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COMBINED EFFECTS OF WEED CONTROL AND NPK FERTILIZER ON YIELD COMPONENTS OF KENAF (*Hibiscus cannabicus* L.)

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ABSTRACT

Two field trials were conducted during the wet season of 2017 at Zaria and Kaduna to evaluate the influence of weed control methods and NPK application on yield components of kenaf. The treatments consisted of five weed control methods, which included three pre-emergence herbicides (Pendimethalin at 2.0 kg a.i ha^{-1}, S- Metolachor at 1.0 kg a.i ha^{-1} and Tank mixture of Pendimethalin, and S- Metolachor at 1.0 + 0.5kg a,i ha-^{1}), hoe weeding at 3 and 6 weeks after sowing (WAS) and an unweeded check (control) and four levels of NPK application (0:0:0, 30:15:15, 60:30:30 and 90:45:45 kgha^{-1}). The treatments were laid out in 5 × 4 factorial arrangements fitted into randomized complete block design (RCBD) and replicated three times. The results showed that among the weed control methods evaluated, the application of S- Metolachor at 1.0kg a.i ha^{-1} gave lower weed cover score, weed dry weight and higher weed control efficiency, while hoe weeding control method resulted in highest yield components. Pendimethalin at 2.0 kg a.i ha^{-1} , S- Metolachor at 1.0 kg a.i ha^{-1} and Tank mixture of Pendimethalin at 1.0 + 0.5kg a,i ha^{-1} gave varied weed control efficiencies with fibre yield of 845.37 kg (98.7%), 851.16 kg (97.4 %) and 531.91kg (61.8%) respectively at Samaru location and 638.30 kg (93,5%), 744.68 kg (83.6%) and 433.67 kg (57.6%) respectively at Kaduna location when compared to the hoe weeded control treatment with fibre yield of 866.98 kg (100%) at Samaru and 754.12 kg (100%) at Kaduna respectively. NPK application had negative influence on weed infestation but positive effect on weed control efficiency. Application of 90:45:45 kg NPK ha^{-1} had highest yield components. It can be concluded that, hoe weeded control treatment combined with application of NPK 90:45:45 kg ha^{-1} gave the best weed management that resulted to highest ribbon and fibre yield compared to all herbicides evaluated.

Keywords: Kenaf; weed management; NPK fertilization; herbicides

INTRODUCTION

Kenaf *(Hibiscus cannabinus* L.), a potential jute substitute in the manufacturing of rope, twine and carpet (Alexopoulou *et al*., 2000) is a warm-season annual plant. The crop is

very promising fibre source for production of paper pulp; as its stems consist of an inner thick core of short woody fibres 0.5 to 1 mm long, and an external bark with fibres of 3 to 4 mm long (Webber, 1993). The fibres are of better quality than the core fibres; both, however, can be utilized in various blends for the production of pulp (Danalatos and Archontoulis, 2004). Kenaf pulps have been used in making several grades of paper including newsprint, bond, coating raw stock and surfaced size, with Kugler (1989) reporting results that were positive, particularly in terms of paper quality, durability, print quality and ink absorption. Other potential commercial uses of kenaf are being investigated, such as animal feed (Webber, 1993), poultry litter (Tilmon *et al.*, 1988), bulking agent for sewage sludge and for oil absorption (Webber, 1992). The leaf is consumed as vegetable and can be used as silage for feeding livestock, while the seed can be processed into edible oil and cake for livestock feeding. Kenaf has a high potential as a board raw material with low density panels suitable for sound absorption and thermal resistance. It is also a good carbon sequester and can improve soil fertility being a fast growing and multipurpose. Retted fibre is mixed with jute for the manufacture of jute sacks and hessian materials used for packing of commodities. The fibre can also be processed and used for impregnating cement for the production of roofing sheets, boards for ceiling and several furniture works. It is also an excellent forage crop (Muchow and Wood, 1980), containing 1830% crude leaf protein and stalk protein 5.812.1% (Ogbonnaya *et al.*, 1997). Manual hoe weeding is the most popular method of weed control among Nigerian and most third world countries` farmers, however, the method is not economically viable because is tedious, expensive, slow and drudgery. Chemical weed control may provide a better alternative to manual hoe weeding in kenaf production (Ogundale, 2006). The effective weed management that will greatly reduce time, money and energy necessitate the choice of the pre-emergence herbicides in this research. Hence this study was undertaken to identify the most appropriate weed control method and the NPK application level that will give optimum yield components of kenaf.

