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Smallholder Farmers' Knowledge, Perception and Management of Rice Blast Disease in Upland Rice Production in Tanzania

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Abstract

The objective of this paper was to investigate farmers' knowledge and management of rice blast disease in Tanzania. Farmers' household survey was conducted in five districts namely Mvomero, Morogoro rural, Ulanga, Korogwe and Muheza in April and May 2017. Data were collected through face-to-face interviews using semi-structured questionnaire and observations made through transect walks across selected villages. Farmers observed symptoms of rice blast disease for the first time in the past 3 to 10 years, with higher severity of blast disease in April to May each year. About 46.3% of the respondents were not aware of the cause and spread of rice blast disease. About 39.9% of the respondents associated rice blast disease with drought, high rainfall and temperature (8.7%) and soil fertility problems (5.1%). About 18.7% of the farmers reported burning of crop residues, 17.0% use of ash, 4.0% use of nitrogen fertilizer and 6.3% application of fungicide for management of rice blast disease. The majority (54.0%) of farmers did not apply any management method. Most farmers planted local upland rice varieties, with only 7.7% using improved varieties. About 69.6% of the respondents shared information on disease management among themselves. Lack of knowledge, ability to afford and unavailability of effective blast disease control methods were reported to affect the management of the disease. Strengthening the capacity of farmers to identify the disease and proper management practices will sustainably solve the problem of rice blast disease in upland rice production.

Keywords: farmers' perception, *Oryza sativa*, *Pyricularia oryzae*, rice blast, Tanzania

1. Introduction

Rice (*Oryza sativa* L.) is the second most widely cultivated and consumed staple crop and cash grain after maize (*Zea mays* L.) (Mghase et al., 2010). In Tanzania, the average yield production is 2.4 t/ha and 3.0 tons/ha for local and improved varieties, respectively (Lwezaura et al., 2011). The rice yield in Tanzania is lower than that from other countries in Africa (4.4 tons/ha and 3.4 tons/ha from Madagascar and Benin) respectively, (FAOSTAT, 2016). Rice diseases, use of improper agronomic practices, drought, low yielding varieties, soil infertility and lack of knowledge on good agronomic practices by farmers contributed to low grain yield (Lwezaura et al., 2011; Chuwa et al., 2015). Among these constraints, rice blast disease caused by *Pyricularia oryzae* Cav. is an important disease that causes yield loss of 10 to 100% (Chuwa et al., 2015; Velusamy, 2008; Hai et al., 2007).

Persistence of the disease is attributed to lack of knowledge on how the diseases are transmitted, their infection cycle and farmers perception on synthetic pesticides as the only option to control disease (Schreinemachers, et al., 2015). The majority of smallholder farmers did not adopt recommended cultural and chemical management practices due to the high cost of implementation or ineffectiveness of the method. Furthermore, during the development of technology, farmers' knowledge and perception were neglected (Roling & Fliert, 1994). The great success of farmers' involvement in the development of technologies has been reported (Adesina et al., 1994;

Roling, & Fliert, 1994; Traoré et al., 2015). Traoré et al. (2015) reported the role of integrating farmers' knowledge with the modern technologies in disease management.

Despite the importance of farmers' knowledge on disease management in rice, there is scanty information of this knowledge in Tanzania. Assessment of rice production constraints, farmers' perceptions of rice blast disease and farm management practices is essential in designing appropriate control options that meet farmers' needs. An important component in achieving these objectives is insight into farmers' knowledge of the disease and farm practices influencing the disease. This study, reports on farmers' perceptions of rice production constraints, with reference to rice blast and farm management practices affecting the disease in upland rice in Tanzania.

