IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 6, June 2015.
www.ijiset.com
ISSN 2348 – 7968

Participatory Rural Apraisal On Farmers Preferences Rice Varieties In Three High Alkalinity Zones Of Office Du Niger In Mali

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Abstract

Participatory rural appraisal was conducted in three highly alkalinized zones of Office du Niger. Two villages per zone were involved in the study. Fertilizer cost, water management, lack of agricultural materials and declining soil fertility were identified as the main constraints of rice production. Overall, alkalinity was the most important abiotic stress affecting rice production. Crop rotation, use of organic matters, plowing followed by flooding and use of tolerant varieties were the strategies developed by farmers to overcome alkalinity. Taste and swelling were important for home consumption and grain color and size for marketing were preferred traits. Kogoni 91-1, BG 90-2 and Adny 11 were farmer preferred varieties. Research priorities important to the farmers included alkalinity tolerance at seedling and reproductive stages combined with yield and taste or yield alone. Improvement of these characters in new varieties with alkalinity tolerance would enhance productivity with likely positive impact on small scale farmers' food security, incomes and livelihoods. Farmers had high interest in participatory varietal selection and participatory plant breeding.

1. Introduction

In Mali, rice is grown in every region of the country and is increasingly favored by consumers, primarily in urban zones but also in the rural areas where it is produced predominantly by resource-poor farmers. Rice production in Mali relies on large amounts of irrigation water and is the main reason for soil alkalinization in Office du Niger. Water, soil and fertilizer management are the main factors used as remedies to solve the alkalinity constraint, but they were and are insufficient. Little work has been done on breeding for tolerance to alkalinity. Breeding for alkalinity tolerance is, however, regarded as an important means of bridging the yield gap between potential and actual yield.

Inclusion of farmers in developing tolerant varieties is an important requirement. Farmers have preferences for varietal characteristics such as grain size and color, taste, cooking qualities and high yield. Consideration of farmer preferences in the varietal development process can help the breeders to select appropriate genetic materials (Witcombe *et al.*, 1996; Zhou *et al.*, 2013). Unfortunately, formal research systems in developing countries are highly centralized and do not target the problems of resource-poor farmers (Zhou *et al.*, 2013). It is important for breeders to clearly understand farmers' constraints and preferences for production, marketing and utilization of crop varieties they produce.

Therefore, to improve rice varieties grown by farmers for alkalinity tolerance, it is imperative that farmer's needs and preferences are understood for integration into the breeding programs.

Soil degradation through salts concentration is one of the major constraints for rice production but its current status is not well known and the factors that contribute to such constraints may not be known by farmers. Rice varieties that are released in Mali are mostly farmers preferred varieties, but sensitive to alkalinity stress. Tolerant varieties developed by Africa Rice (WARDA) and IRRI have low adoption by farmers and this could be attributed to the non integration of farmers' needs in the breeding programs.

In this study, a PRA was conducted to evaluate farmers' traits preferences, perception in relation to salts stress particularly soil alkalinity and crop management practices in Office du Niger rice production zones of Mali. Participatory Rural Appraisal was conducted in these zones to determine farmers' perceptions and preferences as well as management practices under alkalinity conditions that often occur. This enabled this study to determine ways of ameliorating effects of alkalinity and enhancing irrigated rice production in Office du Niger.

The specific objectives of the study were to:

- identify production constraints of rice farmers in areas with high soil alkalinity;
- assess the effectiveness of strategies adopted by farmers in their production environments;
- explore farmer's preferences and selection criteria for future varietal development.

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2 Research Methodologies

PRA approaches which lead to the interaction between breeders and farmers and mutual exchange of knowledge and experience were used to facilitate the interaction with farmers in three zones of Office du Niger in 2011. The aim was to identify farmer needs, preferences and the reasoning behind them.

2.1 Site selection

The PRA and survey were conducted in the Office du Niger regions of Mali. Three zones were chosen because they had high rates of degraded soils (alkaline) and also offer an opportunity for comparing farmer preference for rice varieties susceptible to alkalinity in irrigated ecosystems. The selected zones were: Niono, Molodo and N'Debougou. Two villages per zones were selected and focus group discussions and structured interviews were used as tools for PRA and data collection in each village.

2.2 Selection of farmers

Twenty farmers were selected from two villages in each zone of Office du Niger. In Niono zone, the study was conducted in Gnoumanke and Kolodougou villages, in Kangaba and Fabacoura villages in Molodo zone and Banissirela and Siengo in N'Debougou zone. In addition to the twenty farmers per village, one group of fifteen to forty farmers per village was formed for focus group discussions. These groups were selected based on their experiences with rice production in alkaline soil conditions.

