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Weed Management Practices by Lowland Rice Farmers in the South West of Nigeria

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Abstract

Report has shown that effective weed management strategy will result in better productivity which will in turn improve food security in Nigeria. However, little is known about weed management strategies practices by rice farmers and their performance in southwest agro-ecological zone. The aims of this study were to determine the weed management practices among lowland rice farmers and to assess the factors limiting productivity of lowland rice farmers in Southwestern Nigeria.

Survey on weed management practice among lowland farmers in Southwestern Nigeria was carried out. A multi-stage sampling technique was adopted for this study. Ondo and Ekiti states were purposely selected with four local governments in each state. Questionnaires were administered to 200 rice farmers in rice producing villages visited. All data collected were analyzed using descriptive statistics. The result of this study shows that 99% of farmers adopted chemical weed control than other methods. Pre-plant herbicides namely; glyphosate and paraquat were more available to lowland rice farmers in SW than post-emergence herbicides however, most products are applied with little or no reference to recommended rate. Also, most farmers cannot afford the cost of herbicide products, only few farmers (6%) have limited financial support consequent to poor literacy level among rice farmers in Southwest. It is recommended that weed scientists and weed control extension officers are needed to train farmers on effective weed management strategies. Adequate funding support for lowland rice farmers will enhance effective weed management in southwestern agro-ecological zone.

Keywords: Low land rice; Weed management; Agro-ecological zones; Socio-economic growth

Introduction

Rice (*Oryza sativa* L.) has the potential to play a critical role in contributing to food security, income generation, poverty alleviation and socio-economic growth of Africa [1]. Biyi [2] reported that Nigeria is currently the highest rice producer in West Africa producing about 6,734 metric tons [3]. Nigeria is also the highest consuming nation because of its large population, consuming an average of 24.8 kg of rice per year [4].

Rain-fed rice production is the main production system, while irrigated rice is the best performing in terms of yields (3.5 t/ha), followed by rain-fed lowland (2.2 t/ha) and mangrove swamp (2 t/ha). Rice production in lowland with wet soil zone is favoured within the country, given its resistance to drought. Rice producers in Nigeria are majorly smallholders with an average farm size of less than 2 ha in mixture with other crops [2].

Rice importation in Nigeria depletes the economy of limited funds. Nigeria spent an average of US $ 1.6 million on rice importation per annum [5]. This high level of rice importation is not sustainable. Therefore, the Nigeria government is refocusing attention on stimulating domestic rice production through a number of strategies, some of which are the establishment of rice processing factories in Kano, Kwara, Ogun, and Benue States with a combined installed capacity of 730,000 metric tons per annum. It is very important to take advantage of the substantial processing capacity available in the country by boosting paddy rice production.

According to Godwin et al. [6] rice is produced in all agro-ecological zones in Nigeria, with the Middle belt having a comparative advantage in production over other parts of the country, followed by the Northwest while Southwest is the lowest. Moreso, little is known about weed management strategies practiced by rice farmers and their performance in southwest agro-ecological zone.

Akintayo et al. reported that rice farmers in Niger state, a Guinea savanna agro-ecological zone, employed sub-optimal recommended management practices; seed rate, fertilizers and agrochemicals (such as herbicides for weed control) [7]. Thus, yield obtained by rice farmers in the zone fall short of expected yield of the improved varieties cultivated.

Effective weed management strategy will result in better productivity and increase net rice production which will in turn improve food security in Nigeria. The objectives of this study were to determine the weed management practices among lowland rice farmers, and to access factors limiting productivity of lowland rice farmers in the south west of Nigeria.

Materials and Methods

Study area

Data at the farm level were collected from 200 rice farmers in two states, Ondo and Ekiti states in Southwestern Nigeria between September and December 2013. The states are located in the tropical rainforest area of Nigeria with a heavy rainfall that makes it suitable for both upland and lowland rice cultivation. Figures 1 and 2 shows the study area map in Ekiti and Ondo States.

