

**EVALUATION OF THREE PRE-EMERGENCE HERBICIDES FOR WEED CONTROL IN SOYA BEAN [*Glycine max* (L.) Merr.] IN DUTSINMA AND SOKOTO, SUDAN SAVANNA*****¹Ezebuio, P. U., ²Yakubu, A. I. ³Audu, M.**¹Department of Agronomy, Federal University Dutsinma, Katsina State²Department of Crop Science, Usmanu Danfodiyo University, Sokoto³Department of Soil Science, Usmanu Danfodiyo University, Sokoto*Corresponding Author's Email Address: pezebuio@fudutsinma.edu.ng**ABSTRACT**

Field trials were conducted during the 2017 wet season at the Dryland Teaching and Research Farm of , Usmanu Danfodiyo University Sokoto (Latitude 13° 7'N, Longitude 5° 10'E') and Dutsinma in Katsina State (longitude 7° 29'E, Latitude 12° 27'N). The aim was to evaluate Pendimethalin, Butachlor and S-Metolachlor for weed control in soya beans. Treatments consisted of Pendimethalin at 0.8, 1.0 and 1.2 kg a.i./ha, Butachlor at 1.5, 1.8 and 2.0 kg a.i./ha and S-Metolachlor at 0.6, 1.3 and 1.9 kg a.i./ha and control where weeding was done manually at 4 and 6 weeks after sowing. The experiment was laid out in a Randomized Complete Block Design and replicated three times. Data were collected on weed parameters. Results obtained indicated that all the herbicide treatments significantly reduced weed infestation during the first four weeks after sowing but the crop experienced competition with weeds thereafter which varied according to the types of herbicides and their rates. Pendimethalin (1.0 and 1.2 kg a.i./ha, S-Metolachlor (1.9 kg a.i./ha) and Butachlor (2.0 kg a.i./ha) exhibited superior performance over other herbicide treatments. However, Pendimethalin at 1.2 kg a.i./ha caused injury to the plants though not prolonged. Hoe weeded plots faced early competition with weeds but were relatively weed-free during the reproductive phase of the crop. Soya bean farmers in Katsina and Sokoto could apply Butachlor 2.0 kg a.i./ha or S-Metolachlor 1.9 kg a.i./ha or Pendimethalin 1.0 kg a.i./ha for good control of weeds during the establishment phase of soya bean.

Keywords: herbicides, weed, control, pendimethalin, s-metolachlor and butachlor**INTRODUCTION**

Soybean (*Glycine max* (L) Merr.) is an annual legume cultivated in many parts of the world for its edible grains rich in protein and oil (Ajokporise *et al.*, 2018). It has become one of the most important grain legume and oilseed crops in the world (Daramola *et al.*, 2019). It ranks fifth in the world production of major crops after wheat, maize, rice and potato (Sedaghati and Hokmabadi, 2014). Soya bean accounts for more than 50 % of the global oilseed production (Imoloame, 2014) and is a cheap source of protein in Sub-Saharan Africa (Kolapo, 2011). The crop improves soil fertility through nitrogen fixation and provides useful crop residue for feeding livestock (Dugje *et al.*, 2009). Global, soya bean grain production in 2019 was 27690 (Hg/Ha) from 120,501,628 hectares of land with the United States of America as the highest producer. Africa produced 12,537 (Hg/Ha) of soya bean grains from 2,470,555 hectares of land while Nigeria produced 9,599 (HG/Ha) of soya bean grains from 656,304 hectares of land (FAO, 2021).

Nigeria is the second-largest producer of soya beans after South Africa in Sub Saharan Africa, with a larger percentage has grown mainly by smallholder farmers (Khojely *et al.*, 2018). The average yield of soya bean in Nigeria is 1,000 kg

ha⁻¹, while the world average yield is about 1,800 kg ha⁻¹ (Imoloame, 2014). This situation is attributed to poor yields obtained by farmers. Daramola (2019) and Olumide *et al.* (2020) reported that weed infestation is a major reason for low yields of soya bean in Nigeria and other parts of Sub-Saharan Africa The crop is susceptible to early weed competition, when weeds are uncontrolled for the entire season, yield reduction of up to 75% occurs due to weed soya bean competition (Sedaghati and Hokmabadi, 2014). Akporise *et al.* (2018) also found out that at early growth stages, soya bean is a poor competitor to weed competition and weeds outgrow it in the absence of proper weed management. Soya bean production thus requires early-season weed management to achieve economically acceptable yields (Knezevic *et al.*, 2003; Hock *et al.*, 2005). The cost of controlling weeds has become a major constraint especially where manual methods are employed due to reducing labour force and increasing wages (Imoloame, 2014). Efforts are being channeled towards using herbicides to control weeds. According to Chauhan *et al.* (2012), weed management using herbicides has become an integral part of modern agriculture. Herbicides offer greater flexibility of operation, are more effective, and are often cost-effective compared with most other methods of weed management. Knowing the best herbicide to use in controlling

weeds in Soya bean farms will bring great relief to farmers. It will lead to an increase in soya bean yield and invariably lead to improvement in farmers' income and standard of living. Objectives of this research therefore are to determine the best level of application of each of the three pre-emergence herbicides (Pendimethalin, Butachlor and S-Metolachlor) for effective weed control in soya bean in Sokoto and Dutsinma, Sudan savannah, as well as to compare the effectiveness of the three herbicides used with the manual method of weed control.

