Effects of Delayed Pollination on Kernel Development in Corn

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ABSTRACT

Receptivity of corn silk to pollen decreases with time. For effective pollination, it is important to study the receptivity of corn silks in relation to time elapsed after their emergence. Two commercial corn hybrids, 'Kwanganog' and 'Suwon 19', were tested for their silk growth and effects of delayed pollination on kernel development for 1 to 13 days after emergence of the first silk. Silks elongated rapidly for the first 3 days and then gradually decreased. Silks grew more than 30mm per day for the first 3 days and stopped growing on the 11 or 12th day after emergence of the first silk. Filled ear length decreased slowly for the first 8 days, and then decreased rapidly. Similar trends were observed for number of kernel rows and number of kernels per row or ear. The highest numbers of kernels per row or ear were observed when plants were pollinated 2-4 days after silking. These numbers decreased gradually up to 8 days, and then decreased sharply. This result indicates that 8 day-delayed pollination has no influence on kernel development. There were negative correlations between silk length and ear characteristics except kernel weight. Silk growth rate was positively correlated with filled ear length, row number, and kernel number. It might be assumed that delayed pollination by one week after the first silk emerged would not affect on kernel set.

Key words : receptivity of corn silk, silk elongation, delayed pollination.

Corn silks are pollinated within 1 or 2 days after emergence under normal condition. However, pollination is delayed for several days if two parents are different in flowering time. In that case, the parents should be planted at different times, resulting in more complexity of cultivation for hybrid seed production or breeding nursery. Early studies have reported that silk receptivity was related to the capacity to produce seeds by delayed pollination (Jones & Newell, 1948; Westigate & Boyer, 1985). Pollination activity of silk was reported to be maintained up to 4 to 10 days after the first silk emerged, and varied depending on the genotype (Lonnquist & Jugenheimer, 1943; Peterson, 1942). It was reported that the longevity of corn silk was reduced because of silk senescence (Bassetti & Westigate, 1993a). Kernel loss with delayed pollination was also observed (Bassetti & Westigate, 1993b; Jones & Newell, 1948). Silks in the mid-region of the ear failed to set kernels when pollinated 7 or more days after the first silks appeared (Bassetti & Westigate, 1993b). They observed that reduction of seed set of the ear was related to senescence of the emerged silks. The rate of silk elongation decreased rapidly for the first 4 or 5 days after the first silk appeared (Bassetti & Westigate, 1993a). They found that silk elongation was constant with 5-8mm per day between 5 and 8 days after the first silk emergence. Silks were receptive to pollen until they were severely senescent. The silks at the mid-region of the ear lost their activity first and were followed by the silks of the lower region of the ear (Bassetti & Westigate, 1993b). Water stress condition caused more rapid loss of silk receptivity (Bassetti & Westigate, 1993c; Du Plessis & Dijkhuis, 1967; Hall et al, 1982; Herrero & Johnson, 1981). Little is known about the delayed pollination on the response of yield components such as number of kernel rows, number of kernels per row, and kernel weight. The objective of this study was to examine the silk elongation pattern and responses of yield components with delayed pollination.

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MATERIALS AND METHODS

Two corn hybrid cultivars, Kwanganog and Suwon 19, were planted on April 25, 1995 in the Agricultural Experiment Station at Dongguk University. Planting space was 60cm between rows and 25cm between plants. Two seeds were planted per hill and thinned to one plant at the 7-8th leaf stage. The amount of N, P_2O_5, and K_2O were 150, 100, and 100kg/ha, respectively. The split of basal and sidedressing application of fertilizers except P_2O_5 was 7:3. P_2O_5 was applied at basal application before planting. Herbicide (alachlor) was applied at a rate of 30 kg/ha after planting. Hand weeding was applied.

Individual plants were evaluated every morning for silking date. Pollination was made from 1 to 13 days after the first silk emerged. Fresh pollen was collected from different plants or hybrids. Pollination was conducted between 9 and 10 a.m. Silks were cut to be 2cm in length for uniform pollination after measuring silk length on five ears. Filled ear length and ear characteristics such as number of kernel rows, number of kernels per row and ear, and ear weight were measured.

