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HOUSEHOLD SOCIO-ECONOMIC FACTORS AND SOIL FERTILITY MANAGEMENT ON MILLET FIELDS OF SOUTHWESTERN NIGER

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ABSTRACT

Declining soil fertility is a major threat to agricultural productivity and livelihoods in sub-Saharan Africa, particularly in Niger, where most farmers have few resources and depend on degraded lands. Large-scale adoption of soil fertility management technologies (SFMT) by small-scale farmers is among the proposed solutions, but this remains low because of various constraints. A better understanding of the socio-economic factors that influence farming practices is needed to adapt SFMT to farmers' use. A survey using semi-structured interviews with 101 household heads was conducted in 2013 in Karabedji, Niger. The influence of household socio-economic factors on soil fertility management practices (SFMP) was assessed through farmers that were involved in demonstration activities as part of a long-term research project (13 years) on the restoration of soil fertility on farmers' fields. The results showed that the farmer's household size was between 9 and 14 people and that the majority of farmers did not attain formal education. Fifty percent (50%) of the non-participating farmers and 69% of the participants of the demonstration were affiliated with farmers' organizations. The proportion of demonstration participants and non-participants having an average farm income of less than 300,000 FCFA (about US $ 600) was 70 to 75%. Logistic regression analysis showed a significant positive effect ($P < 0.05$) of affiliation in FBO on chemical fertilizer acquisition and use of other SFMP, while participation to demonstration activities and resource endowment was negatively associated with the purchase of these chemical inputs. Animal drawn cart possession and average farm income had a positive impact on farmers' SFMP. These results call for increased support towards all initiatives aimed at strengthening local farmer organizations and raising farmers' awareness, in order to improve farmers' access to inputs and use of the SFMT. Further investigations should also be focused on the influence of conditions that can motivate farmers to acquire inputs, such as fertilizer, at the times when they have the means and saving it for future use.

Key words: Livelihood, Farmer-Association, Resource-Endowment, Pearl Millet, Fertilizer, Soil fertility, sub-Saharan Africa

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RESUME

La baisse de la fertilité des sols est une menace majeure pour la productivité agricole et les moyens de subsistance en Afrique subsaharienne, en particulier au Niger, où la plupart des agriculteurs disposent de peu de ressources et dépendent de terres dégradées. L'adoption à grande échelle de technologies de gestion de la fertilité des sols (SFMT) par les petits agriculteurs fait partie des solutions proposées, mais reste faible en raison de diverses contraintes. Une meilleure compréhension des facteurs socio-économiques qui influencent les pratiques agricoles est nécessaire pour adapter SFMT à l'utilisation par les agriculteurs. Une enquête utilisant des entretiens semi-structurés avec 101 chefs de ménage a été menée en 2013 à Karabedji, au Niger. L'influence des facteurs socioéconomiques des ménages sur les pratiques de gestion de la fertilité des sols (SFMP) a été évaluée à travers des agriculteurs participant à des activités de démonstration dans le cadre d'un projet de recherche à long terme (13 ans) sur la restauration de la fertilité des sols dans les champs des agriculteurs. Les résultats ont montré que le ménage de l'agriculteur comprenait entre 9 et 14 personnes et que la majorité des agriculteurs n'assistaient pas à l'éducation formelle. Cinquante pour cent (50%) des agriculteurs non participants et 69% des participants à la démonstration étaient affiliés à des organisations d'agriculteurs. Les participants à la démonstration et les non-participants ayant un revenu agricole moyen inférieur à 300 000 FCFA (environ 600 USD) représentaient entre 70 et 75%. Une analyse de régression logistique a montré un effet positif significatif (P <0,05) d'affiliation en FBO sur l'acquisition d'engrais chimiques et l'utilisation d'autres SFMP, tandis que la participation à des activités de démonstration et la dotation en ressources étaient négativement associées à l'achat de ces intrants chimiques. La possession d'une charrette et le revenu agricole moyen ont eu un impact positif sur les SFMP des agriculteurs. Ces résultats plaident en faveur d'un soutien accru aux initiatives visant à renforcer les organisations locales des producteurs et à sensibiliser les agriculteurs, afin d'améliorer l'accès aux intrants et l'utilisation des SFMT. Les études suplémentaires devraient également porter sur l'influence des conditions susceptibles de motiver les agriculteurs à acquérir des intrants, tels que les engrais, au moment où ils en ont les moyens et qui les reserve pour une utilisation future.

