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EFFECT OF DIFFERENT WEED CONTROL METHODS ON GROWTH AND YIELD OF TURMERIC (CURCUMA LONGA L.) AT AFAKA KADUNA, NIGERIA

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ABSTRACT
A field experiment was carried out at Department of Agricultural Technology Experimental Farm, Federal College of Forestry, Afaka, Kaduna, Nigeria to determine the effect of different weed control methods on growth and yield of turmeric. The experiment was carried out between 2018 and 2019 cropping/rainy seasons. Turmeric was subjected to ten weed control regimes using randomized complete block design with three replications. Data were collected on weed samples on the experimental field, growth parameters such as leaf area, number of leaves per plant, plant height and yield parameters such as number of rhizomes per plant and number of rhizomes per plot. Data collected were subjected to analysis of variance (ANOVA) and the mean separated using Duncan Multiple Range Test (DMRT). The result showed that the major weeds recorded were: *Commelina benghalensis*, *Cyperus rotundus linn*, *Digitaria nuda schumach, Digitaria longiflora*, *Eleusine indica*, *Eragrostis ciliaris ans.* The result also revealed that turmeric leaf area was significantly ($p<0.05$) affected by weed control method regimes at 4 and 12WAT. Plant height was also significantly ($p<0.05$) affected by weed control method regimes at 8 WAT. The result also revealed that yield in term of number of rhizomes produced per plant and per plot were also significantly ($p<0.05$) affected by weed control method regimes at harvest with highest yield recorded for turmeric plants that were treated with pre emergence Metolachlor at the rate of 1.0 litre per hectare plus two supplementary hoe weeding at 4 and 8 WAT. The study therefore recommend the use of Metolachlor at the rate of 1.0 litre per hectare plus two supplementary hoe weeding at 4 and 8 WAT for farmers in the ecological zone of study area.

KEY WORDS
Effect, weed control methods, weed samples, growth parameters, yield, turmeric.

Turmeric (*Curcuma longa linn*) is a perennial herb plant of the ginger family (*Zingiberaceae*). Turmeric is an erect perennial herb, but grown as an annual crop. The leaves are alternate obliquely erect, lanceolate and green acuminate with long leaf sheaths forming a pseudo stem. The underground stem or rhizome is flashy at the base of each aerial shoots consisting of an erect, void or ellipsoid structure (mother rhizome), ringed the base of old scale leaves, bearing when matured, several horizontal or curved horizontal or curved rhizomes (finger), which are again branched (secondary). The rhizomes show yellow to bright orange yellow colour within the rhizomes and are rich in curcumin for which turmeric is valued. Leaf blades are usually more or less erect, often with a purple, flushed strip on either side of the midrib. The inflorescence is terminal and borne in between the leaf sheaths. It is cultivated in diverse tropical conditions up to 1600m above sea level with a temperature range of 20 to 40 degree centigrade and rainfall above 1500mm (Olojede *et al;* 2017), India is the largest producer, consumer and exporter of turmeric in the world market because of its high curcumin content; it accounts for 80% of word production figure and 60% of world exports. Nigeria is rated fourth among the leading producers of turmeric in the world. Other major producers are Pakistan, China, Haiti, Jamaica, Peru, Taiwan and Thailand.

On analysis, the nutrition composition of turmeric (100g) consist of water 6.0g, food energy 390 kcal, protein 8.9g carbohydrate 69.9g, calcium 0.20g, phosphorus (Phosphomes) 260 mg, sodium 30mg, potassium 20000mg, iron 47.5g, thiamine 0.09mg, riboflavin 0.19mg, niacin 4.8mg ascorbic acid 5.0mg.Turmeric is usually grown for its culinary, cosmetic and

medicinal purpose. It is the major ingredient used for curry meant for adding flavour to our meals. It is also being used as dye or colouring agent. The medicinal properties of this spice have been exploited over the centuries. The main active compound of turmeric is Curcuminiods, and curcumin is the most active Curcuminoids found in it. Research has shown that turmeric can be used for the treatment of so many medical problems and conditions ranging from constipation to skin diseases, it is used in the treatment of wounds, infections, dysentery, arthritis, jaundice, liver problems, cancer, Alzheimer's diseases (Osawa *et al;* 1995).

