International Journal of
Agricultural
Research

Factors Influencing Adoption of Chemical Pest Control in Cowpea Production among Rural Farmers in Makarfi Local Government Area of Kaduna State, Nigeria

[1]R.A. Omolehin, [2]T.O. Ogunfiditimi and [1]O.B. Adeniji
[1]Department of Agricultural Economics and Rural Sociology,
Ahmadu Bello University, Zaria, Nigeria
[2]Department of Agricultural Extension, University of Ibadan, Nigeria

Abstract: This study examines the factors influencing the adoption of chemical pest control in cowpeas production in Makarfi Local Government Area of Kaduna State, Nigeria. Data were collected using stratified random sampling method from 61 farmers adopting chemical pest control and 79 non-adopters making up a total of 140 respondents. A Probit analysis was used to ascertain factors influencing farmers' adoption of chemical pest control while the t-test was used to determine whether there is statistical significant difference between the productivity of adopters and non-adopters to enable us draw inference on the food security and poverty reduction ability of the chemical pest control practice. The results reveals that the adoption of chemical pest control in cowpeas production is influenced by farmers' age, marital status, educational qualification, the desires of farmers for higher yields and the contact with extension activities. The results also helped to establish that chemical pest control could help the farmers in making sure that higher yields are obtained from cowpeas production thus helping the rural farmers to become food secured since cowpeas are very good protein rich food. Moreover, the result of the yields from adopters has shown that the practice could help farmers realize marketable surplus that will lead to higher income generation thereby reducing poverty among the rural farmers.

Key words: Adoption, chemical pest control, cowpeas production, food security, poverty reduction

INTRODUCTION

Cowpea is an important protein food consumed by virtually all people of various economic classes in Nigeria. This crop is produced majorly in the northern parts of the country while the bulk of the shortfalls in production are augmented through the cross-border trade between Niger and Nigeria through the porous border informal trade (Abdusalam, 2004). There are no practical reasons why Nigeria should not be self sufficient in cowpea production to meet her local food demand. However, the prevalent of insect pest and diseases poses serious threat to cowpea production and these two problems have been the major impediments to the goal of our realization of self-sufficiency in cowpea production. Pests are insects, birds, rodents, monkeys, weeds, fungi, bacteria and fungi that feed on growing plants, injure them and kill them and introduce diseases (Kolawole *et al.*, 1979; Agrios, 2005). Chemicals that are used for pest control are known as pesticides.

A lot of extension activities have been on for many years on the need for farmers to adopt chemical pest control in cowpea production in Nigeria. Few of the many advantages of chemical pest control in cowpea production includes the fact that it enhances plant vigour and healthy growth, lead

Corresponding Author: R.A. Omolehin, Department of Agricultural Economics and Rural Sociology,
Ahmadu Bello University, Zaria, Nigeria

to higher plant yields and consequently increased productivity and leads to improved quality of the harvested crops (Agrios, 2005). However not all farmers are presently adopting this all-important agronomic practice. This study objective is the evaluation of factors influencing the adoption of chemical pest control in cowpea production in the study area. The study main hypotheses are that the adoption of chemical pest control in the study area is not influenced by socio-economic factors and that there is no significant difference in the yields of farmers adopting chemical pest control in cowpea production and other farmers not adopting the practice.

MATERIALS AND METHODS

Study Area and Data Collection

This study was carried out in Makarfi Local Government Area of Kaduna State. Makarfi Local Government shares boundary with Zaria Local Government in the south and Kano State in the north. The climate of this area is that of northern Guinea Savannah with rainfall ranging between 700-1000 mm per annum. This rainfall is fairly distributed over a period of 3-5 months in the year; each year has two seasons (i) the rainy season, which starts around May and ends in September and (ii) the dry season that lasts for about 7 months compared to 5 months of rain. The dry season starts in October and ends in April (Kowal and Kassam, 1987). The lighter rainfall in this area compared with that of southern parts of the country makes the area to be more conducive for cowpea production.