2. Methods

2.1 Description of the Study Site

The study was conducted in Morogoro and Tanga regions in Tanzania. These regions represent areas where upland rice production is constrained by rice blast disease (Figure 1). Mvomero, Morogoro rural and Ulanga districts represented Morogoro region. These districts are located at 6°49′15″S and 37°39′40″E, 6°14′8.22″S and 38°41′37.49″E, and 9°00′00″S and 36°40′00″E, respectively, with an altitude of 500-1500 m above sea level. The sites are dominated by soil of various types and characteristics due to variation in topography and ecological zones. In these areas, Oxisols dominated in the mountainous and hilly, and alluvial soil in valley and low lands. Sandy and clay soil dominated in the woodlands and grassland areas. The area experienced a bi-modal rainfall (seasons) with long rains in March to May and short rains in November to January. Average annual rainfall is 800 mm to 1600 mm with a mean temperature ranging from 18 °C in June to 26 °C in October.

Tanga region was represented by Korogwe and Muheza districts. The districts are located at 5°00′00″S and 38°25′00″E (Korogwe) and 5°00′00″S and 38°55′00″E (Muheza) with an altitude of 200-1200 m above sea level. The area experience warm weather with average temperatures of 24-28 °C in May to October and 28-30 °C in December to March. The area experiences two rain seasons, the long season from February to May and the short rains in October to December each year. Soil characteristics varied from low fertility with medium water holding capacity to medium fertility with high water holding capacity.

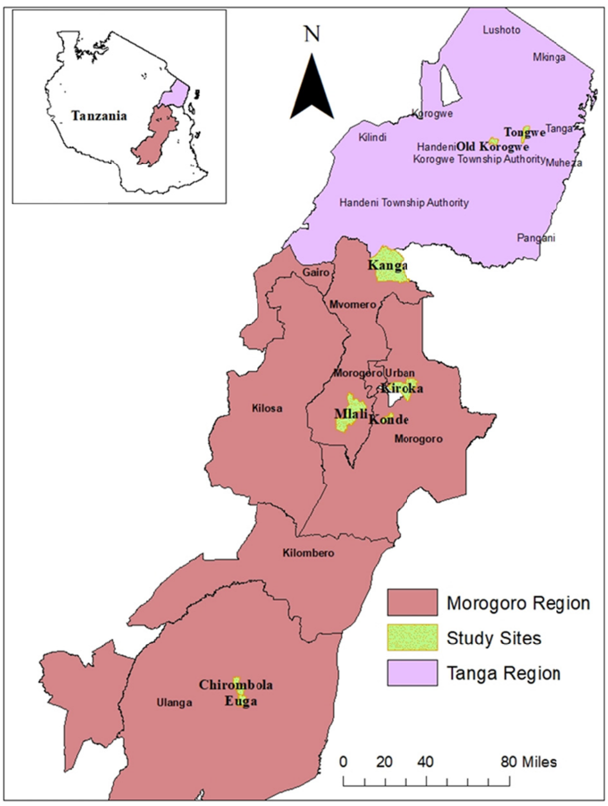

Figure 1. The map of Morogoro and Tanga regions showing the study areas

2.2 Sample Selection

Interviewed farmers were selected using a multi-stage random sampling procedure (Schreinemachers et al., 2015). In Morogoro region, three districts (Mvomero, Ulanga and Morogoro rural) and Tanga region two districts (Muheza and Korogwe) were selected. These districts were selected based on their long history of upland rice production. The district's administration was contacted to select villages where upland rice was widely grown. In each district two villages were purposively selected, namely Kanga and Mlali (Mvomero), Diovuva and Rusiwa (Morogoro Rural), Chirombola and Euga (Ulanga), Old Korogwe and Lwengela (Korogwe) and Tongwe and Masimba (Muheza). The sample size (n = number of farmers to be interviewed) was determined using the formula suggested by Wonnacott & Wonnacott (1990) (as cited in Mghase et al., 2010).

