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APPLICATION OF PRE-EMERGENCE HERBICIDE PLUS MANUAL WEEDING ON CONTROL OF WEED, 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 Crop production Experimental Farm, Federal College of Forestry, Afaka, and Kaduna, Nigeria to investigate the application of pre-emergence herbicide followed by manual weeding as an integrated weed management control system on growth and yield of turmeric. The experiment was carried out between 2019 and 2020 cropping/rainy seasons. Turmeric was subjected to ten weed control methods using randomized complete block design with three replications. Data were collected on weed samples on the experimental field, plant height and weight of rhizomes harvested per hectare. 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: Acanthospermum hirspidum, Achyranthes aspera, Amaranthus spinosus, Ageratum conyzoides, Synednella nodifora, Tridax procumbens, Dactyloctenum aegyptium, Corchorus biflorus, Eleusine indica and Cyperus rotundu The result also revealed that the integrated weed management system of combining pre-emergence and manual weeding had significant effect (P< 0.05) on the weight of weed collected. Plant height was also significantly (p<0.05) affected by the application of pre-emergence herbicide and manual weeding at 4 and 12 WAT. The result showed that yield in term of weight of rhizomes produced per hectare was also significantly (p<0.05) affected by the application of pre –emergence herbicide followed by manual weeding 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 one supplementary hoe weeding at 4 WAT. The study therefore recommend the use of Metolachlor at the rate of 1.0 litre per hectare followed by one supplementary hoe weeding at 4 WAT for farmers in the ecological zone of study area.

Key Words: *Pre-emergence herbicide, manual weeding, weed samples, crop height, yield, Turmeric*

Introduction

Turmeric (*Curcuma longa* L.) is a perennial herbaceous plant of the ginger family Zingiberaceae. native to southern Indonesia, is widely cultivated on the mainland and in the Island of the India Ocean in ancient times. Although, turmeric is an erect perennial herbal, but grown as an annual. The leaves are alternate obliquely erect or sub sessile, lanceolate and green acuminate with long leaf sheaths, forming a pseudo stem. The underground stem or rhizome is fleshy at the base of each aerial shoots consisting of an erect, void or ellipsoid structure (mother rhizome), round the base of old scale leaves, bearing when matured with 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.

Weed competition with cultivated plant is one of the factor causing low yield of crop. Krishnamurti and Ayyaswamy (2000), reported 30-70% yield losses of turmeric as a result to improper weed management. Turmeric crop cultivation required a long duration of more than 280 days and therefore requires an integrated weed management system that will combine the use of different weed control measures such as combination of pre – emergence herbicides, post – emergence herbicides and cultural weeding practices together. According to Deshmukh *et al.* (2018) the use of pre-emergence herbicides alone in weed control in turmeric farm does not control weeds throughout critical crop weed competition period of the crop and there is needs for an integration of post-emergence application of herbicides as well as the use of intercultural operation plus the application of straw mulch in combination with pre-mergence herbicide application.

In Nigeria, farmers generally control weeds through the use of manual weeding, with hoe, but with the scarcity and increase in labour cost, manual weeding with hoe has become a difficult task to achieve. In support of this assertion, Akobundu, (1987) opined that manual hoe weeding is the most commonly employed by poor farmers and frequent hoe weeding can disturb soil, stimulate weed seed germination and persistence in many ways. This traditional methods of weed control by manual hoe weeding are the commonest method 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, labour availability is uncertain thus making timeless of weeding difficult to attain. This according to Adigun and Lagoke (2003), resulted in yield loss. The use of herbicides became necessary as a result of the scarcity of labour, increase in cos per man day plus the drudgery involved in carrying out manual weeding operation with hoe. Herbicides are develop as synthetic chemical used to kill or suppress unwanted vegetation. The herbicides should be selected for it harmlessness to the desired vegetable as well as its toxicity to weed. Herbicides are classified as pre-emergence herbicides either to the crop or weed as the case may be. Common pre-emergence herbicides within the organic group are acetamides (Butachlor and

