Effect of Graded Levels of Wheat Bran Supplementation on Intake, Nutrient Digestibility, Microbial N Yield and Growth Rate of Native Bulls Fed Rice Straw Alone

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ABSTRACT : The dose response effects of different levels of wheat barn (WB) supplementation to a rice straw based diet has been studied in growing native (*Bos indicus*) bulls of Bangladesh. Twelve bulls of 266 ± 29.6 kg live weight and 32 ± 9.5 months old were given either of three diets of *ad libitum* untreated rice straw alone (T1) or straw supplemented with 2 (T2) or 3 (T3) kg WB. Besides, the experimental animals also received a mineral mixture. In 4 weeks, data were recorded on the intake, digestibility, microbial N (MN) yield, N balance (NB) and growth rate (GR). In the three diets, WB was 0 (T1), 29.6 (T2) and 42 (T3) percent of the total DM intake. With the increasing levels of WB supplementation, the total DM and OM intake increased, but the straw intake decreased linearly. WB supplementation increased the digestibilities of DM, OM and N but had no effect on ADF digestibility. The urinary purine derivative excretion and hence the MN yield increased with WB supplementation. The total MN yield were 7, 26 and 35 g/d respectively for 0, 2 and 3 kg WB supplementation. However, the efficiency of MN yield was highest (13 g/kg DOMR) at 2 kg WB level. Despite the increase DOM intake, the dietary ME content remain below 6 MJ/kg DM even at 3 kg WB supplementation. The NB were −84, 467 and 1,620 mg/kg $W^{0.75}$/d which were reflected on the GR of −186, 346 and 554 g/d for 0, 2 and 3 kg WB supplementation respectively. Depending on the cost effectiveness, on an untreated rice straw diet, WB may be supplemented by up to 3 kg/d (42% of the diet) or more. However, if the maximum utilization of roughage is the main concern, the optimum WB level would probably be around 2 kg (30% of the diet) daily.
(Key Words: Rice Straw, Wheat, Bran, Microbial N Yield, N Balance and Growth Rate)

INTRODUCTION

Inadequate year round nutrition is a major constraint for smallholder ruminant production in Bangladesh. Here, ruminants owned by the smallholder subsists mostly on rice straw with little unimproved native pasture supplementation. These poor quality roughages are bulky, high in fibre, poorly degraded in the rumen, low in N and minerals resulting in very low intake (Chowdhury, 1997). Several factors limits the utilization of poor quality roughages by ruminants. This includes rumen environments (pH > 6.2, NH_3 > 5 mmol/l), microbial adhesion, particle size reduction, passage rate both particulate and liquid digesta, roughage degradation rate and VFA production, adequate supply of iso-acids for microbial protein production and availability of by-pass protein (Osuji et al., 1995). To correct the nutritional imbalance of a rice straw based diet, supplementation of energy and protein rich concentrates has often been suggested (Umunna et al., 1995). Population pressure limit the use of grain for animal feeding in most of the developing countries. However, cereal miling by-products like wheat bran, rice bran, pulse brans, oil cakes are available round the year in reasonable amounts. Wheat bran is the most commonly used supplement of cattle on a straw diet in Bangladesh. It is the covering of wheat endosperm consisting of two kinds of fibrous coating: a coarse outer coating and under it a less fibrous aleurone layer with a fair coating of flour. It contain most of the vitamins and protein of the wheat grain.

Supplementation of wheat bran with other ingredients e. g., rice bran (Khandaker et al., 1995) fish meal (Chowdhury and Huque, 1995), oil cake or algal suspension (Chowdhury et al., 1995) resulted stimulatory interaction effect on rice straw based diet. However, no effort has been made to obtain 'dose response' effect of wheat bran supplementation on a rice straw based diet. The present trial was designed to determine the effect of different levels of wheat bran supplementation including

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the '0' level, of a rice straw based diet, on the performance of native growing bulls.