MATERIALS AND METHODS

Study Area

Field trials were carried out during the wet season of 2017 at Institute for Agricultural Research (IAR) farm, Ahmadu Bello University, Zaria (Latitude 11° 11'N and Longitude 07° 38' E) 686m above sea level and experimental research farm of College of Animal Science, Mando, Kaduna (Latitude 7° 26' E and Longitude 10° 31' N) 576m above sea level both in northern guinea savannah ecological zone of Nigeria. Soil composite samples were taken using an auger at random from the experimental sites at a depth of 0-30cm prior to land preparation for determination of physical and chemical properties using standard procedures (Black, 1965).

Experimental Design

The treatments consisted of five weed management treatments (Pendimethalin at 2.0 kg a.i /ha, S- metolachor at 1.0 kg a.i /kg, tank-mixture of S-metolachor and Pendimethalin (1.0+0.5 kg a.i /ha. hoe-weeded control at 3 and 6 WAS and weedy check) and four levels (0:0:0, 30:15:15, 60:30:30 and 90:45:45 kg/ha) of NPK fertilizer. These treatments were laid in 5 × factorial arrangement fitted into a randomized complete block design (RCBD) and

replicated three times. The gross plot size consisted of six ridges measuring 5 x 4.5m (22.5 m^2) and the net plot size was two inner ridges measuring 5.0 x 1.50m (7.50 m^2). Two outer ridges which served as border ridges were used for destructive sampling. The kenaf variety "IFEKEN 400" an improved variety with medium height and high seeds yield, good fibre and ribbon quality, was released by Institute for Agricultural Research and Training (IAR&T), Ibadan in 2015 was used for the study.

Cultural Practices

The experimental fields in both locations (Zaria and Kaduna) were ploughed and harrowed twice to fine tilth, ridged at 75cm and marked out into plots and replications. Seed of kenaf were sown manually at a spacing of 75 x 20cm and 4 seeds were sown per stand which were thinned to 2 plants per stand. Two weeks after sowing, pre-emergence herbicides (Pendimethalin at 2.0 kg a.i, S- Metolachor at 1.0 kg a.i kg/ha and tank mixture of Pendimethalin and S- Metolachor at 0.5 kg a.i kg/ha) were applied with a green deflector nozzle at a pressure of 2.1kg/cm^2 same day after planting according to the treatments using CP 15 knapsack sprayer. Hoe weeding in the hoe-weeded control was carried out at 3 and 6 WAS.

Observation and Data Collection

Weed dry weight (g/m^2)

Weed samples were taken using 1 m^2 quadrant placed randomly in each plot before each weeding was carried out at 3, 6, 9 and 12 WAS. Weed samples were cleaned free of soil and then oven dried at 70^0C to a constant weight and weighed using Mettler Toledo weighing balance. The weights were recorded and expressed in gramme per square meter (g/m^2).

Weed cover score

Weed cover score was taken at 3,6,9 and 12 WAS by visual assessment, using a scale of 1-9, where 1 represented no weed and 9 represented complete weed cover.

Weed control efficiency

Efficiency of weed control by treatments were ascertained using $1/m^2$ quadrant placed randomly in each net plot at 3, 6, 9 and 12 WAS. The observed and collected weeds samples were counted to obtain the weed control efficiency using the formula:

Weed control efficiency (WCE) = $\frac{WDC-WDT}{WDC}$ (Das, 2011).
WDC = weed density (number/m^2) in control plot
WDT = weed density (number/m^2) in treated plot

Number of capsules per plant (g)

This parameter was determined from the five tagged plants per plot, their capsules were counted and the number of capsules per plant was determined and recorded.

