Varietal Characteristics and Breeding of New Varieties in Italian Ryegrass

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Italian ryegrass is grown and used widely from Hokkaido to Kyushu region and is one of the major forage crops in Japan.

The breeding program of this forage crop was initiated in 1964. At present the breeding works are going on in the Ibaraki Prefectural Livestock Experiment Station in charge of eastern Japan, the Yamaguchi Prefectural Agricultural Experiment Station in charge of western Japan, the Hokuriku National Agricultural Experiment Station in charge of basic study on breeding for snow tolerance which is required in the Japan Sea side of the country, and in the National Institute of Agricultural Sciences and National Grassland Research Institute in charge of basic research for increasing breeding efficiency.

In the present paper, varietal comparisons with important characteristics and breeding of new varieties of Italian ryegrass will be briefly presented, mostly on the basis of the research results obtained in the Yamaguchi Agricultural Experiment Station.

Comparison of varietal characteristics

Morphological and ecological characteristics of a total of 134 varieties collected from 18 countries were examined, and grouping of varieties was made. In addition, varietal differences in major characteristics, and genetic variation of them were studied. The materials used included *Lolium multiflorum* Lam, *L. westerwoldicum* and *L. rigidum* Gaud.

1) Grouping of varieties

Italian ryegrass is a long-day plant. When it is sown in autumn in Japan, heading occurs in the following spring. However, the heading time varied greatly with varieties, showing the range of about 50 days. Plant type also showed a wide variation from creeping type to erect type. Using these two characteristics, i.e. heading time and plant type both having a high heritability, grouping of varieties was made as shown in Fig. 1.[3] The group I is characterized by extremely early to early heading and creeping plant type, the group II by early heading and erect type, the group III by medium maturity and medium-creeping plant type, the group IV by late maturity and medium-creeping plant type, and the group V by late maturity and erect plant type.

Relationship between these groups and place of origin of varieties (from where seeds were introduced) was found to be as follows: Varieties of Europe with high latitude belong to the group IV and V, those of North America belong to the group III, Japanese native varieties to the group II, and varieties of Australia to the group I. There is a tendency that the lower the latitude the greater number of early-maturing varieties were found. It is suggested that natural condition especially day length and air temperature might have played an important role in the development of ecotypes.[1] Furthermore, close relationships between these groups of varieties and morphological and ecological characteristics were also found as given in Table 1, 2 and 3.

In the following section, important char-

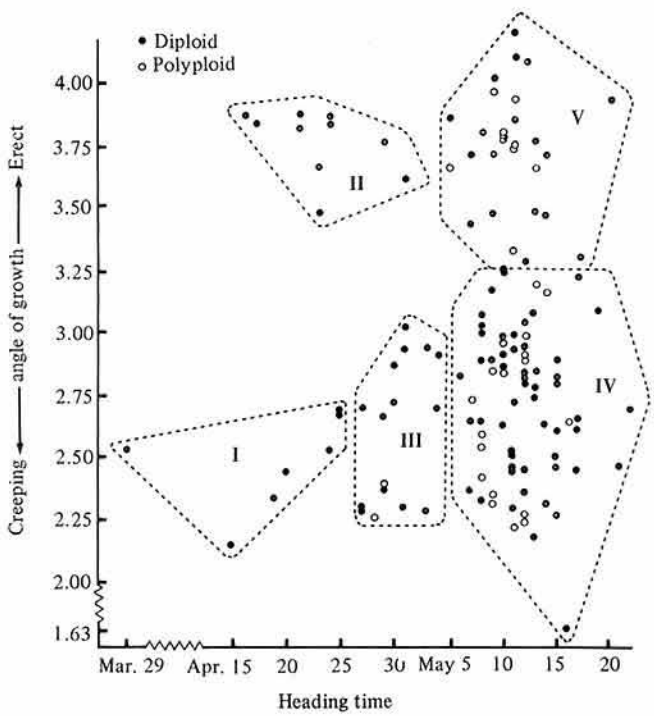

Fig. 1. Classification of Italian ryegrass varieties according to their heading time and plant type

