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REVIEW

Development of Quattro-TK5, a New, Snow-Endurant, Early-Heading Italian Ryegrass Cultivar

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Abstract

Quattro-TK5 is a new, snow-endurant, early-heading cultivar developed for double-crop cultivation in locations with 80 days of snow cover. Areas with 100 days of snow cover are unsuitable for Quattro-TK5 cultivation. This study investigated the yield and map cultivation area of Quattro-TK5 in nine locations in Japan. This strain showed better snow endurance and headed three days earlier than Waseaoba, which previously had the best snow endurance among early-heading cultivars in Japan. In locations with prolonged snow cover, the dry matter yield of the first cut of Quattro-TK5 at the heading stage was superior to that of Waseaoba. In areas of short snow cover, the dry matter yield of the first cut of Quattro-TK5 at the heading stage was equal to that of Waseaoba.

Discipline: Crop Science
Additional key words: *Lolium multiflorum*, snow mold, tetraploid, *Typhula incarnata*

Introduction

Italian ryegrass (*Lolium multiflorum* LAM.) is a popular forage grass in Japan, and it is cultivated in paddy fields due to its tolerance to wet conditions. Double-crop cultivation—corn silage in summer and Italian ryegrass in winter—is common in warm climates. However, Italian ryegrass is not popular in cold climates, such as the Tohoku region, because of its low snow endurance. Long snow cover induces snow mold, which is caused by *Typhula incarnata* Lasch in Tohoku. Waseaoba has the best snow endurance of the early-heading cultivars in Japan, but its yield is decreased if exposed to more than 60 days of snow cover (Ueyama et al. 2006). Although some middle-heading cultivars, such as Nagahahikari, are snow-endurant, it is difficult to prepare corn silage after cultivating the middle-heading Italian ryegrass cultivar because the warm period is so short. Therefore, a snow-endurant, early-heading cultivar for double-crop cultivation in cold climates, Quattro-TK5, was developed and has been available in Japan since 2023. It was first evaluated in four locations along the Pacific Ocean (Kubota et al. 2017). Although it had higher yields than Waseaoba, it is unclear whether this is true in snow-covered areas along the Sea of Japan since the snow quality and quantity of the two areas differ. The Quattro-TK5 yield was also evaluated for five locations along the Sea of Japan (Kubota et al. 2021). The yields were higher than in Waseaoba in locations with long snow cover, and they matched those where the snow cover was short. This study investigated the yield and map cultivation areas of Quattro-TK5 in nine locations in Japan. All data are based on the yield tests from two published articles (Kubota et al. 2017, Kubota et al. 2021).

Materials and methods

1. Materials

This study compared Quattro-TK5 and Waseaoba, which had the best snow endurance of all early-heading cultivars in Japan. Waseaoba is an old diploid cultivar, whereas Quattro-TK5 is a tetraploid cultivar that was

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developed because tetraploid Italian ryegrass cultivars or strains have better snow endurance than diploids (Okabe 1975). Quattro-TK5 was bred via maternal-line selection for its high snow endurance and dry matter content from Tohoku 2, a tetraploid, snow-endurant, early-heading breeding strain (Kubota et al. 2017).

2. Methods

Quattro-TK5 yields were evaluated in nine locations: Iwate Prefecture (Morioka and Takizawa), Akita Prefecture (Oga), Yamagata Prefecture (Shinjo), Miyagi Prefecture (Osaki), Fukushima Prefecture (Nishigo), Niigata Prefecture (Sanjo), Toyama Prefecture (Toyama), and Ishikawa Prefecture (Hodatsushimizu). Researchers at the livestock experiment station of each location were responsible for each evaluation. We adopted a randomized block design with four replications, each plot being at least 6 m^2. Different seeding methods were used, with broadcasting and stripe seeding having row spacings of 30 cm, and the usual autumn seeding date was chosen for each location. We applied conventional fertilization for each location. The seeding year, seeding dates, harvesting dates, and snow cover periods of each location are listed in Table 1. Continuous snow cover of less than 30 days was not counted as part of a snow cover period. We investigated the snow endurance of locations where snow mold was found, the heading date, and the dry matter yield of the first cut at the heading stage.

