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Technology Adoption and Productivity Difference among Growers of New Rice for Africa in Savanna Zone of Nigeria

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Summary

The use of New Rice for Africa (NERICA) and complementary rice production technology is being promoted by Nigeria government in order to increase productivity of upland rice farming. This study examines the levels, determinants and effects of complementary technology adoption on productivity of NERICA rice farming. Data for the study were obtained from sample survey of 227 NERICA rice farmers in the guinea savanna zone using multistage sampling technique. Data collected were analyzed using Tobit regression model and Cobb-Douglas production function. Results showed that the average technology score was 52.1 percent (± 0.242). Fifty-five percent of the farmers who scored above the mean were categorized as low technology users. Tobit regression estimation shows that farmers' technology score was affected significantly (P< 0.05) by farmer's level of education (0.0127), extension visit (0.0145), farming experience (0.0085), land ownership status (0.0687), credit use (0.0698) and level of rice commercialization (0.3783). Cobb-Douglas production estimation shows a neutrally outward shift in production function as the level of complementary technology increases, indicating increasing productivity. Thus, promotion of complementary technology in NERICA rice production is a worthwhile effort and should continue to be funded. Improvement of those factors that significantly affect adoption of complementary technology is recommended.

Résumé

Adoption de technologie et différence de productivité parmi des cultivateurs de nouveau riz pour l'Afrique dans la zone de la savane du Nigeria

L'utilisation du nouveau riz pour l'Afrique (NERICA) et la technologie complémentaire de production de riz est favorisée par le gouvernement du Nigeria afin d'augmenter la productivité de la production de riz de montagne. Cette étude examine les niveaux, les causes déterminantes et les effets de l'adoption complémentaire de technologie sur la productivité de la production du riz de NERICA. Des données pour l'étude ont été obtenues à partir de l'enquête par échantillonnage de 227 fermiers de riz de NERICA dans la zone de la savane de Guinée en utilisant la technique d'échantillonnage à plusieurs étages. Des données rassemblées ont été analysées en utilisant la fonction de production de modèle de régression de Tobit et de Cobb-Douglas. Les résultats ont prouvé que les points moyens de technologie étaient de 52,1 pour cent (+ 0,242). Cinquante-cinq pour cent des fermiers qui ont marqué au-dessus de la moyenne ont été classés par catégorie en tant que faibles utilisateurs de technologie. L'évaluation de régression de Tobit montre que la technologie des fermiers ont été affectés sensiblement (P< 0,05) par le niveau d'éducation (0,0127), la visite de prolongation (0,0145), l'expérience (0,0085), le statut de propriété terrienne (0,0687), l'utilisation de crédit (0,0698) et le niveau de la commercialisation de riz (0,3783). L'évaluation de la fonction de production de Cobb-Douglas montre une variation extérieure neutre dans la fonction de production à mesure que le niveau de la technologie complémentaire augmente, indiquant la productivité croissante. Ainsi, la promotion de la technologie complémentaire dans la production de riz de NERICA est un effort valable et devrait continuer à être financée. L'amélioration de ces facteurs qui affectent de manière significative l'adoption de la technologie complémentaire est recommandée.

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Introduction

Self-sufficiency in rice production has been a major focus of food policy goal of Nigeria government in the last two decades due to deficit in rice production which has cost a substantial amount of foreign exchange to import rice into the country. In response to this goal, upland production system which is the most common and accessible among the three major production systems is being exploited for rice production (10). This effort has led to output growth mainly through increase in land area rather than productivity increase (4). The declining productivity was traced to low yield of upland production system when compared with the lowland and irrigated systems (2, 13). Success in achieving self-sufficiency in rice therefore depends largely on the extent to which upland rice yield can be increased. Toward this end, the New Rice for Africa (NERICA) which was specifically bred by scientists of Africa Rice Center (WARDA) to address the problem of low productivity of upland rice in sub-Sahara Africa has been introduced to Nigeria rice farming system through Multinational NERICA rice dissemination project which was launched in 2002. Recent studies in Nigeria have shown appreciable adoption of NERICA varieties by farmers (14, 15), however, no empirical study has been carried out to actually evaluate farmers' adoption of complementary technology in NERICA rice production and its impact on productivity of upland rice. This study is an attempt to provide empirical information on the possibilities of enhancing productivity gains in upland rice through adoption of complementary technology. The specific objectives of this study are: (i) to determine adoption rate and factors affecting farmers' adoption of complementary technologies and (ii) to analyze the effect of different level of technology adoption on productivity of rice farming.

