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Variation in Straw Grain Ratio and Straw Quality in Different Rice Cultivars of India

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ABSTRACT

Straw grain ratio (S/G ratio) of paddy cultivars available across the country in different states was determined. Variation in straw quality was also estimated. Sampling locations were from farmers field spread over 9 major paddy producing states *viz.*, Bihar, Chhatishgarh, Gujrat, Haryana, Jharkhand, Tamilnadu, Uttar Pradesh, Uttrakhand and West Bengal. A significant variation ($P<0.001$) in straw to grain ratio was recorded among the paddy cultivars grown by the farmers in different states.Variability($P<0.05$) within cultivar was also observed among cultivars grown under different agro-climatic regions and agronomical practices. Similarly, significant variations ($P<0.01$) quality attributes *viz.*, CP, NDF, ADF, hemicelluloses, cellulose and lignin content was recorded among the paddy cultivars. Among the various chemical constituents, the lignin content varied greatly (126%) followed by CP(76.15%), hemicelluloses(72.34%), cellulose (37.67%), ADF (25.39%), and NDF (15.48%). The DM degradability of straw from different paddy cultivars ranged from 35 to 64.4%, whereas, NDF digestibility varied from 63.52 to 80.74 %. NBDMD was negatively correlated with ADF and lignin content of straw.It can be concluded that the variability in nutritional parameters among varieties /cultivars need to be exploited by plant breeders, particularly in paddy growing areas where paddy straw is a major roughage source for ruminant diet.

Key words: Agro-climatic regions, Chemical composition, Nylon bag degradability, Paddy cultivars, Straw grain ratio

INTRODUCTION

Rice straw is abundantly available from cultivating rice, farmers offer rice straw as the main roughage source to their animals especially in eastern and southern region of the country.In India, ruminants depend on year-round grazing on natural pastures or they are fed with cut grasses and crop residues. India occupies the world's largest area under rice, grown under a wide range of agro-ecological conditions, the second-largest producer and consumer of rice in the world and accounts for 22.3% of global production. The share of paddy in total food grain production in India is around 41.36 % and share in acreage is about 35.39 % of the total area under food grains (Annual report 2016-17).According to Mandal *et al.* (2004), the total amount of crop residue generated in India is estimated at 350×106 kg/year of which wheat residue constitutes about 27 % and rice residue about 51 %. Production of crop residues is most commonly expressed as straw:grain (S:G) ratios. Variability of environmental and agronomic factors greatly influence the crop residue production (Norton *et al.,* 2017).

The land under green fodder cultivation in the country is decreasing day by day and the farmers of the paddy growing areas will be more dependent on the crop residues specially the paddy straws for feeding their livestock. Therefore, there is a need for systematic evaluation of the nutritive values of different cultivars/varieties of rice straw to develop a feeding system for its efficient utilization and exploitation of variation in nutritional attributes among varieties / cultivars by plant breeders,. The present study was undertaken to determine the straw: grain ratio, the chemical composition and *in sacco*-degradability of different varieties of rice straw.

MATERIALS AND METHODS

The sampling locations were the farmer's field spread over 9 major paddy producing states (Bihar,

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Chhatishgarh, Gujrat, Haryana, Jharkhand, Tamilnadu, Uttar Pradesh, Uttrakhand and West Bengal. Multi-stage random sampling procedure was adopted for sampling and representative plant samples were collected following the standard procedure (Snedecor and Cochran, 1967). Hand sickles were used to harvest the above ground plant biomass. All hand-clipped samples collected from 10 different locations of the field were placed in a paper sack and then dried in an oven at 50°C and then thrashed to determine grain yield, straw yield, and straw/grain ratios. After determination of straw yield, the plant samples of 10 different locations of each field were pooled together for chemical analysis.

The plant samples were dried at 60 to 70°C and ground to pass through 1mm sieve and analysed. The OM was determined by ashing at 550°C for 4 h and nitrogen was determined by Kjeldahl technique (AOAC, 2000). Neutral detergent fibre (NDF) and acid-detergent fibre (ADF) were determined by a procedure of Van Soest *et al.* (1991). Acid-detergent lignin (ADL) was determined according to the method described by Robertson and Van Soest, (1981).