MATERIALS AND METHODS

Experimental Sites

The field trials were conducted at the Dryland Teaching and Research Farm of the Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto (Latitude 13° 56'N and Longitude 5° 15'E) (Kowal and Knabe, 1972) and Dutsinma in Katsina State (Latitude 12° 27'N and Longitude 7° 29'E). Both locations fall within the Sudan Savanna with an annual rainfall range of between 380 mm and 889 mm per annum. The sites experience a short rainy season which falls between the months of May and September and a long dry season from October to April. Their minimum and maximum temperatures range from 15 °C to 40 °C respectively (Agabi, 1995).

Treatments and Experimental Design

The treatments consisted of three pre-emergence herbicides (Pendimethalin, Butachlor and S-Metolachlor). Pendimethalin was applied at the rates of 0.8, 1.0 and 1.2 kg a.i./ha. Butachlor was applied at the rates of 1.5, 1.8 and 2.0 kg a.i./ha. S-Metolachlor was applied at the rates of 0.6, 1.3 and 1.9 kg a.i./ha and a control, where weeding was done manually at 4 and 6 weeks after sowing. Each plot was 4 m x 4 m (16 m²) comprising 5 rows of soya beans. The net plot was 2.25 m x 4 m (9m²) comprising 3 rows of soya beans.

Land preparation

Each experimental site was cleared, plowed and harrowed using a tractor.

Seed treatment

The soya bean seeds were treated with ' Dress Force' 45 WS (20% Metalaxyl, 15% Carboxin, 7% Furathiocarb) at the rate of one sachet (10 g) per 4 kg of seed. The seeds were put into a bag, lightly moistened with water and Dress Force was added to it. The mouth of the bag was tied with rope, and the bag was thoroughly shaken to ensure proper mixing of the seeds with the chemical. The seeds were then dried under shade for one hour and kept for sowing.

Sowing

Three seeds were dibbled per hole at a spacing of 10 cm apart within the rows and 75 cm between rows. The sowing depth was approximately 3-5 cm. The plants were thinned to two plants per stand at two weeks after sowing (WAS).

Weed control

The weeds were controlled according to the treatments. For the plots where weeds were controlled with herbicides, they were applied immediately after the seeds were sown. The

herbicides were measured using a syringe and applied to each plot according to treatment using 2 Litre capacity hand sprayer while weeding was carried out in control plots manually at 4 and 6 WAS.

Fertilizer application

Fertilizer was applied during land preparation in line with the recommended fertilizer rate for soya bean production in Nigeria of 20 kg N/ha, 40 kg P₂O₅/ha and 20 kg K₂O/ha. This was achieved using 133 kg/ha of NPK 15:15:15 fertilizer and 100 kg/ha of Single Super Phosphate.

Pests and disease control

Pests observed during the field trial were caterpillar (*Vanessa cardui*) at 4 WAS and stink bug (*Halyomorpha halys*) at 8 WAS. They were controlled with Lambda (Cypermethrin 10% EC) at the rate of one litre per hectare. No disease symptom was observed throughout the trial.

Harvesting

The pods were harvested manually at physiological maturity. This was attained when 95 percent of the pods changed from green to brownish colour (Kandel, 2013).

Drying and shelling of harvested pods

The harvested pods were further dried under shade until they attained constant weight and shelled, for data collection.

Data Collection

The following data were collected from the field trials: stand establishment count, weed count, weed density, weed cover score, crop vigour score, and crop injury score. Stand establishment count was obtained by counting the number of plant per stand in the net plots two weeks after sowing and the values obtained were extrapolated and expressed as the number of stands per hectare. Weed count was obtained by randomly placing one m² quadrant inside the net plots and counting and recording the number of weeds inside the quadrant. Weed density was obtained by dividing the total number of individual weeds of a species in all quadrants with the total number of quadrants studied multiplied by the area in metre square of a quadrant (Das, 2008). Weed cover score and crop vigour score were obtained with scales of 9 to 1 while crop injury score was obtained with a scale of 1 to 9 (Ishaya *et al.*, 2008).