Data for this study were collected from 140 respondents in the study area between November 2005 and February 2006. The respondents were made up of 61 cowpea farmers that adopted chemical pest control practice in their production and 79 non-adopters. These respondents were selected using stratified random technique from the list of adopters and non-adopters provided by the Makarfi Local Government Agricultural Department. The villages covered were Makarfi, Mayere, Gubuchi, Doka and Tashayari all in Makarfi Local Government Area. The information collected were whether a farmer has adopted chemical pest control or not as the dependent variable. Those that adopted were scored 1 while the non-adopters were scored 0. Information on factors influencing their adoption was also collected. Moreover, socio-economic characteristics of farmers such as age, education, family size and marital status were also collected. Also collected were production information such as hectares of land cultivated, labour used and the yields realised. All these information were analysed to determine the factors influencing adoption of chemical pest control in the area and also to determine the impact of the adoption of crop yields as well as food security and poverty reduction in the area.

General Theoretical Considerations of the Modelling of Adoption Behaviour

Since the early work on adoption by Rogers (1962), efforts that have been made to explain the determinants of adoption have received a boost. There are two major groups of paradigms for explaining adoption found in literature: The innovation-diffusion and the economic constraint paradigms.

The innovation-diffusion model, following the work of Roger, contended that access to information about an innovation is the key factor determining adoption decisions (Agrarwal, 1983). The appropriateness of the innovation is already assumed here and the problem of technology is reduced to communicating information on technologies to potential end users. By emphasizing the use of extension, media, and local opinion leaders, or by the use of experimental station visits and on-farm trials, sceptic non-adopters can be shown that it is rational to adopt (Adesina and Ziunah, 1993).

In contrast, the economic constraint model (Aikens *et al.*, 1975) contends that economic constraints, reflected in asymmetrical distribution patterns of resource endowments, are the major determinants of the observed adoption behaviour. A lack of access to capital (Havens and Fliun, 1976) or land (Yap and Mayfield, 1978; Ogunfiditimi, 1981) is seen as factor significantly constraining adoption decisions. While attempts have been made to assert the superiority of the economic constraint model over the iunovation model (Hooks *et al.*, 1983), such conclusions have been challenged (Nowak, 1987; Ogunfiditimi, 1987).

Many other concepts have recently been developed and used to quantitatively determine adoption processes. One of these concepts, which is implicitly used in one form or the other in agricultural economics literature (Gould *et al.*, 1989; Norris and Jansen, 1987; Lynne *et al.*, 1988; Adesina and Zinnah, 1993), suggests that the perceived attributes of innovation conditions determine adoption behaviour. Farmers, as reasoned, have subjective preferences for technology characteristics (Ashby and Sperling, 1992; Ashby *et al.*, 1989; Ogunfiditimi, 1981) and these could play a major role in technology or practice adoption. The adoption or rejection of technologies or farm practices by farmers may be based upon farmers' perceptions of the appropriateness or inappropriateness of the characteristics of the practices under consideration.

A number of studies have investigated the influence of various socio-economic factors on the willingness of decision makers to use new technologies (Nerlove and Press, 1973; Shakya and Flinn, 1985). From most of these studies of adoption behaviour, the dependent variables are constrained to lie between 0 and 1 and the models used are exponential functions. One common feature of these models is that Univariate and Multivariate Logit and Probit models and their modifications have been used extensively to study adoption behaviour of farmers and consumers (Nerlove and Press, 1973; Schmidt and Strauss, 1975; Garcia *et al.*, 1983; Akinola, 1987; Akinola and Young, 1985; Adesina and Zinnah, 1993). Maddala (1983) and Shakya and Fliun (1985) have recommended Probit models for the functional forms with limited dependent variables that are continuous between 0 and 1 and Logit model for discrete dependent variables. The Probit model was used for this study since the dependent variable in this case was 1 for adopters and 0 for non-adopters.

Statistical Consideration of Probit Modeling for Chemical Pest Control Adoption Behaviour

The concern here is to estimate the determinants of farmers' participation in the adoption of chemical pest control in cowpea production for improved productivity.