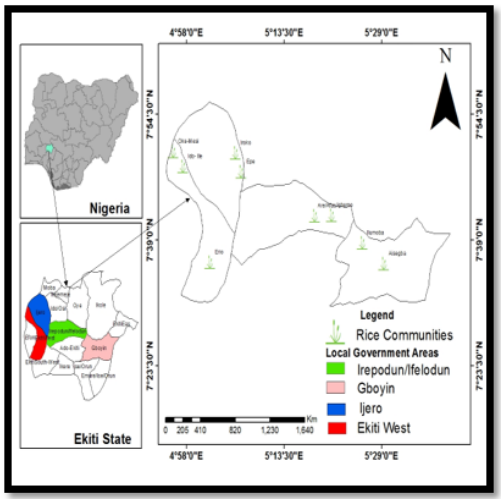

Figure 1: Study area map showing sampled rice communities in Ekiti State. Source: Field survey, 2013.

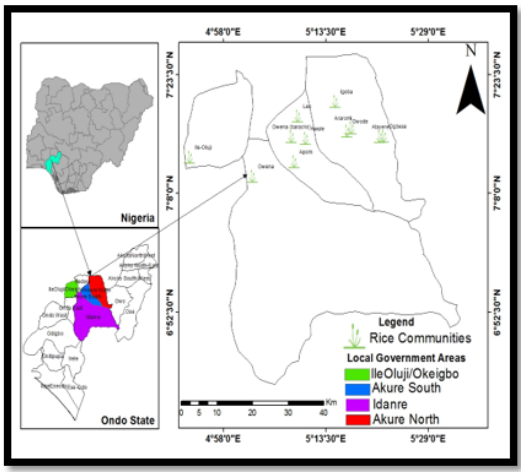

Figure 2: Study area map showing sampled rice communities in Ondo State. Source: Field survey, 2013.

Sampling technique

A multi-stage sampling technique was used for the study. In the first stage, Ekiti and Ondo states were selected based on the predominance of rice farmers in the states. In the second stage, four Local Government Areas (LGAs) each were selected based on the volume of rice production.

The LGAs in Ekiti State are; Ekiti West, Irepodun/Ifelodun, Ijero, and Gbonyin, while those of Ondo State were Akure South, Akure North, Idanre, Okitipupa and Ile-Oluji/Oke-Igbo. In the third stage, 2 villages per LGAs were randomly selected using simple random technique. In the fourth and final stage, 10 rice farmers per village were selected making a total of 100 farmers per state.

A total of 200 questionnaires were administered to farmers out of which 118 questionnaires were certified as containing enough information for analysis with distribution as shown in Table 1.

The choices of Local Government Areas were based on information collected from the Agricultural Development Programme (ADP) office in each state. Focus group discussion was also conducted with the rice farmers being clustered in the states of study to support respondent's information. Primary data were collected through the use of structured questionnaires distributed to rice farmers.

Method of data analysis

All data collected were analyzed using descriptive statistics such as percentages, frequencies; means and standard deviations. These were used in the description of adoption level and constraints to adoption by lowland rice farmers in the study area.

State/LGA	Towns	Longitude	Latitude	Altitude*
EKITI				

Ekiti west	Oke Mesi	4°55' 19.39'E	7°50' 07.23" N	408 m
	Ido- Ile	4°57' 26.05" E	7°48' 03.45" N	409 m
	Erio	5°00' 31.85" E	7°43' 49.14" N	485 m
Ijero	Epe	5°07' 00.21" E	7°47' 35.58" N	499 m
	Iroko	5°05' 43.17" E	7°49' 42.23" N	544 m
Irepodun/Ifelodun	Are/Afao	5°18' 20.49" E	7°41' 59.07" N	390 m
	Igbemo	5°21' 00.60" E	7°42' 01.48" N	378 m
Ggbonyin	Ilumoba	5°25' 51.37" E	7°38' 36.83" N	379 m
	Aisegba	5°28' 49.63" E	7°36' 04.93" N	409 m
ONDO				
Akure North	Ogbese	5°22' 13.79" E	7°15' 28.41" N	311 m
	Owode	5°16' 39.55" E	7°16' 06.14" N	332 m
	Araromi	5°17' 21.88" E	7°16' 28.86" N	334 m
	Igoba	5°14' 53.09" E	7°19' 59.58" N	340 m
	Alayere	5°21' 36.02" E	7°15' 25.52" N	315 m
Akure South	Awule	5°10' 25.31" E	7°16' 24.98" N	342 m
	Leo	5°09' 14.21" E	7°18' 00.61" N	362 m
	Owena(Baracks)	5°08' 14.49" E	7°15' 28.09" N	349 m
	Aponmu	5°03' 45.20" E	7°14' 23.31" N	278 m
Idanre	Owena	5°01' 10.65" E	7°11' 45.65" N	252 m
Ile-Oluji/Oke-igbo	Ile-Oluji	4°51'21.93" E	7°13' 19.15" N	229 m

