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Research Article

Application of Innovative Extension Advisory Services for Management of Problematic Soil (Acidic Soil) and Food Security in Niger State. Nigeria.

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Abstract

The paramount means of sustaining crop management is a "healthy" soil. This implies that a healthy soil will produce healthy crop that have optimum vigor and are less susceptible to pests. This necessitated the conduct of this study, which examined the adoption of innovative extension advisory service on management of problematic soil (acidic soil). Multi-stage sampling techniques was used to select 180 project farmers; primary data were elicited from the respondents with interview schedule from June to July 2021. Data were analysed using descriptive statistics and factor analysis. The results how that mean age was 44 years and average household size of 14 persons. Majority (97.2%) were married while about 65% had no formal education. The most extension advisory services adopted by maize farmers for management of problematic soil were agric, lime and NPK with the mean value of ($\overline{X}$ =4.0), application of agric. lime 3 weeks before planting with the mean value of ($\overline{X}$ =3.9) ranked first and second respectively while for soybean spacing 5cm by 75cm ($\overline{X}$ =3.9) was mostly adopted. The major problem faced by the respondent in the study area in terms of innovation adoption was low income level of the respondents which was economic factors with the agein value .739 and banditry attacked with agein value of .611 which was cultural factors. The study recommended that OCP Africa should be encouraged by the project coordinators to establish one of their One Stop Shop across the study areas to enhance the utilization of this innovation.

Introduction

Land is an asset of enormous importance to billions of rural dwellers in the developing world. Right from creation, man depends on land for his basic needs of life. Martin (2010) describes land as a gift of nature to man which remains the most important factor of production. The rural dwellers depend on the environment, especially natural resources such as land, for the satisfaction of their basic needs. Land is essential natural resources, particularly land for agriculture (Umukoro, 2014). Africa is blessed with enough land mass to undertake small and large scale activities to support household security, national development, trans-boundary cooperation and regional integration to transform trade, and create new opportunities for sustainable development that is sensitive to the environment and social and economic issues (Bangladesh, 2001; Umukoro, 2014). The economic development of most developing countries, including Nigeria, however, revolves, largely around the exploitation and use of land resources especially in the primary industry such as, agriculture (Titilola and Jeje, 2008). As land deteriorates in quality, the poor become poorer. Soil is the most crucial resource on which agriculture is based. Proper management of this valuable resource is vital to sustain long-term agricultural productivity. According to Ashokkumar (2019), soils which are characterized uneconomical for the growing and cultivation of crops without adopting proper reclamation measures are known as problematic soils. Akinnagbe (2010) opined that soils in Nigerian are found to be within medium to high potentials. Soil acidity is one of the limiting factors of nitrogen fixation by the legume-rhizobia symbiosis (Van Zwieten et al., 2015). Acidic soils are deficient in phosphorus (P), magnesium (Mg), calcium (Ca), molybdenum (Mo), and potassium (K) with a high concentration of iron (Fe),

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aluminium (Al), hydrogen (H), copper (Cu) and manganese (Mn) ions (Keino et al. 2015). (Jérôme et al., 2019). Soil acidification largely depends on the nature of soil, agro-ecology and farming systems. It can also occur through natural leaching of CO2 after rainfall and excess application of nitrogenous fertilizer or organic matter. Adoption of innovative extension advisory services for management on problematic soil can produce interesting effects on the maize and soybean farmers. Improved agricultural practices have various impacts. In essence increased agriculture productivity and household food security and nutrition can be achieved through adoption of improved agricultural technology. Increased technology development and adoption can raise agriculture output, hence improved household food intake which in turn serves to improve the functioning of the human body and performance of a healthy, normal life required to promote work output. However, increase technology adoption may result in high labour demands and less time available for other household activities by women (e.g household chores like child care, and fuel wood and water collection) (Washington et al., 2012). Nigeria is blessed with arable land and fresh water resources when viewed as a whole with approximately 61 million hectares of the land cultivable while the total renewable water resource is estimated about 280 km3/year (Victor, 2018). Soil condition and water availability if effectively managed will help boost food production and address food crisis in the nation.. Soil acidity which is the major problematic soil in the study area poses serious land degradation reducing the yield of crops especially Maize (*Zea mays* L.) and Soybean (*Glycine max* (L.) Merrill). The acidification of soil in the study area maybe natural occurrence or aggravated by farmers activities. Soil acidity is usually been referred to because of its impact on crop yields. It pushes soil nutrients out of reach of the plant, leading to stunting of root system and plant. As a result, the plant becomes also less tolerant to drought (Jérôme et al., 2019).