RESULTS AND DISCUSSION

Silk elongation was rapid immediately after the first silk emerged and gradually slow with delayed pollination for both hybrid cultivars (Fig. 1). Kwanganog had longer silks than Suwon 19. From this result, it might be assumed that Kwanganog would be greater than Suwon 19 for silk viability or receptivity to pollen. The decreased silk elongation with time might be due to the increased number of cells of final size because the silk elongation is a

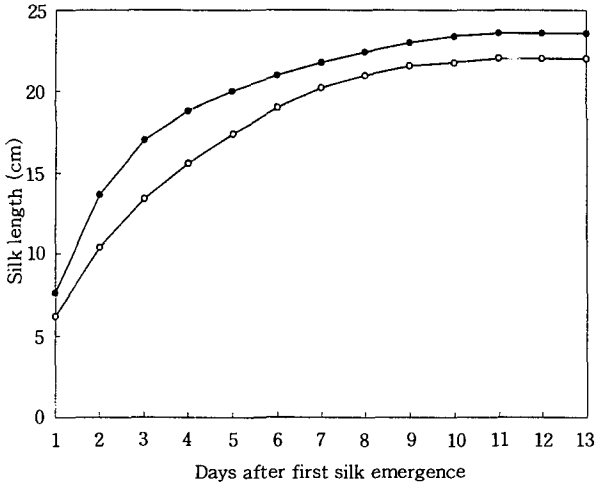

Fig. 1. Elongation of silk after first silk emergence.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Hybrid=0.5, Day=1.3)

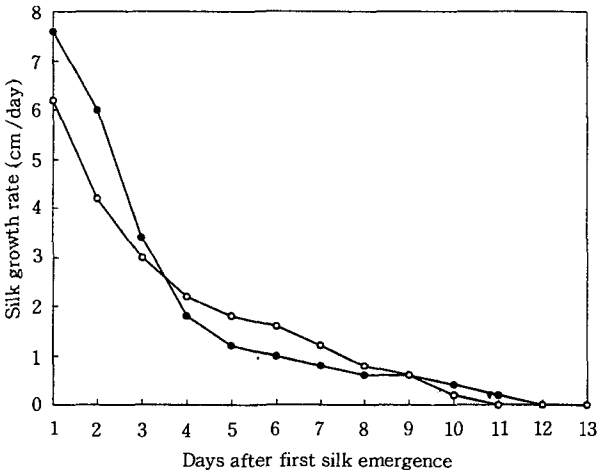

Fig. 2. Silk growth rate per day after first silk emergence.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Day=0.9)

function of cell expansion (Heslop-Harrison et al., 1935; Westigate & Boyer, 1985). The silk growth rate per day decreased rapidly with time for both hybrids (Fig. 2). The silk growth rate on the first day after emergence was more than 60 mm for both hybrids, and then decreased gradually with time. The growth rate for the first 3 days was more than 30mm per day and was higher for Kwanganog than Suwon 19. However, Suwon 19 was higher than Kwanganog for the growth rate between 4 and 8 days after emergence of the first silk. Silk growth completed 11 days after emergence for Suwon 19 and 12 days after emergence for Kwanganog. It would be assumed that corn silks might continue to grow and be receptive to pollen up to 10 days after emergence even though their viability would not be high enough for normal pollination.

Response of filled ear length by delayed pollination is shown in Fig. 3. Filled ear length of the two hybrid cultivars was similar for the first 8 days after emergence of the first silk. Suwon 19 was about 2 cm longer in filled ear length than Kwanganog on the 9th day after emergence of the first silk. It was observed that kernel set was poor at the lower part of the ear in both cultivars when pollinated at 9 to 12 days after the first silk emerged. Filled ear length decreased most rapidly during this period. This trend was also observed for the number of kernel rows for both hybrids (Fig. 4). Kwanganog with longer ear length when pollinated at 8 days after silk emergence had more kernels than Suwon 19. This difference might be due to the different ear characteristics of both hybrids. For the number of kernels per row, the response with delayed pollination was similar to those of filled ear length and number of kernel rows (Fig. 5), reaching a maximum at 3 to 4 days for Kwanganog and