2.3 Data collection

Different PRA techniques were used to obtain information about the farming problems, varietal selection criteria, research priorities and opportunities. A combination of three data collection techniques was employed. These included (1) semi-structured interviews for focus group discussion (FGD); (2) survey questionnaires for individual interviews (Appendix 3.1.); (3) and transect walks for field observation with the groups.

Semi-structured interviews were conducted with 10 rice growers from two villages in each zone. The discussions were followed by transect walks through the rice fields during which alkalinity problems and other biotic and abiotic constraints were identified and rated with the farmers' groups. Group discussions were held with a selected sample of 10 farmers in each zone to confirm results from questionnaires for individual interviews.

Rank matrices were drawn to rank the constraints. Individual farmers ranked biotic and abiotic constraints independently. The constraint with the highest score was considered the most important constraint. Transect walks in the fields of farmers were conducted and observations made. Different traits and plant characters that were considered by farmers in variety selection were recorded. In addition to providing information on variety preferences, special preferences of farmers were identified for home consumption and marketing.

2.4 Data Analysis

Data from questionnaires for individual interviews were coded and analysed using SPSS computer package (version 18.0). Average scores and average ranks were calculated for data obtained from both group discussions.

3. Results

3.1 Rice production constraints

Ten (10) constraints were identified as important in rice production zone of Office du Niger. Fertilizer costs were ranked as the most important constraint (15.22%) for farmers in rice production (Table 1). Water management (12.08 %) was ranked as the second most important constraint, followed by insufficient Agricultural materials (11.80%). Varietal quality was ranked low at almost all zones.

Eight causes of alkalinity were identified as being important in affecting rice production although their importance varied among locations. Nature of soil ploughing (22.5%) and sandy soils (21.4%) were identified by farmers as the first and second most important causes of alkalinity in Office du Niger (Table 2). Water quality (surface and ground) and non drainage of irrigated water were third and fourth alkalinity causes. At Gnoumanke, clay soils and poor drainage were the important causes besides nature of ploughing.

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Table 1: Rice production constraints and their relative importance

Constraints	N'Debougou[a]		Niono		Molodo		Average	Ranking
	Siengo[b]	Banissirala	Kolodougou	Gnoumankè	Kangaba	Fabacoura		
Fertilizer cost	11.29	12.63	18.29	17.54	16.09	15.50	15.22	1
Water management	12.60	11.61	9.03	14.45	16.09	8.68	12.08	2
* Insuf. agricultural equip.	11.29	9.78	12.83	14.45	13.79	8.68	11.80	3
Declining soil fertility	13.65	7.74	9.03	16.59	9.20	10.33	11.09	4
Land shortage	16.27	9.78	9.03	7.11	10.34	13.84	11.06	5
Disease	8.66	14.46	9.03	11.37	9.20	11.98	10.78	6
Seed cost	12.60	12.63	9.03	5.21	9.20	11.98	10.11	7
Delay in land preparation	3.67	8.76	10.93	3.08	3.45	10.33	6.70	8
Weeds	4.99	6.72	5.46	7.11	10.34	5.17	6.63	9
Varietal quality	4.99	5.91	7.36	3.08	2.30	3.51	4.52	10

[a] Zones, [b] Villages, *Insufficient of agricultural equipments

Table 2: Causes of alkalinity affecting rice production in Office du Niger

Causes of alkalinity	N'Debougou[a]		Niono		Molodo		Average
	Siengo[b]	Banissirela	Kolodougou	Gnoumanke	Kangaba	Fabacoura	
Continuous cropping	9.7	23.7	12.1	2.7	2.6	5.6	9.4
Water Quality	19.4	7.9	9.1	16.2	15.8	11.1	13.2
*Non-drainage of Irrig. Water	12.9	5.3	9.1	24.3	15.8	5.6	12.2
Clay soils	6.5	5.3	12.1	24.3	5.3	0.0	8.9
Sandy soils	12.9	21.1	21.2	2.7	26.3	44.4	21.4
Silt soils	9.7	10.5	6.1	0.0	2.6	0.0	4.8
Fertilizer application	3.2	10.5	12.1	8.1	0.0	11.1	7.5
Nature of soil plowing	25.8	15.8	18.2	21.6	31.6	22.2	22.5

*Non drainage of irrigated water: Surface and Ground water; [a] Zones, [b] Villages

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3.2 Strategies adopted by farmers in alkalinized affected soil of Office du Niger

In Gnoumanke, oil salt has the greatest impact of 46.2% and at Fabacoura black salt had 62.5%. Farmers' adopted various strategies for alkalinity impacts control including crop rotation (25%), use of organic matter (24%) and puddling followed by flushing (22%) (Table 3). The adoptions of the above strategies were higher than the use of tolerant varieties (17%) and pre flooding (12%).