metolachlor) azoles oxadiazone, pendimenthalin, organophosphorus, sulpurnyurea, they are classified into 32 group (Das, 2011). Other methods of weed control are biological, cultural, salinization and integrated weed control method. 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). Pre-emergence herbicides, such as pendimethalin, atrazine or metribuzin was reported to save the crop from severe weed competition at an early stage. However, sole usage of any one single method of weed control may not give an effective weed management in a crop like turmeric that required long life cycle (Deshmukh *et al.,* 2018). Deshmukh *et al.* (2018), also observed that there is the need to remove weeds at 70 to 160 days after planting turmeric, signifying that it requires a longer weed free period than other crops. In consideration of the above reasons, it is necessary to develop an economically, effective and better integrated weed management system for turmeric in order to obtain optimum growth rate, higher productivity and yield. Therefore, the study was conducted to investigate the application of pre-emergence herbicides in combination with manual weeding in integrated weed management (IWM) on weed control, growth and yield of turmeric.

Methodology

Experimental Site

The experiment was carried out at the Federal College Forestry Mechanization Farm, at Afaka. The school lies between on latitude 10^{o} 32' N and longitude 7^{o} 17' E. (Otegbeye *et al*., 2001). It is situated in the Northern Guinea Savannah Ecological Zone of Nigeria.

Soil Sampling

The soil sample at the experimental site was taken. The area was diagonally selected and intercept of a point was considered for soil sampling at a depth of 0 – 20cm sample was analysed for physicochemical analysis.

Experimental Treatment and Design

The treatment consisted of pre-emergence herbicides at different high rates and weeding at various interval with control of no weeding and herbicide application. The treatments combinations are as follows:

1. Metolachlor at 1.5L/ha alone
2. Metolachlor at 1.5L/ha + 1 SHW (Supplementary hoe weeding at 4 WAT).
3. Metolachlor+ 1.5L/ha + 2 SHW (Supplementary hoe weeding at 4, 8 WAT).
4. Metolachlor at 2.0L/ha alone.
5. Metolachlor at 2.0L/ha + 1 SHW.
6. Metolachlor at 2.0L/ha + 2 SHW.
7. Plot kept weed free for 4, 8 weeks after transplanting.
8. Plot kept weed free for 4, 8, 12 weeks after transplanting.
9. Plot kept weed free/throughout.
10. No weeding and herbicide application.

The experimental design was randomized complete block design replicated three times.

Plot Size: The plot size was 4.2m × 4.2m with 1m between replicate and 0.5m between plots.

Preparation of nursery bed: Nursery bed was prepared by removal of weed on the field bed size of 2.0m × 2.0m. Poultry

manure of 1kg was broadcast and incorporated into the bed.

Watering of beds: Watering of planted bed was carried out on daily basis to ensure the soil was well moistened and to dissolve the poultry manure properly into the soil.

Seed and seed treatment: Turmeric was purchased from reputable farmers. This was cut to 5cm size with two-three nodes and uniform sizes were selected. The seeds were treated with Apron star at 10g and 3kg seed in a gourd and was mixed thoroughly.

Planting: Planting was done with treated seed at the prepared nursery. The seed was sowed on prepared seed bed covered with soil, then were covered with dried leaves as mulch.

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

Transplanting: Transplanting of seedlings was carried out at 5 WAS by selecting the vigorous and uniform sizes. This was done in the early morning, hole was dug to 5cm size and the seedling transplanted at spacing 25cm × 25cm.

Herbicides application: Herbicides application was carried out based on the recommended treatment rate. Pre-emergence application was done using knapsack sprayer at spray volume of 240L/ha.

Weed control: Manual weed control was done by hoeing at the recommended treatments of 4, 8, 12 WAT on specific plots only. Weed free plot was weeded throughout the experimental period. Un-weeded plot was kept weedy throughout.

Observation and Data Collection

Weed sample: Common weed sample on the screened and field plots was observed at 4, 8 and 12 Week after transplanting (WAT). The weeds were classified as broadleaves, sedges, and grasses. The extent of infestation was classified as low, medium and high.

