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Usage of Regenerative Agricultural Practices by maize farmers in Kwara State, Nigeria

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ABSTRACT

The study investigated usage of regenerative agricultural practices (RAPs) among maize farmers in Kwara State, Nigeria. A multi-stage sampling technique was employed in the selection of respondents. The first stage involved a random selection of two Local Government Areas from each of the four Kwara Agricultural Development Project (KWADP) zones of Kwara State. The second stage involved a random selection of three communities in each of the selected Local Government Areas. In the final stage, a proportionate sampling of 40% of identified maize farmers in each selected community was used. This resulted in selection of 350 respondents in all. The collected data were analysed using both descriptive and inferential statistics. Results showed that the most used RAPs were cover crops, green manure, mulching, and reduced fertilizer use. The least used were compost, tree crop planting, permaculture, and biochar. RAPs usage was moderately low. The most preferred sources of information by the farmers on RAPs were farmers' association, extension agents, family and friends, and radio. Severest constraints to the use of RAPs were lack of resources for RAPs, ineffective policies and legislations, high cost of operation. At $P = 0.05$, respondents' marital status, education, access to extension, farming as a primary work, and access to market were determinants of the usage of RAPs. RAPs usage was moderately low in the state for sustainable food production. Better sensitization on RAPs is recommended for the enhancement of their better usage. This is vital to ensure sustainable agricultural production in this era of climate change.

Keywords: Climate smart, farming, sustainable agriculture

1. INTRODUCTION

Practices of regenerative agriculture (RA) have been deeply rooted in the context of history, practically owing to its ability to sustainably manage ecosystems before the development of the methods of modern agriculture. Regenerative agricultural practices (RAPs) are distinguished by their holistic farming approach which involves the systematic integration of soil health, animals, plant, and humans (Montgomery, 2023). Historically, intercropping of different crops was practiced to enhance varying benefits to the crops planted, and the soil – the medium of plant growth by the indigenous Iroquois (Bybee-Finley and Ryan, 2018). For example, the intercropping of beans, corn, and squash enables the corn to provide the structure that the beans can climb.

The beans fix nitrogen in the soil, and the squash provides coverings to the soil, thereby retaining the soil moisture and suppressing weeds (Marques et al., 2020). RAPs are therefore holistic farming and soil management approach with primary focus on restoration and enhancement of the health of ecosystems (Alexanderson et al., 2023). The core principles focus in soil health, biodiversity, water management, ecosystem restoration, and community and economic resilience. RAPs have been famed for their role in the management and enhancement of soil health through the maintenance of the fertility of the soil (crop rotation, cover cropping, composting, mulching) (Singh and Nath, 2020). It also enhances soil structure (reduced tillage, biochar, green manures), and strengthens the growth of microorganisms (composting, animal integration) (Sánchez et al., 2017).

Planting of grasses and legumes as cover crops during off-seasons contributes to the enrichment and protection of the soil (Ban, 2024). It also aids in the enhancement of soil fertility, and prevents soil erosion (Seitz et al., 2019). Crop rotations rend the cycles of plants' diseases and pests. It amplifies the contributions of different nutrients from different crops into the soil thereby minimizing dependence on synthetic fertilizers (Shah et al., 2021). RAPs are efficient soil management practices. Practice such as reduced tillage aids in the maintenance of the structure of the soil, enhances the integration of soil aggregates, and boosts the activity of soil microorganism (Hartmann and Six, 2023). Composting of farm waste encourages the proliferation of soil organic matter and essential nutrients of the soil, and enhances soil health and fertility (Singh et al., 2022).

Green manures add organic matter and nutrients to the soil, and improve soil structure and fertility (Das et al., 2020). Animal integration strengthens the management of cover crops and weeds, and boosts soil nutrients through animal droppings (Carvalho et al., 2018). The application of wood chips or straws as mulch suppresses weeds and retains the moisture of the soil while enhancing soil fertility through their decomposition (Prem et al., 2020). Biochar however aids the fertility of the soil, increases the soil water holding capacity, and encourages the proliferation of important microbes of the soil. Maize has been noted for its importance in RA because of its versatility and benefits for health of soil, and ecosystem management.