Table 1: Geographical Coordinates of Surveyed Rice Communities in Southwest Nigeria. *Altitude above sea level. Source: Field Survey, 2013.

Results

Demographic and socio-economic characteristics of lowland rice farmers

The personal and socio-economic features of farmers in southwest Nigeria (Table 2). Result reveals that majority of the lowland rice producer's fall in the productive age category of 20-50 years.

Majority of the respondents are males (66.1%) while female constitute the remaining 33.9% of the farming population. Farmers with formal education in primary and secondary school (32.8% and 33.8% respectively) are in the majority among the respondents (Table 2).

Results also indicate that 63.9% of the farmers have their major occupation as rice farming. In addition, many of the farmers are producing rice for commercial purposes. This may influence the quest for them to acquire more information on improved weed management practices for rice production.

About 45.8% of the respondents had 1-10 years of farming experience, 31.8% had 11-20 years, while 3.7% minority are 31 years and above respectively.

Considering the size of rice farm, 30.1% of the respondents had rice farms less than 1 hectare, 51.3% between 2-5 hectares. Only 4.4% cultivates above 11 hectares. From the above result, about 50% of farmers cultivate between 2-5 hectares of land. As the size of farmland increases the cost of labour and time spent on weed control may increase.

A good number of the respondents (69.7%) have access to extension services. Majority (76.5%) belongs to at least one farmer's association, 15.1% are not in any association. Majority of rice farmers source their farming expenditure personally (83.2%) and through cooperative (32.8%), while minority source from friends (2.5%), relatives (4.2%), bank (0.8%) and Government (5.0%) (Table 2).

Socio Economic Variables	Frequency	Percentage
Age (year)		
20-30	21	18.4
31-40	35	30.7
41-50	28	24.6
51-60	20	17.5

60 and above	10	8.8
Gender		
Male	78	66.1
Female	40	33.9
Educational level		
No formal education	26	21.8
Primary	39	32.8
Secondary	40	33.8
Tertiary	13	10.9
Occupation		
Farming	76	63.9
Others	41	34.5
Farming Experience (years)		
01-Oct	49	45.8
Nov-20	34	31.8
21-30	16	15.0
31-40	4	3.7
41 and above	4	3.7
Rice Farm Size (ha)		
0-1	34	30.1
2-5	58	51.3
06-Oct	16	14.2
11 and above	5	4.4
Extension Services		
Access to Extension Services?	83	69.7
No Access to Extension Services?	26	21.8
Belong to an Association?	91	76.5
Does not belong to an association?	18	15.1
Source of funds		
Cooperative	39	32.8
Personal	99	83.2
Friends	3	2.5
Relatives	5	4.2
Bank loan	1	0.8
Government	6	5.0

Table 2: Demographic and Socio-Economic Characteristics of Lowland Rice Farmers in Southwest. Source: Field Survey, 2013.

Weed management practices among lowland rice farmers in Southwest Nigeria

Most farmers (56%) apply herbicides for weed control, 0.9% engage in the old cultural practices such as hand weeding, while 47% of rice farmers combine the use of herbicides and hand weeding as a weed control option. More than half of the respondents depend fully on herbicides while others engage in hand weeding to support the use of herbicides (Tables 3 and 4).

Weed Control Methods	Frequency	Percentage (%)[1]
Herbicide alone	61	56
Hand weeding alone	1	0.9
Flooding alone	0	0 [2]
Herbicide+Hand weeding	47	43.1
Herbicide+Hand weeding+Flooding	0	0
Herbicide+Flooding	0	0

Table 3: Weed Management Practices Among Lowland Rice Farmers in Southwest Nigeria. 1. (%) Percentage number of respondents at adopt a particular weed control method. 2. (0) Non-Adoption. Source: Field Survey, 2013.

