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Effects of Weed Control on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.) in the Sudan Savanna, Sokoto State, Nigeria

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ABSTRACT

Pearl millet was grown in the rainy season of 2018 at the Research Farm of Usmanu Danfodiyo University, Sokoto, Nigeria (Pennisetum glaucum L.). In the RCBD experiment, eight treatments of weed management regime and three replications were used. Weeding was performed at 3 and 6 weeks after sowing (WAS), and a control plot was established (weedy check). Plant height at 6, 9 and 12 WAS, tiller number, weed density, weed dry weight, weed control efficacy, panicle length and days to 50 percent heading were all significantly affected by weed management. En revanche, plant height at 3 WAS, plant stands, and weight of 1000 grains did not have significant effects. At 3, 6, and during harvest, the lowest and lowest dry weights of weeds, respectively, were achieved with the application of Metolachlor at 1.6 kg a.i. ha^{-1} and supplementary hoe weeding at six WAS. The highest weed control quality was achieved with the application of Metolachlor at 6 WAS and supplementary hoe weeding at six WAS (944.46 per cent). This treatment yielded significantly more grain (3030.37 kg ha^{-1}), possibly due to the substantially higher plant height (240.33 cm) and the number of tillers (5.2 $hill^{-1}$) at harvest.

Keywords: Pearl millet; Herbicides; Atrazine; Metolachlor; Weed; Pre-emergence; Sokoto

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INTRODUCTION

Under irrigated and upland conditions, pearl millet is heavily infested with weeds (Adikant and Sonboir, 2009). A diverse weed flora gradually become a severe constraint to pearl millet development (Prajapathi et al., 2007). If millet crops are competing with weeds for limited resources such as soil moisture, sunlight, nutrients, and space, outcome is lower yields, poorer grain quality, and greater production costs. Crop cultivars, weed kind and severity, weed infestation period, and environmental variables and management approaches determine the extent of the losses (Mishra, 2015). Due to this, it is crucial to maintain good weed management during the important crop growth cycle. Due to its nutritional value, investigations on pearl millet weed management have been limited. For this crop, it is necessary to combine chemical weed control with hand weeding.

Uncontrolled weed growth on the savannas of Guinea and Sudan like Sokoto has caused crop losses in Africa, particularly in Nigeria. It is estimated that in northern Guinea and Sudan, uncontrolled weeds reduced millet and Sudan savanna production by 44 to 53 per cent, respectively (Lagoke, 1983). Hoe-weeding is used by farmers in the Sudan savanna to control weed growth (Joshua et al., 2011). As a result, yields are lost because of lack of appropriate weed eradication.

Agriculturalists around the world now approach weed control differently because of chemical weed control. All food-sufficient countries throughout the world have embraced it (Akobundu, 1987). Because of its effectiveness in large-scale production, chemical weed management is more cost-effective than other methods of weed control (Andrews et al., 1993; Joshua and Gworgwor, 2000; Imoloame, 2009). It was also hoped that by employing pesticides and manual weeding, the yield of pearl millet could be improved.

MATERIALS AND METHODS

To investigate the different parameters of the soil, soil samples were taken in two depths of 0-15cm and 15-30cm from various sites on the site. The composite sample was allowed to air dried before being gently crushed and sieved with a 2mm sieve. Each soil sample's particle size distribution was calculated using Boyoucous hydrometer methods with sodium hexametaphosphate (Calgon) as a dispersant, and the data was inserted into the USDA soil texture triangle to display the textural groups (Page et al., 1982). A pH meter was used to calculate the pH of the soil in water. The Walkley-Black method was used to calculate organic carbon (1934). Saturating soil samples with ammonium acetate at pH 7.0 determined the cation exchange capability (Chapman, 1965). To remove exchangeable bases, normal ammonium acetate solution was utilised. A flame photometer was used to determine potassium (k) and sodium (Na) in addition to the EDTA titration method for calcium (ca) and magnesium (Mg) (Maclean, 1965). The total nitrogen (N) was calculated using the micro Kjeldahl digestion distillation method (Jackson, 1962). The amount of accessible phosphorus was calculated using the Bray No. 1 method (Bray and Kurtz, 1945).