Maize (*Zea mays* L.) and Soybean (*Glycine max* (L.) Merrill) is one of the most widely grown crops in the world after rice (*Oryza sativa* L.). Maize forms the bedrock for food security in some of the world's poorest regions in Africa including Nigeria. It is estimated about 100 million hectares cultivated in 125 developing countries (Tandzi et al., 2018). Acidic soils hamper maize production, causing yield losses of up to 69%. Low pH acidic soils can lead to aluminum (Al), manganese (Mn), or iron (Fe) toxicities. Also Soybean requires high nutrients, with P and K being most crucial for optimal production (Sikka et al., 2012). Soybean production in the study area is also low and this could be due to its sensitivity to low soil pH. Soil pH below 5.2 and above 6.5 does not favour soybean growth; hence poor yields are experienced under such conditions (Peters et al. 2004). High levels of aluminium and low levels of phosphorus in acidic soils affect the growth of symbiotic nitrogen-fixing bacteria. Soil pH < 5.0 limits soybean nodulation due to toxicity effects of Al and Fe ions causing poor nodules formation and functioning (Nisa et al., 2012). Acidic soils also face reduced organic matter breakdown, nutrient cycling by microorganisms, and reduced uptake of nutrients by plant roots and inhibition of root growth (Fageria et al., 2013). The paramount means of sustaining crop management is a "healthy" soil. This implies that a healthy soil will produce healthy crop plants that have optimum vigor and are less susceptible to pests. As a result of enormous consequences of acidic soil on maize and soybean in the study area, the average yield per/ha is 3tones and 2tones for maize and soybean respectively. Adoption of improved innovation practices appears to be an appropriate strategy for improving the poor soil fertility and enhancing farmer's livelihood. Much of the adoption studies in soil fertility management that have examined determinants of farmers' decisions to adopt soil fertility enhancing technologies have focused on adoption of a single technology. Farmers no doubt, are the most valuable asset of any developing nation and anything that affects them directly or indirectly affects the nation as such would constitute a national threat to food security. The outcome of this research work would be useful to government and policy makers provide information to benefiting LGAs whether to continue, amend or change the pattern of the delivery, enrich the body of literature for both students and researchers that may conduct similar studies and generate useful information to soil scientist for further modification. There is dearth of document on effects of innovation application on management of problematic soil. It is based on the foregoing the researcher objectives were formulated:

The aim of the study is to ascertain the effects of adoption of innovation on management of problematic soil (acidic soil) while the specific objectives are to: describe the socio-economic characteristics of respondents; examine the level of application of innovative extension advisory services and identify the constraining factors hindering the adoption of innovation.

Methodology

The study was conducted in Niger State. The State was created in 1976. It lies within the latitude 10°00'N and Longitude 6°00'E. Annual rainfall varying from 1300mm in the North to 1600mm in the south. The major languages are Nupe people in the south, the Gwari in the east, the Busa in the west, and Kamberi (Kambari), Hausa, Fulani, Kamuku, and Dakarki (Dakarawa) in the north. Most of the inhabitants are engaged in farming. Cotton, shea nuts, yams, and peanuts (groundnuts) are cultivated both for export and for domestic consumption. Sorghum, millet, cowpeas, corn (maize), tobacco, palm oil and kernels, kola nuts, sugarcane, and fish are also important in local trade. Paddy rice is widely grown as a cash crop in the floodplains of the Niger and Kaduna rivers, especially in the area around Bida. Cattle, goats, sheep, chickens, and guinea fowl are raised for meat. Pigs are raised around Minna for sale to southern Nigeria.

Gold, tin, iron, and quartz (used by the glass artisans in Bida) are mined mainly for local craftsmen. Pottery, brass work, glass manufactures, raffia articles, and locally dyed cloth are significant exports. Marble is quarried at Kwakuti, near Minna, the State capital; and Minna has a brick-making factory. Niger State has a share in all three dams of the Niger Dams Project, including one at Shiroro Gorge on the Kaduna River and one at Jebba (in Kwara state), the reservoir of which lies partly in Niger state. The Kainji Dam (1969) and part of its reservoir, Kainji Lake, also lie in the state. They have land mass of 29,484 square miles (76,363 square km) with a population of 3,950,249 according to 2006 Population Census.

