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Performance of Cowpea and Soybean in Nigerias' Sudan Savanna as Influenced by Pendimethalin Application Rates

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ABSTRACT----*Field experiment was conducted at Gombe during the 2012 wet cropping season situated at Lat.11^{0} 30^{II} N and Long.10^{0} 20^{II} E at an altitude of 240m above sea level to evaluate the performance of two leguminous crops (cowpea & soybean)under different rates of Pendimethalin in the sudan savannah zone of Nigeria. The experiment consisted of six different rates of Pendimethalin (1.0, 2.0, 3.0, 4.0, 5.0, 6.0kg a.i.ha^{-1}) + weed free and weedy check (controls) making a total of eight possible treatments which was laid in a split plot design and replicated three times. Results indicates that high rate of Pendimethalin resulted in an increase to days to 50% emergence, injury score (phytotoxicity), decrease in plant height as well as number of leaves of respective crops (P=0.05). However, the same higher rates resulted in maximum decrease in weed cover score, weed dry weight, number of pod plant^{-1} and eventually the final yield of both cowpea and soybean respectively.*

Keywords--- Performance, legumes, *Pendimethalin*, Sudan savanna

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1. INTRODUCTION

Legumes are the most important tropical food crops of the family *Fabaceae* with approximately 650 genera and 18,000 species. Tropical legumes originated in areas characterized by humid, semi-arid, cool sub-tropical and tropical climate. These areas include South America, South West Asia, Ethiopia, India, Japan, China, and West Africa (Hymowitz, 1990). The importance of legumes as food lies primarily in their high protein content. Most legumes contain 20-25% crude protein which is 2-3 times the protein content of most cereal grains. Groundnut has a protein content of 27%, soybean contains 40% (Adetiloye *et al*., 2005), and cowpea about 22% (Nanyelogu *et al*., 1997), mucuna 11-25% (Anon, 2008) and lap lap beans 23-28% (Muphy, 1998). In recent years, the use of forage legumes in livestock production system in the tropics has increased. Forage legumes offer several advantages to tropical farming systems. First, leguminous cover reduces soil erosion and runoff. This cover is able to conserve soil, improve organic matter content and compete with weeds (Hurnphreys, 1995 and Duda *et al.*, 2003).

Secondly, the legume-rhizobial symbiosis converts atmospheric nitrogen (N) to forms of N which plant can take up and cycled within the plant-animal-soil-system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N for use by plants. This symbiosis does not involve the consumption of fossil fuel, as occur in the production of N fertilizer which can contribute to global warming and exacerbates the foreign exchange balance of tropical countries lacking in oil resource (Said and Tolera, 1993; Humphreys, 1995). Causes of low yield in crop production are weed infestation, sowing on marginal land, no/low and imbalance use of fertilizer, conventional sowing methods, low rainfall, lack of improved varieties and pest and disease attack etc. Among these yield limiting factors weed competition stands out as especially important. Weed control is usually greater in legumes than in cereals because they have short status and therefore, weed constituting of grasses, broadleaved and sedges irrespective of their short or tall stature usually have dense growth and smother the growth of majority legumes/pulses. Therefore, maintenance of farm environment at least for or during the critical period of weed is a prime necessity for harnessing higher yield in legumes/pulses. Weeds cause 24-80% yield losses in chickpea (Vaishya *et al*., 1996; Tanveer *et al*., 1998; Tiwari *et al*., 2001; Mohammadi *et al*., 2005; Aslam *et al.*, 2007). Weeds decrease the quality of chickpea and also reduce its market value (Marwat *et al*., 2005).