Treatment and experimental design

The Atrazine and Metolachlor were applied at rates of 0.8, 1.2, and 1.6kg a.i. ha^{-1}, respectively, and two hoe-weeding treatments were carried out at 3 and 6 WAS. Detailed information about the treatment is provided below:

Table 1. Treatments and their rate of application

Treatments	Rate (kg a.i ha^{-1})	
	Pre-emergence	Post-emergence
Atrazine	0.8	Fb SHW (6WAS)
Atrazine	1.2	Fb SHW (6WAS)
Atrazine	1.6	Fb SHW (6WAS)
Metolachlor	0.8	Fb SHW (6WAS)
Metolachlor	1.2	Fb SHW (6WAS)
Metolachlor	1.6	Fb SHW (6WAS)
Hoe weeding	-	3 and 6 WAS
Weedy check	-	

ai = active ingredients; Fb = followed by; SHW = supplementary hoe weeding; WAS = weeks after sowing.

Cultural practices

A manual hoe was used to level the soil after it had been ploughed and harrowed. This was done by dividing the plots into three blocks, each with eight plots. Each plot was 5 x 3 ft (15 ft^2) in size. In terms of size, the net plots were 4.4 x 1.5 metres (6.6m2). Apron Star 42 WS containing 20 per cent thiamethoxam, 20 percent metalaxyl-M, and 2 percent difenoconazole was applied to pearl millet seeds of the SOSAT variety before planting to prevent seedborne infection during the trial. As soon as the rains began to fall in July, we began to sow our crops. Inter and intra row spacing was 75cm by 30cm, and stands were thinned to two plants per stand at 2WAS. The seeds were manually planted by dibbling at 75cm by 30cm inter and intra row spacing. This provided 60 kg of N, 30 kg of P, and 30 kilogrammes of potassium per hectare. During the 2WAS mission, the maximum P and K rates were used. When it came to the application of N, however, it was divided into two equal dosages. It was applied in two doses at 2 WAS and 6 WAS using band techniques around 15 cm away from the millet stand, respectively (46 per cent). In accordance with the treatments, weeding was carried out on the farm (Table 1).

Data collection

In a random selection, five plants were picked and their heights were measured. We measured the height of the plants at 3, 6 and 9 weeks following seeding. It was measured at 12 weeks following sowing, from plant base to panicle tip, using centimetre rule.

It was estimated by counting the days from seeding to when 50 percent of a plant's leaves were in full bloom. Five plants in each net plot were tagged and their panicle lengths measured using the metre rule. Panicle stalks were gathered and threshed. Grain was separated from stalks by cleaning and weighing separately. Eventually, the yield per net plot was converted to kilogrammes per hectare (kg ha^{-1}). In order to record 1000grain weight in g, grain samples were obtained from net plots of product.

Weed identification

Each weeding was preceded by the detection and recording of weeds in a 1m2 quadrat. Herbarium specimens were made using West African weed handbooks (Akobundu and Agyakwa, 1987). The number of weeds per square metre of each species was counted and recorded. Weed character assessments were done on weed flora at 3 and 6 WAS, and during harvest.

In the net plot, a quadrat of (1 x 1) m^2 was designated for recording the number of weeds in each treatment to estimate the density of weed growth. The number of weeds in the quadrat was counted, registered, and then statistically analysed. Weeds within a quadrat area of (1 x 1) m^2 were uprooted to determine weed dry weight. The weeds were dried until the constant weights were collected, then weighed and statistically analysed. Weed control efficiency was calculated using the formula proposed by Mani et al (1973).

$$WCE\ (\%) = \frac{WPC - WPT}{WPT} \times 100$$

WCE, Weed control efficiency in %; WPC, Weed population in control plots (kg ha^{-1}); WPT, Weed population in treated plots (kg ha^{-1}).

Data analysis

An analysis of variance was performed using the data DMRT was employed to isolate the treatment means. SPSS 19.0 version used for all the statistical analysis.