$$n = \frac{Z^2 p\,(1-p)}{Q^2} \quad (1)$$

Where, n = required sample size, Z = confidence level at 95% (standard value of 1.96), p = estimated proportion of an attribute (percent of farmers in population), estimated at 90% and the Q = margin of error at 5% (standard value of 0.05). Therefore, the number of farmers interviewed were determined as shown below:

$$n = \frac{Z^2 p\,(1-p)}{Q^2} = \frac{(1.96)^2(0.9)\,(1-0.9)}{(0.05)^2} = 138.297 \approx 138 \quad (2)$$

One hundred thirty eight (138) farmers in ten villages. Fifteen farmers per village were chosen in Mvomero, Morogoro rural and Ulanga districts and 12 farmers per village in Korogwe and Muheza districts.

2.3 Data Collection

Data were collected through face-to-face interviews and observations made through transect walks across selected villages. The semi-structured questionnaire was prepared based on factors related to farmers' preferences in rice production, production constraints, rice blast disease infestation, and control practices. To assess farmers' perception of rice blast disease, respondents were shown a series of colored photograph of rice plants with rice blast disease symptoms (Schreinemachers et al., 2015). Colored photographs of rice plant with symptoms of rice brown spot and rice yellow mottle virus disease were included in the list to avoid confusion as these diseases have similar symptoms as rice blast disease. The data collected included farmers' socioeconomic profiles (*e.g.* age, gender and education), farm characteristics, knowledge and perceptions of the blast disease and their management practices.

2.4 Data Analysis

Quantitative and qualitative data collected through the questionnaire, were coded and subjected to statistical analyses using the Statistical Package for Social Sciences software (IBM SPSS Statistics 21). Cross-tabulations tables were constructed and descriptive statistics were calculated to summarize data from the questionnaires. To make statistical inferences, contingency chi-square tests were computed at $P \leq 0.05$ levels of significance to analyze relationships between variables. This allowed empirical analyses and description of associations between the collected parameters across the three study districts.

3. Results

3.1 Description of Households and Their Demographic Characteristics

Among the respondent interviewed, about 58.5% were male and 41.5% female. Their ages ranged from 20 to 69 years. Significant differences ($\chi^2 = 26.301$; P = 0.01) were observed among respondents on the level of education. About 89.5% of the respondent were completed primary education; however, 3.3% had secondary education (Table 1). The majority of the interviewed farmers have worked on rice production for 3 to 10 years, however, their experience on rice farming did not differ significantly ($\chi^2 = 9.51$; P = 0.656). Their average land unit devoted to rice production ranged from 1 to 2 ha (Table 1).

Significant differences ($\chi^2 = 6.301$; P = 0.178) were not detected among farmers concerning rice varieties they cultivated, however the majority (92.3%) planted local upland rice varieties, and only 7.7% planted New Rice for Africa (NERICA) an introduced improved variety. The response of interviewed farmers on the sources of advice on rice production activities showed that, 69.6% shared information among themselves, 17.4% received information from agriculture extension officers and 13.0% attended various training. However, the use of these sources of information across the districts did not differ significantly ($\chi^2 = 9.643$; P = 0.291).

Table 1. Demographic characteristics of farmers from three rice-growing districts used in this study