According to Pandey and Mishra (2003) the decrease in mungbean productivity due to weed competition was 45.6%. Chemical + cultural, hand-weeding and chemical treatment significantly suppressed mungbean weeds and caused a marked increase in grain yield. Seed yield of mungbean was maximum (2108 kg ha^{-1}) in the weed free treatment and decreased by 29.5%, 23.5% and 45.8% with 160 plants m^{-2} of *Trianthemaportula castrum, Echinochloa colona* and *Cyperus rotundus*, respectively (Punia *et al*., 2004). About 69% reduction in mungbean grain yield due to weeds was estimated by Yadav and Sing (2005). According to Raman and Krishnamoorthy (2005) presence of weeds reduced the seed yield of mungbean by 35%.Preventive measures for weed control in legumes includes the use of clean seeds, proper seedbed preparation, timing of sowing, hand weeding, soil solarization and a good crop husbandry practice (Fryer,1983). Similarly, good crop husbandry can be adopted + chemical control + hoe weeding in an integrated approach. For example, good crop husbandry + recommended pre-emergence herbicide + hoe weeding to control late emerging annual as well as perennial weeds such as *Cynadondactylon* and sedges (Fryer, 1983).

Weeds can be controlled by different methods such as manual, mechanical, and chemical methods. Manual weed control is always laborious, costly, and uneconomical as compared to chemical weed control. Weed control with herbicides is an effective, quick in action, and time saving (Esterminos and Moody, 1988; Ahmed *et al.*, 2005). Chemical weed control is increasingly becoming more attracted to farmers in the developing world (Anon, 1994). For example herbicide use has been reported to be more profitable than hoe-weeding in the production of various crops in Nigeria, and it is labour saving (Usoro, 1983 and Adigun *et al.*, 1993). Fadayomi (1999) noted that there is extensive adoption of chemical weed control in Nigeria. With the use of herbicide large areas can be brought under legumes production. This will result in higher output of food crops and help in meeting the food requirement of the country. *Pendimethalin* is an important herbicide for weed control in legumes and some cereals. Information on the use of *Pendimethalin* in legume is limited. There is also limited information on comparative tolerance and performance of legumes to *Pendimethalin* most especially in the savannah region of Nigeria. Therefore, this research was set with the aim to determine the relative tolerance of two legumes to different rates of *Pendimethalin*.

2. MATERIALS AND METHODS

The study was conducted under rain fed condition at Gombe, located in the Sudan Savannah agro-ecological zone of Nigeria situated at Lat.11^0 30^{II}N and Long.10^0 20^{II} E at an altitude of 240m above sea level (Kowal and Knabe,1972) during the 2012 wet cropping season. The experimental site which measured 28m x 11m ($308m^{-2}$) each was harrowed, leveled and ridges made before individual plots were marked out. The plot size was 3mx3m ($9m^2$) with a distance of 1m between replications and plots respectivelywith net plot size of 3m x 1.5m ($4.5m^2$). The soil of the experimental site was collected and analyzed for physico-chemical properties using standard procedure as described by Black (1965) (Table 1). The rainfall, temperature (mean, min. & max.) and relative humidity of the experimental locations was collected and reported in (Table 2)

2.1Treatments and experimental design

The treatment consisted of six different rates of *Pendimethalin* (1.0, 2.0, 3.0, 4.0, 5.0, 6.0kg a.i.ha-^{1}) + weed free and weedy check (controls) making a total of eight possible treatments. The experiment was laid in a split plot design replicated three times. The herbicide rates wereassigned to the main plots as maintreatment while legume crops were allocated to the sub-plots as sub-treatments. 3-4 seeds of cowpea (IAR00-1074) and soybean (TGX 1448-2E) were sown on mid-July at a spacing of 75cmx30cm and 75cmx15cm for inter and intra row spacing respectively. Herbicide (pendimethalin) was applied pre-emergence to the two crops using a CP_3 knapsack sprayer fitted with a green deflector nozzle set at a pressure of $2.1kgcm^3$ and in spray liquid volume of 240Lha-^{1}.The recommended dose of $400kgha^{-1}$ of NPK. 20:10:10 for maize half dose was applied to the two tested crops at 2WAS while the second dose was applied at 6WAS.

