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Herbicide Use Dynamics on Cassava-Based Farming Systems in Yewa Division of Ogun State, Nigeria: Economic, Environmental and Health Perspectives

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Abstract

Weed reduces cassava crop yields by competing for essential nutrients, leading to yield loss above 70 per cent of the yield potentials. Manual weeding has often been the predominant weed control practice to smallholder farmers, claiming about 50–70 per cent of their total labor time. Chemical weed control provides economically viable alternatives to hand weeding, with its attendant disruption of soil ecology, and health hazards to the farmer. This study assesses the dynamics of herbicide use on cassava-based farming systems in Yewa communities of Ogun State, Nigeria. Primary data were obtained from 128 cassava farmers, using multi-stage sampling technique. Data were analysed using descriptive statistics, and logit/covariance model estimations. Descriptively, herbicide adopters (74 per cent) were of mean age 52 years, average farm size (2 hectares); and average household size (6 persons). The environmental effect of herbicide use was 61.06 per cent on cultivated crops; 12.63 per cent on soil micro-organisms; and 26.31 per cent on the farmer/his livestock. To all respondents, herbicide use helped to boost soil organic regeneration. Barely 52 per cent of the perceived health hazards of herbicide use was on farmer's sensitive organs (eye, nose and skin), followed by body weakness (28.42 per cent) and vomiting (8.42 per cent). Empirically, sex (0.466; $p<0.01$), education (0.008; $p<0.05$), farm plot consolidation (0.138; $p<0.05$), and large-scale farming (0.120; $p<0.05$) significantly influenced farmers' decision to use herbicides, while age (-0.005; $p<0.1$) and high cost (-0.051; $p<0.01$) reduced it. Herbicides use intensity (HUI) increased with weeding frequency and farmland segregation; but decreased with high application costs. Training of farmers to embrace herbicidal options was recommended to boost cassava production in the study area.

Key words: cassava farmers, herbicides use, weed control, Yewa division

JEL Classification: Q1, Q2, Q12, I31

Introduction

Cassava is a very important food crops in Nigeria, as in most developing countries, where it is one of the most important sources of carbohydrate. The crop plays a dominant role in the food security of rural households because of its capacity to yield under marginal soil conditions and its tolerance to drought (Nwaiwu, 2017). Cassava is especially an important food crop in south-eastern Nigeria where it contributes to about 15 per cent of the daily dietary energy intake of most Nigerians and supplies about 70 per cent of the total calorie intake of about 60 million people in Nigeria (Ezulike *et al.,* 2006). Nigeria is one of the world's largest producers of cassava; with about 37 million tons of cassava cultivated on 2.5 hectares of land; and with a national average yield of 14.8 metric tons per hectare (Adamu *et al.,* 2016). Nigeria's production account for 19 per cent of the world output and 34 per cent of Africa's output (Agwu and Anyaeche, 2007). Most families in Nigeria, especially in the South-East, consume the storage roots in various forms, such as garri, fufu, starch, fresh and dry flakes (abacha*)* and tapioca. Also, cassava often serves as the main crop or the dominant component in crop mixtures in South-Eastern Nigeria (Ikeorgu and Mbah, 2007). As a cash crop, about 45 per cent of it is sold for various household income needs (Udensi *et al.,* 2011).

As important as this crop is to the food security status and agro-allied industry throughout the African continent, one major setback to its effective cultivation and productivity is weed pest. Weeds are the most universal of all crop pests, proliferating each year on every farm in Africa. A review

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of crop pests in sub-Sahara Africa indicated that weeds are the most important pest to control in all zones studied (Sibuga, 1997). Broadleaf weeds and grasses dominate the weed spectrum, whereas sedges are minor. Weed problems are more severe in African tropical regions than in Europe and North America because weeds grow more vigorously and regenerate more quickly because of the heat and higher light intensity. Weeds reduce crop yields by competing with crops for light, water, nutrients and space. Numerous studies have documented the negative effects on yield of season-long weed competition in Africa. Under unweeded conditions, crop losses have been measured for cassava to reach as high as 90 per cent of the potential yield (Ambe *et al.,* 2002).

