Varietal Improvement of Forage Crops in Japan

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Before the War, forage crops were rather neglected, being regarded as less important, in Japan because there were only few domestic animals like dairy cattle and they were usually fed concentrates. However, after the War, forage crop production by live-stock farmers and grassland development by national government were promoted with an aim of developing stable dairy production not depending on purchased feedstuffs. As a result, a total area under forage crop including farm land and grassland have doubled in ten years, reaching about 800,000 ha in 1973, and the area of grassland has quadrupled to 430,000 ha in 1973.

Forage crops, particularly grasses and legumes, were entirely new to most farmers, and research had to be initiated on almost all aspects of varietal improvement, cultural management and utilization. As the importance of varietal improvement was recognized since an early date, systematic breeding programs were carried out by establishing breeding laboratories and breeding stations.

Regional classification of Japan

As Japan consists of a long chain of islands, the climatic condition differs markedly between northernmost Hokkaido and southern Kyushu and Okinawa islands. Each region requires different species of forage crops. In general, in warm regions, south of the Central region, intensive cultivation of forage crops on upland farms or on paddy fields as a second crop is practiced with an aim of obtaining high yields, whereas in cool northern regions or in cool highlands of southern regions pasture plants are grown on grasslands.

Major species of forage crops

Forage crops currently included in the national breeding program are listed in Table 1. They cover most of the species now under cultivation. One of the most important crops is maize, which is grown from Hokkaido to Kyushu. Italian ryegrass, orchardgrass, red clover, and white clover are also widely adapted. Sorghum is of tropical origin and grown mostly in warm regions (south of the Central region) and tropical grasses like Dallisgrass etc. are adapted to the very warm region.

Breeding of pasture crops

Pasture crops in Japan are grouped into temperate type and tropical type, and the former is more important than the latter. Selection of adaptable species and varieties was initiated after the War with full efforts. Systematic collection and testings conducted in recent ten years made it possible to establish the regional adaptability of varieties of major crops. In the course of the study, it came to be known that native (local) varieties were generally better than introduced varieties and useful as breeding materials.

Breeding organization was further strengthened in about 1959, and the full scale operation was started. In an early stage,

Table 1. Important forage species included in the National Breeding Program

Species	Adaptation*	Acreage**
Cool-season grasses		
Orchardgrass or cocksfoot, *Dactylis glomerata*	N–S	V L
Timothy, *Phleum pratense*	N	L
Italianryegrass, *Lolium multiflorum*	C–S	V L
Perennial ryegrass, *L. perenne*	C–N	S
Meadow fescue, *Festuca pratense*	N	S
Tall fescue, *F. arundinacea*	N–S	L
Bromegrass, *Bromus*, spp.	N	V S
Warm-season grasses		
Dallisgrass, *Paspalum dilatatum*	S	S
Bahiagrass, *P. notatum*	S	S
Herbage legumes		
Red clover, *Trifolium pratense*	N–S	V L
White clover, *T. repens*	N–S	V L
Alfalfa or lucerne, *Medicago sativa*	C–N	S
Crops for silage or soiling use		
Corn or maize, *Zea mais*	N–S	V L
Sorghums, *Sorghum* spp.	C–S	L
Oats, *Avena sativa*	C–S	L

* N—Northern Japan
C—Central "
S—Southern "

** V L—Very large
L—Large
S—Small
V S—Very small

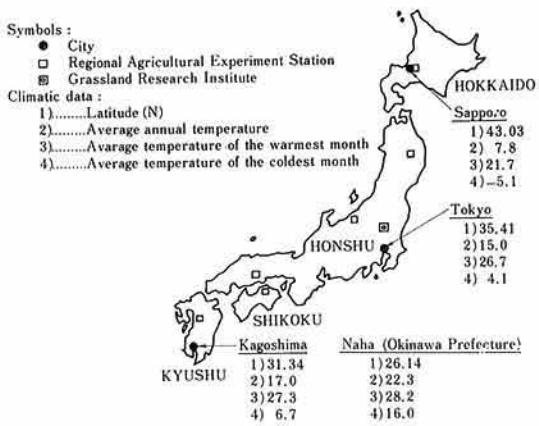

Fig. 1. Distribution map of Regional Agricultural Experiment Station with the climatic data of the typical locations

relatively simple methods such as mass selection and maternal line selection were applied with an emphasis on breeding for high yields of hay. In recent years, however, varieties with better seasonal distribution of production have come to be required due to an increased grazing management caused by promoted grassland development. Varieties to be used for grazing must be tolerable to frequent grazings and treading of animals and of good palatability. Therefore, criteria for selecting pasture type varieties is different from that of hay type varieties.

Breeding of pasture type varieties is still at its initial stage.

Efficient methods of breeding has been looked for under the condition of limited area of experimental farms and of shortage of animals available for tests of the breeding program. Yield assessment of pasture crops should include digestibility tests, and recently a simple technique of testing digestibility *in vitro* test was developed and applied for selection.

