Some Problems in Culture and Utilization of Tropical Grasses in Japan

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Tropical grasses are seemingly not adaptable to Japan as the greater part of the country is located in middle latitudes, extending between 30° and 46°N. However, many scientists and cattle raisers in southern Japan belonging to the temperate and subtropical zones are greatly involved in the utilization of tropical grasses[2,3]. There are two reasons why they are keenly interested in the tropical grasses in rather cool areas as above. Firstly the climate in the summer season is quite favorable for growing tropical grasses, and secondly by taking advantage of this fact tropical grasses are grown as summer forage crops for hay and silage making. As the country has a large seasonal variation in temperature even under the influence of marine climate, high monthly mean temperature above 20°C and rich rainfall occur during a period of four months starting from June in southern Japan although annual mean temperature is only above 14°C and annual rainfall more than 1,500 mm.

In lowland areas of the southern Japan typical dairy farmers hold generally cultivated land of approximately 5 ha growing forage crops for feeding 35 to 40 of drylot cattle. This means that high level of dry matter yield of approximately 27 t/ha in a year is expected for raising 7 to 8 milking cows or 10 pregnant beef cattle, while similar amount of purchased concentrates has to be supplemented. To meet the above requirement, tropical grasses are grown as annual summer forage crops in rotation with annual winter forages such as Italian rye-grass, expecting the highest dry matter (DM) yield, with a very intensive management at a high fertilization level as practiced in horticulture. Expected DM yield of tropical grasses as summer forages is 15 t/ha, and they are used primarily for hay and occasionally for silage and soilage with 3 cuttings a year. This type of tropical grass utilization is different from that in the tropics.

Permanent pastures employing tropical grasses are only limitedly distributed in undulating piedmont areas with elevations lower than 500 m in the southernmost area, and in isolated islets in Nansei Islands where annual mean temperature is 16°C or higher. The permanent pastures are in mixture with white clover for beef cattle grazing about 4 times in a summer season, then Italian ryegrass is overseeded in late autumn. Expected DM yield in a summer growing season is 12 t/ha or more.

Nansei Islands belonging to the subtropics appear promising not only in herbage production but also in seed production of tropical grasses.

Table 1 shows types of forage production and cattle raising as related to land elevation in Kyushu, where the use of tropical grasses seems to be most promising.

Present status of speces and acreage in use

As shown in Table 2, total area of tropical grasses planted in the country accounts for approximately 6,000 ha, as of 1976. Although the figure is still small in comparison with

Table 1. Scheme of forage production in Kyushu in relation to elevation

Principal agricultural land use	Feeding system	Main cattle raised	Elevation (m)	Typical plant species and their rotation in use (Summer) (Winter)
Grassland pasture range	Pasturing	Beef cattle	↑	• Pasture Temperate grasses Orchardgrass (Supplement.) Perennial ryegrass Red clover (Kenland) Tall fescue Italian ryegrass White clover (N. Z. W.) Red top (at slope)
			700	
Grassland	Pasturing	Beef cattle Dairy cattle		• Pasture Temperate and tropical grasses Tall fescue + Italian ryegrass overseeding (Bahiagrass ?) (Dallisgrass ?) Edible weeds (Crabgrass, Pigeongrass, *Paspalum* spp.) White clover
Upland field	Stall-feeding	Dairy cattle Beef cattle		• Upland field Same as below
			300	
Paddy and upland field	Stall-feeding	Dairy cattle Beef cattle		• Paddy & Upland Fields (including Ley) Summer fodders/grasses+Winter fodders/grasses {Maize, Sorghum, Rhodesgrass, Panicum} + {Italian ryegrass, Turnip, Rape, Rice straw (supplement)}
(Grassland)	(Pasturing)	Beef cattle Dairy cattle		• (Pasture)—steep or rolling sites only Tropical grasses {Bahiagrass, Dallisgrass} +Italian ryegrass overseeding
			0	

leading summer fodders such as sorghums and maize, a fairly rapid increase in area, in particular with annual forage grasses, has taken place recently. Annual forage grasses planted to cultivated lands account for 80% of the whole area. Most of them are grown in Kyushu, the southernmost island. Among them rhodesgrass led by cultivars, Fords Katambora, Katambora, Gunsons and Pioneer, is most popularized in wide areas for hay making. African millet, originally being a cereal grass, is primarily used for silage and soilage; leading cultivars are Yukijirushi and Iyazairai. Panicums including green panic, cultivar Petrie, and colored guineagrass have spread mainly on upland fields in southern Kyushu for hay making. A stout grass, napiergrass, has also been utilized locally in the same areas for soilage and partly for silage. Cutting frequency of these species in a growing seasons is about 3 times. Promising ones under trial are fall panicum (*Panicum dichotomiflorum*), fingergrass (*Digitaria smutsii*), vaseygrass (*Paspalum urvillei*), knotgrass (*Paspalum distichum*) and so forth.