MATERIALS AND METHODS

Experimental design, animals and diet

The experiment was conducted during the August, 1995 for four weeks. Twelve indigenous growing bulls of 266 ± 29.6 kg weight and 32 ± 9.5 months old were randomly assigned to three treatments in a completely randomized design. The three treatments were 0 (T1), 2 (T2) and 3 (T3) kg wheat bran (WB) to an *ad libitum* chopped (15 cm) rice straw diet. Besides, individual animal also received 50 g salt and 30 g oyestershell powder as mineral supplement. The diets were offered twice daily (08:00 and 17:00 h) and straw was given 15% in excess of intake. Rice straw was of unknown high yielding variety cultivated during the winter months collected from north-central region of Bangladesh. Wheat barn was collected from the local market. Chemical compositions of straw and wheat bran are shown in table 1. The animals were housed in a Face-out-Stanchion barn except during the digestibility measurement when they were moved to metabolic stalls having facilities of separate faeces and urine collection.

Table 1. Chemical composition of feed ingredients used in the trial

Ingredients	Dry matter (g per 100 g fresh)	g per 100 g of Dry matter		
		Organic matter	Nitrogen	ADF
Rice straw	85.8	82.2	0.81	47.7
Wheat bran	87.7	94.5	3.25	20.1

Liveweight change

Animals were weighed weekly before morning feed. Liveweight change was calculated as the slope of the individual regression of live weight *vs.* time.

Chemical analysis

Samples of feeds, refusals and faeces were analysed for dry matter (DM), organic matter (OM) and N according to AOAC (1984). Urinary N also measured in the same way. The acid detergent fibre (ADF) was determined according to Goering and van Soest (1970). The urine sample were analysed for determining purine derivatives (allantoin + 15% correction for uric acid) and the microbial protein absorbed in the intestine was estimated from the knowledge of the purine : protein ratio in microbial biomass, (Chen and Gomes, 1992.)

Statistical analysis

The data were analysed by an ANOVA of completely randomized design with appropriate standard error of mean differences. Simple linear regression of the form $y = a + bx$ was used where appropriate. Statistical method of Snedecor and Cochran (1967) was used for the analysis.

RESULTS

Intake

Intake of total DM, OM and straw is presented in table 2. The supplementation of 0, 2 and 3 kg WB corresponds to 0, 29.6 and 42.2% of the total DM intake. Wheat bran supplementation significantly ($p < 0.01$) improve both total DM and OM intake. At 0, 2 or 3 kg of WB supplementation, the total DM intake were 74, 90 and 94 g/kg $W^{0.75}$/d and the OM intake were 61, 78 and 84 g/kg $W^{0.75}$/d respectively. However, the straw DM intake reduced ($p < 0.01$) from 74 to 62 and 54 g/kg $W^{0.75}$/d respectively at 0, 2 and 3 kg WB supplementation.

Table 2. Dry matter intake (DMI) from straw and/or wheat bran by native growing bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg wheat barn (WB) daily

Parameters	T1	T2	T3	SED (*Residual df* = 9)	Significance
Total DMI (kg/d)	4.73	6.08	6.40	0.095	$p < 0.01$
Straw DMI (kg/d)	4.73	4.28	3.70	0.76	NS
WB DNI (kg/d)	0	1.80	2.70	–	–
Straw DMI (g/kg $W^{0.75}$/d)	74	62	54	3.2	$p < 0.01$
Total DMI (g/kg $W^{0.75}$/d)	74	90	94	4.58	$p < 0.01$
Total OMI (g/kg $W^{0.75}$/d)	61	78	84	4.9	$p < 0.01$
WB as % of Total DMI	0	29.6	42.2	–	–
WB as % of live weight	0	0.66	0.99	–	–
Substitution rate (%)	–	9.53	21.90	–	–

The fitted regression between the level of WB as % of total DMI (X) and the straw (Equation 1) or the total (Equation 2) DMI g/kg $W^{0.75}$/d (Y) are as follows (see figure 1):

$$Y = 74 - 0.44X \quad (r^2 = 0.76;\ n = 12;\ p < 0.01) \ldots\ldots \quad \text{(Eqn. 1)}$$

$$Y = 74 - 0.51X \quad (r^2 = 0.72;\ n = 12;\ p < 0.01) \ldots\ldots \quad \text{(Eqn. 2)}$$

The substitution rates, which is the decrease in roughage DM intake per unit of supplement DM given, were 9.53 and 21.9% respectively at 2 and 3 kg of WB supplementation (figure 2).