Mots-clés: Subsistance, Organisation paysanne, Ressources, Mil, Engrais, Fertilité sol, Afrique Subsaharienne ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 20 No. 1 February 2020 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Soil fertility decline is a major concern in sub-Saharan Africa, particularly in Niger where agricultural activities generally depend on rainfall [1-4]. The rainfall pattern is unimodal and spread over a 3 to 4 month period (June- September). Poor fertility of the highly weathered and mostly sandy soils, where pearl millet (*Pennisetum glaucum*) is generally grown, combined with low input cropping, typical high rainfall variability and high temperatures lead to frequent and severe droughts which are responsible for recurrent crop failure [5-8].

Several studies have evaluated the potential of Soil Fertility Management Technologies (SFMT) to cope with the fertility problems in sandy soils [9]. These studies have shown that the application of inorganic and organic amendments in combination with soil and water conservation measures can significantly increase crop yields, while significantly improving soil fertility [1, 10, 11, 12]. However, there is a low adoption of SFMT by the predominantly peasant farmers, practicing low input agriculture, which continuously aggravates the soil fertility problem [5, 12,13]. A variety of constraints, that explain this poor adoption, has been unveiled in several adoption studies in sub-Saharan Africa [12, 13 – 16]. Poor mineral fertilizer use or application below recommended rates in Niger has been ascribed to limited access to credit, purchasing power and knowledge [13, 17, 18]. [13, 16] attributed low uptake of new technologies in West Africa to limited productivity gain and differences in priorities between the agronomists, whose aim is to improve yields, and the Sahelian farmers who seek to reduce the risk of crop failure. In the case of crop residue management, low adoption is due to competitive domestic use for animal feed, building material and fuel. Furthermore, crop residues are required in large quantities while the practice of continuous cropping does not generate enough to be used appropriately [19 – 22]. Limited availability of manure and lack of knowledge on water and soil conservation practices are the main reasons for poor technology adoption in Western Niger [12]. Similar reports from the eastern part of Africa indicated factors such as farmers' access to land and capital resources to be important determinants of decision to adopt Integrated SFMT or not [23, 24]. An adoption study in the Meru South District of Kenya noted farmers' ability to hire labour, age of household head, and household food security as important elements of soil fertility management [25].

Agricultural activities in Niger are known to be nutrient mining [5]. In such systems, more nutrients are being exported than applied, which leads to a complete loss of soil productivity. Nutrients that are exported as harvest and crop residues from the soils should be replenished in order to alleviate this problem [6]. To that effect, farmers traditionally use local strategies including long bush fallow, corralling, application of household and farm yard manure or application of crop residues [7]. However, due to high demographic pressure combined with other socio-economic and cultural beliefs such as uncontrolled grazing and farm fragmentation, some of these practices have been abandoned [8] and are replaced by unsustainable soil management practices that expose the soil surface, remove crop residues or resort to cultivation of marginal lands. These unsustainable practices lead to further degradation of soil physical quality including complete loss of soil structure, organic matter decline, leaching losses and surface sealing which ultimately leads to excessive run-off.

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There is still need for better understanding of socio-economic factors that enhance farmers' access to farm inputs and those that influence their ability to invest in fertility maintenance of their farms, for better targeting of future interventions. A long-term on-farm trial involving pilot farmers, aimed at identifying sustainability indicators and optimizing resources on soil fertility restoration, which has just been concluded and lessons learned on biophysical aspects [26] could be used. This could better help appreciate socio economic conditions affecting farmers SFMP. This could similarly help in devising appropriate and practicable soil management practices that can conserve soil and sustain crop production while replenishing and maintaining soil fertility. The objective of this paper was therefore to explore the influence of farmers' socio-economic conditions on soil fertility management and farm income among small-scale farmers in the study area. It was hypothesized that participation by farmer in project or farmer group activities, resource endowment and farmer SFMP are associated, and that participant farmers who are resource endowed use SFMP better than those that do not participate and are resource constrained.