It particularly improves soil health when it is planted as cover crop, and also benefits from the nitrogen fixed by legumes in crop rotation thereby reducing reliance on synthetic fertilizer (Ananda et al., 2022). It enhances biodiversity as it has the ability to break the life cycles of pests and diseases also in crop rotation thereby reducing reliance on chemical pesticides (Gomiero, 2019). By virtue of its adaptability, it can be well integrated into agroforestry systems alongside trees thereby strengthening the ecosystem and enhancing biodiversity. The root biomass of maize enhances its contribution to soil organic matter thereby aiding the sequestration of carbon (Hirte et al., 2018). Despite these, the survival of maize in a warm condition due to climate change is marked by uncertainty (Pawlak and Koodziejczak, 2020).

This particularly makes maize to be highly susceptible to changes in climatic condition. Kwara State of Nigeria has been identified with the possibility of increasing values of relative humidity and temperature. These could portend a serious challenge to the health of humans and also trigger a change in climate with its attendant effects on crops (Adedapo, 2020). As a result, issues such as possibility of combining biodiversity preservation and productivity, soil health restoration, and reinvention of a sustainable relationship between nature and farmer through RAPs become critical in the state (Çakmakçı et al., 2023).

Ayinde et al., (2018) noted that Maize production is predominant among small scale farmers in Kwara State, and identified that maize farmers in Kwara State have a low capacity needed for adapting and mitigating the effects of climate. The dearth of empirical information on the usage of RAPs by maize farmers in the state makes it a focus for research. This study therefore investigated the usage of RAPs by maize farmers in Kwara State, Nigeria. It determined their preferred information sources, and how the farmers were constrained on the usage of RAPs. These paved the way for appropriate recommendations that ensure better usage of RAPs for sustainable agricultural production that would ensure food security while adapting to and mitigating climate change.

2. METHODOLOGY

The study was carried out in Kwara State of Nigeria, and the population involved maize farers in the state. A three-stage sampling method was employed to ensure a statewide selection of respondents through the KWADP zones. Particularly, the first stage involved a selection of two Local Government Areas from each of the four ADP zones. The second stage involved a random selection of three communities with optimum farming activities from each of the selected Local Governments. In the final stage, maize farmers were identified in each of the selected communities through extension agents, and 40 percent of the identified maize farmers in each community were selected for this study. This made up 350 respondents. Questionnaires and interview schedules were used to elicit needed information from the respondents. The instrument was validated through expert review, and a reliability coefficient of 0.78 was obtained from the reliability testing of the instrument.

Maize Farmers Preferred Sources of Information on RAPs

Sources of information of maize-based farmers on RAPs was examined by listing all identified sources of information, and the respondents were asked to select the ones applicable to each of them on a multiple-choice basis. The ones with the highest frequencies were the most preferred while others with the lowest frequencies will also be determined.

Usage level of RAPs by Maize farmers in Kwara State

The usage of RAPs followed Giller et al., (2021) by listing the RAPs and the respondents were requested to indicate their usage of RAPs through the use of a 4-point Likert-type scale. Respondents were asked to indicate their usage of each listed RAPs by selecting either of the scales as follows: Never used (0), rarely used (1), sometimes used (2), and often used (3). The midpoint was calculated and the ones with high usage were differentiated from the ones with low usage trough ranking.

However, further classification of the respondents was later done according to their usage level of RAPs. This was achieved by considering the lowest achievable score which was 0, and the highest achievable score which was 3. The highest achievable score of 3 was multiplied with the total number of usage of RAPs variables (20), and it gave 60 This was divided into the three expected usage level of low, medium, and high.

Category 1: Usage level score of 0 - 20 was considered as very low usage;

Category 2: Usage level score of 21 – 40 was considered as moderate usage;

Category 3: Knowledge level score 41– 60 was considered as high usage;

Usage score for each respondent was calculated by summing up each respondent's responses from the usage of the 20 identified RAPs as coded on the Likert-type scale ($0 \leq i \leq 3$) as follows;

$$\mathrm{UI} = \sum_{i=0}^{n} x \ldots \mathrm{Eqn}\ 1$$

From equation (1), UI is the Usage Index

n is the number of identified RAPs

x denotes each RAP under investigation, and

i denotes response on the usage of each RAP x, and it takes the value of between 0 (Never used), 1 (Rarely used), 2 (Moderately used), and 3 (Always used).