Hand weeding is the predominant weed control practice on smallholder farms (Vissoh *et al.,* 2004). Hand weeding is the oldest method of weed control, consisting of pulling and slashing weeds by hand and hoeing. It has been reported that smallholder farmers spend 50–70 per cent of their total labor time hand weeding (Chikoye *et al.,* 2007) while women contribute more than 90 per cent of hand weeding labor for most crops (Ukekje, 2004). Seven out of every 10 farm children between the ages of 5 and 14 are forced to leave school and work in the agricultural sector at the peak period of weeding (Ishaya *et al.* 2008). Optimal weeding is critical to production; not only the timing of weeding but the frequency is also important. For example, Ishaya *et al.* (2007) discovered that about 309 hours were required to hand weed one hectare of maize while 324 hours of weeding were needed for one hectare of sorghum in northern Nigeria. Use of herbicides provides an economic alternative to hand weeding. Herbicides can be sprayed before planting to remove weeds from afield, applied directly to soil at planting for residual control of germinating weed seeds, or applied directly on weeds during the growing season. Residual herbicides applied to the soil before the crop and weeds emerge from the ground remain active in controlling germinating weed until the critical period of weed competition has passed.

Herbicides are the categories of pesticides used to kill unwanted plants, commonly known as weeds. The World Health Organization had estimated that at least 3 million cases of acute poisoning and 20,000 deaths occur annually due to exposure to pesticides (Orhii, 2010). Just as about 70% of agricultural chemicals are is used in the form of agricultural pesticides (herbicides) in the United States of America, Orhii (2010) also reported that the sales, use and dependence of farmers on pesticides is in gradual increase in developing countries. Agrochemicals are essential agricultural inputs that are engaged in managing the agricultural ecosystem (community of organisms) in a farming area. Different kinds of agrochemicals are used to protect crops from diseases (e.g, fungicides), pests (pesticides/rodenticides) and weeds (herbicides), while some others contribute to healthy growth of crops (fertilizers), and ensure stable supply of agricultural produce for the increasing global population. Careful usage of herbicides also contributes to the improvement of farm work efficiency thereby reducing overall cost of crop farm management. Experiment documentaries shows that use of chemical herbicides is more cost-effective and produces better weed control than hand weeding. It was being reported by Chikoye *et al.* (2007), that chemical control of weeds decreases costs by as much as 50 per cent and increases yields up to 55 per cent on Nigerian cassava, yam, and soybean plots.

Undoubtedly, the greatest obstacle between herbicide technology and African farmers is lack of awareness and training on adoption techniques. Specifically, constraints involve an inadequate knowledge of which herbicide to use in a given weed-crop situation; deficiency of extension services; scarcity of trained weed science personnel; uncertainty as to the availability of herbicides; and lack of herbicides in farmer-friendly packages (Mavudzi *et al.*, 2001). For herbicides to be successfully introduced, several major infrastructure systems must also be improved. Due to rapid population growth, Africa can no longer be viewed as a land-abundant region where food crop supply could be increased by expansion of land used in agriculture. Large areas in Africa are increasingly becoming marginal for agriculture and arable land has become scarce (Saka *et al.,* 2011). This makes the need for intensification of land use through adoption of productivity enhancing technologies (such as fertilizer and herbicides) crucial for achieving food security. For instance, in order to feed her growing population, Otunaiya *et al.* (2012) had postulated that Nigeria must increase food production by 4% per year for the next 10 years.

Use of herbicides on crop farms has benefited farmers by reducing pest attack and preventing weeds from competing for soil water and nutrients with farm crops, which both have a significant effect on increased crop yield. Compared with alternative means of weed control such as mechanical weeding by hand and machine, herbicides are less expensive, often safer, faster, and sometimes more selective. Notwithstanding the economic effect of herbicide use on crop yield, there are undeniable environmental and health hazards emanating from inadequate knowledge regarding safety measures in agrochemical applications on the part of the farmers (Miller, 2004). For instance, herbicides eradicate beneficial insects (such as aphids) that prey on common crop pests, predisposing farm crops to attacks by large congregation of pests which in turn leads to colossal loss in quantity and quality of crop outputs. Herbicides also kill such insects as butter flies, moths, spiders, and bees which benefit the environment through the biological process of plant pollination. Therefore, the increasing global awareness of the health and environmental hazards of herbicides use has made it imperative to formulate regulatory policies that would reduce the environmental risks associated with its use, while also guaranteeing the realization of its enormous economic benefits to the farmers. Risk has been viewed as an unavoidable component of life whose outcomes must be weighed against the likely benefits resulting from any particular action (Avav and Oluwatayo, 2006). Consequently, this study was carried out to assess the economic and environmental effects of herbicide use, and to estimate the factors influencing farmers' decision to adopt herbicides on cassava farms in the Yewa division of Ogun State, Nigeria.