Methodology

Kaduna and Nasarawa States in the savanna agro-ecological zone of Nigeria were chosen for this study, based on their consistent participation in NERICA dissemination activities since inception. Multistage sampling technique was adopted in selecting 227 growers of NERICA varieties that provided data for this study. Data were collected based on production activities for 2006 cropping season using structured questionnaires. Data collected were analyzed using Tobit regression model (1) and Cobb-Douglas production function (6).

Tobit regression equations are expressed as follows:

$$I = b_o + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n = f(X_i) \qquad \ldots 1$$
$$\text{and } y = g(I) \qquad \ldots 2$$

$$\text{where } y = 0 \quad \text{if } I < I^* \qquad \ldots 3a$$
$$y = I - I^* \quad \text{if } I \geq I^* \qquad \ldots 3b$$

Specifically: $y = biXi + ei$

Where y= level of technology adoption, bi= parameters of I, ei= random error term,
Xi is socioeconomic variables i (i= 1, 2, 3… 12), such as:
age of farmers in years (X_1), education in number of years spent in schools (X_2), land tenure status (X_3) as dummy (1 for owners, 0 otherwise), years of rice farming experience (X_4), farm income in the previous year (X_5), farm family size (X_6), family labour (X_7), number of contact with extension agent per cropping season (X_8), membership of association (X_9) as dummy (1 for member, 0 otherwise), credit use (X_{10}) as dummy (1 for user, 0 otherwise), extent of commercialization (X_{11}) as fraction of total output offer for sale.
Adoption index of individual farmers was developed using the following formula (5):

$$AIi = \Sigma\{(ATi/RTi)ISi)\}$$

where AIi is adoption index of ith farmer, AT is the level or quantity of input the farmer actually applied, RT is the recommended level or quantity of an input he ought to apply, ISi is the proportion of score attributable to a particular input (as given by percentage for each innovation). A maximum adoption score obtainable is fixed at 1 (100%), after summing up for all the elements of the package of recommendations. For each of the innovations, the weight assigned on conversion to the percentage scale is as follows (5 and 6): inorganic fertilizer 40%; improved cultural practices 30%; herbicide and other agrochemicals 20%; mechanical device (e.g. planter, tractor or animal traction) 10%. Farmer's group is dictated by his/her position with respect to grand mean adoption score. A farmer whose score is higher than the grand mean is said to be a high adopter of technology, otherwise he is categorized as low adopter.

Cobb-Douglas production functions in the logarithmic form were estimated for pooled sample of farmers and separately for each group of technology users (6) as follows:

$$\ln Y_L = \ln\alpha_1 + a_1\ln X_1 + a_2 \ln X_2 + a_3\ln X_3 + a_4\ln X_4 + U_1 \qquad \ldots 4$$
$$\ln Y_H = \ln\alpha_2 + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + U_2 \qquad \ldots 5$$
$$\ln Y_p = \ln\alpha_3 + c_1\ln X_1 + c_2\ln X_2 + c_3\ln X_3 + c_4\ln X_4 + + U_3 \qquad \ldots 6$$
$$\ln Y_p = \ln\alpha_4 + d_1\ln X_1 + d_2\ln X_2 + d_3\ln X_3 + d_4\ln X_4 + d_5D + U_4 \qquad \ldots 7$$

where Y= total rice output (kg), X_1= rice farm size (ha), X_2= total labour used in rice production (mandays), X_3= quantity of seeds used in planting (kg), X_4= quantity of fertilizer (kg), D= technology use dummy, 1 for high, and zero for low level, U= error term and Subscript L, H, and P stand for low, high and pooled production functions respectively.

