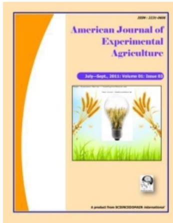

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An Analysis of the Adoption of Glyphosate Herbicide for the Control of *Speargrass* (*Imperata cylindrica*) by Yam Farmers in Guinea Savanna Agricultural Zone of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author SA designed the study, wrote the proposal and collected the data while author CPOO reviewed the literature and author OJS analyzed the data. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To analyse the adoption of glyphosate herbicide on the control of speargrass.
Study Design: Three local government areas were purposively selected. Data collection was carried out in three stages. First stage was through purposive sampling. The second stage was by random sampling to pick three cells of Agricultural Development Project (ADP), Agricultural Extension Structure from each of the three local government areas. In summary 108 participating and 108 non-participating farmers were randomly selected in the three identified LGAs to make a total of 216 respondents (see Table 1).
Place and Duration of Study: Department of Agricultural Economics and Extension, Faculty of Agriculture, Kogi State University, Anyigba from June 2011 – December, 2012.
Methodology: The sampling technique used were interviews, structured questionnaire, use of descriptive statistics, use of logit regression analysis, and z-test was used to analyzed the variables.
Results: The results showed that the yam farmers were in various stages of adoption. The three yam packages introduced to the farmers, directs application of glyphosate at 4

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and 8 weeks after planning+ 1hoe weeding at 12 weeks after planting has the highest percentage of 53.24 and therefore has the patronage of the farmers. The results of logit regression showed that Extension visits and knowledge of the use of glyphosate herbicide significantly influenced the adoption of glyphosate herbicide at 100%. Mean score showed that high cost of herbicides, lack of capital, lack of access to credit and lack of technical know-how were very serious constraints, while unavailability of herbicide and lack of Extension services were less serious.

Conclusion: Aggressive and sustainable training and visit on glyphosate adoption should be put in place by both public and private extension outfits who advocate glyphosate usage for the control of this stubborn, energy shaping weed.

Keywords: Adoption; Glyphosate herbicides; Imperata cylindrical; yam farmers and Guinea savanna.

1. INTRODUCTION

Few decades ago, Nigeria was ranked as the top producer of yam, providing 36.72 million metric tons annually, Food and Agricultural Organization of the United Nations, [1]. Yams are excellent sources of carbohydrate and some minerals. About 85% of a tuber is edible which partly composed of 65–75% water, 15–33% starch, 1–2.5% protein, 0.5–1.5% fibre, 0.7–2% ash and 0.05–0.2% fat. According to Consultative Group on International Agricultural Research [2]. Carbohydrates rich food like yam and cassava products make up to 60 – 90% of daily food intake in West Africa when compared to about 50% in developed countries. Yam has ritual, socio-cultural and economic influences on the lives of the people [3].

However, yams are particularly sensitive to competition from weeds during part of their growth. Weeds such as *Imperata cylindrica* interferes with crop growth through direct competition for resources that determines growth and through allelopathic interactions thus reducing the quality and quantity of harvest [4].

Imperata cylindrica is a serious weed pest among African farmers. It reduces crop yield and quality, limits farm size to the level that family labour can handle and, increases labour requirement for weeding. The weed also causes physical injury to the skin, and increases the presence of pathogens and insects of economic importance.

[5] Asserted that the area affected by *Imperata* expands as fallow length becomes shorter. In many farming systems recurrent fires are used to clear vegetation and continuous cropping is replacing the traditional cropping/bush fallow due to increase in population and pressure on land. Small scale farmers suffer more from *Imperata* infestation because they do not have sufficient resources to purchase inputs to control the weed in a sustainable manner.

Technologies developed to control *Imperata* have been used successfully in large estates or commercial farms where there is an ample supply of labour, capital, and herbicides. However, very few have been widely adopted by small – scale farmers [6]. There are serious concerns about the impact of weeds, particularly *Imperata* and *Striga*, on agricultural production and productivity and the low adoption rate of the existing *Imperata* management technologies by small – scale farmers in Nigeria, especially in the savanna zone. This development prompted the international institute for the tropical agriculture (iita), Ibadan to request financial assistance from the department for international development (dfid) to implement a 3 – year participatory project (2002–2004) on *Imperata* and *Striga* control in Nigeria.