Table 3: Farmers' strategies for alkalinity control across Office du Niger villages

Strategies	Percent
Puddling following by flushing	22
Pre-flooding	12
Use of organic matters	24
Crop rotation	25
Tolerant varieties	17

Kogoni 91-1 variety was selected by farmers as being tolerant to alkalinity in all villages except Kolodougou and Fabacoura (Table 4). On average, 19% of farmers selected Kogoni 91-1 as tolerant to alkalinity; and 66%, with a range of 54 to 76% did not consider any variety as being tolerant to alkalinity

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Table 4: Farmers perception of tolerant varieties to alkalinity in Office du Niger

	N'Debougou[a]		Niono		Molodo		(%)
Varieties	Siengo[b]	Banissirela	Kolodougou	Gnoumanke	Kangaba	Fabacoura	
Kogoni 91-1	24	33	0	22	35	0	19
Nionoka	0	0	23	0	0	0	4
Adny11	0	0	8	9	0	25	7
Nerica L2-IER	0	0	8	0	0	0	1
Gambiaka dian	0	0	8	0	0	0	1
Nerica7	0	0	0	0	0	8	1
no variety	76	67	54	69	65	67	66

[a] Zones, [b] Villages

3.3 Farmers' varietal preference and selection criteria

There were a number of rice varieties grown by Farmers in Office du Niger although they varied from one village to another (Table 5). Kogoni 91-1 was grown more than the others varieties. ''Nionoka'' with an average of 13.4% was also grown in all six villages.

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Table 5: Percentage of farmers growing different rice varieties in Office du Niger

varieties	N'Debougou[a]		Niono zone		Molodo zone		
	Siengo[b]	Banissirela	Kolodougou	Gnoumanke	Kangaba	Fabacoura	(%)
Kogoni 91-1	36.2	25.6	27.6	40.4	46.5	40.7	35.3
BG 90-2	5.2	1.3	13.8	12.3	0.0	11.1	6.2
Sambala	19.0	10.3	0.0	10.5	0.0	14.8	9.9
Nerica L2-IER	0.0	9.0	3.4	1.8	0.0	0.0	3.1
Nerica L1-IER	0.0	1.3	0.0	0.0	0.0	0.0	0.3
Nionoka	24.1	5.1	41.4	7.0	4.7	11.1	13.4
Telimani	0.0	0.0	0.0	8.8	0.0	3.7	2.1
Wassa	5.2	21.8	0.0	5.3	18.6	18.5	12.3
Adny11	8.6	25.6	13.8	14.0	30.2	0.0	17.1
ECIA	1.7	0.0	0.0	0.0	0.0	0.0	0.3

[a] Zones, [b] Villages

Across the six villages, taste and swelling after cooking (30.9%) were more appreciated by farmers than other attributes (Table 6). Taste (21.8%), swelling after cooking (20%) and the storage after cooking (15.5%) were identified by farmers as good criteria for rice preference for home consumption.

Table 6: Criteria for selecting rice for home consumption

Consumption criteria	Percent
Ability to store	15.5
Swelling after cooking	20.0
Taste	21.8
Swelling after cooking and storing	10.9
Taste and swelling after cooking	30.9
No response	0.9

For preference for marketing, grain colour and size were identified by farmers as most important (Table 7). For color, white (57.3%) and the white yellowish (26.4%) were preferred by rice buyers in the market. The long slender grain and less breaking were identified by 90% of farmers as rice buyer's preference in the market.

Table 7: Attributes of grain considered by farmers for selection for the market

Grain color	Percent
White bluish	3.6
White yellowish	26.4
White	57.3
White greenish	2.7
No response	10.0
Grain size	
Long slender and less breakage	90.0
Medium and less breakage	0.9
No response	9.1

3.4 Farmer priorities for research needs

Table 8 shows farmers' suggestions on what traits they preferred to be incorporated into rice varieties. A total of 58.2% of the farmers interviewed wanted vegetative tolerance to salts and spikelet fertility, 13.6% wanted yield and taste, 10% wanted yield and 13.6% did not suggest any specific trait.