After the generation of Usage Index for each respondent, scores of respondents between 0 and 20 were categorized as low. Respondents with score between 21 and 40 were categorized as moderate users, and respondents with scores between 41 and 40 were categorized as high users.

Constraints Faced by Maize Farmers from the Usage of RAPs in Kwara State

To determine the constraints militating against the farmers' usage of RAPs, a list of identified constraints was generated and respondents were asked to identify the severity of each constraint on a 3-point Likert-type scale of Very severe (4), Severe (3), Not Severe (1). The mean and standard deviation of each identified constraint was determined and the constraints were ranked according to their order of severity.

Determinants of the usage of RAPs by the maize farmers

This study investigated the determinants of the usage RAPs by the maize farmers by regressing their usage of RAPs with selected independent variables (socioeconomic characteristics). Multiple regression (Ordinary Least Square) was used for the analysis. Here, the usage level of RAPs (Y) was the dependent variable. It was, however, regressed by 11 independent variables. The model, as advanced by Omotesho et al., (2019) was written as:

$Y = \beta 0 + \beta 1 X1 + \beta 2 D1 + \beta 3 X3 + \beta 4 X4 + \beta 5 X5 + \beta 6 X6 + \beta 7 D1 + \beta 8 D2 + \beta 9 D3 + \beta 10 D4 + \beta 11 D5 + u$...Eqn (2)

From Eqn (3), Y = log (usage of RAPs); β0 =intercept; β1- β11= coefficients; X1 = age (years); X2 = household size (count); X3 = years of education (count); X4 = farming experience (in years); X5= farm size (count, acres), X6= labour force (counts), D1 = farming as primary work (dummy, yes=1, no=0); D2 = marital status; (dummy, married =1, others= 0); D3= sex (dummy, male=1, female=0); D4 = access to market (Dummy, 1= yes, 0= no), D5 = Access to extension; u= error term.

3. RESULTS AND DISCUSSION

Respondents' sources of information on the usage of RAPs

From Table 1, farmers' association/cooperative (0.81) was the most preferred sources of information by the farmers, and was ranked first. Farmers to farmers interaction and socialization was the easiest means of getting information by the farmers for increased agricultural production. According to Ma et al., (2023), farmers' organizations/cooperatives promote the adoption of innovative practices by the farmers, while outsourcing services that farmers' organization provides increases farmers production and technical efficiency. Furthermore, farmers' cooperative activities strengthen their bargaining power and ensures a higher price for their products, while rural labourers were always motivated to work in off-farm sectors as a result of their cooperative membership.

For maize farmers in Kwara State, farmers' organization portends to be the most important medium through which regenerative agricultural information can be relayed to the farmers. Agricultural extension service was another essential, preferred information source by the farmers, and was ranked 2nd. Undoubtedly, agricultural extension service has been pivotal to technology diffusion among farmers (Norton and Alwang, 2020). The most critical function of extension service is its relationship with agricultural information providers vis-à-vis the dissemination of the information to farmers who are the users of the information (Prokopy et al., 2015). The preference of the extension agents by the respondents as an information source might be consequent to the effectiveness of the agents in information dissemination and feedback mechanism in the state.

Table 1 Maize farmers preferred sources of information

Sources of information	Frequency	Mean	SD	Rank
Farmers' associations/cooperatives	282	0.81	0.396	1st
Agricultural extension services	257	0.76	0.426	2nd
Family members	203	0.58	0.494	3rd
Radio	181	0.52	0.500	4th
Television	154	0.44	0.497	5th
Phone	145	0.41	0.493	6th
Fellow farmers	140	0.40	0.491	7th
Non-Governmental Organizations	132	0.38	0.485	8th
Research institutions/universities	111	0.32	0.466	9th
Community/village leaders	100	0.29	0.452	10th
Social gatherings	74	0.21	0.409	11th
Religious organization	70	0.20	0.401	12th
Community-Based Organizations	59	0.17	0.375	13th
Age grades	59	0.17	0.375	14th
Internet	47	0.13	0.341	15th
Donor-funded projects	45	0.13	0.335	16th
Newspaper	38	0.11	0.312	17th
Printed materials	20	0.06	0.232	18th