The objectives of the project were to: identify, evaluate, and develop methods for controlling *Imperata cylindrica*. Disseminate improved *Imperata* management options using participatory research and extension approach (prea) and increase the capacity of ngos (cbos), research institutions/private sector to facilitate uptake of improved weed management practices in small – scale, disadvantaged farming communities.

The weed has been identified as the major natural problem affecting the production of yam by many farmers in some rural communities in Kogi, Benue, cross river state and other parts of Nigeria [7]. Past research in West Africa has shown that selected herbicides, mechanical, cultural, biological, chemical, alley cropping and cover crops were used individually or as integrated programmes for effective combat of spear grass. For example, [8] showed that the use of herbicides such as glyphosate or cover crops gave higher crop yield and net benefits in corn, cassava and yam than hand weeding. Cover crops have the ability to shade spear grass and reduce it to non-competitive levels within 2-5 years [9]. The use of glyphosate, also, gave higher grain yields and crop value in soybeans, higher tuber yields and crops benefit in yam, higher tuber and stem yields in cassava than the farmer's control. The use of the herbicide gave significantly higher control of spear grass in soybeans when compared with traditional weeding with hoe [10].

Glyphosate technology has been introduced to farmers by iita in the study area for over 7 years. The percentage of the farmers who adopted the integrated technologies that were introduced by iita has not been determined. After the intervention, it is expected that the herbicide should have been adopted by now while yam production should be on the increase in the study area. However yam output has not seems to be significantly improved upon. It is therefore, important to ascertain the extent of adoption of the technology. Has the glyphosate technology witnessed high or low adoption? Could the problem of poor yam yield be that of inability to adopt the glyphosate technology correctly? This study therefore attempted to ask: what are the socio-economic factors influencing the adoption of glyphosate herbicide technology? What are the adoption levels of the glyphosate technology among yam farmers? What is the output valued in naira of yam between the contact and non-contact yam farmers? What are the constraints to the adoption of the glyphosate herbicide technology in Kogi State?

1.1 Objectives of the Study

The specific objectives of this study are to:

- I. Ascertain the socio-economic factors influencing the adoption of glyphosate herbicide technology.
- Ii. Determine the level of adoption of glyphosate herbicide among the yam farmers in kogi state.
- Iii. Compare the output valued in naira from yam between the contact and the non – contact yam farmers.
- Iv. Identify the constraints to the adoption of the glyphosate herbicide technology.

2. METHODOLOGY

2.1 The Study Area

The study was conducted in Kogi State which is in Guinea Savanna Agricultural Zone of Nigeria (see Fig. 1). The state is located in the middle belt region of Nigeria. It is known as confluence state because the confluence of rivers Niger and Benue met at its capital Lokoja. The State was created on the 27th August, 1991 from parts of Kwara and Benue States. The State lies between latitude 7º30^{I}N and 7º50^{I}N and Longitude 6º42^{I}E and 6º70^{I}E. Kogi State is made up of 21 local government areas and divided into four agricultural zones namely:- Zone A, with Ayetoro-Gbede as headquarter, zone B with Anyigba as headquarter, zone C has Koto-Karfe as headquarter, while Zone D with Alloma as the headquarter. The State comprises of three major ethnic tribes namely Igala, Ebira and Yoruba (Okun), other minor groups include Kankanda, Kupa, Ogori-Mangongo, Nupe, Bassa-Komo, Bassa-Nge, and Gwari [11].

