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Socio-Economic and Field Performance Evaluation of Different Rice Varieties under System of Rice Intensification in Morogoro, Tanzania

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Abstract

Worldwide, many Studies on the System of Rice Intensification (SRI) indicate that, the practice has promising results on increased rice productivity especially with high-yielding varieties. Therefore, it was necessary to validate the system at smallholder farmers' level under Tanzanian condition. The study sought to evaluate the performance of selected rice improved varieties under SRI in different fields and locations in Morogoro region through an action research. Four rice varieties were planted in Completely Randomized Block Design (CRBD) experimental fields at the spacing of 25cm x 25cm transplanted at 10 days after emergence. Experimental fields were set in three locations. The evaluation was followed by socio-economic participatory variety selection (pairwise and matrix scoring methods) which involved 36 farmers from all the three locations. It included both consumption (aroma, panicle size, grain weight, milling quality, cookability and palatability) and production traits (Yield, threshability, lodging, maturity, plant height, shuttering, disease tolerance and drought tolerance) of rice varieties. A statistical Package for Social Science computer software (SPSS) and Genestat were used in data analysis. Field results based on production trait (yield) indicated TXD 88 to have the highest yield (9.13t/ha). Other yield levels were 8.7t/ha, 8.4t/ha and 6.2t/ha for TXD 307, TXD 306 and Supa respectively. Yield was significantly influenced by number of productive tillers ($P<0.05$). Participatory Variety Selection results with consideration of both production and consumption traits highlighted TXD 306 to be suitable for farmers. We recommend the use of improved rice varieties under SRI. The dissemination efforts need to foster on the extensive promotion of TXD 306 since it serves the dual purposes by having competitive production and consumption traits under SRI production system. Breeding programs need to also embark on improving TXD 88 removing its chalkiness.

Keywords: Rice Variety; Evaluation; Farmer Preference; Systems of Rice Intensification

Abbreviations: SRI: System of Rice Intensification; CRBD: Completely Randomized Block Design; SPSSL: Social Science computer software; PVS: Participatory Variety Selection; DMRT: Duncan's Multiple Range Test; OLS: Ordinary Least Square; AMCOS: Marketing Cooperative Societies; SACCOS: Savings and Credit Cooperative Societies; ROSCAs: Rotating Savings and Credit Associations; COSTECH: Commission for Science and Technology

Introduction

More than half of the world population depend on rice as their staple food. In Asia alone more than 2000 million people obtain 60-70 percent of their calories from rice and its products. It has been cultivated throughout the world for several thousand years. Between 2001 and 2007 global rice prices nearly doubled, primarily because of a drawing down of stocks to fill the gap caused by stagnating yields. Global rice stocks have declined from a 135-day supply to a 70-day supply over the last seven years a 44% drop from 147 million tons in 2001 to 82 million tons in 2008. Fifty-nine million tons of additional milled rice will be needed by 2020 above the 2007 consumption of 422 million tons. Since there is not much scope to increase the area of rice cultivation (due to urbanization and severe water constraints), the additional production has to come from less land, less water and less production costs [1].

In Africa, the production is only 3% of the world total production. The biggest producers of rice are Western Africa countries, Nigeria, Cote d'lvoire and Mali. Other major producing countries are Egypt, Madagascar, Tanzania and Mozambique [2]. In Tanzania, about 90% of rice is grown under continuous flooding, a practice that requires large amount of water. The shortage of water across the country brought about by climate change leads to low exploitation of suitable land for irrigation. Tanzania is one of the most vulnerable countries to climate change. Extreme climatic conditions, for instance droughts and floods have already affected production of rice on one hand. On the other hand the estimated rice consumption does not match with the level of production in the country. For example, [3] report milled rice production of 1.4 million tons against the consumption of 1.6 million tons in 2014. Rice demand expected to triple over the next decade as population grows and becomes more urbanized. Changes in consumers' preference of rice both in urban and rural areas is also another demand driver. Rice consumption symbolizes increased status. It is the premium staple consumers aspire to move to as their incomes increase.