RESULTS AND DISCUSSION

Weed flora composition associated in pearl millet

The Table 2 shows the overall weed flora of the investigational area in the cropping period. The broad-leaved weeds were found predominant and this includes, *Centella asiatica* (Linn.), *Conyza canadensis* (Linn.), *Zornia gibbosa* (Linn.), *Alternanthera brasiliana* (Linn.), *Commelina benghalensis* (Linn.), *Cassia pumila* (Linn.), *Sida cardifolia* (Linn.), *Blainvilla acmella* (Linn.), *Alysicarpus ovalifolius* (J.), *Amaranthus spinosus* (Linn.), *Acalypha indica* (Linn.), *Alternanthera bettzickiana* (Regoi.), *Euphorbia hirta* (Linn.), *Cassia occidentalis* (Linn) and *Corchorus olitorius* (Linn.). Due to their ecological adaption and dominance on sandy loam soils in the Sudanese savanna region, these weed species are most likely to be found in pearl millet fields. The grasses include; *Pennisetum pedicellatum* (Linn.), *Cynodon dactylon* (Linn.) and *Digitaria smustii* (Linn.). The sedges found includes; *Cyperus eragrostis* (Linn.), Cyperus esculentus (Linn.), *Cyperus compressus* (Linn.), *Cyperus tenuispica* (Linn.) and Cyperus brevifolius (Rottb.). Vinothini and Murali reported similar findings (2017).

Table 2. Weed flora composition at the experimental site

Scientific name	Common name	Family	Growth form
Broad leaved			
Centella asiatica (Linn.)	Asiatic pennywort	Fabaceae	PBL
Alternanthera brasiliana (Linn.)	Brazilian joyweed	Fabaceae	PBL
Commelina benghalensis (Linn.)	Tropical spiderwort	Commelinaceae	ABL
Cassia pumila (Linn.)	Dwarf cassia	Fabaceae	PBL
Sida cardifolia (Linn.)	Smooth sowthistle	Asteraceae	ABL
Blainvilla acmella (Linn.)	Para cress flower	Asteraceae	ABL
Amaranthus spinosus (Linn.)	Spiny pigweed	Amaranthaceae	ABL
Acalypha indica (Linn.)	Indian copper leaf	Euphorbiaceae	ABL
Euphorbia hirta (Linn.)	Asthma herb	Euphorbiaceae	ABL
Cassia occidentalis (Linn.)	Coffee senna	Fabaceae	ABL
Alysicarpus ovalifolius (J.)	Over leafed alysicarpus	Fabaceae	ABL
Zornia gibbosa (Linn.)	Grass-like zornia	Fabaceae	ABL
Sedges			
Cyperus compressus (Linn.)	Poorland flatsedge	Cyperaceae	AS
Cyperus tenuispica (Linn.)	Slender spiked sedge	Cyperaceae	AS
Cyperus esculentus (Linn.)	Yellow nutsedge	Cyperaceae	PS
Cyperus brevifolius (Rottb.)	Mullimbimby couch	Cyperaceae	PS
Cyperus eragrostis (Linn.)	Pale galingale	Cyperaceae	PG
Grasses			
Cynodon dactylon (Linn.)	Bermuda grass	Poaceae	AG
Pennisetum pedicellatum (Linn.)	Kyasuwa grass	Poaceae	AG
Digitaria smustii (Linn.)	Wooly finger grass	Poaceae	AG

AG, Annual grass; PG, Perennial grass; AS, Annual sedge; PS, Perennial sedge; ABL, Annual Broad Leaved; PBL = Perennial Broad Leaved

In table 3, the data for plant heights are shown. Data on plant height during the third week following seeding showed that there was no significant difference across treatments, this shows that the weed has no effect on the plant height at early stage of pearl millet, while a significant enhancement was noticed in plant height at other various growth stages due to different herbicide rates practices, this is as a result of increase in weed density. The Treatment hoe weeding showed tallest plants (150.33 cm, 243.37 cm, and 246.37cm at 6 WAS, 9 WAS, and 12 WAS respectively and shortest plant was noticed in weedy check (90.53 cm, 100.50 cm, and 105.90cm) at 6 WAS, 9 WAS, and 12 WAS respectively.

Plant establishment is not affected by the varied herbicide rates practiced at 3WAS and during harvest (Table 4).

