Feeding Value of Forage Sorghum

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In warm areas of Japan, forage sorghum has been cultivated for green-chopped feeds or ensilage for dairy and beef cattle during the summer season. Forage sorghum is not heavily damaged by high temperature, typhoon and drought, and shows higher production than other forage crops during the hot summer in warm areas of Japan.

However, from the standpoint of animal feeding, the forage sorghum has some defects. For example, digestibility and feed intake decreases rapidly with the growth of plants, and when fed dairy cattle about 50% of the stem portion are refused by the animals and have to be discarded[1].

The purpose of this paper is to present recent research on the feeding value of forage sorghum.

Changes in digestibility with plant growth

As the growth advanced, the contents of NFE (nitrogen free extract) and crude fiber among the chemical components of forage sorghum showed a sharp increase, but that of crude protein showed only a slight increase. Consequently, the ratio of crude protein to crude fiber became lower and lower with the growth (Fig. 1).

Crude fiber and crude protein contents in a forage crop are important factors in estimating the feeding value of a forage crop. It was reported that more than 28% of the crude fiber content or less than 10% of the crude protein content affected the digestibility and feed intake[2].

According to the experimental results of the author (Fig. 2), EDMD (estimated dry matter digestibility) of Pioneer-985 (Sorghum-Sudangrass hybrid) determined by the *in vitro* method was significantly related to

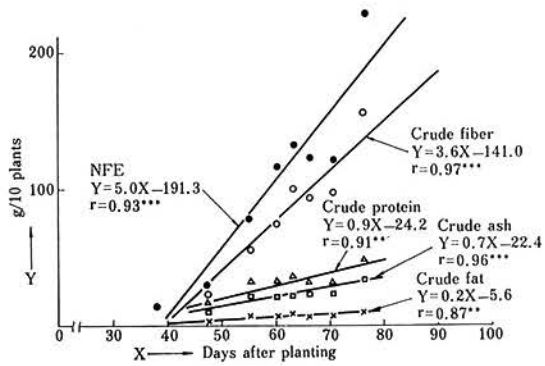

Fig. 1. Correlation between yield of NFE, crude fiber, crude protein, crude ash and crude fat and days after planting (Pioneer-985)

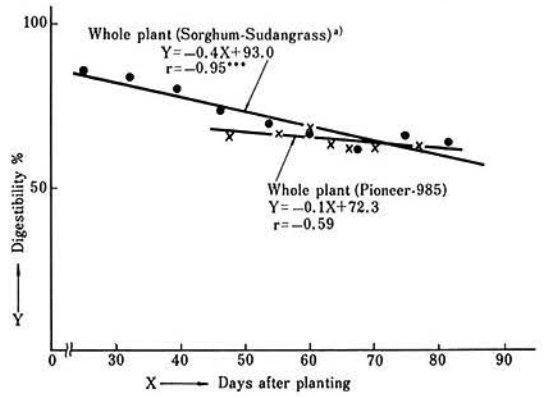

Fig. 2. Correlation between dry matter digestibility of whole plant and days after planting. [a): Quoted from Agron. J., 63, 267-271 (1971)]

crude fiber and crude protein contents, and also it showed a decrease with the growth.

When forage sorghum was divided into leaf and stem + sheath portions, the stem + sheath constituted more than 2/3 of a whole plant after the bloom stage. EDMD of the leaf showed a little variation throughout all stages of growth, but that of the stem + sheath showed a sharp decrease with the growth. As a result, the digestibility of the whole plant become very low at the later stages.

Changes in feed intake with plant growth

When green-chopped forage sorghum was fed to dairy cattle freely, daily dry matter intake showed a decrease with the aging of plant. Usually it is desirable that the dry matter of a forage crop consumed by dairy cattle is equivalent to the TDN requirement for maintenance plus 5 kg or more of milk yield[3].

However, with green-chopped forage sorghum, harvested at the bloom stage, the dry matter consumption was equivalent to the TDN requirement for maintenance plus only 3 kg milk yield, and a large amount of stem portion remained to be discarded (Table 1).