Pests and diseases were controlled when the cowpea plant has started flowering so as to manage the effect of the insect pest such as flower thrips *(Megalurothripss jostedti*), *maruca vitrata,* as well as cowpea scab (*Spaceloma sp*.) using *Cypermethrin* (Cypertex) a broad spectrum insecticide was sprayed at 500ml per 40L of water per hectare. Nevertheless, the weed free check (control) was kept weed free by regular weeding. Harvest was done manually when the crops have reached physiological maturity i.e by picking the pods that have changed from green to brown in color as in cowpea and cutting of the whole plant and drying them in a shed and bitten them softly with a stick as in soybean. Data were collected on growth parameters as 50% Emergence (DAS), Crop injury score, plant height, number of leaves, 50% flowering (DAS); yield parameters as number of pod plant$^{-1,}$ grain yield $kgha^{-1}$, and weed parameters as weed cover score and weed dry weight for both crops respectively.

2.2 Data analysis

The data collected were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980) using the General Linear Model (GLM) in SPSS (1996) for windows. Means of treatments were compared using Duncan Multiple Range Test (DMRT), calculated only when analysis of variance (F-test) was significant at P=0.05 (Duncan, 1955).

3. RESULTS AND DISCUSSION

Rainfall during the field experiment revealed that a total of 1278mm was recorded with a mean monthly distribution of 182.6mm. However, rainfall was at its peak during the month of August and September (313.3 and 304.4mm). A mean monthly temperature of (21.3 and 31.90^0c) was also observed for minimum and maximum temperatures respectively during the period of field trial as well as mean monthly relative humidity of 41.70 was recorded (Table 1).The result of physical and chemical analysis of soil of the experimental area prior to the establishment of the field trial was equally reported (Table 2). The soil textural class was between sandy loam to sandy clay loam with pH of acidic soil. The organic carbon, total N and available P were slightly higher; with relatively low CEC. It can therefore be infer that the soil is of low fertility status which can be augmented by the application of fertilizer of both organic and inorganic in nature.

3.1Weeds cover score of legumes

At 4WAS, WDC (weedy check) plots had the highest weed cover score (WCS) which differ significantly with all treatments followed by 1.0 kg a.i.ha^{-1} which was statistically comparable to plots with 2.0,3.0 and 4.0 kg a.i.ha^{-1} which also differ significantly with 5.0, 6.0 kg a.i.ha^{-1} and weed free check (WDFC) plots which had the least WCS of cowpea (Table 3).Similarly, WDC had the highest WCS which differs significantly across all treatments followed by 1.0, 2.0, 3.0 and 4.0 kg a.i./ha plots which though similar had WCS significantly lower than the former but higher than WDFC plots .However, WDFC plots had significantly the least WCS of soybean. At 8WAS, WDC plots had the highest WCS which vary with all treatments followed by 1.0, 2.0, 3.0 and 4.0 kg a.i.ha^{-1} which were statistically alike with significant lower WCS than the former but higher than plots with 5.0 and 6.0 kg a.i.ha^{-1} which also had significantly lower WCS than WDFC plots. However, WDFC plots had significantly the least WCS of cowpea. Similarly, WDC had the highest WCS which differs significantly across all treatments followed by plots with 1.0, 2.0, 3.0 and 4.0 kg a.i.ha^{-1} which though similar had WCS significantly lower than the former but higher than WDFC plots .However, WDFC plots had significantly the least WCS of soybean which was strictly labor intensive to keep field weed free compared with chemical weeding which was effective, quick action and time saving which was in conformity with the findings of Esterminos and Moody(1988) and Ahmed *et al.*(2005).

At 12 WAS, WDC plots had the highest WCS which do not vary significantly with 1.0, 2.0 and 3.0kg a.i.h^{-1}a but vary significantly with 4.0, 5.0,6.0kg a.iha^{-1} which were similar with significant higher WCS than WDFC plots which however had significantly the least WCS of cowpea. However, the herbicide was not capable of given season long weed control of greater than 8WAS (Table 3).However, WDC and 1.0kg a.iha^{-1} plots had the highest WCS which differ significantly with other treatments followed by 2.0 and 3.0 kg a.i.ha^{-1} which had WCS significantly lower than former but higher than plots with 4.0 kg a.i.ha^{-1} as well as WDFC plots which virtually had significantly the least WCS of soybean. These signifies that pre-emergence application of *Pendimethalin* gave a relatively season long weed control of upto 7-8WAS and at that time the cowpea plant have flowered, however efficacy of weed control can be enhanced if supplemented with hoe weeding for soybean which will resume flowering later on if resources to cater for weeding are available, otherwise the plant is capable of competing with the late season weeds at that particular period. Therefore, the best alternative strategy is to “do nothing”, to reduce drudgery which was in line with reports of Anon (1994); Fadayomi (`1999) and Ahmed *et al.* (2005) that if crops have exceeded critical period of weed infestation even if late season weed appears to be present, there will not be a significant decrease in the expected yield.