Perceived weed incidence among lowland rice farmers in Southwest Nigeria

Most farmers perceived grasses as prevalent weeds (40.7%). A mixture of grasses and sedges, broadleaves and grasses, grasses and sedges in combination are not significantly different (Figure 3).

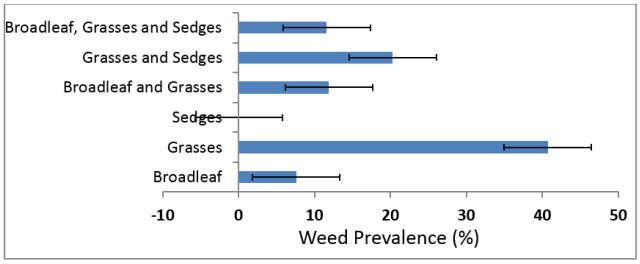

Figure 3: Common Class of Weeds in Lowland Ecologies in Southwest Nigeria.

Prevalent weed species in lowland rice ecologies in Southwest Nigeria

Most of the respondents (22%) noted stubborn grass (*Sporobulus pyramidalis* P. Beauv.) as a noxious weed in their rice field, followed by siam weed (*Chromolaena odorata* (L.) R. M.) (14.4%), elephant grass (*Pennisetum purpureum* Schum.) and carpet grass (*Axonopus compressus* (Sw.) P. Beauv.) (9.3%) respectively (Table 4).

Weed Species	Life Cycle	Lowland [2]	
Broad Leaves	(P/A) [1]	F	(%)
Talinum triangulare (Jacq.) Wild.	A	6	5.1

Chromolaena odorata (L.) R. M.	P	17	14.4
Grasses			
Pennisetum purpureum Schum.	A	11	9.3
Sporoblus pyramidalis P. Beauv.	A	26	22
Cynodon dactylon (Linn.) Pers.	A	3	2.5
Imperata cylindrical (Linn.) Raeuschel var.Africana (Anderss) C.E. Hubbard	P	9	7.6
Axonopus compressus (Sw) P. Beauv.	A	11	9.3
Sacciolepis africana Hubb and Snowden	P	-	-

Table 4: Prevalent Weed Species in Lowland Rice Ecologies in Southwest Nigeria. [1]F-Frequency, %-Percentage, [2]P-Perennial weed species, A-Annual weed species. Source: Field Survey 2013.

Available herbicides used by rice farmers in lowland ecology in Southwest Nigeria

Twenty-two herbicides with different trade names were documented for weed control in the study area (Table 5). Nineteen of these herbicides are preplant application (PPA) herbicides and three post emergence (PE). Most respondents applied glyphosate formulations (namely; Forceup® (17.8%), Roundup® (13.6%), Clearweed® and Tackle® (10.2%) respectively, Vinash® and Fiscosate® (9.7%) respectively) and paraquat formulations (namely; Slasher® (10.2%), Weedcrusher® and Paraforce® (5.1%) respectively) as PPA for weed control in lowland rice.

Most respondents apply Orizo Pro® (2,4-D Amine+Propanil formulation (57.6%), followed by 2,4-D amine salt formulation (33.9%) as PE in lowland ecology. A formulation of Pretilachlor+Pyribenzoxim (Solito®), one of the available herbicides for PE application is limited in use (0.8%). This result is also in support of the fact that majority of weeds available in lowland ecology are either grasses or a mixture of grasses and broadleaves, hence the need for an herbicide with selectivity for broadleaves and grasses in lowland field.