Characteristics	Percentage of respondents					Mean	df	χ^2	*P*-value
	Mvomero (n = 30)	Morogoro rural (n = 30)	Ulanga (n = 30)	Korogwe (n = 24)	Muheza (n = 24)				
Age of respondent (years)									
20-39	23.3	30.0	43.3	41.7	37.5	35.2			
40-59	70.0	46.7	53.3	29.2	20.8	44.0			
60-69	6.7	23.3	3.3	29.2	41.7	20.8			
Sex of the respondent									
Male	76.7	73.3	46.7	62.5	33.3	58.5	4	15	0.005
Female	23.3	26.7	53.3	37.5	66.7	41.5			
Education level									
None	0.0	10.0	0.0	0.0	12.5	4.5	12	26.3	0.01
Adult education	6.7	6.7	0.0	0.0	0.0	2.7			
Primary	93.3	83.3	100.0	95.8	75.0	89.5			
Secondary	0.0	0.0	0.0	4.2	12.5	3.3			
Size of the rice farm (acres)									
0.5	23.3	26.7	40.0	4.2	29.2	24.8			
0.75	0.0	0.0	20.0	0.0	20.8	8.1			
1	26.7	50.0	36.7	41.7	41.7	39.3			
2	33.3	23.3	3.3	37.5	4.2	20.3			
3	13.3	0.0	0.0	16.7	4.2	6.8			
> 5	3.3	0.0	0.0	0.0	0.0	0.7			
Experience in rice farming (years)									
1-3	13.3	13.3	3.3	25.0	25.0	16.0	12	9.51	0.656
4-7	16.7	13.3	16.7	12.5	8.3	13.5			
8-10	16.7	13.3	13.3	12.5	4.2	12.0			
More than 10	53.3	60.0	66.7	50.0	62.5	58.5			
Type of rice varieties									
Local	93.3	100.0	83.3	100.0	85.0	92.3	4	6.301	0.178
Improved	6.7	0.0	16.7	0.0	15	7.7			
Source of advice on rice production									
Extension staff	13.3	10.0	26.7	8.3	29.2	17.4	8	9.643	0.291
Training on upland rice	13.3	10.0	16.7	8.3	16.7	13.0			
Own, fellow farmer /friend	73.3	80.0	56.7	83.3	54.2	69.6			

Note. df = degree of freedom, χ^2 = Chi-Square test, $P \leq 0.05$ shows there was a significant difference.

3.2 Upland Rice Production Constraints

The ranks of farmers' production constraints are summarized in Table 2. Rice blast disease was ranked the first by 48.0% of the respondents, followed by insect pests (19.9%), drought (14.9%), lack of knowledge (9.5%) and lack of access to input (7.7%) (Table 2). The majority of the interviewed farmers have observed the rice blast disease for the first time in the past 3 to 10 years, both in their neighbors' and in their own rice fields. There were no significant differences (χ^2 = 5.621; P = 0.229) and (χ^2 = 2.579; P = 0.630) among farmers who have observed rice blast disease in their own rice fields and in their neighbors' fields, respectively. The majority of the respondents (86.2%) reported the occurrence of high blast disease severity in April and May each year (Table 2). Other diseases reported were rice yellow mottle virus (26.1%), rice brown spot disease (8.7%) and bacterial leaf blight (0.7%) (Figure 2).

Table 2. Rice production constraints and the history of rice blast disease in the study area

Constraints and rice blast disease history	Percentage of respondents					Mean	df	χ^2	*P*-value
	Mvomero (n = 30)	Morogoro rural (n = 30)	Ulanga (n = 30)	Korogwe (n = 24)	Muheza (n = 24)				
Rice production constraints									
Rice blast disease	56.7	40	33.3	45	65	48.0	28	55.89	0.01
Drought	16.7	6.7	18.3	21.3	11.7	14.9			
Insects (stem borer, leaf rollers, Army wormy)	23.3	21.3	0.0	4.2	0.0	19.9			
Lack of knowledge	6.7	8.9	12.7	8	11.3	9.5			
Lack of access to inputs	3.3	6.3	6.7	17	5	7.7			
Rice blast disease in farmer's field									
Observed	90.0	83.3	100.0	83.3	87.5	89.1	4	5.621	0.229
Not observed	10.0	16.7	0.0	16.7	12.5	10.9			
Rice blast disease in neighbor's field									
Observed	96.7	93.0	96.7	100.0	100.0	97.3	4	2.579	0.630
Not observed	3.3	7.0	3.3	0.0	0.0	2.7			
First time rice blast disease observed in the field									
10 years ago	0.0	20.0	16.7	12.5	29.2	15.2	16	34.36	0.05
5-9 years ago	6.7	6.7	3.3	12.5	20.8	9.4			
3-4 years ago	46.7	43.3	33.3	16.7	16.7	32.6			
1-2 years	43.3	16.7	46.7	54.2	20.8	36.2			
I don't remember	3.3	13.3	0.0	4.2	12.5	6.5			
Time of the year with high rice blast disease severity									
April and May	76.7	96.7	86.7	91.7	79.2	86.2	8	14.283	0.075
June	3.3	0.0	10.0	0.0	12.5	5.1			
Do not know	20.0	3.3	3.3	8.3	8.3	8.7			