Seed yield per plant (g)

The capsules counted were sun dried, threshed and the seeds contained were weighed. The weight per plant was determined and expressed in grammes.

Ribbon yield per hectare

Plants from net plot were harvested fresh at 12 WAS. The stems were carefully peeled to separate the ribbon from the stem. The components were oven-dried to constant weights and the weighs per hectare were determined, expressed in kilogrammes.

Fibre yield per hectare

Plants were harvested from the net rows of each plot at 12 WAS. The stems were carefully peeled and retted, and the fibre strands were removed. The fibre strands were oven-dried and weighed and the yield per hectare were determined and expressed in kilogrammes.

Statistical Analysis

Data collected were subjected to Statistical Analysis of Variance (ANOVA) and using model procedure of statistical analysis system (SAS) software version 8. Means were separated using the least significant different (LSD) at p = 0.05 (Rangaswamy, 2010).

RESULTS

Result of the physical and chemical properties of soil at the experimental sites (Samaru and Kaduna) are presented in Table 1.

Table 1: Physical and chemical characteristics of the soil of experimental sites during 2017 wet season

Soil Depth	Samaru (0-30 cm)	Kaduna (0-30 cm)
Physical properties (g kg^{-1})		
Clay	12.4	11.0
Silt	45.0	44.0
Sand	42.6	45.0
Total	100	100
Textural class	Loam	Loam
Chemical properties		
pH(H_2O) 1:2.5	6.37	6.10
pH0.01M$CaCl_2$	5.39	5.47
%Total Nitrogen	1.80	1.40
Available P $mgkg^{-1}$	5.04	6.04
% Organic Carbon	15.5	16.1
Exchangeable bases (cmol kg^{-1})		
Calcium	2.91	3.10
Magnesium	0.51	0.59
Potassium	0.15	0.09
Sodium	0.15	0.17
CEC	3.90	4.10

The soils of both experimental sites were loam. The soil at Samaru was loam and moderately acidic, low in organic carbon, total nitrogen and available phosphorous. Exchangeable calcium and CEC were low but exchangeable magnesium, potassium and sodium were adequate. At Kaduna the soil was moderately acidic, low in organic carbon, total nitrogen and available phosphorous. Exchangeable bases were adequate except potassium and CEC.

Table 2: List of weed species observed at Samaru and Kaduna experimental sites in 2017 wet season

Types of weeds	Family	Samaru	Kaduna
		Level on infestation	
Grasses			
Chloris pjlosa Schumachs	Poaceae	+	++
Cynodon dactylon (L), Pers	Poaceae	+++	+++
Digitaria horizonfialis Wild	Poaceae	+++	++
Panicum maximum Jacq	Poaceae	+	+++
Eragrostis atravirens (Dest) Trin	Poaceae	++	+
Rottboellia cochinchinensis (Clayton)	Poaceae	+++	+++
Sida acuta	Poaceae	++	+++
Broadleaves			
Acanthospermum hispidium D C	Asteriaceae	++	++
Boerhaavia diffusa	Asteriaceae	++	++
Commellina benghalensis	Commelinaceae	++	+++
Euphorbia heterophylla	Euphorbiaceae	+++	+++
Sedges			
Cyperus esculentus Linn	Cyperaceae	++	+++
Cyperus rotundus Linn	Cyperaceae	+++	++

+ = Low Infestation ; ++ = Moderate Infestation; +++ = High Infestation

Weed Dry Weight

Weed dry weight as influenced by weed control methods and NPK application of kenaf at (3 and 6 WAS) at Samaru and Kaduna is presented are Table 3. At Samaru in both sampling periods (6 and 9 WAS), weedy check recorded significantly ($P<0.05$) higher weed dry weight among all other treatments. Weed dry weight were least on plots hoe weeded. Weed dry weight as influenced by application of S- Metolachlor at 1.0 kg a.i ha^{-1} performed better than the Pendimethalin at 2.0 Kg a.i ha^{-1}. At Kaduna location, application of Pendimethalin at 2.0 Kg a.i ha^{-1} gave significantly lower weed dry weight compared to the application of S-Metolachlor at 1.0 kg a.i ha^{-1} and tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1}. The hoe weeded control recorded least weed dry weight and weeded check resulted in highest weed dry weight.