Table 3. Effect of weed control treatments on plant height

Treatments	Rates (kg a.iha^{-1})	Plant height (cm) 3WAS	6WAS	9WAS	12WAS
Atrazine	0.8 fb SHW	29.50	128.03^{d}	204.40^{e}	210.33^{e}
Atrazine	1.2 fb SHW	31.00	137.47^{c}	216.63^{d}	217.40^{d}
Atrazine	1.6 fb SHW	31.10	136.50^{c}	220.63^{d}	221.40^{d}
Metolachlor	0.8 fb SHW	30.30	137.40^{c}	227.50^{c}	228.87^{c}
Metolachlor	1.2 fb SHW	28.80	143.03^{bc}	235.60^{b}	237.70^{b}
Metolachlor	1.6 fb SHW	30.30	146.00^{ab}	239.67^{ab}	240.33^{b}
Hoe weeding	3 and 6WAS	28.90	150.33^{a}	243.37^{a}	246.37^{a}
Weedy check		29.70	90.53^{e}	100.50^{f}	105.9^{f}
SE±		0.94	2.24	2.10	1.57
Significance		NS	*	*	*

Mean within a column carrying the same letter (s) are not significantly different from each other at 5% level using DMRT. Fb, followed by; SHW, supplementary hoe weeding; WAS, weeks after sowing, SE, standard error, Significance at 5% level, NS = no significance difference.

Table 4. Effect of weed control treatments on plant stand per net plot

Treatments	Rates (kg a.i ha^{-1})	Plant stand/net plot Initial at 3WAS	At harvest
Atrazine	0.8 fb SHW	27.67	27.00
Atrazine	1.2 fb SHW	28.00	27.33
Atrazine	1.6 fb SHW	27.33	27.33
Metolachlor	0.8 fb SHW	28.00	27.00
Metolachlor	1.2 fb SHW	27.67	27.33
Metolachlor	1.6 fb SHW	27.33	27.33
Hoe weeding	3 and 6WAS	28.00	27.67
Weedy check	-	28.00	27.00
SE±	-	0.25	0.4
Significance	-	NS	NS

The number of tillers per hill observed at 3WAS is unaffected by weed management interventions. At the harvest stage, a significant variation was seen (Table 5). Metolachlor administered at a rate of 1.6 kg a.i ha^{-1} (5.2 hill^{-1}) resulted in a higher number of tillers at harvest compared to the other weed control treatments. There were less tillers on the un-weeded check (3.52 hill^{-1}).

Table 5. Effect of weed control treatments on number of tillers

Treatments	Rates (kg a.i ha^{-1})	Number of tillers hills^{-1} Initial at 3WAS	At harvest (Productive tillers)
Atrazine	0.8 fb SHW	3.00	3.72^{c}
Atrazine	1.2 fb SHW	2.67	3.79^{c}
Atrazine	1.6 fb SHW	3.67	4.20^{b}
Metolachlor	0.8 fb SHW	2.67	3.80^{c}

Metolachlor	1.2 fb SHW	27.67	3.90[b]
Metolachlor	1.6 fb SHW	3.67	5.20[a]
Hoe weeding	3 and 6WAS	3.00	3.90[b]
Weedy check	-	3.33	3.52[d]
SE±	-	0.41	0.67
Significance	-	NS	*

Weed density

Different weed management methods affect the total density of weeds at different growth phases, according to Table 6. Herbicide treatments changed the density of weed species compared with untreated areas of weedy vegetation. At varied rates of metolachlor application, grass, sedge, and broad-leaved weed density were reduced significantly. At both pre-germination and early weed establishment, metolachlor spraying at 1.6 kg a.i ha^{-1} effectively controlled all species of weeds that were dominant in the study region. A hoe was used to control weeds. The result was that the soil became porous, making it ideal for crop development and weed control. These studies found that Metolachlor, applied at an application rate of 0.5 kg ha^{-1}, after that two inter-cultivations and manual weeding, reduced the complexity of the herbaceous plant flora and reduced weed density. Weed density was higher in the unweeded control at all phases of crop growth, which was consistent with Prajapathi and colleagues' findings (Prajapathi et al (2007).