Table 1. Groups of Italian ryegrass varieties and their origin and cultivation period

Variety Group	No. of Varieties	Origin	Cultivation period	Representative varieties
I	7	Australia	Extremely short	Wimmera ryegrass, C.O.I. 10438
II	10	Jap. ecotypes	Short	Strain Tottori, Strain Kochi
III	14	U.S.A.	Short-middle	Gulf, Stonevill Rust-Resistant
III-P[1)]	2	Uruguay	Short-middle	Tetraploid Line No. 1
IV	54	Europe	Long	Fat, L 17, S 22
IV-P	18	Europe	Extremely long	Tetrone, Tedis
V	19	Netherlands	Middle-long	W : Sceempter
V-P	10	Netherlands	Long	W : Billion

Note P: Polyploid W: Westerwolds ryegrass

acteristics in view of cultivation and use of Italian ryegrass will be discussed in relation to the groups of varieties.

2) Growth duration

Remarkable varietal differences in growth duration were observed. When sown in autumn in Japan, some varieties died in April of the next year (short-life one), whereas others continued their growth even after the summer was over (long-life one). A close correlation was found between heading time and growth duration: late-heading varieties showed longer growth duration. However, this correlation was not clearly recognized among varieties in the late-maturing group. A tendency that the

Table 2. Groups of Italian ryegrass varieties and morphological characteristics

Variety group	Heading time		Growth angle		Culm length (cm)		Culm diameter (mm)		Panicle number		Leaf width		1000 kernel weight (g)	
	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
I	April 17	10.05	2.48	0.20	88.3	12.99	3.4	0.45	146.2	35.76	2.6	0.41	2.45	0.42
II	April 25	3.83	3.77	0.10	109.5	2.43	4.0	0.14	88.5	6.50	3.3	0.15	2.55	0.26
III	May 1	2.17	2.71	0.29	100.1	12.26	3.7	0.49	118.5	50.91	2.6	0.29	1.99	0.38
III-P	April 29	0.71	2.34	0.09	105.5	0.71	4.9	0.28	67.0	7.07	4.0	0.35	3.06	0.25
IV	May 13	3.54	2.80	0.29	99.1	5.23	3.7	0.41	103.0	19.19	2.8	0.22	1.76	0.16
IV-P	May 8	1.47	2.57	0.18	102.7	3.61	4.5	0.29	75.8	7.28	3.6	0.19	3.04	0.32
V	May 11	2.45	3.79	0.23	110.8	3.71	4.1	0.34	91.4	8.72	3.0	0.18	2.04	0.16
V-P	May 11	0.55	3.82	0.09	111.4	4.83	5.0	0.42	71.2	11.05	3.6	0.16	3.19	0.45

Note: Growth angle 1 (creep)————(erect) 5
Leaf width 1 (narrow)————(wide) 5

growth duration is longer with creeping plant type than with erect type was also found.

Relation of growth duration to the variety groups was found as follows: the group I showed the shortest growth duration, followed by group III, group II, and group V in an increasing order, and varieties of group IV showed the longest growth duration. As to the relation to chromosome number, tetraploid varieties have longer growth duration than diploid ones. Particularly, tetraploid varieties of the group IV are of extremely long life.

3) Yielding ability

The total yield varies greatly with varieties. When the yield of early growing season (by the end of May) and that of later growing season (starting from June) were compared among different variety groups, the varieties of the group I showed low yields for both seasons, the group II high yields in early season, but low yields in later season, the group III medium yields for both seasons, and the group IV and V medium to high yields in early season and high yields in later season[7].

4) Resistance to crown rust

Crown rust (*Puccinia coronata*), an important disease in western Japan, causes not only yield decrease but also serious decrease of feeding value of forage, when it outbreaks severely[2]. Remarkable varietal differences in the resistance to this disease are recognized[6]. It can be generally said, though there are some exceptions, that varieties of the group II and V are less resistant, while the group III includes many varieties with high resistance.