As a first step, it is assumed that the adoptions of chemical pest control practice by different classes of farmers are a linear function of farm household characteristics and the attributes inherent in chemical pest control practice. However, the decision as to whether a farmer adopts or not is based on self-selection rather than random assignment. Thus adoption A_i should be endogenised using an index function model (Heckman, 1976; Maddala, 1983; Greene, 1997; Greene, 2003). This index to estimate farm household adoption of chemical pest control in cowpea production is:

$$A_i^* = Z_i'\gamma + \mu_i \tag{1}$$

Where, A^* is an unobservable index variable denoting the difference between the utility of adopting chemical pest control in cowpea production (U_{1i}) and the utility of not adopting the practice (U_{0i}). If $A_i^* = U_{1i} - U_{0i} > 0$, then the individual household $_i$ will adopt a chemical pest control practice. The term $Z'\gamma$ provides an estimate of U_i1-U_i0, using farm household characteristics and the attributes of the chemical pest control measure, Z_i, as the explanatory variables, while U_i is an error term unobserved by the researcher and assumed to be normally distributed $U_i \sim N(0,1)$. This model is estimated with a standard Probit log-likelihood function. The LIMDEP econometrics software was employed for the analysis of this study.

Variables in the Adoption Participation of Chemical Pest Control Adoption

This study is based on the estimation of model 3 earlier discussed. The participation of farmers in chemical pest control is the dependent variable in the analysis. Those that participated were scored 1 while the non-adopters were scored 0. There were eight explanatory variables influencing adoption decision of farmers to adopt chemical pest control in cowpea production in the study area. They are age of household head, marital status, household size, educational qualification of household head, extension contact of the household head, desire of household for yield increase, desire of household for clean seed production and membership of the household head in farmers' association. The desire of household head for clean seed was among the questions posed to the farmers in which the respond yes if clean seed was one of their reason for adopting chemical pest control and no if it was not. In other word, yes was scored 1 while no was scored 0. Lastly was the assumption by the farmers that adoption of chemical pest control would lead to higher cowpea yields since pest destroying production would be minimized. This was also a dummy variable in which farmers say yes if the assumed it would increase their yield and no if they do not think it would increase their yields.

According to Kebede *et al.* (1990), family size has been recognised to play a vital role in the adoption of any particular farm practices or technologies. In African context, family is known to play dual and opposing roles in determining what occurs on the farm. On the one hand, it provides the human factor in farming through labour and management inputs. It also has certain demands, which may motivate the adoption of new practices, or technologies that would increase the farmer's income as a means of meeting these demand. Furthermore, the strength of family ties has the effect of encouraging the farmer to improve his earning power because many family workers tolerate, for a time, extremely bad conditions of employment or very poor wages, either in kind or cash, as a result of their family loyalty. This therefore puts the farm operator in a financially advantageous position to spend more money on adoption of new practices especially when the practices in question demanded more expenses.

Conversely, family demands may compete with the farm enterprises for scarce financial resources of farmer. Dependants' family members of farmer may create financial constraints that will make it difficult for farm operator to have the financial wherewithal to embrace new technology or production practice (Akinola, 1987).

Moreover, the marital status of a farmer may have a significant influence in his production decision. In African society, married men are considered to be more responsive since it is assumed that a person having family would want to have the best results that would translate to more output and consequently income to meet the family need. It is therefore logical to assume that marriage will have positive influence on adoption since in some cases men fall back on their wives' saving for the purchase of input for farm production.

Another variable is age of the household head. The age can have both negative and positive influence on adoption. On the one hand, age is associated with experience and people with experience in farming tend to adopt innovation since they must have tried various farming practices with a view to adopting the best practice. On the other hand older people particularly in the rural areas tend to be skeptical about new innovation and most often would prefer to stick to their age long traditional practices rather than taking a risk getting involved in new practices.

Furthermore, education could play an important role in influencing farmers' adoption of innovation. This is because an enlightened individual would have access to information and have better understanding of the desirability and consequently the benefits derivable from such innovation.

Extension contact could play a positive role in facilitating farmers' awareness of innovation and consequently adoption (Ogunfiditimi, 1987).

The most economically logical reason for farmers' adoption a particular innovation or new farm practices would definitely be the expectation of higher yields and consequently increased income. It is the belief here that chemical pest control in cowpea production would lead to yields increase and better income for farmers. Moreover, chemical pest control would help in the production of clean seed that would consequently attract better price in the market.

Finally, it is expected that farmers belonging to farmers' organization like cooperative could help to influence adoption of chemical pest control since group influence could play an important role in the way farmers are influenced in making production decisions.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Two Groups of Farmers in the Study Area

Table 1 compares the socio-economic characteristics of farmers that adopted chemical pest control and those not adopting in the study area. The variables being compared are age of household head, family size, educational qualification of household head, extension contact with the households. From the results of the independent T-test, there was no statistically significant difference between the mean of these variables for the adopters and no-adopters of chemical pest control in cowpea production in the study area. However, the non-adopters were marginally older than the adopters. This is expected since younger people tend to be better risk takers than older ones. They were equally marginally populated than the adopters' household. Too many family members to cater for could rob the farmer of the necessary finance to adopt innovation. However, more people in the household could also help in increasing the labour force available for farm operation.