Data Sources and Methodology

This study was carried out in selected communities in Yewa division of Ogun State, Nigeria. Ogun State is divided into four divisions, namely Egba, Ijebu, Remo and Yewa, all of which belong to three senatorial districts, namely Ogun Central (comprising Egba division with six local government areas, LGAs); Ogun East (comprising Ijebu and Remo divisions with nine LGAs), and Ogun West (comprising Yewa division with five LGAs). Yewa division comprises five (5) LGAs, namely Yewa North ([1]Ayetoro), Yewa South (Ilaro), Imeko/Afon (Imeko), Ipokia (Ipokia) and Ado-odo/Ota (Ota), and predominantly made up of seven different tribes, majority of who are largely arable crop farmers, export produce merchants, and nomadic herdsmen.

The data used for this study were obtained from primary sources with the aid of structured questionnaire administered on the sampled cassava farmers in a multi-stage random sampling technique, in the 2017/2018 arable crop growing season. At the first stage, three (3) LGAs were purposively selected from the division for their relatively large concentration of small-holder farmers who largely compliment manual weeding with herbicide application on their cassava farms. These LGAs were namely Yewa North, Yewa South, and Imeko/Afon. At the second stage, four (4) towns/villages were randomly selected per LGA, and subsequently, a proportionate selection of a minimum of ten (10) cassava farmers was made across the (12) communities earlier selected. This resulted in a total of one hundred and eight (128) cassava farmers whose data were used for the study.

The data obtained from this study were analysed using both descriptive and inferential analytical techniques. Descriptive statistical tools were used in analyzing socio-economic characteristics of the cassava farmers and the types of herbicides adopted. This involved frequency and percentage tables. Logit model was used to estimate the factors that influenced the cassava farmers' decision to use herbicide on their farms. This dichotomous model assumes the underlying stimulus index (I_i) is a random variable, which predicts the probability of a farmer adopting the use

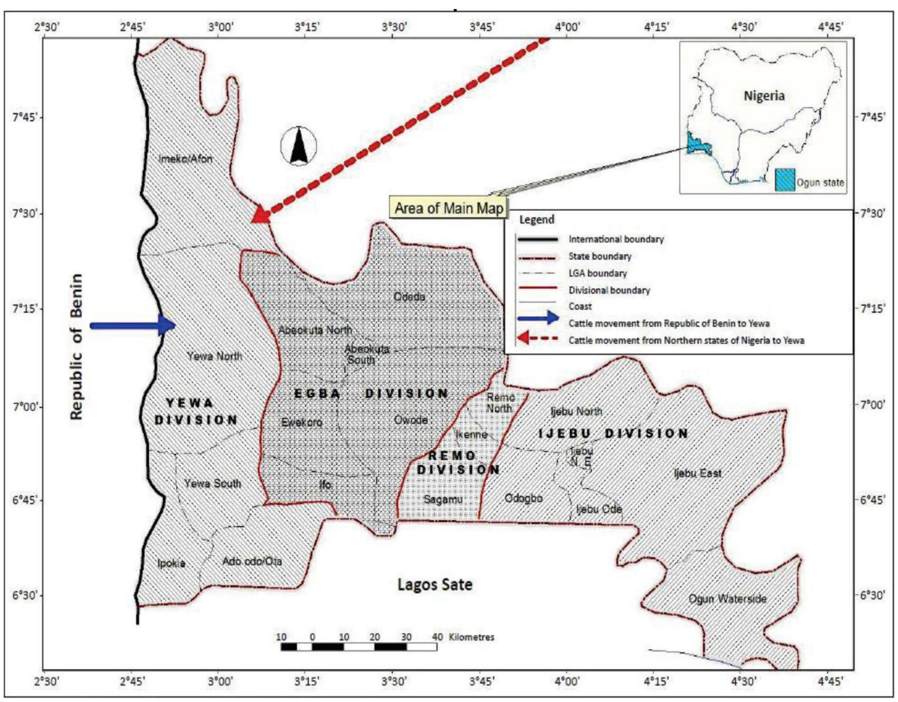

Figure 1. Map of Ogun State showing Yewa division as the study area

[1]The headquarter town of each LGA is enclosed in parenthesis

of herbicides on his cassava farm. Therefore, for the i^{th} observation (an individual respondent):

$$I_i = \ln \frac{P_i}{1-P_i} = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ji}$$

The relative effect of each explanatory variable (X_{ji}) on the probability of a farmer to use herbicides on his cassava farm is measured by differentiating with respect to X_{ji}. Using the quotient rule,

$$\frac{dP_i}{dX_{ji}} = \left[\frac{e^{Ii}}{1+e^{Ii}}\right]\left[\frac{I_i}{X_{ji}}\right]$$

The model is further expressed as:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \ldots + \beta_n X_n + \varepsilon_i$$

where:

P_i = the probability of i^{th} farmer using herbicides on his cassava farm in the 2017/2018 planting season;

β_0= Intercept β_ι(1,2,3,...,1) = Regression coefficients, (X_i (1,2,3,...,1) = Independent variables, and ε_i = error term.