Two buffalo calves (335+12.5 kg BW and 36-40 months of age) fitted with rumen cannulae were used *in sacco* degradability trial. Calves were maintained on wheat straw-based diet (roughage to concentrate ratio, 65:35). The paddy straw samples were ground through 1 mm sieves before *in sacco* rumen incubation. Triplicate samples of 2.5 g DM of each test straw were weighed in to separate nylon bags. Nylon bags were suspended in the rumen as per the method described by Mehrez and Ørskov (1977) for 48 h. After incubation, the bags with residues were taken out from rumen, dipped immediately into cold water to stop the microbial activity and then rinsed with cold water to remove the particles from outside the bags. There after the bags were washed in a washing machine for 15 minutes. The bags were dried at 45°C till the constant weights were achieved.Statistical analyses, including ANOVA and Pearson correlation analysis (Snedecor and Cochran, 1968) were performed with SPSS13.0 (SPSS software products, 1997, USA).

RESULTS AND DISCUSSION

Straw/grain (S/G) ratios varied greatly (P<0.01) among the states and also within the states covered for sampling (Table 1). Average S/G ratios ranged from 0.75(Haryana) to 1.76(Bihar). Varietal variations (P<0.01) in S/G ratios were also evident in the samples collected from different locations (Table 2). Mean S/G ratios were observed highest for the variety Lok 355(2.35) and the lowest for Purnima (0.73). However,Schiere *et al.*(2004) reported straw to grain ratio of 1.6 in rice crop. These ratios were affected by the phenotypic, genotypic and environmental factors (Khaire *et al.,* 2017). Straw/grain ratios were generally increased by available soil N levels (Kumar *et al.,* 2005).

Table 1. Straw to grain ratios (kg straw/kg grain) in paddy cultivars grown in different parts of India

State (n)	Average S/G ratio	Range	SEM
Bihar (34)	1.76	0.90-2.91	0.07
Gujarat (50)	1.06	0.60-1.72	0.04
Chhattisgarh (100)	1.54	0.74-3.33	0.06
Haryana (120)	0.75	0.29-1.97	0.02
Jharkhand (360)	1.03	0.40-4.33	0.02
Uttar Pradesh (250)	1.37	0.33-3.81	0.03
West Bengal (150)	1.28	0.54-3.57	0.04
Uttrakhand (80)	1.24	0.78-2.24	0.04
Tamilnadu (140)	1.16	0.52-2.25	0.03
P value	0.001**	-	

Figures in parenthesis indicate the number of sampling locations; P= Statistical significance; **= P<0.01; SEM= Standard error of means

Table 2. Varietal variations in straw to grain ratios (kg straw/kg grain) in paddy cultivars

Paddy cultivars[1]	Sample size	Mean	Range
Ad2235	10	1.32	0.85-1.81
Ad97191	10	1.34	1.13-1.80
Ad99039	10	1.33	0.97-1.91
AD9910	10	1.6	1.34-1.88
ADT38	10	1.02	0.80-1.26
Basmati 30	10	2.14	2.12-2.21
Basmati local	50	1.98	0.87-3.33
Basmati370	10	2.05	2.03-2.24
Bhagirathi	10	1.78	1.57-2.21
BirsaMoti	10	1.26	1.13-1.66
BPT 5204	20	1.49	0.91-2.31
CR 1017	20	1.48	0.99-1.97
CR1009	80	1.03	0.52-2.25
Cr1010	10	1.45	1.10-2.12
Doon hybrid	10	1.27	1.15-1.61
Dwarf mansoori 7029	30	1.27	0.86-1.63
Giri	10	2.16	1.35-3.57
GR4	10	1.06	0.89-1.36
Gurjari	20	0.98	0.60-1.46
IET1444	10	1.18	0.86-2.19
IET4094	10	0.98	0.75-1.27
IR 36	20	1.08	0.82-1.59
IR64	50	1.07	0.40-2.23
Lalat	50	0.91	0.61-1.51
Local	50	1.31	0.81-2.10
Lok 355	10	2.35	2.04-2.98
Mahamaya	20	0.79	0.55-1.31
MTU 7029	20	1.19	0.80-1.46
MUT1010	60	0.74	0.29-1.97
PA6444 Proagro hybrid	60	0.82	0.58-1.50
Parimal	9	2.06	1.48-2.91
PHB 71	60	0.83	0.47-1.98
PR 4	40	1.1	0.74-2.16
Purinma	20	0.73	0.53-1.46
Pusa 1001	10	1.11	0.88-1.54
Pusa 831	5	1.7	1.20-2.24
Pusa RH 10	14	1.5	0.90-1.85
Ranjit	10	0.8	0.68-1.06
S 52	10	1.57	0.94-2.20
Sarbati	10	0.98	0.92-0.99