Results and discussion

Because snow cover in Takizawa, Shinjo, Sanjo, and Morioka was sufficiently long to induce snow mold, these locations were chosen for investigating snow endurance. Table 2 shows the snow endurances, heading dates, and dry matter yields of each location's first cut at the heading stage and their averages. These averages do not match the mean values in Table 2 because the values for Oga and Morioka were taken over two and four years, respectively; the others were over three-year periods. Quattro-TK5 exhibited better snow endurance and headed three days earlier than Waseaoba. Dry matter yields of the first cut at the heading stage depended on snow cover duration to some extent, so the nine locations were divided into three groups: those with short snow cover, others with long snow cover, and those unsuitable for Quattro-TK5. The short-period group comprised Oga, Osaki, Nishigo, Toyama, and Hodatsuhimizu, and the long-period group included Sanjo and Morioka. Takizawa and Shinjo were deemed unsuitable for Quattro-TK5. The average dry matter yields of the first cut at the heading stage for each group are shown in Figure 1. The dry matter yield of Quattro-TK5 was at least equal or superior to that of Waseaoba for all groups, but the yield level was very low. From these results, it was concluded that Quattro-TK5 can be cultivated in locations with a snow cover period of 80 days. Locations with 100 days or more of snow cover are unsuitable for Quattro-TK5 cultivation. The area suitable for Quattro-TK5 cultivation based on Agro-Meteorological Grid Square Data, NARO, is shown in Figure 2. Note that the area with no snow cover in the middle of March (less than 80 days) was suitable for Quattro-TK5 cultivation. This area includes Okinawa Prefecture and parts of Hokkaido Prefecture. Quattro-TK5 has never been cultivated in these prefectures, so the suitability of Quattro-TK5 could only be tested on a small scale. Particularly in Okinawa, it is unclear whether Quattro-TK5 shows enough heading despite having a spring habit.

Double cropping in cold climates like the Tohoku

Table 1. Seeding year, seeding dates, harvesting dates, and snow cover periods of each yield test location

Locations	Seeding years	Seeding dates	Harvesting dates	Snow cover periods
Takizawa (Iwate Pref.)	2012-2014	September 19	May 19	106
Shinjo (Yamagata Pref.)	2016-2018	September 15	May 20	103
Sanjo (Niigata Pref.)	2016-2018	September 20	May 8	80
Morioka (Iwate Pref.)	2013-2017 (except 2015)	September 19	May 20	77
Oga (Akita Pref.)	2017-2018	September 24	May 8	50
Osaki (Miyagi Pref.)	2012-2014	September 28	May 7	0
Nishigo (Fukushima Pref.)	2012-2014	September 30	May 7	0
Toyama (Toyama Pref.)	2016-2018	October 4	May 3	0
Hodatsushimizu (Ishikawa Pref.)	2016-2018	September 29	April 27	0

Seeding dates, harvesting dates, and snow cover periods were the average of tested years.
Continuous snow cover of less than 30 days was not counted as a snow cover period.

Table 2. Snow endurance, heading date, and dry matter yield (g/m^2) of the first cut in the heading stage of each yield test location

Locations	Snow endurance		Heading date		Dry matter yield of first cut	
	Quattro-TK5	Waseaoba	Quattro-TK5	Waseaoba	Quattro-TK5	Waseaoba
Takizawa (Iwate Pref.)	2.4	1.6	May 13	May 14	241	70
Shinjo (Yamagata Pref.)	2.9	2.8	May 16	May 17	233	169
Sanjo (Niigata Pref.)	3.6	1.6	May 1	May 3	570	400
Morioka (Iwate Pref.)	5.4	4.2	May 4	May 7	809	662
Oga (Akita Pref.)	-	-	-	-	769	781
Osaki (Miyagi Pref.)	-	-	April 30	May 3	863	857
Nishigo (Fukushima Pref.)	-	-	April 29	May 1	737	746
Toyama (Toyama Pref.)	-	-	April 23	April 24	1079	1247
Hodatsushimizu (Ishikawa Pref.)	-	-	April 13	April 18	803	871
Average	3.8	2.7	April 30	May 2	680	640