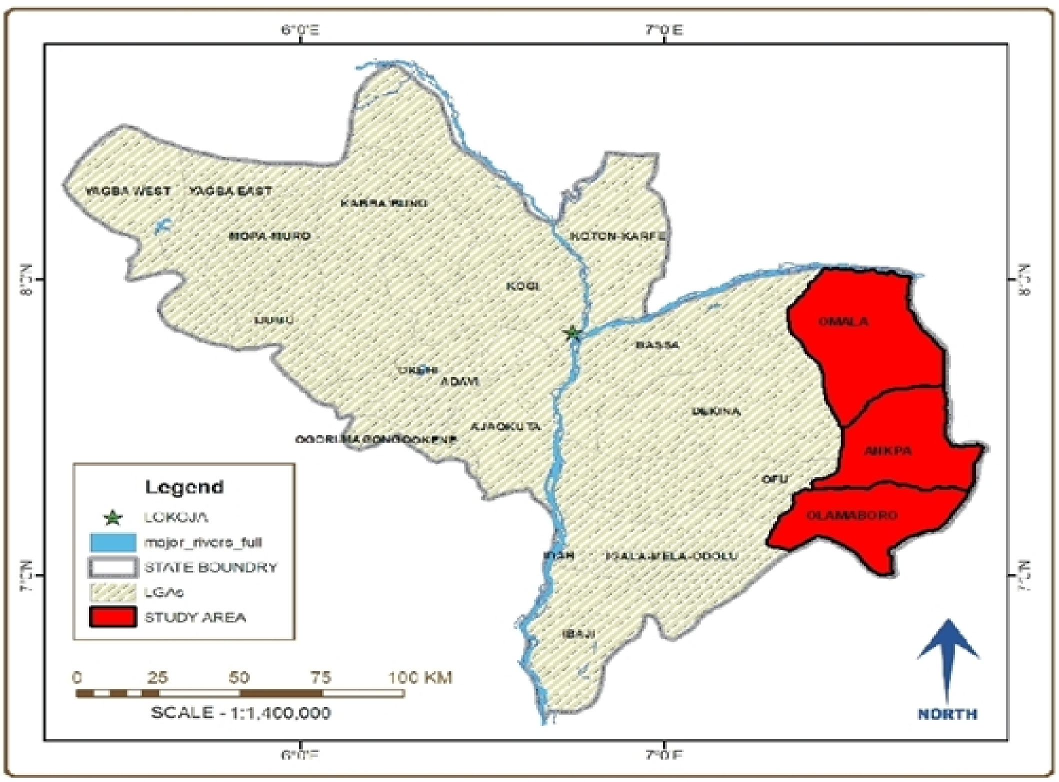

Fig. 1. The study area
Source: GIS Lab, Kogi State University, 2013

Kogi State has total land mass of about 30,354.4 km and is the fifteenth largest state in the country in terms of land mass. The state is bordered by nine other states and is the most centrally located state in the country [11]. Based on the 2006 census Kogi State population stood at 3,278,487. Kogi State has an average maximum temperature of 32.2c and average minimum of 28.8c. Lokoja, the State capital is generally warm throughout the year.

Kogi State has two distinct climate; dry season which starts from November and ends in February while raining season begins from March and stops in October. Annual rainfall ranges from 1016mm - 1524mm. About 80% of the populations are involved in subsistence farming. Among the arable crops grown in the state are: yam cassava, sweet-potatoes, cocoyam, groundnut, beniseed, rice, maize, millet, sorghum, bambara nuts, and pigeon pea, while tree crops include oil palm, citrus, mango, cashew, plantain, banana, guava, and kolanut and livestocks such as goats and sheep are reared [11].

2.2 Population and Sampling Technique

Data collection was carried out in three stages. The first stage was through the use of purposive sampling to select three local government areas (Ankpa, Olamaboro and Omala) (Table 1) where the adoption of the glyphosate technology was experimented by IITA. The second stage was by random sampling to pick three cells of Agricultural Development Project (ADP), Agricultural Extension Structure from each of the three local government areas. Each of the cells has 20 participating farmers. The last stage was the use of random sampling to pick 12 participating and 12 non-participating farmers of the technology from each cell. This translated to 36 respondents who participated and 36 who did not in each of the three local government areas. In summary, 108 participating and 108 non-participating farmers were randomly selected in the three identified LGAs to make a total of 216 respondents. The summary of the sampling procedure is given in Table 1.

Table 1. Distribution of respondents by local government/communities

Zone	Local government area	Adpagric extension cells	Herbicide contact farmers	Herbicide non-contact farmers	Total no of respondents
A	Ankpa	Inye	12	12	24
		Ankpa town	12	12	24
		Ogodo	12	12	24
	Subtotal		36	36	72
B	Olamaboro	Okpo town	12	12	24
		Imane	12	12	24
		Ogugu	12	12	24
	Subtotal		36	36	72
C	Omalla	Abejukolo	12	12	24
		Ibado	12	12	24
		Ogodu	12	12	24
	Subtotal		36	36	72
	Total		108	108	216

Source: Field survey, 2012

2.2 Data Collection Methods

Data for this study were gathered essentially from primary source. The primary data were collected by a structured questionnaire containing thirty six (36) relevant questions for the study. These were validated by experts in the Department of Agricultural Economics and Extension, Kogi State University, Anyigba to reflect all the objectives of the study. The questionnaire was divided into four sections and each section contained relevant questions on the objectives.

