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By-Product Utilization for Animal Production

Proceedings of a workshop
on applied research
held in Nairobi, Kenya,
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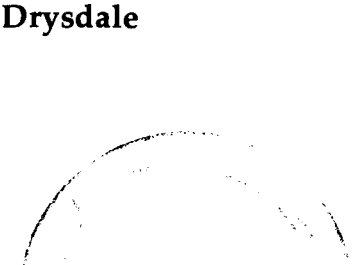
Editors: Berhane Kiflewahid, Gordon R. Potts, and Robert M. Drysdale



Résumé[1]

L'utilisation de sous-produits agricoles pour la production animale a fait l'objet d'un grand intérêt de la part des spécialistes de l'alimentation du bétail et à cet égard, le Centre de recherches pour le développement international (CRDI) a subventionné un certain nombre de projets de recherche sur l'alimentation du bétail faisant appel aux sous-produits agricoles et à de nouveaux aliments au cours des neuf dernières années.

Cette monographie est le compte rendu des travaux et délibérations d'un atelier tenu à Nairobi, au Kenya, du 26 au 30 septembre 1982, pour examiner les résultats de recherches prometteuses, qui semblent sur le plan technique et économique être applicables aux systèmes d'alimentation des animaux, pour discuter et recommander les méthodes de recherche appropriées à l'évaluation des sous-produits spécifiques destinés aux systèmes de production animale identifiés ainsi que la normalisation des méthodes d'analyse pour la description de la valeur alimentaire des sous-produits et des aliments nouveaux.

On y trouvera une description des résultats de recherches sur les sous-produits effectuées en Égypte, au Soudan, en Indonésie, en Tanzanie, au Pakistan et au Kenya, suivie d'un résumé des débats sur les avantages et inconvénients de l'approche et des méthodes utilisées dans les essais de composition et de rations de ces sous-produits. Y figurent également des rapports sur les essais de bilan de la valeur nutritive des aliments, l'évaluation des expériences sur les animaux, et les aspects économiques dont il est nécessaire de tenir compte en matière de recherches sur l'utilisation de sous-produits pour l'alimentation du bétail. Et en dernier lieu, cette monographie traite des essais réalisés dans des exploitations agricoles, dans les conditions réelles d'emploi.

[1] Chaque communication du présent compte rendu des travaux et délibérations est accompagnée d'un résumé en anglais, en français et en espagnol.

Resumen[1]

El empleo de subproductos agrícolas para la producción pecuaria es un tema que ha recibido la atención de los especialistas en nutrición animal. El Centro Internacional de Investigaciones para el Desarrollo (CIID) ha apoyado durante los últimos nueve años un buen número de proyectos de investigación sobre alimentación de ganado con subproductos agrícolas y otros alimentos no convencionales.

Este libro contiene los trabajos presentados en un taller celebrado en Nairobi, Kenia, del 26 al 30 de septiembre de 1982 con el objeto de revisar los avances investigativos que se consideran técnica y económicamente factibles de aplicar en sistemas de alimentación animal, de discutir y recomendar metodologías de investigación que permitan evaluar subproductos específicos con destino a sistemas definidos de producción animal, y de discutir la normalización de los métodos analíticos empleados en la descripción del valor nutritivo de los subproductos y las raciones no convencionales.

Los resultados de las investigaciones sobre subproductos en Egipto, Sudán, Indonesia, Tanzania, Paquistán y Kenia, van seguidos de un recuento de las discusiones sostenidas sobre la validez o debilidad de los enfoques investigativos aplicados en la modificación y administración de los subproductos. También se presentan los trabajos sobre medición de la calidad nutricional de los alimentos, su evaluación en pruebas de alimentación y los aspectos económicos que deben tenerse en cuenta en este tipo de investigaciones. Finalmente, se describen y discuten ensayos en finca de los subproductos como alimento animal.

[1] Cada trabajo va accompañado de un resumen en español, francés e inglés.

