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Evaluation of Pearl Millet Fertilization Practices in the Fields of Farmers from Different Socioeconomic Categories in the Villages of Boussin, Djenné and Timissa in the Sahel Area of Mali

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ABSTRACT

One study was undertaken during 2010 and 2011 in 35% of the households in the Sahel area of Mali dispersed as follow: 98 in the site of Boussin, 71 in Djenné, and 80 in Timissa. Its objective was to point out pearl millet fertilization practices in farmer categories and to analyze reasons behind these practices. Results have shown 4 farmer categories (method of Barbara, 1988). Rich farmers are representing 5, 25 and 2% of households in Boussin, Djenné and Timissa respectively. Medium farmers are representing 4% of households in Boussin, 26% in Djenné and 29% in Timissa. Poor farmers involving more farmers are 91, 59 and 69% of households in Boussin, Djenné, Timissa respectively. The very poor farmers the last category identified in Boussin was representing 3% of households. Farmers have many practices of fertilizer applying in their fields. In Boussin, all the 4 categories of farmers are using manure in their fields. Rich farmers are applying in more, recommended rates of mineral fertilizers. Medium and poor farmers are applying micro dose of mineral fertilizers. Yield in rich and medium farmers' fields was 1 200 kg/ha. Poor farmers have produced 25% less than this group and the very poor 43% less than the poor. In Djenné, rich farmers are applying manure and recommended rates of mineral fertilizers that yielded 1 600 kg of grain/ha while medium and poor are applying manure and mineral fertilizer microdose. Medium and poor farmer have produced 56% less than the rich farmers. In Timissa, rich and medium farmers are using manure and mineral fertilizer microdose that yielded 1 500 kg of grain/ha. While poor farmers are using mineral fertilizer microdose only for 1 000 kg/ha. These results have moreover shown the increasing cost of fertilizer practices from poor to rich farmers. Rich farmers are expending more money in mineral fertilizers. While poor and very poor farmers are expending more in manure. Farmers are not endowed with factors and means of production like: number of active labors, bullock, land, fertilizers, education level and access to market. There are correlations between these different factors showing the vast intervention area of extension agencies.

Keywords

Categories, manure, mineral fertilizer, cost, correlation.

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Introduction

In the tropical semi-arid zone of West Africa, the agricultural sector is very important in the national economies. It accounts for 35% of the regional GDP and occupies 65% of the working population and is characterized by low productivity of farms and limited intensification of industrial crops (ECOWAS, 2006). Population and production increased by 2.4 and 1.95 times respectively, indicating strong population pressure on arable land (CILSS, 2012). In Mali, the economy employs 80% of the population and contributes 50% of GDP (Kieft *et al.*, 1994). Land used in agriculture, livestock and forestry is prone to degradation due to irrational exploitation, water and wind erosion (Consortium AGRACO, 2014). This degradation is also accentuated by the economic exploitation of soils: deforestation, agricultural clearing, overgrazing, land clearing for infrastructure construction and urbanization.

Harvesting crops and exporting crop residues result in an export of soil nutrients that are not replaced by adequate nutrient intakes. This leads to an impoverishment of the soils exploited by farms. Samaké and Kodio (2004) linked the decline in soil fertility to the abandonment of shifting cultivation, the abandonment of reduced fallow periods and the practice of cereal monoculture. Researchers Okalebo *et al.*, (2007), Gichangi *et al.*, (2007) and Tabo *et al.*, (2005) observed the decline in soil fertility at farm level in sub-Saharan Africa. To address this problem, national and international research institutions have developed farmer-scale fertilization strategies (Kihara *et al.*, 2008; Hayashi *et al.*, 2008). Many land fertilization techniques have been popularized. Despite this popularization, the problem of low soil fertility remains. Households practice fertilization techniques according to their

socio-economic conditions. Accessibility to land, work, capital, management strategy of family farming, commodity markets and processing, to activities that are not household, varies between households and within Of the same household.