Note. df = degree of freedom, χ^2 = Chi-Square test, $P \le 0.05$ shows there was a significant difference.

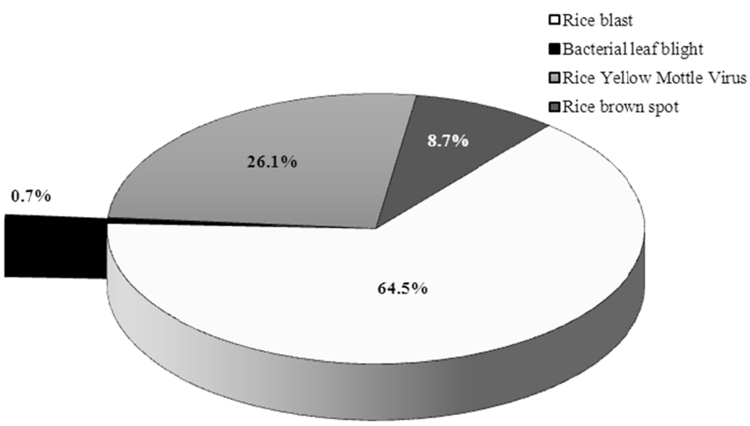

Figure 2. Rice diseases reported by farmers in the study area

3.3 Farmers Knowledge of Rice Blast Disease

Significant differences (χ^2 = 37.142; P = 0.000) were observed among farmers in perception of the rice blast disease. About 46.3% of the respondent were not aware of the cause and spread of rice blast disease (Figure 3). When they were asked about the association of the disease with other environmental factors, they reported that rice blast disease was associated with drought (39.9%), high rainfall and temperature (8.7%) and soil fertility problems (5.1%).

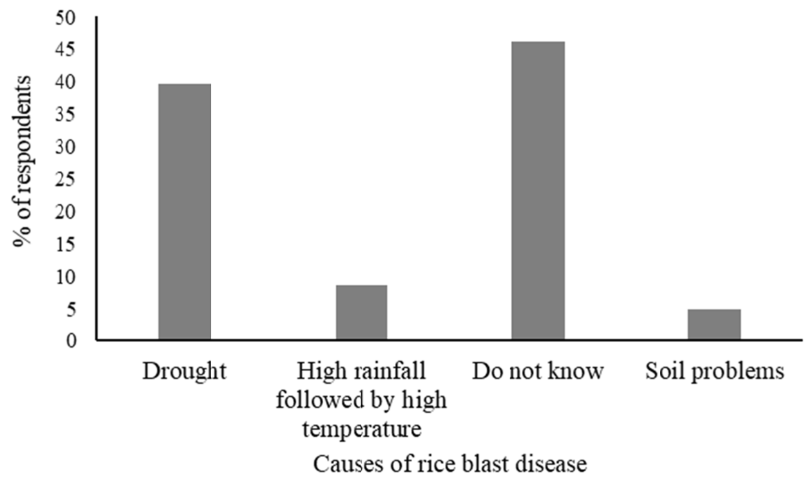

Figure 3. Farmers' perception of the possible major causes of rice blast disease (χ^2 = 37.142; P = 0.000)