Common Names	Trade Names	Time of Application [1]	Level of Use [2]	
			F	%
2,4-D Amine salt	Aminoforce®	PE	41	40
2,4-D Amine salt+Propanil	OrizoPro®	PE	68	57.6
Glyphosate	General®	PPA	2	1.7
Glyphosate	Bushfire®	PPA	4	3.4
Glyphosate	Clearweed®	PPA	12	10.2
Glyphosate	Delsate®	PPA	3	2.5
Glyphosate	Fiscosate®	PPA	10	8.5
Glyphosate	Forceup®	PPA	21	17.8
Glyphosate	Glycel®	PPA	2	1.7
Glyphosate	Roundup®	PPA	16	13.6
Glyphosate	Sarosate®	PPA	8	6.8
Glyphosate	Tackle®	PPA	12	10.2
Glyphosate	Torchdown®	PPA	44	3.4
Glyphosate	Uproot®	PPA	9	7.6
Glyphosate	Vinash®	PPA	11	9.7
Paraquat	Dragon®	PPA	2	1.7
Paraquat	Grammaxone®	PPA	7	5.9
Paraquat	Paraforce®	PPA	6	5.1
Paraquat	Slasher®	PPA	12	10.2
Paraquat	Weedcrusher®	PPA	6	5.1
Paraquat	Weedoff®	PPA	5	4.2
Pretilachlor+Pyribenzoxim	Solito®	PE	1	0.8

Table 5: Available herbicides used by rice farmers in lowland ecology in Southwest. [1] PPA-Pre-Plant Application, PE-Post Emergence application. [2] F-Frequency, %-Percentage. Source: Field Survey, 2013.

Mean value of rate of herbicides use in lowland rice in Southwest Nigeria

Farmers mix, on the average, between 231.9-250.5 ml of glyphosate in approximately 17.0 ml of water in knapsack sprayer estimated to cover about 0.1 ha. This shows that the rate of glyphosate applied by farmers is between 2.6-2.8 litres per hectare. This rate is about 47% of the recommended rate (Table 6). Underutilization of glyphosate might be as a result of unaffordable cost of product by farmers as a result of low status of education among most rice farmers (Table 2) or ignorance.

Farmers mix between 176.4-196.2 ml of paraquat with approximately 17.0 ml of water in a knapsack sprayer estimated to cover 0.05 ha. The result shows that the rate of paraquat applied by farmers is between 3.6-4.0 litres of product per hectare. Farmers in this study areas applied about 34% of paraquat above the recommended rate i.e., a difference of 1 litre from the recommended rate of 3 litres per hectare (Table 6).

Between 197.4-218.4 ml of 2,4-D amine is mixed with approximately 16.0 ml of water in knapsack sprayer estimated to cover about 0.05 ha. This result also implies that about 4.0-4.4 litres of product per hectare of 2,4-D amine is applied by rice farmers. This rate is 200% above the recommended rate of 1-1.5 litres of product per hectare for lowland rice (Table 6).

Another formulation of 2,4-D amine and propanil applied as post-emergence is between 202.8-230.0 ml mixed with approximately 18.0 ml of water in a knapsack sprayer estimated to cover averagely 0.1 ha. The result implies that farmers apply between 2.25-2.56 litres of product per hectare of 2,4-D amine+propanil in the study areas. This rate of application is 65% below the recommended rate of 4 litres per hectare (Table 6).

	PPA		PE	
	Glyphosate	**Paraquat**	**2,4-D amine**	**2,4-D amine+Propanil (mixture)**
Herbicide Quantity in Sprayer (ml)	241.19 ± 9.29	186.27 ± 9.91	207.88 ± 10.49	216.38 ± 13.63
Amount of Water in Sprayer (ml)	17.24 ± 0.22	16.82 ± 1.03	16.34 ± 0.30	17.74 ± 0.30
Area Covered by Sprayer (ha)	0.09 ± 0.02	0.05 ± 0.01	0.05 ± 0.01	0.09 ± 0.02
Herbicide Application (litre/ha)	2.6-2.8	3.6-4.0	4.0-4.4	2.3-2.6
Recommended Rate (litre/ha)	6	3	1-1.5	4
% of Recommended Rate Used	47%	34% >	200% >	65%

Table 6: Mean values for rate of herbicide used in lowland rice Southwest Nigeria. PPA-Pre-Plant Application, PE-Post Emergence application. Source: Field Survey 2013.