X_1 = Sex of the farmer (1= male; 0 = female), X_2 = Age (years), X_3 = Household size (Number), X_4 = Formal education (years), X_5 = Farming experience (years), X_6 = Farm size (Ha), X_7 = Number of farm locations, X_8 = Amount of credit used in farming operation (₦), X_9 = Number of contacts with extension agent, X_{10} = Purpose of cassava production (1= commercial, 0 = otherwise) and X_{11} = Cost of herbicides application (₦/Ha).

Covariance model

Covariance model estimation was specified and used to determine factors influencing herbicide use intensity on cassava-based farming systems in the study area. The dependent variable in this study was the i^{th} farmers' herbicide use-intensity (HUI). The groupings were ranked as 1, 2, and 3 for low, medium and high herbicides use level respectively, and later aggregated to generate a composite HUI group on a 6-point likert scale as low level herbicide adopters = 1-2; medium level herbicide adopters = 3-4; high level adopters = 5-6. Analysis of Covariance (AnCova) was used to examine the interrelationship between levels of herbicide-use intensity and some specified variables. The choice of the model as noted by Okike *et al* (2001) lies in its ability to control for the influence of continuous variables (covariates) when determining the influence of grouping variables (factors) on the identified levels of herbicide-use intensity among the farmers. Consequently, the interest was to estimate the effects of factor variables on the mean value of the various groupings of a joint distribution of herbicide use intensity, in addition to determining the influence of the covariates on the level of herbicide-use intensity among the farmers.

The analysis of covariance model is specified as:

$$HUI = \alpha + \phi_1 Z_1 + \ldots + \phi_n Z_n + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \mu_i$$

Where:

HUI = Herbicide use-intensity = (0 < R ≥ 1)

Consequently, the farmers were grouped into herbicide adoption level using the indices generated above, whereby R < 0.33 = Low herbicide adoption level, 0.33 ≤ R ≤ 0.66 = Medium herbicide adoption level and R > 0.66 = High herbicide adoption level. β_i = Vector of unknown parameters. The (Z_i) are the grouping variables while the covariates (X_i) comprise selected farmer's socio-economic characteristics and farm-specific variables.

The grouping variables are: Z_1 = Sex of cassava farmer (male = 1; 0 otherwise), Z_2 = Cassava production technology (1= mechanized, 0 = otherwise), Z_3 = Purpose of cassava production (1= commercial, 0 = otherwise), Z_4 = Variety of cassava planted (1= improved, 0 = otherwise)

Farmer's socio-economic characteristics and farm-specific variables: X_1 = Age, X_2 = Farmers farming experience (years), X_3 = Farm labour engaged (number), X_4 = Weeding frequency (proxied by the weeding expenditure share, ₦), X_5 = Price of herbicide used (₦/liter), X_6 = Number of farm locations, X_7 = Number of contact with extension agent and U_i = stochastic error term.

Results and Discussion

Socio-economic characteristics of the cassava farmers

Table 1 shows the socio-economic characteristics of the respondent cassava farmers. As shown on Table 1, majority (95.3 per cent) of the cassava farmers were male, about 83 per cent of whom were married, with a mean household size of 6 members indicating a fairly large family labour at the disposal of a cassava farmer, in spite of which about 74 per cent of the farmers still adopted the use of herbicides for their weeding operation (Table 2). About 98 per cent of the farmers had also acquired up to secondary school education, a factor that would have further contributed to the farmers' disposition to adopt herbicides usage as a more viable option for cassava weeding operation. The farmers were of mean age 52 years, cultivating an average farm size of 2 hectares, and had been engaged in cassava farming for upwards of 15 years. Physical ability and productivity reduce with age, which in turn negatively affects farmers' agricultural investment (Orebiyi *et al.,* 2002).