Table 6. The effect of weed control treatments (WCT) on weed density

Treatments	Rates (kg a.iha^{-1})	Weed density (m^{-2}) 3WAS	6WAS	At harvest
Atrazine	0.8 fb SHW	6.00[b]	40.00[b]	35.00[b]
Atrazine	1.2 fb SHW	5.00[b]	38.00[bc]	32.67[bc]
Atrazine	1.6 fb SHW	4.00[bc]	35.00[c]	23.00[e]
Metolachlor	0.8 fb SHW	5.67[b]	34.00[cd]	31.00[bc]
Metolachlor	1.2 fb SHW	4.00[bc]	36.33[c]	30.00[c]
Metolachlor	1.6 fb SHW	3.00[c]	30.00[d]	24.00[de]
Hoe weeding	3 and 6WAS	11.00[a]	25.00[e]	25.00[d]
Weedy check	-	13.00[a]	150.00[a]	250.67[a]
SE±	-	0.66	1.55	1.99
Significance	-	*	*	*

Weed dry weight

Weed dry weight is an important metric for determining weed competitiveness in relation to plant growth and productivity. An important difference in weed dry weight was observed at 3 and 6 WAS and at harvest due to the implementation of weed control treatments, as shown in Table 7. In comparison to the other therapies, Metolachlor at 1.6 kg a.i ha^{-1} resulted in a significant reduction in weed dry weight at various growth stages. This may be because the overall weed density was lower during the cropping season (Adikant Pradhan et al. 2012; and Chopra and Angiras (2008).

Table 7. Effect of WTC on weed dry weight

Treatments	Rates (kg a.i ha^{-1})	Weed dry weight (kg ha^{-1}) 3WAS	6WAS	at harvest
Atrazine	0.8 fb SHW	100.8[b]	800.24[b]	451.73[b]
Atrazine	1.2 fb SHW	82.26[c]	743.20[b]	436.90[b]
Atrazine	1.6 fb SHW	72.77[de]	703.93[c]	333.20[d]

Metolachlor	0.8 fb SHW	96.54^{bc}	632.37^{d}	411.10^{b}
Metolachlor	1.2 fb SHW	75.57^{d}	722.74^{bc}	400.63^{c}
Metolachlor	1.6 fb SHW	60.70^{e}	602.40^{d}	330.57^{d}
Hoe weeding	3 and 6WAS	210.57^{a}	508.23^{e}	335.20^{d}
Weedy check	-	215.61^{a}	3502.10^{a}	5028.53^{a}
SE±	-	5.98	102.64	11.07
Significance	-	*	*	*

Weed control performance measures the amount of dry weight reduction achieved by different weed control treatments during the crop cycle. It was found that the Metolachlor treatment (T6) on 6 WAS was more effective at controlling weeds than any of the other weed control techniques (225.21, 481.35 and 1421.17 per cent at 3, 6 WAS and at harvest, respectively). These were the only weeds that were efficiently controlled by Metolachlor (Table 8).

Table 8. Effect of WTC on weed control efficiency

Treatments	Rates (kg a.i ha^{-1})	Weed control efficiency (%) 3WAS	6WAS	at harvest
Atrazine	0.8 fb SHW	113.89	336.54	1013.17
Atrazine	1.2 fb SHW	162.11	371.22	1050.96
Atrazine	1.6 fb SHW	196.29	397.51	1409.16
Metolachlor	0.8 fb SHW	123.34	453.81	1123.19
Metolachlor	1.2 fb SHW	185.31	384.56	1155.16
Metolachlor	1.6 fb SHW	225.21	481.85	1421.17

The data on panicle length is presented in table 9. Significant enhancements were noticed in panicle length under different treatment practices. The maximum length of the panicle was recorded under the hoe weeding (34.01 cm). This might be due to proper weed management, which allows adequate growth of the plant, while the minimum length of panicle was recorded under un-weeded plots; this is due to uncontrolled weeds. It was confirmed the report of Adikant and Sonboir (2009).