In section A, respondents provided information on their socio-economic characteristics. Section B focused information on the levels of adoption of glyphosate herbicide technology among the yam farmers. Section C obtained information on the output valued in naira from yam by participating glyphosate herbicide and non participating. Section D contained information about the constraints to the adoption of glyphosate while Section E provided information about the factors influencing the adoption of glyphosate herbicide among farmers. The researcher collected the data with the assistance of ADP extension workers who were trained and used as enumerators.

2.3 Method of Data Analysis

2.3.1 Objective 1

To find out the socio-economic factors influencing the adoption of glyphosate herbicide. Logit regression was used to achieve this as adopted by [12] to analyze the influence of socio-economic characteristics on the adoption of improve maize varieties in southern Ethiopia. The model is specified as follows:

$$Lny = Ln(P/(1- P) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$
$$Ln(P/(1-P) = bo + b_1x_1 + b_2 x_2+\_\_\_ \_\_ \_\_\_ \_\_ \_\_ b_8+x_8$$

Where;

Y= glyphosate usage (1= usage, 0 = otherwise)
P = probability of the use of glyphosate.
Ln = natural logarithm function.
Bo = constant.
B_1 - b_8 = logistic regression coefficients.
X_1 = age of the farmer (in years).
X_2 = level of education (in years).
X_3 = household size (number of persons).
X_4 = farm size (in hectares)
X_5 = farming experience (in years)
X_6 = yam output valued (in naira)
X_7 = extension contact (no of visits in the year)
X_8 = ability to apply agro- chemicals (yes = 1, no = 0).

2.3.2 Objective 2

To determine level of adoption of glyphosate herbicide control packages among the yam farmers in Kogi State, (IITA) International Institute for Tropical Agriculture introduced three glyphosate herbicide control packages to the yam farmers. The packages were: Direct application of glyphosate at 4 and 8 weeks after planting + 1 hoe weeding at 12 weeks after planting, fusillade post-emergence at 3 weeks after planting + 2 hoe weeding at 8 to 12 weeks after planting and pre-tillage application of glyphosate followed by mucuna at 6 weeks after planting + 2 hoe weeding at 8 to 12 weeks after planting. Percentage of adopters was used to measure the adoption level of the packages.

2.3.3 Objective 3

Z-test statistics was used to determine the significant differences in yam output valued in Naira between glyphosate herbicide participating farmers and non- participating farmers. The z-test model can be explained as used by [13] where z-test was computed as;

$$\bar{Z} = \frac{\bar{X}_A - \bar{X}_B}{\bar{Sd}}$$

Where $\bar{X}_A$ = Mean of sample A (Participating farmers)

$\bar{X}_B$ = Mean of sample B (Non-participating farmers)

$\bar{Sd}$ = Standard error of the difference between means obtained

$$\bar{Sd} = \bar{SX}_A - \bar{SX}_B = \sqrt{\frac{S^2_A}{N_A} + \frac{S^2_B}{N_B}}$$

2.3.4 Objective 4

This objective was achieved by calculating the mean score from 3-point likert rating scale to indicate level of seriousness of the constraints (see Table 5), in this case, very serious attracts 3 points, serious was 2 points while not serious attracts 1. These points were summed up to get a total point of (3+2+1 = 6). The total point was divided by 3 to have an average of 2 points. In essence, a mean score above 2 was categorized as very serious constraints and any one below 2 was grouped as non-serious constraint. This description was in accordance to [14].

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Factors Influencing the Adoption of Glyphosate Herbicide Technology

The result of the logistic regression analysis for the determinants of socio-economic factors influencing the adoption of glyphosate herbicide among yam farmers in the study area is shown in Table 2 it contains the explanatory variables which have been found to be significant at 10% and 1% level of probability using logistic regression statistics.