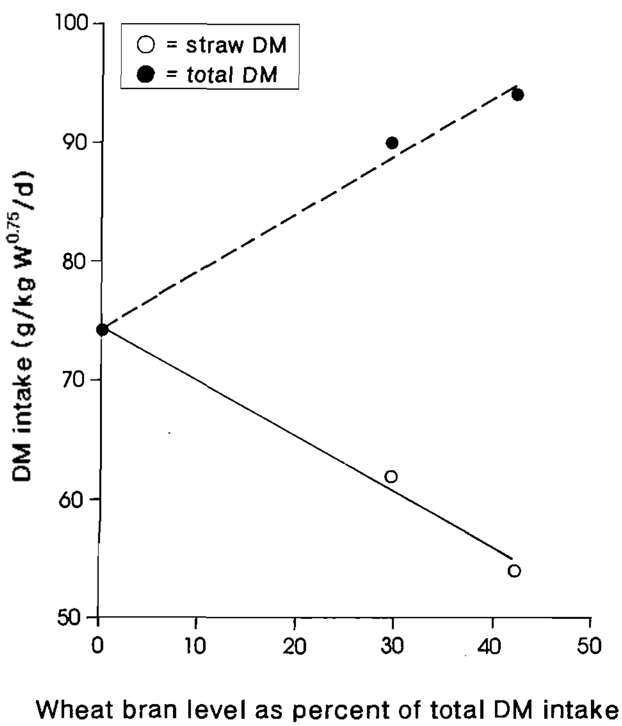

Figure 1. Effect of different levels of wheat bran supplementation on a straw diet on the total (●) and straw (○) DM intake of native (*Bos indicus*) growing bulls. Each point represents the mean of four observations.

Digestibility

Whole gut digestibilities of different nutrients are presented at table 3 and figure 3. Digestibilities of DM and OM increased significantly ($p < 0.01$) with the 2 kg WB supplementation, which improved further with 3 kg WB but difference was not statistically significant ($p > 0.05$). The N digestibility at 0, 2 or 3 kg of WB were 10,

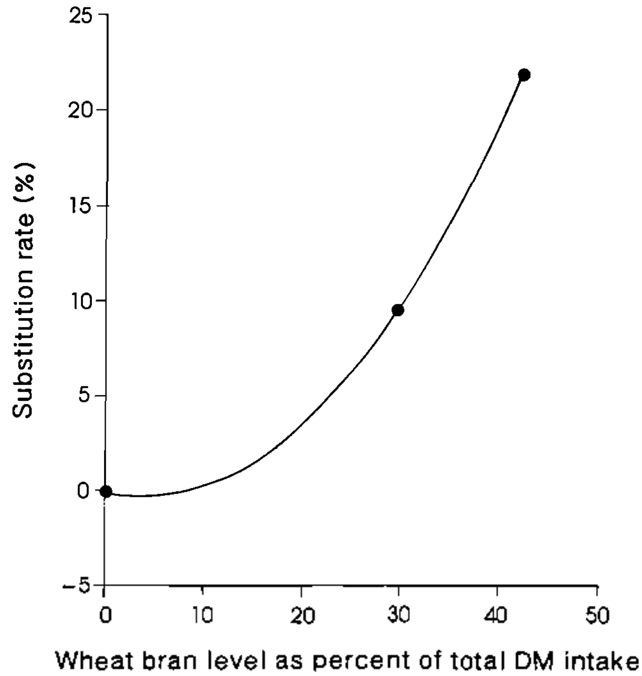

Figure 2. Effect of different levels of wheat bran supplementation on a straw diet on the substitution rate. Each point represents the mean of four observations.

Table 3. Nutrient digestibilities (%) of different groups of growing native bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg wheat bran (WB) daily

	T1	T2	T3	SED (*Residual df* = 9)	Significance
Dry matter	48[b]	54[a]	57[a]	2.96	$p < 0.05$
Organic matter	56[b]	60[a]	66[a]	2.71	$p < 0.05$
Nitrogen	10[c]	56[b]	76[a]	6.83	$p < 0.05$
ADF	62	60	59	3.67	NS

56 and 76% respectively and the differences were highly significant ($p < 0.01$) at all levels of supplementation. Supplementation of WB, however, had no effect on the ADF digestibility which were 62, 60 and 59 respectively at 0, 2 and 3 kg of WB.