According to Das (2011), the term "weed" encompasses a collection of plant ranging largely in morphological and physiological characteristics. Weeds are harmful to crop and cause reduction in crop yields. Weeds generally remove 30- 40 KgN, 10- 15 Kg P and 20-40 KgK per hectare of nutrients (Alagh, 1988). The aim of weed control is not to kill weed completely but to tip the balance of nature in favour of desirable species (Das, 2011). Manual hoe weeding is the most commonly employed weed control measure by poor farmers and frequent hoe weeding can disturb soil, stimulate weed seed germination and persistence in many ways (Akobundu, 1987). Herbicides are synthetic chemical used to kill or suppress unwanted vegetation. The herbicides should be selected for it harmlessness to the desired vegetation as well as its toxicity to weed. The traditional methods of weed control by manual hoe weeding is the commonest method used by farmers in Nigeria. This method is laborious, expensive and strenuous; it can also cause damage to the growing branches and roots of the plant, in addition to high cost, uncertainty in labour availability thus making timeless of weeding difficult to attain, which result to loss in yield (Adigun and Lagoke, 2003).

Turmeric is a perennial-rhizomatous crop, grown annually in Asian countries, is presently introduced in guinea savannah zone of Kaduna State, where ginger thrives mainly. No research work has been carried out on weed studies on the crop despite its importance. Presently, there is scarcity of information on the use of herbicides on weed. Moreso recommended comparative weed control, method hardly exist as a practice in ginger growing area. Yield losses due to lack of timely weed control or management necessitates the use of herbicides which could reduce the weeding frequency required for weed control at early or late crop growth stages (Joshua and Gworgwor, 2001). Several research have carried out works on weed management practice in order to ascertain the tolerance of crops to suitable methods. This could ascertain the efficacy of the weed control method leading to improved crop growth and yield of turmeric, especially in the northern guinea savannah, agro-ecological weed competition is known to cause yield loss in crop In other to improve on the growth and yield of the crop, the study aimed at determine the effect of different weed control methods on growth and yield of turmeric.

METHODS OF RESEARCH

The experiment was carried at the Federal College Forestry Mechanization Experimemtal Farm, at Afaka. The college lies between latitude 10 ^{o} 35 N and longitude 07^{o} 21 E (Otegbeye *et al.,* 2001). It is situated in the Northern Guinea Savannah Zone.

The soil sample at the experimental site was taken. The area was diagonally marked and intercept of a point was considered for soil sampling at a depth of 0 - 20cm. The replicate sample was analyzed for physico chemical analysis.

The treatment combinations for this study are as follows: Metolachlor at 0.6L/ha alone, Metolachlor at 0.6L/ha + 1 Supplementary Hoe Weeding (SHW) at 4 week after transplanting (WAT), Metolachlor at 0.6L/ha +2 SHW at 4 and 8WAT, Metolachlor at 1.0L/ha alone, Metolachlor at 1.0L/ha + 1 SHW at 4WAT, Metolachlor at 1.0L/ha + 2 SHW at 4 and 8WAT, Weeding at 4, 8 (WAT), Weeding at 4, 8, 12 WAT, Plot kept weed free and Plot kept weedy. The experimental design was randomized complete block design (RCBD). The treatments were replicated three times..

The plot size 4.2m x 4.2m with 1m between replicate and 0.5m between plots as gross plot and net plot size of 2.I m x 2.1m.

Nursery bed was prepared by removal of weed on the field bed size of 2.0 m by 2.0 m. Poultry manure of 1kg was broadcast and incorporated into the bed.

Watering of planted bed was carried out on daily basis to ensure that the soil is well moisture and to dissolve the poultry manure properly into the soil.

Turmeric was purchased from reputable farmers. The seeds are about 5cm in size with two-three nodes to ensure that sizes are uniformly selected. The seeds were treated with Apron star at 10g/3kg seeds on a ground and mixed thoroughly.