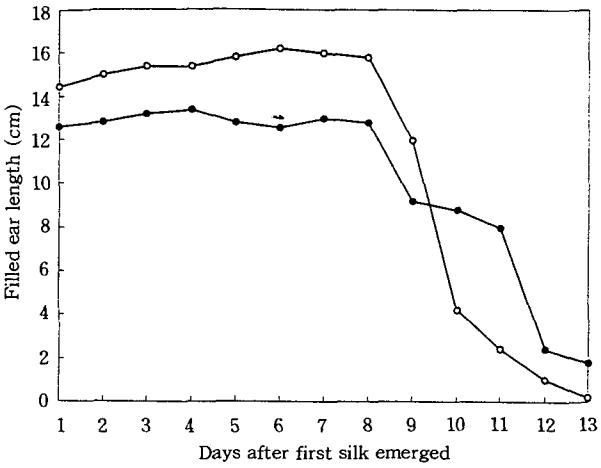

Fig. 3. Filled ear lengths with delayed pollination.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Hybrid=0.6, Day=1.5)

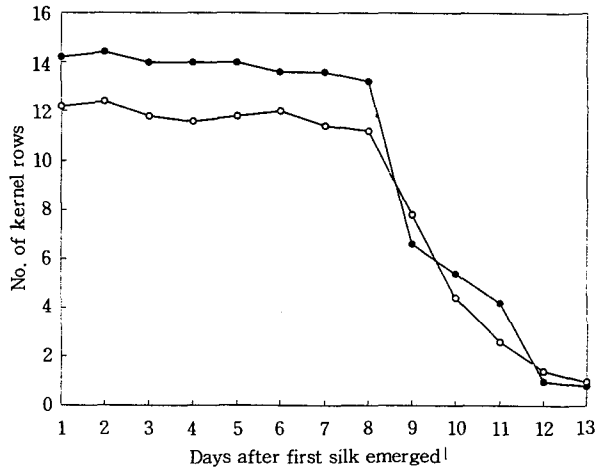

Fig. 4. Number of kernel rows with delayed pollination.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Hybrid=0.6, Day=1.5)

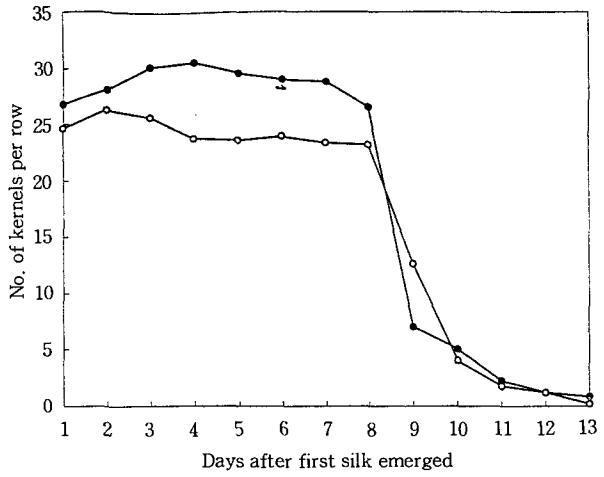

Fig. 5. Kernel number per row with delayed pollination.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Hybrid=0.9, Day=2.2)

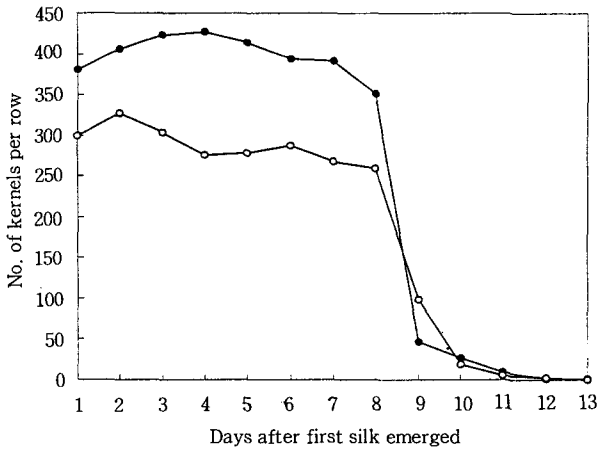

Fig. 6. Kernel number per ear with delayed pollination.
● Kwanganog, ○ Suwon 19. ($LSD_{(0.05)}$: Hybrid=15.9, Day=40.5)