3.2Weed dry weight of legumes

At 4WAS, WDC plots had the maximum dry weight of weed which differ significantly across all treatments followed by plots with 1.0kg a.i/ha with dry weight significantly lower than former but higher than plots with 2.0, 3.0, 4.0, 5.0 and 6.0 kg a.i./ha which were statistically comparable with minimum dry weight similar to WDFC plots in cowpea field (Table 4).At 8WAS, WDC plots had the maximum dry weight which vary significantly with 4.0, 5.0, 6.0 and WDFC plots but was statistically comparable to plots with 1.0, 2.0 and 3.0kg a.i/ha with dry weight comparable with the former in cowpea field. At 12WAS, WDC plots had the maximum dry weight which vary significantly with all treatment followed by plots with 1.0, 2.0, 3.0, 4.0, 5.0, 6.0kg a.i/ha and WDFC which were statistically comparable with a magnitude of decrease in dry weight. However, WDFC plots resulted in the minimum dry weight of weed on cowpea field.

At 4WAS, WDC plots had the maximum dry weight which vary significantly with all treatments followed by plots with 1.0kg a.i/ha with dry weight lower than former but higher than plots with 2.0, 3.0 and 4.0kg a.i/ha which were statistically comparable with each other. However, WDFC plots had significantly the minimum dry weight of weed in soybean field. At 8WAS, WDC plots resulted with the maximum dry weight which was statistically comparable to plots with 1.0, 2.0, 3.0 and 4.0kg a.i/ha with decrease in magnitude of dry weight of weed in that order. However, WDFC plots had the minimum dry weight which varies with all treatment. At 12WAS, WDC, 1.0 and 2.0kg a.i/ha which though similar had the maximum dry weight of weed which vary significantly with plots treated with 3.0 and 4.0kg a.i/ha of *Pendimethalin* with dry weight lesser than the former but higher than WDFC plots which had the minimum dry weight of weed in soybean field.

3.3Days to 50% emergence of legumes

WDFC, WDC, 1.0, 2.0 and 3.0, kg a.i./ha though similar had the minimum number of day which varied significantly from plots treated with 5.0 and 6.0kg a.i/ha which had the maximum number of days to 50% emergence which was statistically comparable to plots with 4.0kg a.i/ha with lower number of days than former but higher than later for cowpea (Table 5).Similarly, WDFC, WDC and 1.0kg a.i/ha resulted with the minimum number of days which vary significantly with plots treated with 4.0 and 5.0kg a.i/ha which resulted with the maximum number of days to 50% emergence of soybean but was however statistically comparable to plots treated with 2.0 and 3.0kg a.i/ha with number of days slightly higher than former but also lower than later in soybean field. These findings indicates that high rates of herbicide (*Pendimethalin*) can bring about delay on emergence of the tested crops keeping in view that each crop vary in their degree of tolerance to that herbicide.

3.4Crop injury score

Plots with 6.0 and 5.0kg a.i/ha had the maximum injury which vary significantly with all treatments followed by plots with 4.0kg a.i/ha with injury significantly lower than plots with 3.0 and 2.0kg a.i/ha due low phytotoxic effect of herbicide at lower rates of application (Table 5). However, WDFC, WDC and 1.0kg a.i/ha plots recorded no injury which therefore signifies that 1.0kg a.i/ha of *Pendimethalin* has no phytotoxic effect on cowpea. Similarly, plots treated with 6.0, 5.0 and 4.0kg a.i/ha recorded the maximum injury which was comparable to plots with 3.0, 2.0 and 1.0kg a.i/ha with minimum phytotoxic effect compared with the former. Meanwhile, 5.0 and 6.0kg a.i/ha rates of *Pendimethalin* were highly injurious (phytotoxic) to soybean which leads to complete crop mortality on regards to these trial. This indicates that cowpea responds well to high rates of *Pendimethalin* of up to 6.0kg a.i/ha as compared to soybean which tolerates only up to 4.0kg a.i/ha. These confirms the findings of Yadav (2005) who reveals the response of different legumes to *Pendimethalin* and found that the *Vigna* family responds better than other legumes counterpart with *Vigna unguiculata* showing the best performance with adequate weed control comparable to weed free plots.

