한작지(Korean J. Crop Sci.), 65(4): 477~484(2020)
DOI : https://doi.org/10.7740/kjcs.2020.65.4.477

ISSN 0252-9777(Print)
ISSN 2287-8432(Online)

Original Research Article

Effects of the Slow-releasing Fertilizer and Sowing Date on Waxy Corn "Mibaek 2" Propagated through Double Cropping without Tillage in the Middle Region of Korea

Jae-Wung Lee[1,†], Se-Gu Hwang[2], Hye-Rim Moon[1], Ik-Jei Kim[2], and Young-Ho Kim[2]

ABSTRACT This study was conducted to investigate the effects of slow-releasing fertilizer and sowing date on waxy corn propagated through double cropping without tillage. "Mibaek 2" was sown for first cropping on March 25th, April 5th , and April 15th, and for second cropping on July 5th, July 15th, and July 25th in 2018-2019. In order to save labor, slow-releasing fertilizer was utilized only one time before sowing. The accumulated temperature from sowing to silking was about 590-700℃. It took 65-77 days when "Mibaek 2" was sown in early April, but the one sown in early July took 42-52 days. In the first cropping, the culm length and ear length caused by the sowing date had no statistical significance, but the kernel set length was the highest at 123 cm in the sowing district on April 5th. The weight of marketable ears was the highest at 100%, in addition to soil testing-based recommended fertilization. Meanwhile, in the second cropping, culm length, ear length, and yield were less compared to the first cropping. The culm length, kernel set length, ear length, and seed set length decreased as sowing date was delayed. The number and yield of marketable ears were the highest at 100%, in addition to soil testing-based recommended fertilization like in the first cropping. It has been found that securing yield by July 15th to finish the second seeding of the crop in the central part of Korea is advantageous. These results of this study will be helpful to farmers for the double cropping of waxy corn cultivation and management.

Keywords : double cropping, Mibaek 2, slow-releasing fertilizer, sowing date, waxy corn

Most of Korea's edible corn is made up of waxy corn and was grown in about 15,000 ha in 2019 (MIFAFF, 2019). Generally, the cultivation of waxy corn is conducted in the form of sowing in April and harvesting in mid-July and late July, so the harvest is concentrated in the summer, causing frequent price falls due to large quantity (Kim *et al*., 2014).

Many studies have been conducted on the timing of sowing to prevent such harvesting concentration. Park *et al*. (1987) showed that waxy corn exhibited a tendency to decrease in yield due to faster transition from vegetative growth to reproductive growth when the seeding period was late. In addition, the yield of waxy corn was reduced in terms of sowing on May 27th compared to April 15th when it was grown in Hongcheon, Gangwon-do (Yoon *et al*., 1999) although the critical sowing period may be delayed due to recent temperature increases. Global warming is a risk factor for deepening weather disasters, including pests; on the other hand, it is also a window of opportunity due to the increased period of crop cultivation. Because the period of growth of vegetable waxy corn is relatively short, it is possible to establish the double cropping system, which is expected to increase the utilization rate of land and to improve income.

However, the lower yield and marketability of vegetable waxy corn have been pointed out as problems due to the lack of technology for the cultivation of a double cropping system (Jung *et al*., 2012). The present method of cultivation in the double cropping system of the newly developed and distributed waxy corn has diversified its harvest time compared with the past method. Recent studies have shown that the timing of vegetable waxy corn supply has been extended from the early part of July to the early and middle part of October by mens of advancing the

[1)]Junior Researcher, Chungbuk Agricultural Research and Extension Services, Cheong-ju 28130, Republic of Korea
[2)]Senior Researcher, Chungbuk Agricultural Research and Extension Services, Cheong-ju 28130, Republic of Korea

[†]Corresponding author: Jae-Wung Lee; (Phone) +82-43-220-5561; (E-mail) leepodo@korea.kr
<Received 19 May, 2020; Revised 22 September, 2020; Accepted 7 October, 2020>

sowing time of the first cropping and delaying the sowing time of the second cropping (Jung *et al*., 2012; Kim *et al*., 2000).

In addition, the use of slow-releasing fertilizer once when growing double cropping waxy corn can reduce labor and environmental pollution due to low nitrogen loss.

In previous studies, the use of slow-releasing fertilizers increased the plants' dry weight by increasing the use of nitrogen over more effective fertilizers (Choi *et al*., 2002).