Planting was done with treated seed of about 5cm length with 2 - 3 nodes in the prepared nursery. The seed were planted on prepared seed bed covered with sand and also covered with dried leaves as mulch.

The site was cleared of debris, tilth and prepared by ploughing, harrowing and ridging.

Transplanting of seedlings was carried out on beds at 5 week after sowing (WAS) by selecting the vigorous and uniform sizes. This was dug in the early morning. Hole was dug to 5cm depth and the seedling transplanted at spacing 25cm x 25cm.

The CP3 knapsack sprayer with green deflector nozzle and pressure of 2.1L/ha was used to apply the pre-emergence at recommended rate of 0.6L/ha and 1.0L/ha.

Manual weed control was done by hoeing as in the treatments at 4, 8, 12 WAT. On specific plots only weed free plot was weeded throughout the experiment period. Un-weeded plot was kept weeded throughout.

Common weed samples on the field plots were observed at 4, 8 and 12 WAT. The weeds were classified as broadleaves, sedges, and grasses. The extents of infestation are classified as low, moderate and high.

The leaf area was determined by measuring the length and the widest point of function at 4, 8 and 12 WAT.

The number of leaves per tagged plant was counted and taken at 4, 8, and 12 WAT.

Plant height was measured using meter rule. The measurement was from the ground level of the plants to the tip of the terminal bulb and was recorded at 4, 8 and 12 WAT.

The number of Rhizome/plant was counted and recorded.

The number of Rhizome/plot was counted and recorded.

Data collected was subjected to statistical analysis using analysis of variances (ANOVA) described by Snedecor and Cochran (1994). The mean was separated according to Duncan Multiple Range Test (DMRT) as described by Duncan (1994).

RESULTS OF STUDY

The result of the physical-chemical characteristic of soil sample at the experimental site during 2018 and 2019 rainy season is shown in Table 1.The result indicated that pH (H0) value is 6.40 indicating that it is within the level of recommendation for guinea savannah soil. The low nitrogen of 0.38%, organic matter O.65% and organic carbon 0.03% respectively is an indication that the soils are low in fertility. Similar result was obtained in the analysis conducted at Afaka. The analyzed soil result also showed that the soil in the experimental site contained sand (80.40%), clay (3.60%) and silt (16.00) and the textural class of the soil was loam sand.

The result of different types of weed observed on field plots at the experimental site, at Afaka with their level of infestation is presented in Table 2. Six different types of weed were identified at the experimental site. The identified weeds are *Commelina benghalensis* which was classified as broadleaves weed type, *Cyperus rotundus linn* classified as sedge weed type and the remaining four weeds observed were grasses and they are; *Digitaria nuda schumach, Digitaria longiflora*, *Eleusine indica*, *Eragrostis ciliaris ans* The result showed that grasses were prominent and dominant weed at the experimental site. The level of infestation of the observed weeds at 4WAT were low except for *Cyperus rotundus linn* and *Eragrostis ciliaris* that have moderate level of infestation, at 8 WAT, the observed weeds showed moderate level of infestation except for *Commelina benghalensis* and *Digitaria nuda schumach* that have low level of infestation, while Digitaria *longiflora* had high level of

infestation at 12 WAT, the other observed weeds were at moderate level of infestation except for *Commelina benghalensis* that did not infest the farm.

Table 1 – Mean values of physico-chemical characteristic of soil sample at the experimental site at Afaka during 2018 and 2019 rainy seasons

Physico-Chemical Characteristics	Value
Chemical characteristics	
pH (H,O)	6.40
Total nitrogen (%)	0.03
Calcium (cmo/kg) (%)	0.71
Magnesium (cmo/kg) (%)	0.06
Organic Matter (%)	0.65
Organic Carbon (%)	0.38
Potassium (K20%)	0.03
Phosphorus (mg/kg)	-
Exchangeable acidity (cmo/kg)	0.50
Effective cat ion exchange capacity (cmo/kg)	1.35
Electrical conductivity (ds/m)	0.09
Physical characteristics	-
Sand	80.40
Clay	3.60
Silt	16.00
Textural class	Loam sand

Sources: Federal Department of Agriculture and Climate Change Management Service (2019).