Sampling and data collection

A multi-stage sampling technique was adopted. At first stage 3 Local Government Areas were purposefully selected because of existence of National programme for food security (NPFFS) project, Second stage involve selection of one village from each of the selected Local government areas. At the third stage 180 respondents were randomly selected based on established sample frame of 1,301 Farmers from National Institute of Soil Scientist (NISS) using 10% of 600 for Bosso (60), 15% of 401 for Lapai (60) and 20% of 300 for Mokwa (60). After administration of questionnaire one questionnaire was missing. Primary data were used and obtained from the respondents with the aid of a structured questionnaire which was subjected to face and contents validity alongside with test and re-test for reliability and interview schedule to elicit information with the help of trained enumerators and extension agents.

Statistical analyses

Data were analyzed using descriptive statistics (Frequency, mean and percentages derived from Likert types scale) and Factor analysis.

Results and Discussion

Socioeconomic characteristic of cereal farmers in the study area

The mean age of the respondents was 44 years. This implies that respondents were relatively active and energetic to cope with the daily challenges and demands of applying extension advisory services. This finding agreed with Langat et al. (2011), who reported higher adoption of improved farming practice among mid-age in their study area. Majority (90%) were male, married (98.3%) with mean house hold of 13 persons. The dominance of male over female could be attributed to drudgery and physical strength associated with agriculture. This agrees with Aboaba et al**.** (2019) who concluded that majority of rice farmers in Ogun State were mostly male farmers. Large household size is proportional to labour availability and reduce the cost of hired labour. Only 7.3% had tertiary education. The implication is that educational status of the project respondents were low this is in contrast with findings of Alderman and Linnemayr (2009), who found a positive relationship between education and application of new farming practices.

Level of adoption of innovative extension services by respondents

For maize, adoption of Agric. lime + NPK ($\bar{X}$ =4.0) Agric. lime three (3) weeks before planting 3WBP ($\bar{X}$ =3.9) and Agric. Lime + FYM + NPK ($\bar{X}$ =3.9), were ranked first and second respectively and for Soybeans, spacing 5cm by 75cm ($\bar{X}$ =3.9), Agric. lime ($\bar{X}$ =3.7) and Agric. Lime + FYM + SSP ($\bar{X}$ =3.6) were ranked first, second and third respectively from the pooled results. The adoption of extension advisory service of each Local Government reveals that, Bosso maize farmers applied agric. lime 3WBP ($\bar{X}$ =4.0) and agric. lime + NPK+ FYM ($\bar{X}$ =3.8) which were top. While for Lapai LGA adoption of Agric lime + NPK ($\bar{X}$ =4.1), Agric. Lime +FYM+ NPK ($\bar{X}$ =4.0) were also the major innovative extension advisory services applied and for Mokwa LGA adoption of agric. lime 3WBP ($\bar{X}$ =3.9), Agric. Lime ($\bar{X}$ =3.8), Agric. Lime +FYM+ NPK ($\bar{X}$ =3.8) were ranked first and second. Problematic soil (acidic soil) has caused lots of havoc in the productivity of agricultural commodity especially those crops that are acid sensitive. Maize and soybean are not immune to these effects across the study areas.

The major recourse to reduce or manage the problematic soil (acidic soil) was to adopt sustainable cultural and soil conservation practices that will enhance the productivity and food security status of project farmer across the study areas.