As can be seen in Fig. 3, if the consumed dry matter of green-chopped forage sorghum is to meet the TDN requirement for maintenance, the crop has to be harvested and fed to dairy cattle until 79 days after planting.

In Japan, forage sorghum to be used for

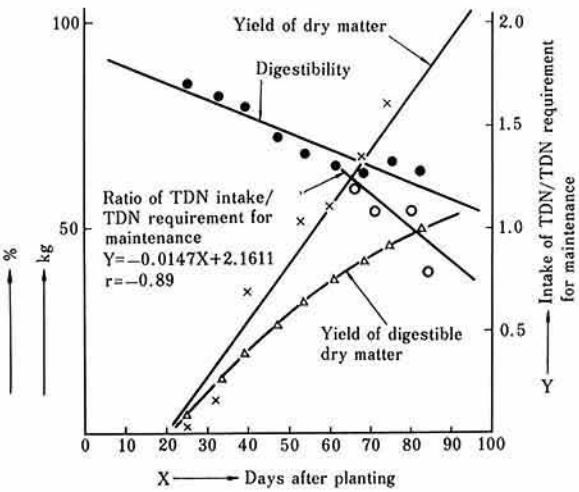

Fig. 3. Correlation between digestibility, yield of dry matter, ratio of TDN intake/TDN requirement for maintenance and yield of digestible dry matter and days after planting

Table 1. Offered material, refused material and voluntary intake (Dry weight basis)

Plant stage	Offered material				Refused material				Voluntary intake	
	Leaf		Stem		Leaf		Stem		Leaf	Stem
	g	%	g	%	g	%	g	%	g	g
Booting	4, 933	(49. 8)	4, 964	(50. 2)	64	(22. 9)	216	(77. 1)	4, 869	4, 748
Bloom	3, 800	(40. 4)	5, 610	(59. 6)	253	(19. 7)	1, 030	(80. 3)	3, 547	4, 580

Figures in parentheses are ratio of each portion to whole plant.
Sheath was contained in leaf portion.

Table 2. Voluntary intake and digestibility of sorghum silages

Silage	Dry Matter intake	DM intake/ Body weight	Digestibility (%)						
			Organic matter	Crude protein	Crude fat	NFE	Crude fiber	NDF	ADF
Pioneer-985	6, 905 g	1. 03%	45. 0	37. 3	64. 9	35. 6	53. 9	42. 3	43. 1
Zairai-kuro	8, 113	1. 20	47. 2	40. 2	71. 8	38. 5	56. 3	41. 5	41. 1

Table 3. Digestibility of leaf, and stem + sheath

Portion	Dry matter intake	D.M. intake/ body weight ×100(%)	Digestibility (%)				
			Organic matter	Crude protein	Crude fat	NFE	Crude fiber
Leaf	10.0	1.71	69.1	77.5	72.6	66.4	66.1
Stem and sheath	4.9	0.68	60.2	48.7	68.5	61.4	60.3

the silage is usually harvested at or after the milk-ripe stage, so that low digestibility and palatability are expected. Results of feeding the sorghum silage to dairy cattle are shown in Table 2. The consumed sorghum silage was found to be equivalent to about 65% and 80% of the TDN requirement for maintenance of a 650 kg cattle.

From the above fact, Kawazeki[4] stated that sorghum silage had to be used as a supplemental roughage during the time of shortage of roughage in practical dairy farming because of its low feeding value.

In order to clarify the cause of the low daily dry matter intake, green-chopped forage sorghum was separated into leaf and stem + sheath portions and each portion was fed separately to dairy cattle.

Results are shown in Table 3.

The daily dry matter intake of the stem + sheath is about a half of that of the leaf, indicating that the stem + sheath is responsible for the low dry matter intake.

In addition, forage sorghum at an earlier stages has high contents of HCN and nitrate, which are poisonous to cattle.