Previous research has shown that the difference between socio-economic groups is fundamental in the smallholder community. However, many development and research programs continue to believe that peasants are the same in the same production area (Gradin, 1988).

In this research, we were interested in households producing millet in the same agro-ecological zone. We have worked on the following research questions: Does socio-economic status affect the practice of fertilizing fields? Soil fertilization practices differ from the rich to the poor, what are the mechanisms behind this? How are they related to access to land, labor, capital, livestock, household income?

Our objective was to highlight and analyze the practices of millet fertilization in the categories of farmers to see their adaptability at the household level.

Materials and Methods

Selection of sites

The three villages surveyed are all located in the Sahelian zone which covers an area of 320,000 km² (Ministry of Rural Development, 2002) with average rainfall ranging from 300 to 600 mm. The climate is characterized by a rainy season (June to September) and a dry season (October to May). The soil is sandy and there are places flooding in pockets of depression. The tree stratum is dominated by thorns such as *Acacia albina*, *Acacia nilotica*, Senegalese acacia.

The villages were selected because they are research villages of the AGRA Micro Dose Project (2009 AGRA SHP 003) in which interventions were made by other development agencies in the field of crop fertilization Mopti Rice, Regional Directorate for Agriculture, ICRISAT, NGO

Signokonjè, Syngenta Foundation for Sustainable Agriculture). The villages of Boussin, Djenné and Timissa are all in the intervention zone of the NGO EUCORD, one of the 4 NGOs that have implemented the AGRA Micro dose project.

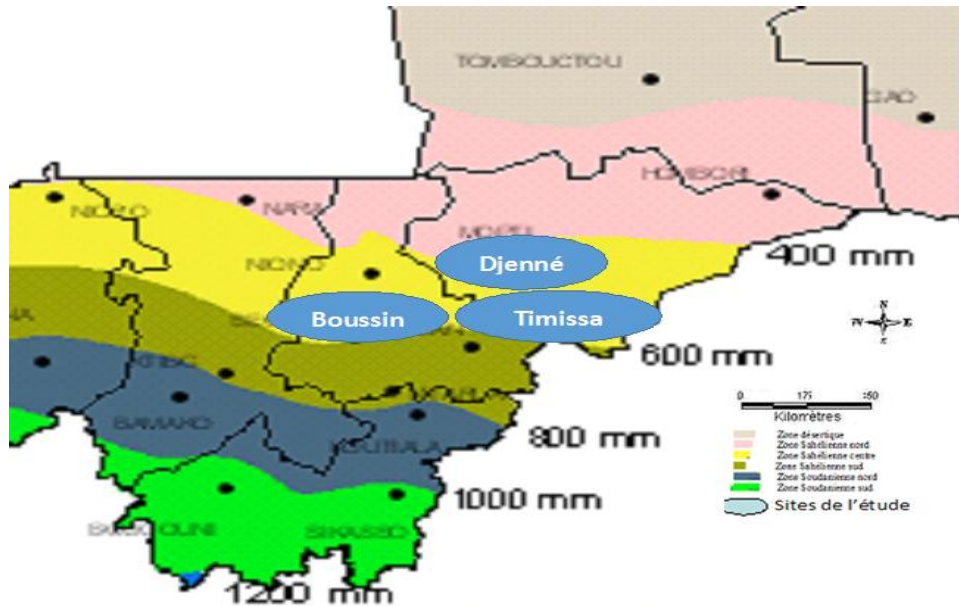


Figure 1 : Les sites de l'étude au Mali/Study areas in Mali (source : LABOSEP de Sotuba, Mali, 2000)

Method of data collection and analysis

Qualitative and quantitative methods of data collection were used. The Barbara method (1988) was used in the first part to categorize households because it is based on access and control of resources (land, labor, capital) that affect the adoption of new Technologies at the household level.