STATISTICAL ANALYSIS

The data collected were subjected to statistical analysis of variance (ANOVA), using GenStat® 18th Edition where the effects of the treatment were observed to be significant, mean separation was carried out using Duncan's Multiple Range Test (DMRT)

RESULTS

Stand Establishment Count

Stand count of soya bean as influenced by three pre-emergence herbicides for weed control treatments at Dutsinma and Sokoto during the 2017 wet season indicated no significant

($P > 0.05$) effect of weed control methods on the stand count of the crop in both locations.

Weed Count Per Plot

Results from Dutsinma indicated that weed count per plot was highly significant ($P < 0.001$) at all the sampling stages. At 2 WAS, hoe weeding produced more weeds and was followed by S-Metolachlor (0.6 kg a.i./ha) and Butachlor (1.5 kg a.i./ha) which was similar to Pendimethalin (0.8 kg a.i./ha), S-Metholachlor (1.3 kg a.i./ha) and Butachlor (1.8 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha) and Butachlor 2.0 kg a.i./ha produced the lowest weed count but were comparable to Pendimethalin (1.0 kg a.i./kg), S-Metolachlor (1.3 and 1.9 kg a.i./ha) and Butachlor (1.8 kg a.i./ha).

. At 4 WAS, hoe weeded plots also produced the highest number of weeds. It was followed by Pendimethalin (0.8 kg a.i./ha), S-Metholachlor (0.6 kg a.i./ha) and Butachlor (1.5 kg a.i./ha) which were comparable to Pendimethalin (1.0 kg a.i./ha) and S-Metholachlor (1.3 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha), S-Metolachlor (1.9 kg a.i./ha) and Butachlor (2.0 kg a.i./ha) produced the lowest number of weeds, but was comparable to Butachlor (1.8 kg a.i./ha). At 6 and 8 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest number of weeds but was comparable to S-Metolachlor (0.6 and 1.3 kg a.i./ha) and Butachlor (1.5 kg a.i./ha). Hoe weeded plots produced the least number of weeds.

Table 1: Effect of per-emergence herbicide application on soya beans stand count at Dutsinma and Sokoto locations during 2017 wet season.

Treatment	Dutsinma	Sokoto
Pendimethalin 0.8kg a.i./ha	129259 a	132593 a
Pendimethalin 1.0kg a.i./ha	129259 a	131481 a
Pendimethalin 1.2kg a.i./ha	126296 a	130000 a
S-Metolachlor 0.6kg a.i./ha	128889 a	133333 a
S-Metolachlor 1.3kg a.i./ha	130370 a	131481 a
S-Metolachlor 1.9kg a.i./ha	131111 a	131111 a
Butachlor 1.5kg a.i./ha	128889 a	130000 a
Butachlor 1.8kg a.i./ha	130741 a	132963 a
Butachlor 2.0kg a.i./ha	130370 a	130741 a
Hoe weeding	129259 a	130741 a
SE	1750.7	1230.2
Significance Level	NS	NS

Means in a column followed by same letter(s) are not significantly different at 5% level using Duncan's Multiple Range Test (DMRT). NS = not significant at 5%. * = significant at 5% level of significance, ** = significant at 1% level of significance.

Table 2: Effect of pre-emergence herbicide application on weed count in soya beans farm at 2, 4, 6 and 8 WAS at Dutsinma and Sokoto during 2017 wet season.

Treatment	Dutsinma				Sokoto							
	2WAS	4WAS	6WAS	8WAS	2WAS	4WAS	6WAS	8WAS				
Pendimethalin 0.8kg a.i./ha	13.33bc	38.00 b		51.00a		61.67a		6.67 cde	19.33 bc	29.33 a	36.00 ab	
Pendimethalin 1.0kg a.i./ha	6.67 cd		34.67 bc	37.67b	46.33bcd		4.67 efg	14.00 def	20.00 cd	25.33 de		
Pendimethalin 1.2kg a.i./ha	3.67 d		20.00 d	24.67c	40.67cd		3.00g	10.33 f		15.33 de	18.67 e	
S-Metolachlor 0.6kg a.i./ha	15.33 b	39.00 b	49.33ab	56.33ab	12.33 b	20.67 b		28.67 a	43.00 a			
S-Metolachlor 1.3kg a.i./ha	10.33bcd	34.33 bc	45.00ab	50.33abc	8.00 cd	17.00 bcd	27.33a	35.33abc				
S-Metolachlor 1.9kg a.i./ha	6.33 cd		16.00 d	26.00c	43.00bcd		6.00 def	15.33 cde	24.67 abc	27.00cd		
Butachlor 1.5kg a.i./ha	14.67 b	36.67 b	44.00ab	52.00abc	9.00 c	18.67 bc		26.33 ab	37.67ab			
Butachlor 1.8kg a.i./ha	10.67bcd	24.33 cd	38.33b		43.67bcd		6.00 def	15.67 cd	21.00bcd	28.67bcd		
Butachlor 2.0kg a.i./ha	5.00 d		16.67 d	24.00c	34.00d			3.33 fg	11.33 ef	17.00 de	22.67de	
Hoe weeding at 4 & 6 WAS	23.00 a		59.00 a		9.33d	13.00e			26.00 a	39.33 a	12.00 e	3.67f
SE	2.261		3.84		3.79	4.61		0.903	1.320	1.777	2.960	
Significance Level	**	**	**	**			**	**	**	**	**	