METHODOLOGY

Description of the study area

The current study was carried out in Karabedji (13°16′ N, 2°30′ E) situated at about 60 km from Niamey in the Southwestern part of Kouré District (**Figure 1**). Kouré is in the Sahel Soudan agro-ecological zone, characterized by a 3 to 4 months growing season (from July to September) and a long dry season spanning October to June. Rainfall in the area is highly variable in time and in space [3] with a five-year average of about 550 mm. The dominant agricultural system is subsistence crop-livestock system, in which pearl millet is grown by farmers as a sole crop, in mixed cropping with sorghum, groundnut, and cowpea and in rotation with legumes (cowpea and groundnut). The dominant soil type is classified as Arenosol [27] or Psammentic Paleustalfs [28]. This soil type is characterized by coarse texture, high infiltration rate, low organic carbon content, low cation exchange and buffer capacities and low available phosphorus (P) and total nitrogen (N) contents [9].

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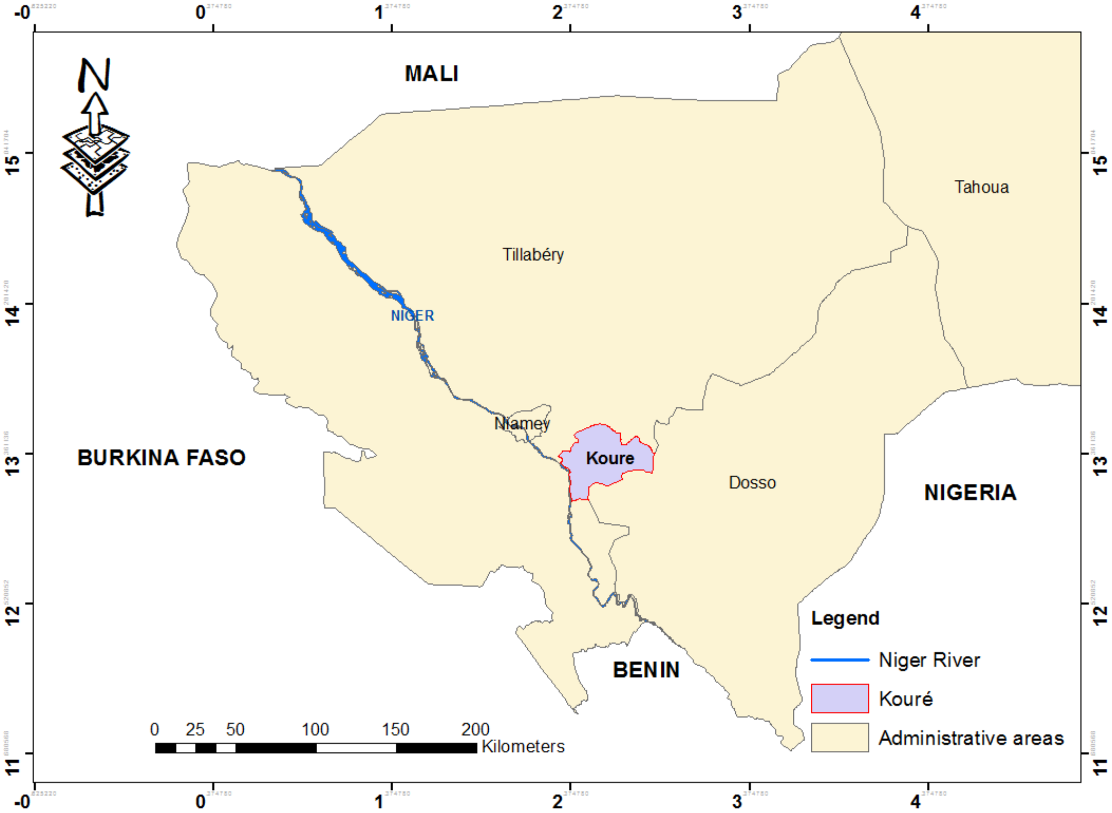