Application timing of herbicide usage by lowland rice farmers

The result reveals that most farmers (82.3%) cultivating lowland rice indicate glyphosate application at pre-plant stage to control weeds. Majority also apply 2,4-D amine salt (57.5%) and 2,4-D amine +Propanil (59.6%) as post-emergence herbicides for weed control at 2-3 WAP. Respondents also indicate that all herbicide of choice are applied once in a production cycle (Table 7).

Herbicides	**Time of application**			**No of times applied**	
	Pre-planting	**2-3 WAP**	**6 WAP**	**Once**	**Twice**
Glyphosate	82.3% (99) [1]	--	--	81.5% (97)	--
Paraquat	7.6% (9)	--	--	7.6% (9)	--
2,4-D amine salt	--	57.5% (42)	8.2% (6)	58.9% (43)	--
2,4-D amine salt+Propanil	--	59.6% (68)	6.1% (7)	60.5% (69)	--

Table 7: Application timing of herbicide by lowland rice farmers in Southwest Nigeria. [1] %-Percentage of respondent, F-Frequency of respondents are in parenthesis. Source: Field Survey, 2013, WAP-Weeks After Planting.

Factors limiting farmers productivity among lowland rice farmers in Southwest Nigeria

A lot of factors have been reported to hinder peasant farmers productivity in crop production and these include: farm size, mixed cropping system, water availability, high cost of herbicides and sprayers [8].

Availability and affordability of some determinant factors such as land, labour for weeding, rice herbicide, input markets and farm credits for weeding to the adoption of improved weed control technology by rice farmers in Southwest Nigeria are shown in Table 8.

Most (66.9%) of the respondents indicated that there is available land and 73.3% of rice producers can reasonably afford to possess this land as a resource for rice cultivation. The result shows that farmers have the potential to increase their production output in terms of land resources.

A larger percentage (80.6%) of the respondent also indicated that there is available labour for weed control practices; 60% of the respondent can reasonably afford the cost of employing labour for weeding while 40% shows their inadequacy in affording the cost of labour for controlling the weeds on their rice farm.

Most (84.3%) rice farmers indicated that there are rice herbicides available for use. Only 45.1% of respondents can adequately afford the cost of these herbicides while the remaining 54.9% cannot reasonably afford the cost of herbicides in the market.

Another factor that can contribute to effective weed control is farm credit source. Majority (72.8%) of farmers indicated inadequate source of funding. 40.7% of the respondents indicate they cannot reasonably afford the cost of weeding. This is because most farmers depend on their own personal source of income to produce rice.

Factors	**Availability**		**Affordability**	
	Adequate	**Inadequate**	**Reasonable**	**Unreasonable**
Farm Size/Land	79 (66.9%) [1]	26 (24.8%)	77 (73.3%)	28 (26.7%)
Labour for Weeding	83 (80.6%)	20 (19.4%)	60 (60%)	40 (40%)
Rice Herbicides	86 (84.3%)	16 (13.6%)	46 (45.1%)	56 (54.9)
Input Markets	2 (1.7%)	--	1 (0.8%)	--

Farm Credits for Weeding	22 (22.2%)	59 (72.8%)	24 (20.3%)	48 (40.7%)

Table 8: Some Constraints to Adoption of Improved Weed Control Technology Among Rice Farmers in Southwest Nigeria. [1] % - Percentage of respondent, F- Frequency of respondents are in parenthesis. Source: Field survey, 2013.

Discussion

Weed management practices among lowland rice farmers in Southwest Nigeria

A large percentage of farmers depend fully on chemical method of weed control. However, some farmers still engage in hand weeding to support the use of herbicides; this may result from farmers inability to afford herbicide cost for weed control. Lowland rice farmers have recognized the need to increase their output to meet the increasing demand of rice in the country through chemical weed control method known to efficient and time saving [9]. Other integrated forms of weed control practices such as the combination of chemical, cultural and mechanical methods have not been fully adopted in the study areas except hand weeding combined with chemical methods.

It has been reported that integrated weed management (IWM) involves the combination of a number of weed control practices that reduce the dependence on any one type of control method and lowers the input of herbicides. This approach is important for the control of perennial weeds that are inadequately controlled by any single method [10]. In view of the state of adoption of improved weed control technology, herbicide technology is receiving a wide acceptance by lowland rice producers. Farmers need to be supported to fully adopt herbicide as a technology that can enhance massive rice production in southwest of Nigeria [11].