Types of herbicides adopted by the cassava farmers

As shown on Table 2, only 33 (about 26 per cent) of the respondent cassava farmers did not use any form of herbicide on their farms. Among the 95 majority (about 74 per cent) that adopted herbicides, 22 per cent used only pre-emergence herbicides, 32 per cent only post-emergence

Table 1. Distribution of cassava farmers by their socio-economic characteristics

Variables	Frequency	Percentage of farmers	Mean value
Age (Years)			
30 - 40	22	17.2	52 years
41 - 50	38	29.7	
51 - 60	37	28.9	
61 - 70	21	16.4	
Above 70	10	7.8	
Sex			
Male	122	95.3	
Female	6	4.7	
Education level			
No formal education	2	1.6	
Primary education	74	57.8	
Secondary education	52	40.6	
Household size			
≤ 4	21	16.4	6 persons
5 – 8	96	75.0	
9 – 12	11	8.6	
Marital status			
Married	106	82.8	
Divorced	6	4.7	
Widower	16	12.5	
Primary occupation			
Farming	51	39.8	
Trading	35	27.3	
Civil servant	8	6.3	
Others	34	26.6	
Farming experience (Years)			
1 - 10	59	46.1	15 years
11 - 20	33	25.8	
21 - 30	26	20.3	
> 30	10	7.8	
Farm size (ha)			
1.00 - 2.00	98	76.6	2.0 ha
2.01 - 3.00	15	11.7	
3.01 - 4.00	15	11.7	
Total	128	100.0	

Source: Field Survey, 2018

herbicides, while the vast majority (about 46 per cent) used both types of herbicide. However, the focus of this study is not on the physiological specificity as to whether the used herbicide was contact/systemic, or general/selective in its operational mode.

Environmental effect of herbicide use as reported by the cassava farmers

Table 3 reported the environmental effects of herbicide use as perceived by the cassava farmers. Prominent among these observed environmental effects were non-target

Table 2. Distribution of cassava farmers by the type of herbicides used

Herbicide adoption decision	Type of herbicides used	Frequency of farmers	Percentage of farmers	Percentage of herbicide users
Non-herbicide users	Nil	33	25.80	-
Use of herbicide	Only pre-emergence	21	16.40	22.11
	Only post-emergence	30	23.44	31.57
	Both pre- and post-emergence herbicides	44	34.36	46.32
Total		128	100.00	100.00

Source: Field Survey, 2018

damages on grown food crops (40 per cent), on other beneficial crop and animal stocks (40 per cent), and on soil micro-organisms (20 per cent). According to the respondent farmers, the observed non-target damages were usually as a result of spray drifts from unguarded spray jets.

The main positive environmental effect of herbicide use as perceived by all the respondent farmers was the revamping of soil organic matter as a direct resultant effect. Herbicides use causes weeds to die and reintegrate into the soil to promote soil fertility. Accumulation of soil organic matter can enhance the ability of the soil ecosystem to recover from various disturbances, such as prolonged drought, flooding, tillage, fire, among others. The resultant organic matter is eventually formed as an assorted mixture of organic compounds derivatives from decayed plant parts (e.g. leaves, roots, and trunks and fruits), having been processed over varying lengths of time by the activity of soil micro-organisms (Kassie and Zikhali, 2009).

Non-beneficial effect of herbicide use on the other hand, arises partly as a result of the percolation effect of rain water which often washes the chemical substances of herbicides into under-ground water ways overflowing into streams and rivers in the local communities, thereby causing contamination to humans and livestock via oral consumption of contaminated water. For instance, Orhii (2010) made reference to the World Health Organization report that estimated some 3 million cases of acute poisoning and 20,000 deaths occurs annually due to exposure to pesticides. Likewise, the report of Mada *et al*. (2013) showed that there is critical decrease in the quantity of uncropped vegetables in areas where herbicide is used as a result of the drifting effect of toxic chemical substances, causing mild starvation among farmers, livestock, birds and fish which depend upon them for their survival.

Perceived health effect of herbicide use by the cassava farmers

Table 4 shows the health effect of herbicide use as perceived by the respondent farmers. From the result, farmers that used herbicides on their cassava farm in the 2017/2018 cropping season experienced one form of health hazards or the other; ranging from runny nose (about 18 per cent); eye-related ailment (about 34 per cent); skin diseases (about 12 per cent); gastro-intestinal disorders that cause vomiting (8

Table 3. Distribution of cassava farmers by their perceived environmental effect of herbicide use

Environmental effect of herbicide use		Recipient of benefit/ hazards	Percentage of incident	Frequency of farmers	Percentage of farmers
Positive effect (benefit)	Revamping of soil organic matter	Soil	100.00	95	100.00
Negative effect (hazards)	Mortality of non-pest plant and animal species	Grown crops/ beneficial insects	20.00	23	24.22
	Contamination of economic crops	Cultivated crops	20.00	35	36.84
	Mortality of non-target soil micro-organisms	Soil	20.00	12	12.63
	Contamination of foodstuffs	Humans/livestock	20.00	17	17.89
	Contamination of soil underground/run-off water	Humans/livestock	20.00	8	8.42
	Total		100.00	95	100.00