3.4 Farmers Management of Rice Blast Disease

The majority (54.0%) of farmers did not apply any control measures on rice blast disease (Figure 4). The possible reasons were lack of knowledge (70.3%), high cost and unavailability of effective pesticides (16.0%) and low disease incidence (13.7%) (Table 3). However, few farmers reported to use several management practices of rice blast disease. About 18.7% of farmers reported burning of crop residue, 17.0% use of ash, 4.0% use of nitrogen fertilizer and 6.3% application of fungicide. None of the respondents knew the names and handling procedures of pesticides. Management practices were significantly different (χ^2 = 36.142; P = 0.003) across the districts (Figure 4). In addition, respondents in Mvomero and Morogoro rural district reported the use of rice straws for mulching in vegetable production.

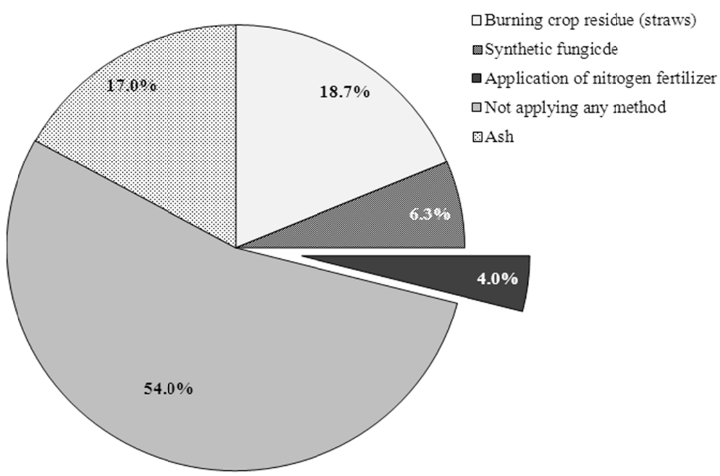

Figure 4. Management methods for rice blast disease used by farmers in the study area (χ^2 = 36.142; P = 0.003)

Table 3. The possible reasons for farmers not applying any management methods for rice blast disease in the study area

Reasons	Percentage of the respondents					Mean	df	χ^2	*P*-value
	Mvomero (n = 30)	Morogoro rural (n = 30)	Ulanga (n = 30)	Korogwe (n = 24)	Muheza (n = 24)				
Lack of knowledge	60.0	56.7	70.0	95.0	70.0	70.3	8	16.48	0.036
Low blast disease incidence	16.7	16.7	26.7	5.0	15.0	16.0			
Cost and unavailability of effective pesticides	23.3	26.7	3.3	0.0	15.0	13.7			

4. Discussion

In this study, the majority of the respondents have seen rice blast disease for the first time in the past 2 to 10 years, both in neighbors' and in their own rice fields, with high severity occurring in April to June each year. This indicates that rice blast disease remains a main threat to rice production in the study area. The recent introduction of new rice varieties by farmers from other rice-growing areas and expansion of rice fields may have also contributed to the abundance of the rice blast disease.

Most farmers used their own saved rice seeds; only 7.7% of them used improved rice varieties. These improved rice varieties are New Rice for Africa (NERICA); five of them were officially released in Tanzania (Lwezaura et al., 2011). The low adoption of these rice varieties may be due to unavailability in terms of source, time and the inability of farmers to afford the costs of buying seeds. Factors such as preference, availability in terms of quantity and market prices have also forced farmers to use their own saved rice seeds (Hubert et al., 2014). Many farmers preferred local rice varieties due to their good milling qualities, drought tolerance, early maturity and cooking qualities like good aroma and taste (Hubert et al., 2014). High yield and marketability were reported to increase the preference of rice varieties (Traore et al., 2015). However, some local varieties had good milling and cooking qualities, were susceptible to rice blast disease and cultivated for own consumption to increase farmers' food security.