Most of the respondents reported high incidence of grasses alone followed by a mixture of either grasses and sedges or broadleaves. Grasses are commonly attributed to lowland ecology than any other class of weeds. Also, a combination of grasses with any other classes of weeds such as broadleaves and sedges are commonly experienced in rainfed lowland ecology. The ecological distribution of these classes of weeds attributed to different rice ecology influences the type of improved weed control technology to be adopted by rice farmers.

Most weed species perceived by farmers in lowland rice ecologies in Southwest Nigeria are stubborn grass (*Sporobulus pyramidalis* P. Beauv.), siam weed (*Chromolaena odorata* (L.) R. M.), elephant grass (*Pennisetum purpureum* Schum.) and carpet grass (*Axonopus compressus* (Sw.) P. Beauv.), and other perennial grasses such as *Sacciolepis africana* (Hubb and Snowden) and Spear grass (*Imperata cylindrica*). The effective control of any particular weed species is influenced by a number of factors which include correct identification of weed species and the type of crop environment where such weed is found. Farmers encounter different types of weeds on their farms and the method adopted for controlling these weeds together with the problems associated with each weed species differ from one location to the other [12].

A larger percentage of the respondents applied *Forceup*®, followed by *Roundup*®, *Clearweed*® and *Tackle*® respectively as pre-plant application (PPA) herbicides (all glyphosate formulations). Also, *Slasher*® a paraquat formulation is most used by farmers for weed control in lowland rice. A good reason for high adoption of glyphosate herbicide as a PPA for weed control is it's broad-spectrum activity. Glyphosate is a broad-spectrum herbicide known widely in the tropics for the control of annual and perennial weeds including grasses such as spear grass (*Imperata cylindrical* (Linn.) Raeuschel var Africana (Anderss) C.E. Hubbard), Guinea grass (*Panicum maximum* Jacq.) etc. It has also been noted for its use as PPA to control perennial weeds in reduced tillage systems and for the clearing of bush regrowth in newly opened up field for cultivation [9]. Glyphosate is now being used particularly in lowland ecology for field clearing in preparation for rice cultivation particularly in lowland rice fields where machineries like power tillers are not available to farmers. Farmers prefer to spray glyphosate to destroy any form of noxious weeds for about two weeks after which clearing, and burning is easy to carry out. The use of glyphosate has substituted for manual method of field clearing in many rice fields hence, reducing the cost and energy farmers dissipate for production. In the same vein, the use of PPA herbicide such as glyphosate and paraquat influence positively the farm size cultivated by small holder farmers in this study area unlike the years back when farmers practice cultural weed control methods.

Majority of the lowland rice farmers apply *Orizo Pro*® (2,4-D Amine +Propanil formulation), and 2,4-D amine salt formulation as post-emergence (PE) herbicide in lowland ecology. This result is also in support of the fact that majority of weeds available in lowland ecology are either grasses or a mixture of grasses and broadleaves, hence the need for herbicides which can selectively control broadleaves and grasses in this study area.

Ibrahim et al. [4] has reported a list of available herbicides for post-emergence control of weeds in rice in Nigeria which includes propanil, oxadiazon, butachlor; 2,4-D amine salt formulation, bisbyribac sodium +pyribenzoxim formulation, pretilachlor+pyribenzoxim formulation, propanil+2,4-D amine salt formulation and pretilachlor+propanil formulation. Despite the availability of these herbicides for weed control in the country, few of these herbicides namely: 2,4-D amine salt, propanil+2,4-D amine salt and pretilachlor+pyribenzoxim formulations are accessible to lowland rice farmers in the Southwest agro-ecological zone. A formulation of Pretilachlor+Pyribenzoxim (*Solito*®), one of the PE herbicides is still not accessible to most farmers. There is a need to improve farmer's awareness through extension agents and the introduction of new products or technology to control weeds in rice in Southwest Nigeria.

Underutilization of glyphosate and a formulation of 2,4-D amine and propanil might also result from unaffordable cost of product by farmers or lack of knowledge on the recommended dosage due to poor education.