The NPK application had significant (<0.05) on weed dry weight both sampling weeks at both locations. At Samaru, plots supplied with 90:45:45 kg NPK ha^{-1} had significantly highest weed dry weight compared to other rates of NPK application. Application of 60:30:30 kg NPK ha^{-1} had the lowest weed dry weight compared to 30:15:15: and 0 kg NPKha^{-1} at 6

WAS. At Kaduna location, application of 30:15:15 kg NPK ha^{-1} resulted significantly in the highest weed dry weight but at par with the application of 0 kg NPK ha^{-1} at 6 WAS and Pendimethalin and Metolachor (1.0 + 1.5) kg. At 6 WAS, it was at par with other treatments except weed check and Pendimethalin2.0 kg a.i ha^{-1}. In Kaduna, at 6 WAS, hoe weeding was at par with S-Metolachlor at 1.0 Kg a.i ha^{-1}. 60:30:30 kg NPK ha^{-1} only at 9WAS. Application of 30:15:15 kg NPK ha^{-1} gave least weed dry weight compared with all other NPK rates but at par with 0:0:0 kg NPK ha^{-1}.

Table 3: Effect of weed management methods and NPK fertilization on weed dry weight (gm^{-2}) of kenaf in Samaru and Kaduna during 2017 wet season

Treatments	Weed Dry Weight (gm^{-2}) 6WAS		Weed Dry Weight (gm^{-2}) 9WAS	
	Samaru	Kaduna	Samaru	Kaduna
Weed Control Methods (W)				
Pendimethalin 2.0 kg a.i ha^{-1}	27.83b	31.71b	45.19a	50.03c
S-Metolachor 1.0 kg a.i ha^{-1}	21.17e	29.97d	34.87c	55.86b
Pendimethalin + S-Metolachor (1.0 + 0.5) kg a.i ha^{-1}	23.91c	30.94c	38.33b	54.30b
Hoe weeding (3&6 WAS)	22.32d	27.10e	28.82d	38.69d
Weedy check	31.84a	37.03a	45.39a	56.73a
S.E (±)	0.147	0.165	0.151	0.204
Fertilizer Rate (kgNPK ha^{-1}) (F)				
0:0:0	26.05b	32.37a	28.66c	50.01c
30:15:15	26.15b	33.47a	28.88c	50.09c
60:30:30	24.96c	31.56b	39.47b	68.45a
90:45:45	27.17a	31.73b	40.87a	61.28b
S.E (±)	0.118	0.132	0.145	0.163
Interaction				
WxF	NS	NS	NS	NS

Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of Significance. [2]WAS – Week after sowing. [3]NS – Not Significant

Weed Cover Score

Weed cover score as influenced by weed control methods in kenaf in sampling periods at Samaru and Kaduna is presented in Table 4. The results were consistent at both locations. At 3 and 6 WAS, the weedy check recorded significantly highest weed cover score compared to all other treatments. Hoe-weeded control had the least weed cover score at 3 and 6 WAS in both locations. However, in Samaru at 3 WAS, it was at par with a mixture of Pendimethalin and Metolachlor (1.0 + 1.5) kg. At 6 WAS, it was at par with other treatments except weed check and Pendimethalin 2.0 $kgha^{-1}$. In Kaduna, at 6 WAS. Hoe weeding is at par with S-Metolachlor at 1.0 Kg a.i ha^{-1}.