Figure 1: **Study area location in Kouré District, Niger**

Selection of respondents and sample size

The socio-economic survey was conducted between May and June 2013 to study the influence of some socio-economic factors on farmers' SFMP. General census records and key informants were used to randomly select non-demonstration participant respondents. Survey respondents included inhabitants of 5 neighboring villages namely, Seké Koira Zeno, Seké Koira Tegui, Gobriko Béri, Gobriko Zanguina and Karabedji.
The farmers from Karabedji village consisted of respondents who were either or not involved in a project dealing with a long-term on-farm demonstration (demo) for evaluation of soil fertility restoration technologies (SFRT). The aim of this long-term SFRT trial, initiated in 1999 on 23 famers' fields, was to identify sustainability indicators and optimize the use of both organic and inorganic resources available to famers. The trial consisted of millet cultivation under three different rates of fertilizer micro dosing and a control treatment (no fertilizer) on the farmers' fields. The fertilizer rates were: i) control (no fertilizer), ii) 4 kg P ha^{-1} as NPK 15-15-15, iii) 4 kg P ha^{-1} as DAP (Di-ammonium phosphate) and iv) 4 kg P ha^{-1} as NPK 15-15-15 + 13 kg P ha^{-1} PR (Rock phosphate).

Besides 17 out of the 23 farmers involved in the long-term on-farm trial (demonstration participants), 24 other farmers from Karabedji were interviewed together with 15 farmers from each of the four neighboring villages, making a total of 101 households. Population sizes in the survey-villages were about 6000, 2000, 1500, 1800 and 1900 people for

Karabedji, Seké Koira Tegui, Seké Koira Zeno, Gobriko Béri and Gobriko Zanguina respectively, according to local District office documents.

Data collection and processing

The survey was carried out using a semi-structured questionnaire with questions on individual and household information, farmers' resource endowment, SFMP and farmers' view about farming-related constraints and opportunities. The questionnaire was pretested one week before the survey. Questions on farm income and inputs seemed very sensitive to farmers in the locality, therefore farmers were asked to choose a range of income to which they belonged, as respondents hesitated during the questionnaire pretesting phase. Moreover, for comparison purposes, among respondents, the total number of animals and birds possessed by a farmer was expressed as Tropical Livestock Unit (TLU), where one TLU is equivalent to 250 kg of biomass [29, 30]. The conversion factors used were 0.7 for cattle, 0.5 for donkey, 0.10 for sheep and goat, and 0.01 for chicken and the calculation was undertaken following completion of the survey.

The total quantity of yearly-applied household manure was assessed through the number of carts of transported manure. Where farmers solicited corralling from Fulani herdsmen to settle on their farms (during the dry season) for manure, compensation in kind is given such as 100 kg bag of millet, sorghum or maize to the herder. Therefore, the equivalent value (in Fcfa) of the compensation given out by the farmer was used to estimate the cost of manure. The total household wealth (resource endowment) was estimated using the total value of animals and assets possessed as follows: cow = Fcfa 90,000, calves = Fcfa 60,000, donkey = Fcfa 40,000, sheep = Fcfa 25,000, birds = Fcfa 1,500, cart = Fcfa 100,000, radio = Fcfa 10,000, TV = Fcfa 40,000, bicycle = Fcfa 45,000, motorcycle = Fcfa 300,000 and barrow = Fcfa 35,000 [38, 39]

Data analysis

The survey data was analyzed using cross tabulation and logistic regression in SPSS (21st edition). The logistic regression indicates how independent variables (farmer's socio-economic characteristics) influence the probability of the application of different SFMP (dependent variables) in the study area. Likelihood Ratio (LR) tests are used to test the null hypotheses that there is no relationship between the log of odds of the soil fertility management practices and the set of independent variables included in the models.