From the result of the logistic regression in Table 2 the coefficient of determination (LR) of 68.65 and the adjusted (pr) 0.0000 which implies that 100% of the changes experienced in the total adoption glyphosate herbicides farmers were explained by the variables in the model and the prior ratio of 68.65 was significant at 1% and 10%. The result indicates that age of the respondents had coefficient of -0939357 on the adoption which is statistically negative significant at 10%. This implies that age of the farmer was not a significant determinant of adoption of glyphosate herbicides in the study area. Education of the respondents had a coefficient of .0190617 which was not significant but positive. Household size with coefficient of .0916096 was not statistically significant to the adoption. This implies that the size of the household does not affect family labour on the adoption of glyphosate herbicides. From the results, it shows that farming experience with coefficient of .0450444 was not statistically significant. However experience had some effect on adoption of the herbicide as experience is the best teacher. Great lessons are learnt from experience. Past odds or negative experiences will be avoided or minimized to avoid a repeat of such occurrences which results on better performances. Also the more experience the better the practices and the farmers tendency to accept innovations or extension messages. The result showed that income had positive influence with coefficient of 8.8007 which was statistically not significant. The result revealed that extension visits with coefficient of .1381565 was statistically significant at 1% and had positive effect on adoption. This means that more extension visits will lead to positive change in attitudes and practice of adoption of new technology which may translate to increase in yield and income of yam farmers. The result also shows that knowledge of application of glyphosate was positive with a coefficient of 3.274187 and was statistically significant at 1%. This means that acquisition of knowledge has a positive and significant influence on the adoption of glyphosate herbicide.

Table 2. Result of the logit regression analysis of socio-economic factors influencing adoption of glyphosate herbicide

Variables	Coefficients	Std error	Z	P>[z]
Age	-.094	.0353428	2.66	0.008*
Education	.019	.046789	0.41	0.684
Household size	.092	.0756999	1.21	0.206
Farm size	.092	0756651	1.22	0.223
Farm experience	.045	.030775	1.46	0.143
Income.	8.80	3.60e-06	0.24	0.80
Extension visit	.138	.082071	1.68	0.092*
Knowledge of application of glyphosate	3.27	.5606729	5.84	0.000**

Source: computed from field survey data 2012
*LR Chiz (8) = 68.65****
Pr = 0.0000
NB: P> (z) values and ** denotes 10 and 1 percent level of significance respectively*

3.2 Level of Adoption of Herbicide Control Package on Yam Production

Table 3 shows the distribution of respondents according to levels of adoption. The result of this study showed that package I (Direct application of glyphosate at 4and8 weeks after planting +1 hoe weeding at 12weeks after planting) had 53.24 percent adoption while package II (application of fusillade at post-emergence at 3weeks after planting + 2hoe weeding at 8-12weeks after planting) recorded adoption level of 37.03 percent of herbicide control. Package III (pre-tillage application of glyphosate followed by mucuna at 6weeks after planting + 2hoe weeding at 8-12weeks after planting) had adoption level of 9.72 percent.

This implies that direct application of glyphosate at 4 and 8weeks after planting + 1hoe weeding at 12weeks after planting enjoyed the highest adoption level by the farmers and therefore could be most preferred. This is inline with ([15] who worked on integrated management on *Imperata cylindrica* (Spear grass) in yam and cassava, weed pressure in crop, crop growth and yield. He stated that there was 12 percent increase of tuber yield of yam over fallow plot.

Table 3. Distribution of farmers by level of adoption of herbicide control package on yam production

S/N	Herbicide Control package	Frequency	Percentage
1.	Direct application of glyphosate at 4 and 8 weeks after planting + one hoe weeding at 12 weeks after planting.	115	53.24
2.	Fusillade post emergence at 3 weeks after planting + 2 hoe weeding at 8 to 12 weeks after planting.	80	37.03
3.	Pre- tillage application of glyphosate followed by mucuna at 6 weeks after planting + 2 hoe weeding at 8 to 12 weeks after planting.	21	9.72
	Total	**216**	**100**

Source: Computed from field survey, 2012

3.3 Comparison of the Yam Output Valued in Naira of Participating and Non-Participating Farmers on Glyphosate Adoption

The z-test results showed that z-calculated was 1.935 while the z-tabulated was 1.960. Since the z-tab was higher than the z-cal it means there was no significant difference between the output valued in Naira of glyphosate participating and non-participating farmers. This could be due to the fact that most of the glyphosate herbicides farmers were low or medium adopters as indicated in Table 4. This implies that even when some adopted, it was not properly adopted to significantly influence the output (valued in naira) of the yam production.