Results and discussion

The summary of farmers' socioeconomic characteristics and input use based on technology use classification was presented in table 1. The mean technology use score (index) for low technology category was 32% while that of higher technology group 75%.
The mean technology use score of the whole sample was 52 per cent indicating that rice farmers adopted about half of the complementary technology on the average. Forty five per cent of the sample farmers scored above the mean showing that majority of the sample farmer (55%) belongs to low technology adopters. This means that the adoption of technology had not made an appreciable headway and traditional methods of rice cultivation still dominate the production system. This low level of technology adoption may be responsible for the relatively lower yield of 1479 kg/ha obtained by the sampled farmers compared with the average of 2100 kg/ha obtained from NERICA rice trials conducted in 21 states by the National Rice/Maize Centre (7). In this study the mean yield for low technology users was 1212 kg/ha while it was 1786 kg/ha for high technology category.

Technology score was regressed against farmers' socioeconomic variables including: age of farmers, education, tenure status, farming experience, farm size, farm income, labour availability, membership of association, credit use, level of commercialization and extension contact. The choice of these variables is based on the findings of previous studies on technology adoption (3, 8, 9, 11) which identify those variables as significant factors affecting agricultural technology adoption in developing countries.
Age of farmer is expected to influence technology adoption in any direction depending on his position in the life cycle, education level and experience. Younger farmers are more likely to be interested in adopting new technologies if they are not constrained by limited cash resources, while older farmers are less likely to be able to use new technologies if they require extra physical labour and/or older farmers may be less interested because they have less need for extra income. Age contributed positively if the level of farmer's education and experience in farming is high, and negatively, if the level of education and experience of farmers is low. Education is expected to affect the level technology adoption positively through effective skill acquisition in choosing better inputs.
Tenurial arrangement may influence the extent to which a given crop could be cultivated, in view of the problem posed by supply of land in Nigeria agriculture. Since inheritance was the most common form of ownership, it can be passed from one generation to the other. This arrangement is expected to affect technology adoption positively.

Farming experience could take on either negative or positive sign depending on the length of period. It is expected to demonstrate increasing returns

Table 1
Descriptive statistics of respondents based on technology use grouping

Socio-economic demographic variables	Low technology group N= 120	High technology group N= 106	All N= 226
Age of farmer (years)	48	39	44
Education (school year)	0.95	6.5	3.5
Tenure status (dummy)	0.56	1	0.76
Rice farming experience(year)	22	26	24
Farm income (N'000)	279	321	299
Family size	10	8	9
Family labour	7	6	6
Extension contact per season	0.9	6	3.2
Membership of association	0.27	0.67	0.45
Credit use	0	0.41	0.19
Commercialization level	0.55	0.75	0.64
Input-Output variables			
NERICA farm size (ha)	1.07	1.8	1.4
Labour use (mandays)	94 (88)	134 (74)	112 (83)
Quantity of seed (kg)	59 (55)	106 (59)	81 (57)
Quantity of fertilizer (kg)	92 (86)	277 (153)	178 (116)
Volume of herbicide (litres)	0.75 (0.70)	5.9 (3.3)	3.16 (2.0)
Output of rice paddy (kg)	1323	3263	1713
Yield (kg/ha)	1212	1786	1479
Index of technology use	0.32	0.75	0.52
Technology use score	0	1	0.45

Source: Computed from field data, 2006
*inputs use per hectare are in parenthesis.

up to a stage and later diminishing return as more elderly farmers have been reported to be more risk averse, hence are less likely to experiment with new technologies.
Income derived from the farming activities indicates the level of profit of the farmers. The expectation is that farmers will have as much capital to plough back into the production process in order to increase profit. Wealthier farmers are more likely to be able to afford and apply expensive inputs aimed at increasing productivity; hence income is expected to influence technology adoption positively.

The family size is an important socio-economic characteristic because it often determines how much family labour will be put into use on the farm and also determines the extent to which a household is able to respond to innovative change. The variable is expected to influence technology adoption positively.

Extension contact is very important determinant of technology adoption because, any newly developed technology is introduced to farmers through the activities of extension agents. A farmer whose contact with extension agents is very high is expected to be more familiar and more knowledgeable about the use of improved agricultural innovations. This variable is expected to be positively related to technology adoption.