Saryu 52	140	1.3	0.33-3.81
Savita	10	1.8	1.27-2.64
Sita	20	1	0.72-1.65
Sugandha	10	1.21	0.93-1.37
Sugandha 3	6	1.68	1.42-2.18
Sugandha 5	5	1.84	1.52-2.14
Sugandha2	5	1.87	1.67-2.15
Suruchi	10	0.84	0.70-1.22
Swarna	70	1.08	0.54-4.33
Swarna white	20	1.21	0.97-2.05
Type 3	10	1.87	1.51-3.08
VL Dhan207	70	1.13	0.78-1.81
White punny	10	1.4	1.16-1.99
Pvalue		*	
SEM		0.21	

SEM= Standard error of means; *= P<0.05; [1]Name of paddy cultivars are based on information provided by the farmers during sample collection

Tingxian *et al.*(1993) observed great differences in plant height and grain yield at differently matured varieties. They also observed that plant height and grain yield is much higher in medium maturing rice than early maturing rice varieties.

Straw quality parameters of different paddy cultivars are presented in Table 3 and 4. Significant variations (P<0.01) in all the quality attributes *viz.*, CP, NDF, ADF, hemi cellulose, cellulose and lignin were observed among the paddy cultivars.Among the various chemical constituents, the lignin content varied greatly (126%) followed by CP (76.15%), hemicelluloses (72.34%), cellulose (37.67%), ADF (25.39%), and NDF (15.48%). These large variations among quality attributes of some paddy cultivars have already been reported earlier by Peripolli *et al.* (2016). Nader *et al.* (2012) also observed substantial variability in the nutrient levels and feeding value among rice straws because the nutritional value of the straw is directly related to its chemical composition, combined with genetic factors (Capper, 1988), climate (Sannasgala and Jayasuriya, 1986), morphological composition (Nakashima and Orskov,1990) and cultivation practices such as fertilizer application, water management, harvest maturing stage (Ibrahim *et al.,* 1988). Nori *et al.* (2006) reported great variability in chemical composition among rice straws. Tingxian *et al .* (1993) also observed that NDF content of medium maturing rice was significantly higher than that of early maturing and late maturing varieties.The lignin content of early maturing rice straw was significantly less than that of medium, and late maturing varieties. Rice straw from more productive cultivars had lower levels of lignin and C fraction as well as higher levels of crude protein and B3 fraction compared to straws from less productive cultivars. Perpolli *et al.*(2016) observed that straws derived from early maturing cultivars showed the lowest levels of neutral detergent fiber, acid detergent fiber, acid detergent insoluble nitrogen and C nitrogen fraction in comparison with straw originating from mid cycle cultivars.

Much of the variations observed may also be due to differences in the proportions of plant morphological fractions, rather than differences in cell wall composition *per se.*In medium and late maturing varieties the proportion of leaf sheath is higher than leaf blade and followed by stem (Tingxian *et al.,*1993). Combined leaf blade and leaf sheath constituted about 75% of the total rice straw. Nori (2005) also reported great variability in proportion of morphological fractions

Table 3. Variability in nutrient content (% DM basis) and DM degradability (%NBDMD) of straw of different paddy cultivars grown in various regions