N utilization

Nitrogen utilization by differenct groups of animals are shown in table 4. Dietary N intake increased significantly ($p < 0.01$) with the increasing amounts of WB, which were 599, 1,373 and 2,610 mg/kg $W^{0.75}$/d respectively at 0, 2 and 3 kg of WB (see figure 4). Urinary and faecal N also increased significantly ($p < 0.05$) due to WB supplementation. N balances at 0, 2 or 3

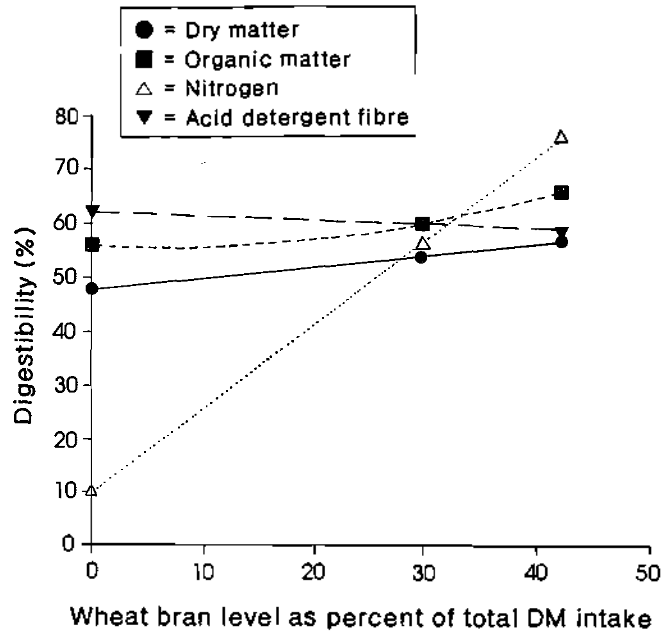

Figure 3. Effect of different levels of wheat bran supplementation on the digestibilities of different nutrient of native (*Bos indicus*) growing bulls fed rice straw. Each point represents the mean of four observations.

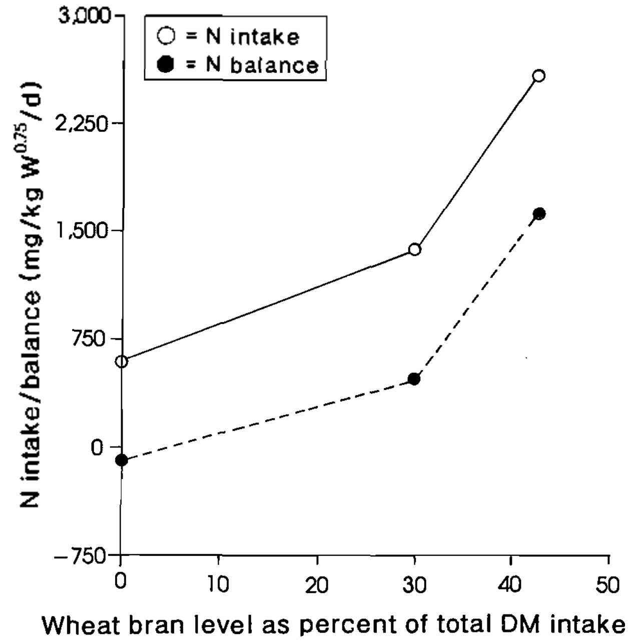

Figure 4. Effect of different levels of wheat bran supplementation on the N intake (○) and the N balance (●) of native (*Bos indicus*) growing bulls fed rice straw. Each point represents the mean of four observations.