5) Crude protein and nitrogen free extract (NFE)

Percent content of crude protein and NFE at the heading stage showed varietal differences[8]. In general, crude protein content is high in the group I, and low in the group IV and V, the difference being 4–5%. Varieties with high NFE content tend to be found more frequently in the group IV and V.

Breeding of new varieties

There is a great diversity in cultivation and use of Italian ryegrass in Japan. In the Yamaguchi Prefectural Agricultural Experiment Station, the breeding for high-yielding and disease resistant varieties has been conducted for each of the following 4 different cropping types, classified on the basis of length of cropping period: extremely short period type, short period type, long period type, and extremely long period type. Breeding for crown rust resistant varieties, and

Table 3. Groups of Italian ryegrass varieties and growth and yielding ability

Variety group	Spring vigor		Growing period index		Plant height (cm)				Dry matter yield (kg/a)					
					April 15		June 15		Former period		Later period		Total	
	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
I	3.0	1.26	4.5	4.49	55.5	3.73	31.5	7.18	78.1	7.31	13.8	5.75	91.9	12.10
II	2.2	1.17	19.3	1.79	66.8	2.23	59.2	1.94	90.2	2.63	37.1	2.97	127.3	4.85
III	3.4	1.42	9.4	5.81	55.9	5.67	43.4	9.22	80.6	8.49	25.1	9.02	105.7	13.21
III-P	2.5	0.71	7.4	1.63	63.0	1.41	41.5	0.71	81.1	1.77	17.6	0.64	98.7	2.40
IV	5.5	1.25	60.7	11.83	58.0	2.36	62.4	2.35	83.6	3.09	50.1	3.53	133.7	5.37
IV-P	4.5	0.55	77.5	8.08	59.2	1.17	64.3	1.51	87.4	3.07	55.5	2.84	142.9	5.16
V	4.1	1.45	32.6	9.11	57.8	1.93	62.9	2.02	80.8	4.30	44.7	1.71	125.5	5.72
V-P	1.6	0.55	41.0	9.46	64.4	2.97	70.2	1.10	84.2	3.49	52.5	1.56	136.7	2.11

Note: Spring vigor: 1 (best) ———— (poor) 9
Growing period index: viability × K

Table 4. Breeding materials, breeding methods and characteristics of varieties bred at Yamaguchi Prefectural Agricultural Experiment Station

Variety	Parental materials	Breeding method	Characteristics
Minamiwase	11 varieties (4,1 and 6 varieties from Japan, U.S.A. and Australia, respectively)	Maternal line selection	Semi-erect type, extremely early heading, narrow leaf, profuse tillering, less remained root, and used for short period cultivation
Waseyutaka	3 native lines (Tottori, Kuroishi, Kōchi)	Synthetic variety	Erect type, early heading, good early growth, high yield in early spring, less remained root, and used for short period cultivation
Yamaaoba	Introduced 3 varieties	Maternal line selection	More or less prostrate type, late heading, good regrowth, resistance to crown rust, and used for long-period cultivation

varieties to be used for silage and hay is also in progress[1]. Breeding method and characteristics of new varieties developed so far are shown in Table 4.

In the breeding work, above-mentioned data on varietal characteristics and genetic variation of characters are used as a powerful guidance in choosing parental materials. As Italian ryegrass is an allogamous plant, mass selection, maternal line selection, or synthetic variety method are mainly employed. In addition, polyploidy breeding, inter-specific hybridization and intergeneric hydridization are also adopted.

Since the intiation of breeding program of Italian ryegrass, more than 10 years have passed, and a nation-wide breeding system for forage crops has been developed. Breeding works are going on well, and excellent varieties have been released. The future target is to make a leap in yielding ability, yield stability and quality. For that purpose, intensive searching for gene sources and research for highly efficient breeding methods are in progress.

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(Received for publication, March 4, 1981)