Zootechnical assessment of straws from different varieties of upland rice (*Oryza sativa L.*) grown in Vakinankaratra region, Madagascar

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Introduction

In the Vakinankaratra region, upland rice production has increased since new cold-tolerant altitude varieties have been developed and disseminated. Upland rice represented about 20% of the total rice surface in the high altitude areas in 2012. Rice cultivation provides considerable amounts of straw, which represents an important feed resource for ruminants, especially during periods of green forage deficit.In this region, cattle population is estimated at more than 300,000 heads. The nutritive value of straw is relatively low (low protein content and digestibility) and its fill unit value is high. Improving nutritive value of rice straw could improve animal performance and feed autonomy. Physical and chemical treatments as well as feed supplementation improve straw digestibility and its ingestion by animals. Plant breeding and cultivation techniques remain potential ways to improve the nutritive value of straw without affecting grain productivity (Vadiveloo, 1995).The variability of production, of chemical composition and of nutritive value of the straw among rice varieties was investigated through the effect of the soil (Williams *et al.*, 1996), of the season (Vadiveloo and Phang, 1996), the mowing techniques (Dong *et al.*, 2013), and fertilization or irrigation (Agnihotri*et al.*, 2003; Demarquilly*et al.*, 1998; Baumont*et al.*, 2008).

The present study focuses on the analysis of the variability of grain and rice straw production of nine upland rice varieties in selection trials, under farm and optimized management conditions. Improving the nutritional quality of rice straw would improve the autonomy of farmers for forage resources, reduce livestock production costs and improve milk production.

Materials and methods

The Dairy Basin of Antsirabe is in a high altitude area (>1300 m asl). The climate is characterized by the alternation of a hot rainy season and a cold dry season. The mean temperatures range from 18°C during rice-sowing season (October) to 20°C during the reproductive stage. This study is basedon the results of varietal trials conducted in 2011-12. The cropping season was considered as a regular year, without low temperatures during pollination which is associated to high risk of sterility(Chabanne and Razakamiaramanana, 1997).

Nine varieties of rice from the FOFIFA CIRAD breeding program have been evaluated (Raboin*et al.*, 2011; Raboin *et al.*, 2014). Varieties were grown in a randomized block design with four replicates.The varieties were grown under farm (Farm; 5 ton.ha^{-1} manure) and optimized (Advi; 5 ton.ha^{-1} manure, 500 kg.ha^{-1} dolomite, 300 kg.ha^{-1} NPK 11-22-16 and 50 kg.ha^{-1} urea) fertilization conditions.The soil was plowed and crop residues from preceding crops were incorporated in the soil. Sowing was done with seeds treated with an insecticide (5-7 seeds per hole, Insector T45WS 4g.kg^{-1} and 15kg.ha^{-1}Furadan 5G).

Two manual weeding operations were performed under Farm management whereas weeding was performed whenever necessary under Advi management. Nofungicide was appliedagainstblast in Farm trial whereas fungicides were applied twice a week in Advi trials.

The production of rice and straw was measured at harvest on plots (3.0 x 6.2m for Farm; 2.6 x 4.4m for Advi). Grains and straws were sampled for analysis after drying in an oven (60°C for 72h) and crushing (Cyclotec ™ 1093, 1 mm). The chemical composition of straws (crude protein, cellulose) and the digestibility of the organic matter (Aufrère, 1982) were obtained by spectral reading (NIRS). Indicators of nutritional quality of rice straw were calculated per hectare to estimate the amountof nutrients available for ruminants.

We performed correlation tests (Pearson, 5%) between these variables for the two types of management conditionstested. We analyzed the variability of straw and grain yields, as well as the chemical composition and digestibility of straws for the nine varieties and for the two types of management conditionstested.