For permanent pasture use, bahiagrass (mainly cultivar Pensacola), dallisgrass (mainly Louisiana B230) and their mixture are most popular in rolling piedmont areas.

Table 2. Major tropical grass species in use in Japan (1976)

Common name	Scientific name	Planted area	Current trend of increase or decrease
		ha	
Rhodesgrass	*Chloris gayana*	1,913	↑
African millet	*Eleusine corocana*	1,657	↗
Napiergrass	*Pennisetum purpureum*	715	→
Panicum spp.	*P. maximum, P. coloratum*	127	↗
Barnyard millet	*Echinochloa crus-galli*	92	↗
Bahiagrass*	*Paspalum notatum*	927	↗
Pangolagrass*	*Digitaria decumbens*	150	→
Dallisgrass*	*Paspalum dilatatum*	125	→
Miscellaneous	*Cynodon, Brachiaria* etc.	307	↗
Total		6,014	
(Sorghums	*Sorghum bicolor* etc.	18,800	→)
(Italian ryegrass	*Lolium multiflorum*	66,300	↗)

Remarks: 1. Figures excluding two prefectures and some species such as teosinte
2. * : perennial pasture grass
3. ( ): a typical fodder crop and a non-tropical grass
4. ↑ : rapid increase, ↗: slow increase, → : no change
5. These tropical grasses are grown exclusively in southern Japan

Owing to heavy ergot injury and poor persistence in dallisgrass and low palatability in bahiagrass, little increase in acreage of perennial pasture grasses is expected. Paragrass and pangolagrass are grazed for a long period of a year in a small area of Nansei Islands in a similar way as in Southeast Asia.

Tropical legumes are recognized not promising at present due to their poorness in yield, overwintering and in palatability. Japan is accustomed to use cheap fertilizers as the source of plant nitrogen, instead of utilizing legume nitrogen, and cheap imported concentrates as the source of animal protein.

Problems in culture and utilization of tropical grasses in Japan

When tropical grasses are grown as summer forage crops on cultivated lands in competition with other economical crops, the following characteristics in herbage production are greatly required compared with those in pasture use; high DM yield, easiness in cultural practices, stability in plant growth, easiness in hay- and silage-making, high feeding value and low production cost. Unfortunately past growers' experiences have shown rather critical weakpoints in the tropical species introduced already, unlike summer fodders and temperate grasses grown in the middle latitudes. They are as follows:

(1) Low DM yield owing to the shortness of stable "productive" period.
(2) Low feeding value and difficulty in silage making.
(3) Difficulty in seed production.

Additionally the following has also been indicated in the case of dallisgrass on pasture.

(4) Low resistance to highly fertilized condition.

To overcome these weakpoints great efforts are required to develop cultural practices suitable to Japanese condition or to introduce more adaptable species. Apart from a large number of biological research findings on photosynthesis, respiration and so forth[1] of tropical grasses, some research results obtained from the practical points of view will be described hereinafter.

1) To increase DM production

Although the expected DM yield is as high

Table 3. Effects of various treatments on plant number per square meter in green panic and grass weeds

Treatment	Green panic	Grass weed	
		Crabgrass	Foxtail
GA_3 50 ppm 24h treatment	217	37	49
No treatment	97	40	55
1/2 NK fertilizer as basal dressing, 1/2 at 3 leaf stage	166	29	46
All applied as basal dressing	148	48	58
Paraquat 3ℓ/ha post-sowing application	143	10	6
No application	172	67	98

as 15 t/ha in a summer season, the actual yield level is 12 t/ha or less. To attain the above high yield, easiness of germination and early seedling growth leading to early first cutting are the most important factors among others. In southern Japan the most suitable sowing time is from late May to early June with mean daily temperature of approximately 20°C based on the prevalent cropping system and to escape from rainy season injury. Under favorable condition, most tropical grasses can uniformly germinate in 4 to 5 days after sowing, and reach 30 cm in plant height one month after sowing. However, it is of frequent occurrence that unfavorable conditions cause delayed germination up to 10 to 14 days and low plant height such as 20 cm with large variations one month later, as a result, the crops are liable to be suffered seriously from rapidly growing weeds, diseases and insects, and finally their productive period is shortened remarkably.

