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Farmer's Knowledge on Weed Management, Soil Fertility and Moisture Conservation Practices on Rice Production, A Case Study of Mbarali District in Tanzania

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Abstract

This study was intended to investigate farmer's knowledge on weed management, soil fertility and moisture conservation in rice production. A field survey was conducted between December 2020 and February 2021 in Mbarali District involving 90 rice growers, whereby structured questionnaire was used cropping seasons 2020-21. The collected data were analysed to determine distribution of respondents per variables using statistical package for social sciences (SPSS) version 16. Mean separation in each variable was done using independent sample t-test at p≤0.05 level of significance to determine whether there was statistically significance different between each agronomic practice and productivity. The results revealed that weeds and soil fertility were big problems on rice productivity in Mbarali. The majority (98.9%) of interviewees reported to have challenges of weed infestation and all (100%) responding inadequate soil fertility constrains rice productivity, which forced them to use inorganic fertilizer for better yield. Farmers (43.3%) interviewed reported to have applied herbicides to control weed and majority (56.7%) of interviewees' practised hand weeding as measures to manage weed infestation. Three practices which are application of inorganic fertilizer (100%) incorporating crop residues (90%) and application of organic manure (6.7%) were determined as being practised by farmers that facilitate the improvement of soil nutrients and conservation of water. Furthermore three types of seeds were identified as being used by farmers; Certified (6.7%), Quality declared seed (QDS) (36.7%) and Farmer saved seed (FSS) (56.7%). Furthermore, the results indicated significantly higher yield of famers use certified seeds (2.83 t/ha, P≤0.041), (23.67 t/ha, P≤0.001) and (3.52t/ha P≤0.001) for 2017-18, 2018-19 and 2019-20 production seasons respectively.

Keywords: Rice; Weeds; Fertilizer; Herbicides; Soil nutrients; Productivity.

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1. Introduction

Rice (*Oryza sativa* L.) is the main food and cash crop; the crop is consumed by more than 3 billion people around the world [1]. Worldwide rice growers include China, India, Bangladesh, Indonesia, Vietnam and Thailand [2]. In Africa, about 75% of the African countries grow rice, with the estimated 26.4 million African people engaging in rice production [3]. The biggest rice producers in Africa include Egypt, Mali, Ghana, Mozambique, Sierra Leone, Tanzania and Nigeria [3].

In Tanzania rice is the third grown staple food crop after maize and cassava [4], largely rice produced in Morogoro, Mbeya, Shinyanga, Tabora and Coast Region [5]. In Mbeya Region, rice is mostly grown in Mbarali and Kyela Districts [6]. However, despite its nutritional and economic importance, the production of rice in many rice growing areas in Africa including Tanzania is challenged with weeds, poor soil fertility, insect pests, water withdrawal, diseases, rodents, birds and low use of agricultural inputs [7, 8]. Various techniques, including, herbicides, hand weeding, crop rotation, intercropping, mulching, cover crops and fertilizers have been employed by farmers to reduce incidences of pests, improve soil heath and fertility and increase crop yields [9]. Previous studies that documented farmers' crop protection practices in the reduction of yield losses due to pests, reported the use of herbicides to reduce crop loss of from 35% to 14% [10]. However, a study showed weed biomass were reduced when applied weed managements of post-emergence herbicides (86% reduced), pre-emergence herbicides (17.8% reduced) and Hoe weeding (12.3% reduced) [3]. Practice of intercropping was more effective in weeds control than mono cropping [9]. Moreover studies documented practice of crop rotation, row spacing and cover crops, helps to break pest and disease cycle, and suppress weed development and growth hence improve productivity [11-14]. Other studies identified traditional weed control methods, such as hand pulling and hoe weeding are still being practised in African countries such as Tanzania [9]. However, the methods are slow and laborious, making farmers spending more time and power on manage weed than other aspect of crop production [9]. Continued dependence on hand pulling and hand hoe to manage weeds by smallholder farmers is not effective in optimal weed management for the prevention of significant yield losses [9]. Therefore, this study intended to investigate various techniques used by farmers in Mbarali on rice production.

2. Materials and Methods

The study was carried out at Mapogoro Ward, covers three surveyed villages namely Mbuyuni, Nyanguru and Mabadaga in Mbarali District. The area has an altitude of 1047 m (above the sea level) with dominant clay loam soil and with temperature ranging from 11.7°C to 29.9°C and an average annual rainfall of 873.4 mm. The area experiences unimodal type of rainfall which falls between November and April and a dry season is experienced between May to October [1].