Source: Authors Field Survey

Regenerative agricultural practices need better awareness by the farmers, and it is the extension agents that are saddled with the knowledge of these practices, and they know the best way of disseminating it. Family members as medium of information source was ranked 3rd by the respondents. This implied that the respondents, aside from the farmers' association and extension agents, preferred their family members. According to Lowder et al., (2016), small holder farming is sometime regarded as family farming. Information sharing through family members who are together in agricultural production seems easy and understandable, as displayed by the preference of the medium by the respondents. Other more preferred information sources by the respondent were radio (0.52), television (0.44), phone (0.41).

According to Hampson et al., (2014), radio has been a vital and cheap medium of information dissemination to the farmers across the world. Also, Isaya et al., (2018) added that many farmers have access to radio, and as such, it remains a cheap source of information on regenerative practices. Television ranked 5th, and phones ranked 6th. There were television programmes designed for farmers for the ease of information on marketing, innovative practices, and demonstrations. As a result, television provided audiovisual experience on agricultural production for the farmers, and this justified its preference by the farmers. The advent of mobile phones eased the reception of information by the farmers. Syiem and Raj, (2015) noted that phones were used by farmers for social communication. Specifically, phones were used to contact middle men, experts, dealers, and advisories for marketing, input supply, and other advisory services.

More importantly, phones were a vital medium of communication to the farmers during emergencies on the farms. Meanwhile, internet (0.13), donor-funded projects (0.13), newspaper (0.11), and printed materials (0.06), were the least preferred sources of information on regenerative agricultural practices, and were ranked 15th, 16th, 17th, and 18th respectively. In many agrarian communities, internet facilities are always unavailable, and as such internet cannot be more preferred by the farmers, as the case was in Kwara State. Also, donor-funded projects were minimal or even non-existent in many rural areas in Kwara State. As such, it was not a preferred medium. Furthermore, many farmers lack access to newspapers, and there were also many who were not educated. This might be the reason for its less preference. Lastly, printed materials are always used to disseminate agricultural information by the extension and international organizations. This was also less preferred by the farmers, and this might be due to its ineffectiveness or its unreliability.

Usage of regenerative agricultural practices

Table 2: Usage of regenerative agricultural practices by the maize farmers

From Table 2, cover crops (1.72), green manure (1.69), mulching (1.51), reduced use of fertilizer (1.25), rotational grazing (1.20), reduced tillage (1.12), and diverse crop rotation (1.12) were identified to be most used by the maize farmers. This enhanced their rankings from 1st, 2nd, 3rd, 4th, 5th, 6th, and 6th respectively. Cover crops have been identified to be assets to sustainable agriculture by virtue of their importance in the adaptation and mitigation of climate change (Koudahe et al., 2022). Specifically, cover crops increase the activities of soil microbes through ecosystem services Vukicevich et al., (2016), and preserve the quality of the soil by virtue of its erosion control capability (Adetunji et al., 2017). In Kwara State, Elenwa and Emodi, (2019) had identified cover crops as important management practice of the soil, especially among smallholder farmers who are cereal based.