Contents

Experiences in On-Farm Research and Application of By-Product Use for Animal Feeding in Asia

I.S. Agarwal and M.L. Verma[1]

There is a great need to conduct research on farm animals to determine the response of improved methods of utilizing agricultural by-products in physical and economic terms. An on-farm testing program on urea treatment of straw to improve its nutritive value was started in two clusters of 4–5 villages each in the hills and *tarai* tract of Uttar Pradesh, India. Similar on-farm trials were carried out in Bangladesh and Sri Lanka. The results of these on-farm studies have clearly demonstrated that feeding of urea-ensiled straw offers great promise for better feeding of dairy cattle and buffaloes. However, a more simplified method of stacking and a better system of feeding the treated straw should be developed for village conditions. More and more farmers should be involved in such on-farm testing programs to evaluate the economic benefits of straw treatment under diverse situations.

Il y a un grand besoin d'effectuer des recherches sur le bétail afin d'évaluer, sur le plan physique et économique, les résultats de l'amélioration des méthodes d'utilisation des sous-produits agricoles. Un programme d'essais sur la ferme même, du traitement de la paille à l'urée, pour améliorer sa valeur nutritive, a commencé dans deux groupes de quatre ou cinq villages situés dans les collines et la zone *tarai* d'Uttar Pradesh, aux Indes. Des essais similaires furent effectués dans des fermes du Blangladesh et de Sri Lanka. Les résultats de ces études ont clairement démontré que les rations de paille enrichie d'urée et ensilée sont très prometteuses pour l'amélioration de l'alimentation des vaches laitières et des buffles. Il est cependant nécessaire d'adapter certains aspects aux conditions villageoises : de simplifier la méthode de mise en meules de la paille et d'améliorer le mode d'alimentation. Un plus grand nombre de fermiers devraient participer à ces programmes d'essais au niveau des fermes, afin de pouvoir évaluer les avantages économiques du traitement de la paille dans diverses conditions.

Hay necesidad de realizar investigaciones sobre los animales de finca para determinar la respuesta de los métodos mejorados de utilización de los subproductos agrícolas en términos económicos y físicos. En dos grupos de 4 a 5 aldeas hindúes se inició un programa de pruebas en fincas de un tratamiento para mejorar el valor nutritivo de la paja con úrea. En Bangladesh y Sri Lanka se realizaron pruebas similares. Los resultados de estos estudios en finca han demostrado claramente que la paja ensilada con úrea ofrece buenas perspectivas para una mejor alimentación del ganado de leche y los búfalos. Sin embargo, se requiere un método más sencillo de apilamiento y un mejor sistema de administración de la paja tratada para las condiciones de las aldeas. Hay que involucrar más agricultores en tales programas de pruebas para poder evaluar los beneficios económicos del tratamiento de la paja bajo diferentes situaciones.

A number of new techniques have been developed that increase efficiency of utilization of crop residues (Jackson 1977). These have been tested predominantly on animals maintained on research stations in controlled experiments. These techniques, however, need to be tested on farmers' animals under village conditions to find out whether or not they maintain their effec-

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tiveness under the village environment. If not, it is desirable to continue the work until all constraints for its adoption by farmers have been fully identified and removed. The conditions under which village animals live, grow, and produce cannot be simulated on the experimental stations in general, and in the countries of Southeast Asia in particular. It is also essential that the economic usefulness of a new technology be assessed within the system into which it is to be eventually used. Furthermore, on-farm research provides exposure to research scientists of the problems of feeding farm animals under village conditions and an insight into the conditions of the rural people. Considering the importance of on-farm testing programs, a proposal for a coordinated field-testing and demonstration project, similar to the field-testing program now beginning with crops (Izuno 1977), was submitted to the Food and Agriculture Organization of the United Nations (FAO) by one of its consultants (Jackson 1978). In brief, the main objectives of an on-farm testing program should be to generate a technology suitable to the farmer's conditions, ascertain the constraints that limit animal production, and fix research priorities.

