www.hasanu.webs.comb on April,4, 2019. 6pp.
32. OYEWOLE, C.I., SHUAIB, H. & MUSA, U.T. (2016). Sustainable Crop Production: and Yield Response of Three Varieties of Groundnut (*Arachis hypogaea L.*) Sown to Three Weeding Regimes and Two Plant Spacing in Anyigba, Kogi State, *Nigeria. Agricultural and Food Journal of International Scientific* Publications. ISSN 1314-8591, **4**: 373-385.
33. DAUDA, S. (2014). *Effects of Butachlor on Weed Control Management, Growth and Yield of Groundnut* (*Arachis hypogaea* L.) in Mubi and Yola, Adamawa State, Nigeria. A Thesis submitted to the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola. 65pp.
34. WILCUT, J.W., ALAN, C.Y., GRICHAR, J. & GLEEN, R.W. (2015). The Biology and Management of Weeds in Pea (L.). *Advances in Peanut Science* 207-223. 2222. Retrieved from http://apresinc.comwp-content>uploads>2015/12>12APS-Chapter-6 on August 17, 2019.
35. CLEWIS, S.B., ASKEW, S.D. & WILCUT, J.W. (2001). Common ragweed Interference in Peanut. *Weed Science*, **49**: 768.772.
36. HARRISON, K.D., IBRAHIM, M. & RICHARD, T.A. (2014). Phenological Development and Yield of Three Groundnut Varieties as Influenced by Plant Density in a Forest-Savanna Transition. *International Journal of Agricultural Research*, **9**(2): 87-98.
37. GUNRI, S.K., SENGUBTA, A., NATH, R. & PUSTE, A.M. (2014). Evaluation of Post Emergence Herbicides on Summer Groundnut (*Arachis hypogaea* L.) in New Alluvial Zone of West Bengal. *African Journal of Agricultural Research Academic Journal*, **9**(40): 2971-2974. Retrieved from

http://www.academicjournal.org/AJAR on September 9, 2018.

38. ABDUL-RAHMAN, T. & DANIEL D.Q. (2014). performance of Groundnut (*Arachis hypogaea* L.) Varieties in Two Agro-ecologies in Sierra Leone. *Journal of Agricultural Research*, **9**(19): 1442-1448.
39. KHAN, M.S., ZAIDI, A. & AAMIL, M. (2004). Influence of Herbicides on Chickpea Mesorhizobium Symbiosis. *Agronomie*, **24**: 123-127.
40. ALMAS, Z., SARGHIR, K.M.D. & PERVEZ, Q.P. (2005). Effects of Herbicides on Growth, Nodulation and Nitrogen Content of Green gram. *Agronomy for Sustainable Development*, Springer, **25**(4): 497-504.
41. YOHANNA, M.K., MONYAMYAH, S. & SAMUEL, B.K. (2015). Effects of Different Rates of Pendimethalin on Weed Control in Bambara Groundnut (*Vigna subterranean* L. Verd.) in Semi-Arid Savanna of Nigeria. *Global Advanced Research Journal of Agricultural Science*, **4**(12): 905-910. Retrieved from http//garj.org/garjas/home on October 11, 2018.
42. Dzomeku (2017). Evaluation of Herbicides for Weed Control Efficacy in Groundnuts (*Arachis hypogaea* L.) in Guinea Savannah. *UDS International Journal of Development*, **3**(2) Retrieved from http://www.udsijd.org on November 15, 2018. 15pp.
43. STATISTICAL SOCIETY OF LONDON (1865). The Piece Work Principles in Agriculture. *Journal of Statistical Society of London.* **28**: 29-31.
44. SEMALULU, O., KASENGE, V., MAKHOSI, P., GITA, R. & GUMISIRIZA, C. (2012). *Production and Profitability of Groundnuts with Phosphorus Fertilizer in Mbale District, Uganda.* National Agricultural Research Laboratories – Kawanda, P. O. Box 7065, ‘‘KAMPALA’’ Uganda. 24pp.
45. ARUN, K., VEVEK, NRESH, R.K., GHASAL, P.C, ROBIN, K., VINEET, S., SUNIL, K. & KAUTALYA, C. (2017). Weed Management Effects on Weed Control Efficiency, Yield and Economics of Transplanted Rice in Typic Ustochrept Soil of Uttar Pradesh. *International Journal of Chemical Studies*, **5**(4): 1346-1351.
46. TELI, I.A., GWORGWOR, N.A., JOSHUA, S.D. & IMOLOAME, E.O. (2011). Economic assessment of some pre-emergence herbicides in the production of millet-cowpea intercrop in the Sudan Savanna Zone of Nigeria. *African Journal of Plant Science*, **5**(12): 688-696. Retrieved from http:perperwww.academicjournals.orgperAJPS on October, 18 2019.
47. HOSSAIN, A. & MONDAL, D.C. (2014). Weed Management by Herbicide Combinations in Transplanted Rice. *Indian Journal of Weed Science*, **46**(3): 220-223.
48. ABDURAJAK, C. (2011). *Effects of Pre and Post Emergence Herbicides in Groundnut* (*Arachis hypogaea* L.). A Thesis submitted to the Department of Agronomy, College of Agriculture, Dharwad. University of Agricultural Sciences, Dharwad. 580 005 104pp.
49. GERALD, S. (2014). *An Overview of Benefit-Cost Analysis*. Research gate. file:///C:/Users/HP/Downloads/Benefit-Cost_Analysis.pdf 11pp.
50. SAMPSON, K. (2010). *GROUNDNUT Variety Response to Spacing in Guinea Savannah and Forest Zones of Ghana.* A Thesis Submitted to the Department of Crop and Soil Sciences, Faculty of Agriculture, College of Agriculture and Renewable Natural Resources, Kwame Nkrumah University of science and Technology, Kumasi, Ghana. 175pp.
51. SAMANT, T.K., DHIR, B.C. & MOHANTY, B. (2015). Weed Growth, Yield Components, Productivity, Economics and Nutrient-uptake of maize (*Zea mays* L.) as influenced by various herbicides applications under rain-fed condition. *Scholars Journal of Agricultural and Veterinary Sciences*, **2**(1B): 79-83.