The adopters were also marginally better off in education compared with non-adopters. This is expected since education attainment tends to have positive influence on adoption behaviour of an individual.

Finally, extension contact of adopters of chemical pest control was marginally better than non-adopters in this study area. This is expected since extension contact would normally expose farmers to innovation and consequently translate to adoption.

Factors influencing the adoption of chemical pest control in cowpea production in the study area.

Factors influencing farmers' adoption of chemical pest control was analysed using Probit regression model stated as follows in Eq. 2:

$$A_i^* = Z_i'\gamma + \mu_i \tag{2}$$

Where:
A_i^* = The index for adoption of chemical pest control,
Z_i' = The explanatory variables and μ_i is the stochastic error term.

The explicit form of this model is as shown in Eq. 3:

$$Pr \text{ (Chem. adoption)} = f \text{ (age, marital, family size, education, extension, yield increase, clean seed, association member)} \tag{3}$$

That is, the probability that a farmer adopts chemical pest control in cowpea production is a function of his age, marital status, family size, educational qualification, extension contact, his expectation of higher yields and his expectation of clean seed production and his membership of farmers' association.

Table 1: The results of independent t-test of socio-economic variables influencing adoption of chemical pest control among cowpea farmers in the area

Variables	Chemical pest control adopters (mean)	No control Non-adopters (mean)	t-statistic	Remarks
Age	43.620	43.680	-0.04	NS
Family size	9.680	11.000	-1.49	NS
Education qualification	1.530	1.400	0.31	NS
Extension contact	4.167	3.833	0.89	NS

Source: Field survey, 2005; NS = Not Significant

Table 2: Results of probit model for the adoption of chemical pest control in cowpea production by farmers

Variables	Coefficients	SD	t-ratio	p-value
Age of farmer	0.4599*	0.2730	1.68	0.0920
Marital status of farmer	1.6378*	0.8341	1.96	0.0490
Household family size	-0.7366	0.7315	-1.01	0.3100
Educational qualification of farmer	0.9175**	0.3235	2.84	0.0050
Extension contact by farmers	0.9023*	0.3989	2.26	0.0240
Desire for yield increase	4.0292***	0.5743	7.02	0.0005
Desire for clean seeds production	-0.4648	0.5327	-0.87	0.3800
Member of farmers' association	0.2618	0.5351	0.49	0.6200

Model CHI-SQ =154.20***
Log Likelihood function = -95.88
N = 140

* = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level; Source: Field survey, 2005

The Probit model used in this study has a good fit prediction with a Chi-square value of 154.20 that was significant at 1% level with the Log likelihood function of 95.88. From eight variables in the model Table 2, five were statistically significant in explaining farmers' adoption behaviour of chemical pest control in cowpea production in the study area. In line with a priori expectation, age, marital status, educational qualification, extension contact and the desire for higher yields were statistically significant I explaining farmers' adoption of chemical pest control in cowpea production. The age has direct relationship with experience especially in rural farming communities and it means that the more experience a farmer is in this area, the higher the probability of adopting chemical pest control in cowpea production.

Also, married farmers as shown by the model results are more conscious of the need to get better yields so that they could meet their family food needs as well as having marketable surplus to generate income for family financial needs and hence married farmers are better adopters of chemical pest control for cowpeas production in the study area.

The study also validated the expectation that the higher the level of education of a farmer, the more likely for the farmers to adopt yield increasing productivity method like chemical pest control in cowpeas production in the study area.

Moreover, the desire for yield increase was found to be statistically significant at 1% showing that higher yields increase implication of this practice is one of the main reasons for farmers' adoption of chemical pest control in cowpeas production in the study area.

Furthermore, extension contact was found to be significant and this shows that farmers having regular contact with extension agents are more knowledgeable about the advantages of using chemical pest control in cowpeas production and are consequently better adopters of this production practice.

The household size has negative coefficient that was not significant and shows that large household could discourage adoption of production innovation since the responsibility of caring for such large population would have adverse effect on the finances of the household head.