3.5Plant height

WDFC and WDC plots resulted with the highest plant height which varies significantly from plots with 5.0 and 6.0kg a.i/ha which resulted with the least plant height but were statistically comparable with other treatments. At 8 and 12WAS, WDFC plots resulted with the highest but comparable to plots with 1.0, 2.0, 3.0kg a.i/ha which also differ significantly with less plant height than plots with 4.0, 5.0 & 6.0kg a.i/ha significantly with the least plant height of cowpea.At 4WAS, WDFC plots vary significantly from 4.0kg a.i/ha plots with the highest plant height of soybean but was statistically comparable to plots with WDC, 1.0, 2.0 and 3.0kg a.i/ha (Table 6). However, plots with 4.0kg a.i/ha recorded the least plant height. At 8WAS, WDFC plots vary significantly with the highest plant height followed by 1.0, 2.0, 3.0 and 4.0kg a.i/ha. However, WDC plots gave significantly the least plant height of soybean. At 12WAS, there was no significant difference observed across all the treatments. However, WDFC and WDC plots gave the highest and lowest plant height of soybean respectively. It can be infer from this trial that high rates of *Pendimethalin* can decrease the height of cowpea plant which also did not significantly decrease the economic yield of cowpea. However, higher rates of *Pendimethalin* decrease the height of soybean but also did not significantly affect the final yield of soybean.

3.6Number of leaves plant^{-1}

At 4WAS, WDFC, 1.0 and 2.0kg a.i/ha plots resulted significantly with the maximum number of leaves which was statistically comparable to plots with 3.0, 4.0, 5.0 and 6.0kg a.i/ha with lower number of leaves in that order (Table 7). However, WDC plots gave the minimum number of leaves plant^{-1} of cowpea. At 8WAS, WDFC plots vary significantly with WDC plots which had the minimum number of leaves plant^{-1} but was however comparable with other treatments. At 12WAS, there was no significant difference observed across all treatments. However, WDFC and WDC plots had the maximum and minimum number of leaves plant of cowpea respectively.

At 4WAS, WDFC plots had the maximum number of leaves plant which vary significantly with plots treated with 4.0kg a.i/ha but was comparable with other treatments. At 8WAS, WDFC plots vary significantly with the maximum number of leaves plant^{-1} followed by plots with 1.0, 2.0, 3.0 and 4.0kg a.i/ha with lesser number of leaves that former but higher than WDC plots which significantly had the minimum number of leaves plant^{-1}of soybean. At 12WAS, WDFC plots had the maximum number of leaves plant^{-1} which varies from all treatments followed by plots with 4.0, 3.0, 2.0, 1.0 and WDC which were statistically comparable with number of leaves plant^{-1} less than the former. These indicates that higher rates of *Pendimethalin* resulted in less number of leaves plant-1 but did not significantly affects the final yield of both legume component crops.

3.7Days to 50% flowering

WDFC, 6.0 and 5.0kg a.i.ha^{-1} plots resulted significantly with the highest number of days to 50% flowering followed by plots with 4.0, 3.0 and 2.0kg a.i.ha-^{1} which were statistically comparable with less number of days to 50% flowering than former but higher than WDC and 1.0kg a.i.ha^{-1} plots which however resulted in the least number of days to 50% flowering of cowpea (Table 8). Conversely, plots with 4.0kg a.i.ha^{-1} had the highest number of days to 50% flowering followed by plots with 3.0, 2.0, 1.0kg a.i.ha^{-1} and WDC which were statistically comparable with number of days lower than former. However, WDFC plots had significantly the least number of days to 50% flowering of soybean. These shows that plots with high rates of *Pendimethalin* brings about less weed cover and density which automatically bring about early time of flowering as compared those plots with low rates of *Pendimethalin* application in both cowpea and soybean respectively.