Table 4: Effect of weed management methods and NPK fertilization on weed cover score of kenaf in Samaru and Kaduna during 2017 wet season

	Weed Cover Score 3WAS		Weed Cover Score 6WAS	
Treatments	Samaru	Kaduna	Samaru	Kaduna
Weed Control Methods (W)				
Pendimethalin 2.0 Kg a.i ha^{-1}	2.37c	2.50b	3.33c	3.18b
S-Metolachor 1.0 Kg a.i ha^{-1}	2.26d	2.17d	3.12d	3.08c
Pendimethalin + S-Metolachor (1.0+0.5) Kg a.i ha^{-1}	2.63b	2.33c	3.48b	3.17b
Hoe weeding (3 and 6 WAS)	2.17e	2.17d	3.00e	2.67d
Weedy check	2.83a	2.75a	3.67a	3.75a
S.E (±)	0.058	0.051	0.055	0.056
Fertilizer Rate (KgNPK ha^{-1}) (F)				
0:0:0	2.27d	2.10d	3.00c	3. l8c
30:15:15	2.40c	2.34c	3.00c	3.13d
60:30:30	2.47b	2.40b	3.07b	3.19b
90:45:45	2.60a	2.53a	3.33a	3.27a
S.E (±)	0.047	0.041	0.044	0.045
Interaction WxF	NS[4]	NS	NS	NS

[1]Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of significance. [2]WAS —Week after sowing [3]Weed cover score using scale of 1-9 where 1= least weedy plot and 9= most weedy plot [4]NS - Not Significant.

Weed Control Efficiency

Weed control efficiency as affected by weed control methods and NPK application in kenaf at 6 and 9 WAS at Samaru and Kaduna are presented in Table 5. Results were consistent in both locations at 6 and 9 WAS, the hoe weeded control recorded significantly the highest weed control efficiency compared to all other weed control treatments. Among the herbicide treatments application of S- Metolachlor at 1.0 kg a.i ha^{-1} gave a better weed control efficiency compared to the application of Pendimethalin at 2.0 kg a.i ha^{-1} and tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1}. The application of Pendimethalin at 2.0 Kg a.i ha^{-1} had higher weed control efficiency than treated plots with application of tank mixture of Pendimethalin + S- Metolachlor at 1.0 + 0.5 kg a.i ha^{-1}. The weedy check treatments consistently resulted in the lowest weed control efficiency in both locations at 6 and 9 WAS.

The effect of NPK application on weed control efficiency at the sampling weeks at both locations indicated that application of 90:45:45kg NPKha^{-1} resulted to significantly highest weed control efficiency compared to other rates of NPK application at both locations.

Table 5: Effect of weed management methods and NPK fertilization on weed control efficiency of kenaf in Samaru and Kaduna during 2017 wet season

Treatments	Weed Control Efficiency 6WAS		Weed Control Efficiency 9WAS	
	Samaru	Kaduna	Samaru	Kaduna
Weed Control Methods (W)				
Pendimethalin 2.0 Kg a.i ha^{-1}	65.41c	60.25c	62.19c	55.24c
S-Metolachor 1.0 Kg a.i ha^{-1}	71.83b	66.13b	68. 11b	64.49b
Pendimethalin + S-Metolachor (1.0+0.5) Kg a.i ha^{-1}	55.35d	54.81d	52.11d	50.11d
Hoe weeding (3 & 6 WAS)	83.25a	79.66a	78.95a	76.54a
Weedy check	0.00e	0.00e	0.00e	0.00e
S.E(±)	0.242	0.215	0.203	0.198
Fertilizer Rate (KgNPK ha^{-1}) (F)				
0:0:0	0.00d	0.00d	0.00d	0.00d
30:15:15	17.27c	16.30c	18.65c	17.68c
60:30:30	25.76b	24.27b	27.07b	22.78b
90:45:45	33.33a	32.97a	35.53a	34.87a
S.E (±) Interaction	0.193	0.172	0.162	0.159
WxF	NS	NS	NS	NS

[1]Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of significance. [2]WAS -Week after sowing [3]NS - Not Significant

Number of Capsules per Plant

Number of capsules per plant in kenaf as influenced by weed control methods and NPK application on kenaf at Samaru and Kaduna are presented in Table 6.