In the study of the crop application of slow-releasing fertilizer, Yoo *et al*. (1998) and Chi *et al.* (2013) reported that the rate of nitrogen utilization was the highest at 50 days after the nitrogen treatment and that nitrogen was slowly released based on the latex-coated fertilizer.

Therefore, this study was conducted to investigate the effects of the slow-releasing fertilizer and seeding date on waxy corn propagated through double cropping without tillage. It also compared the ear yields according to the sowing date with "Mibaek 2" as a test variety in order to investigate the effect of the slow-releasing fertilizers.

MATERIALS AND METHODS

Study field characteristics

This experiment was conducted from 2018 to 2019 at the Chungcheongbuk-do Agricultural Research and Extension Services, and the test waxy corn hybrid was called "Mibaek 2", a crop mostly cultivated as an early maturing type in the central region of Korea. "Mibaek 2" was sown for first cropping on March 25th, April 5th, and April 15th and for second cropping on July 5th, July 15th, and July 25th six times overall, at 10-day intervals. The slow-releasing fertilizer employed in this study was Latex Coating Urea (LCU), which was used as a full-scale fertilizer once before vinyl mulching.

Fertilizer application and crop cultivation

The level of distribution was different depending on the soil testing-based recommendation (STBR), which was N-P_2O_5-K_2O = 16-3-3 kg/10a. The fertilizer level of the control was N-P_2O_5-K_2O = 30-3-6 kg/10a, with nitrogen separated twice in the first cropping and second cropping. 50% addition to soil testing-based, recommended fertilization (150% STBR) increased the fertilizer level by 1.5 times, while 100% addition to soil testing-based, recommended fertilization (200% STBR) increased the fertilizer level by 2 times. With the aim of producing 6,600 plants per 10a, the sowing was set to 60 cm in width and 25 cm in length, while planting density was maintained uniformly by thinning out and with only one head left in the growing season. The placement of the test tools was tested through a three-repeated split-plot arrangement method, with the seeding dates as a main plot and fertilizer levels as a sub plot. Plant height was investigated in accordance with the Agricultural Science and Technology Research and Analysis Standards of the Rural Development Administration about a week before the harvest. The characteristics of ears were averaged about 26 days after silking by way of harvesting the waxy corn ears, removing the leaves, and investigating 10 pieces of ear weight, ear length, seed set ear length, and ear diameter.

Soil and statistical analyses

Soil samples were taken by a hand spiral auger at growing season. Collected soil samples were air-dried at room temperature for chemical quantification. Soil pH and EC were determined from the 1:5 of soil/water suspension using a pH/conductivity meter (Horiba, F-54). Available phosphorus was analyzed by Lancaster method employing continuous flow spectrometer (Bran + Luebbe Analytics, Autoanalyzer 3). The 1N-NH_4OAC (adjusted pH 7.0) was utilized to extract exchangeable cations (K, Ca, Na and Mg) and quantified by inductively coupled plasma spectroscopy (PerkinElmer, Optima 3300DV). Experimental data were statistically analyzed through the analysis of variance (ANOVA) with the Raleigh program (SAS Inc. ver. 9.2, USA).

RESULTS AND DISCUSSION

Soil nutrient content

Prior to the test, the pH of the soil was slightly acidic at 6.5, and the organic content was 23g/kg, showing the distribution of the average organic content in the central region (Table 1). After the test, the soil showed an increase in pH value and soil salinity compared to the period prior to the test.

Growth of first cropping

There were no differences in the tasseling dates and silking dates according to the fertilizer levels but the days from planting to emergence was shortened as the sowing period was delayed (Table 2). Thus, the sowing on April 15th shortened the days to

Table 1. Physical and chemical properties of soil after first cropping at 115 days after fertilization.