There were 710 households divided between 202 in Djenne, 280 in Segou and 228 in Timisa. From the list of households that is at the level of the rural communes, 35% of the households were drawn at random in each village. This was the case for 71 households in Djenné, 98 in Boussin and 80 in Timissa. Five persons with a good knowledge of households had to find in the local context of the village a definition of prosperity,

categories of households and criteria for classifying each household into its category. Then these people separately categorize households.

In the second part, a structured questionnaire was administered to the 249 selected households. The questionnaire included: identification of the site and farmer, education level of head of household, number of assets, number of working oxen, area in millet, methods of fertilizer supply to field crops, Existence of market, yield of millet field in 2010 and 2011.

The fertilization practices identified in the survey area were coded: (1) popularized dose (100 kg DAP / ha in bottom fertilizer + 50 kg urea / ha at runoff), (2) 50 kg (15K-15P-15K), (3) 50 farm manure carts (10,000 kg / ha) +

vulgarized fertilizer dose (100 kg / ha cereal complex + 50 kg urea / ha,) 30 fertilizer manure cartridges (6,000 kg / ha) + micro doses of cereal complex (2 g / pile or 31 lg / ha), (5) complex fertilizer (31 kg / ha or 2 g / (6) control: supply of 8 household waste carts / ha (1 600 kg / ha).

The scale for assessing the level of education was: (1) illiterate, (2) literate, (3) basic school, (4) Koranic school. The codification used in the field of market attendance was: (1) does not go to market, (2) irregular market attendance, (3) regular market attendance.

The statistical analysis of the variables and the illustration of results by tables and figures were made with INSTAT and Excel software. The economic evaluation focused on the analysis of variable loads in millet production in the field.

Results and Discussion

Criteria for classification of farmers

Table 1 shows several criteria contributing to household prosperity. These criteria can be grouped into 7 major groups: (1) possession of a factor of production: land capital that can be inherited or acquired, appears important in the categorization of heads of households (2) the management of this factor of Production: household heads are distinguished from each other by their way of managing their land capital

(3) meeting the basic needs of household members, which may be monetary, health, education, housing, food (4) the source of monetary income to cover these needs: small trade, market gardening, handicrafts, (5) use of household monetary income: investments in new housing, health, food, schooling, traditional ceremonies, purchase of agricultural equipment (6) the marital status

of the head of household: the confidence level of a household increases when the household has many married women (7) the managerial capacity of the head of household in the management of the fertility of the cultivated land of the household (Negotiating shepherds transhumant to park animals in the fields, exerting a direct or indirect influence on the local authorities in reaching the objectives of the household).

Among these criteria, there are 5 criteria common to the three villages: the total household population, the total area under cultivation, the food needs of the household by agricultural production, means of transport (bicycle, cart) and capacity to Help other households. The practice of Income Generating Activity, commercialization of agricultural production came out in Djenné a tourist site where households undertake commercial transactions in the weekly market. The departure of the able-bodied women in rural exodus is organized at the level of the household in the villages of Boussin and Timissa which practice only rain-fed agriculture on sandy soils. The second wave of young people only goes into exodus when the first is back.

These two villages are also important markets for small ruminants (sheep and goats). Households compete in the breeding of these animals. In Timisa there is a tradition of manure negotiation between transhumant breeders and indigenous farmers. The farmer and his animals camp in the farmer's field. The animals graze the crop residue and deposit excrement in the field whose well is used to water them. The village of Djenne practicing a rice cultivation of natural submersion offers good conditions of breeding of oxen. Oxen are raised for several reasons: labor power, manure production, feeding, money hoarding, social status enhancement.

Distribution of peasants between classes

The work of local resource persons revealed three large groups of households in the Djenné and Timissa sites (Table 2). The group of the rich peasants which counts 25, 5 and 2% of the households respectively in Djenné, Boussin and Timissa. The group of middle-income peasants comprising 26, 4 and 29% of the households of Djenné, Boussin and Timini. The group of destitute peasants constituting the bulk comprises 59, 91 and 69% of the households of Djenné, Boussin and Timissa respectively (Table 2). In Boussin, there is a very poor group of peasants (3% of households).