Table 4. Comparison of the yam output valued in Naira of participating and non-participating farmers of Glyphosate herbicide

Variables	Mean	Standard error of mean difference	Z-cal	Z-tal	Df
Contact (sample A)	136628	20808.51	1.9348	1.960	
Non-contact (sample B)	96366.67	20808.51			

Source: Field survey, 2011

3.3 Constraint to the Adoption of Glyphosate Herbicide Technology

The result revealed that the yam farmers with mean score of 2.58 (about 86%) agreed with the fact that high cost of herbicide was a serious constraint to the yam production in this area. Furthermore, the mean score of 2.62 (about 87.3%) said lack of access to credit was a very serious problem. This finding is in line with report of [16] that capital was still a major obstacle to increase rural production in Owerri Imo State, Nigeria. The implication is that credit is needed to buy farm inputs and improved techniques. Yam farmers in the study area might have found it difficult to access loan from banks in order to increase their production. Also 85.6% with a mean score of 2.57 agreed with the statement that lack of capital was a very serious constraint. Among very serious constrained is lack of technical know-how with mean score of 2.33 about 77.66%.

Table 5. Mean score on the constraints to the adoption of Glyphosate herbicide technology

Constraints	Very serious 3	Serious 2	Not serious 1	Total no of resp (n)	Total no of score (σfiai)	Mean score	Proportion of resp in %
High cost of herbicides	138	65	13	216	557	2.58	86
Unavailability of herbicide	54	78	84	216	402	1.86	62
Lack of capital	148	108	14	216	553	2.57	85.8
Illiteracy	189	85	85	216	427	1.97	65.6
Lack of access to credit	152	45	19	216	565	2.62	87.3
Ecological pollution	15	70	131	216	316	1.46	48.66
Cultural belief	26	55	135	216	323	1.49	49.66
Lack of technical know-how	102	84	30	216	504	2.33	77.66
Poor market information	40	94	82	216	390	1.80	60
Lack of extension services	70	49	97	216	405	1.88	62.66

Source: Field survey, 2012

While unavailability of herbicides, illiteracy, poor market information, and lack of extension services with mean score of 1.82, 1.97, 1.80 and 1.88 with 62%, 65%, 60%, and 62% respectively were listed as serious constraints while cultural belief, ecological pollution with 49.66%, and 48.66% with score of 1.46 and 1.49 were listed not serious in the constraints. These means scores that were below 2 can be interpreted to mean that poor market, herbicide unavailability among others were no serious problems.

4. CONCLUSION

From the findings one can draw a conclusion that glyphosate adoption has not been properly adopted as recommended. Inadequate knowledge of use of the technology, high cost and inaccessibility to fund were the major draw backs to the adoption. Aggressive and sustainable training and visit on glyphosate adoption should be put in place by both public and private extension outfits who advocate glyphosate usage for the control of this stubborn, energy shaping weed. Cooperative society can also be embraced by yam farmers to jointly share the cost of purchasing a large bulk of glyphosate herbicide which will partly reduce cost and enhance a greater access to the use of the technology. However, farmers and extension workers must exercise restrain to the over use of the herbicide because of it detrimental effect on soil and the crop planted.

5. RECOMMENDATION

This study therefore recommends that;

1. Extension agents should step up their visits on glyphosate adoption education in rural areas on how to use the technology as recommended.
2. Workshops should be organized by Ministry of Agriculture and private organizations to educate farmers and update extension workers on knowledge of glyphosate usage.
3. More collaborative research with relevant bodies to bring about a less, costly but effective herbicides for control of spear grass.
4. Groups have been found to be important information sharing and in creating a spread, diffusion or multiply effect with relevant improved technologies adoption. Therefore farmers should be encouraged by extension agents to join cooperative societies so as to benefit from the groups which may reduce cost of purchase of glyphosate and enhance availability and successful adoption of the technology.
5. Adequate supply of herbicides in agro-service centers in rural communities should be put in place and within reach of farmers.
6. Provision of credit facilities to farmers without given much collateral at low interest rate and also cut down bureaucratic bottlenecks so as to enable the farmers access agricultural loans.
7. Provisions of herbicides to farmers at subsidized rate, so that the less privileged can have access to them should be encouraged.

COMPETING INTEREST

Herbicides use often requires additional land to increase the size of farm and justify the huge financial outlay. However, land tenure which is held unto tenaciously by the traditional farmers always hinders the possibility of increasing the land size for yam production.

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