Rice farmers were sourcing advises on production and disease management from the agriculture extension workers and fellow farmers or friends. Most of the farmers were using advice from their fellow farmers or friends followed by agricultural extension officers. This implies that farmer-to-farmer interactions were the main source of advice and the method can be used in sharing knowledge on rice disease management. Farmers' knowledge has been acquired through long experience of rice farming regarding different challenges encountered in rice production (Traore et al., 2015). To improve farmers' understanding of the management options for the rice blast disease, there is a need of creating awareness on the possible control measures to farmers.

Training has been reported to improve knowledge and change the farmers' attitude in crop pest management, which leads to the use of proper and safe crop disease management methods (Gautam et al., 2017). Lack of awareness on the course and spreading of rice blast disease reported by the majority of the respondents has also been reported by Adam et al. (2015). In his studies, farmers were able to identify unhealthy sweet potato plants, but unable to tell the specific type of disease infecting the plants both from direct and photographic observations. Rice blast disease was observed in the parts of the rice field which were prone to drought and high disease severity was observed after a period of rainfall. These factors may be the reason for farmers to associate the disease with drought condition, high rainfall and temperature and soil problems. Consistent prevalence of the disease during April to June, each year, indicated a season of the year with conditions that favors disease outbreak. This study showed that the severity of rice blast disease has been increasing year after year for the last 3-10 years. However, most of farmers hardly adopted management methods of blast disease on their farm. Consistent increase in disease abundance may be attributed to lack of information, knowledge of blast disease and the high cost and unavailability of effective fungicides. The use of rice straws for mulching on vegetable production reported by most of the respondents in Mvomero and Morogoro rural may also be one of the reasons that contributed to the increase of the disease incidence reported. Crop residues (mulch) act as a source of inocula for the next rice growing season. The sources of inocula for rice blast disease are mycelia and conidia from infected rice straws and seeds (Webster, 2000). The pathogen can over season in piles of rice straws and seeds during unfavorable conditions (Webster, 2000).

Ash was used as a traditional method for rice blast disease management in Mvomero, Morogoro rural and Muheza districts. The method was reported to be cheap and easy to use but less effective on rice blast disease. Burning of crop residues was used to manage rice blast disease; however, some farmers believed that burning rice crop residues discouraged grazing of livestock on harvested rice farms. Farmers who associated rice blast disease with soil fertility problem, applied nitrogen fertilizer such as urea to manage the rice blast disease. This was due to lack of knowledge on proper identification of rice diseases from nitrogen deficiency, especially when the plants were infected with blast disease and exposed to nitrogen deficiency.

The use of pesticides to control rice blast disease was reported by very few respondents in Mvomero (13.33%), Morogoro rural (10%) and Ulanga (3.33%). The awareness of using pesticides to manage blast disease was attributed to the experience of pesticide use on vegetable diseases. However, pesticide names and proper handling practices were not known. Mendesil et al. (2016) reported similar information that a survey conducted in Ethiopia showed that most farmers did not know the name of the pesticide applied on pea weevil in storage. Furthermore, the pesticide used by farmers was not effective in controlling rice blast disease. The use of non-recommended pesticides, improper application of pesticides, counterfeit and expired pesticides were among the reasons reported for the persistence of the crop diseases (Ngowi et al., 2007; Nonga et al., 2011; Lahr et al., 2015; Mendesil et al., 2016). Training of farmers enhances adoption of Integrated Pest Management practices (IPM), reduce the quantity of pesticide use, frequency of spraying and the habit of mixing different pesticides (Gautam et al., 2017).

5. Conclusion and Recommendation

Generally, lack of information, knowledge, and ability to afford the cost of buying fungicides and unavailability of effective control methods were the main reasons limiting the effective management of rice blast disease. The use of susceptible rice varieties and improver agronomic practices were additional constraints to management of rice blast disease. The interactions of farmer to farmer and farmer to agricultural extension staff were the main source of information on disease management. To improve rice yield, there is a need for strengthening the capacity of farmers in identifying and controlling rice blast disease.

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