Paddy cultivar	CP	NDF	ADF	HC	Cellulose	Lignin	NBDMD
Basmati 30	3.25	63.99	45.22	18.77	37.95	6.13	53.07
Basmati local	-	70.4	46.92	23.49	37.65	8.53	58.44
Basmati370	4	69.99	47.26	22.73	41	6.11	50.74
Bhagirathi	3.56	74.59	48.51	26.08	36.16	8	49.89
BirsaMoti	3.49	70.37	51.06	19.3	40.39	7	64.91
BPT 5204	3.38	71.92	41.36	30.56	35	13.23	66.79
CR 1017	3.58	73.49	48.35	25.15	36.42	7	48.95
Cr1010	3.67	72.14	49.15	22.98	38.12	7	49.52
Doon hybrid	3.02	73.18	46.58	26.6	36.23	10.6	66.4
Dwarf mansoori 7029	4.41	70.88	47.18	23.69	38.14	11.93	49.03
Giri	3.89	69.97	48.2	21.77	35.23	8	49.56
GR4	5.32	72.5	52	20.5	32.24	7.5	48.02
Gurjari	5.02	71.11	46.91	24.21	29.78	7.76	55.76
IET1444	3.98	68.75	44.48	24.27	35	7.32	50.05
IET4094	3.86	72.97	51	21.97	37.43	8	51.02
IR 36	3.44	69.98	46.95	23.03	34.55	7.77	60.41
IR64	3.53	70.88	45.74	25.14	35.29	7.14	60.33
Lalat	4.07	70.41	51.22	19.19	38.88	7.8	50.11
Local	2.99	68.67	46.68	21.99	35.29	7.68	50.03
Lok 355	3.84	74.5	35.68	38.82	35	13.59	61.24
Mahamaya	3.6	71.33	51.86	19.48	35.48	8	44.61
MTU 7029	3.08	72.65	45.5	27.15	36.2	10.96	59.67
MUT1010	3.15	71.42	50.38	21.04	34.33	8	48.56
PA6444 Proagro hybrid	3.41	72.22	44.71	27.52	36.5	7.04	59.76
Parimal	5.18	68.92	47.54	21.38	36.48	7.33	55.91
PHB 71	3.45	73.9	46.83	27.08	37.21	8.29	57.77
PR 4	4.5	70.09	47.22	22.87	36.88	7.96	62.06
Purinma	3.63	72.97	49.89	23.09	33.9	8	45.97
Pusa 1001	3.86	68.23	45.11	23.11	32.98	5	53.42
Pusa 831	4.8	68.29	51.5	16.79	36.38	8	52.72
Pusa RH 10	4.73	69.79	49.01	20.78	35.81	8	58.44
Ranjit	3.89	70.55	47.88	22.67	35.1	8	50.21
S 52	4.31	69.25	45	24.25	35	11.32	61.26
Sarbati	4	68.28	45.31	22.97	34.98	13.81	53.2
Saryu 52	4.38	70.59	45.39	25.2	35.87	8.18	59.76
Savita	3.89	69.79	48.57	21.22	36.29	8	50.21
Sita	3.76	70.98	51.84	19.15	39.21	8	57.84
Sugandha	5.67	69.33	48.06	21.27	35.73	8	52.93
Sugandha 3	4.5	69.51	50.8	18.71	35.79	5.92	52.36

Sugandha 5	4.56	69.46	50.86	18.6	35.63	6.28	58.87
Sugandha 2	4.6	68.43	48.75	19.67	36.36	8	54.56
Suruchi	3.37	72.35	40	32.35	40.43	7	58.33
Swarna	3.98	73.24	49.05	24.19	35.97	7.65	56.71
Swarna white	3.76	72.99	49.82	23.17	37.68	8	49.89
Type 3	3.5	68.87	45	23.87	35	12.85	63.91
VL Dhan 207	389	69.83	45.8	24.03	37.29	11.03	44.87
P	*	*	**		**	**	*
SEM	0.2	1.81	1.17	1.1	1.03	0.77	1.44

P= Statistical significance; SEM= Standard error of means; *P<0.05, **= P<0.01

in rice straws. The concentration of straw nitrogen was significantly affected by the site where the rice plants were grown, if they were grown under alternate wetting and drying or continuous flooding,difference was significant among the cultivars (Norton *et al.*2017).