Disease resistance is an important breeding objective in areas with humid summer

season like Japan. As diseases cause not only yield decrease and quality deterioration but also decreased persistency of pastures, the disease resistance is always examined in field selection. Recently effective methods of screening at the seedling stage by the use of inoculation have been established for the crown rust of ryegrass, stem rust (*P. graminis*) of orchardgrass, northern anthracnose (*Kabatiella caulivora*) of red clover, etc. Mode of heredity of the resistance against some diseases and the race differentiation of stem rust were made clear. Thus, research was gradually specialized.

On the other hand, diseases in winter season are also important: resistance to snow mold occurring in cold and snowy areas is always tested in the breeding of ryegrass, etc.

Tropical grasses, introduced into warm regions of Japan, grow vigorously during the summer season in contrast to retarded growth of temperate grasses, and are rather resistant to diseases and insect pests. However, they have a long dormant season from early autumn to late spring, resulting in a limited period for utilization. Low palatability and rather poor quality of them are also problems. Although the breeding of dallisgrass and bahiagrass, etc. is now under way, panicgrass and rohdesgrass were recently found to be attractive, so that it is necessary to continue systematic introduction and selection in research for more adaptability.

For cross-pollinated grasses relatively simple breeding procedures such as mass selection and maternal line selection were applied in an early stage, but recently it became usual to develop synthetic varieties by examining general combinnig ability by means of polycross, etc. Polyploid breeding is also being carried out with red clover and ryegrass. With tropical grasses, there is a difficult problem to be solved such as how to control an apomictic behavior.

Breeding of maize and sorghum

Maize was introduced to Japan about 400 years ago and was widely distributed, giving a number of local varieties. Later, since about 1870 new varieties were introduced from U.S.A. and other countries, and at the beginning of 1900's there were several recommended varieties in Hokkaido. Some of them are still used widely to-day. The present improved varieties are consisted of improved varieties originated from traditional local varieties, F_1s of varietal crosses, and F_1 hybrids between inbred lines. Traditional varieties, which are mostly of flint type, are still grown in some areas, and are playing an important role as parents of F_1 hybrids. Since about 1940, the emphasis has been shifted to the breeding of F_1 hybrids. Varietal hybrids were more easily popularized than F_1 hybrids between inbred lines, due to less labor required for seed production and is still used as an useful one.

Major breeding objective of maize for silage is to increase TDN and DCP yields. As these are strongly influenced by the degree of maturity of ears, it is necessary to breed varieties with maturity adapted to each region. For example, in cool areas with a short season, only early varieties can be used with good nutritional yields.

Major diseases are leaf blight (*Trichometasphaeria turcica*), leaf spot (*Cochliobolus heterostrophus*), and maize streaked dwarf caused by virus, occurring sometimes. Typhoons in the growing season of maize cause lodging. In addition, recent mechanization of harvesting requires lodging-resistance.

Sorghum, which is more resistant to drought than maize and is utilized by repeated harvestings, is grown in areas with high temperature and drought. A pure type sudan grass has once attracted attention for its high regrowth potential and yield, but it is not grown now because of the susceptibility of leaf blight. In stead, F_1 hybrids

of sudan grass with sweet sorghum and grain sorghum introduced mainly from U.S.A. are mostly grown. Recently, Japanese F_1 hybrids were produced by the use of male sterility and are now recommended for extension. There are some varieties of sweet sorghum which can be used for feedstuff.

Breeding of other forage crops

As oats is used for green fodder and silage in warm areas, the breeding for high yield, resistance to crown rust, and lodging resistance is now in progress. Breeding of turnip, fodder soybean, Chinese milk vetch (*Astragalus sinicus*), and vetches (*Vicia* spp) was continued until recently, and two improved varieties of turnip and a variety of fodder soybean extremely resistant to soybean beetle (*Anomala rufocuprea*) were developed.

National system of breeding and seed multiplication

Breeding of forage crops is being assigned to four Regional Agricultural Experiment Stations of the Ministry of Agriculture and Forestry (MAF) and ten prefectural agricultural experiment stations designated by MAF. Local adaptability of strains newly produced in these breeding stations is examined by prefectural agricultural experiment stations entrusted by MAF. Basic research on breeding is carried out in the National Grassland Research Institute and National Institute of Agricultural Sciences.

New varieties developed by the national breeding system described above are registered by MAF, after examined by the Screening Committee for New Varieties organized by MAF. Qualified varieties are registered with a serial numbers and official variety names.

Production of foundation seeds is as a rule carried out in national organizations. In case of pasture crops, four national livestock breeding stations are in charge of production of foundation seeds, which are at the second generation through the breeder's stock. Production of seeds for farmer's use is made by private farms. However, because commercial seed production is difficult in Japan due to unfavorable climatic condition, it is made mostly by overseas firms by contract. Seed production of forage crops like maize is made by farmers or seed companies of the country, but due to low profitability they are not so earnest in doing the job, causing a slow extension of new varieties.

Institutional systems to certify the origin and quality of forage crop seeds on the domestic market have not been well developed as in Europe and U.S.A., and it is urgently needed to establish seed laws and to level up the farmer's knowledge on varieties and seeds by the extension activities.