Sowing date	Fertilization† method	pH (1:5)	OM (g/kg)	P_2O_5 (mg/kg)	K	Ca	Mg	CEC	Na	EC (dS/m)
					----(cmol[+]/kg)----					
Pre-test		6.5	23	229	0.32	8.4	2.0	11.9	0.1	0.26
March 25th	Control	6.6	21	217	0.29	7.2	1.6	12.1	0.1	0.54
	STBR	6.8	22	215	0.38	6.5	2.0	11.9	0.1	0.93
	150% STBR	6.9	22	228	0.38	6.6	2.0	12.5	0.1	1.36
	200% STBR	7.1	24	246	0.41	7.0	2.2	12.4	0.1	1.53
	Mean	6.9	22	227	0.37	6.8	2.0	12.2	0.1	1.09
April 5th	Control	6.5	20	225	0.43	6.4	1.9	11.1	0.1	0.78
	STBR	6.9	22	231	0.47	6.3	1.8	12.2	0.1	1.21
	150% STBR	6.8	22	243	0.50	6.6	2.0	12.2	0.1	1.23
	200% STBR	7.0	24	253	0.55	6.7	2.0	12.5	0.1	1.26
	Mean	6.8	22	238	0.49	6.5	1.9	12.0	0.1	1.12
April 15th	Control	6.6	17	209	0.43	6.4	1.8	11.9	0.1	1.13
	STBR	6.6	17	220	0.48	6.5	1.8	11.6	0.1	1.16
	150% STBR	6.6	18	224	0.48	6.6	1.7	11.3	0.1	1.27
	200% STBR	6.6	18	241	0.51	6.8	1.7	13.4	0.1	1.35
	Mean	6.6	18	224	0.48	6.6	1.8	12.1	0.1	1.23

†Control : 2 split application of urea ($N:P_2O_5:K_2O=30:3:6$)
STBR : 1 application of soil testing-based recommendation rates ($N:P_2O_5:K_2O=16:3:3$)
150% STBR : 1 application of 50% add to soil testing-based recommendation rates ($N:P_2O_5:K_2O=24:4.5:4.5$)
200% STBR : 1 application of 100% add to soil testing-based recommendation rates ($N:P_2O_5:K_2O=32:6:6$)

Table 2. Tasseling and silking date of "Mibaek 2" according to sowing date and fertilizer rates in the first cropping.

Sowing date	Fertilization† method	Rate (kg $10a^{-1}$)			Tasseling Date	Silking Date	Days to silking
		N	P_2O_5	K_2O			
March 25th	Control	30.0	3.0	6.0	6.08	6.11	77
	STBR	16.0	3.0	3.0	6.08	6.11	77
	150% STBR	24.0	4.5	4.5	6.08	6.11	77
	200% STBR	32.0	6.0	6.0	6.08	6.11	77
	Mean				6.08	6.11	77
April 5th	Control	30.0	3.0	6.0	6.13	6.16	72
	STBR	16.0	3.0	3.0	6.13	6.16	72
	150% STBR	24.0	4.5	4.5	6.13	6.16	72
	200% STBR	32.0	6.0	6.0	6.13	6.16	72
	Mean				6.13	6.16	72
April 15th	Control	30.0	3.0	6.0	6.16	6.19	65
	STBR	16.0	3.0	3.0	6.16	6.19	65
	150% STBR	24.0	4.5	4.5	6.16	6.19	65
	200% STBR	32.0	6.0	6.0	6.16	6.19	65
	Mean				6.16	6.19	65

†Refer to Table 1.

Table 3. Culm and ear length of "Mibaek 2" according to sowing date and fertilizer rates in the first cropping.

Sowing date	Fertilization† method	Rate (kg 10a^{-1})			Culm length (cm)	Kernel set length (cm)	Ear length (cm)	Seed set ear length (cm)
		N	P_2O_5	K_2O				
March 25th	Control	30.0	3.0	6.0	200	95	21.1	18.2
	STBR	16.0	3.0	3.0	209	100	20.6	16.5
	150% STBR	24.0	4.5	4.5	216	101	20.5	16.8
	200% STBR	32.0	6.0	6.0	217	106	20.5	16.8
	Mean				211	101	20.7	17.1
April 5th	Control	30.0	3.0	6.0	227	120	20.5	18.0
	STBR	16.0	3.0	3.0	233	122	20.4	17.8
	150% STBR	24.0	4.5	4.5	234	125	20.6	17.4
	200% STBR	32.0	6.0	6.0	237	125	20.8	18.1
	Mean				233	123	20.6	17.8
April 15th	Control	30.0	3.0	6.0	232	118	20.3	17.1
	STBR	16.0	3.0	3.0	233	118	20.9	18.1
	150% STBR	24.0	4.5	4.5	236	119	20.3	17.8
	200% STBR	32.0	6.0	6.0	240	120	20.8	18.2
	Mean				235	119	20.6	17.8
					F value			
Two-way ANOVA	Planting date (A)				1.02	23.67**	0.32	7.52*
	Fertilizer (B)				0.73	1	0.94	0.60
	A x B				0.99	0.35	2.33	1.78

†Refer to Table 1.
ns, *, **, *** ; Nonsignificant of significant at p=0.05, 0.01 or 0.001 by ANOVA.

silking by 7 days compared to the sowing on April 5th and by 12 days compared to sowing on March 25th.