Source: Field Survey, 2018

Table 4. Distribution of cassava farmers by their observed health hazards of herbicide use

Perceived health hazards	Recipient of hazards	Frequency of farmers	Percentage of farmers
Runny nose	Human	17	17.89
Eye dizziness/drowsiness	Human	19	20.00
Itching or protruding eye	Human	13	13.68
Skin rashes	Human	11	11.58
Nausea/vomiting	Human	08	8.42
Fatigue/body weakness	Human	27	28.42
Total		95	100.00

Source: Field Survey, 2018

per cent); as well as fatigue and general body weakness (28 per cent).

Precautions observed by cassava farmers to mitigate environmental/health hazards of herbicide use

On Table 5, the distribution of cassava farmers by the precautionary measures adopted to mitigate the effect of environmental and health effect of herbicide use was presented. As indicated on Table 5, about 63 per cent of the respondent cassava farmers used various protective kits to reduce the direct health implication of the constituent chemicals on their skins, eyes and nostrils while applying herbicides on their farms. The kits commonly in use among the farmers included nose guides, head masks, eye glasses, overall coats and boots. Use of spray guide was common among only about 14 per cent of the farmers, intended mainly to protect cassava and other intercrops against likely environmental hazards. Only about 23 per cent of the farmers reported adherence to label instructions as precautionary measure to curb the likely effect of both environmental and health hazards on crop plants, soil, animal and fish stocks, natural habitats, as well as humans within the herbicide-spray ecosystem. This is at variance with the finding of Kughur (2012) who reported that 100 per cent of the sampled farmers read label instructions on herbicides before applying them.

Determinants of farmers' decision to use herbicide on the farm plots

The factors influencing farmers' decision to use herbicide among cassava farmers in the study area is presented on Table 6. Among the factors that significantly influenced the cassava farmers to adopt the use of herbicides in the study area were sex (0.466; $p<0.01$), higher educational attainment (0.008; $p<0.05$), ownership of consolidated farm plots (0.138; $p<0.05$), and commercial scale production (0.120; $p<0.05$). On the other hand, age of farmer (-0.005; $p<0.1$) and high cost of herbicide application (-0.051; $p<0.01$) significantly reduced the probability of the cassava farmers using herbicides as a weed control option. From the result, it was obvious that male farmers were more likely to adopt the use of herbicides compared to their female folks (Saka *et al*., 2011). Also, educated farmers were likely more disposed towards adoption of chemical weeding due to their level of enlightenment on the benefits of improved

Table 5. Distribution of cassava farmers by the precautionary measures adopted against environmental/health hazards of herbicide use

Precautionary measure	Agent(s) protected against hazards	Category of hazards prevented	Frequency of adopters	Percentage of farmers
Use of spray guide when spraying	Grown crop(s)	Environmental hazard	13	13.68
Adherence to label instructions	All recipient categories	All recipient categories	22	23.16
Use of nose cover	Humans	Health hazard	15	15.79
Use of eye shade when spraying	Humans	Health hazard	6	6.32
Wearing of head mask when spraying	Humans	Health hazard	3	3.16
Wearing of overall coat when spraying	Humans	Health hazard	17	17.89
Wearing of protective boot when spraying	Humans	Health hazard	19	20.00
Total			95	100.00

Source: Field Survey, 2018

Table 6. Determinants of farmers' decision to use herbicides on their cassava farm plots

Variables	Variables definition	Coefficient	Standard error	t-value	Marginal Effects
	Constant	0.846***	0.227	3.736	-
X_1	Sex	0.466***	0.131	3.551	0.0009
X_2	Age	-0.005*	0.003	-1.785	0.9510
X_3	Household size	0.002	0.017	0.124	0.9081
X_4	Formal Education	0.008**	0.004	2.091	0.9340
X_5	Farm experience	-0.011	0.008	-1.340	0.1867
X_6	Farm size	-0.005	0.290	-0.017	0.9220
X_7	Number of farm location	0.138**	0.059	2.353	0.0344
X_8	Amount of credit used	-0.064	0.040	-1.602	0.0321
X_9	Contact with extension agents	-0.132	0.094	-1.413	0.7849
X_{10}	Purpose of cassava production	0.120**	0.059	2.027	0.0344
X_{11}	Cost of herbicide application	-0.051***	0.004	-12.258	0.1784

**** Significant at 1 per cent level; ** 5 per cent level and * 10 per cent level,*
Source: Field Survey, 2018

Table 7. Covariance Analysis of the factors that influence the level of herbicide application