Factors inducing poor germination are deep seed dormancy and unfavorable condition at germinating time. The degree of dormancy varys among species; the panicums being very deep and rhodesgrass shallow. As effective methods for dormancy breaking, storage at temperature as high as 30° to 40°C and gibberellin treatment (50 ppm × 24 h) for the panicums, dehulling for rhodesgrass and sulphuric acid treatment for bahiagrass have been suggested. Unfavorable conditions at germination imply, for instance in the case of green panic, soil water stress more than pF 2.7, salt accumulation higher than 1 mv/cm of electric conductivity in 1:5 water-extracted soil solution mainly due to N and K fertilizers, deep soil coverage more than 1 cm in depth and poor contact between soil and seeds in volcanic ash soils and low temperature below 20°C. Furthermore, immediately after grass emergence, there are heavily competitive weeds; crabgrass, goosegrass and broadleaf weeds such as amaranthus. Broad-

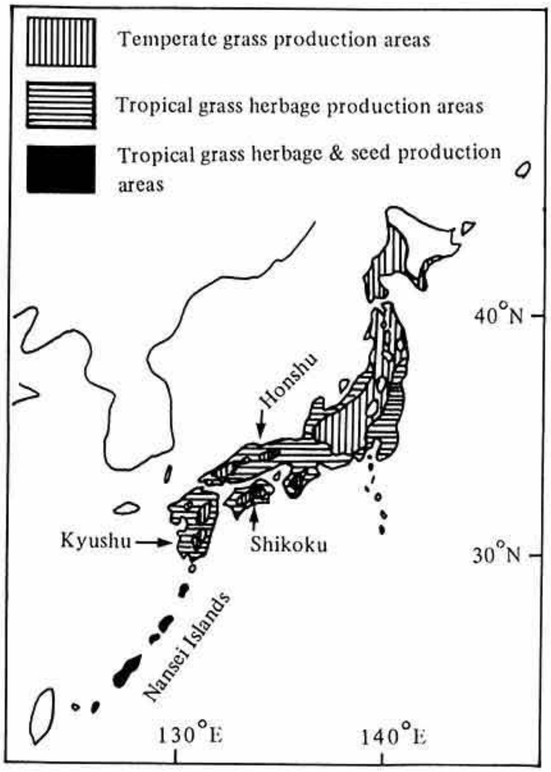

Fig. 1. A proposed classification of regions in Japan related to grass growing

leaf weeds have recently increased due to their N-favorate characteristic and resistant seed longevity in the liquid manure lagoons or tanks popularized among large-scaled farmers. Application of herbicides such as paraquat for crabgrass preemerged and 2,4-D for broadleaf weeds competitively co-existed with herbage grasses have been proved effective to control these weeds selectively. Delayed germination of tropical grasses sometimes gives rise to wet injury and damping-off damage in early growth, too.

For the safe establishment of green panic, a series of farm operations for the sowing is recommended by the authors[4]; i.e. land preparation following phosphatic fertilizer application 10 days prior to planting, sowing dry seeds treated with GA_3 (gibberelin) solution before seeding, application of basal NK fertilizers less than 50 kg/ha each in shallow depth and spraying 3 l/ha of paraquat to emerged weeds on the second day after sowing. Seeds at the rate of 15 to 20 kg/ha are broadcast to obtain an adequate planting density; approximately stands of 500/m^2. Closer density aptly causes a poor regrowth at the late growing period. Adequate amounts of NK fertilizers for one growth season are estimated from 300 to 400 kg/ha each. All of excessive fertilizer application, tractor-wheel stamping under wet soil condition and cutting height lower than 10 cm similarly bring about poor regrowth, in particular, with African millet.

In permanent pasture use of perennial grasses, the following cares should be taken; late summer sowing for avoiding weed competition and promoting early growth which gives frost-resistant in the coming winter season, keeping away from overgrazing and early spring clipping of Italian ryegrass overseeded in late autumn.

These cares taken in establishment and management will bring about good harvest of 15 t/ha for an annual forage grass or 12 t/ha for a permanent pasture grass in one growing season.

2) To improve feeding value and silage making

It is well known that feeding value of tropical grasses is inferior to those of temperate ones; lower contents of crude protein and carbohydrates, higher crude fibre and lignin, and lower digestibility as shown in Table 4[5]. It is also natural that there are large variations in the composition depending on not only species, but also growing seasons, growth stages and fertilization status. As these grass harvests are mainly used for hay- and silage-making, the easiness of preservation processes is one important specificity. For instance, specially quick drying due to fine and leafy herbage composition in rhodesgrass makes it suitable for hay making. In general, cutting at comparatively early stage prior to heading leads to high content of crude protein. On the other hand the following facts should be considered in silage making: high carbohydrate content and low water content are necessary; late harvesting after heading; ensilaging with some amounts of preservative and

Table 4. Average composition and DM digestibility in grasses and fodders[5]

