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Research Article

Effect of Different Seeding Rates on Seed Productivity of the "Kowinearly" Cultivar of Italian ryegrass (*Lolium multiflorum* Lam.) in Paddy Field

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ABSTRACT

The present study investigated the effects of different seeding rates on growth characteristics and seed productivity of the "Kowinearly" cultivar of Italian ryegrass (*Lolium multiflorum* Lam.) in paddy fields. Sowing Kowinearly in paddy fields under growing rice at the rates of 20, 30, 40, and 50 kg/ha resulted in seed yields of 1.57, 1.92, 2.06, and 2.09 ton/ha, respectively. Seed yield of Kowinearly was the highest at a seeding rate of 50 kg/ha ($p<0.05$), at which the cultivar was able to survive in winter and the weed ratio was low. Under these conditions, most growth characteristics such as winter survival (85%), weed ratio (10%), stems per square meter (1,006) were superior than those sown at other seeding rates ($p<0.05$). In addition, it has been reported that the economic efficiency of the 50 kg/ha seeding rate was higher than that of the other seeding rates.
(**Key words :** Italian ryegrass, Kowinearly, Seeding rate, Seed productivity)

Ⅰ. INTRODUCTION

Italian ryegrass (*Lolium multiflorum* Lam., IRG) is an important forage crop in Korea, which accounts for approximately 70% or higher of the winter forage crop acreage. IRG has good productivity and high feed value of forage. In Korea, the area of land under IRG cultivation was approximately 94,000 ha in 2015. Among the 12 cultivars of IRG developed in Korea, Kowinearly is the most widely grown in farmlands because of its cold tolerance and early harvest time. Out of the 1,251 tons of domestic cultivar seeds supplied to farms in 2015, Kowinearly comprised 843 tons (67%) (Kim et al., 2015).

Although many cold-tolerant cultivars have been developed in recent years and the distributed seed amount increased rapidly, most of the seeds were produced by other countries and distributed in Korea (Kim et al., 2015). In the case of any issues related to the import of IRG seeds, the farmers are unable able to grow IRG. Therefore, it is necessary to develop a technology for the domestic production of IRG seeds.

The study of seed production of pasture and forage crops in Korea has been conducted since the mid-1980s (Kim et al., 2013). Lee and Kang (1985) reported that the optimum seeding time for the seed production of IRG is around 20 September and the suitable seeding rate is approximately 20 ~30 kg/ha. Studies on IRG seed production in Korea showed a seed yield of 1.6 ton/ha for the Hwasan 101 variety (Choi et al., 2000) and Kim et al. (2010) reported a seed yield of 2.7 ton/ha for the Kogreen variety (Choi et al., 2006).

The present study investigated the effect of different seeding rates on the growth characteristics and seed yields of Kowinearly in paddy fields. Growth characteristics such as winter survival ratio, heading date, lodging tolerance, weed ratio, plant length, number of effective stems, ear length, and spikelets per spike, and seed yields of IRG were investigated.

Ⅱ. MATERIALS AND METHODS

1. Treatments

The study was conducted on the Kowinearly variety of IRG (Choi et al., 2011), which was developed in Korea, for two years from 2012 to 2013 in Gimje, Jeonbuk of Korea. The experiments were conducted in a cultivated area of 2,652 m^2, which was divided into four test plots, and the

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treatments comprised four seeding rates 20, 30, 40, and 50 kg/ha.

2. Cultivation method

IRG was sown in experimental paddy fields under growing rice before rice harvest in early October (Seeding dates of IRG were October 4, 2011 and October 5, 2012). Rice was harvested in mid-October (October 18, 2011 and October 14, 2012). Rice straw was collected and fertilizer was sprayed immediately after the harvest of rice followed by the installation of watercourses. In late November and early March, the paddy field in which IRG was grown was leveled using a roller.

Nitrogen, phosphorous, and potassium fertilizers were applied at rates of 90 kg/ha, 150 kg/ha, and 150 kg/ha. Nitrogen fertilizer was applied at 40 kg/ha as the base fertilizer and 50 kg/ha as added fertilizer. Phosphorous and potassium fertilizers were both applied at 75 kg/ha as the base fertilizer and 75 kg/ha as added fertilizer, respectively. The weather conditions of the Gimje region (National Weather Service (NWS), Korea) during the study period are presented in Table 1 and Fig. 1.

3. Investigation of growth characteristics and seed yield

IRG seeds were harvested at the seed shattering stage from plots of 1 m × 1 m size with three replications per treatment. The harvested seeds were sufficiently dried in a greenhouse, and then the seed yield was determined by weighing the seed after removing the immature seeds and debris. Mean values and standard deviations of the experimental results were obtained using the SAS (Statistics Analytical System, USA) Program (2010); Duncan's multiple comparison test was used to identify differences among the treatments, which was considered significant if $p<0.05$.