It was thought that this was due to the delay in sowing period, which led to the arrival of the silking date of waxy corn in the range of 1,400-1,420°C, and that these results were consistent with the findings of Kim *et al*. (2014) who reported that silking dates from the seeding dates of the "Ilmichal" varieties were about 70 to 78 days.

Culm height and ear length had no statistical significance, but the kernel set length was the highest at 123 cm in the sowing date on April 5th (Table 3). In addition, the seed set ear length was 17.8 cm long in the sowing date on April 5th and April 15th, indicating that the later the sowing period is, the more marketable it becomes.

Nielsen (2007) showed that the grain line number of corn had a strong genetic effect, while the ear length and the seed set ear length had a great influence on the cultivation environment.

This test also showed that the kernel set length and seed set ear length varied depending on the sowing time.

Culm height, kernel set length, ear length, and seed set ear length tended to elongate in 100% addition to soil testing-based recommended fertilization, but there was no statistical significance. Park *et al.* (2015) reported that as nitrogen content increased, chlorophyll content increased until the late stages of corn production, resulting in high light utilization, whereas, Lim *et al.* (2014) showed that there was no significant difference in culm height, kernel set length, and ear length in the treatment zones of 18 kg and 36 kg of nitrogen per 10a.

However, despite the increased volume of the fertilizer, the fact that it did not show much difference in growth was attributed to the ingredients of the slow-release fertilizer being slowly eluted and having no significant impact on the first cropping production.

The weight of marketable ear was the heaviest in the sowing date on April 5th, although ear weight and number of marketable ears per 10a showed no statistical significance (Table 4).

The number of marketable ears will be the most important factor in income, as early harvests can get high prices while corn

Table 4. Ear and marketable ear characteristics of "Mibaek 2" according to sowing date and fertilizer rates in the first cropping.

Sowing date	Fertilization† method	Rate (kg 10a^{-1})			Ear diameter (mm)	Ear weight (g)	Wt. of marketable ears (kg/10a)	No. of marketable ears (ea/10a)
		N	P_2O_5	K_2O				
March 25th	Control	30.0	3.0	6.0	42.2	273	1,704	6,250
	STBR	16.0	3.0	3.0	40.3	269	1,848	6,250
	150% STBR	24.0	4.5	4.5	40.2	277	1,790	6,458
	200% STBR	32.0	6.0	6.0	40.3	297	1,854	6,875
	Mean				40.8	279	1,799	6,458
April 5th	Control	30.0	3.0	6.0	41.4	289	1,990	6,875
	STBR	16.0	3.0	3.0	42.0	285	1,898	6,458
	150% STBR	24.0	4.5	4.5	44.0	297	1,921	6,667
	200% STBR	32.0	6.0	6.0	43.9	297	1,979	6,667
	Mean				42.8	292	1,947	6,667
April 15th	Control	30.0	3.0	6.0	43.8	276	1,725	6,250
	STBR	16.0	3.0	3.0	45.1	294	1,550	5,625
	150% STBR	24.0	4.5	4.5	43.6	266	1,615	5,833
	200% STBR	32.0	6.0	6.0	44.2	287	1,838	6,250
	Mean				44.2	281	1,682	5,990
					F value			
Two-way ANOVA	Planting date (A)				14.18*	0.39	20.75**	5.56
	Fertilizer (B)				0.16	1.24	3.48**	1.65
	A x B				3.0*	0.93	2.00	1.55

†Refer to Table 1.
ns, *, **, *** ; Nonsignificant of significant at p=0.05, 0.01 or 0.001 by ANOVA.

sales are most common in 30 single-sack units.

Therefore, it was thought that the sowing time for the first cropping propagated through double cropping system in the central region of the country could be advanced by March 25th.