Results and discussion

Correlation tests

For the two management conditions tested, rice straw production is not significantly correlated to rice production (Table 1). Optimized management significantly increased straw production, decreased cellulose content and increased the digestibility of the organic matter compared to farm management conditions. The cellulose content of straw is negatively correlated to the protein content and organic matter digestibility. Under farm management, production of rice straw is positively correlated with the digestibility of organic matter. Grain production is positively correlated with the digestibility of organic matter and negatively correlated with protein content of straw. Underfarm management conditions, rice grains fromblast susceptible varieties are not well filled (low rice yield) and nitrogen remains in the straw (higher protein content).

Table 1. Pearson correlationmatrixandp-values

Farm / Advi	Straw production	Rice production	Crudeprotein	Cellulose content	Digestibility of organicmatter
Straw production		0,115 NS	0,235 NS	-0,594 ***	0,751 ***
Rice production	0,320NS		0,058 NS	-0,103 NS	0,229 NS
Crudeprotein	0,022 NS	-0,627 ***		-0,358 *	0,461 **

Cellulose content	-0,203 NS	-0,266 NS	0,216 NS		-0,628 ***
Digestibility of organicmatter	0,332 *	0,773 ***	-0,496 **	-0,595 ***	

Newm*alpha=0,05*:*, ** and ***significant at level p < 0.05, p < 0.01 and p < 0.001, respectively; NS: not significant.

Variability in production of grain and straw, composition and nutritive value of rice straw according tomanagement

Rice and straw yields are significantly different betweenthe varieties (Table 2). ChhomrongDhanand SCRiD 6-2-4-2-3 present good grain yield in both management conditions. Fofifa 172 hasthe highest rice productivity under Advimanagement conditions. Fofifa167 presents a good grain yield and is not sensitive tomanagement conditions. Rice productivityof Fofifa 133, 152, 154, 161, 171 and 172varieties is reduced under Farmmanagement conditions. The productivity of rice straw is affected by the level of fertilization. The limited nitrogen fertilization resulted in a lower straw yield. Under optimized management, SCRiD 6-2-4-2-3 and Fofia 167 are the most productive varieties for straw. Neutral Detergent Fiber (NDF)content of SCRiD 6-2-4-2-3 variety is significantly lower than those from Fofifa 133, 152, 161, 167 and 171 varieties. Limited fertilization is accompanied by a high contentof protein in rice straw, particularly for varieties Fofifa 133, 152 and 154; but a reduced digestibility of organic matter of straws.

Table 2. Effectsof varieties and management conditions on yields of rice and straw and on composition and digestibility of straw

	Riceyield		Strawyield		CP%		NDF%		OMD %	
Varieties	**ADVI**	**FARM**	**ADVI**	**FARM**	**ADVI**	**FARM**	**ADVI**	**FARM**	**ADVI**	**FARM**
ChhomrongDhan	4.98 ab	3.25 ab	4.55 b	2.39 a	3.31 a	3.10 b	72.10 ab	73.03 a	43.89 abcd	40.55 abc
FOFIFA 133	3.04 c	1.13 c	3.54 b	2.72 a	3.68 a	5.13a	73.42 a	74.53 a	37.42 d	33.18 e
FOFIFA 152	3.66 bc	1.51 c	3.64 b	2.27 a	3.95 a	4.73 a	74.49 a	72.61 a	39.60 cd	36.71 d
FOFIFA 154	4.17 bc	1.32 c	3.41 b	2.45 a	3.42 a	5.26 a	72.86 ab	72.84 a	38.56 cd	35.83 de
FOFIFA 161	4.22 bc	2.49 b	3.59 b	2.07 a	3.14 a	3.40 b	73.56 a	73.28 a	38.94 cd	38.13 cd
FOFIFA 167	3.27 c	3.15 ab	6.22 a	3.07 a	3.71 a	2.90 b	71.98 ab	73.00 a	46.53 ab	40.99 abc
FOFIFA 171	3.59 bc	2.67 b	4.83 b	2.74 a	3.38 a	3.08 b	73.12 a	73.61 a	42.42 bcd	39.60bcd
FOFIFA 172	5.77 a	2.67 b	4.85 b	2.90 a	3.69 a	3.55 b	72.75 ab	69.92 b	44.71 abcd	43.99 a
Scrid 6-2-4-2-3	4.91 ab	3.91 a	6.31 a	3.19 a	4.07 a	3.63 b	69.19 b	71.81 ab	48.72 a	42.8 ab
Varieties	***		***		NS		**		NS	
Varieties& management	***		***		***		***		***	
Management	***		***		***		***		***	

NewmansKeuls (5 %):** and ***significant at level p < 0.01 and p < 0.0001, respectively; NS: not significant.
Means with different lowercase letters in the same column are significantly different.