Table 6: Effect of weed control methods and NPK fertilization on number of capsules per plant of kenaf at Samaru and Kaduna during 2017 wet season

Treatment	Rate	Number of Capsules per Plant	
		Samaru	Kaduna
Weed control methods (W)	(kg a.i ha^{-1})		
Pendimethalin	2.0	38.83b	32.41c
S-Metolachor	1.0	43.50b	35.42b
Pendimethalin + S-Metolachor	(1.0 +0.5)	23.75c	22.25d
Hoe- weeded (3 and 6 WAS)	_	43.42a	37.81a
Weedy Check	_	23.25c	19.58c
S.E (±)	_	0.157	0.147
Fertilizer Rate (NPK kg ha^{-1}) (F)			
	0: 0: 0	29.80d	26.60d
	30:15:15	32.40c	28.20c
	60:30:30	34.00b	29.46b
	90:45:45	42.00a	35.73a
S.E ±	_	0.126	0.117
W x F		NS	NS

[1] Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of Significant [2] WAS- Week after sowing [3] **NS**- Not Significant

At Samaru location, the hoe weeded control, was comparable with the application of S-Metolachlor at 1.0 kg a.i ha^{-1} and produced crops with the highest number of capsules per plant compared to other treatments. Application of Pendimethalin at 2.0 Kg a.i ha^{-1} resulted to higher number of capsules per plant than tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1} which was statistically similar to weedy check. At Kaduna location, the hoe weeded control resulted in the highest number of capsules per plant compared to other treatments. Among the herbicide treatments, application of S-Metolachlor at 1.0 kg a.i ha^{-1} produced crops with higher number of capsules per plant compared to other herbicides. Application of Pendimethalin at 2.0 Kg a.i ha^{-1} resulted in higher number of capsules per plant than tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1}while the weedy check produced least number of capsules per plant. The effect of NPK application with respect to number of capsules per plant at both locations, showed that application of 90:45:45kg NPKha^{-1} significantly produced crops with the highest number of capsules per plant compared to other rates of NPK application. Increase in NPK rate from zero to 90:45:45kg NPKha^{-1} resulted to corresponding increase in number of capsules per plant (Table 6).

Seed Yield per Hectare (kg ha^{-1})

Seed yield per hectare in kenaf as influenced by weed control methods and NPK application at Samaru and Kaduna are presented in Table 7.

Table 7: Effect of weed control methods and NPK fertilization on seed yield per hectare (kgha-1) of kenaf at Samaru and Kaduna during 2017 wet season

Treatment	Rate	Seed Yield per Hectare ($kgha^{-1}$)	
Treatment	Rate	Samaru	Kaduna
Weed control methods (W)	(kg a.i ha^{-1})		
Pendimethalin	2.0	75.93c[1]	58.90c
S-Metolachor	1.0	85.60b	62.25b
Pendimethalin + S-Metolachor	(1.0 +0.5)	56.47d	48.76d
Hoe- weeded (3 and 6 WAS)	_	88.61a	75.44a
Weedy Check	_	45.40e	33.50e
S.E (±)	_	0.380	0.242
Fertilizer Rate (NPK kg ha^{-1}) (F)			
	0: 0: 0	58.29c	39.52c
	30:15:15	66.32b	41.87b
	60:30:30	66.49b	45.31b
	90:45:45	82.56a	62.88a
S.E ±	_	0.302	0.194
Interaction			
W x F		[3]NS	NS

[1] Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of Significant [2] WAS- Week after sowing [3] NS- Not Significant

Results were consistent at both locations. Among the weed control methods, the hoe weeded control produced the highest seed yield per hectare compared to other weed control

treatments. Among the herbicide treatments, application of S-Metolachlor at 1.0 kg a.i ha^{-1} produced significantly higher seed yield per hectare compared to other herbicides. Application of Pendimethalin at 2.0 Kg a.i ha^{-1} produced higher seed yield per hectare than tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1} The weedy check treated plots consistently produced crops with least seed yield per hectare at both locations. The effect of NPK application on seed yield per hectare at both locations showed that application of 90:45:45kg $NPKha^{-1}$ produced significantly the highest seed yield per hectare compared to other rates of NPK application. Application 60:30:30kg $NPKha^{-1}$ produced seed yield per hectare that was statistically similar to that produced by 30:15:15kg $NPKha^{-1}$, while 0kg $NPKha^{-1}$ consistently produced least seed yield per hectare.