2.1. Baseline Survey

The field survey was conducted from December 2020 to February 2021, whereby standard survey procedures [15] were followed and the number of respondents was determined as per formula developed [15]**.** The population consisted of smallholder rice growers from three villages where a sample of 90 respondents were picked from a population of 1732 of irrigation organizations (IO), based on farm size, sex, age and experience in rice production.

2.2. Data Collection

Field Interviews were conducted using a structured questionnaire on a one to one discussion. The data collected included demography, farm size, rice production constraints, common weeds, weed management methods, crop management practices and productivity per hector.

2.3. Data Analysis

The collected data were coded and analysed using the Statistical Package for Social Science (SPSS) version 16, computer programme. Descriptive statistics where used to determine distribution of respondents in variables and mean separated by independent Sample t-test $P \leq 0.05$ level of significance.

3. Results

3.1. Description of Respondents and Their Demographic Characteristics

The findings indicate that rice farming is dominated by female farmers (53.3%), whereby majority (37.8%) of farmers belong to the age group of 26-35 years, while 13.3% belong to the age group of 51-70 years. However, 66.7% of the interviewed farmers have been growing rice for over 5 years, 82.2% of farmers were married while few (14.4%) were single and only 3.3% were divorced. However 43.3% of the respondents had attained primary education while 40% attained secondary education, a few (10%) attained college education and only 6.7% had not gone to school. All (100%) farmers growing rice in the study area were practising a mono-cropping system. However, 90% of farmers incorporate rice straw residues in the soil and the remaining, 10% still practise burning of crop residues. However results shows soil nutrients management practices which all 100% of interviewed farmer respond to use inorganic fertilizer principally UREA (46%N), DAP (18:46:0), CAN (27%N), SA (21%N:24%S) and few (6.7%) organic fertilizer (manure). The results identified two methods which were used, in which 43.3% use hand weeding (hand pulling) and majority 56.67% use herbicides.

The study identified three types of rice seeds namely certified seeds (CS) (6.6%), Quality Declared seed (QDS) (36.7%) and Farmer saved seed (FSS) (56.7%) were commonly used by farmers in Mbarali. However the study identified three-row spacing were identified, namely, 15 × 15 cm whereby 20% of interviewed farmer use it, also 15 × 20 cm in which 26.67% farmers respond to use it and 20 × 20 cm which is recommended spacing for rice (MAFC, 2022) whereby most 53.33% respond to used it. The survey results shown respondent results on rice production constraints in Mbarali, whereby all (100%) interviewer reports soil fertility is problem in their farms and majority (98.9%) of interviews report weeds infestation as challenges on rice production, while most (53.3%) reports rice diseases and 44.4% of respondents reports insect and vertebrates pest (Table 1).

Table-1. Distribution of the Respondents based on Demographic Characteristics (n=90)

Demographic characteristics	Frequency	Percent (%)
Sex		
Male	42	47.0
Female	48	53.0
Age (years)		
18 – 25	17	18.9
26 – 35	34	37.8
36 – 50	27	30.0
51 - 70	12	13.3
Engagement in rice production (Years)		
1 – 5	30	33.3
6- 10	27	30.0
11-20	18	20.0
Above 20	15	16.7
Marital status		
Married	74	82.2
Single	13	14.4
Devoice	3	3.3
Education level		
Primary school	36	40.0
Secondary school	39	43.3
University/college	9	10.0
No school	6	6.7
Farmers knowledge on rice production		
Cropping system and residues management		
Mono cropping	90	100
Incorporating crop residues	81	90
Burning crop residues	9	10
Type of Fertilizer applied		
UREA	90	100
DAP	75	83.3
SA	9	10
CAN	27	30
Manure	6	6.7
Pest control methods		
Hand weeding	39	43.3
Herbicides	51	56.7
Type of seed used		
Certified	6	6.6
QDS	33	36.7
FFS	51	56.7
Planting space		
15 × 15 cm	18	20.0
15 × 20 cm	24	26.7
20 × 20 cm	48	53.3
Rice Production Constraints		
Weeds	89	98.9
Soil fertility	90	100
Disease	48	53.3
Insect and vertebrate pests	40	44.4

3.2. Yield Responses on Farmers Rice Production Practices

3.2.1. Yield Response in Relation to the Management of Crop Residues

The uses of crop residues were significant (P=0.03) for the 2019-20 production season, but not so during 2017-18 (P = 0.99) and 2018-19 (P= 0.24) production seasons, whereby farmers who incorporated crop residues had high yield (2.8 t/ha) compared to farmers who burned (2.31 t/ha) crop residues (Table 2).