Early April is reported to be the economic sowing limit of the super sweet corn hybrid in southern Korea (Yang *et al*., 2007) while it is mid-May in central and northern Korea (Sim, *et al*., 2019).

Therefore, given that sowing early at an appropriate time increases the number of marketable ears compared to late sowing, the sowing time could be advanced with global warming if conditions are not to advance sowing to an extreme degree.

Moreover, due to the increase in the fertilizer levels, there was no statistical significance in the ear weight and the number of marketable ears, but the weight of marketable ear was the highest when there is in the 100% addition to soil testing-based, recommended fertilization.

Growth of second cropping

There was no difference in days in terms of tasseling and silking according to the fertilizer levels but the days from planting to emergence was shortened as the sowing period was delayed (Table 5).

In this test, the longer the sowing date was delayed, the faster the silking date was. This is consistent with the report of Jung *et al*. (2012) which stated that the sooner the seeding period was, the faster it was by 33 days for the "Ilmichal" variety.

The possible reason for this decrease in silking days may be the presence of differences in photoperiod and temperature among sowing dates.

As the sowing date was delayed, the culm height, kernel set length, ear length, and seed set ear length were shortened, with the decline being the largest in the sowing date on July 25th, the latest sowing date (Table 6).

These results are due to the shorter day effect of late sowing during the growth period of the waxy corn and supported by

Table 5. Tasseling and silking date of "Mibaek 2" according to sowing date and fertilizer rates in the second cropping.

Sowing date	Fertilization† method	Rate(kg 10a^{-1})			Tasseling Date	Silking Date	Days to silking
		N	P_2O_5	K_2O			
July 5th	Control	30.0	3.0	6.0	8.17	8.21	52
	STBR	16.0	3.0	3.0	8.17	8.21	52
	150% STBR	24.0	4.5	4.5	8.17	8.21	52
	200% STBR	32.0	6.0	6.0	8.17	8.21	52
	Mean				8.17	8.21	52
July 15th	Control	30.0	3.0	6.0	8.25	8.28	44
	STBR	16.0	3.0	3.0	8.25	8.28	44
	150% STBR	24.0	4.5	4.5	8.25	8.28	44
	200% STBR	32.0	6.0	6.0	8.25	8.28	44
	Mean				8.25	8.28	44
July 25th	Control	30.0	3.0	6.0	9. 4	9. 5	42
	STBR	16.0	3.0	3.0	9. 4	9. 5	42
	150% STBR	24.0	4.5	4.5	9. 4	9. 5	42
	200% STBR	32.0	6.0	6.0	9. 4	9. 5	42
	Mean				9. 4	9. 5	42

†Refer to Table 1.

Table 6. Culm and ear length of "Mibaek 2" according to sowing date and fertilizer rates in the second cropping.

Sowing date	Fertilization† method	Rate (kg 10a^{-1})			Culm length (cm)	Kernel set length (cm)	Ear length (cm)	Seed set ear length (cm)
		N	P_2O_5	K_2O				
July 5th	Control	30.0	3.0	6.0	172	70	18.4	14.9
	STBR	16.0	3.0	3.0	174	72	18.4	15.0
	150% STBR	24.0	4.5	4.5	177	73	18.7	15.1
	200% STBR	32.0	6.0	6.0	180	72	18.7	15.4
	Mean				176	72	18.6	15.1
July 15th	Control	30.0	3.0	6.0	171	71	16.9	14.3
	STBR	16.0	3.0	3.0	169	69	17.0	14.3
	150% STBR	24.0	4.5	4.5	174	72	17.0	14.5
	200% STBR	32.0	6.0	6.0	176	72	17.2	14.5
	Mean				173	71	17.0	14.4
July 25th	Control	30.0	3.0	6.0	159	68	16.2	11.8
	STBR	16.0	3.0	3.0	158	67	16.4	11.8
	150% STBR	24.0	4.5	4.5	164	70	16.4	12.0
	200% STBR	32.0	6.0	6.0	166	71	16.5	12.3
	Mean				162	69	16.4	12.0
					F value			
Two-way ANOVA	Planting date (A)				152.9**	21.93**	189.2**	24.58**
	Fertilizer (B)				56.12	18.58	0.07	0.15
	A x B				2.02	4.71**	0.32	0.15

†Refer to Table 1.
ns, *, **, *** ; Nonsignificant of significant at p=0.05, 0.01 or 0.001 by ANOVA.