Ribbon Yield per Hectare (kg $ha^{-1)}$)

Ribbon yield per hectare in kenaf as influenced by weed control methods and NPK application of kenaf at Samaru and Kaduna are presented in Table 8. Result at both locations showed that among the weed control methods, the hoe weeded control produced the highest ribbon yield per hectare compared to other methods. Among the herbicide treatments, application of S-Metolachlor at 1.0 kg a.i ha^{-1} produced higher ribbon yield per hectare compared with others. Weedy check plots consistently produced crops with lower ribbon yield per hectare at both locations.

Table 8: Effect of weed management methods and NPK fertilization on Ribbon yield per plant and per hectre of kenaf in Samaru and Kaduna during 2017 wet season

Treatments	Ribbon weight/Plant (g $plant^{-1}$)		Ribbon yield $kgha^{-1}$	
Weed Control Methods (W)	Samaru	Kaduna	Samaru	Kaduna
Pendimethalin 2.0 kg a.i ha^{-1}	28.69c	26.58b	62.22c	57.52c
S-Metolachor 1.0 kg a.i ha^{-1}	32.73a	28.42a	66.66b	62.22b
Pendimethalin + S-Metolachor (1.0 + 0.5) kg a.i ha^{-1}	20.48d	19.94c	44.44d	40.64d
Hoe weeding (3&6 WAS)	30.19b	28.83a	71.11a	66.45a
Weedy check	18.42e	16.26d	40.00e	35.56e
S.E (±)	0.014	0.008	0.014	0.008
Fertilizer Rate (kgNPK ha^{-1}) (F)				
0:0:0	20.84d	18.52d	46.28d	43.97d
30:15:15	24.74c	22.74c	53.33c	48.89b
60:30:30	26.67b	28.25b	57.55b	52.45c
90:45:45	36.81a	30.67a	80.00a	69.12a
S.E (±)	0.011	0.006	0.011	0.006
Interaction				
WxF	NS[3]	NS	NS	NS

[1]Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of Significance. [2]WAS – Week after sowing. [3]NS – Not Significant

The effect of NPK application with respect to ribbon yield per hectare at both locations showed that application of 90:45:45kg NPK ha^{-1} significantly had the highest ribbon yield

per hectare compared with other rates of NPK applied. To every increase in NPK rate from zero to 90:45:45kg NPKha^{-1} there was a significant increase in ribbon yield per hectare at both locations.

Fibre Yield per Hectare (kg ha^{-1})

Fibre yield per hectare in kenaf as influenced by weed control methods and NPK applicaation on kenaf at Samaru and Kaduna are presented in Table 9. At Samaru location, the result showed that among the weed control methods, the hoe weeded control produced significantly the highest fibre yield per hectare but was statistically similar to that produced by the application of S-Metolachlor at 1.0 kg a.i ha^{-1}. The application of tank mixture of Pendimethalin + S- Metolachlor at 1.0 + 0.5 kg a.i ha^{-1} produced lower fibre yield per hectare but comparable to the fibre yield produced by the weedy check. At Kaduna location, the hoe weeded control resulted in significantly higher fibre yield per hectare but was at par with the application of S-Metolachlor at 1.0 kg a.i ha^{-1} .The application of Pendimethalin at 2.0 Kg a.i ha^{-1} produced higher fibre yield per hectare than the application of tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1} while weedy check that produced crops with least fibre yield per hectare. The effect of NPK application with on fibre yield per hectare at both locations showed that application of 90:45:45kg NPKha^{-1} resulted in significantly the highest fibre yield per hectare compared to other rates of NPK applied. Each increase in NPK rate from 0 to 90:45:45kg NPKha^{-1} gave a significant increase in fibre yield per hectare at both locations.