3.8Number of pods plant^{-1}

WDFC and 6.0kg a.i.ha^{-1} gave significantly the highest number of pods plant^{-1} of cowpea which vary among all treatments followed by plots with 5.0, 4.0, 3.0, 2.0 and 1.0kg a.i.ha^{-1} which were statistically alike with number of pods plant^{-1} significantly lower than former but higher than WDC plots which had significantly the least number of pods plant^{-1} of cowpea. Conversely, WDFC plots vary significantly with the highest number of pods plant^{-1} followed by plots with 4.0, 3.0, 2.0 and 1.0kg a.i.ha^{-1} with less number of pods than former but significantly higher than WDC plots which resulted with the least number of pods plant^{-1} of soybean (Table 8). These indicates that plots which received higher rates of *Pendimethalin* application usually shows less weed cover which eventually leads to early flower setting and consequently higher number of pods plant^{-1}.

3.9Grain yield kgha^{-1}

WDFC and 6.0kg a.i/ha plots had the maximum grain yield which differ significantly with all treatments followed by plots with 5.0, 4.0, 3.0, 2.0 and 1.0kg a.i.ha^{-1} which were statistically alike with grain yield lower than former but significantly higher than WDC plots which had the minimum grain yield of cowpea (Table 8). Similarly, WDFC plots gave the maximum grain yield which differs significantly with all treatment followed by plots with 4.0, 3.0, 2.0 and 1.0kg a.i.ha^{-1} which were statistically similar with grain yield significantly below the former but higher than WDC plots which had the minimum grain yield of soybean. These findings indicates that *Pendimethalin* application at levels that can be tolerated by cops can result to economic yields equal or comparable to that of hoe weeding which can in turn reduce the time wasted, money spent and drudgery encounter in keeping the farm weed free as compare to chemical weeding. These findings agrees with that of Lagoke *et al.* (1982) who reported that *Metalachlor* at 1.5 and 3.0kg a.i.ha^{-1} and *Prometryne* at 2.0, *Norflurazon* 2.0 and *Diuron* 1.6kg a.i.ha-^{1} gave good weed control with high grain yield of cowpea. However, the grain yield obtained with *Alachlor*, *Metalachlor*, *Pendimethalin* and *Norflurazon* and their mixtures with *Prometryne*, *Luiron*, *Diuron* and *Metobrumuron* were comparable to that of hoe-weeding treatment. Parasuramin (2000) and Jaibir *et al*. (2004) found that application of *Pendimethalin* (1.5-2.0 Lha-^{1}) and (1.0kg ha-^{1}) + hoe weeding at 30 DAS gave the highest cowpea yield respectively.

4. CONCLUSION

These result of these trials comprehensively indicates that legume crops can tolerates and perform under high rates of *Pendimethalin* application, with cowpea performing best under high rates of (5.0 and 6.0kg a.i/ha) as compared to the weed free plots while soybean tolerates up to 4.0kg a.i/ha with performance next to the weed free treatments. However, higher rates bring about an increase in number of days to 50% emergence, phytotoxicity (injury) level, and decrease in plant height as well number of leaves plant^{-1}of respective leguminous crops. Nevertheless, minimum weed cover score, weed dry weight, increase in days to 50% flowering, number of pods plant^{-1} as well as grain yield were obtained with higher rates of *Pendimethalin* application when compared with the control plots for respective crops.