Variables	Factors/Variables definition	Coefficient	Standard error	t –value
	Intercept	0.549*	0.310	1.771
Z_1	Sex of cassava farmer	0.768***	0.305	2.518
Z_2	Cassava production technology	-0.119	0.219	-0.543
Z_3	Purpose of cassava production	1.281***	0.247	5.194
Z_4	Variety of cassava planted	0.327	0.202	1.617
	Covariates			
X_1	Age	0.001	0.004	0.300
X_2	Farmers farming experience	0.006	0.005	1.298
X_3	Number of farm labour engaged	-0.018	0.024	-0.726
X_4	Weeding frequency	0.210***	0.060	3.523
X_5	Price of herbicide used	-0.323***	0.057	-5.667
X_6	Number of farm locations	0.150*	0.077	1.946
X_7	Contacts with extension agent	-0.016	0.023	-0.698
	R-Squared	0.625		
	Adjusted R-Squared	0.571		
	Levene's test of homogeneity: F(P):	2.077 (0.037)		

**** Significant at 1 per cent level; ** 5 per cent level and * 10 per cent level,*
Source: Field Survey, 2018

farm technology, while as *a priori* expected, older farmer tend to stick more to the more traditional manual weeding rather than embrace chemical weeding technology to enhance agricultural productivity, as earlier reported in the study of Ikeorgu and Mbah (2007).

Factors influencing the herbicide use level of cassava farmers

Results of the analysis of covariance (AnCova) are presented in Table 7. The result showed about 57 per cent explanatory power for the model specified to estimate the factors influencing the herbicide use level of the farmers. The non-significant value of the Levene's test of homogeneity showed that the assumption of homogeneity of variance for the AnCova model has not been violated in the specified model. The estimated coefficients showed that herbicide use intensity differed between farmers after controlling for the effect of the covariates (continuous) variables. Herbicide use intensity differed among farmers by sex of cassava farmer (0.768; $p<0.01$) and commercialization of cassava production (1.281, $p<0.01$). Herbicide use intensity was significantly higher among male farmers than their female counterparts, and also, farmers who cultivated cassava for commercial purpose had higher herbicide use level than subsistence farmers, confirming the findings of Udensi *et al.* (2011). Also, the results on Table 7 showed that herbicide use was significantly intensified as the weeding frequency and the number of farm locations increased; but reduced with increase in the cost of herbicide application.

Conclusions and Policy Implications

This study had focused on the dynamics of herbicide use, and its economic, environmental and health implications among cassava farmers in Yewa Division of Ogun State, Nigeria. The descriptive results of the socio-economic characteristics of the respondent farmers revealed a gradually aging population with a fairly large household size (6 members) and a mean farm size of 2 hectares. While the result of the logit model revealed the likelihood of herbicide use level to increase with higher educational attainment and commercialization of cassava production scale, result of the covariance analysis of the factors influencing the level of herbicide use empirically confirmed that intensity of herbicide use was higher among male, commercial, and financially solvent farmers. Based on the findings of this study, educating farmers on the enormous benefits of herbicide adoption for sustainable weed control; provision of financial and technical supports, as well as herbicides supply incentives will further boost cassava production in the study area.

References

Adamu, B. D.; Sambo, B. E; Barnabas T. M and Ajibola B. O. 2016. Determinants of Adoption of Recommended Cassava Production Practices on Yield and Income among Farmers in Bwari and Kuje Area Council, Abuja, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology* **9**: 1-7. DOI: 10.9734/AJAEES/2016/22088.

Agwu, A. E and Anyaeche, C. L. 2007. Adoption of improved cassava varieties in six rural communities of Anambra State, Nigeria. *Africa Journal of Biotechnology;* **6**: 89-98. Available online at http://www.academicjournals.org/AJB

Ambe, J.T.; Agboola, A.A and Hahn, S.K. 1992. Studies of weeding frequency in cassava in Cameroon, *Tropical Pest Management*, **38**:302-304. https://doi.org/10.1080/09670879209371713.

Avav, T. and Oluwatayo, J.I. 2006. Environmental and Health Impact of Pesticides. Jolytta Publications, Makurdi, Nigeria.

Chikoye, D.; Ellis-Jones, J; Riches, C. and Kanyomeka, L. 2007. Weed management in Africa: experiences, challenges and opportunities, *XVI International Plant Congress*, pp. 652–653; 15-18 October, Glasgow, Scotland.

Ezedinma, C., Nkang. N. M and Simon, E. M. 2009. Price Transmission and Market Integration: A test of the Central Market Hypothesis of Geographical Markets for Cassava Products in Nigeria, *International Institute of Tropical Agriculture* ; **15**:271-278.