These substances also seem to affect the feed intake, but are omitted in this paper.

Histological observation on forage sorghum digestion

Forage sorghum was divided into leaf and stem + sheath portions immediately after harvesting, and cut into pieces of approximately 5 cm of length. Then, 50 g of the leaf and 100 g of the stem + sheath were put into 11 by 22 cm silk bags, separately. The bags were placed into the rumen of a fistulated Holstein cattle and removed after 24, 36, 48, 50 and 70 hr. Mode and extent of the digestion were examined after various digestion periods with the naked eye and/or microscope.

Results obtained are as follows:

After 24 hr of digestion

The digestion of stems began to progress starting from the cut surface inward. Sheaths were removed from the stems. The digestion of leaves also started from the cut surface inward except midribs and vascular bundles.

After 36 hr of digestion

The digestion of leaves progressed more than that at 24 hr, and leaf surface was degenerating. But midribs and vascular bundles were not yet digested.

After 48 hr of digestion

The digestion of leaves progressed much more. Midribs, vascular bundles and little mesophyll and sclerenchyma adjacent to the vascular bundles are left undigested.

After 50 hr of digestion

The digestion of stems progressed more than that at 24 hr and the digestion began with epidermis. Tissues of sheath were degenerated and changed to lighter color.

After 70 hr of digestion

Sheaths were completely digested except midribs and vascular bundles (Sieve tube had disappeared). Stems were also completely digested except the epidermis and vascular bundles.

But the epidermis was partly degenerated.

It was found that the stem + sheath portion was mostly composed of undigested tissues; i.e., epidermis, vascular bundles and midribs[5]. On the other hand, the leaf portion was mostly composed of digestible tissues.

From the histochemical observation, it was observed that the cell wall of undigestible tissues was covered with lignin.

Plates 1 and 2 show that the bundle sheath is not yet digested at the end of the digestion trial because the cell wall is covered with lignin. But the sieve tubes not covered with lignin were digested.

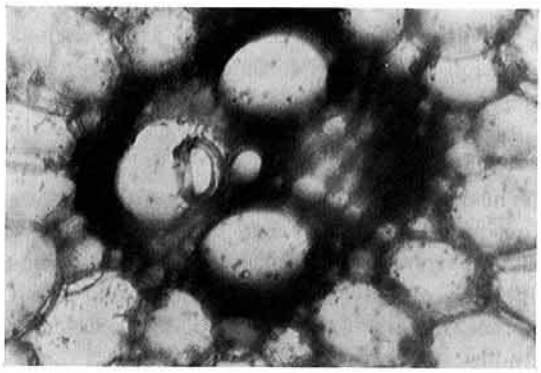

Plate 1. A cross section of lignified bundle sheath of stem

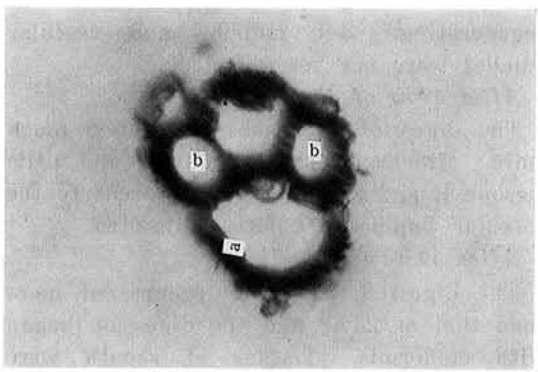

Plate 2. A cross section of undigested vascular bundle of stem. (a) Sieve tube digested and disappeared. (b) Metaxylem

Conclusion

At the present, it can be concluded that from the standpoint of both animal feeding and forage production forage sorghum has to be harvested during a period from booting to the bloom stage. But, in case of using as a silage for dairy cattle, being harvested after the milk-ripe stage, the sorghum silage should be used together with other good-quality roughage.

Although high yields are desirable for crop production, development of new strains with high feeding values or improvement of cultivation method to maintain high feeding values even at the later stages are required.

References

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