Table 2 Usage of regenerative agricultural practices by respondents

RAPs	**NU**	**RU**	**SU**	**AU**	**Mean**	**SD**	**Rank**
Cover crops	34 (9.7)	90 (25.7)	167 (47.7)	59 (16.9)	1.72	0.858	1st
Green manure	47 (13.4)	92 (26.3)	134 (38.3)	77 (22.0)	1.69	0.962	2nd
Mulching	80 (22.9)	76 (21.7)	130 (37.1)	64 (18.3)	1.51	1.037	3rd
Reduced use of fertilizer	77 (22.0)	122 (34.9)	138 (39.4)	13 (3.7)	1.25	0.838	4th
Rotational grazing	101 (28.9)	106 (30.3)	115 (32.9)	28 (8.0)	1.20	0.949	5th
Reduced tillage	104 (29.7)	109 (31.1)	127 (36.3)	10 (2.9)	1.12	0.873	6th
Diverse crop rotation	109 (31.1)	121 (34.6)	89 (25.4)	31 (8.9)	1.12	0.953	6th
Maintaining living roots	101 (28.9)	130 (37.1)	110 (31.4)	9 (2.6)	1.08	0.838	8th
Controlled traffic	133 (38.0)	83 (23.7)	111 (31.7)	23 (6.6)	1.07	0.979	9th

Animal manure	131 (37.4)	94 (26.9)	101 (28.9)	24 (6.9)	1.05	0.968	10th
Pasture cropping	126 (36.0)	112 (32.0)	103 (29.4)	9 (2.6)	0.99	0.871	11th
Zero tillage	126 (36.0)	116 (33.1)	101 (28.9)	18 (5.1)	0.97	0.854	12th
Agroforestry	133 (38.0)	121 (34.6)	78 (22.3)	9 (2.6)	0.95	0.899	13th
Inoculation of soil	130 (37.1)	122 (34.9)	89 (25.4)	7 (2.0)	0.93	0.852	14th
Compost	147 (42.0)	108 (30.9)	88 (25.1)	16 (4.6)	0.87	0.858	15th
Tree crops planting	156 (44.6)	101 (28.9)	77 (22.0)	18 (5.1)	0.87	0.913	15th
Permaculture	178 (50.9)	88 (25.1)	70 (20.0)	14 (4.0)	0.77	0.905	17th
Compost tea	188 (53.7)	92 (26.3)	60 (17.1)	10 (2.9)	0.69	0.854	18th
Biochar	226 (64.6)	87 (24.9)	28 (8.0)	9 (2.6)	0.49	0.752	19th
Silvopasture	227 (64.9)	98 (28.0)	20 (5.7)	5 (1.4)	0.44	0.669	20th

NB: NU (Not used), RU (Rarely used), SU (Sometimes used), AU (Always used)

Source: Author's field survey

This might be due to the low organic carbon content of the soil in Kwara soils in comparison to some southwestern states. Furthermore, the immense benefits of green manure to increase maize production to the tune of about 37-98% among the resource-poor farmers have been identified by (Fabunmi and Balogun, 2015). The usage of green manure in the place of fertilizer by Kwara maize farmers was due to this strength of fertility. Mulching ranked 3rd among the regenerative agricultural practice used by the maize farmers. Li et al., (2020) has identified that mulch increases and sustains maize yield and maintain a balance of the soil water in regions that are semiarid. While also noting that mulching is among the three most important practices of soil conservation, Kodzwa et al., (2020) identified functions of mulching to be reduction of compaction, improvement of soil structure and moisture, and reversal of land degradation.

For maize farmers in Kwara State, the usage of mulching cuts the costs of inorganic fertilizer for increased production. In addition, farmers in Kwara State realized that prolonged use of fertilizer leads to the degradation of the soil. This is in addition to the high cost of procuring fertilizer, which may increase the production cost of farmers and reduce farm's profit. Therefore, exploring alternative farming practices that increase the soil fertility and ensure better yield will, in small measure, be significant. From Table 2, the majority (62.6%) of the respondents reared livestock. With livestock, rotational grazing is possible. Rotational grazing is the act of allowing livestock to graze on a specific plot of land in a season, and then being moved to another plot in another season. Plots of land where livestock have grazed becomes a fertile land for planting maize.

This is particularly the practice of Fulani maize farmers, and it makes the farmers regenerative agriculture farmers. Besides, reduced tillage and diverse crop rotation ranked 6th. As a way of reducing the emission of greenhouse gases and promoting climate-smart practices, extension agents in Kwara State have been disseminating the information of reduced tillage to farmers in Kwara State, but there are little studies to substantiate it. Meanwhile, Pearsons et al., (2023) identified that the need to reduce the costs of farm labour and energy, conserve the moisture content of the soil, and preserve the soil organic matter through proper crop residue management is critical. That was actually what informed the drive for reduced tillage. According to López-Garrido et al., (2014), reduced tillage is a better alternative to zero tillage.