Results of micro and macro nutrient analysis (Table 5 and 6) of rice straw samples indicated that calcium content was sufficient (0.49 to 0.88%) to meet the requirements of dairy animals. However, phosphorus (0.03-0.15%) was deficient in samples collected from all the states except Uttarakhand (0.22%) as compared to its required level (0.22 %).Norton *et al.*(2017) recorded that the concentration of straw phosphorus was 0.03-0.06% among different rice cultivars and was significantly affected by site, treatment, and cultivar as well as interactions between site × treatment and site × cultivar. Similarly, magnesium content was also low (0.06-0.1%) in major rice producing area as compared to its required level (0.20 %). The copper content of rice straw samples ranged from 4.88 to 7.78 ppm, which was considered low in meeting the dietary requirement. Dash *et al.* (2010) reported higher Cu content (7.9-14.43 ppm) in paddy straw with application of inorganic and organic sources of N. Likewise, zinc content was also low and it varied greatly (12.46 to 28.83 ppm) among rice straw samples and corroborated with the findings of Dash *et al.* (2010).Lakshmanan *et al.* (2005), however,reported 50-94.7 ppm Zn in straws of different varieties of basmati rice and Norton *et al.* (2017) recorded the Zn concentration of 18.54-61.04 ppm in different cultivars of paddy straws grown in different sites. The concentration of iron and manganese, however, in rice straw samples were many folds higher than their required levels of 50 and 40 ppm, respectively.

A significant (P<0.01) variability (35.0 to 64.4 percent) in *in sacco* straw DM disappearance was observed (Table 7) among different rice cultivars. Agbagla *et al.* (2003) reported DM degradability in the range of 41.7-47.8% in different rice varieties. Nori *et al.* (2006) observed great variability in *in vitro* digestibility of rice straw cultivars. Tingxian *et al.* (1993)

Table 4. Fibre, protein and DM (NBDMD) degradability (% of DM) of straw of paddy cultivars collected from different locations

Attribute	n	Mean	Minimum	Maximum	SEM	SD
NDF	162	72.1	63.52	80.74	0.24	3.1
ADF	162	48.38	35.49	57.71	0.34	4.33
Hemi cellulose	162	23.73	14.61	38.82	0.33	4.23
Cellulose	162	35.97	28.68	46.16	0.2	2.61
Lignin	162	7.92	5.02	12.85	0.16	2.02
Protein	162	3.95	2.27	5.86	0.07	0.83
NBDMD	162	51.65	35	64.4	0.76	6.42

Table 5. Macro and micro mineral status of rice straw-State wise

State	Ca (%)	P (%)	Mg (%)	Cu (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)
Bihar	0.88	0.03	0.07	6.5	12.46	122.85	247.68
Chhattisgarh	0.6	0.08	0.07	4.88	20.69	132.91	203.78
Gujarat	0.49	0.12	0.07	5.39	22.68	134.25	159.67
Haryana	0.53	0.12	0.06	5.16	21.21	133.65	240.52
Jharkhand	0.61	0.15	0.06	6.59	28.83	133.45	252.1
Tamil Nadu	0.71	0.03	0.09	6.72	17.48	99.53	225.91
Uttar Pradesh	0.6	0.12	0.07	5.38	15.91	211.15	167.57
Uttarakhand	0.56	0.22	0.07	5.38	25.11	79.93	119.31
West Bengal	0.82	0.03	0.1	7.78	20.24	115.22	261.52

also recorded significant differences ($P<0.05$) for whole plant DMD values from different varieties in the order of: early maturing highest, the medium maturing higher and the late maturing lowest. However, there were no significant differences between CPD values of whole plant.The high levels of cell wall constituents were inversely related to the straw nutritional value, similar to that observed by Agbagla *et al.* (2001).Saebarinoto *et al.* (1993) also showed higher *in vivo* digestibilities and intake of the dry season straws, concomitant with a lower lignin and silica, but higher hemicellulose contents. The higher quality of stem compared to the leaf is a characteristic of rice straw (Vadiveloo, 1995) and higher quality of straw could be obtained from modem, semi-dwarf varieties because of their low leaf proportions.

Lignin located between the cellulose microfibrils is regarded as the most abundant natural aromatic organic polymer that plays a role in resisting compressing forces, and also inhibiting the rate and degree of microbial degradation (Iiyama *et al.,*1990). Lignin forms the complex with plant carbohydrate which remains un-dissociated under anaerobic environment of rumen (Sarnklong *et al.,*2010) as lignin degrading enzyme system does not exist in anaerobic environment.