5. RECOMMENDATION

Based on the results of this investigation, it can be infer that application of higher rates of *Pendimethalin* to cowpea and soybean can enhance better performance of the crops when hoe weeding is not available during critical period of weed interferences as it relatively persists for more than 6WAT, and that period cowpea and soybean are capable of smothering the late emerging weeds. Therefore, it is recommended that up to 6.0kg a.i/ha can be tolerated by cowpea while up to 4.0kg a.i/ha can be tolerated by soybean with a better crop performance of respective leguminous crops in the sudan savanna agro-ecological zone of Nigeria,

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Table 1: Meteorological data of 2012 wet cropping season showing monthly rainfall, minimum and maximum temperature and relative humidity at Gombe

Months	Rainfall (mm)	R. Humidity (%)	Temperature (^{O}C)	
			Minimum	Maximum
April	54.8	20.0	15.5	37.4
May	125.8	45.6	25.7	36.8
June	179.6	54.6	24.8	32.1
July	199.7	41.2	21.2	31.2
August	313.3	42.5	20.8	29.6
September	304.4	42.7	20.6	28.9
October	100.4	25.3	20.8	24.1
November		45.6	20.4	24.0
Total	1278			
Mean	182.6	41.7	21.3	23.9

Source: Meteorological Station, Federal Ministry of Aviation, Gombe State R. Relative

Table 2: Physico-chemical analysis of the experimental site within 0-30cm depth at Gombe during the 2012 wet cropping seasons

Particle size distribution (g kg^{-1})	
Sand	68.6
Silt	17.2
Clay	15.2
Texture	Sandy Loam
Soil p^{H} 1:2 ($H_{2}0$)	6.44
Organic carbon(g kg^{-1})	4.6
Available P(mg kg^{-1})	7.24
Total N (g kg^{-1})	0.69
CEC[C mol (+)kg^{-1}]	3.70
Ca	2.88
Mg	0.42
K	0.58
Na	0.46
Sand	68.6
Silt	17.2
Clay	15.2

Table 3: Effect of pendimethalin on weed cover score of cowpea and soybean in Gombe during the 2012 wet cropping seasons

Treatments	Weed cover score					
	Cowpea			Soybean		
	Weeks after sowing					
	4	8	12	4	8	12
WDFC	0.67d	1.00e	2.33d	0.67c	1.33c	2.33d
WDC	4.33a	8.00a	10.00a	4.33a	8.00a	10.00a
Pendimethalin (Kg a.i ha^{-1})						
1	3.00b	6.33b	9.67ab	3.00b	6.33ab	10.00a
2	2.87bc	6.33b	9.00ab	3.00b	6.33ab	9.00b
3	2.87bc	5.67bc	8.67b	2.67b	5.86ab	8.67b
4	2.00c	4.67c	7.67c	2.00c	5.33ab	7.67c
5	1.33cd	4.67c	7.33c	0.00d	0.00d	0.00e
6	1.33cd	2.67d	6.67c	0.00d	0.00d	0.00e
SE±	0.21	0.30	0.24	0.26	0.60	0.18

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)

WDFC= Weed Free Check

WDC= Weedy Check

Table 4: Effect of pendimethalin on weed dry weight of cowpea and soybean in Gombe during the 2012 wet cropping seasons

Treatments	Weed dry weight gm^{-2}					
	Cowpea			Soybean		
	Weeks after sowing					
	4	8	12	4	8	12
WDFC	30.00e	52.30d	53.70d	33.00e	37.30d	53.70c
WDC	120.70a	215.00a	216.70a	120.70a	215.00a	216.70a
Pendimethalin (Kg a.i ha^{-1})						
1	37.70b	171.00ab	126.70b	37.70b	172.70ab	186.70a
2	24.70c	129.70b	120.00b	24.70c	124.70bc	170.00a
3	17.70cd	154.00b	100.00bc	17.70cd	123.30bc	100.00b
4	13.30d	94.00cd	88.00c	13.30d	93.30c	87.30b
5	10.30de	92.70cd	82.00cd	0.000f	0.000e	0.000d
6	10.00de	92.70cd	68.70cd	0.000f	0.000e	d.000e
SE±	5.2	11.2	65.0	21.0	13.4	6.3

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)

WDFC= Weed Free Check

WDC= Weedy Check

Table 5: Effect of Pendimethalin on 50% emergence and crop injury score of cowpea and soybean in Gombe during the 2012 wet cropping seasons