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Table 8: Farmers' preference for rice traits in Office du Niger

Suggested traits	Percent
Vegetative and spikelet fertility tolerance	58.2
Yield	10.0
Taste	.9
Yield and taste	13.6
Avoid lodging	.9
Swelling	1.8
Store after cooking	.9
No proposition	13.6

4. Discussions

A number of factors were listed as constraints to rice production across the three zones in Office du Niger. These included fertilizer costs, water management, insufficient agricultural equipment, declining soil fertility and land shortage. These constraints are in agreement with a previous survey conducted in 1995 (Ouvry *et al.*, 1999). In that study, the nature of plowing the soil was the most important cause of alkalinity curtailing rice production in Office du Niger, followed by sandy soil type, water quality and non drainage of irrigated water. In this study, differences were observed in ranking the causes of alkalinity across the three zones. In N'Debougou and Niono, nature of plowing the soil was the number one cause of alkalinity. This could probably be attributed to three factors. The first one is the impact of cropping systems (Bagayoko *et al.*, 2010). Most farmers have continued to use the local plow for rice field plowing and this is unable to level the soil surface efficiently. It creates shallow areas in the field where salt concentration is high. This situation can explain the constraint of insufficiency of agricultural equipment mentioned by farmers. The second factor is the effect of soil types on evolution of water table in terms of dynamics and quality (Bagayoko *et al.*, 2010; N'Diaye, 1998; Ouvry *et al.*, 1999). The soil type in these two zones is largely clay soil. Sodicity and alkalinity are environmental factors that greatly affect plant growth and development in clay soils. Harmful high alkalinity is related principally to the presence of sodium carbonate and sodium bicarbonate (Bagayoko *et al.*, 2010; Ouvry *et al.*, 1999). Accumulation of these salts in the soil and soil water occurs when groundwater with a high content of bicarbonate ions evaporates. Initially, calcium and magnesium carbonates precipitate upon evaporation, immobilizing part of bicarbonate ions. If excess bicarbonate is present (called residual alkalinity), high pH values will develop, even at initially low concentrations of sodium carbonate. In strongly alkaline soils, sodium carbonate and bicarbonate become prevalent salts, and sodium will replace calcium and magnesium in the clay complex (sodic soils). This leads to the formation of sodium clays; those are strongly dispersed and highly impermeable to water. The third factor is the lack of tolerance to alkalinity in improved rice varieties being grown. Alkalinity has been an abiotic stress of importance in Office du Niger but there has not been any active breeding programme in Mali specifically addressing tolerance to alkalinity stress. The environmental conditions in the breeding area have not favored the selection for tolerance against alkalinity. Hence most of the materials released do not have the genetic tolerance against soil degradation by alkalinisation.

Soils of irrigated areas in Sub Sahara African countries have continued to be degraded as a result of poor irrigation management practices. In the Office du Niger zones, for example, producers and extension workers are concerned about emerging soil degradation symptoms such as salinisation/alkalinisation or sodisation. Whereas the above problems require urgent attention, the phenomenon has been treated as localised and therefore not very important. From 1995 to 1999, studies were conducted by "Pole regional de recherche sur les Systèmes Irrigués (PSI)" which was a regional networking project, to determine the nature, importance and dynamics of soil degradation processes in irrigated zones of Mali. The results clearly show soil geochemical changes of the irrigated areas (Marlet *et al.*, 1998). However it is important to note that, during these studies, the breeding program was not included and this could be the main reason for the lack of rice genotypes tolerant to alkalinity, although all rice varieties produced are improved for yield, grain quality and taste.

Alkalinity tolerance is a polygenic trait acting both additively and with interactions between the alleles at some loci (Singh *et al.*, 2001), which implies that there will always some symptoms even when improved materials that carry the tolerant genes are used. For farmers, most improved varieties suffer alkalinity damage and among them Kogoni 91-1 is considered as tolerant to alkalinity by 19% of farmers.

All seeds for sale by certification systems are considered as commercialized seeds in Mali (Dembélé, 2006). The seed that is grown for many years and not renewed is also considered as commercialized seed. Often the commercial seed producers don't observe the precautions that require the maintenance of the purity and the genetic identity. As a result, the commercialized seeds of most of the varieties are not genetically homogeneous. By selecting for seeds from uninfected rice plants, farmers tend to accumulate susceptible materials hence increasing alkalinity damage.

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Most released varieties grown by farmers were not improved for salinity and alkalinity tolerance and could have a negative impact with alkalinity problems.