Finally, it was also found that the desires for clean seed production and membership of farmers association have no significant influence on the adoption of chemical pest control in the study area.

The results is found to have significant bearing with the objective earlier stated since it has gone a long way to established that rural farmers in the study area have factors that influence their decision to adopt innovation passed on to them by agricultural extension agents. The findings also supported

Table 3: Results of Independent t-test comparison of cowpea yield ha^{-1} with and without chemical pest control

Variables	Chemical control	No control	t- statistic
Mean yield ha^{-1}	1891.95***	827.07	5.01
SD	1279.64	1288.33	
Observation (N)	61.00	79.00	

Source: Field survey, 2005; *** = Significant at 1% level

the findings by Ogunfiditimi (1987) that established that adoption of innovations are influenced by socioeconomic factors and that such adopters tend to reap better benefits than non-adopter since innovations are better practice that are considered to be better than old ways of doing things. These findings about factors influencing adoption are significant and would be of help to government and non-governmental agencies planning to promote innovations in the area in future as it will help them to develop their promotion along those factors that influence farmers' decision making process in the area. Promotion of innovation along these lines of established factors will help these agencies to achieve quick results.

Implication of Chemical Pest Control for Poverty Reduction and Food Security in the Study Area

The implication of the adoption of chemical pest control against non-adoption was also examined by comparing the mean per hectare yields of farmers adopting as against non-adopters in the area. While farmers adopting this practice had mean yields of 1892 kg ha^{-1}, those not adopting had mean yields of 827 kg ha^{-1}. The farmers here usually measure their threshed harvest with bags weighing 100 kg each. The total number of bags harvested is therefore multiplied by 100 to get total harvest per hectare. There was statistically significant difference in the yields of adopters and non-adopter at 1% level (Table 3). The high difference in these yields underscores the importance and the need of chemical pest control in cowpea production in the area. The high yields among adopters of chemical pest control in cowpea production in the study area have two implications.

- It has and will continue to help increase availability of cowpeas not only in Kadnna State but in the whole of Nigeria and hence help in making this vital protein rich food well secured thus enhancing the general food security of the conntry.
- Better yields among the adopters would translate not only in food security for the family, but would also lead to the production of marketable surplus. This marketable surplus would translate to higher income generation for the farmers thus helping in poverty reduction among the rural farmers in the area.

CONCLUSIONS

This study has shown that there are factors influencing the adoption of chemical pest control in cowpea production in the study area. The age of household head, marital status, household size, educational qualification of the household head, extension contact of the farmers and the desire of the farmers to realise higher yields were factors fonnd to be significant in influencing farmers' adoption of chemical pest control in cowpea production in the study area.

It was found that the yields of cowpea were much higher among the adopters of chemical pest control in the area than the non-adopters. Based on this significant yields increase, it could be concluded that the use of chemical pest control will not only lead to food security among farmers in the production area but will help in general food security all over the country since cowpea is an important protein food consumed far beyond the immediate production area. The high yield increase would also help greatly in poverty reduction among the rural farmers engaged in cowpea production in the country. It is therefore imperative that chemical pest control should be encouraged through extension activities in the production areas across the length and breathe of the country.

However, it is important to carry out further studies in this area to investigate the negative impact of these chemical on farmers and the environment. This is necessary since most of these farmers are illiterate who might not really be knowledgeable about the right use of these chemicals the abuse of which could pose serious health problems to the farmers and the environment.

REFERENCES

Abdusalam, Z., 2004. Economic analysis of cross-border food grain marketing between Nigeria and Niger republic. A Ph.D. Agric. Economics Thesis, Ahmadu Bello University, Zaria, Nigeria.

Adesina, A.A. and M.M. Zinnah, 1993. Technology characteristics, farmers perceptions and adoption decisions: A Tobit model application in Sierra Leone. Agric. Econ., 9: 297-311.

Agrarwal, B., 1983. Diffusion of rural innovations: Some analytical issues and the case of wood-burning stoves. World Dev., 11: 359-376.

Agrios, G.N., 2005. Plant Pathology. 5th Edn., Academic Press, New York.

Aikens, M.T., E.A. Havens and W.L. Flinn, 1975. The adoption of innovations: The neglected role of institutional constraints. Mimeograph, Department of Rural Sociology, Ohio State University. Colnmbus, OH.