This demand can be minimized through increasing production of rice in the irrigated schemes which now stands at 3.5-6tons/ha with yield varying depending on the varieties grown. The improved varieties have high yield compared to local varieties. Studies worldwide indicate that, the system of rice intensification (SRI) doubles yield of rice varieties both improved and local [4-7].

SRI is a set of farming practices developed to increase the productivity of land, water as well as other resources. SRI practice was first developed by Fr. Henri de Laulanie S.J. in 1980s in Madagascar after a series of observations from farmers' fields and his experiments with various practices of the crop [4]. Principles of SRI which includes: Transplanting seedlings at much early stage (7-15 days seedling) and a single seedling per hill, wider spacing i.e. recommended 25cm x 25cm, intermittent water application, early and regular weeding and use of organic fertilizers where available to enhance soil fertility. Thus, the use of expensive inorganic fertilizers and other agro-chemicals is minimized, which is a cost-saving advantage [8]. SRI is therefore a "designer" innovation. It efficiently uses the scarce land, labour, capital and water resources and is more accessible to poor farmers than input dependent technologies that require capital and logistical support in achieving maximum yields. With SRI, farmers do not necessarily need new varieties, all varieties respond positively, but best yields have been achieved with high yielding ones. Under SRI, this study evaluated the performance of four rice varieties namely TXD 306, TXD 88, TXD 307 and Supa to determine their suitability in terms of yield, adaptability, farmers' preference and their selection based on rice production and consumption traits. Evaluation involved the use SRI principles and was carried out under Tanzanian condition in three irrigation schemes in Morogoro region.

Materials and Methods

Treatments used were 4 rice varieties, namely, TXD 306 (semi-aromatic/high yielding), TXD 88 (moderate aromatic and high yielding), TXD 307 (semi- aromatic and high yielding) and Supa (high aromatic, but low yielding). The design of the experiment was Completely Randomized Block Design (CRBD) in which the sites acted as blocks for this case. It should be noted that the number of replications is equal to the number of blocks under CRBD. These sites were three irrigation schemes in Morogoro region. These sites were Ilonga in Kilosa district, Hembeti and Dakawa in Mvomero district.

Each variety was planted in an area of 100m2. Agronomic package of SRI was controlled throughout the growing period. This included; nursery management, land preparation, early transplanting (8 - 15 days), single seedling per hill, spacing (25cm by 25cm), disease and pest management, water management and fertilizer application being applied equally.

Agronomic package included soil analysis done at the beginning of the experiment where 'P' was found to be deficient in the soils. This was corrected through NPK (20:10:10) fertilizer application during transplanting. Seed amount equivalent of 4kg/ha of each variety was sown on the nursery in each site. Land preparation involved ploughing, harrowing and leveling of both nursery and experimental plots. Transplanting was done on 10th day after sowing. A single plant per hill at a spacing of 25cm x 25cm was adopted. Weeding was done two times throughout the growing period. Control of white fly infestation was done by applying thionex insecticide. NPK (20:10:10) was applied as basal application (40kg P/ha) both in the nursery and in experimental plots. Top dressing was done in two splits (100kg N/ha) using UREA (46% N). In the case of water management, water was maintained at the level of 2.5cm throughout the growing period except during fertilizer application.

Data collected included; Number of effective tillers per plant, plant height (cm), panicle length (cm) and grain yield (tons/ha). A total of 10 plants from each farmers' plot were diagonally selected to constitute a sample size for measurement. From each selected plant hill, number of tillers and effective tillers were counted, followed by measuring plant height and panicle length by using a ruler. Lastly, grain yield was determined by harvesting rice in a one meter square in each plot followed by measuring its corresponding weight in tons per hectare.