Cosmas M. and Mbah, E.U. 2007. Productivity of cassava/ okra intercropping systems as influenced by okra planting density*, African Journal of Agricultural Research;* **2**: 223-231.

Ishaya, D.B.; Dadari, S.A. and Shebayan, J.A.Y. 2007. Evaluation of herbicides for weed control in sorghum (*Sorghum bicolour*) in Nigeria. *Crop Protection*, **26**: 1697–1701.

Ishaya, D.B., Tunku, P. and Kuchinda, N.C. 2008. Evaluation of some weed control treatments for long season weed control in maize under zero and minimum tillage at Samaru in Nigeria. *Crop Protection*, **27**:1047-1051.

Kassie, M. and Zikhali, P. 2009. Sustainable Land Management and Agriculture Practices in Africa: Bridging the Gap between Research and Farmers. Paper prepared for Expert Group Meeting. Gothenburg, Sweden. April 16-17.

Kughur, Peter Gyanden 2012. The effects of herbicides on crop production and environment in Makurdi Local Government Area of Benue State, Nigeria. *Journal of Sustainable Development in Africa*, **14**:1-12.

Mada Daniel; Duniya N. and Idris G. Adams 2013. Effect of Continuous Application of

Herbicide on Soil and Enviroment with Crop Protection Machinery in Southern Adamawa State. *International Refereed Journal of Engineering and Science*; **2**:4-9. Also available at www.irjes.com.

Mavudzi, Z.; Mashingaidze, A.B.; Chivinge, O.A.; Ellis-Jones, J. and Riches, C. 2001. Improving weed management in a cotton-maize system in the Zambezi Valley, Zimbabwe, Brighton Crop Protection Conference; pp. 169–74.

Miller, G. T. 2004. Sustaining the Earth. 6th Edition. *Thompson Learning Inc. Pacific Grove, California USA*. pp. 211-216.

Nwaiwu J.C 2017. Farmers perceived effects of soil degradation on the yield of improved cassava varieties in south east Nigeria. *Agricultural Science Research Journal* **7**: 122-128.

Orebiyi, J.S; Ben-Chedo, N.G. and Odurukwe, S.N. 2002. Financing of Swine Production in Owerri Agricultural Zone of Imo State, Nigeria. In: Iloeje, M.,G. Osuji,Udoh Herbert and G. Asumugha (eds). Agriculture: A Basis for Poverty Eradication and Conflict Resolution. Proceedings of the 36th Annual Conference of the Agricultural Society of Nigeria Held at the Federal University of Technology Owerri, Nigeria, 20-24 October, pp.385-387.

Orhii, P. 2010. Sensitization Workshop on Safe and Responsible use of Agro chemical.

National Agency for food and Drug Administration and Control reports, Abuja, Nigeria. pp. 2-6.

Otunaiya Abiodun Olanrewaju.; Peter A. Okuneye and Aihonsu, John O. Yetonyon 2012. Pattern of Inorganic Fertilizer use among Food Crop Farmers in Ogun State, Nigeria. *Asian Journal of Agricultural Sciences* **4**: 26 – 31.

Saka J. O.; Okoruwa, V. O.; Oni, O. A. and Oyekale, A. S. 2011. The Structure and Determinants of Land-use Intensity among Food Crop Farmers in Southwestern Nigeria. *Journal of Agricultural Science;* **3**; 194 – 250.

Sibuga, K.P. 1997. Weed management in Eastern and Southern Africa: challenged for the 21st century. 16th East African Biennial Weed Science Conference Proceedings, pp 5–11.

Udensi E. U; Tarawali, G.; Favour, E. U; Asumugha, G.; Ezedinma, C.; Okoye, B. C.; Okarter, C.; Ilona, P.; Okechukwu, R. and Dixon, A. 2011. Adoption of selected improved cassava varieties among smallholder farmers in South-Eastern Nigeria. *Journal of Food, Agriculture & Environment;* **9**; 329 – 335.

Ukekje, E. 2004. *Modernizing Small-holder Agriculture to Ensure Food Security and Gender Empowerment: Issues and Policy*, Inter-governmental Group of Twenty Four, http://www.g24.org/researchpapers.html

Vissoh, P.V.; Gbehounou, G.; Ahanchede, A; Kuyper, T.W.; and Roling, N.G. 2004. Weeds as agricultural constraint to farmers in Benin: results of a diagnostic study, *Nigerian Journal of Agricultural Science*, **52**:305– 329.

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