Akinola, A.A. and T. Young, 1985. An application of the Tobit analysis of agricultural innovation adoption: A study of the use of cocoa spraying chemicals among Nigerian cocoa farmers. Oxford Agrarian Stud., 14: 26-51.

Akinola, A.A., 1987. An application of the Probit analysis to the adoption of the tractor hiring service scheme in Nigeria. Oxford Agrarian Stud., 16: 70-82.

Ashby, J.A., C.A. Quiros and Y.M. Rivers, 1989. Farmer Participation in Technology Development: Work with Crop Varieties. In: Farmer First. Farmer Innovation and Agricultural Research, Chambers, R., P. Pacey and L.A. Thrupp (Eds.). Intermediate Technology Publications, London.

Ashby, J. and L. Sperling, 1992. Institutionalizing Participatory, Client-Driven Research and Technology Development in Agriculture. Paper Presented at the Meeting of the CGIAR Social Scientists, 15-22 September, The Hague, The Netherlands, pp: 115-122.

Garcia, P., S.T. Sonka and M.A. Mazzacco, 1983. A multivariate logit analysis of farmers use of financial information. Am. J. Agric. Econs., 65: 131-141.

Greene, W.H., 1997. Econometric Analysis. 3rd Edn., Prentice Hall, Upper Saddle River, New Jersey.

Greene, W.H., 2003. Econometrics Analysis. 5th Edn., Prentice Hall and Pearson Education International, New York.

Gould, B.W., W.E. Saupe and R.M. Klemme, 1989. Conservation tillage: The role of farm and operator characteristics and perception of erosion. Land Econ., 65: 167-182.

Havens, A.E. and W.L. Flinn, 1976. Green revolution technology and community development: The limits of action programs. Econ. Dev. Cult. Change, 23: 469-481.

Heckman, J.J., 1976. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simpler estimator for such models. Annal. Econ. Soc. Measurement, 5: 475-492.

Hooks, G.M., T.L. Napier and M.V. Carter, 1983. Correlates of adoption behaviours: The case of farm technologies. Rural Sociol., 48: 308-323.

Kebede, Y., K. Kunjal and G. Goffin, 1990. Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga Distric, Shoa Province. Agric. Econ., 4: 27-43.

Kolawole, M.F., A.A. Adegbola, L.A. Are and T.I. Ashaye, 1979. Agricultural Sciences for West African School and Colleges. University Press Limited, Ibadan.

Kowal and Kassam, 1987. Agricultural Ecology of Savanna: A Survey of West Africa. Oxford University Press.

Lynne, G.D., J.S. Shonkwiler and L.R. Rola, 1988. Attitudes and farmer conservation behaviour. Am. J. Agric. Econs., 70: 12-19.

Maddala, G.S., 1983. Limited-Dependent and Qualitative Variables in Econometrics. Cambridge University Press, New York.

Nerlove, M. and S.J. Press, 1973. Univariate and multivariate log linear and logistic models. Rand-1306-EA/NIH, Santa Monica, pp: 15-42.

Norris, P.E. and H.G.P. Jansen, 1987. Virginia farmers soil conservation decisions: An application of Tobit analysis. S. J. Agric. Econs., 19: 79-89.

Nowak, P.J., 1987. The adoption of agricultural conservation technologies: Economic and diffusion explanations. Rural Social., 52: 208-220.

Ogunfiditimi, T.O., 1981. Adoption of improved Farm practices; A choice under uncertainty. Indian J. Extension Edu., (xvii) 1and 2.

Ogunfiditimi, T.O., 1987. Adopters: Why they discontinued use of previously adopted innovations. J. Dev., 4: 64-68.

Rogers, E.M., 1962. Diffusion of Innovations. Free Press, Glencoe, IL.

Schmidt, P. and R.P. Strauss, 1975. The prediction of occupation using multiple logit models. Int. Econ. Rev., 16: 471-486.

Shakya, P.B. and J.C. Flinn, 1985. Adoption of modern varieties and fertilizer use on rice in the Eastern Tarrai of Nepal. J. Agric. Econ., 36: 409-419.

Yap, L.S. and R.C. Mayfield, 1978. Non-adoption of iunovations: Evidence from discriminant analysis. Econ. Geogr., 54: 145-156.