Table 4. Nitrogen utilization of different groups of growing bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg of wheat bran daily

	T1	T2	T3	SED (*Residual df* = 9)	Level of significance
Feed N intake (g/d)	38.38	92.60	178.00	1.745	$p < 0.01$
Feed N intake (NI mg/kg $W^{0.75}$/d)	599	1,373	2,610	93.3	$p < 0.01$
Faecal N excretion (g/d)	34.50	40.61	42.20	3.628	$p < 0.05$
Urinary N excretion (g/d)	9.43	20.26	24.03	3.421	$p < 0.05$
Total N excretion (g/d)	43.94	60.87	66.78	3.727	$p < 0.05$
N balance (g/d)	−21.24	126.90	444.90	3.674	$p < 0.01$
N balance (mg/kg $W^{0.75}$/d)	−84	467	1,620	90.91	$p < 0.01$

kg of WB were −84, 467 and 1,620 mg/kg $W^{0.75}$/d respectively (see figure 4). The fitted regression between the N intake (X) and N balance (Y) was as follows (see figure 5):

$$Y = 0.885X - 638 \ (r^2 = 0.997;\ n = 3 \text{ and } p < 0.05)$$

Here X = N intake (mg/kg $W^{0.75}$/d) and Y = N balance (mg/$W^{0.75}$/d)

Microbial N yield

The microbial N (MN) yield in response to different levels of WB supplementation are presented in table 5. The urinary purine deriveatives (PD) excretion and hence the MN yield increased significantly ($p < 0.01$) with the 2 kg WB supplementation, which improved (but not statistically significant) further with 3 kg WB. The MN yield were 6.61, 262.25 and 35.31 g/d respectively at 0, 2 and 3 kg WB supplementation. The fitted regression between the dietary WB levels (X) and the MN yield (Y) are shown in figure 6. For unit (% of the total DMI) increase in WB supply in the diet, the MN increased by 0.68 g daily ($r^2 = 0.998$; $p < 0.05$). Increase of WB from 0 to 2 kg significantly ($p < 0.01$) increased the MN yield per kg DOM apparently fermented in the rumen (i. e., the efficiency of MN yield) from 4.64 to 12.97 g, but further increase of WB to 3 kg, slightly reduced the efficiency of MN production (see figure 6).

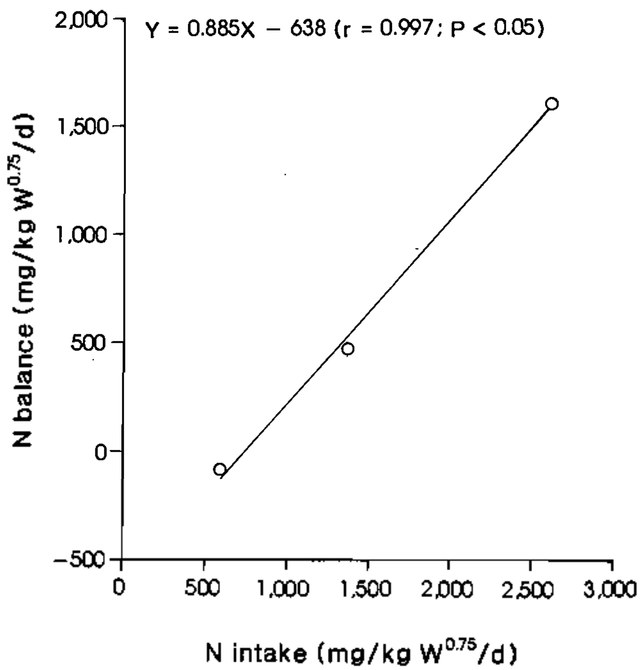

Figure 5. N balance response in relation to N intake of native (*Bos indicus*) growing bulls fed rice straw supplemented with different levels of wheat bran. Each point represents the mean of four observations.