Participatory Variety Selection (PVS) was done using pair-wise ranking and matrix scoring methods and involved a total of 36 farmers, 12 farmers from each site. Pair-wise ranking is the method in which farmers compared two varieties at a given time by assigning 1 for superior and 0 for the inferior variety during participatory seed selection. This is a qualitative method of selecting suitable varieties based on farmers' preference criteria. The matrix scoring method involved farmers scoring the varieties using qualitative scores that ranged from 1- 4, where by 1 is the lowest score and 4 the highest score. The implications of the score were that, 1 score implies 1/4 (25%), the variety on the particular criterion is below average. 2 score this implied 2/4 (50%), the variety on the particular criterion is satisfactory/average. 3 score this implied 3/4 (75%), a good variety on the particular criterion and 4 score implies 4/4 (100%), the variety on the particular criterion is very good. Farmers identified the criteria to be used and it included both consumption (aroma, panicle size, grain weight, milling quality, cookability and palatability) and production traits (Yield, threshability, lodging, maturity, plant height, shuttering, disease tolerance and drought tolerance) of rice varieties. Unstructured simple question was used to capture the socio-economic characteristics of the 36 farmers involved in the Participatory Variety Selection. Generally, data were analyzed using Genstat and Statistical Package for Social Science (SPSS) computer software.

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Results and Discussion

Yield performance of rice varieties under system of rice intensification

The yields of the four varieties are shown in Figure 1 below. These results showed TXD 88 to have the highest yield of 9.1t/ha. SUPA yielded the lowest (6.2t/ha). This justifies the assertion that SRI doubles the productivity of most of the rice varieties. The other varieties, TXD 306 and TXD 307 had 8.5t/ha and 8.7t/ha respectively. These yields are good for all the varieties under SRI. Yields among these varieties were statistically different as indicated by the Analysis of Variance (ANOVA) (P=0.034).

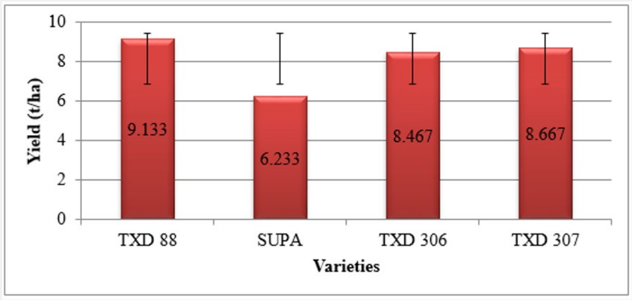

Figure 1: Yield performance of varieties under System of Rice Intensification.

Comparisons of varieties using Duncan's Multiple Range Test (DMRT) showed further that, SUPA is significantly different with all other varieties evaluated. Other varieties were not statistically significant. Although SUPA showed significant difference with other varieties, its yield of 6.2t/ha which is above its normal yield of 2.5t/ha under conventional cultivation implies that it can do better under SRI (Table 1).

Table 1: Multiple comparison test.

Varieties		Mean Difference
SUPA	TXD 306	-2.24**
	TXD 307	-2.44**
	TXD 88	-2.9**
TXD 306	SUPA	2.24**
	TXD 307	-0.2*
	TXD 88	-0.66*
TXD 307	SUPA	2.44**
	TXD 306	0.2*
	TXD 88	-0.46*
TXD 88	SUPA	2.9**
	TXD 306	0.66*
	TXD 307	0.46*
CV		6.70%
LSD		1.864

**Significant at 95% level of significance (If the mean difference is above LSD value) and *Not significance (If the mean difference is below LSD value). Mean differences are considered in absolute values.

Parameters driving yield performance of rice varieties

Plant height, panicle length and number of productive tillers were found to positively influence the yield of varieties. The number of productive tillers was the only variable that was found to significantly influence the yield of the varieties (P<0.05). The coefficient indicated that on average an increase in one productive tiller per plant leads to an increase of about 0.1t/ha. Furthermore, when the Ordinary Least Square (OLS) model was adjusted for the number of explanatory variables used, 89% of the observed variations in yield was found to jointly being explained by plant height, panicle length and number of productive tillers. These findings conforms to the results by Katambara et al. [6] & Krishna et al. [9] who found that the increase in number of tillers were associated with the increase in spacing that has repercussion in yield increase (Table 2).

Table 2: Parameters driving yield performance of varieties.