at 2 to 3 days for Suwon 19, then decreased gradually with time up to 8 days after emergence of the first silk. Bassetti & Westigate (1993a) reported that the number of kernel set was highest when pollination was made at 4 to 8 days after the first silk appeared. From this study, it was found that the ideal pollination time for good kernel set would be 2 to 4 days rather than 1 day after emergence of the first silk. In the case of selfing in breeding nursery, it might be expected that the appropriate time for pollination would be earlier than that in this study. This is because pollen would not be available for a long period. For effective pollination or hybrid seed production, the total number of kernels per ear would be more important than other components of ear. The response of the total number of kernels per ear by delayed pollination was similar to those of other yield components. The highest number of kernels per ear was observed when pollinated at 2 to 3 days after the first silk appeared and decreased slowly up to 8 days for both hybrids (Fig. 6). After 8 days, it decreased rapidly, suggesting that silk might be senesced more rapidly in this period. The kernel set in the ear was closely related to the percentage of silks that had not senesced by the day of pollination (Bassetti & Westigate, 1993b). This suggested that silk senescence would be the main cause for poor kernel set. From this study, it can be assumed that one week difference in flowering for both parents would create little problem for hybrid seed production, thus allowing planting on the same date in any cases. This would simplify fertilizer and herbicide application and other management problems caused different planting dates. However it would be necessary to study the response of delayed pollination for inbred lines. Yield components except kernel weight decreased significantly with delayed pollination(data not shown). In the case of Kwanganog, kernel weight tended to be increased by delayed pollination. This could be explained by less competition among kernels for photosynthate due to fewer kernels on an ear.

Analysis of variance showed that hybrid was significant for all traits except silk growth rate (Table 1). Pollination date was highly significant for all traits except 100 kernel weight. Hybrid × date interactions were significant for filled ear length, number of kernels per ear, and kernel weight.

Silk length was negatively correlated with all traits except kernel weight (Table 2). This shows that delayed pollination would affect adversely on kernel development. Silk growth rate was positively correlated with ear length, row number, and kernel number, indicating that actively growing silks would be more receptive to pollen and

Table 1. Analysis of variance for silk characteristics and yield components.

SV	df	Silk length	Silk growth rate	Filled ear length	No. of kernel rows	No. of kernels per row	No. of kernels per ear	100 kernels weight
Hybrid (H)	1	61.8**	0.6	7.3**	21.0**	29.3**	61.3**	86.1**
Date (D)	12	109.1**	40.7**	96.7**	81.0**	233.1**	123.3**	1.2
H×D	12	0.7	1.2	9.2**	1.4	5.1**	5.9**	2.8**
CV (%)		7.9	30.3	15.6	18.8	13.9	21.3	5.9

*, ** : Significant at 5% and 1% probability levels, respectively.

Table 2. Correlation coefficients among silk characteristics and yield components.

Characteristics	SGR†	FEL‡	Row	Kernel	Total	Kernel weight
Silk length	−0.78**	−0.48**	−0.52**	−0.55**	−0.53**	0.08
Silk growth rate (SGR)		0.44*	0.53**	0.51**	0.52**	0.05
Filled ear length (FEL)			0.85**	0.85**	0.77**	−0.00
No. of kernel rows (ROW)				0.93**	0.94**	−0.00
No. of kernels per row (KERNEL)					0.97**	−0.03
No. of kernels per ear (TOTAL)						−0.02

*, ** : Significant at 5% and 1% probability levels, respectively.
† SGR; Silk growth rate.
‡ FEL; Filled ear length.

more viable for fertilization. Highly significantly positive correlations were observed among filled ear length, row and kernel numbers. This showed that those traits were similar for the response to delayed pollination and the viability of silk.

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