Snow endurance, heading dates, and dry matter yield averaged over the tested years.
Snow endurance was graded visually from withered leaves: 1 (bad) - 9 (good).
Hyphens indicate no data.

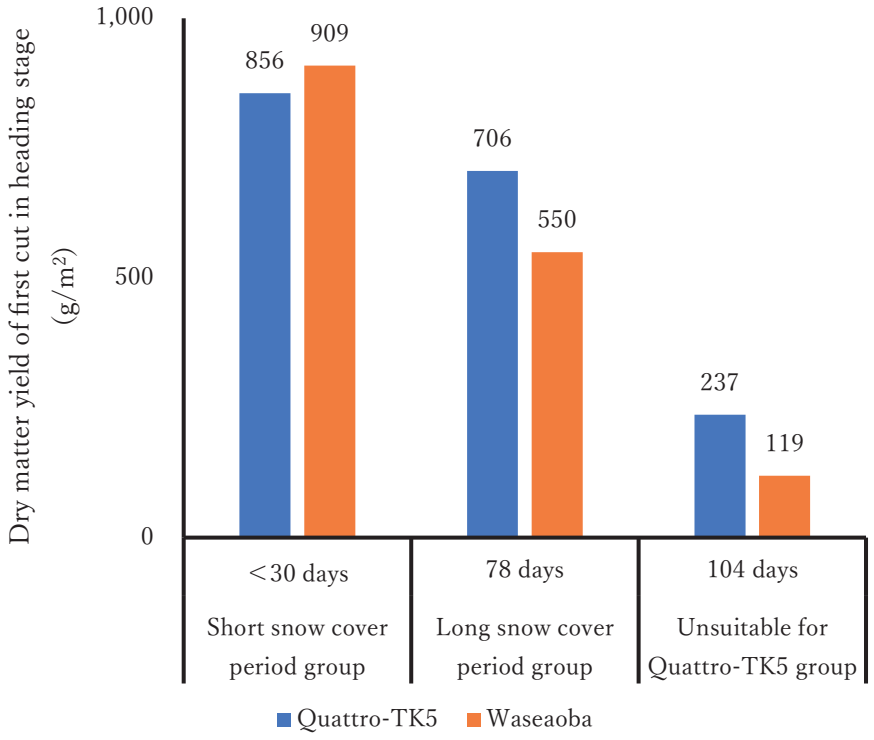

Fig. 1. Average dry matter yields of the first cut in the heading stages for each group
This figure was taken from Kubota (2024).