CONCLUSIONS

Traditionally, straw production in the country is estimated by multiplying grain yield with a constant factor of straw to grain ratio. These estimates may require the precision due to variability in straw grain ratios. Results from this study demonstrate that application of prediction models based on region specific straw grain ratios would provide considerably better and precise estimates of straw yield. Chemical composition and digestibility of straw varied greatly among paddy cultivars/ varieties. This variability

Table 6.Variability in macro (% on DM basis) and micro (ppm) nutrient in straw of rice cultivars collected from different locations

Macro and Micro nutrients	Mean	Minimum	Maximum	SEM	SD
Phosphorus	0.12	0.024	0.245	0.008	0.058
Calcium	0.612	0.44	0.977	0.017	0.115
Magnesium	0.068	0.054	0.108	0.001	0.007
Copper	5.853	2.266	9.956	0.246	1.707
Zinc	22.102	8.498	40.976	1.081	7.493
Iron	215.077	105.784	611.838	14.398	99.75
Manganese	143.53	36.407	285.175	8.679	60.13

Table 7. Correlation among chemical constituents and DM degradabilityof paddy straw

Attribute	ADF	Lignin	Protein	NBDMD
Protein	-0.02	-0.26**	1	0.64**
NDMD	-0.40**	-0.59**	0.64**	1
ADF	1	0.1	-0.02	-0.40**
Lignin	0.1	1	-0.26**	-0.59**

*,**Correlation is significant at the level P<0.01 and P<0.05, respectively; n=162

presumably could be exploited to improve the nutritional value of the straw of future varieties. The straw crude protein and lignin contents are directly related with DM digestion. Therefore, the variation in nutritional parameters among the paddy cultivars/varieties needs to be exploited by the plant breeders.

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REFERENCES

Agbagla, A., Gaillard-Martinie, B., Puard, M. and Doreau, M. 2003. Effect of silica content on rice straw ruminal degradation. *J. Agric. Sci.* 140: 183 192.

Agbagla-Dohnani, A., Nozière, P., Clement, G. and Doreau, M. 2001. In sacco degradability, chemical and morphological composition of 15 varieties of European rice straw. *Anim. Feed Sci. Technol*. 94: 15-27.

Annual Report (2016-17) Directorate of Agricultural Cooperation and Farmers Welfare (DAC&FW)

AOAC. 2000. *Official Methods of Analysis*, 17th ed. Association of Official Analytical Chemists, Gaithersburg, MD.

Capper, B.S. 1988. Genetic variation in the feeding value of cereal straw. *Anim. Feed Sci. Technol*. 21: 127-140.

Dash, D., Patro, H., Tiwari, R.C. and Shahid, M.2010. Effect of organic and inorganic sources of nitrogenon Fe, Mn, Cu and Zn uptake and content of rice grain at harvest and straw at different stages of rice (*Oryza sativa*) crop growth. *Adv. Appl. Sci. Res*. 1: 36-49.

Ibrahim, M.N.M., Tharmaraj, J. and Schiere, J.B. 1988. Effect of variety and nitrogen application on the nutritive value of rice straw and stubble. *Biol. Waste*. 24: 267-274.

Iiyama, K., Lam, T.B.T. and Stone, B.A. 1990. Phenolic acid bridges between polysaccharides and lignin in wheat internodes. *Phytochem*. 29: 733-737.

Khaire, A.R., Kunkerkar, R.L., Thorat, B.S., Gavai, M.P. and Bhave, S.G. 2017. Studies on genetic variability for yield and yield contributing traits in local rice (*Oryza sativa* L.) *J. Pharmacogn. Phytochem.* 6: 1376-1378.

Kumar, K.S., Nagarajan, R., Nagarajan, S.K., Jawahar, D. and Pandian, B.J. 2005. NPK fertilizers for hybrid rice (*Oryza sativa* L.) productivity in alfisols southern districts of Tamil Nadu. *Asian J. Plant Sci*. 4: 574-576.

Lakshmanan, R., Prasad, R. and Jain, M.C. 2005. Yield and uptake of micronutrients by rice as influenced by duration of variety and nitrogen fertilization. *Arch. Agron. Soil Sci*. 51: 1-14.

Mandal, K.G., Misra, A.K., Hati, K.M., Bandyopadhyay, K.K., Ghosh, P.K. and Mohanty, M. 2004. Rice residue management options and effects on soil properties and crop productivity. *Food Agric. Environ*. 2: 224-231.