Weed dry weight: Weed sample collected within quadrant of 50cm × 50cm and transform to 1m × 1m size was used. The weed sample was cleaned of sand and air dried initially, later dried in the oven at a temperature of 70°c until constant weight was attained. The weight was recorded at sampling period of 4, 8, 12 week after transplanting.

Growth and Yield Parameters: Growth and yield parameters were observed at sampling interval of 4 weeks till 12 weeks, using four tagged plants per plots. The mean of the four tagged plants was calculated and recorded accordingly. The parameters are as follows.

Plant Height: The height was determined by using a metre rule from the soil surface to the largest tip of the plant at various sampling periods in the areas. The heights were recorded at sampling period of 4, 8, 12 WAT.

Weight of turmeric rhizome: This was determined by taking the weight of the turmeric rhizome per plant and per plot at harvest using the scale. Initially, the rhizome was cleaned of soils particles before weighing.

Data Analysis

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

Results and Discussion

Physicochemical Characteristics of Soil Sample in the Study Area

The result of the physico – chemical characteristics of soil sample at the experimental site is shown in Table 1.The chemical characteristics indicated that pH (H_20) at 6.40 is within the level of recommendation for g uinea savannah soil. The low nitrogen of 0.38%, organic matter 0.65% and organic carbon 0.03% respectively is an indicating that the soil are low in fertility. Physical characteristics on analysis resulted in sand 80.40%, clay 3.60% and 16.00(%) and the textural class was sandy loam.

Table1: Mean values of physico- chemical characteristic of soil at Afaka during rainy seasons of 2019/2020

Chemical Value	Soil
pH (H_2O)	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 (K_20%)	0.03
Phosphoros (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	Sandy loam

Sources: Federal Department of Agriculture and climate change management service (2019/2020)

Weed Parameters

Types of weeds and their level of infestation: Types of weeds and their level of infestation observed on application of pre – emergence herbicide combined with manual weeding on weed suppression, growth and yield of turmeric during 2019 and 2020 raining seasons at Afaka is presented in Table 2. The prominent weed species occurring at the experimental sites were mainly broadleaves, with six (6) types. The highest level of occurrence was *Acanthospermum hirspidum*, while *Achyranthes aspera*, *Amaranthus spinosus*, *Ageratum conyzoides* *Synednella nodiflora* and *Tridax procumbens* had least level of infestation. The common grasses at the experimental site occurred at low level as *Dactyloctenum aegyptium*, *Corchorus biflorus* and *Eleusine indica* were observed at medium level of infestation. Only *Cyperus rotundus* appeared as sedge plant at medium level of infestation. According to Das (2011), the aim of weed control is not to kill weed completely, but to tip the balance of nature in favour of desirable species. This was observed in this study

whereby virtually all the weed control management practice suppressed weed at various sampling periods on the growth, thereby resulting in the high yield obtained. The 14 weed species observed during the study was minimal due to the ability of the integrated weed management approach of application of pre-emergence herbicide of metolachlor combined with manual weeding control methods used which further suppressed weed growth. The result conform to Olorukooba (2014) whereby 20 weed species were identified in a weed control study on rice production.

Table 2. Weed samples observed and level of infestation during the study at Afaka.

	Common names	Level of infestation
Broadleaves		
Achyranthes aspera	Thorn pig weed	+
Amaranthus spinosus	Spiny amaranthus	+
Acanthos permum hispidum	Bristly starbur	+++
Ageratum conyzoides	Billy goat weed	+
Synedrella nodiflora	Nodi weed	+
Tridax procumbens	Tridax	+
Grassess		
Dactyloctenum aegyptium	Crowfoot-grasses	+
Cenchrus biflorus	Hedgehog grass	+
Eleusine indica	Goose grass	++
Sedges		
Cyperus rotundus	Purple nutsedges	++