Means in a column followed by same letter(s) are not significantly different at 5% level using Duncan's Multiple Range Test (DMRT). NS = not significant * = significant at 5% level ** = significant at 1% level WAS = weeks after sow in

At Sokoto, weed count per plot was highly significant ($P < 0.01$) at all sampling stages. At 2 WAS, hoe weeded plots produced the highest number of weeds. It was followed by S-Metolachlor (0.6 kg a.i./ha) Pendimethalin (1.2 kg a.i./ha) produced the lowest number of weeds but was comparable to Pendimethalin (1.0 kg a.i./ha) and Butachlor (2.0 kg a.i./ha) . At 4 WAS, hoe weeded plots also produced the highest number of weeds and were followed by S-Metolachlor (0.6 kg a.i./ha) which was comparable to Pendimethalin (0.8 kg a.i./ha), S-Metolachlor (1.3 kg a.i./ha), and Butachlor (1.5 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha) produced the least number of weeds but was comparable to Pendimethalin (1.0 kg a.i./ha) and Butachlor (2.0 kg a.i./ha).

Weed Density

At Dutsinma no significant effect of weed control treatments on weed density was observed at 2 WAS. However, at 4, 6 and 8 WAS, the effects of treatments on weed density were highly significant. At 4 WAS, hoe weeded plots recorded the highest weed density followed by S-Metholachlor (0.6 kg a.i./ha) which produced higher weed density but was comparable to Pendimethalin (0.8 and 1.0 kg a.i./ha), S-Metholachlor (1.3 kg a.i./ha) and Butachlor (1.5 kg a.i./ha). S-Metholachlor (1.9 kg a.i./ha), Butachlor (2.0 kg a.i./ha) and Pendimethalin (1.2 kg a.i./ha) produced the least weed density but was comparable to Butachlor (1.8 kg a.i./ha). At 6 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest weed density but was comparable to S-Metholachlor (0.6 and 1.3 kg a.i./ha) and Butachlor (1.5 kg a.i./ha). Hoe weeded plots,

Table 3: Effect of pre-emergence herbicide application on weed density in soya bean farm at 2, 4, 6 and 8 WAS at Dutsinma and Sokoto during 2017 season.

Treatment	Dutsinma				Sokoto			
	2WAS	4WAS	6WAS	8WAS	2WAS	4WAS	6WAS	8WAS
Pendimethalin 0.8kg a.i./ha	0.89	2.48bc	3.40a	4.11a	0.47bc	1.29bc	2.29a	2.51abc
Pendimethalin 1.0kg a.i./ha	0.44	2.42bc	2.51bcd	2.86bc	0.31de	0.93cde	1.17cd	1.87abc
Pendimethalin 1.2kg a.i./ha	1.33	1.36d	1.64e	2.71bc	0.13f	0.69e	1.07d	1.56c
S-Metolachlor 0.6kg a.i./ha	1.02	2.59b	3.39ab	2.78bc	0.82a	1.38b	1.91ab	2.87a
S-Metolachlor 1.3kg a.i./ha	0.69	2.29bc	2.99abc	3.03bc	0.53bc	1.13bcd	1.82ab	2.69ab
S-Metolachlor 1.9kg a.i./ha	0.40	1.07d	1.7de	2.47bc	0.40cd	1.02bcde	1.65bc	1.60bc
Butachlor 1.5kg a.i./ha	0.98	2.47bc	3.07abc	3.33ab	0.60b	1.02bcde	1.87ab	2.85a
Butachlor 1.8kg a.i./ha	0.69	1.62cd	2.35cde	2.91bc	0.40cd	1.05bcde	1.47bcd	2.4abc
Butachlor 2.0kg a.i./ha	0.39	1.11d	1.60e	2.00c	0.22ef	0.76de	1.13cd	1.48cd
Hoe weeding at 4 & 6 WAS	1.47	3.60a	0.62e	0.71d	0.86a	2.51a	1.30cd	0.24de
SE	4.855	0.399	0.365	0.474	0.068	0.162	0.231	0.499
Significance Level	NS	**	**	**	**	**	**	**

Means in a column followed by same letter(s) are not significantly different at 5% level using Duncan's Multiple Range Test (DMRT). NS = not significant at 5%. * = significant at 5% level of significance, ** = significant at 1% level of significance. WAS = weeks after sowing

Butachlor (2.0 a.i./ha) and Pendimethalin (1.2 kg a.i./ha) produced the least weed density but was comparable to Butachlor (1.8 kg a.i./ha) and S-Metolachlor (1.9 kg a.i./ha).