Table 2
Tobit Model estimates for adoption of improved rice technologies

Variable	Coefficient	Std Err.	Mean
X_1 (age)	-0.001384	0.001478	44
X_2 (education)	0.01271 **	0.002412	3.5
X_3 (tenure status)	0.06868**	0.01755	0.76
X_4 (rice farming experience)	0.0085**	0.00271	23
X_5 (farm income)	-0.00005	0.00008	298,700.44
X_6 (family size)	0.00361	0.004275	9
X_7 (family labour)	0.00038	0.00985	6
X_8 (extension contact)	0.01446**	0.00356	3
X_9 (membership of association)	0.01155	0.0152	0.45
X_{10} (rice farm size)	0.0356	0.021	3.24
X_{10} (credit use)	0.0698**	0.0245	0.19
X_{11} (extent of commercialization)	0.3783**	0.1113	0.64

**significant at 1%.

Membership of association is expected to assist farmers to get easy access to credit and other production inputs. It can also enhance access to technological information. The sign of the parameter of this variable is expected to be positive.
Credit use is expected to assist farmers purchase necessary inputs for crop production. Many sources of credit give the farmer more chances of securing improved inputs. It also provides farmers with additional source of investment in new ideas and therefore is expected to be positively related to technology adoption.

Commercial farming in contrast to subsistence farming is more likely to contribute positively to technology use as farmers will strive hard to attain high level of productivity in order to earn maximum income possible. Commercialization is expected to empower farmers get assess to cash which can be ploughed back into production to purchase necessary inputs for production. The extent of rice commercialization is defined in this study as the proportion of total rice output offerred for sale to earn cash income. It is expected that this high level of commercialization will contribute positively to technology adoption.

The result of Tobit regression analysis is presented table 2. All the variables in the model except farm income have the expected signs and six are significant in explaining use of improved rice technologies. The positively related and significant variables include: farmers' level of education, extension visits, rice farming experience, land ownership, credit use and level of rice commercialization as expected. This means that improvement in these major factors would lead to higher level of technology use.

Results of the estimated Cobb-Douglas production function are presented in table 3. The signs of the parameters came out as expected in all the equations. The coefficient of farm size was statistically significant at 5%, except for low technology situation. Coefficients for labour, seeds and fertilizer were significant at 1% level in all equations. All parameters in the pooled equation were significant at 1% except technology dummy that was significant at 5%. Production function shifts neutrally outward with increase in the level of utilization of complementary technology.

Table 3
Estimates of Cobb-Douglas production function for technology users

Technology	N	Constant	X_1	X_2	X_3	X_4	D*	R^2	F
1. Low**	120	0.899	0.166	0.814a	0.320a	0.282a		0.93	374
2. High**	106	2.637a	0.294b	0.452a	0.278a	0.314a		0.97	938
3. Pooled	226	1.839a	0.216b	0.537a	0.355a	0.324a		0.98	2739
4. Pooled +	226	1.967a	0.209b	0.541a	0.341a	0.300a	0.061b	0.98	2312

a significant at 1% b significant at 5% + with technology dummy variable, D
* D is not in logarithmic form **A farmer whose technology use score is less than the grand mean of 52% is said to be a low adopter, otherwise he is categorized as high adopter.

A comparison of low and high technology regressions show that:

*. the production function for the low technology users has a lower intercept than the production function of the high technology users. This implies that the higher technology gave a higher output per unit of each input than the lower technology. This shows that the farms with high technology were more productive;

*. labour, seed and fertilizer were positive and significant at 1% in all the equations, showing that use of those inputs in NERICA rice production is very essential;

*. the coefficients for labour and seed are higher for low technology users, showing that addition to output resulting from the use of units of labour and seeds is higher for the low technology users;

*. the coefficients for land and fertilizer are higher for high technology users, showing that addition to output resulting from the use of units of land and fertilizer is higher for the high technology users;

*. the use of technological innovations by farmers was positively related to output and significantly influence output of rice paddy among the sampled farmers.

Conclusion

This study provides empirical information on the possibilities of enhancing productivity gains in upland rice through promotion of NERICA and complementary technology. Results show that adoption of complementary technology had not made an appreciable headway and traditional methods of rice cultivation are still predominant among rice farmers. Technology adoption is affected significantly by farmers' level of education, extension visits, rice farming experience, tenure status, credit use and level of rice commercialization. Use of complementary technology at relatively higher level will contribute to higher productivity of upland rice farming. It is therefore concluded that the promotion of complementary technology in NERICA rice production is a worthwhile effort and should continue to be funded by government. Those significant factors that positively affect technology adoption need to be improved if technology promotion is to be the policy focus in increasing upland rice productivity in Nigeria.

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