Table 1. Distribution of respondent according to socio-economic characteristics

	Bosso			Lapai			Mokwa			Pool		
Variables	F	%	Av	F	%	A	F	%	A	F	%	A
Age												
<30	5	8.3		6	10.0		4	6.8		15	8.4	
30 – 39	22	36.7		15	25.0		14	23.7		51	28.5	
40 – 49	17	28.0	43	24	40.0	44	20	33.9	46	61	34.1	44
50 – 59	12	20.0		11	18.3		13	22.0		36	20.1	
60 and above	4	6.7		4	6.7		8	13.6		16	8.9	
Marital status												
Married	58	96.6		58	96.7		58	98.3		174	97.2	
Single	1	1.7		2	3.3		1	1.7		4	2.3	
Gender												
Female	53	88.3		6	10.0		6	10.1		19	10.6	
Male	7	11.7		54	90.0		53	89.9		160	89.4	
Household size												
<5	4	6.7		7	11.9		4	6.8		15	8.4	
5 – 9	19	31.7		19	31.7		16	27.1		54	30.2	
10 – 14	14	23.3	13	13	21.7	13	12	20.3	13	39	21.8	14
15 – 19	9	15.0		9	15.0		9	13.3		27	15.1	
20 and above	14	23.3		12	20.0		18	30.5		44	24.6	
Level of education												
No formal	13	21.7		12	20.0		14	23.7		39	21.8	
Primary	5	8.3		8	13.3		4	6.8		17	9.5	
Secondary	15	25.0		15	25.0		13	22.0		43	24.0	
Tertiary	3	5.0		7	11.7		3	5.1		13	7.3	
Adult	5	8.3		8	13.3		6	10.2		19	10.6	
Quranic	19	31.7		10	16.7		19	32.2		48	26.8	

Sources: Field survey, 2021

Note: F = Frequency, % = percentage and A = average

Findings from the study reveals that, the use of agricultural lime was generally adopted across the study areas to reduce the acidity of the soil. Majority of farmer's cultural practices including bush burning, method of fertilizer application, clean clearing and crop removal among others leads to acidification of soil. Also, natural occurrences like leaching may also cause acidification of soil. Thus, the agricultural liming introduced by the project met the felt needs of project beneficiaries which accounted for it general acceptance and adoption across the study areas. Agric lime + NPK was the second mostly adopted innovative practice for maize production. Generally maize is a cereal crop which requires high Nitrogen for its growth and development. Thus the use of lime and nitrogen as exemplified by the project leads to their higher adoption. NPK (Special blend (OCP) were also highly adopted across the study areas. The reason for this result could be attributed to the fact that NPK special blended OCP were specially formulated to enhance the productivity of nitrogen demanding crops. The result demonstration as shown by the project might likely be the reason for it adoption. Spacing 25 by 75cm was highly adopted, proper spacing help to reduce the competition for soil nutrient, enhance proper growth and facilitate weed control. It was gathered that across the study areas farmers planted randomly using legs this tends to reduce the planting density and invariably reduce the yield and productivity of farmers. This may likely be the reason for the adoption of proper spacing across the study areas.

Table 2. Distribution of respondent according to application of innovative extension advisory services to problematic soil

	Bosso							Lapai							Mokwa							Pooled						
Maize																												
Variable	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM
Agric. Lime	8	1	14	7	30	230	3.8*	9	0	18	4	29	224	3.7*	7	0	18	9	25	222	3.8*	24	1	50	20	84	676	3.8*
Agric. lime 3WBP	5	0	14	10	31	242	4.0*	6	0	20	8	26	228	3.8*	4	0	21	7	27	230	3.9*	15	0	55	25	84	700	3.9*
NPK(Spec. blend (OCP)	23	6	14	12	5	150	2.5	27	8	12	7	6	137	2.3	31	5	13	6	4	124	2.1	84	16	39	25	84	753	3.0*
Urea 46% N	4	4	23	16	13	210	3.5*	5	6	26	8	15	202	3.4*	3	7	30	4	15	198	3.4*	12	17	79	28	43	610	3.4*
farmyard manure	4	6	24	12	14	206	3.4*	8	4	24	7	17	201	3.4*	7	5	23	4	20	202	3.4*	19	15	71	23	51	609	3.4*
Farmer practice (NPK only)	5	6	24	11	14	203	3.4*	5	3	20	11	21	220	3.7*	4	2	26	7	20	214	3.6*	14	11	70	29	55	637	3.6*
Agric lime + NPK	4	4	14	16	22	228	3.8*	4	2	11	12	31	244	4.1*	3	2	11	12	31	243	4.1*	11	8	36	40	84	715	4.0*
Agric. Lime +FYM+ NPK	5	2	15	10	28	234	3.9*	4	1	15	11	29	240	4.0*	3	5	16	11	24	225	3.8*	12	8	46	32	81	699	3.9*
FYM+NPK	3	2	22	13	20	225	3.8*	9	0	18	4	29	224	3.7*	7	6	22	8	16	197	3.3*	18	9	66	33	53	631	3.5*
Seed rate 290kg per ha	9	4	13	15	19	211	3.5*	6	6	10	19	19	219	3.7*	5	8	11	17	18	212	3.6*	20	18	34	51	56	642	3.6*
Spacing 25by 75cm	7	5	11	13	24	222	3.7*	5	5	13	14	23	225	3.8*	4	4	13	16	22	225	3.8*	16	14	37	43	69	672	3.8*
Soybean																												
Agric lime	8	9	8	6	29	219	3.7*	6	10	12	7	25	215	3.6*	5	7	11	11	25	221	3.7*	19	26	31	24	79	655	3.7*
Agric 3WBP	8	6	13	3	30	221	3.7*	7	7	16	4	26	215	3.6*	24	9	9	5	12	149	2.5	69	34	29	17	30	442	2.5
NPK(Spec. blend (OCP)	24	14	9	6	7	138	2.3	21	11	11	6	11	155	2.6	6	7	18	14	14	200	3.4*	15	28	58	35	43	600	3.4*
FYM	3	10	19	10	18	210	3.5*	6	11	21	11	11	190	3.2*	2	7	22	12	16	210	3.6*	9	27	61	37	45	619	3.5*
Farmer practice(SSP)	3	11	18	12	16	207	3.5*	4	9	21	13	13	202	3.4*	2	14	20	8	15	197	3.3*	9	20	68	37	45	626	3.5*
Agric. Lime + SSP only	2	11	20	9	18	210	3.5*	3	14	21	8	14	196	3.3*	8	7	16	1	27	209	3.5*	7	39	61	25	47	603	3.4*
Agric. Lime + SSP+ FYM	4	9	13	3	31	228	3.8*	9	6	14	3	28	215	3.6*	2	5	19	9	24	225	3.8*	21	22	43	7	86	652	3.6*
Seed rate (40kg)	2	12	22	8	16	204	3.4*	5	14	21	11	9	185	3.1*	1	8	13	9	28	232	3.9*	10	37	63	33	36	585	3.3*
spacin5cmby 75cm	1	8	12	8	31	219	3.7*	2	9	13	8	28	231	3.9*	3	5	20	12	19	216	3.7*	4	25	38	25	87	703	3.9*