Characterization of peasant categories in land fertilization

Out of a total of 41 ha of land, 22 ha are used by rich farmers who use 30% of the workforce (Table 3). There is a strong and low utilization of wage labor among the rich and middle-income peasants, a weak and strong use of self-help work among poor and very deprived peasants. High-income farmers do not experience a shortage of grain for household food throughout the year, unlike peasants in other classes where the stock-out period varies between one and more than five months. Except for very poor farmers, all other farmers use mineral and organic fertilizers in different doses. The rich peasants have a great capacity for investment in agriculture. The level of prosperity of the household is high when one goes from the category of very deprived peasants to that of the haves and the household can invest more in the fertilizers, the new seeds.

Yield of millet

Boussin

Medium-sized and poor farmers use the same type of fertilizer (6,000 kg of manure / ha on

the surface before the first rains and 31 kg of cereal complex / ha during sowing). The rich farmers bring in their fields: 10,000 kg of manure / ha on the surface before the first rains, 100 kg of cereal complex / ha at sowing and 50 kg of urea / ha at the run (Table 4).

The very poor farmers bring to the field before sowing, 1,800 kg of household waste / ha collected through the village.

Fields of rich and middle-income peasants yielded statistically equivalent yields (1200 kg / ha). Poor farmers have produced 24% less than the poorest and the poorest 44% less than the destitute (Table 4).

Djenné

The field of millet of the rich farmers receives on the surface before the first rains 10 000 kg of manure / ha, 100 kg of cereal complex / ha at sowing and 50 kg of urea / ha during the run (Table 5). Farmers in the other two categories use the same manure (6,000 kg of surface manure before sowing and 31 kg of cereal complex at sowing).

The rich and medium-sized farmers produced identical yields (1,600 kg / ha). Poor farmers produced significantly less than the peasants in the first two categories.

Timissa

Two fertilization techniques are used by farmers (Table 6). These include the supply of 10 000 kg of surface manure before the first rains and 31 kg of cereal complex / ha at the seedlings of the rich and medium-sized farmers, the supply of 31 kg of cereal complex / ha Sowing among poor peasants.

The rich and middle-income peasants have identical millet yields of 1 500 kg / ha (Table 6). With 1000 kg of grain / ha, poor farmers

were significantly less productive than the first two categories.

Economic evaluation

The rich, medium-sized and poor have average investment in mineral fertilizer 25%, 12% and 23% of variable costs respectively. In the case of manure, rich, middle-income, destitute and very poor people invest 45, 55, 79% and 80% of the variable costs respectively (Table 7). Mineral fertilization takes more share in the variable costs in the households of the rich peasants. Whereas

when one goes from peasants to the very poor, the share of organic manure in variable costs is increasing.

Heads of households have a perception of the resemblance or the difference between their respective farm households. Criteria often varying between sites have emerged in household categorization. The Barbara method used for this purpose was used in a soil fertility management study in northeastern Zimbabwe (Carter *et al.*, 1993) and Mongolia (Mans *et al.*, 1992) in a study of the operation of farms Agro-pastoral.

Table.1 Criteria for peasant categorization of households in the study area, 2011.

Criteria	Djenné	Boussin	Timissa
Total population of the household	+	+	+
Number of plowed cattle and size of rest of flock	+		
Number of small ruminants		+	+
Total cultivated area	+	+	+
Satisfaction of household food needs by agricultural production	+	+	+
Means of transport (bicycle, cart)	+	+	+
Ability to help other households	+	+	+
Income Generating Activity (AGR)	+		
Practice of rural exodus		+	+
Capacity to negotiate partnership with transhumant herders for cattle manure			+
Commercialization of agricultural production	+		
Type of culture land inherited	+	+	