In this paper, the methodology and results of new on-farm trials on treatment of crop residues and the experiences of the participating farmers are discussed.

Review articles by Jackson (1977) and Sundstøl et al. (1978) showed ammonia as a possible alternative to sodium hydroxide, with an added advantage that it supplies nonprotein nitrogen. Urea as a source of ammonia has been used recently in several areas. It has been reported that the treatment of wheat straw with urea (4.0 kg urea/100 kg straw) solution to produce a moisture content of 45–55%, followed by putting it into a silo or stacking it for more than 4 weeks, produced wheat straw comparable in nutritive value to that obtained after treatment with sodium hydroxide spray (Verma 1981; Saadullah et al. 1982; Jayasuriya and Perera 1982). In view of the ready availability; low price; ease of handling, with known yield-promoter qualities for crops; and versatility of its use in ruminant feeding; urea was chosen for treating straw for the on-farm trials.

Materials and Methods

The first on-farm trial was carried out in the hills district of Uttar Pradesh in a cluster of 4–5 villages. Twenty-seven calves of 1.5–2.0 years of age were selected and grouped in such a way that three calves from each group were almost similar in age and body weight. Nine such blocks were made. An animal from each block was allotted to one of three treatments/diets. The calves on the first diet were fed untreated rice straw and a small supplement of grass. The second diet was identical to the first, except that the calves in this group were given a daily supplement of 30 g commercial mineral mixture. The third diet was identical to second, except that the untreated straw was replaced with urea-treated straw. All of the animals were fed on a free-choice basis. The experiment lasted for 4 months and was then discontinued due to a lack of treated straw. Body measurements were taken to calculate the body-weight gains of calves.

Method of Treatment

Rice straw was treated by spraying it with 5% urea solution (1L/kg straw). The straw was spread in a 15–20 cm thick layer in a high place where it was to be stacked. It was moistened thoroughly with urea solution, using a garden sprinkler, and simultaneously pressed by the persons spraying the solution. A second layer of rice straw was spread over the first layer and the same procedure was carried out. This process was continued until a conical structure of about 2.5 m in height was formed. The stack was kept for a 4-week period to complete the reaction with the ammonia produced from the urea. The treated straw stack was subsequently opened, the straw was sun-dried, and then restacked. This helped prevent the growth of moulds. Sun-drying of treated straw is, however, not essential if chaffed straw is used instead of long straw.

The second on-farm study was conducted in *tarai* tract of Uttar Pradesh in a cluster of 4–5 villages. The object of this study was to allow the farmers to continue using their normal feeds and enrich them with a urea supplement when nonleguminous forages and straw were fed. A mineral mixture was provided to all of the animals. Urea was supplemented at 1.0 kg/100 kg of dried

Table 1. Quantities of feeds fed to dairy cattle in India.

Category	Type of animal	Quantity fed daily[a] (kg/day)		
		Dry fodder	Green fodder	Concentrate
Milch	Cows	3.5	4.4	0.3
	Buffaloes	5.9	6.8	0.8
Dry	Cows	2.8	2.8	0.1
	Buffaloes	4.0	4.3	0.1
Adult male	Cows	5.7	5.0	0.3
	Buffaloes	5.4	6.5	0.2
Young	Cows	1.5	1.6	Nil
	Buffaloes	1.7	1.6	Nil

Source: Amble et al. (1965).
[a] The quantities do not include the amount grazed.

straw and 0.2 kg/100 kg green sorghum, sugarcane tops, and other nonleguminous forages. In order to avoid miscalculations, farmers were supplied with suitable containers to measure the quantity of urea required for each basket (a measure) full of feed. Simultaneously, a group of farmers was selected who were not feeding urea-supplemented roughages. The advantages of using urea for the treatment of straw were explained to the farmers by nutrition specialists at a number of group meetings conducted during late-evening and early-morning hours. A village-level worker was also posted to train all the members of the farmer's family on the method of urea supplementation. Body measurements of all the animals were recorded at monthly intervals and used to predict body-weight changes.