Source: Field survey, 2021
Note: A=Awareness, I=Interest, E=Evaluation, Trial and A=Adoption (Ibrahim., 2019)
3WBP= 3 weeks before planting
*significant.

Constraining factors hindering the adoption of innovation

Principal component analysis using the varimax rotated factors with Kaiser Normalization was used to analyze the Constraining factors hindering the innovation application. The factorability of the constraint variables was examined. The result presented in Table 4.6 shows that the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0. 838 which is adequate and acceptable based on the KMO classification. The Bartlett's test of sphericity X_2 = 2769.570) also was significant at 0.01 probability level which shows that the matrix is significantly different from zero (0), that is, the matrix is significantly different from identity matrix. This implied that there were sufficient inter-correlations to conduct the factor analysis. More so, variables with factor loadings of less than 0.40 were not used. The outcome of factor loadings from principal component analysis after varimax rotation of the project farmer's responses to questions on constraints hindering the innovation application in the study area is presented. These constraints were listed according to the proportion of variance associated with them and were classified as economic, policy, cultural and attitude factors and are discussed as follows:

The problem constraining adoption of innovative extension advisory services for the management of problematic soil were Economic factors (low level of income; agein value .739; inadequate technical knowhow, agien value .758;. Despite the enormous benefits associated with this innovation on managing problematic soil, it is very expensive this may likely reduce the rate of adoption as most project farmers across the study areas were low income earners. Cultural related factors (insufficient rainfall, agein value .433; banditry attack, agein value .611; farmers herders clash, agien value .589;). This is similar to the report of FAO (2011) who reported that variation in weather condition caused by greenhouse emission may alter the rainfall pattern of particular area. This particular scenario may likely leads to reduction in adoption of technology as farmers may not be willing to continue with a particular technology after the first trial was not successful due to weather variation. The high rate of insecurity in the country has pose threat to our food security and poverty status of Nigerian as farmers cannot freely go to their farm without the fear of been kidnap or killed by bandit while other fear herders grazing on their farm land. The study area is not exempted to this threat, thus, the rate of adoption of innovation may likely reduce as nobody want to invest on a technology where his security and that of crops are not guarantee and Attitudinal factors (wrong view of farmers incapable of taking decision agein value .698; untimely delivery of inputs, agien value .497). To ensure high adoption of agricultural innovation farmers needs to be motivated, the project farmers complaint about low motivation from the project coordinators as they are only given little incentive during flag off of the project