Table.2 Distribution of peasants among categories in survey villages in 2011

Categories	Djenné (n=71)	Boussin (n=98)	Timissa (n=80)
Secured(%)	25	5	2
Moderately affluent (%)	16	4	29
Disappointed (%)	59	88	69
Very poor (%)	-	3	-

Table.3 Characterization of peasant categories

Indicators	Secured	Moderately affluent	Disappointed	Very poor
Earth	10 Ha of land with 4 ha rented 8 ha of submersion rice	8 ha of land 4 ha of submersion rice	5 ha of exposed soil	2 ha of rented land rented
Workforce	12 people	17 people with the 1/3 practicing the rural exodus	8 people with more than half practicing rural exodus	3 people
Food self-sufficiency	No food shortages	1 to 3 months of food shortage	3 to 5 months of food shortage	More than 5 months of food shortage
Livestock	100 oxen 20 small ruminants	20 cattle, 30 small ruminants	15 small ruminants for women	5 small ruminants
Mineral fertilizers	Doses vulgarized 100 kg DAP + 50 kg Urea / ha	Micro dose: 31 kg / ha Complex Cereal	Micro dose: 31 kg / ha Complex Cereal	-
Organic fertilizers	Manure of stable + Compost (60 manure carts / ha)	Manure stable + Manure pit (30 manure carts / ha)	Manure Pit + Household waste (30 carts / ha)	Household waste (8 carts / ha)
Improved varieties	Improved varieties	Local varieties	Local varieties	Local varieties
Use of crop residues	Total export	Total export	Partial export	Partial export
Agricultural equipment	4 plows, 2 seeders, 2 carts, 2 threshers, 1 tractor	3 plows, 1 cart	1 plow	Manuals: daba, machetes, baskets and bicycle for transport
Sources of income	Sale of agricultural products, master koran, tractor rental	Small trade and market gardening Agricultural machinery rental	Rural exodus Wage labor Sale of charcoal	Donations and alms Farm worker

Table.4 Rendement de mil enregistré dans les différentes classes paysannes à Boussin.

Categories	Fertilization practices (*)	Grain of millet kg / ha		
		2010 (*)	2011 (**)	Moyenne kg/ha
Good	3 (0,63)	1148 (74,44)	1340 (121,5)	1244
Moderately affluent	4 (0,71)	1079 (64,47)	1425 (135,9)	1252
Poor	4 (0,15)	983,8 (21,06)	946 (29,65)	964.5
Very poor	6 (0,63)	600 (60,78)	740 (121,5)	670
CV%	32,9	18,9	27,9	

3 = 50 Farm manure carts + popularized fertilizer dose (100 kg / ha cereal complex + 50 kg urea / ha

4 = 30 Cartridges of farm manure + micro dose of cereal complex (2 g / poquet or 31 lg / ha)

6= Contribution of 8 household waste carts / ha.

CV= Coefficient of variation (... ..) = standard deviation of mean (*) = significant difference at 5%. (**) = highly significant difference at 1%

Table.5 Yield of millet recorded in the different categories of peasants in Djenne.

Categories	Fertilization practices (*)	Fertilizing practices Mill grain kg / hation (*)		
		2010 (*)	2011 (**)	Moyenne kg/ha
Good	3 (0,37)	1806 (44,41)	1494 (79,76)	1648
Moderately affluent	4 (0,46)	1445 (56,80)	1600 (99,15)	1522
Poor	4 (0,24)	1000 (35,60)	1051 (51,36)	1025
CV%	39,4	14,1	26,2	

3 = 50 Cartridges of farm manure + vulgarized fertilizer dose (100 kg / ha cereal complex + 50 kg of urea in a.