Results and Discussion

In India, crop residues such as wheat *bhusa*, rice straw, sorghum, *bajra*, and maize stovers are the staple livestock feeds. These roughages are fed to livestock either alone or supplemented with a small amount of green forage with or without concentrates (Table 1). The future holds no hope of increasing the availability of concentrates for the majority of livestock. The situation is not much different in Bangladesh, Sri Lanka, and a few other countries of Southeast Asia. The straws and stovers will occupy an even more important place in the feeding of farm animals in years to come. Concerted efforts must be continued to work out economical and practical methods of improving the feed value of crop residues. Such methods should always be tested under village conditions. Urea as a source of ammonia has been tried recently in laboratory experiments and farm trials in India and elsewhere, and it appears to be a promising method (Tables 2, 3).

The on-farm study carried out in the hills of Uttar Pradesh clearly demonstrated that calves on treated-straw diets gained an average of 260 g/day (Table 4), which was significantly ($P<0.05$) higher than the untreated-straw group. Even a small supplement of mineral mixture improved the weight gains by nearly 50 g/day. This is in agreement with the findings of Walker et al. (1976) who reported a comparable figure of 89 g for untreated straw and 138 g for rice straw treated with 5% aqueous NH_4OH and then pelleted. Sundstøl and Matre (1980) also observed similar differences. This was primarily due to increased consumption and higher digestibility of treated straw. The consumption of straw could not be measured in the study because the animals

Table 2. Comparative feed value of NaOH and ammonia (through urea) treated wheat straw.

	NaOH-treated	Ammonia-treated
Dry-matter intake ($g/kg_w^{0.75}$)	86.0	89.3
Dry-matter digestibility (%)	55	49
Digestible dry-matter intake ($g/kg_w^{0.75}$)	47	43
Average daily gain (g)	158	181

Source: Verma (1981).

Table 3. Mean live-weight change and ration digestibility of calves fed with differently treated rice straw.

	Treatment				
	A	B	C	D	E
Initial live weight (kg)	54	58	58	57	56
Final live weight (kg)	57	65	67	65	66
Daily gain (g)	35[a]	75[b]	110[cd]	99[c]	120[d]
Apparent digestibility					
Dry matter	40[a]	46[b]	51[c]	48[bc]	62[d]
Crude fibre	58[a]	63[b]	65[b]	65[b]	74[c]
Crude protein	—	54[a]	58[b]	50[a]	65[c]
Total dry-matter intake (kg)	1.8	1.8	2.0	1.7	1.7

Source: Saadullah et al. (1982).
NOTE: A = untreated; B = urea-supplemented; C = 5% urea-treated; D = 4% lime-treated; E = 3% NaOH + 1% lime-treated. Values followed by different superscripts are significant at $P<0.05$.

Table 4. On-farm trials involving the feeding of urea-treated straw.

	Diets		
	Farm diet	Farm diet + mineral mixture	Farm diet of urea-treated straw + mineral mixture
DM digestibility of straw (%) (nylon bag)	32	32	57
Nitrogen content of straw	0.5	0.5	1.3
Ca content	0.5	0.5	0.6
Average daily weight gain (kg)			
By difference	0.12[a]	0.17[ab]	0.26[b]
By regression analysis	0.13[a]	0.17[a]	0.26[b]

Source: M.G. Jackson (personal communication).
NOTE: Values followed by different superscripts are significant at $P<0.05$.

Table 5. Regression equations for body-weight change in village cows and buffaloes given urea-supplemented roughage diets ($Y = a + bx$).