Table-2. Yield response in relation to the use of crop residues

Season (year)	Crop residues management	Mean yield (t/ha)	SD	df	P – value
2017-18	Incorporated	2.63	0.8	88	0.99
	Burning	2.63	0.7		
2018-19	Incorporated	2.67	0.8	88	0.24
	Burning	2.34	0.5		
2019-20	Incorporated	2.8	0.9	88	0.03
	Burning	2.31	7.0		

SD=standard deviation, df = degree of freedom, P-value at 5%level

3.2.2. Yields Response to Fertilizers

The productivity for different fertilizers used by farmers was significant at P=0.001 in the 2018-2019 production season, where a combination of UREA, DAP and manure had high yields of 4 t/ha, followed by combination of UREA, SA and Manure had yield of 3.5 while application of UREA only had lower yield of 2.25 t/ha and combination of UREA and Manure had yield of 2.34 t/ha (Table 3). However for season 2019-20 and 2017-18 had not significant.

Table-3. Yield response on fertilizer applied for production season 2018-2019

Season (year)	Fertilizer used	Means (t/h)	SD	df	P - value
2018-19	UREA	2.25	0.5	82	0.001
	UREA and DAP	2.41	0.5		
	UREA, DAP and CAN	2.83	0.7		
	UREA, DAP and Manure	4.00	1.0		
	UREA, DAP, CAN and Manure	3.25	2.5		
	UREA, SA and Manure	3.5	0.7		
	UREA and SA	2.8	0.8		
	UREA and Manure	2.34	1.1		

Note: SD=standard deviation, df = degree of freedom, P-value at 5%level of significant

3.2.3. The Impact of Seeds on Productivity

The difference between seeds used by farmers and productivity was significant at P=0.041, P<0.001 and P <0.001 for 2017-18, 2018-19 and 2019-20 production seasons respectively. Productivity of CS was higher (2.83 t/ha, 3.67 t/ha and 3.52 t/ha), followed by QDS (2.77 t/ha, 2.71 t/ha and 3.00 t/ha) while FSS had lower 2.36 t/ha, 2.37 t/ha and 2.26 t/ha in all the three production seasons of 2017-18 to 2019-20 respectively (Table 4).

Table-4. Impact of seeds on productivity

Season (year)	Seed used	Means (t/h) ± SD	P - value
2017-18	CS	2.83 ± 1.291	0.041
	QDS	2.77± 0.658	
	FSS	2.36 ± 0.753	
2018-19	CS	3.67 ± 0.816	<0.001
	QDS	2.71 ± 0.68	
	FSS	2.37 ± 0.29	
2019-20	CS	3.52 ± 1.594	<0.001
	QDS	3.00 ± 0.851	
	FSS	2.26 ± 0.696	

Note: SD=standard deviation, df = degree of freedom, P-value at 5%level of significant.

3.2.4. Influence of Row Spacing on Productivity

The effect of spacing was significantly different at P=0.041 and P = 0.014 on productivity for the 2017-18 and 2019-20 production seasons respectively. However, it was not statistically significant at P=0.083 for the 2018/2019 production season. Whereby spacing 20 × 20 cm had high yield of 2.77 t/ha, 2.73 t/ha and 2.92 t/ha while spacing 15 × 15 had lower yield of 2.17 t/ha, 2.29 t/ha and 2.19 t/ha for production season 2017-18 to 2019-20 respectively (Table 5).

Table-5. Influence of row spacing on productivity

Season (year)	Spacing (cm)	Means (t/h) ± SD	P-value
2017-18	15 × 15	2.17 ± 0.8	0.04
	15 × 20	2.73 ± 0.8	
	20 × 20	2.77± 0.7	
2018-19	15 × 15	2.29 ± 0.7	0.08
	15 × 20	2.72 ± 0.8	
	20 × 20	2.73 ± 0.7	
2019-20	15 × 15	2.19 ± 0.8	0.01
	15 × 20	2.89 ± 1.0	
	20 × 20	2.92 ± 0.9	

Note: SD=standard deviation, df = degree of freedom, P-value at 5%level of significant