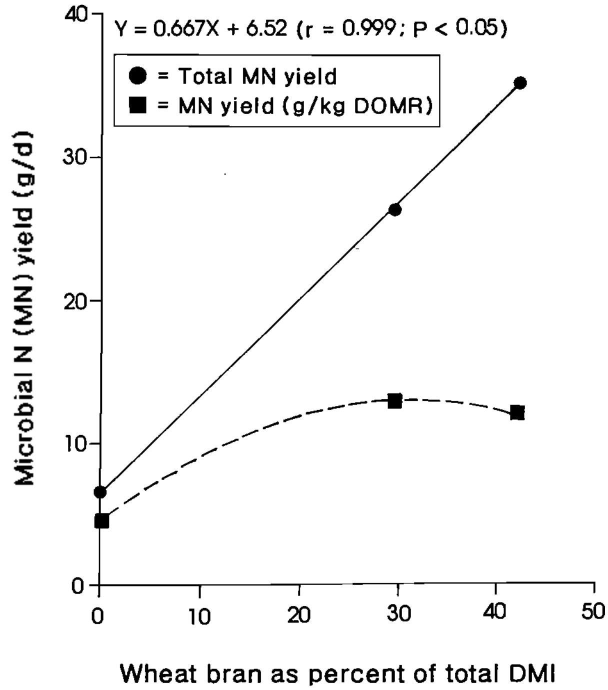

Figure 6. Effect of different levels of wheat bran supplementation on the total microbial N (MN) Yield (g/d) and the efficiency of MN production (g/kg DOMR) of native (*Bos indicus*) growing bulls fed rice straw. Each point represents the mean of four observations.

Table 5. Urinary purine derivatives and microbial N yield of different groups of growing bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg of wheat bran daily

	T1	T2	T3	SED (*Residual df* = 9)	Level of Significance
Purine Derivatives excretion mmol/d§	9.09	36.10	48.57	8.047	$p < 0.01$
Microbial N production (g/d)	6.61	26.25	35.31	6.298	$p < 0.01$
Microbial N yield (g/kg DOMR)¶	4.64	12.97	12.09	2.489	$p < 0.01$

§ Estimated from the urinary allantoin excretion plus 15% allowance for uric acid excretion.

¶ Digestible organic matter apparently fermented in the rumen (DOM × 0.65 = DOMR, ARC, 1980).

Energy intake

The metabolizable energy intake (MEI) were estimated from the digestible OM intake (DOMI) as MJ MEI = 15.58 × kg DOMI (ARC, 1980). The MEI significantly ($p < 0.01$) increased with the 2 kg WB supplementation (336 vs. 476 kJ/kg $W^{0.75}$/d), which improved further (but not statistically significant) with 3 kg WB (535 kJ/kg $W^{0.75}$/d). The dietary energy concentration (M/D) at 0, 2 and 3 kg of WB supplementation were 4.6, 5.2 and 5.8 MJ/kg DMI respectively. The ratio of MEI and the maintenance ME (MEm) requirement were 0.75, 1.06 and 1.19 for 0, 2 and 3 kg WB supplementation respectively.

Growth rate

On the absolute straw diet, animal lost 186 g live weight daily. As expected, live weight gain (LWG) significantly ($p < 0.01$) increased to 346 and 554 g daily with 2 and 3 kg WB supplementation respectively. For 1% increse in the dietary WB level, the LWG increased by 17.6 g daily ($r^2 = 0.998$; n = 3 and ($p < 0.01$; see figure 7). The feed conversion ratio (kg feed/kg weight gain) with 0 kg WB was −25.43, which improved to 17.57 and 11.54 respectively with 2 and 3 kg of WB supplementation.

Table 6. Energy utilization of different groups of growing bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg of wheat bran daily

	T1	T2	T3	SED (*Residual df* = 9)	Level of Significance
DOM intake (kg/d)	2.71	3.11	3.65	0.155	$p < 0.01$
ME intake (MJ/d)[¶]	21.95	31.47	36.90	1.569	$p < 0.01$
MEI (kJ/kg $W^{0.75}$/d)	336	476	535	35.7	$p < 0.01$
MEI/MEm[§]	0.75	1.06	1.19	–	–
M/D (MJ/kg DM)	4.639	5.176	5.77	–	–

¶ Assuming 1 kg DOM = 15.58 MJ ME (ARC, 1980).
§ Assuming the maintenance ME requirement of 450 kJ/kg $W^{0.75}$/d.