Table 9. Effect of WTC on panicle length

Treatments	Rate (kg a.iha^{-1})	Panicle length (cm)
Atrazine	0.8 fb SHW	31.30^{d}
Atrazine	1.2 fb SHW	33.00^{bc}
Atrazine	1.6 fb SHW	33.40^{bc}
Metolachlor	0.8 fb SHW	32.53^{c}
Metolachlor	1.2 fb SHW	33.73^{b}
Metolachlor	1.6 fb SHW	33.17^{bc}
Hoe weeding	3 and 6WAS	34.01^{a}
Weedy check	-	25.23^{e}
SE±	-	0.55
Significance	-	*

A effect of weed control treatments on days to 50% heading was presented (Table 10). Very early 50 % heading (56.50 days) was noticed in control and delayed 50 % heading (64.33 days) in treatment Metolachlor at 1.6 kg a.i ha^{-1}. Effect on 50 % days to flowering and days to maturity may be attributed to higher soil moisture conservation, enhancing the plant's metabolic activities. This resulted in more accumulation of photosynthetic material and auxin hormones during the growth phase, vegetative and delayed flowering and crop maturity. Uttam and Das (1992) and Kumar et al. (2014) reported similar results.

Table 10. Effect of WTC on days to 50% heading

Treatments	Rate (kg a.i ha^{-1})	Days to 50% heading
Atrazine	0.8 fb SHW	63.03^{b}
Atrazine	1.2 fb SHW	60.17^{d}
Atrazine	1.6 fb SHW	62.60^{c}
Metolachlor	0.8 fb SHW	59.50^{de}
Metolachlor	1.2 fb SHW	62.07^{c}
Metolachlor	1.6 fb SHW	64.33^{a}
Hoe weeding	3 and 6WAS	58.40^{e}
Weedy check	-	56.50^{f}
SE±	-	0.77
Significance	-	*

Effect of WTC on 1000 grain weight (g) and grain yield (kg ha^{-1})

Table 11 shows that, except for weedy check, all treatments increased yields. The improved growth yield and yield attributes under Metolachlor at 1.6 kg a.i ha^{-1} can be due to improved soil moisture and nutrients management, which improves the metabolic activities of plants, resulting in increased water capacity, transpiration quality, rate of stomatal conductance, and more photosynthate accumulation in flag leaves, which are transported from source to sink, increasing crop yield (Tripathi and Tomar 1997) and Kumar et al. (2014). The weedy check had the lowest yield; this is due to the uncontrolled plant, which resulted in a competition for moisture, nutrients, and sunlight between the crop and the weeds. Concerning 1000 grain weight, there was no significant difference. This demonstrates that grain size is a relatively stable characteristic, which may be attributed to genetic composition.

Table 11. Effect of WTC on 1000 grains weight (g) and grain yield (kg ha^{-1})

Treatments	Rate (kg a.i ha^{-1})	1000 grain weight (g)	Grain yield (kg ha^{-1})
Atrazine	0.8 fb SHW	10.04	2271.90^{d}
Atrazine	1.2 fb SHW	10.05	2121.50^{d}
Atrazine	1.6 fb SHW	10.00	2575.80^{c}
Metolachlor	0.8 fb SHW	10.04	2756.83^{bc}
Metolachlor	1.2 fb SHW	10.00	2878.30^{b}
Metolachlor	1.6 fb SHW	10.01	3030.37^{a}
Hoe weeding	3 and 6WAS	10.07	2944.07^{a}
Weedy check		9.90	1363.43^{e}
SE±		0.05	53.82
Significance		NS	*

CONCLUSION

At six weeks after seeding, metolachlor at 1 kg ha^{-1} was used and hand weeding was performed (3030.37 kg^{-1}). The lowest yield of pearl millet was obtained with a pre-emergence treatment of Metolachlor followed by hand weeding 6 weeks after sowing (1363.43 kg^{-1}). In terms of grain yield and weed management, other treatments performed well as well. Accordingly, this study advises a two-herbicide treatment at rates of 0, 1, and 2 kg of herbicide ha^{-1}, followed by hoe-weeding at 6 WAS, as well as two hoe-weeding treatments at 3 and 6 WAS, to effectively control weeds and improve pearl millet yield, respectively. Herbicides appear to be more efficient and economical than hoe weeding in this context.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by Authors.

REFERENCES

Adikant, P., Rajput, A. S., & Thakur, A. (2010). Effect of weed management on growth and yield of pearl millet. *Indian Journal of Weed Science, 42*(1-2), 53-56.

Adikant, P., Rajput, A. S., & Thakur, A. (2012). Effect of weed management practices on pearl millet under rainfed condition. *Indian Journal of Weed Science, 44*(2), 115-117.