Table 9: Effect of weed management methods and NPK fertilization on Fibre Yield per Plant (g) and per hectare (kg) of kenaf in Samaru and Kaduna during 2017 wet season

Treatments	Fibre weight / Plant (g plant^{-1})		Fibre Yield kgha^{-1}	
	Samaru	Kaduna	Samaru	Kaduna
Weed Control Methods (W)				
Pendimethalin 2.0 kg a.i ha^{-1}	19.98c	14.82b	845.37c	638.30c
S-Metolachor 1.0 kg a.i ha^{-1}	20.76b	19.78a	851.16b	744.68b
Pendimethalin + S-Metolachor (1.0 + 0.5) kg a.i ha^{-1}	12.74d	12.17c	531.91d	433.67d
Hoe weeding (3&6 WAS)	21.54a	19.85a	866.89a	754.125a
Weedy check	10.56e	9.67d	527.78e	425.53e
S.E (±)	0.014	0.008	0.006	0.005
Fertilizer Rate (kgNPK ha^{-1}) (F)				
0:0:0	10.96d	10.06d	537.91d	446.23d
30:15:15	12.46c	11.48c	638.30c	565.98c
60:30:30	14.54b	13.99b	734.65b	675.76b
90:45:45	19.45a	17.49a	989.01a	858.44a
S.E (±)	0.011	0.006	0.005	0.004
Interaction				
WxF	NS[3]	NS	NS	NS

[1]Means followed by the same letter within the same treatment group are statistically the same using DMRT at 5% Level of Significance. [2]WAS – Week after sowing. [3]NS – Not Significant

DISCUSSION

Effective weed control is essential for kenaf growth and optimum productivity; the critical period for weed control in kenaf is during the period of crop establishment (Das, 2011). Pre- emergence herbicides such as S-Metolachlor and Pendimethalin are some of the effective herbicides for weed management in kenaf production (Othman *et al.*, 2006). Among the herbicides, application of S-Metolachlor at 1.0 kg a.i ha^{-1} significantly gave higher weed control efficiency, lower weed cover score, weed density and weed dry weight but was lower compared to the hoe- weeded control treatments that performed outstanding among the weed control methods but however the control method was not economically viable. This verified the report by Vencill (2002) that S-Metolachlor is a good weeds growth inhibitor. However, in this study, S-Metolachlor was inferior to hoe weeding in both sample periods. Pendimethalin herbicide was effective in controlling weeds of grasses families but performed poor in broadleaves weeds, this was manifested by its lower weed control efficiency, high weed cover, weed density and weed dry weight compared to the latter. The application of tank mixture of Pendimethalin + S-Metolachlor at 1.0 + 0.5 kg a.i ha^{-1} gave lower weed control efficiency, high weed cover, weed density and weed dry weight but better than the weedy check control treatments. Vencill (2002) reported that the mixture of Pendimethalin and S-Metolachlor herbicides will reduce the efficacy of the herbicides due to the antagonistic effect of their chemical composition rather than synergic effect and in turn result to poor weed control as shown in weed control efficiency and other weeds parameters

The productivity of kenaf as shown in its yield parameters such as ribbon and fibre yields were generally affected by methods of weed control treatment at both locations. Among the weed control treatments, the hoe weeded control treatment performed best followed by the application of S-Metolachlor at 1.0 kg a.i ha^{-1}. This could be attributed to the fact that, S-Metolachlor was very effective due to its active ingredients' composition, thus helped in suppressing both broadleaves and grasses weed seedlings emergence and weed competition, thereby promoting efficient crop growth. Weed infestation could led to reduction in yield of kenaf as observed by Kuchinda *et al.* (1993), who reported significant decrease in yield parameters in the weedy check control treated plots when compared to other controlled with herbicides and hoe weeded.

Kenaf in 90:45:45kg ha^{-1} NPK treatment produced higher yield than the other treatments during the period. The report justified the earlier works of Wood and Muchow, (1980) that higher yield of kenaf was attributed to higher rate of NPK application.

CONCLUSION

This study has demonstrated that hoe weed control method was very effective by giving the highest seed, ribbon and fibre yield compared to other weed control methods. NPK application enhanced weed dry weight and weed cover score but improved weed control efficiency and yield components. Based on the findings of this study, hoe weeding at 3 and 6 WAS and application of 90:45:45 kg NPK ha^{-1} are thereby suggested for kenaf farmers at Samaru and Kaduna.

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