At 8 WAS, Pendimethalin (0.8 kg a.i./ha) also produced the highest weed density but was comparable to Butachlor (1.5 kg a.i./ha). Hoe weeded plots produced the least weed density.

In Sokoto, different weed treatments produced significant effects on weed density on soya bean plots at all sampling stages. At 2 WAS, hoe weeded plots and S-Metolachlor (0.6 kg a.i./ha) produced the highest weed density, followed by Butachlor (1.5 kg a.i./ha) but was comparable to. Pendimethalin (0.8 kg a.i./ha) and S-Metholachlor (1.3 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha) produced the least weed density but was comparable to Butachlor (2.0 kg a.i./ha). At 4 WAS, hoe weeded plots produced the highest weed density followed by S-Metolachlor (0.6 kg a.i./ha) which was comparable to all the other rates of S-Metholachlor, Butachlor (1.5 and 1.8 kg a.i./ha) and Pendimethalin (0.8 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha) produced the lowest weed density but was comparable to all the rates of Butachlor, S-Metolachlor (1.9 kg a.i./ha) and Pendimethalin (1.0 kg a.i./ha).

At 6 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest weed density but was comparable to S-Metolachlor (0.6 and 1.3 kg a.i./ha) and Butachlor (1.5 kg a.i./ha). The least weed density was produced by Pendimethalin (1.2 kg a.i./ha) which was comparable to Pendimethalin (1.0 kg a.i./ha), hoe weeded plots and Butachlor (1.8 and 2.0 kg a.i./ha). At 8 WAS, S-Metolachlor (0.6 kg a.i./ha) and Butachlor (1.5 kg a.i./ha) produced the highest weed density but was comparable to Pendimethalin (0.8 and 1.0 kg a.i./ha), S-Metolachlor (1.3 kg

a.i./ha) and Butachlor (1.8 kg a.i./ha). Hoe weeding produced the lowest weed density.

Weed Cover Score (WCS)

Results indicated that weed Cover Score was highly significantly influenced by the weed control treatments ($P < 0.001$) at all the sampling stages in both locations

At Dutsinma location, hoe weeding had the highest weed cover score at 2 and 4 WAS and was followed by S-Metolachlor (0.6 kg a.i./ha) which was comparable to Butachlor (1.5 kg a.i./ha).

S-Metolachlor (1.3 and 1.9 kg a.i./ha), Pendimethalin (1.0 and 1.2 kg a.i./ha), Butachlor (1.8 and 2.0 kg a.i./ha) had the lowest weed cover score.

At 4 WAS, hoe weeding also had the highest weed cover score and was followed by Pendimethalin (0.8 kg a.i./ha) and S-Metolachlor (0.6 kg a.i./ha) which were comparable to S-Metolachlor (1.3 kg a.i./ha). S-Metolachlor (1.9 kg a.i./ha) and Butachlor (2.0 and 1.8 kg a.i./ha) had the least weed cover score.

At 6 and 8 WAS, Pendimethalin (0.8 kg a.i./ha) and S-Metolachlor (0.6 kg a.i./ha) produced the highest weed score and were followed by Pendimethalin (1.0 kg a.i./ha) and S-Metolachlor (1.3 kg a.i./ha) which were comparable to Butachlor (1.5 kg a.i./ha) and S-Metolachlor (1.9 kg a.i./ha). Hoe weeding produced least weed cover but was comparable to Butachlor (2.0 kg a.i./ha). At 8 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest weed cover score but was comparable to S-Metolachlor (0.6 kg a.i./ha). Pendimethalin (1.0 kg a.i./ha) produced higher

Table 4: Effect of pre-emergence herbicide application on weed cover score in soya beans farm at 2, 4, 6 and 8 WAS as at Dutsinma and Sokoto during 2017 wet season.