4 = 30 Cartridges of farm manure + micro dose of cereal complex (2 g / poquet or 31 lg / ha)

CV= Coefficient of variation (... ..) = standard deviation of mean (*) = significant difference at 5%. (**) = highly significant difference at 1%

Table.6 Rendement de mil enregistré dans les différentes catégories de paysans à Timissa

Categories	Fertilization practices (**)	Grain of millet kg / ha		
		2010 (*)	2011 (**)	Average kg/ha
Good	4 (0,32)	1750 (209,90)	1250 (284,5)	1500
Moderately affluent	4 (0,09)	1065 (87,52)	1652 (83,88)	1358.5
Poor	5 (0,06)	1150 (57,12)	1004 (54,25)	1077
CV%	9,2	36,4	33,6	

4 = 50 Cartridges of farm manure + micro dose of cereal complex (2 g / poquet or 31 lg / ha)

5 = Micro-dose of complex fertilizer cereal (31 kg / ha or 2 g / poquet)

CV= Coefficient of variation (... ..) = standard deviation of mean (*) = significant difference at 5%. (**) = highly significant difference at 1%

Table.7 Variable production costs in millet culture among farmers in the study area, 2011

	Categories									
	Secured			Moderately affluent			Poor			Very poor
	Coûts variables									
Villages	Boussin	Djenné	Timissa	Boussin	Djenné	Timissa	Boussin	Djenné	Timissa	Boussin
Fertilizer 190 F / kg	28500	28500	5890	5890	5890	5890	5890	5890	5890	-
Manure 750 F / cart	37500	37500	37500	22500	22500	37500	22500	22500	-	6000
Man input. Fertilizer 500 F / d	6000	6000	-							
Mechanical seeding 4000 F / d	8000	8000				-				
Sowing + Eng. Man. 500 F / d	-	-	6000	6000	6000	6000	6000	6000	6000	-
Seed treatment 1500 F / sachet	3000	3000	3000	3000	3000	1500	1500	1500	1500	1500
Manure spreading 1000 F / d	10000	10000	10000	8000	8000	8000	-	-	-	-
Total Variable costs FCFA / ha	93000	93000	62390	45390	45390	58890	35890	35890	13390	7500

At the level of the categories of households, the best yields of millet are obtained in fields where mineral fertilizer and manure are simultaneously supplied. The 50, 30 and 8 cartridges of manure are transported to the field during 45 and 25 days respectively before June, the first rainy season. Scattering the piles of manure in the field is a job for the children and it is the middle-income peasants who seem to be doing this work well with their more abundant family labor. There are correlations between certain factors. Wealthy peasants use more wage labor (Peasant classes x Number of assets, $R^2 = 0.5286$). Very poor and destitute peasants who do not mix fertilizer have the lowest yields of millet (Fertilization practices x Farmers' classes, R^2

$= 0,1152$). The size of livestock increases from destitute peasants to rich peasants (Peasant classes x Oxen, $R^2 = 0.7106$). The rich peasants are more regular and sell more products to the market than the other peasants. The income earned allows them to increase their investment capacity in the cultivation of millet (Farmers' classes x Market participation, $R^2 = 0.2052$). The simultaneous use of cereal complex and manure is common in households headed by neo-literates, former students (Fertilization Practices x Education Level, $R^2 = 0.0246$).

Our results show that all fertilizer recommendations offer real opportunities for improving the yield of small millet among

farmers in different categories. Behind these returns there is a whole set of factors on which the peasants must act. The capacity of farmers to act on these factors is not the same for all farmers (Woomer, 2007). It is strongly influenced by agro-ecological, socio-economic conditions, resources, knowledge and energy available on farms (IIED, 1995; Hiilhorst *et al.*, 1997).

In conclusion, the categorization revealed four socio-economic groups of farmers according to a dozen criteria: the haves, the wealthy, the destitute and the very poor. Each group of farmers was characterized and this made it possible to understand according to their endowment of resources, the choice and the practice of fertilization techniques in force among the peasants in each category. The peasants are in the habit of combining mineral and organic fertilizers in the field of millet. The yield of millet decreases from the peasant to the poorest peasants. Taking this information on agricultural households into account in agricultural extension programs will allow sustainable management of the fertility of millet growing areas in this agro-climatic zone.

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