RESULTS AND DISCUSSION

Characteristics of participant and non-participant respondents of the demonstration

The household characteristics of demonstration participants and non-participants are presented in Table 1. Although forty-three (43 %) of demonstration non-participants and 29 % of the participants of the on-farm evaluation of SFMT, respectively, did not attend formal school, an important part of participants and non-participants of the demonstration (53 % and 39 %, respectively) did Koranic studies. There is a high proportion of non-educated farmers, showing a low level of formal education of the farming communities in the study area which could affect the dissemination of SFMT as

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this can interfere with the learning process through extension materials as previously reported [31].

The mean household size among respondents ranged between 9 to 14 dependents. Niger has one of the world's highest childbirth rates (3.7 %) and has a fecundity of about seven children per woman [32]. However, despite the high birth rate and large household size, labour availability could be one of the main constraints to the adoption of new technologies. A local common practice in the study area is the seasonal migration to urban areas and neighboring countries. This has a direct effect on labour availability and contributes majorly to the household income and the remittance received from migrants is used to purchase farm inputs back home. The seasonal migrants furthermore do not return in time to provide help with the high labour demand for farm management operations such as planting and weeding at the beginning of the rainy season. This notwithstanding, innovative soil management technologies such as fertilizer micro-dosing technique generally requires more labour than the conventional practice.

Sixty nine percent (69%) and 55% of participant and non-participant farmers of the demonstration, respectively, were affiliates of FBO. Whereas, 70% of participant and 75% non-participant respondents had average farm income lower than Fcfa 300,000 (Table 1). Twenty nine percent (29 %) of demonstration participants had average farm income greater than Fcfa 300,000 compared to 24 % for the demonstration non-participants. The characteristics of both demonstration participants and non-participants were similar for other parameters.

All demonstration participant farmers used chemical fertilizer and 65% of them used crop residue (straw) mulch. However, more demonstration non-participant farmers use hand or hoe cultivation practice (Table 2).

Farmers' socio-economic characteristics and the application of different soil fertility management practices

Maximum likelihood estimates of parameters in the logistic regression models characterizing SFMP of demonstration participants and non-participants are presented in Table 3. The log likelihood tests showed that the estimated models, including the constant and set of explanatory variables, fit the data better compared with those containing the constant only. Therefore, there is a significant relationship between the logs of odds probability of using SFMP, and the explanatory variables included in the models. This relationship suggests that these variables contribute significantly, as a group to the explanation of SFMP of the sample farmers although several coefficients were not significant individually.

The R^2 values ranged from 40 to 84%, which also suggest that the estimated soil fertility-management models had a good explanatory power, particularly the one for the hoe cultivation method. Overall, the majority of variables had the expected signs of coefficients and those with unexpected signs were mostly statistically not significant (Table 3).

Of the independent variables, affiliation to FBO, average farm income and ownership of animal-draught cart had significant positive effects on chemical fertilizer use by farmers **(Table 3).** The first two variables were also found to be positively associated with the use of other special SFMP such as Zaï (planting pits) and treatment of erosion-affected areas on the farm.

Moreover, participation in demonstration activities, resource endowment, average farm income, and ownership of assets such as carts, motorcycle and bicycles were significantly associated with the purchase of chemical fertilizer. However, the negative association between participation in demonstration activities and resource endowment on one hand, and the purchase of chemical fertilizer on the other was surprising.

Furthermore, average farm income was significant and positively correlated with purchase, use of chemical fertilizer and straw mulch, and other special soil fertility management works. In addition, membership of FBO, possession of animal drawn cart, average farm income and education level were positively associated with straw mulching practice. Whereas, village status, amount of hired labour, ownership of animal drawn cart and resource endowment had a significant negative relationship with hoe cultivation practice. Among other variables that showed unexpected signs of coefficients are resource endowment, which had a significant negative effect on straw mulch application, and village status found to be negatively associated with cultivation practice and use of special SFMP.

The main findings of this study are in the relationship between participation in FBO and demonstration activities, possession of cart and average farm income and SFMT in the evaluation of socioeconomic factors influencing farmers' practices.