Treatment	Dutsinma				Sokoto			
	2 WAS	4 WAS	6 WAS	8 WAS	2 WAS	4 WAS	6 WAS	8 WAS
Pendimethalin 0.8kg a.i./ha	3.33c	5.67b	7.67a	7.67a	4.67c	8.00ab	7.33a	8.33a
Pendimethalin 1.0kg a.i./ha	2.00d	4.67cd	5.67b	6.33bc	5.00c	5.67de	4.33de	7.00bc
Pendimethalin 1.2kg a.i./ha	2.00d	4.00dc	4.00cd	5.33cd	2.00e	4.00f	4.00e	5.00d
S-Metolachlor 0.6kg a.i./ha	4.00b	5.67b	8.00a	7.00ab	4.33c	7.33bc	6.00bc	8.00ab
S-Metolachlor 1.3kg a.i./ha	2.00d	5.00bc	5.33b	5.00d	3.33d	5.67de	5.33cd	7.00bc
S-Metolachlor 1.9kg a.i./ha	2.00d	3.67e	5.00bc	4.67de	3.33d	5.00ef	5.33cd	5.00d
Butachlor 1.5kg a.i./ha	3.67bc	4.67cd	5.00bc	6.00bcd	6.00b	6.33cd	7.00ab	6.33c
Butachlor 1.8kg a.i./ha	2.00d	3.67e	3.67d	5.00d	4.33c	4.33f	5.00cde	5.00d
Butachlor 2.0kg a.i./ha	2.00d	3.33e	3.33de	3.67e	2.00e	2.67g	4.00e	4.00d
Hoe weeding at 4 & 6 WAS	9.00a	9.00a	2.33e	2.33f	9.00a	9.00a	2.67f	2.00e
SE	0.1449	2.2789	0.350	0.413	0.3083	0.408	0.374	0.382
Significance Level	**	**	**	**	**	**	**	**

Means in a column followed by same letter(s) are not significantly different at 5% level using Duncan's Multiple Range Test (DMRT). NS = not significant at 5%. * = significant at 5% level of significance, ** = significant at 1% level of significance WAS = weeks after sowing

weed cover score and was comparable to Butachlor (1.5 kg a.i./ha). Hoe weeding produced the least weed cover score.

At Sokoto, hoe weeding produced the highest weed cover score at 2 and 4 WAS, followed by Butachlor (1.5 kg a.i./ha). S-Metolachlor (1.3 and 1.9 kg a.i./ha) produced the lower weed cover score while Butachlor (2.0 kg a.i./ha) and Pendimethalin (1.2 kg a.i./ha) produced the lowest weed cover score.

At 4 WAS, hoe weeding produced the highest weed cover score which was comparable to Pendimethalin (0.8 kg a.i./ha) while S-Metolachlor (0.6 kg a.i./ha) produced lower weed cover score. Butachlor (2.0 kg a.i./ha) produced the lowest weed cover score.

At 6 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest weed cover score but was comparable to Butachlor (1.5 kg a.i./ha). It was followed by S-Metolachlor (0.6 kg a.i./ha) which was comparable to S-Metolachlor (1.3 and 1.9 kg a.i./ha) and Butachlor (1.8 kg a.i./ha). Hoe weeding produced the lowest weed cover score.

At 8 WAS, Pendimethalin (0.8 kg a.i./ha) produced the highest weed cover score which was comparable to S-Metolachlor (0.6 kg a.i./ha). Pendimethalin (1.2 kg a.i./ha), S-Metolachlor (1.9 kg a.i./ha) and Butachlor (1.8 and 2.0 kg a.i./ha) produced lower weed cover score while hoe weeding produced the lowest weed cover score.

Crop Injury Score (CIS)

Crop injury score of soya bean at 4 WAS as influenced by the pre-emergence herbicides for weed control in soya bean at Dutsinma and Sokoto locations during 2017 season. At Dutsinma and Sokoto locations, soya bean treated with Pendimethalin (1.2 kg a.i./ha) exhibited slight injury. The leaves exhibited yellow colouration. None of the other treatments exhibited discolouration of leaves.

Crop Vigour Score (CVS)

Crop vigour score of soya bean as influenced by three pre-emergence herbicides for weed control treatments in soya bean at Dutsinma and Sokoto during 2017 wet season was highly significant ($P < 0.001$) at 4, 6 and 8 WAS.

At Dutsinma, at 4 WAS, all the treatments produced vigorous crops except Pendimethalin (1.2 kg a.i./ha), Butachlor (1.5 kg a.i./ha) and hoe weeded plots which produced the least vigorous crops.

At 6 WAS, all the treatments produced vigorous crops except Pendimethalin (0.8 kg a.i./ha), S-Metolachlor (0.6 kg a.i./ha) and Butachlor (1.5 kg a.i./ha) which produced less vigorous crops. At 8 WAS, hoe weeding, Butachlor (2.0 kg a.i./ha), and Pendimethalin (1.2 kg a.i./ha) produced the most vigorous crops which were comparable to Butachlor (1.8 kg a.i./ha) and Pendimethalin (1.0 kg a.i./ha). Pendimethalin (0.8 kg a.i./ha), S-Metolachlor (0.6 and 1.3 kg a.i./ha) and Butachlor (1.5 kg a.i./ha) produced the least vigorous crops which were comparable to S-Metolachlor (1.9 kg a.i./ha).

Effect of pre-emergence herbicide application on crop injury score of soya beans at 4 WAS and crop vigour score at 4, 6 and 8 WAS at Dutsinma and Sokoto during 2017 wet season.