The protein yields (kg CP.ha^{-1}) of rice straw are not significantly different between varieties but are dependent of crop management conditions(Figure 1). Reduced nitrogen fertilization generates a reduction of protein yieldfor ChhomrongDhan, SCRiD 6-2-4-2-3 and Fofifa 167 and 171.Reduced nitrogen fertilization generates a reduction of protein content in the straw except for sensitive varieties to blast. These varieties have low yield of grain and proteins are concentrated in the straw (Fofifa 133, 172, 152 and 154). The yield of digestible organic matter is significantly different between the rice varieties tested.Fofifa 167 and SCRiD 6-2-4-2-3 present the best digestible organic matter yields under Advimanagement conditions. The farm management is accompanied by a reduction in yield of digestible organic matter.

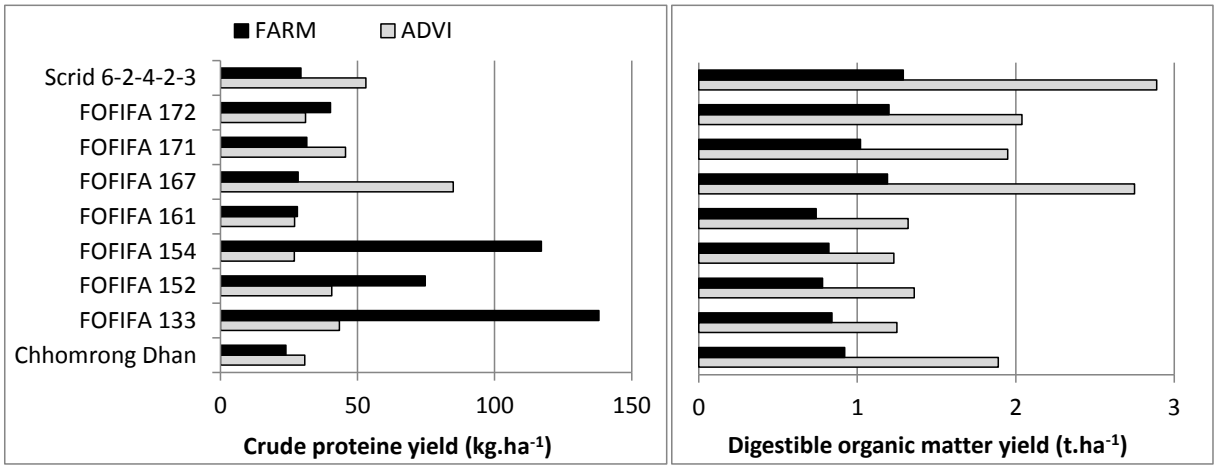

Figure 1. Effects of varieties and cultivation conditions on crude protein and digestible organic matter yields of rice straw

Conclusion

Varietal selection of upland rice could improve the nutritional value of straw available for ruminantswithout affecting rice productivity. Consequently, this canallow decreasing the use of green fodder and concentrates, improve the autonomy of farmers, reduce production costs and improve milk production.

From a zootechnical assessment point of view, the ChhomrongDhan, Fofifa 167 and SCRiD 6-2-4-2-3 varieties seem to be the most interesting ones.From livestock point of view, Fofifa 167 would be interesting (good crude protein and digestible organic matter yields), but this variety has a rice production limited under optimized management. A change of the current varieties towards dominance of SCRiD 6-2-4-2-3 variety could result in an increase of rice production and a gain of digestible organic matter available for ruminants. This change of rice variety could be a source of livestock development considering that the energyrequirements of animals can be met from alternative sources.

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