Affiliation to FBO was found to be significantly and positively associated with SFMP such as chemical fertilizer use, application of straw mulch and practicing other special work intended to improve soil quality. This positive relationship suggests that membership in FBO has influence on farmers' capacity to manage the fertility of their farm. Indeed, participation to FBO activities would not only improve farmers' awareness of farm inputs, but also enhances their skills through better access to technical know-how, training provided by projects and extension [33]. Farmers' associations serve as entry point for both public and other development agencies' interventions in rural areas. Moreover, FBO farmers get involved in other local initiatives that strengthen exchanges between members and thereby facilitate the passing on of information about new technologies or the availability of farm inputs among farmers. Accessibility to advisory services and farmers' perception on SFMT has been reported to impact sorghum production in Busia county of Kenya [34]. Earlier studies in Northern Ghana reported membership of FBO among several factors affecting fertilizer technologies adoption by farmers [35, 36].

The negative association between farmers' purchase of chemical fertilizer and participation in a particular project activity and resource endowment status is surprising and may be due to the fact that mineral fertilizer loans are supplied by the project during the demonstration activities. Actually, farmers involved in on-farm demonstration activities received some quantities of fertilizer supplied by the project as loans in order to enable adequate and timely application. As for the negative association between resource endowment status of the farmer and fertilizer purchase, it clearly illustrates the key role played by other behavioral factors [35]. Often farmers attribute their inability to purchase and use chemical fertilizer to the lack of purchasing power, which was earlier reported as a factor of fertilizer adoption [13]. Most farmers do not purchase and keep fertilizer when they have enough cash such as after selling their crop produce. Yet, Adolwa [36] noted that adoption is a nuanced process, which may require non-adoption, re- testing and continuous adoption.

Average farm income and possession of animal drawn cart also positively influenced purchase and use of chemical fertilizer meaning that farmers with high average farm income and those possessing cart are more likely to purchase and use it. Fertilizer price relative to millet price was reported among the major factors determining fertilizer use in the Sahel [17]. Farmers' resource endowment was previously reported to influence fertility status of the farm [37].

CONCLUSION

This study showed that farmers' socio-economic factors influence their SFMP. Affiliation to FBO was found to influence farmers' decision to purchase and apply chemical fertilizer, and their ability to use other soil fertility management practices such as straw mulch application. The results also highlighted the fact that farmers' demonstration participation and resource endowment status does not necessarily imply that they purchase and use mineral fertilizer. Yet, high average farm income of the farmer and possession of assets such as animal drawn cart were found to be positively related with SFMP tested. To enhance farmers' access and use of agricultural inputs such as fertilizer, policy efforts should not only focus on timely supply, but also on organization and awareness creation particularly conditions that will enable farmers to acquire fertilizer and keep it for future use, as they may not have cash during the planting season when they mostly purchase food. Further studies could also look at the benefit of such purchase ahead of time by farmers on their fertilizer use.

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Table 1: Descriptive information of participant and non-participant respondents of the demonstration

Characteristics	Statistics		
	Participants	Non-participants	Units
Number of respondents	17	84	Number
House hold size (persons)	13.65	8.98	Mean
Gender			
Male	100	98.02	Percentage
Female	0	1.98	Percentage
Educational Level			
No formal education	29.4	42.9	Percentage
Primary education	5.9	4.8	Percentage
Secondary education	5.9	2.4	Percentage
Koranic education	52.9	39.3	Percentage
Adult literate	5.9	6.0	Percentage
Affiliation to Farmer- Based Organization			
Members	68.8	54.8	Percentage
Non-members	31.3	45.2	Percentage
Assets			
TLU	0.83	1.2	Mean
Cart	0.88	1.52	Mean
Radio	0.82	0.64	Mean
TV	0.00	0.18	Mean
Bicycle	0.18	0.19	Mean
Motorcycle	0.00	0.02	Mean
Land Area	6.32	6.43	Ha
Wealth			
Total Estimated Household Wealth in Fcfa	725676.4	764391.4	Mean
Farm income in Fcfa			
< 100 000	29.4	16.7	Percent
100 001 – 300 000	41.2	58.3	Percent
300 001 – 500 000	17.6	14.3	Percent
> 500 000	11.8	9.5	Percent