Degradation control methods being employed by the farmers are limited and consist of crop rotation, use of organic matter, puddling followed by flooding and use of tolerant varieties. Many do not practice any control method, either because they lack knowledge on control technologies, or they could not afford to use chemical control.

For alkalinity, the effectiveness of these control methods depends on a number of factors including, soil and irrigated water management, crop growth stage at which the susceptibility of plant is shown and the genetic make-up of the plant variety in question. Rice is more sensitive to salts during early seedling stage than at reproductive stages (Flowers and Yeo, 1981). Practices such as pre-flooding, puddling, flushing and use of chemical and organic matters could help control yield reduction (Dicko, 2005). A more effective and practical solution for subsistence farmers is high yielding rice varieties that are tolerant to alkalinity stress (Singh and Flowers, 2010).

Farmers' preferences when choosing varieties for market and home consumption differed. Farmers identified taste and swelling after cooking as important criteria for home consumption and grain colour and size as criteria for market.

In comparison to many other nationalities in West Africa, the majority of Malian consumers prefer local rice over the imported rice, due to its preferred taste and swelling after cooking (IFDC, 2008). The most popular domestic rice variety is the Kogoni 91-1 variety, which is the dominant variety produced in the control irrigated areas. This variety is more appreciated by urban consumers because of its taste and aroma. However BG 90-2 variety is more preferred by rural consumers for its swelling. These two varieties are improved varieties released by Irrigated Rice Programme of National Institute Research of Mali. It is important to note that these two varieties are susceptible to alkalinity stress and to Rice Yellow Mottle Virus (RYMV) disease.

Standards for grain size and shape differ among countries, although the Food and Agriculture Organization (FAO) has developed international standards. Translucency and color are affected by environment and their assessment is largely subjective. For marketing of milled rice, grain color and size were the criteria identified by farmers as attractive to rice traders in Office du Niger. The white color was preferred by majority of farmers as criteria for selling rice to the traders. White, long and slender grain rice is more preferred by Malian consumers (IFDC, 2008; USAID, 2007). There is a positive correlation between grain length and grain shape (Gupta *et al.*, 2006) suggesting that breeders could select for both traits simultaneously, or they could choose one of the traits to indirectly select for the other. Grain size is usually evaluated by two criteria: grain weight and shape (Fan *et al.*, 2006; Tan *et al.*, 2000). Grain weight and grain shape (length, width, length/width ratio) are positively correlated characters (Fan *et al.*, 2006).

Besides taste and swelling after cooking for home consumption and grain colour and size for market, farmers have some other preferences that were identified by the survey. These included vegetative and spikelet fertility tolerance to alkalinity, a combination of yield and taste and yield alone. There is need to integrate such special farmer preferences into selection criteria. Involvement of farmers in varietal selection would help bridge the information gap between farmers and breeders. It has been reported that farmers grow the same varieties for long periods of time. This could probably be because they have failed to find new varieties with special qualities they desire.

Farmers' preferences for home consumption were different from preference for market consumption. In this regard, different breeding objectives should be formulated with input from the farmers to address these special preferences.

Compared with conventional plant breeding, PPB is more likely to produce farmer-acceptable products, particularly for marginal environments. While meeting the farmers' needs requires continuous engagement of the farmers in the breeding process, the reality of this remains a frightening task to breeders. On the other hand, when a variety fails to meet farmers' needs during participatory varietal selection (PVS), farmers will not adopt it and the effort and resources spent will have been wasted.

5. Conclusion

The survey revealed four dominant factors as rice production constraints, namely fertilizer cost, water management, agricultural materials insufficiency, and declining soil fertility. The combination of the four factors constitutes the main cause of soil alkalinisation in Office du Niger. Overall, alkalinity was the most important abiotic stress for rice production. The type of alkalinity varies from village to village and from zone to zone, however the white salt was more common. To overcome alkalinity constraints, farmers have developed some strategies like crop rotation, use of organic matters, plowing followed by flooding and use of tolerant varieties. The absence or weakness of a breeding programme for alkalinity tolerance was apparent. Farmers have a basic preference for taste and swelling for home consumption and grain colour and size for marketing. Research priorities, as perceived by the farmers, included alkalinity tolerance of vegetative and spikelet fertility combined, combination of yield and taste and yield alone. Farmers had high interest in participatory varietal selection and participatory plant breeding.

ISSN 2348 – 7968

6. Acknowledgements
This work was co-supported by University of Ghana and Rural Economy Institute of Mali through the study grant through West Africa Center for Crop Improvement (WACCI) offered by AGRA (Alliance for Green Revolution in Africa) which provided.

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