Table 2 – Weed samples observed and level of infestation during the study at the farm

Types of Weed	Level of Infestation		
	4	8	12 (WAT)[1]
Broad leaves			
Commelina benghalensis	+	+	
Sedges			
Cyperus rotundus linn	++	++	++
Grasses			
Digitaria nuda schumach	+	+	++
Eleusine indica (L) Gaertn	+	++	++
Digitaria longiflora (Ret) pas	+	++	+++
Eragrostis ciliaris (Linn) R.Br	++	++	++

[1]*(week after transplanting).*
Note: Low (+) Moderate (++) High (+++) Infestations.

During the investigation period of 4, 8, 12 WAT, the leaf area was significant at 4 and 12 WAT as shown in table 3, at 4 WAT, plot kept weed free produced the least leaf area (5.29 cm^2) than all other weed control treatment, while the application of 0. 6 litre per hectare of Metolachlor plus two supplementary weeding at 4 and 8WAT gave the highest leaf area value of 6.57cm^2, all other treatments gave leaf area values that were statistically similar. At 12 WAT, all the weed control method gave similar leaf values except for the plot kept weedy that gave the highest leaf area of 20.62 cm^2 and the hoe manual weeding at 4, 8WAT that gave the least leaf area of 8.46 cm^2 compare to the other treatments.

The results of the numbers of leaves per plant, produced per turmeric plant observed at sampling period of 4, 8,12WAT are shown in table 4. The result revealed that the different weed control treatment methods does not statistically have any effect on the number of leaves per plant. But numerically, application of Metolachlor alone at 0.6 L/ha, pre-emergence application of Metolachlor at 0.6L/ha + two supplementary hoe weeding at 4 and 8 WAT, application of Metolachlor at 1.0 L/ha + one supplementary hoe weeding at 4 WAT and application of Metolachlor at 1.0 L/ha + two supplementary hoe weeding ///at 4 and 8 WAT gave the highest mean value of 5.89 leaves at 4WAT, while application of Metolachlor at 0.6L/ha + one supplementary hoe weeding at 4WAT and plot kept weedy gave the lowest mean value of 5.56 leaves at 4WAT. At 8WAT, plot kept weed free had the highest numerical mean value of 7.56 leaves while application of Metolachlor at 0.6L/ha + one supplementary

hoe weeding at 4WAT and two manual hoe weeding at 4 and 8 WAT recorded the least mean value of 6.67 for number of leaves per plant. At 12WAT, manual hoe weeding at 4, 8WAT and manual hoe weeding at 4,8,12WAT treatments gave the highest numerical mean value of 12.89leaves while least value of 10.67 number of leaves per plant was obtained from plot treated with Metolachlor at 0.6L/ha + two supplementary hoe weeding at 4 and 8 WAT.

Table 3 – Effect of different weed control methods on mean values of leaf area of turmeric (*Curcuma longa linn*) at Afaka during rainy season of 2018 and 2019

Treatment	Leaf Area (cm^2)			
	Rate L/ha	4	8	12 (WAT)[1]
Metolachlor alone	0.6L/ ha	3.36ab	7.47a	10.30ab
Metolachlor +1 SHW[2]	0.6L/ ha	5.57ab	6.17a	9.36ab
Metolachlor +2 SHW[3]	0.6L/ ha	6.57a	6.17a	8.39ab
Metolachlor alone	1.0L/ ha	5.92ab	6.33a	9.28ab
Metolachlor + 1 SHW[2]	1.0L/ ha	5.62ab	5.28a	9.37ab
Metolachlor +2 SHW[3]	1.0L/ ha	6.24ab	6.61a	8.90ab
Weeding at 4, 8		5.65ab	6.88a	8.46b
Weeding at 4, 8, 12		5.63ab	6.78a	9.32ab
Plot kept weed free		5.29b	7.38a	10.27ab
Plot kept weedy		5.81ab	7.24a	20.62a
SE+		0.101	0.864	1.246

[1]Week after transplanting: [a,b,c] mean in a row: followed by the similar letter are not statistically different at P≥0.05 according to (DMRT) [2]supplementary hoe weeding at 4 WAT [3]suplementary hoe weeding al 4 and 8 WAT.