3.3. Relationships of Rice Production Constraints and Villages

Table 6 shows results of Chi-square test were significant at P<0.001, on the relationships of production constraints (weeds, insect, disease and soil fertility) among villages (Mbuyuni, Mabadaga and Nyanguru). Whereby weeds had χ^2 of 93, Insect and vertebrate pest χ^2 of 99.8, disease χ^2 of 98.1 and low soil fertility χ^2 of 92 (Table 6)

Table-6. Responses of interviewed farmers on the rice production constraints in the Mbarali District

	Weeds		Insect and vertebrates pests		Diseases		Low soil nutrients	
Village	**Obs (Exp)**	**Fre(Per)**	**Obs(Exp)**	**Fre(Per)**	**Obs(Exp)**	**Fre(Per)**	**Obs(Exp)**	**Fre(Per)**
Mbuyuni	30 (29.3)	30(100)	21 (16.5)	21 (70)	19 (13.2)	19 (63.3)	30 (29.7)	30 (100)
Mabadaga	29 (29.3)	29(96.7)	12 (16.5)	12 (40)	9 (13.2)	9 (30)	30 (29.7)	30 (100)
Nyanguru	30 (29.3)	30(100)	15 (16.5)	15 (50)	12 (13.2)	12 (40)	30 (29.7)	30 (100)
χ^2	93		99.8		98.1		92	
df	6		6		6		3	
p-value	< 0.001		< 0.001		< 0.001		< 0.001	

Note. Values formatted as Observed [Expected] frequencies; Frequency (Percentage) χ^2 = Chi-square. df = degrees of freedom

4. Discussion

Research findings in this study revealed weeds and poor soil fertility as major rice production constraints. This result is in agreement with the study determined weed as bigger constraints in rice production and can cause yield loss up to 80 % if field remain uncontrolled [16]. The efforts were required on controlling of weeds to improved rice production since, proper management of weed increase yield to grower [17]. The type of production system practiced by rice grower in Mbarali were mono cropping, possible these increase weed density [18]. The practice of mono cropping reads to weed infestation, that annual weed biomass in mixtures cropping was lower than in monocultures by 33 % [19]. Further weed management identified used by farmers in Mbarali were using of herbicides. The lower soil fertility identifies in Mbarali contribute to increase of using inorganic fertilizers, the highly depend on inorganic fertilizer contribute to high yield in Mbarali [6], however the increase on using inorganic fertilizer have negative effect in environment [20]. Moreover, the results show that farmers who applied inorganic fertilizers and organic (manure) had high yield (4 t/ha) compared to those who applied inorganic fertilizers only (2.83 t/ha), these results are supported by the results of Guleria, *et al.* [21] who revealed that the application of chemical fertilizers in combination with organic manures increased grain yield of rice. Organic manure has ability to release nutrient according to the plant need in growth stage [22]. The adoption of applying organic manure to the fields facilitates the improvement of soil fertility [23].

Furthermore the study results show increase of productivity on farmers adopted certified seeds (CS) by 30.24% of yields compared to farmer saved seed (FSS).The increases of yield on using CS are agreement that CS had high yield compared to famer saved seed [24]. The high yield of certified seed was due to characterisers of seed to be free from disease and impurities; hence adoption of certified seeds increased farmers' income [25]. Furthermore the results showed that the productivity of farmers who incorporated crop residues in the soil was higher (2.8 t/ha), which is an increase of 14%, than the productivity of farmers who removed or burned crop residues in the field (2.4 t/ha).These results are consistent with the results that indicated crop residues improved soil nutrients hence facilitating an increase in yields [26]. Crops residues when decompose increase organic carbon, limits water losses by evaporation and prevent soil erosion by wind and water [22]. The application of crop residues improves soil structure, increases organic matter content in the soil and help fix CO_2 in the soil [27].

Moreover, the results showed that the use of the recommended spacing of 20 × 20 cm to rice had higher yields of 2.92 t/ha, which was increase of 25 percent. The increase of yields was due to good neutralization of resources, recommended spacing for crops increased yields [28]. Other study [29] reported using of recommended spacing facilitates the growth of crops and produce high yield since crops grows with good management practice.

5. Conclusions

Thus, study of identify farmer's knowledge on weed management, soil fertility and moisture conservation practices on rice production showed important role in determining farmer weed management and soil moisture conservation practice as a basic for developing appropriate weed management, that weeds and soil fertility were major constraints of rice production in Mbarali District, combination of weeding management (herbicides and hand weeding) and incorporated crop residues is paramount importance in improving soil fertility, weed control and yield increase.

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