Species	Crude protein	Crude protein / N-free extract	Soluble N / Total N	Carbohydrates: Lignin	Carbohydrates: Holo-cellulose	Carbohydrates: Soluble carbohydrate	DM digestibility
Rhodesgrass	10.5	20.8	8.1	11	76	13	57.9
Guineagrass	10.1	19.8	7.3	9	71	20	63.6
Sorghum	5.2	10.3	8.7	11	64	25	57.1
Italian ryegrass	15.4	36.6	4.5	8	70	22	69.2
Orchardgrass	16.2	38.9	4.7	8	66	26	73.0

(% on dry matter basis)

Table 5. Effect of formic acid addition on silage quality in dallisgrass[6)]

Volume of formic acid added	Water content	pH	Organic acid			Grade	Spoilage
			Lactic acid	Acetic acid	Butyric acid		
	%		%	%	%		%
Null	85.5	5.2	0.26	0.55	1.42	poor	10.0
0.3%	85.6	4.9	0.33	0.57	1.08	poor	6.1
0.6%	83.4	3.9	0.68	0.78	0.24	fairy good to good	2.8

keeping as cool as possible. African millet and setaria are high in water content, so that they are not suitable for silage making in general. Effect of formic acid addition is given in Table 5[6)].

Application of large amounts of farmyard- and liquid-manures to cultivated lands as an efficient way of animal waste utilization seems to be specific to the grass growing system in Japan. This practice induces easily mineral unbalance in plants and soils; the excess of NO_3-N and K, and the shortage of Mg and Ca cause NO_3-N poisoning and grass tetany. As the accumulation of NO_3-N more liable to occur in tropical grasses than in fodders as shown in Fig. 2, it must be prohibited to apply large amounts more than 50 t/ha of farmyard manure or 100 t/ha of liquid manure to the grasses for one growing season.

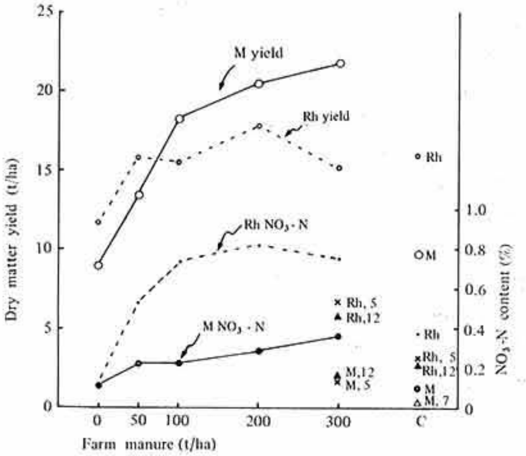

Fig. 2. Effect of farmyard manure on yields and NO_3-N contents of rhodesgrass (Rh) and maize (M) plants

Remarks: (1) C : Chemical fertilizer applied.
(2) To all farmyard manure plots, a half amount of chemical fertilizers was applied equally.
(3) Figures following Rh (rhodesgrass) and M (maize) indicate the date of harvest in days after heading. No figure is shown for harvests at heading stage.

3) *To improve seed production*

Continuous supply of cheap seeds is the first step for the spread of any introduced grasses which were highly evaluated by trials. Nowadays restricted amounts of seeds are imported from foreign countries at price as high as 2,000 ¥/kg. To establish self-supply systems for grass seeds, a serious of studies on seed production under Japanese climatic condition have been made. For instance, in rhodesgrass, an annual forage crop to be sown in late spring, approximately 300 kg/ha of fertile seeds can be obtained with hand harvesting in summer when accumulated temperature reached 270°C after flowering, while autumn-harvested seeds born on the ratoons are mostly unfertile. Therefore, it may be difficult to harvest economical amount of fertile seeds of annual forage grasses in warm temperate zone. Trials in Nansei Islands, where frequent harvests are possible by taking advantage of the perennial habits of tropical grasses, are hopefully expected.

With bahiagrass, a perennial pasture grass, 60 kg/ha of seeds can be harvested even in the warm temperate zone while it is impossible to harvest such amount with dallisgrass due to heavy ergot damage.

Summary

As to the culture and utilization of tropical grasses in Japan, there are many problems caused by the unsuitable climatic condition of Japan located at middle latitudes and the cropping system specific to Japan in which tropical grasses are grown as annual summer forage crops for hay and silage making. To overcome difficulties in getting high yields, good feeding value and silage making, and efficient seed production, many studies, basic or practical, have been carried out on the production and utilization of tropical grasses growing in Japan. Some of the major research results which can be applied practically to improve the production of tropical grasses are briefly presented in this paper.

Exploration and introduction of new species more adaptable to this region, as well as the varietal improvement are also very much needed.

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