Farmers apply paraquat and 2,4-D amine above the recommended rates. This higher rate of application has a tendency of polluting lowland environment (soil and water) due to potentially higher concentration of herbicide residue in the area.

Weed scientists and weed control extension officers are needed to train farmers on the peculiarities of weed species and the application of appropriate quantities of herbicides on their farms for weed control. Farmers will have to know what quantity of the commercial product to be applied to provide an adequate quantity of the active ingredients. Also, they will need to be enlightened about sprayer calibration [8].

Most farmers cultivating lowland rice apply glyphosate herbicide at pre-plant stage to control weeds. They also apply 2,4-D amine salt and 2,4-D amine+Propanil as post-emergence herbicides for weed control

at 2-3 WAP. Respondents also indicate that all herbicides of choice are applied once in a production cycle. This implies that recommended agronomic practices in terms of application timing is commonly practiced by lowland rice farmers [13].

Some factors limiting productivity among lowland rice farmers in Southwestern Nigeria

Considering the high percentage of relatively young farmers, possibility abounds that farmers in this study area have potential to adopt improved weed control technology, thus contributing positively to increased rice production in the area than older farmers. Reports revealed that older farmers are generally slow to change due to fear of the unknown and great aversion to risk. On the other hand, younger farmers are much more receptive to new ideas than older farmers; they may have much wider contact outside farming, alternative employment opportunities and are much more willing to take risk in adopting new practices [14,15]. Majority of the respondents are males while female constitute the remaining of the farming population. Similar report by Isah et al. shows that men are earlier adopters of new technology than women, probably because males carry out agricultural activities that are more labour demanding than the female [15]. Nevertheless, women are found to be actively involved in lowland rice production in the study areas. Farmers with formal education in primary and secondary school are in the majority among the respondents. This might enhance their adoption behaviour for improved weed control technology. Tripathi and Chotelal reported that adoption levels were highest for those farmers of high taste and education above primary school [16]. Rice farming is a major source of income for many of the farmers. In addition, many of the farmers are producing rice for commercial purposes. This may influence the quest for them to acquire more information on improved weed management practices for rice production.

Farmers who had farming experience of 1-10 years constitute a larger proportion of the lowland rice producers, meaning that the years of farming experience influence the adoption of the weed management practices. The longer the number of years of farming experienced by farmers, the more likely they become more aware of effective weed control measures [15]. New farmers are getting involved in rice production, whose level of awareness about the agronomy of lowland rice and effective weed management strategy may still be poor hence, a need to enhance their awareness of available weed control option to enhance rice production in southwest Nigeria.

About half of rice farmers cultivate between 2-5 hectares of land. As the size of farmland increases the cost of labour and time consumption for weed control increases. This might necessitate farmer's quest for adoption of improved weed management practices that saves time and are cost-effective.

A good number of farmers that have access to extension services also belong to an association, for one reason or the other. This shows that farmer's awareness of improved weed management practices and the possibility of reaching out to them with new ideas is possible in the study area. Most rice farmers source for funding personally and through cooperative, only few farmers benefit from government support. Although, a good number of farmers have access to extension services, the cost of effective weed control is high for lowland rice farmers as a result of poor funding to adopt improved weed management practices [17].

Conclusion and Recommendations

The survey study reveals weed management practices and factors limiting lowland rice production among farmers in southwestern Nigeria.

Most lowland rice farmers in southwest depends majorly on chemical method of weed control. Herbicides such as glyphosate and paraquat are mostly available in the zone than post-emergence herbicides. Selective post-emergence herbicides are limited in usage. This may be due to farmers inability to afford herbicides products, risk aversion for fear of crop injury etc. Most herbicides used by rice farmers are applied with little or no reference to recommended rates. Inadequate knowledge of herbicide dosage by farmers may result in higher yield loss as a result of poor weed control, and a high risk of environmental pollution as a result of increased concentration of herbicide residue in the soil and water environment. Hand weeding methods are still employed to compliment herbicide by some famers in the area. Most rice farmers receive little support from government. Weed scientists and weed control extension officers are needed to train farmers on the peculiarities of weed species and the application of appropriate quantities of herbicides on their farms for effective weed control.

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