Adikant, P., & Sonboir, H. L. (2009). Weed management in kodo millet under rainfed condition. *Indian Journal of Weed Science, 41*(3-4), 174-178.

Akobundu, I. O. (1987). *Weed Science in the Tropics*. New York, John Wiley and Sons, p. 522.

Andrews, D. J., Rajewiski, J. F., & Kumar, K. A. (1993). Pearl millet: New feed grain crop. 198-208. In: Janick, J. and Simon, J. E. (eds.), *New crops*. Wiley, New York

Bray, R. H., & Kurtz. L. T. (1945). Determination of Total Organic and Available Forms of Phosphorous in Soils. *Journal of Soil Science*, *59*, 45-49.

Burnside, O. C., & Wicks, G. A. (1965). Effects of herbicide and cultivation treatments on yield components of dryland sorghum in Nebraska. *Agronomy Journal, 57*(1), 21-24.

Chapman, H. D. (1965). Cation exchangeable capacity: In methods of soil analysis part 2, Agronomy No. 9. Black, C. A (Ed.). *America Soc of Agron.* Madison, Wisconsin. p891-901.

Chopra, P., &., Angiras, M. N., (2008). Influence of tillage and weed control methods on weeds, yield and yield attributes of maize (*Zea mays* L.). *Indian Journal of Weed Science, 40*(1&2), 47-50.

Imoloame, E., (2009). Effects of pre- and post-emergence herbicides on weed infestation and productivity of sesame (*Sesame indicum*) in a Sudan Savanna Zone of Nigeria. *Journal on Weed Infestation, 22*(3), 22-25

Jackson, M. L (1962). Soil Chemical Analysis. Advance course of soil Science department. University of Wisconsin, Madison, 120.

Joshua, S. D., &Gworgwor, N. A (2000). Effect of weeding regime on crop performance in millet – cowpea intercrop in the semiarid zone of Nigeria. *Nigeria Journal of Weed Science,* 13, 63- 68.

Kumar, P., Kumar, R., Kumar, S., Singh, S. K., Kumar, A., &., Singh, B. B. (2014). The effect of fertility management on growth, yield and yield attributes of pearl millet under rain fed condition. *International Journal of Tropical Agriculture*, *24*(5), 122-134

Lagoke, S. T. (1983). *Chemical weed control in field crops*. Paper presented at National Workshop on Farming System Research at Kano, Nigeria, 30.

Maclean, F. O. (1965). Aluminum. In C.A. Black (Ed.). Method of soil analysis. Part 1, *Agronomy, 9,* 978-998. *America Soc. of Agron.* Madison, Wisconsin. Maiduguri, 21-24 April, 1997.

Mani, V. S., Mala, M. L., Gautam, K. C., & Bhagavandas. (1973). Weed killing chemicals in potato cultivation. *Indian Journal on weed control, 23*(1), 17-18.

Mishra, J. S. (2015). Weed management in millets*: Retrospect and prospects*. *Indian Journal of Weed Science, 47*(3), 246–253

Page, A. L., Miller, R. H., & Keeney, D. R. (1982). Methods of soil analysis; 2. Chemical and microbiological properties, *2. Aufl. 1184 S., American Soc. of Agronomy (Publ.)*, Madison, Wisconsin, USA.

Prajapathi, B. L., Upadhyay, V. B., & Singh, R. P. (2007). Integrated weed management in rainfed pearl millet*. Indian Journal of Agronomy, 52*(1), 67-69.

Tripathi, A., & Tomar, P. S. (1997). Effect of cultural and chemical method of weed control on pearl millet. *Indian Journal of Agronomy, 36*(2), 436-432.

Uttam, S. K., & Das, S. K. (1992). Studies on fertilizer management, moisture conservation and plant geometry in wheat on eroded soil. *Crop Research, 5*, 44-51.

Vinothini, G., & Murali, P. (2017). Pre emergence herbicide application and hand weeding for effective weed management in irrigated peal millet. *International Journal of chemical studies*, *5*(3), 366-369.

Walkley, A. J., & Black, I.A. (1934). Estimation of soil organic carbon by the chromic acid titration method. *Soil Science, 37, 29-35.*