Table 4 – Effect of different weed control methods on mean values of number of leaves of turmeric (*Curcuma longa linn*) at Afaka during rainy season of 2018 and 2019

Treatment	Number of Leaves			
	Rate L/ha	4	8	12 (WAT)[1]
Metolachlor alone	0.6L/ ha	5.89a	7.45a	10.78a
Metolachlor +1 SHW[2]	0.6L/ ha	5.56a	6.67a	11.22a
Metolachlor +2 SHW[3]	0.6L/ ha	5.89a	7.11a	10.67a
Metolachlor alone	1.0L/ ha	5.67a	6.89a	10.89a
Metolachlor + 1 SHW[2]	1.0L/ ha	5.89a	7.11a	10.78a
Metolachlor +2 SHW[3]	1.0L/ ha	5.89a	6.89a	11.10a
Weeding at 4, 8		5.78a	6.67a	12.89a
Weeding at 4, 8, 12		5.67a	6.78a	12.89a
Plot kept weed free		5.78a	7.56a	11.67a
Plot kept weedy		5.56a	6.99a	12.56a
SE+		0.030	0.079	0.678

[1]Week after transplanting: [a,b,c] mean in a row: followed by the similar letter are not statistically different at P≥0.05 according to (DMRT) [2]supplementary hoe weeding at 4 WAT [3]supplementary hoe weeding at 4 and 8 WAT.

The result of effect of different weed control methods on mean values for plant height of turmeric plant at Afaka during the rainy season of 2018 and 2019 is presented in table 5. The result revealed that the different weed control treatment methods does not significantly have effect on plant height of turmeric at 4 and 12 WAT but the treatments showed a significant differences at probability level of 5% at 8WAT on plant height of turmeric. The plant produced taller plants consistently and almost uniformly as growth progressed. On observation pre-emergence application of Metolachlor at 0.6L/ha alone had tallest plants of 40.22cm at 8 WAT while manual hoe weeding at 4,8WAT recorded the lowest plant height of 28.38cm compared to all other treatments that have plant height values that were statistically similar to each other. Similarly, re-emergence application of Metolachlor at 0.6L/ha alone had tallest plants of 49.69 cm at 12 WAT but the least value of plant height was recorded for plot weeded manually with hoe at 4,8,12 WAT with a value of 47.01cm on numerical basis but not statistically significant (P>0.05) compared to the other treatments.

The numbers of rhizome per plant and per plot at harvest are shown in Table 6. Plot treated with pre-emergence application of Metolachlor at the rate of 1.0 litre per hectare plus

two supplementary hoe weeding at 4,8WAT produced highest number of rhizome per plant (105.33) and plot (421.33) respectively which was statistically significant (P<0.05) compared to other weed control treatments. Metolachlor base treatment at 0.6Lha plus two supplementary weeding with hoe at 4,8WAT and application of Metolachlor at 1.0L litre per hectare plus one supplementary hoe weeding at 4 WAT, respectively produced the second higher number of rhizome per both plant (.86.00) and plot (344). The least tuber of rhizome per plant (31.33) and per plot (125.33) was observed with manual weeding with hoe at 4, 8 WAT.

Table 5 – Effect of different weed control methods on mean values of plant height of turmeric (*Curcuma longa linn*) at Afaka during rainy season of 2018 and 2019

Treatment	Plant Height(cm)			
	Rate L/ha	4	8	12 (WAT)[1]
Metolachlor alone	0.6L/ ha	26.89a	40.22a	49.69a
Metolachlor +1 SHW[2]	0.6L/ ha	27.56a	33.23ab	45.18a
Metolachlor +2 SHW[3]	0.6L/ ha	26.38a	34.22ab	45.24a
Metolachlor alone	1.0L/ ha	27.32a	31.11ab	45.82a
Metolachlor + 1 SHW[2]	1.0L/ ha	27.90a	36.56ab	48.74a
Metolachlor +2 SHW[3]	1.0L/ ha	26.23a	31.11ab	50.83a
Weeding at 4, 8		28.38a	28.58b	47.70a
Weeding at 4, 8, 12		27.56a	36.47ab	47.01a
Plot kept weed free		25.62a	36.29ab	45.43a
Plot kept weedy		29.03a	38.89ab	48.49a
SE+		2.687	7.494	11.652

[1]Week after transplanting: [a,b,c] mean in a row: followed by the similar letter are not statistically different at P≥0.05 according to (DMRT) [2]supplementary hoe weeding at 4 WAT [3]supplementary hoe weeding at 4 and 8 WAT.