Table 3. Distribution of respondents according to constraining factors hindering the adoption of innovative extension advisory services

Variables	Factor 1 (Economic related factors)	Factor 2 (Policy related factor)	Factor 3 (Cultural related factor)	Factor 4 (Attitude related factors)
Inadequate extension contact	.115	.284	.146	-.153
Poor access to credit	-	-	-.219	-.076
Low level of income	.739*	-.049	-.237	-.136
Inadequate technical know how	.758*	.092	-.138	.029
Pest and disease attack	-	.252	-	.049
Insufficient rainfall	.284	.107	.433*	-.073
Low germination rate	-.395	.129	.256	-.056
Wrong view of farmers in capable of taking rational decision	.096	-.168	-.060	.698*
Untimely delivery of input	-	-	-.042	-.497*
High cost of input	-	-	.207	.244
Problem of land tenure system	-.017	-.138	-	-
Inadequate storage facilities	.292	-	-.015	
Problems of banditry attack	.141	-.297	.611*	-.098
Farmers herders clash	.229	.287	.589*	.121
Contradict the norms and values of the society	.285	-.104	.397	.271
Low level of education	-	-	.079	.180
Low level of motivation	-	.116	.232	-
Against the felt needs of the farmers	-	.270	-	-.138
Inappropriate technology	.280	.212	.251	-.017
Long distance to sources of innovation	-	-	-	.169
Kaiser-Meyer-Olkin (KMO)		0.838		
Bartlett' test		2769.570		

Source: Field survey, 2021

Conclusion and Recommendations

Based on the findings of the study, it was concluded that project farmers across the study areas were within their active age, married with large family size as well as low level of education and experienced farmers. It was also concluded that Agric lime, Agric lime 3WBP, Agric. Lime +FYM+ NPK, Agric lime + NPK and NPK (Spec. blend (OCP) were the major type of innovation on problematic soil used by maze project farmers while Agric lime, Agric lime 3WBP, Spacing 5 by 75, Agric. Lime + SSP+ FYM, and FYM+SSP were the major type of innovation on problematic soil used by soybean farmers. It can also be concluded that Agric. lime 3WBP, Agric. Lime +FYM+ NPK, Agric lime + NPK, Agric. Lime and FYM+NPK were the prevalent innovation adopted by project farmers for maize production while Agric. Lime + SSP+ FYM, FYM+SSP, spacing 5cm by 75cm, Agric lime and Agric 3WBP were the major innovative practices adopted by projected farmers. Furthermore, farming experience, relative advantage, compatibility, seed rate influence the maize output of project farmers positively, while complexibility and cost had inverse influence on maize output meanwhile, age, education, relative advantage and seed rate had direct influence on the soybean output of project farmers. Lastly, poor access to credit, low level of income, inadequate technical knowhow, high cost of input, low level of education and long distance to sources of innovation were the economic factors hindering innovation application, the political factors include untimely delivery of input, low level of education and long distance to sources of innovation, that of cultural factor include pest and disease attack, insufficient rainfall, problem of land tenure system, problems of banditry attack and farmers herders clash while wrong view of farmers in capable of taking rational decision and low level of motivation were the attitudinal factors hindering innovation application across the study areas.

From the findings of the study, the following recommendations were drawn:

i. The level of education across the study areas were found to be generally low, it was therefore recommended that state ministry of education and other relevant stakeholders should prioritize adult education across the study areas to broaden their understanding and knowledge of new innovation

ii. The cost of acquiring the innovation was found to be one of the factors hindering the adoption of the technology. Therefore, it was recommended that project beneficiaries should buy the innovation in bulk through their various farmers' groups. Also, the technology should be subsidized by the state government and other relevant stakeholders and ensure it gets to the users at the right time to facilitate its adoption and usage.

iii. Policies should be formulated to support farmers' demography, farm-based characteristics, and institutional factors in order to improve their welfare and promote rural vitalization which will enhance their adoption capabilities

iv. Liming was found to be limiting across the study areas, therefore, it was recommended that project coordinators should try to make necessary contact to ensure that liming is made is available.

v. OCP Africa should be encouraged by the project coordinators to establish one of their One Stop Shop across the study areas to enhance the utilization of this technological package.

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Competing Interest

Competing Interest: We declared that no competing interest.

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