This however corroborate the findings of this study, as zero tillage was less used by the respondent, and was ranked 12th. Also ranked 6th among the regenerative agricultural practices was diverse crop rotation. Diverse crop rotation has been identified with increased yields of crops, pest, weed, and disease management, and an overall farm productivity from the distant past (Tariq et al., 2019). In this age where land degradation has become an issue owing to long-term use of chemicals, crop rotation becomes very paramount (Igberi et al., 2022). The use of crop rotation by farmers in Kwara State points to a better soil conservation process in the State. However, inoculation of soil (0.93), compost (0,87), tree crop planting (0.87), permaculture (0.77), compost tea (0.67), biochar (0.49), and silvopasture (0.44) were least used by the farmers.

Ranked 14th among the regenerative agricultural practices, inoculation of soil functions in reversing degraded soil, prevents erosion, and increase soil fertility (Román et al., 2018). Also, compost tea is also known for the detainment of bioactive compounds that are soluble and beneficial. This makes it a potent source of plant defence and stimulatory component (Eudoxie and Martin, 2019).

Unfortunately, the process of making compost tea of good quality and the application of the tea to crops on the field has been identified as a constraint by the farmers. Tree crop planting has more relevance with perennial crop growers, while silvopasture is more used by ranchers than farmers.

Biochar is an upcoming soil fertility enhancer and an energy source. But it is still less known and used by the maize farmers in Kwara State, though, it has a good prospect as its production site has been located in the state (Zubairu et al., 2023). The greater importance of Biochar will be its provision of clean energy source for cooking and other domestic and local industrial uses. Despite these soil fertility functions of these practices, they were less used by the maize farmers in Kwara State. This might be consequent to low awareness of the effectiveness of these practices, even though maize farmers in Kwara State are faced with soil fertility problems.

Aggregate level of usage of regenerative agricultural practices

From Table 3, only 5 (1.4%) of the respondents were high users of regenerative agricultural practices. These were presumed to be early adopters of improved practices due to their high level of education and much access to information. Moderate users were 49.9% of the respondents, while low users were 48.8%. The gap between the moderate users and the low users was very minimal. This might be due to the fact that the majority of the regenerative agricultural practices like cover crop planting, composting, agroforestry, mulching, among others were not new practices. The majority of the farmers were aware of them, and they have been putting them to use. Nevertheless, driving all farmers to the usage of regenerative agricultural practices for better use of natural resources, avoidance of land degradation, and encouragement of climate adaptation and mitigation is not less important. This result however shows the need for better sensitization on the usage of the many less used RAPs among farmers for better adaptation and mitigation of climate change.

Table 3 Respondents' aggregate level of use of regenerative agricultural practices (n=350)

Obtained score	Level	Frequency	Percentage	Mean ± SD
0 – 20	Low	171	48.8	20.76 ± 10.85
21 – 40	Moderate	174	49.9	
41 – 60	High	5	1.4	

Minimum to maximum possible score: 0-60

Source: Author's field survey

Constraints to the Use of RAPs

From Table 4, all the constraints to the usage of RAPs by the farmers were severe, except the Poor extension services on RAPs (0.98). The categorization of the mean of the severity of the constraints was based on the benchmark of 1 as explained in the methodology. However, lack of resources for RAPs (1.21) was ranked first. Unarguably, some resources or methods of RAPs used by the farmers were easy to obtain or used, while some were far-reaching. Surprisingly, the easily used ones like cover cropping, green manure and mulching were used by the farmers the most according to (Table 2). There were however some resources like biochar, and practices like silvopasture, permaculture, rotational grazing among others that were still less accessible or used by the farmers. Ineffective policies and legislation (1.19) ranked 2nd.