Treatment	Dutsinma						Sokoto			
	4 WAS	CIS 4 WAS	CVS 6 WAS	CVS 8 WAS	CVS 4 WAS	CIS 4 WAS	CVS 6 WAS	8	CVS WAS	CVS WAS
Pendimethalin 0.8kg a.i./ha	1.00b	9.00a	8.33b	8.00c	1.00b	9.00a	8.00b	7.67cd		
Pendimethalin 1.0kg a.i./ha	1.00b	9.00a	9.00a	8.67ab	1.00b	9.00a	9.00a	8.33abc		
Pendimethalin 1.2kg a.i./ha	2.33a	8.00c	9.00a	9.00a	2.33a	8.00b	9.00a	9.00a		
S-Metolachlor 0.6kg a.i./ha	1.00b	8.67ab	8.33b	8.00c	1.00b	9.00a	7.67c	7.33d		
S-Metolachlor 1.3kg a.i./ha	1.00b	9.00a	9.00a	8.00c	1.00b	9.00a	9.00a	8.67ab		
S-Metolachlor 1.9kg a.i./ha	1.00b	9.00a	9.00a	8.33bc	1.00b	9.00a	9.00a	9.00a		
Butachlor 1.5kg a.i./ha	1.00b	8.33bc	8.33b	8.00c	1.00b	9.00a	8.00b	7.67cd		
Butachlor 1.8kg a.i./ha	1.00b	9.00a	9.00a	8.67ab	1.00b	9.00a	9.00a	8.00bcd		
Butachlor 2.0kg a.i./ha	1.00b	9.00a	9.00a	9.00a	1.00b	9.00a	9.00a	9.00a		
Hoe weeding at 4 & 6 WAS	1.00b	8.00c	9.00a	9.00a	1.00b	7.67c	9.00a	9.00a		
SE		0.105	0.157	0.183	1.892	0.105	0.105	0.105	0.105	0.230
Significance Level	**	**	**	**	**	**	**	**	**	**

Means in a column followed by same letter(s) in superscript are not significantly different at 5% level using Duncan's Multiple Range Test (DMRT). NS = not significant at 5%. * = significant at 5% level of significance, ** = significant at 1% level of significance. WAS = weeks after sowing was significant (P<0.001) at 4 WAS

At Sokoto, all the treatments produced vigorous crops at 4 WAS except Pendimethalin (1.2 kg a.i./ha) and hoe weeding. Hoe weeding produced the least vigorous crops.

At 6 WAS, Pendimethalin (1.0 and 1.2 kg a.i./ha), S-Metolachlor (1.3 and 1.9 kg a.i./ha) and Butachlor (1.8 and 2.0 kg a.i./ha) produced vigorous crops followed by Pendimethalin (0.8kg a.i./ha) and Butachlor (1.5 kg a.i./ha). S-Metolachlor (0.6 kg a.i./ha) produced the least vigorous crops. At 8 WAS, hoe weeding, Butachlor (2.0 kg a.i./ha), S-Metolachlor (1.9 kg a.i./ha), and Pendimethalin (1.2 kg a.i./ha) produced the most vigorous crops which were comparable to Pendimethalin (1.0 kg a.i./ha) and S-Metolachlor (1.3 kg a.i./ha). S-Metolachlor (0.6 kg a.i./ha) produced the least vigorous crops.

DISCUSSION

The overall performance of the three pre-emergence herbicides as exemplified by soya bean stand establishment count and weed count indicated that the three herbicides did not exhibit any effect on the germination and establishment of soya bean but hindered early germination of weed seeds. It is a known fact that the pre-emergence herbicides prevent the germination of weed seeds and other weed propagating materials. The herbicides used in this research could be said to be good for pre-emergence weed control in soya beans since they had no harmful effect on the germination of the crop. This is very important when considered in line with observation by Datta *et al.* (2017) that weeds emerging with the soya beans crop cause the greatest reduction in yield potential.

Weed count per plot and weed density during the first four weeks after soya bean seeds were sown indicated a reduction in weed infestation in plots where weeds were controlled with pre-emergence herbicides when compared with hoe weeded plots. This could be attributed to the effects of the herbicides on early weed emergence and growth. The pre-emergence herbicides suppressed germination and growth of weeds during the early growth stage of the crop. Similar findings have been reported by Imoloaeme (2014) who indicated that the application of pre-emergence herbicides resulted in a reduction in weed infestation when compared to plots where they were not applied.