Table 7. Ear and marketable ear characteristics of "Mibaek 2" according to sowing date and fertilizer rates in the second cropping.

Sowing date	Fertilization† method	Rate (kg 10a^{-1})			Ear diameter (mm)	Ear weight (g)	Wt. of marketable ears (kg/10a)	No. of marketable ears (ea/10a)
		N	P_2O_5	K_2O				
July 5th	Control	30.0	3.0	6.0	43.8	215	1,069	4,653
	STBR	16.0	3.0	3.0	42.6	217	949	4,514
	150% STBR	24.0	4.5	4.5	43.5	211	1,010	4,861
	200% STBR	32.0	6.0	6.0	43.6	214	1,207	5,625
	Mean				43.4	214	1,059	4,913
July 15th	Control	30.0	3.0	6.0	38.3	216	590	3,381
	STBR	16.0	3.0	3.0	39.9	201	680	3,542
	150% STBR	24.0	4.5	4.5	39.1	217	665	3,750
	200% STBR	32.0	6.0	6.0	38.9	219	697	4,075
	Mean				39.1	213	658	3,687
July 25th	Control	30.0	3.0	6.0	38.8	186	483	2,431
	STBR	16.0	3.0	3.0	37.9	197	483	2,292
	150% STBR	24.0	4.5	4.5	38.9	192	522	2,635
	200% STBR	32.0	6.0	6.0	37.8	204	536	2,639
	Mean				38.4	195	506	2,499
Two-way ANOVA					F value			
	Planting date(A)				48.0**	6.80	104.6**	134.2**
	Fertilizer(B)				0.26	0.60	3.54**	4.57**
	A x B				1.16	0.89	1.84	0.68

†Refer to Table 1.
ns, *, **, *** : Nonsignificant of significant at p=0.05, 0.01 or 0.001 by ANOVA.

Jung *et al.* (2012) who reported that growth temperature was decreased during the ripening stage of second cropping.

In particular, the large decrease in the ear length and seed set ear length in the sowing date on July 25th was thought to have a significant impact on the decline in the marketability of waxy corn.

The culm length and the kernel set length tended to increase as the fertilizer levels increased, but there was no statistical significance, so it was thought that a one-time, slow-releasing fertilizer application could result in a reduction in labor force without any difference in growth compared with the conventional distribution. The characteristics of culm length and ears differed greatly in the first cropping and the second cropping, showing 69-83% of the previous cropping in culm length, 80-90% in ear length, and 67-88% in seed set ear length.

In the second cropping, growth occurred under higher temperatures, with associated reductions in the duration of growing cycles (Jung *et al*., 2012; Kim *et al*., 2014).

Also, as the sowing date was delayed, the diameter of the ears was reduced, and the weight of marketable ears and the number of marketable ears decreased. At the sowing date of July 25th, especially, the decline was significant (Table 7).

Statistical analysis of the data revealed that marketable ear yield of waxy corn was significantly affected by sowing date and fertilizer. Waxy corn plated on July 5th produced more yild (1,059 kg/10a), while the July 25th sowing produced the lowest marketable ear yield (506 kg/10a).

In particular, since the income of waxy corn is determined by the number of marketable ears (Lee & Kim, 1986), it was thought that the sowing of the second cropping in the cultivation of double cropping without tillage in the central region of the country should be completed by July 15th to secure the yield . The diameter of the ear and the average ear weight were not statistically significant, depending on the difference in the levels of the fertilizers.

However, the weight of marketable ears and the number of

marketable ears were high in the 100% addition to soil testing-based recommended fertilization. It was also thought that it would be appropriate to add 100% to the soil testing-based recommendation for slow-releasing fertilizer. Lim *et al.* (2014) reported that as the ratio of nitrogen increases, photosynthesis also increases, showing a defined correlation with the content of follicle nitrogen.

In this test, the weight of marketable ears and the number of marketable ears differed significantly between each treatment due to an increase of up to 32kg of nitrogen per 10a.

Therefore, it was thought that 100% addition would not only reduce the labor force, but also increase the number of marketable ears, which would be advantageous for farming households.