Table 4 Constraints to the Use of RAPs by Respondents

Constraints	Not Severe	Less Severe	Severe	Mean (SD)	Ranking
Lack of resources for RAPs	72 (20.6)	133 (38.0)	145 (41.4)	1.21 (.760)	1st(S)
Ineffective policies and legislation	79 (22.6)	126 (36.0)	145 (41.4)	1.19 (.779)	2nd(S)
High cost of operation	76 (21.7)	135 (38.6)	139 (39.7)	1.18 (.764)	3rd(S)
Poor communication of RAPs	78 (22.3)	133 (38.0)	139 (39.7)	1.17 (.769)	4th(S)
Possibility of unachievable					
Environmental/economic outcomes	79 (22.6)	139 (39.7)	132 (37.7)	1.15 (.763)	5th(S)
Knowledge and skills requirement	74 (211)	154 (44.0)	122 (34.9)	1.14 (.737)	6th(S)

Poor knowledge of some RAPs	71 (20.3)	162 (46.3)	117 (33.4)	1.13 (.722)	7th(S)
Lack of government support	99 (28.3)	117 (33.4)	134 (38.3)	1.10 (.811)	8th(S)
Lack of understanding of RAPs	105 (30)	112 (32)	133 (38)	1.08 (.822)	9th(S)
Transition to RAPs is cumbersome	87 (24.9)	148 (22.3)	115 (32.9)	1.08 (.757)	9th(S)
Less tilling encourages weeds	95 (27.1)	157 (44.9)	98 (24.0)	1.01 (.744)	11th(S)
Poor extension activities on RAPs	87 (24.9)	184 (52.6)	79 (22.6)	0.98 (.689)	12th (N)

Source: Author's field survey Note: S (Severe), N (Not severe)

There have been policies on advancing local actions in the process of adapting and mitigating climate change, as evidenced in the Glasgow Climate Pact released by the UNFCC in 2021. This was also noted in the Nigeria's National Climate Change Policy (2021-2030), unfortunately, implementing these policies at the grassroot has been a major challenge. High cost of operation (1.18) ranked 3rd among the constraints, and this might be tending towards labour utilization, as regenerative agriculture involves the combination of different farming operations. But in general, in regenerative agriculture, inputs costs are low in comparison to the conventional system (Pretty et al., 2019). The respondents also noted poor communication of RAPs as among the severest constraints.

This is because, there has been confusions regarding the terms "regenerative agriculture" "sustainable agriculture" "conservation agriculture" "carbon farming" and even "organic agriculture" regarding their processes and functions. This puts more confusions regarding the communication of what is regenerative, what is organic, what is conservation and the rest as also identified by (Giller at al., 2021). The possibility of not achieving the environmental and economic outcomes promised by the practices of regenerative agriculture still constrained the farmers' usage of RAPs. Farmers still battle on how conceivable the use of zero tillage and not using any chemical will bring any good outcomes from their farming enterprises. Knowledge and skills requirements of RAPs (1.14) and Poor knowledge of some RAPs (1.13) ranked 6th and 7th respectively.

Farmers in Kwara State are known for the use of chemicals for pest control Alalade et al., (2017), which is an important practice of conventional agriculture. For them to transit into regenerative agriculture, there is the need for pest management systems, and other skill required to effectively use regenerative agriculture. Lack of government support (1.10) also constrained the use of RAPs by the farmers, and was ranked 8th. Though, Nigeria is part of the Conference of the Parties on climate change, yet, little has been done to support the farmers at the grassroots in adapting and mitigating the effects of climate change. The Cumbersome nature of transitioning to RAPs (1.08) was due to the lack of understanding of RAPs (1.08), and was ranked 9th. Though, still a severe constraint but lower in ranking, the farmers were still not convinced of how to use less tillage will not lead to the growth of weeds.

Determinants of the usage of RAPs by the maize farmers

From Table 5¸ the R value of 0.562 implied a simple and good correlation. Also, a R2 value of 0.316 (31.6%) showed that only 31.6% of the dependent variable (usage) can be explained by the respondents' personal characteristics (independent variables). Thus, at 0.05 level of significance, Marital status (β = 0.164, p = 0.004), Education (β = 0.0117, p = 0.022), access to extension (β = -0.140, p = 0.016), and farming as a primary work (β = -0.102, p = 0.040) were all significant determinants of the usage of RAPs by the maize farmers. Also, significant at 0.05 level of significance was access to market (β = 0.432, p = 0.000). This, as well, was a significant determinant of the usage of RAPs by the farmers. Specifically, marriage has been identified with a better contribution to the quality of life of people (QOL), and as such married people enjoy better quality of life (Han et al., 2014).