Table 6 – Effect of different weed control methods on mean values of number of rhizomes produced per turmeric (*Curcuma longa linn*) plant and per plot at Afaka during rainy season of 2018 and 2019

Treatment	Number of Rhizome at		
	Rate L/ha	Per/Plant	Per/Plot
Metolachlor alone	0.6L/ ha	54.67ab	218.00ab
Metolachlor +1 SHW[2]	0.6L/ ha	78.00ab	312.00ab
Metolachlor +2 SHW[3]	0.6L/ ha	86.00ab	344.00ab
Metolachlor alone	1.0L/ ha	43.33b	173.33b
Metolachlor + 1 SHW[2]	1.0L/ ha	86.00ab	344.00ab
Metolachlor +2 SHW[3]	1.0L/ ha	105.33a	421.33a
Weeding at 4, 8		31.33b	125.33b
Weeding at 4, 8, 12		45.33b	181.33b
Plot kept weed free		66.00ab	264.00ab
Plot kept weedy		56.00ab	224.00ab
SE+		27.738	44.457

[1]Week after transplanting: [a,b,c]mean in a row: followed by the similar letter are not statistically different at P≥0.05 according to (DMRT) [2]supplementary hoe weeding at 4 WAT [3]supplementary hoe weeding at 4 and 8 WAT.

DISCUSSION OF RESULTS

Weed management exhibited control of weed on turmeric plant in the sandy loam soil. Only *Commelina benghalensis* and *Cyperus rotundus linn* infested the plant as broadleaves and sedges.However, some permanent grass weed species were observed on the field. At 12WAT, all the weed control treatments were able to suppress the growth of the only broad leaves weed *Commelina benghalensis* completely without zero infestation. Kundu *et al*.also reported maximum suppression of all weeds with twice hand weeding at 20 and 40 days after sowing. The reduced weediness allowed vigorous growth of turmeric plant.

The highest and increased leaf area recorded with Metolachlor at 0.6L/ha +2 SHW at 4,8WAT may have allowed photosynthesis to be carried out more effectively among the plants with this treatment thereby improving the growth of turmeric plant leading to better growth performance of the crop and better yield. The result in this study in which the use of

herbicide with supplementary weeding gave the highest leaf area value was in agreement with the study of Barla. Upasani and Puran, 2015) in which application of Metribuzin herbicide at rate of 0.7 Kg /ha followed by two hoe weeding gave the maximum leaf area index.

The result revealed all treatments reduced the level of weed infestation apart from the plot left weedy but the superiority of plant growth was not manifested by the weed suppression. At any level of growth, weed management exhibited control therefore; plants performed better and resulted in higher yield. However the plot left weedy provided shading effect on the turmeric plant thereby hindering any damage. The plant produced increased rhizome yield with highest number of rhizomes harvested from application of Metolachlor at 1.0L/ha + 2SHW at 4 and 8 WAT. Barla. Upasani and Puran, 2015) also reported highest yield of turmeric rhizomes with the application of Metribuzin herbicide at rate of 0.7 Kg /ha followed by two hoe weeding.

CONCLUSION

Based on the result obtained in this study, it could be observed that among the weed control methods, the used of Metolachlor at the rate of 1.0L/ha + 2 SHW at 4, 8 WAT performed better in term of growth yield of turmeric in the study area. Therefore, it is recommended that the use of herbicide Metolachlor at the rate of 1.OL/ha +2 SHW at 4,8 WAT which gave better yield of turmeric should be adopted by farmers in the study area ecological zone.

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