Treatments	50% Emergence		Crop injury score	
	Cowpea	Soybean	Cowpea	Soybean
WDFC	4.00c	4.67c	0.00d	0.00e
WDC	4.33c	4.67c	0.00d	0.00e
Pendimethalin (Kg a.i ha^{-1})				
1	4.33c	4.67c	0.00d	0.67cd
2	4.33c	5.00bc	0.33cd	1.67cd
3	4.67bc	5.67bc	1.00c	3.33b-d
4	5.00a-c	6.00ab	2.67b	5.33a-c
5	5.67ab	7.00a	4.00a	7.33ab
6	6.00a	0.00d	4.00a	8.33a
SE±	0.26	0.28	0.18	1.10

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)
WDFC= Weed Free Check
WDC= Weedy Check

Table 6: Effect of pendimethalin on plant height of cowpea and soybean in Gombe during the 2012 cropping season

Treatments	Plant height (cm)					
	Cowpea			Soybean		
	Weeks after sowing					
	4	8	12	4	8	12
WDFC	29.00a	65.00a	61.87a	24.11a	60.00a	58.33a
WDC	28.67a	57.67e	54.17d	23.33ab	51.33c	56.40b
Pendimethalin (Kg a.i ha^{-1})						
1	27.67ab	63.67ab	61.23ab	23.33ab	57.00b	57.50ab
2	27.33ab	63.33ab	60.40ab	23.67ab	56.00b	57.64ab
3	28.00ab	63.30ab	60.37ab	22.67bc	55.33b	57.40ab
4	26.67bc	61.67b-d	59.37b	22.00c	53.10bc	57.66ab
5	25.33c	60.67cd	57.13c	0.00d	0.00d	0.0s0c
6	25.67c	60.33d	57.17c	0.00d	0.00d	0.00c
SE±	0.35	0.44	0.38	0.24	0.54	1.10

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)
WDFC= Weed Free Check
WDC= Weedy Check

Table 7: Effect of pendimethalin during the 2012 cropping season

Treatments	Number of leaves					
	Cowpea			Soybean		
	Weeks after sowing					
	4	8	12	4	8	12
WDFC	30.00a	86.00a	73.67a	16.00a	65.67a	67.00a
WDC	23.33e	77.00c	62.33a	14.67ab	50.67c	53.00c
Pendimethalin (Kg a.i ha^{-1})						
1	30.00a	80.00bc	72.67a	14.67ab	58.33b	54.67bc
2	30.00a	84.00ab	71.67a	14.00bc	57.33b	57.33bc
3	28.67ab	83.33a-c	69.67a	13.00c	57.67b	59.33b
4	27.33bc	80.00a-c	69.67a	11.00d	56.00b	59.67b
5	26.67cd	78.33bc	68.00a	0.00e	0.00c	0.00d
6	25.67d	80.67b	72.00a	0.00e	0.00c	0.00d
SE±	0.34	1.25	2.46	0.34	0.90	1.30

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)

WDFC= Weed Free Check

WDC= Weedy Check

Table 8: Effect of Pendimethalin on 50% flowering, number of pods plant^{-1} and grain yield of cowpea and soybean in Gombe during the 2012 wet cropping season

Treatment	50% Flowering		No. pods plant^{-1}		Grain yield kg ha^{-1}	
	Cowpea	Soybean	Cowpea	Soybean	Cowpea	Soybean
WDFC	50.30e	57.00d	41.30a	68.70a	41.30a	68.70a
WDC	57.70a	59.70c	20.30c	60.00c	20.30c	60.00c
Pendimethalin (kg a.i ha^{-1})						
1	56.90ab	60.00c	35.70b	64.30b	35.70b	64.30b
2	54.90bc	61.00bc	35.80b	64.30b	35.80b	64.30b
3	54.80cd	62.30ab	36.00b	63.70b	36.00b	63.70b
4	52.00d	63.70a	36.00b	63.70b	36.00b	63.70b
5	50.50e	0.00e	37.30b	0.00d	37.30b	0.00d
6	50.40e	0.00e	40.80a	0.00d	40.80a	0.00d
SE±	0.40	0.30	0.50	0.56d	0.50	0.56d

Mean followed by common letter(s) are not significantly different at 5% probability level (DMRT)

WDFC= Weed Free Check

WDC= Weedy Check