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Effect of Apical Ear Removal on Characters of Subapical Ear in Corn Inbreds

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옥수수 自殖系統의 上部이삭 除去가 下部이삭의 形質에 미치는 影響

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ABSTRACT : Removal of apical ear after silking is a method to increase seed production in corn inbreds. Due to the phenomenon of apical dominance, the subapical ear would develope and produce seeds following the removal of the apical ear. This experiment was conducted to investigate the varietal difference in subapical ear development and seed production. Days to silking of subapical ears were delayed by about 4 days compared to normal apical ears. Cob length and filled ear length of subapical ears across seven inbreds tested were reduced by 21% and 36%, respectively. Those of inbred INV302 decreased less and subapical ear of inbred NC246 were barren, which incicated the varietal defferences. Number of kernel rows, kernels per row, and total kernels per ear also decreased. The mean reduction rates for those characters were 28%, 37%, and 47%, respectively. Weights of ears and kernels were reduced and showed different response among inbred lines. Coefficients of variations for cob and filled ear lengths, number of kernel rows and kernels were greater in subapical ears than in apical ears. Seed production of subapical ears was 40 ~ 80% of apical ears, depending on inbred lines when the apical ear is removed immediately after silking.

Key words : Removal of apical ear, Subapical ear development, Apical dominance

The amount and size of breeding materials have significant influence on the progress of breeding work. During corn breeding process, it is not easy for breeders to conduct intensive selection and discard unselected lines because they are not sure whether the discarded lines are really inferior to selected lines. Therefore, corn breeders tend to keep a large number of lines which are diverse genetically, beyond their ability to handle. In this case, corn breeders try to reduce the number of plants per line during selection process to reduce the total population size. During the crossing, silk emerges frequently before covering shoot bags and the silked plants are discarded. The phenomenon of apical dominance is common in plants. The subapical ear is expected to develope in the absence of apical ear. Practically, the apical ear of already silked plant is removed and the

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subapical ear is covered by shoot bag for crossing. However, the development of secondary subapical ear varies with inbred lines. Some lines show good development and some lines are not. Sorrell et al.[7] reported that favorable environmental condition increased the formation of subapical ears. The presence of high nitrogen accelerated high translocate rate. However, under the low nitrogen rate conditions the rate deceased in corn hybrids.[1,2,3] They also found that higher nitrogen rate stimulates the formation of both apical and subapical ears. The available photosynthetic energy is used for development of apical ear, but in the absence of apical ear the subapical ear will be developed. Durieux et al.[4] reported that apical and subapical ear weights increased simultaneously with increasing nitrogen rates.

Literatures on the responses of subapical ear development when the apical ear is removed were not found. It might be expected that there would be differences among corn inbred lines for the response of subapical ear development. The objective of this experiment was to investigate the responses of silking and major yield components to the removal of apical ear after silking.

Meterials and Methods

This trial was conducted at the Agricultural Research Station of Dongguk University. Seven corn inbreds used were Ga209, Hi39, INV302, N28, NC246, SC12, and T258. All of the inbreds tested were late in maturity. Planting date was April 22, 1994 and 60cm between rows and 25cm within rows were used. Two seeds were planted per hill and thinned to one plant at 6~7 leaves stage. Rates of fertilizers applied were N-P_2O_5-K_2O=18-15-15 kg /10a.

Apical ear was removed at the first day of silking. The removal was conducted in the morning once a day. Ear leaf was removed simultaneously with the apical ear because it was difficult to remove the ear only without hurting the ear leaf. After removal of apical ears, paper tags were put on the plants to record both apical and subapical silking date. Data for cob length, filled ear length, and yield components were collected using 10~15 ears per treatment.

Results and Discussion

Silking of subapical ears when apical ears were removed delayed from 2.8 to 4.6 days (Table 1). Inbred INV302 showed the longest delay and followed by inbred Hi39 and SC12. The shortest silking delay of subapical ears was observed in inbred T258. This delay for silking date might be one of the causes of poor seed set in subapical ears mainly due to the lack of pollen available for the fertilization. In case of no removal of apical ears, formations of subapical ears were found in some inbreds, but no silk emerged in all inbreds. Inbred NC246 showed no silking of subapical ear even though apical ear was removed, indicating varietal difference in the development of subapical ear after removal of top ears.