The emergence of weeds and subsequent commencement of competition with soya bean crops between 6 and 8 WAS could be an indication that pre-emergence herbicides did not keep soya bean weed-free throughout their growing period. This confirms a report by Hepperly (2016) that although pre-emergence herbicides are good in controlling weeds in soya beans during the early growth stage of the crop, they do not guarantee complete control of weeds throughout the growth phase of the crop as it could still face competition with weeds afterward especially in the tropics which could affect grain yield and quality. Chaunhan and Opena (2013) also observed that most available herbicides do not give full-season weed control and there is hardly any herbicide that controls different

kinds of weeds with one or two applications. Hoe weeding at 4 and 6 WAS kept the hoe weeded plots relatively weed-free till the crop was harvested. This confirms the observation by Duge *et al.* (2009) that twice hand hoeing is good in controlling weeds in soya bean farms in the Northern Guinea savanna of Nigeria. However, it could not take care of weeds that emerged with soya being plants which resulted in to increase in weed count and when compared with herbicide treated plots. Soya bean plants in hoe weeded plots were exposed to early season competition with weeds and since the growth and yield of soya beans are negatively affected by early-season weed competition, delaying hoe weeding till four weeks after planting is not good in soya bean farms in the area where this field trial was conducted.

Treatments where soya beans faced serious competition with weeds produced less vigorous crops when compared with other treatments. Competition with weeds could be said to have a negative effect on soya bean vigour. This concurs with the observation of Rajan and Swanton (2001) that physiological activities and the growth of crops are negatively affected by the presence of weeds. As much as possible, soya bean farmers should keep their farms weed-free in order to have vigorous plants. Application of the highest recommended rate of Pendimethalin also produced the same effect though it lasted for a short time. Hepperly (2016) observed that pendimethalin tends to cause mild crop injury which does not usually last long. This is an indication that farmers in the Sudan Savannah do not need to apply the highest level recommended for Pendimethalin in soya bean farms.

Variation in weed emergence in the plots where the different herbicides and their rates were applied with the lowest rates of the three pre-emergence herbicides having the highest weed count and densities indicated that at their lowest recommended rates, Pendimethalin, S-Metolachlor and Butachlor could not effectively control early weed emergence in soya bean in Sudan Savanna. This is in line with Reddy and Reddi (1992) who reported that the application of low concentrations of herbicides will reduce their effectiveness in controlling weeds. Application of highest recommended rates of Butachlor and S-Metolachlor and medium rate of Pendimethalin resulted in keeping the weeds in check at the early stage of soya bean growth and establishment, the crop still faced competition with weeds at reproductive stage. This indicates the need for another weed control method in soya bean fields when pre-emergence herbicides are used. This could be achieved through hoe weeding, the use of post-emergence herbicides or other appropriate weed control measures.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The field experiment was conducted during the 2017 rainy season at the Dryland Teaching and Research Farm of the Faculty of Agriculture, Usmanu Danfodiyo University Sokoto (Latitude 13° 7'N and Longitude 5° 10'E and lies at an altitude of 350 m above sea level) and Experimental Farm of Federal University, Dutsinma in Katsina State (Latitude 12° 27'N and longitude 7° 29'E and altitude 543 m above sea level), The aim was to evaluate the effects of three pre-emergence herbicides on weed control in soya bean fields. The treatments consisted of the three pre-emergence herbicides (Pendimethalin, Butachlor and S-Metolachlor). Each of the herbicides was applied at three rates using the minimum, average and maximum rates recommended by the manufacturers. Pendimethalin was applied at the rates of 0.8, 1.0 and 1.2 kg a.i./ha. Butachlor was applied at the rates of 1.5, 1.8 and 2.0 kg a.i./ha. S-Metolachlor was applied at the rates of 0.6 kg, 1.3 and 1.9 kg a.i./ha. A control where weeding was done manually by hoe weeding at 4 and 6 weeks after sowing formed the tenth treatment. Each plot was 4 m x 4 m (16 m²) comprising 5 rows of soya beans. The net plot was 2.25 m x 4 m (9 m²) comprising 3 rows of soya beans. The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times.

The results obtained showed that all the herbicides significantly reduced weed infestation during the first four weeks after sowing the crop. Subsequently, weeds emerged in the plots but varied according to the herbicides and the rates applied. Hoe weeded plots experienced competition with weeds during the first four weeks after sowing while the plots treated with pre-emergence herbicides had the problem of weed competition during the reproductive phase. Of the treatments evaluated, Butachlor (2.0 kg a.i./ha), Pendimethalin (1.0 kg a.i./ha), S-Metolachlor (1.9 kg a.i./ha) exhibited superior performance in terms of weed control during the establishment phase of the crop.

CONCLUSION

Based on the findings of this research, Butachlor at the rate of 2.0 kg a.i./ha, Pendimethalin at the rate of 1.0 kg a.i./ha, S-Metolachlor at the rate of 1.9 kg a.i./ha produced the best weed control and vigorous soya bean plants compared to other treatments during the establishment phase of the crop while hoe weeding at 4 and 6 WAS controlled weeds better than plots treated with pre-emergence herbicides during the reproductive phase of the crop. Therefore, they could be adopted by farmers in the study area.

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