Table 5 Result of multiple regression showing the determinants of the usage of RAPs

Socioeconomic characteristics (Model)	**B**	**SE**	**Beta**	**t**	**Sig**
Constant	6.228	5.614	-	1.109	0.268
Sex	-1.228	1.877	-0.41	-0.645	0.520
Age	0.081	0.070	0.080	1.156	0.248
Marital status	3.718*	1.292	0.164	2.878	0.004
Household size	-0.177	0.222	-0.041	-0.795	0.427

Education	1.221*	0.530	0.117	2.303	0.022
Experience	-0.045	0.065	-0.049	-0.690	0.491
Farm size	-0.041	0.064	-0.032	-0.649	0.517
Access to extension	-4.063*	1.682	-0.140	-2.416	0.016
Primary work farming	-3.079*	1.491	-0.102	-2.065	0.040
Labour size	0.089	0.061	0.074	1.463	0.145
Access to market	6.636*	0.812	0.432	08.172	0.000

R = 0.562, R2 = 0.316, * Statistical significance at 5% level of significance

Having a better quality of life is as a result of sense of responsibilities they are saddled with, which makes them explore opportunities that will strengthen their livelihood. Since the majority of the farmers are married, it implies that marriage encourages the usage of RAPs as a livelihood strategy. Also, education enhances the usage of RAPs as evident from the result. This means that the more the farmers are educated, the better the usage of RAPs. This is because RAPs require some knowledge and skills that only a better education can easily ensure, whether formal or informal (Kőmíves et al., 2019). Education enhances better access, and ensures effective communication. Furthermore, with the need to explore precision agriculture that ensures better yield, better nutrient management, and better environmental protection, education is not less necessary.

Access to extension service also enhances the use of RAPs by the farmers. The more the farmers have access to extension services, the better their usage of RAPs. This is because, agricultural extension enhances farm productivity and income (Danso-Abbeam et al., 2018). Farming as a primary education also determined the usage of RAPs. This is because, those who chose farming as their primary occupation create time to explore all available opportunities to ensure increased output and income. Access to market also enhances the usage of RAPs, meaning the more access the farmers have to market, the better the usage of RAPs. Specifically, products from regenerative agriculture are healthier to eat, and commands better appreciation by cautious customers (Brueggemann, 2023).

4. CONCLUSION

The use of RAPs by farmers in Kwara State is moderate, and the most used RAPs were cover crops, green manure, mulching, reduced fertilizer use, and rotational grazing. Least used RAPs were compost, tree crop planting, permaculture, compost tea, biochar, and silvopasture. Biochar is among the least used RAPs, but has a dual function of soil fertility enhancement and clean energy source for rural and urban household needs. The farmers' most preferred sources of information on RAPs were farmers' associations and cooperative, agricultural extension services, family and friends, radio, television, and phone calls.

The severest constraints to the use of RAPs were lack of resources for RAPs, ineffective policies and legislations, high cost of operation, poor communication of RAPs, and the possibility of unachievable environmental/economic outcomes. The respondents generally displayed a moderate use of RAPs, even though critical RAPs were least used. This however exposes a gap necessary to be filled in the context of promoting RAPs for the advancement of Nigeria's National Climate Change Policy for adapting to and mitigating climate change through agriculture.

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Authors' contribution

Sikiru Ibrahim-Olesin (research conception and writing), Lateef Lawal Adefalu (supervision and design of analytical tools), Sidiqat Adeyemi Aderinoye-Abdulwahab (data analysis and result interpretation), Ajoke Oluwatoyin Kayode (Review), and Sanni Bashir Mohammed (data collection)

Ethical approval

The ethical guidelines for Human Subjects are followed in the study.

Informed consent

Written & Oral informed consent was obtained from individual participants included in the study.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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