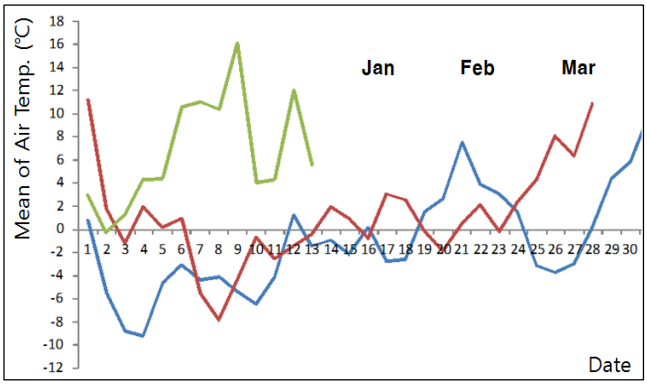

Fig. 1. Meteorological data of the mean air temperature (℃) in the Gimje region during the winter period (December 2012 ~ February 2013, NWS).

Ⅲ. RESULTS AND DISCUSSION

The Kowinearly cultivars were grown at different seeding rates. The weed ratio reduced as the seeding rate increased, whereas the winter survival ratio and seed productivity were increased ($p<0.05$). The main growth characteristics included 85% winter survival, 6 degrees lodging tolerance, 10% weed ratio ($p<0.05$), and 133 cm plant length, with the heading on May 10 at the 50 kg/ha of seeding rate (Table 2). Under these conditions, the seed productivity components were 1,006 stems per square meter ($p<0.05$), 30 cm ear length, and 23 spikelets per spike (Table 3). The seed quantity increased with the number of stems.

The seed yields of Kowinearly were 1.57, 1.92, 2.06, and 2.09 tons at 20, 30, 40, and 50 kg/ha of seeding, respectively. Seed yield was highest at 50 kg/ha of seeding (Table 3) ($p<0.05$). Seed productivity of Kowinearly was high in 2012, but it was low in 2013 (Fig. 1). This may be due to the insufficient growth of Kowinearly before winter

Table 1. Meteorological data of three years (September 2011 ~ March 2013, NWS) in the Gimje region

Division	Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Mean Air Temp. (℃)	'11 ~ '12	21.7	14.1	12.1	1.1	−1.2	−0.6	4.7
	'12 ~ '13	21.0	15.5	7.4	−0.9	−1.1	1.1	6.7
Precipitation (mm)	'11 ~ '12	52.1	25.2	100.3	25.6	33.5	14.6	45.6
	'12 ~ '13	242.1	53.8	52.1	65.9	17.8	33.1	37.0

Table 2. Growth characteristics of IRG at different seeding rates (mean of two years, 2012~2013)

Seeding rate (kg/ha)	Winter survival (%)	Heading date	Lodging tolerance (1-9)*	Weed ratio (%)	Plant length (cm)
20	74[c]	May 10	4[c]	60[c]	131
30	76[b]	May 10	5[b]	30[b]	130
40	84[a]	May 10	6[a]	10[a]	131
50	85[a]	May 10	6[a]	10[a]	133

(1-9)*: 1 = Excellent (or strong), 9 = Worst (or week).

Table 3. Seed yield components and seed yield of IRG at different seeding rates

Seeding rate (kg/ha)	Year	No. of stems (ea/m^2)	Ear length (cm)	Spikelet per spike	Seed yield (ton/ha)	Germination (%)
20	2012	576	32	22	1.75	87
	2013	573	25	21	1.38	86
	Mean	575[d]	29	22	1.57[d]	87
30	2012	813	32	23	2.35	90
	2013	651	27	22	1.48	88
	Mean	732[c]	30	23	1.92[c]	89
40	2012	1,003	27	22	2.53	89
	2013	743	26	22	1.59	89
	Mean	873[b]	27	22	2.06[b]	89
50	2012	1,101	31	22	2.75	92
	2013	910	28	23	1.43	90
	Mean	1,006[a]	30	23	2.09[a]	91

[a-d] Means in the same row with different letters were significantly different ($p<0.05$).

because of lower temperatures in November and December 2012 (Table 1). Moreover, the cultivar was affected by severe moisture damage because of abundant rainfall in December 2012. Kim et al. (2016) reported that the forage yields of IRG were reduced because of low temperatures and excessive moisture during the growing season. Under normal growth and weather conditions, the production of Kowinearly seeds is 2.5 ton/ha in the rice paddy fields. In the present study, the germination ratio of the harvested Kowinearly seeds was 87~91% (Table 3).

In the present study, the optimum seeding time for IRG was early October because the tests were carried out in the southern region of Korea, Gimje, although a previous study reported an optimum seeding time on September 20 and a seeding rate of 20~30 kg/ha (Lee and Kang, 1985) Further, in the present study, in the cultivation method of IRG sown under growing rice in paddy fields the most suitable seeding rate for IRG was 50 kg/ha.

However, the seed yields results reported by Choi et al. (2002) and Kim et al. (2010) were obtained when IRG was cultivated after plowing the land, whereas, in the present study, the seed yields were obtained when IRG was cultivated by a different seeding method of broadcasting under growing rice in paddy fields. Therefore, there will be no effective comparison between these results.

Taken together, the results of thisstudy indicate that higher seed yields of IRG in paddy fields cultivated by the seeding method under growing rice can be obtained at the optimum seeding rate of 50 kg/ha under favorable weather conditions during the growing season.

Ⅳ. ACKNOWLEDGEMENT

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