Weight group	August–December	December–April	April–July	Full year
<100 kg	74.6+4.83x(161)	90.8+7.48x(249)	124.9+8.01x(267)	69.2+6.82x(227)
100–200 kg	150.1+6.08x(203)	184.3+10.85x(362)	214.3+12.02x(401)	140.8+0.32x(344)
201–300 kg	236.7+7.65x(255)	260.8+11.71x(390)	314.1+11.81x(394)	228.8+10.34x(345)
> 300 kg	362.7+8.19x(273)	388.5+12.72x(424)	442.4+9.09x(303)	357.5+10.08x(336)
Overall average	(211)	(335)	(311)	(290)

NOTE: Figures given in parentheses are the average daily weight gain (g).

were not fed in mangers and the residues were used as bedding material. Farmers, however, observed that the animals were eating more straw and the palatability had improved.

The result of a second study carried out in *tarai* tract of Uttar Pradesh showed that the rate of growth was at a maximum in rabi (winter) season (335 g/day), when berseem fodder was available. The rate of growth during the rest of the period ranged between 211 and 311 g/day (Table 5), which is good considering that there is little or no concentrate feeding in these villages. On the basis of an evaluation carried out through a questionnaire, 62, 10, and 20% of the farmers stated that the animals on a urea-supplemented diet (Table 6) grew at a faster, reduced, and normal rate respectively. Results of the same on-farm trial in

Table 6. Effect of urea supplementation on the performance of village cattle and buffaloes (based upon answers to a questionnaire).

Parameter	Percentage distribution of answers			
	Increased	Decreased	No change	Not observed
Feed consumption	85.0	5.0	5.0	5.0
Feed refusals	9.0	71.5	9.5	10.0
Growth rate	62.0	9.5	18.5	10.0
Milk production	81.0	0.0	14.0	5.0
General health	Improved (95)	Deteriorated (0.0)	No change (5.0)	

NOTE: Values in parentheses are percentages of respondents.

Table 7. Change in body weight of calves on untreated and urea-treated straw in *tarai* tract of Uttar Pradesh.

Duration of test (days)	Farm ration of untreated straw + mineral mixture		Farm ration of treated straw + mineral mixture	
	Total weight gain (kg)	Daily gain (kg)	Total weight gain (kg)	Daily gain (kg)
337	131.61	0.390	203.15	0.605
337	121.12	0.359	131.13	0.389
306	109	0.326	148.13	0.484
233	76.28	0.301	75.97	0.300
213	101.76	0.478	51.99	0.244
Average		0.371 NS		0.404 NS

NOTE: NS = nonsignificant.

Table 8. Age, weight, and working hours of bullocks.

	Estimated age (year)	Weight (kg)			Working time (hours)
		Initial	Final	Change	
Treated straw	5.3 ± 1.6	171 ± 32	168 ± 30	−3 ± 3.8	30 ± 23
Untreated straw	6.0 ± 1.5	193 ± 47	188 ± 39	−5 ± 9.4	33 ± 21
Significance		NS	NS	NS	NS

Source: Dolberg et al. (1981).
NOTE: NS = nonsignificant.

another village showed that animals on urea-supplemented rations gained an average of 404 g/day, which was not significantly higher than the 371 g/day gained by those animals on an untreated straw and mineral mixture diet (Table 7). The high growth rate in the unsupplemented group and the nonsignificant increase in liveweight gain as a result of urea supplementation could be due to a better feeding schedule in this particular village compared with other villages. Both studies clearly established that urea treatment and urea supplementation of straws and stovers increases the growth rate of calves.

A similar on-farm study was carried out by Dolberg et al. (1981) involving seven pairs of bullocks averaging 3–8 years of age in a village in Noakhali district, Bangladesh. They reported that the bullocks fed on treated straw lost 3 kg and on untreated straw lost 5.0 kg body weight (Table 8). They concluded that the village cattle could be fed on treated straw alone for maintenance of both energy and protein. A lack of minerals and internal parasites might be the factors responsible for the observed decrease in body weight. Dolberg et al. reported that the urea treatment of straw increased dry-matter intake (Table 9) and found that the intake of treated straw was as high as 4.14% of the body weight. Perdok et al. (1982) carried out a few on-farm trials in Sri Lanka using urea-ensiled straw and

Table 9. Daily intake of straw by bullocks.