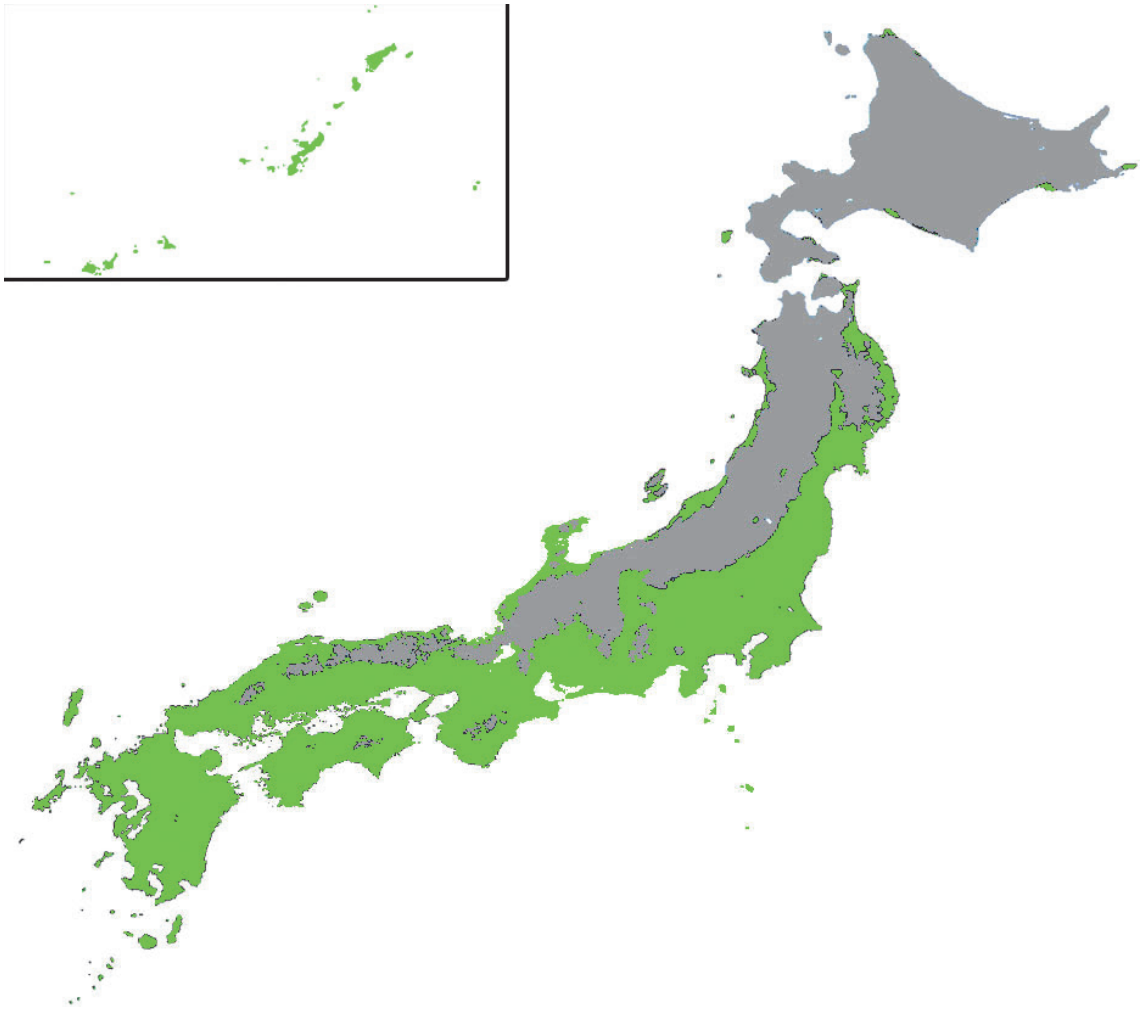

Fig. 2. Green area suitable for Quattro-TK5 estimated from no-snow-cover areas in the middle of March
This figure was taken from Kubota (2024).

region is becoming increasingly necessary. Global warming, as stated by the U.N. secretary-general, continues to impact our lives. In the past, the livestock industries in the Tohoku region were supported by extensive grasslands. However, the grasslands consisted mainly of orchard grass (*Dactylis glomerata* L.), which tends to wither in the summer heat. The crop must be cultivated after corn silage, and Quattro-TK5 is the best answer. Cattle-breeding farmers cultivate Italian ryegrass in winter and Japanese millet (*Echinochloa esculenta* (A. Braun) H. Scholz) or foxtail millet (*Setalia italica* (L.) P. Beauv.) in summer. This double-crop cultivation may need only grass-harvesting machines. These breeders feed Italian ryegrass to calves and millet to breeding cows. With the commercialization of Quattro-TK5, more Italian ryegrass is likely to be cultivated in Tohoku to increase land productivity.

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