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Table 2: **Descriptive information on soil fertility management practices among demonstration participant and non-participant respondents**

Items	Statistics		
	Participants	**Non-participants**	**Units**
Mineral fertilizer			
Use mineral fertilizer	100 (yes)	70 (yes)	Percentage
Organic fertilizer			
Use corralling	12 (yes)	18 (yes)	Percentage
Use straw mulch	65 (yes)	46 (yes)	Percentage
Method of cultivation			
Use hoe	31 (yes)	76 (yes)	Percentage
Use hoe and animal plough	69 (yes)	24 (yes)	Percentage

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Table 3: **Logistic regression, socioeconomic characteristics of farmers correlate soil fertility-management practices**

Independent variables	Dependent variables				
	Apply chemical Fertilizer	Purchase chemical fertilizer	Apply straw mulch	Use hoe cultivation	Apply special work
Village status	1.22 (0.94)[a]	1.01 (0.93)	- 0.47 (0.78)	- 6.23**(1.96)	- 2.98**(0.94)
Education level	0.04 (0.17)	-0.02 (0.18)	0.34* (0.18)	- 0.24 (0.31)	0.31 (0.19)
Participation to project	19.13 (8592)	- 6.53**(1.67)	- 0.33 (0.99)	0.32 (1.48)	- 1.41 (1.08)
Membership to FBO	2.26** (1.03)	1.83 (1.09)	2.51***(0.96)	- 1.05 (1.25)	3.24***(1.18)
Area	0.04 (0.14)	- 0.12 (0.09)	0.11 (0.09)	-0.08 (0.07)	0.23** (0.11)
Family size	0.05 (0.15)	0.02 (0.13)	0.23* (0.12)	- 0.47**(0.18)	0.02 (0.10)
Family labour	- 0.26 (0.26)	- 0.13 (0.24)	- 0.46 (0.30)	-0.18 (0.50)	0.11 (0.31)
Hired labour	0.41 (0.98)	1.47 (1.05)	0.78 (0.75)	- 3.91** (1.69)	- 0.15 (0.86)
TLU	0.10 (0.28)	0.40 (0.35)	0.11 (0.22)	0.48* (0.29)	0.05 (0.15)
Cart	1.50** (0.72)	1.67**(0.76)	0.63 (0.81)	- 3.38** (1.57)	0.40 (0.83)
Radio	- 0.51 (0.81)	- 0.98 (0.88)	1.34 (0.84)	- 0.08 (1.65)	0.19 (0.90)
TV	- 0.15 (0.75)	- 1.00 (0.86)	- 0.85 (1.15)	1.41 (2.07)	- 1.84 (1.33)
Bicycle	0.61 (1.08)	3.39**(1.51)	1.78* (0.91)	- 2.12 (1.66)	- 0.07 (1.01)
Motorcycle	0.13 (1.18)	2.77* (1.49)	- 1.55 (1.00)	3.49* (1.97)	- 0.82 (1.05)
Resource endowment	- 0.53 (0.98)	- 1.81* (1.04)	- 2.38**(1.13)	- 4.48** (1.85)	- 0.07 (0.99)
Average farm income	2.40* (1.34)	2.00* (1.18)	2.97** (1.18)	- 0.58 (1.56)	2.48** (1.10)
Constant	- 1.50 (1.11)	- 1.03 (1.05)	- 5.35**(1.51)	17.30***(5.22)	- 4.41**(1.46)
Likelihood ratio (LR) tests	69.65***	63.34***	68.84***	33.82***	66.60***
Nagelkerke R^2	0.58	0.69	0.66	0.84	0.57
Cox & Snell R^2	0.39	0.51	0.49	0.59	0.40

[a] Values in parentheses represent ± standard error; *P<0.10; **P<0.05; ***P<0.01

[b]TLU is Tropical Livestock Unit, where one TLU is equivalent to 250 kg of biomass. The conversion factors used were as follows: 0.7 for cattle, 0.5 for donkey, 0.10 for sheep and goat, and 0.01 for chicken

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