Table 7. Live weight change and utilization of different groups of growing bulls fed either straw alone (T1) or supplemented with 2 (T2) or 3 (T3) kg of wheat bran daily

	T1	T2	T3	SED (*Residual df* = 9)	Level of Significance
Mean Initial weight (kg)	264.5	267.8	264.8	23.1	NS
Mean Final weight (kg)	259.3	277.5	280.3	23.42	NS
Live weight gain (g/d)	-186^{b}	346^{a}	554^{a}	96.9	$p < 0.01$
Feed conversion ratio (DM basis)	−25.43	17.57	11.54	–	–

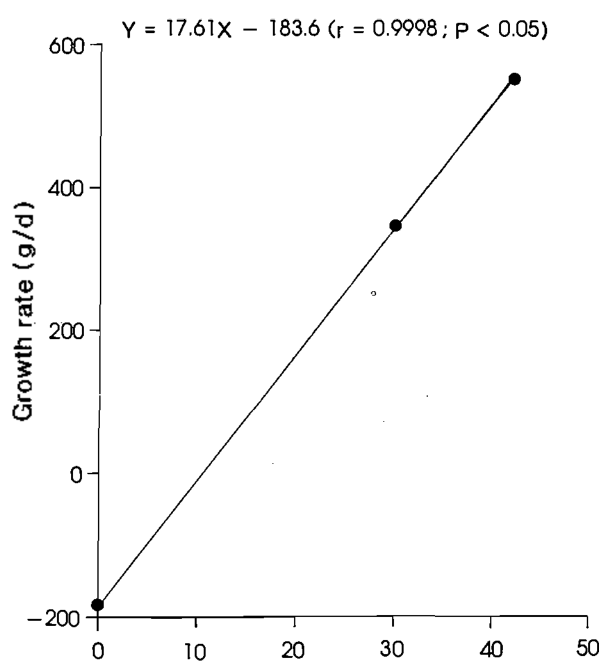

Figure 7. Effect of different levels of wheat bran supplementation on the growth rate of native (*Bos indicus*) growing bulls fed rice straw. Each point represents the mean of four observations.

DISCUSSION

Traditionally, on a straw diet, WB is used as energy concentrate. In the present trial 'dose response' of WB has been measured on the intake, digestibility, NB, MN yield and growth rate of native bulls.

The total DM intake and the digestible OM intake increased with WB supplementation, but the straw DM intake decreased linearly (figure 1). Mulholland et al. (1976) observed a similar response when ground oat straw was supplemented with different levels of starch.

Similar results have also been reported for rice straw supplemented with rice bran (Devendra, 1978) and for other low quality roughages supplemented with concentrates high in readily fermented carbohydrate (Illiott 1967a, b; Fick et al., 1973; Henning et al., 1980). Decrease in roughage intake due to readily fermented carbohydrate (RFC) supplementation may be due to the animal receiving sufficient energy from a more digestible diet to satisfy its energy requirements (Dixon, 1986; Weston, 1984). Trung et al. (1989) observed positive associative effect of concentrate supplementation at 0.8% DMI of live weight. However, in the present trial, WB supplementation at 0.66% DMI of liveweight resulted substitution of straw DMI by 9.53%.

As the ratio of WB: straw DM intake increased, the digestibilities of DM and OM increased proportionally. Similar responses have been observed when corn stalk (McDonell et al., 1979) or oat straw (Mulholland et al., 1976) was supplemented with increasing levels of starch, the digestibilities of DM and OM increased proportionally.

Understandable, this is due to the higher RFC content of WB (having ADF content 20%) than the straw (having ADF content of 48%). Higher levels of RFC often reported to cause a decrease in the fibre digestibility and a reduction in the roughage intake (Dixon, 1986). While in the present trial, the ADF digestibility remain unchanged although the straw DM intake reduced significantly ($p < 0.01$) with the increasing levels of WB supplementation. In one experiment, barley grain supplements for grass hay reduced the cellulose disappearance from nylon bags incubated in the rumen, but did not reduced the whole gut cellulose digestibility, nevertheless the hay intake reduced (Lamb and Edie, 1979). It has been shown that as the fibre digestion in the rumen decreases by RFC the proportion of cellulose digestion in the caecum and colon increases (MacRae and Armstrong, 1969), this may explain why decreased fibre degradability in the rumen may not be observed over the entire digestive tract (Dixon, 1986).