	Daily straw dry-matter intake	
	% of body weight	$g/kg_w^{0.75}$
Treated straw	3.4 ± 0.5	121 ± 17
Untreated straw	2.5 ± 0.5	90 ± 12
Significance	$P<0.05$	$P<0.05$

Source: Dolberg et al. (1981).

Table 10. Gain, feed conversion, calculated metabolizable energy (ME) of straw, and straw dry-matter intake of Sahiwal heifers fed untreated (US) and urea-treated (TS) straw diets.

	US	TS	Difference
No. of heifers	17	17	—
Initial weight (kg)	165.2	166.9	1.7^{NS}
Final weight (kg)	170.3	191.1	20.8**
Gain in 70 days (kg)	5.1	24.2	19.1**
Daily gain (g)	73	346	273**
Feed conversion ratio (kg DM/kg gain)	52.7	13.3	39.4**
Calculated ME value of straw (MJ/kg DM)	6.0	7.6	
Straw dry-matter intake (% live weight)	1.3	1.6	
Total dry-matter intake (% live weight)	2.31	2.58	

Source: Perdok et al. (1982).
** = $P<0.01$; NS = nonsignificant.

Table 11. Milk yield, milk-fat yield, milk-fat percentage, cows milked, live-weight change of cows and their calves, milk intake of calves, and straw dry-matter intake of Gir cows fed untreated (US) or urea-treated (TS) straw diets.

	US	TS	Difference
No. of cows	17	17	—
Overall period (days)	175	175	—
Milk yield (kg/day)	2.42	3.41	0.99**
Milk fat (g/day)	111	168	57**
Milk fat (%)	4.6	4.9	0.3
Live-weight change over 63-day period (g/day)	−266	93	359
Calf live-weight gain (g/day)	181	257	76**
Calf milk intake (kg)	1.35	1.88	0.53**
Straw dry-matter intake (% live weight)	2.0	2.9	

Source: Perdok et al. (1982).
** = $P<0.01$.

observed that the heifers fed on treated straw gained weight at a daily rate of 346 g, which was about five times the rate of the untreated-straw group (Table 10). However, in another experiment involving 60 draft bulls, Perdok et al. found unexpectedly low body-weight gains of 107 and 89 g on untreated and treated straw rations respectively. One of the reasons for the low weight gain might be that the animals were of a slightly higher age group. They also conducted a trial on 34 lactating Gir cows and reported that the daily milk yield in Gir cows increased significantly ($P<0.01$) by 41% and milk fat by 51% on a treated-straw ration (Table 11). On the basis of the results reported, it may be concluded that feeding of urea-ensiled straw offers great scope for cattle owners to increase the productivity of their cattle and buffaloes.

The treatment of straws with urea also suffers from the following limitations:

(1) Nonavailability of a water source near the homestead could be a serious constraint in the hills and some other areas.

(2) The use of unchaffed straw for treatment creates two major problems. Firstly, due to incomplete compaction the treated straw has to be dried and restacked, which makes the process laborious and risky, particularly during bad weather. Secondly, due to substantial wastage on unchaffed straw, the economics of using treated straw may become questionable.

(3) The major effect of treated straw is a substantially higher intake. It is presupposed, however, that the availability of straw is not limited and, hence, in places where the availability of straw is limited the usefulness of this technique becomes doubtful. As such, determination of optimum levels of feeding urea-treated straw to various categories of livestock for increasing the efficiency of utilization becomes a high priority for future research.

The authors realized that farmers who obtain a major source of their income from the sale of milk and other animal products may adopt new technology faster than those whose dairy cattle are kept primarily for providing draft and dung, with milk and meat being by-products.