+ low level ++ medium level +++ high level

Weed weight: The result of the mean weed weight values of turmeric on application of pre-emergence herbicide combined with manual weeding at Afaka during 2019 and 2020 raining seasons is shown in Table 3. The result revealed that during the sampling periods of 4, 8 and 12 WAT, the integrated weed management system of combining pre-emergence and manual weeding had significant effect ($P< 0.05$) on the weight of weed collected. At 4, 8 and 12 WAT, plots kept weedy gave the highest weed weight values which was statistically differ when compared to other weed control methods. The lowest weed weight of 0.13g/m2was observed at 4WAT with the plots kept weed free throughout the experimental period. At 8WAT, the lowest weed weight of 0.36g/m2 was recorded for plots with application of metolachlor alone at 1.5 litre/ hectare and plots kept weed free throughout, respectively. At 12WAT plots sprayed with metolachlor alone at 2.0litre/hectare and those sprayed with metolachlor at 2.0litre/hectare plus two hoe weeding at 4 and 8 WAT recorded the lowest weed weight of 0.30 g/m2. The weed weight observed was significant and minimal throughout the sampling period due to the effectiveness of the integrated weed management method being able to suppressed weed thus resulting in less aggressive effect of the weeds on the field. The high weed weight values obtained in weedy plots could be said to have localized competition for growth factor mainly due to limited soil nutrient at 4, 8

and 12 WAT, and analyzed soil indicated low soil fertility at the experimental site.The reduction in weed weight at 12 WAT observed in this study for application of metolachlor at 2.0 litre/hectare followed by two supplementary hoe weeding was similar to the findings of Barla et al. (2015) that reported that application of pendimethalin at 1.0 kg/ha followed by two supplementary hoeing and application of metribuzin at 0.7kg/hectare, respectively, resulted in reduced weed weight in their study

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Table 3: Mean values of weed dry weight on application of pre-emergence herbicide and manual weeding on weed control, growth and yield of turmeric at Afaka during rainy seasons of 2019/2020

		Weed dry weight(g/m^2) At		
Treatment	**Rate L/ha**	**4**	**8**	**12 (WAT[1])**
Metolachlor alone	1.5 l/ha	0.16b	0.36ab[2]	0.40ab
Metolachlor + 1SHW[3]	1.5 l/ha	2.23ab	0.40ab	0.40ab
Metolachlor + 2 SHW[4]	1.5 l/ha	0.23ab	0.43ab	0.50ab
Metolachlor alone	2.0 l/ha	0.20ab	0.43ab	0.30b
Metolachlor + 1SHW[3]	2.0 l/ha	0.20ab	0.43ab	0.50ab
Metolachlor + 2 SHW[4]	2.0 l/ha	0.20ab	0.43ab	0.30b
Plot kept weed free at 4, 8 weeks		0.16b	0.43ab	0.50ab
Plot kept weed free at 4, 8, 12 weeks		0.25ab	0.40ab	0.50ab
Plot kept weed free throughout		0.13b	0.36ab	0.50ab
No weed control		0.40a	0.50a	0.53a
SE±		2.477	3.519	2.541

[1]Week after transplanting, [2] mean in a row or column follow by similar letter are not statistically different at P>0.05 according to DMRT, [3] supplementary hoe weeding at 4WAT, [4] supplementary hoe weeding at 4 and 8 WAT.

Growth and Yield Parameters

Plant height: The result of the mean height of turmeric on application of pre-emergence herbicide combined with manual weeding at Afaka during 2019 and 2020 raining seasons is shown in Table 4. The result revealed that during the sampling periods of 4, 8 and 12 WAT, the integrated weed management system of combining pre-emergence and manual weeding had significant effect (P< 0.05) on plant height at 4 and 12 WAT. However at 8 WAT weed control methods had no significant effect on turmeric plant height. At 4 and 12 WAT, plots kept weed free at 4 and 8 WAT gave taller plants which was statistically differ when compared to other weed control methods. The shortest plant height of 2.6cm was observed at 4WAT with the application of metolachlor at 1.5l/ha +SHW at 4WAT. Minimal weed competition experienced allowed improve growth performance and resulting in increase in plant height. The significant effect on plant height observed in this study is in agreement with the work of Deshmukh *et al.* (2018) that reported that the use of integrated weed management control methods significantly influenced the plant height.