As the ratio of WB-N : straw-N increases in the diet, N digestibility increases linearly. This ia probably because that approximately 51% of the total straw-N is ADF-N (Walli et al., 1993), which is totally indigestible and of the remaining 49%. only 73% is digestible (Sampath et al., 1993). While, 93% of the total WB-N can be digested and absorbed (Samthah et al., 1993).

On the absolute straw diet (T1), the MN yield (g/kg DOMR) was approximately 5, which confirm our earlier observation of 6 g MN yield per kg DOMR (Chowdhury, 1997) on a similar diet. Although increasing levels of WB supplementation resulted linear increase in the total MN yield g/d, but the MN yield g/kg DOMR showed diminishing return. Almost similar response of diminishing return of MN yield g/kg DOMR to increasing level of leucaena foliage (Chowdhury, 1997) or lablab hay (Osuji et al., 1995) supplementation to straw diet have been reported. Increased MN yield due to WB supplementation could probably be due to the increased N (Goodchild and McMeniman, 1994; Leng, 1995a) readily fermentable energy (Osuji et al., 1995), readily fermentable beta glucans (Silva and Ørskov, 1985) supply. Diminishing return of MN yield above 2 kg WB supplementation probably indicate that this level probably optimizes the rumen condition (e. g., pH, NH_3, and supply of other monomers) for the efficient microbial growth. Although ruminal pH was not measured in the present trial, it is probable that higher (>2 kg) levels of WB might have reduced the rumen pH below the optimum range (6.5 - 7.5) which may resulted decrease efficiency of MN yield.

Dietary N intake in all three treatments was well above the suggested tissue maintenance requirement of 400 N/kg $W^{0.75}$/d for cattle (ARC, 1984). However, on the absolute straw diet (T1), animals were in negative N balance (-84 mg/kg $W^{0.75}$/d) despite 599 mg/kg $W^{0.75}$/d dietary N intake. This confirms our previous observations (Chowdhury, 1977) that rice straw alone can not meet even the maintenance requirement of animals. The estimated (from regression between N intake *vs.* NB) minimum N excretion at '0' N input was 638 mg/kg $W^{0.75}$/d, was much higher than the ARC (1984) recommended value of 400 mg/kg $W^{0.75}$/d but similar to that of the 641 (Ørskov et al., 1983) or 633 (Chowdhury, 1989) mg/kg $W^{0.75}$/d of *Bos torus* steers. On a similar straw diet, the estimated minimum N excretion of growing *Bos indicus* bull found to be 300 mg/kg $W^{0.75}$/d (Chowdhury, 1997). This apparent differences in the minimum N excretion can be explained by the fact that the body protein oxidation depends on the physiological status, e.g., stage of maturity, sex, production status and adiposity of the animal (Ørskov, 1982).

Straw alone fail to met the maintenance ME requirement of 450 kJ/kg $W^{0.75}$/d (ARC, 1980) of the experimental animals. Supplementation of WB improved the estimated ME supply, but the dietary energy concentration was below 6 MJ ME/kg DM even in 3 kg WB supplemented diet. This energy level, according to Walli et al. (1993), is unable to meet the maintenance requirement of animal. However, in the present trial, WB supplementation linearly increased the N balances and growth rate of animals. Here, with 3 kg WB supplementation, the live weight gain was 554 g daily, indicating that the predicted requirement of Walli et al. (1993) was much higher than the actual requirement of animals in the present trail. Another possible explanation is that with adequate protein supply, animal can gain lean tissue even at sub maintenance energy supply possibly by oxidizing the body fat (Chowdhury et al., 1995). In the present trail, with WB supplemented animals, protein supply both from dietary and MN sources was much higher than the maintenance requirement. Thus animal gained weight despite the lower dietary energy content. Improvement in the energy and protein supply due to WB supplementation, improved the feed conversion efficiency and reduced the feed cost per kg weight gain.

With the levels of supplement used in the trial, there was no threshold level of WB which showed exponential (Leng, 1995b) or quadratic (Balch, 1967) responses for total MN yield or N balance or growth rate. Depending on the cost effectiveness, on an untreated rice straw diet, WB can be supplemented by up 3 kg (42% of the diet) or more. However, if the maximum utilization of roughage is the main concern, the potimum WB level would probably be around 2 kg (30% of the diet) daily.

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