Farmers' Experiences with Urea-Treated Straw

The owner of a model cooperative farm

Table 12. Feeding schedule for milch animals.

Month	Type of roughage[a]	Amount of milk produced for ad libitum intake of roughage (L/day)[b]	
		1980–1981	1981–1982
October	Hybrid napier grass	1.5	3.0
November	Hybrid napier grass + wheat *bhusa* (3:1)	1.0	4.0
December	Berseem + wheat *bhusa* (1:1)	4.0	5.0
January	Berseem + wheat *bhusa* (3:1)	6.0	6.0

Source: Dhillon (1982).

[a] In 1981–1982, urea-enriched hybrid napier grass and urea-treated stacked wheat *bhusa* replaced plain hybrid napier grass and wheat *bhusa* respectively.

[b] Concentrate allowance for individual cows was calculated at a rate of 1 kg concentrate for every 2.5 L of additional milk.

Table 13. Feed costs and milk production on untreated and urea-treated straw rations.

Ration	Ingredient	Quality (lb)	Costs	Milk production (lb)
Untreated Straw	Straw	8.0	1.60	1154
	Oil cake	0.5	0.62	
	Soybean gruel	0.5	0.15	
	Pulse bran	0.5	0.75	
Urea-treated straw	Straw	12	3.60	1572
	Oil cake	0.25	0.31	
	Soybean gruel	0.25	0.07	

Source: D'Silva, A.U., Derek (1981).

with 80 crossbred cows having a yield potential ranging from 3500–3600 L/lactation fed urea-supplemented nonleguminous green forages and urea-treated straw to the high producing cattle. Not only was an increase of 2–3 L of milk per head per day obtained but also a saving of 1 kg of concentrate/head/day, in addition to replacing 10% of the costly groundnut cake by cheaper feeds such as brans (Table 12; Fig. 1). The owner proposed the possibility of partially replacing the area under nonleguminous kharif fodders with cereal crops such as rice and using the treated and stacked straw in place of sorghum or hybrid napier grass. D'Silva, A.U., Derek (1981) also reported an increased production of 418 lb of milk in a lactation on a treated-straw diet even after a saving of costly and scarce concentrates (Table 13).

From the foregoing discussion, it is evident that urea supplementation and urea treatment of straws both offer excellent opportunities for cattle owners to increase animal production, and it may become an economical alternate feeding practice in the near future. There is, however, a need for further simplification of treatment procedures and stacking. There is a need to develop a method of treatment that can be used at threshing time so that additional labour is not required. There is also a need to develop suitable structures for stacking treated straw based on locally available material, so that wastage of the straw can be minimized. It is felt that some feeding system should be developed that requires

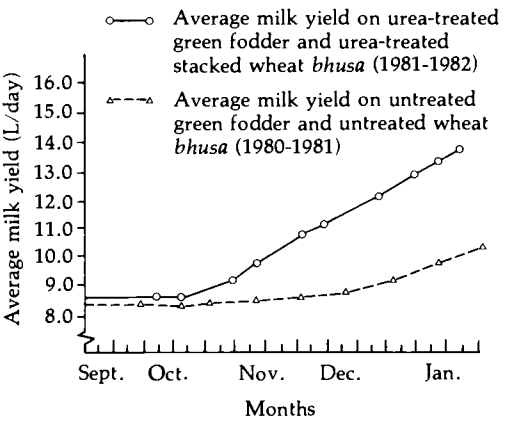

Fig. 1. Effect of urea treatment of green fodder and wheat bhusa *on average milk yield.*

only small quantities of protein supplements (preferably having bypass protein quality) and large quantities of treated straw. Efforts should also be made to minimize losses of ammonia by recycling it. More and more farmers should be involved to work out the economic benefits of straw treatment under diversified situations. This will not only educate them but also their relatives, friends, and neighbours.

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