Variable	Coefficient	Standard error	t-ratio	Sign.
Constant	-4.28	4.279	-1	0.423
Plant height	0.157	0.021	0.977	0.432
Panicle length	0.268	0.204	1.54	0.264
Number of productive tillers Adjusted R-square=0.892	1.015*	0.036	6.209	0.025

*Significant at 5% probability level

Socio-economic participatory variety selection

Socio-economic features of farmers involved shows that, 85.2% had primary education level and 14.8% had attended secondary education. The highest level of education improves the ability of the farmer to access knowledge material that educates the farmers on various agricultural technologies including rice varieties. The average age of the farmers involved was 34 years with more than 5 years' experience in in rice production and marketing. Gender aspect indicated that 58% were female and 42% were male. Results showed further that 96.3% of these farmers had contact with extension staffs (63% frequently and 33.3% less frequently). In terms of collective action, farmers indicated to be members of various organizations. Results showed 96.3% of the farmers to be in different associations. These associations included producer organization, Agricultural Marketing Cooperative Societies (AMCOS), Savings and Credit Cooperative Societies (SACCOS) and Rotating Savings and Credit Associations (ROSCAs). All the 36 farmers were fully involved in the pairwise ranking and matrix scoring method exercises [10-12].

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The pairwise ranking

The method involved farmers comparing two varieties at a given time by assigning 1 for superior and 0 for the inferior variety. Results showed that TXD 306 was the most superior preferred variety followed by TXD 307, SUPA then TXD 88 in terms of preference (Table 3).

Table 3: Pairwise ranking results.

	TXD 306	TXD 307	TXD 88	SUPA	Total Score	Rank
TXD 306		1	1	1	3	1
TXD 307	0		1	1	2	2
TXD 88	0	0		0	0	4
SUPA	0	0	1		1	3

The matrix scoring

The matrix scoring method scores ranged from 1-4 such that 1 score implies 1/4 (25%)-below average; 2 score this implies 2/4 (50%) - satisfactory/average; 3 score this implies 3/4 (75%)-good and 4 score implies 4/4 (100%), the variety on the particular criterion is very good. Results shows that TXD 306 was ranked the first with 48 total score; (85.7%) followed by TXD 307 with the total score of 47; (83.9%) then SUPA with the total score of 42(75%). TXD 88 with total score of 41(73.2%) was ranked the last in general with aroma and palatability as the least scored traits (Table 4).

Table 4: Matrix scoring results of Participatory Variety Selection.

Trait Category	Trait	Variety			
		TXD 306	TXD 307	TXD 88	SUPA
Consumption	Cookability	4	4	3	4
	Milling quality	3	4	3	4
	Grain weight	4	4	4	3
	Palatability	4	4	1	4
	Aroma	3	3	1	4
	Panicle size	3	3	4	4
Production	Yield	4	4	4	2
	Threshability	3	3	2	4
	Lodging	4	4	4	1
	Maturity	2	3	3	4
	Plant height	4	4	3	1
	Shuttering	4	3	4	2
	Disease tolerance	4	3	3	1
	Drought tolerance	2	2	2	4
TOTAL		48	47	41	42
RANK		1	2	4	3

Conclusion

The four varieties evaluated in this study, namely, TXD 306, TXD 307, TXD 88 and SUPA all doubled yields under SRI in all three locations. However, TXD 88 yielded more than the other varieties (9.13t/ha) while SUPA variety yielded the lowest (6.2t/ha). Amongst the yield components determined during the experiments (productive tillers, plant height and panicle length) only number of productive tillers was found to be statistically significant on the contribution to yield in all varieties. Research with farmers indicates that, yield alone is not the criterion for choice of the variety. The criteria used by takes part in the entire rice value chain that is production, processing, marketing and consumption. Results from both pairwise ranking and matrix scoring showed that, TXD 306 was highly preferred by farmers than all other varieties mainly due to aroma, yield, marketability and disease tolerance. We recommend the use of improved rice varieties under SRI. The dissemination efforts need to foster on the extensive promotion of TXD 306 since it serves the dual purposes by having competitive production and consumption traits under SRI production system. Breeding programs need to also embark on improving TXD 88 removing its chalkiness.

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