Cob length of subapical ears decreased in all inbreds tested, however, the reduction rates were significantly different among inbred lines. Cob length of inbred INV302 was reduced only 4% compared to that of the top ear, while NC246 was reduced more than 50%. Filled ear length decreased in subapical

Table 1. Days to silking and ear lengths of apical and subapical ears

Inbred	Days to silking			Cob length			Filled ear length		
	N	R	R-N	N	R	R/N	N	R	R/N
	..... days			..... cm		%	..... cm		%
Ga209	89.6	92.9	3.3	11.3	8.4	74.3	10.5	6.9	65.7
Hi39	88.9	93.3	4.4	14.1	9.6	68.1	11.7	6.7	57.3
INV302	91.3	95.9	4.6	10.4	10.0	96.2	6.8	6.4	94.1
N28	88.7	92.7	4.0	17.7	15.7	88.7	15.3	13.6	88.9
NC246	93.4	*	*	12.8	5.8	45.3	10.3	0.0	0.0
SC12	87.2	91.4	4.2	14.8	13.2	89.2	10.4	7.2	69.2
T258	90.7	93.5	2.8	14.0	12.6	90.0	7.3	5.4	74.0
Mean	89.4	93.4	3.9	13.6	10.8	78.8	10.3	6.6	64.2
$LSD_{0.05}$	2.6	2.2		3.1	4.3		3.7	5.2	

N : Apical ear of normal plant.
R : Subapical ear of apical ear removal plant.
R/N : Removal/Normal x 100.
* : No data observed.

ears more than cob length in all inbreds, but the reduction trend was similar to that of cob length. Inbred NC246 had no matured subapical ear, therefore other yield components data were absent. The phenomenon of more remarkable reduction for filled ear length of subapical ears than cob length when apical ears were removed would be explained by the shortage of photosynthetic energy to be translocated during the grain filling period under normal fertility condition. According to Anderson et al. [1,2,3], translocation rate during grain filling period of prolific hybrid under low N condition initially increased, but then decreased, while translocation rate under high N conditions increased.

Responses for number of kernel rows and kernels are presented in Table 2. Number of kernel rows decreased about 28% across seven inbred lines, ranging 4 to 100%. Num-

Table 2. Numbers of kernel rows, kernels per row, and total kernels per ear of apical and subapical ears

Inbred	No. of Kernel rows			No. of Kernels/row			No. of total kernels/ear		
	N	R	R/N	N	R	R/N	N	R	R/N
	..... no.		%	..... no.		%	..... no.		%
Ga209	10.5	9.1	86.7	12.8	8.3	64.8	134.4	75.5	56.2
Hi39	9.6	7.7	80.2	11.4	8.2	71.9	106.6	63.1	59.2
INV302	5.5	5.1	92.7	5.4	4.8	88.9	29.7	24.5	82.5
N28	12.9	12.4	96.1	30.2	23.4	77.5	389.6	290.2	74.5
NC246	9.0	0.0	0.0	7.5	0.0	0.0	67.5	0.0	0.0
SC12	10.4	8.4	80.8	11.4	6.0	52.6	118.6	50.4	42.5
T258	5.8	3.9	67.2	4.3	3.6	83.7	24.9	14.0	56.2
Mean	9.1	6.7	72.0	11.9	7.8	62.8	124.5	74.0	53.0
$LSD_{0.05}$	2.5	5.3		8.1	9.8		115.0	129.6	

ber of kernels per row also decreased in all inbred, however, the degree of decrease was higher than that of number of kernel rows in all inbred with a exception. Numbers of total kernels per ear were also significantly reduced in subapical ears. INV302 and N28 decreased less than other inbreds. This character would be more important to be considered during F_1 seed production. Seed production of the subapical ears was 40 to 80% of top ear when the top ear is removed. Therefore, corn breeders should investigate the ability of subapical ear development for their breeding materials or inbred lines. This would increase the efficiency of seed production of inbreds.

Ear and kernel weights also decreased by removal of apical ear in all inbreds, but the response varied with the inbred(Table 3). Total kernel weight decreased more than ear weight. Inbred INV302, which showed less reduction for ear length, kernel rows, and kernel numbers, decreased less for ear and kernel weights. Among weight characters, 100 kernels weight decreased less than other characters. This would indicate that reduced number of kernel per ear in the subapical ear might provide less competitive condition among kernels. Kiniry et al. [6] observed that seed weight increased by reducing number of seeds, while no changes of seed weight were reported by reducing number of seeds[5,8]

CV(coefficient of variation) within plants for ear length and yield components are presented in Table 4. CV of removal treatment for cob was much higher than that of normal treatment. Mean CV of subapical ears was more than two times than that of normal apical ears. This trend was also found in filled ear length. The variations become larger under removal condition, suggesting that the variations increase under stressed conditions. These increased variations under removal treatment were also observed for number of kernel rows and kernels per row. Inbred N28 which was vigorous and tall inbred showed the lowest CV for kernel rows and kernel numbers under both normal and removal treatment. Some inbreds indicated more than 70~80% of CV for yield components, showing that genetically fixed individuals plants varied with the change of environment conditions.