However, since the effects of the fertilization are thought to vary depending on weather and soil conditions, it was thought that additional fertilizer spraying in the double cropping of waxy corn should be determined by the examination of the growth of the waxy corn.

ACKNOWLEDGEMENTS

This study was carried out with the support of the “Regional Trial for New Corn Cultivar of Consumer Preference and Cultivation Promotion (Project No. PJ 01485505)” of the Rural Development Administration, Republic of Korea.

REFERENCES

Chi, J. H., B. R. Choi, G. L. Jo, S. J. Kim, K. Y. Park, and O. Y. Kwon. 2013. Effect of the slow-releasing fertilizer applied directly to rice seeling tray before transplanting and practical test at field. Korean J. Crop Sci. 58(1) : 8-14.

Choi, W. Y., M. G. Choi, S. S. Kim, J. K. Lee, and M. H. Lee. 2002. Effect of latex coated urea on growth and yield in rige direct dry seeding for water-saving rice culture. Korean J. Crop Sci. 47(3) : 221-225.

Jung, G. H., J. E. Lee, J. H. Seo, S. L. Kim, D. W. Kim, J. T. Kim, T. Y. Hwang, and Y. U. Kwon. 2012. Effects of seeding dates on harvesting time of double cropped waxy corn. Korean J. Crop Sci. 57(2) : 195-201.

Kim, E. S., S. K. Kim, D. H. Kim, B. Y. Son, D. J. Kang, Z. R. Choe, and G. W. Song. 2000. Effects of planting densities on growth and yield of fresh waxy corn as second crop. Korean J. Crop Sci. 45(3) : 190-194.

Kim, M. J., J. E. Lee, J. T. Kim, G. H. Jung, Y. Y. Lee, S. L. Kim, and Y. U. Kwon. 2014. Changes in ear and kernel characteristics of waxy corn during grain filling stage by double cropping. Korean J. Crop Sci. 59(1) : 73-82.

Lee, S. S. and T. J. Kim. 1986. Temperature and sweet corn production at different planting dates under polyethylene tunnel and mulch. Korean J. Crop Sci. 31(1) : 84-90.

Lim, J. T., J. H. Chang, Y. J. Rho, J. H. Ryu, D. Y. Chung, and J. W. Cho. 2014. The effect of nitrogen rates on the growth and yield of maize in agricultural fields with the stream. Korean J. Crop Sci. 59(1) : 101-108.

MIFAFF. 2019. Food agriculture, forestry and fisheries statistical yearbook. Ministry for Food, Agriculture, Forestry and Fisheries.

Nielsen, R. L. 2007. Ear size determination in corn. Purdue Univ. [On-Line]. Available at http://www.kingcorn.org/news/timeless/EarSize.html (2020.04.13.).

Park, S. H., S. Y. Yoo, M. J. Lee, J. Y. Park, K. T. Song, T. W. Kim, and B. M. Lee. 2015. Photochemical response analysis on different seeding date and nitrogen (N) level for maize (*Zea mays* L.). Korean J. Crop Sci. 60(1) : 1-7.

Park, S. U., K. Y. Park, Y. K. Kang, H. G. Hong, and S. K. Jong. 1987. Effect on the plant density on growth and yield of sweet corn hybrid. Korean Journal of Crop Science. 32(1) : 92-96.

Shim, K. B., J. K. Lee, B. I. Koo, M. N. Shin, and S. K. Yoon. 2019. Determination of adaptable sowing dates of waxy corn using growing degree days in the central northern area of Korea. Korean J. Crop Sci. 64(3) : 269-277.

Yang, S. K., S. B. Hong, and S. S. Lee. 2007. Planting time for the economic yield of a super sweet corn hybrid in the southern part of Korea. Korean J. Crop. 52(3) : 325-333.

Yoo C. H., B. W. Shin, J. H. Jeong, S. W. Kang, S. S. Han, and S. J. Kim. 1998. Effects of application of latex coated urea on yield and N-use efficiency of the direct seeding rice on dry paddy field in the year of high temperature. J. Kor. Soc. Soil Sci. Fert. 31(4) : 324-329.

Yoon, J. T., S. E. Park, S. Y.Lee, S. H. Song, H. G. Moon, and K. H. Kim. 1999. Grain filling characteristics of waxy corn hybrids at different planting dates. Kor. J. Breed. Sci. 31(1) : 7-13.