Mehrez, A.J. and Orskov E.R. 1977. A study of the artificial fiber technique for determining the digestibility of feed in rumen. *J. Agric. Sci. (Camb.)* 88: 645-650.

Nader, G.A., Cunb, G.S. and Robinson, P.H. 2012. Impacts of silica levels, and location in the detergent fiber matrix, on in vitro gas production of rice straw. *Anim. Feed Sci. Technol*. 174: 140-147.

Nakashima, Y. and Orskov, E R. 1990. Rumen degradation of straw. 1. Effect of cellulase and ammonia treatment on different varieties of rice straws and their botanical fractions. *Anim. Prod.* 50: 309-317.

Nori, H. 2005.*Effects of Nitrogen Fertilization Levels on the Straw Nutritive Quality of MR 211 and MR 219 Rice Varieties*. M.Sc. Dissertation. University Putra, Malaysia.

Nori, H., Halim, R.A. and Ramlan, M.F. 2006. The effects of nitrogen fertilization levels on the straw nutritive quality of Malaysian rice varieties. *J. Agron*. 5: 482-491.

Norton, G.J., Travis, A.J., Danku, J.M.C., Salt, D.E., Hossain, M., Islam, M.R. and Price, A.H. 2017. Biomass and elemental concentrations of 22 rice cultivars grown under alternate wetting and drying conditions at three field sites in Bangladesh. *Food Energy Secur.* 6: 98-112.

Peripolli, V., Barcellos, J.O.J., Prates, Ê.R., McManus, C., Silva, L.P., Stella, L.A., Costa Junior, J.B.G. and Lopes, R.B. 2016. Nutritional value of baled rice straw for ruminant feed. *R. Bras. Zootec.* 45: 392-399.

Robertson, J.B. and Van Soest, P.J. 1981. *The Detergent System of Analysis and its Application to Human Foods.* Cornell University, Ithaca, New York.

Sannasgala, K. and Jayasuriya, M.C.N.1987. The influence of plant fractions on the digestibility of rice straw. *Biol. Waste.* 20: 153-156.

Sannasgala, K. and Jayasuriya, M.C.N. 1986. The effect of variety and cultivation season on the chemical composition and *in vitro* organic matter digestibility of rice straw. *Agric. Wastes.* 18: 83-91.

Sarnklong, C., Cone, J.W., Pellikaan, W. and Hendriks, W.H. 2010. Utilization of rice straw and different treatments to improve its feed value for ruminants: A review. *Asian-Australas. J. Anim. Sci.* 5: 680-692.

Schiere, J.B., Chiere, A.L., Joshi, A., Seetharam, S.J., Oosting, A.V., Goodchilds, B.D. and Van Keulen, H. 2004. Grain and straw for whole plant value: Implications for crop management and genetic improvement strategies. *Exp. Agric.* 40: 277-294

Snedecor, G.W. and Cochran W.G. 1968. *Statistical Methods*. 6th ed. The Iowa State College Press, Ames, Iowa, USA.

Soebarinoto, S.C., Hennanto, H., VanBruchern, J.V. and Orskov, E.R. 1993. Nutritive value of straw, with special reference to wet reason rice straw as related to variety and location of growth in East Java, Indonesia, pp.370-377. In: Kiran Singh and J.B. Schiere (eds.). *Feeding of Ruminants on Fibrous Crop Residues*, ICAR, New Delhi and Agric. Univ.,Wageningen.

SPSS. 1997. *Statistical Packages for the Social Sciences. Base* 13 SPSS software products. SPSS Inc., Chicago, IL.

Tingxian, X., Rejun, F., Zhiliang, T., Leihua, H. and Huiping, C. 1993. A study on nutritional characteristics of rice straw in china. *Asian-Australas. J. Anim. Sci.* 6: 291-300.

Vadiveloo, J. 1995. Factors contributing to varietal differences in the nutritive value of rice straw. *Anim. Feed Sci. Technol*. 54: 45-53.

Van Soest, P.J, Robertson, J.B. and Lewis, B.A. 1991. Methods for dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal nutrition. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle. *J. Dairy Sci.* 74: 3583-3597.

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