From this trial, it might be concluded that

Table 3. Weight of ear, total kernels per ear, and 100 kernels

Inbred	Wt. of ear			Wt. of total kernels /ear			Wt. of 100 kernels		
	N	R	R/N	N	R	R/N	N	R	R/N
	..... g		%	..... g		%	..... g		%
Ga209	43.3	21.2	49.0	33.2	14.2	42.8	24.9	18.2	73.1
Hi39	36.4	20.1	55.5	23.0	11.5	50.0	21.3	16.7	78.4
INV302	15.1	15.0	99.3	4.9	4.0	81.6	16.8	16.0	95.2
N28	116.3	81.4	70.0	97.1	67.3	69.3	25.4	24.3	95.7
NC246	28.8	2.2	7.6	11.5	0.0	0.0	17.0	0.0	0.0
SC12	30.6	23.1	75.5	21.9	10.3	47.0	18.9	18.2	96.3
T258	17.3	13.7	79.2	5.5	3.1	56.4	24.3	20.1	82.7
Mean	41.1	25.2	62.3	28.2	15.8	49.6	21.3	16.2	74.5
$LSD_{0.05}$	45.3	33.6		41.9	36.1		4.9	10.1	

Table 4. Coefficients of variation of apical and subapical ears for length and yield components

Inbred	Cob length			Filled ear length			No. of kernel rows			No.of kernels /row		
	N	R	R/N	N	R	R/N	N	R	R/N	N	R	R/N
	%											
Ga209	11.4	30.8	270.2	12.9	36.4	282.2	10.7	24.5	229.0	25.1	47.2	188.1
Hi39	15.5	37.0	238.7	26.7	59.2	221.7	27.0	63.1	233.7	53.2	82.1	154.3
INV302	10.1	21.1	208.9	31.2	70.7	226.6	38.9	53.5	137.5	56.8	72.8	128.2
N28	12.6	21.4	169.8	14.6	24.9	170.6	8.2	10.2	124.4	12.8	25.9	202.3
NC246	18.9	31.9	168.8	39.9	*	*	28.7	*	*	38.5	*	*
SC12	9.4	18.9	201.1	13.7	37.7	275.2	9.8	41.4	422.5	27.4	53.6	195.6
T258	19.2	38.3	199.5	38.4	86.8	226.0	46.8	78.9	168.6	150.4	61.8	122.6
Mean	13.9	28.5	208.1	25.3	52.6	233.7	24.3	45.3	219.3	37.7	57.2	165.2

* : No data obtained.

removal of apical ear in case of already silked plants would accelerate the development of subapical ears. It would be helpful for the plant breeders to utilize the silked plant before shoot bag covering rather than discard it during the pollination work. In this trial, normal and removed subapical ears were pollinated naturally without using artifical hand pollination. Days to silking of subapical ears was delayed about 4 days compared to normal apical ear. This would make worse the pollination condition due to pollen shortage. F_1 seed production using subapical ears might be better than the result obtained in this expreriment if pollen is available.

摘 要

옥수수의 育成過程이나 交雜種 生産時에 암술 봉투를 씌우기 전에 上部이삭이 出絲하는 경우에는 出絲한 개체를 버리지 않고 출사한 이삭을 除去하면 下部이삭이 발육하므로 種子 生産을 기대할 수 있다. 본 실험은 7개의 自殖系統을 공시하여 出絲된 上部이삭의 除去가 下部이삭의 開花와 種子生産에 대한 반응을 검토하고자 실시하였으며 그 결과를 요약하면 다음과 같다.

1. 上部이삭을 除去하였을 때 下部이삭의 출사기는 上部이삭보다 4일 정도 지연되었으며 自殖系統間에 차이가 있었다.
2. 下部이삭의 穗長은 上部이삭에 비하여 평균 36% 정도 짧았으며, 自殖系統 NC246은 下部이삭이 발육출사되지 않아 自殖系統間의 차이를 나타냈다.
3. 下部이삭의 이삭列數와 列當粒數는 각각 28%, 37% 적었고 穗當粒數는 43% 적었으며. 自殖系統間의 감소 범위는 0~82% 이었다.
4. 收量構成 要素中에서 100粒重의 감소 정도가 가장 적었고, 穗長과 收量構成 要素에 대한 變異係數는 上部이삭에 비하여 下部이삭에서 약 2배 정도 컸다.

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