Table 4: Mean values of pant height on application of pre-emergence herbicide and manual weeding on weed control, growth and yield of turmeric at Afaka during rainy seasons of 2019/2020

		Plant Height (cm) At		
Treatment	**Rate L/ha**	**4 WAT**	**8 WAT**	**12 WAT[1]**
Metolachlor alone	1.5L/ha	5.24ab[2]	26.47a	49.35ab
Metolachlor + 1 SHW[3]	1.5L/ha	2.67b	25.16a	48.54b
Metolachlor + 2 SHW[4]	1.5L/ha	5.17ab	26.64a	49.59ab
Metolachlor alone	2.0L/ha	4.58ab	26.58a	53.05ab
Metolachlor+ 1 SHW[3]	2.0L/ha	6.61ab	48.40a	53.32ab
Metolachlor + 2 SHW[4]	2.0L/ha	4.93ab	47.78a	53.30ab
Plot kept weed free at 4, 8 weeks		10.53a	32.55a	53.54a
Plot kept weed free at 4, 8, 12 weeks		5.58ab	27.84a	43.02ab
Plot kept weed free/throughout		6.43ab	21.07a	43.30ab
No weeding		4.45ab	26.73a	43.32ab
SE±		0.058	5.411	4.942

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

Weight of rhizome: The result of the mean weight per hectare of turmeric at harvest on application of pre-emergence herbicide combined with manual weeding at Afaka during 2019 and 2020 raining seasons is shown in Table 5. The result revealed that weight per hectare were significant across the treatments. The application of Metolachlor at 2.0l/ha + 1SHW at 4WAT produced significantly higher weight of turmeric rhizome per hectare that was statistically significant in comparison with the control and all other treatments. The weight per hectare of rhizomes of turmeric that was significant at harvest with treatment combination of metolachlor at 1.5 L/ha and 1 SHW at 4WAT, and better weed suppression could be advocated in turmeric rhizome production. The result conform with the work of Imoloame (2016) and Bature *et al.* (2016) that recorded good yield when they applied metolachlor at 2.64 kg a.i/ha and metolachlor + atrazin at 1.0 + 2.0 kg a.i /ha + one SHW for effective weed control on maize and okra respectively.

Table 5: Mean values of weight of rhizomes per hectare on application of pre-emergence herbicide and manual weeding on weed control, growth and yield of turmeric at Afaka during rainy seasons of 2019/2020

Treatment	**Rate L/ha**	**Weight of turmeric rhizome per/ha (Kg)**
Metolachlor alone	1.5L/ha	136.06ab[1]
Metolachlor + 1 SHW[2]	1.5L/ha	154.76a
Metolachlor + 2 SHW[3]	1.5L/ha	52.72b
Metolachlor alone	2.0L/ha	98.07ab
Metolachlor+ 1 SHW[2]	2.0L/ha	98.07ab
Metolachlor + 2 SHW[3]	2.0L/ha	137.76ab
Plot kept weed free at 4, 8 weeks		130.39ab
Plot kept weed free at 4, 8, 12 weeks		136.06ab
Plot kept weed free/throughout		150.80ab
No weeding		120.75ab
SE±		29.20

[1]Mean in a row: followed by the similar letter are not statistically different at P. ≥ 0.05 according to (DMRT), [2]Suplementary hoe weeding at 4 WAT, [3]suplementary hoe weeding at 4 and 8 WAT

Conclusion

Field experiment was carried out during cropping seasons of 2019 and 2020 at Crop Production Technology Department Farm at Afaka to investigate the best integrated weed management system required to suppress and control weed growth and improved growth and yield of turmeric rhizome. In conclusion, the result showed that treatment combination of metolachlor at 1.5 L/ha and 1 SHW at 4WAT produced the highest yield of 154 kg per hectare of turmeric rhizomes at harvest and therefore, it could be recommended to the farmers in the northern guinea savannah agro-ecological zones as the best integrated weed management system that can adopted to get bumper harvest of turmeric rhizome.

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