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Maize with Multiple Ears and and Tillers(MET)

IV. Leaf Characteristics of IK Type Maize with Tillers**

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多蘖性 옥수수 硏究

IV. IK型 分蘖 옥수수의 잎 特性**

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ABSTRACT

Leaf characteristics of main stem and tiller of IK type maize (IK//IRI/B68) were compared with those of Jinjoo Ok hybrid which are not usually tillered. A total of nine leaves from flag leaf to the third or the fourth leaf below ear-bearing node were sampled from each stem or tiller. There was no significant difference in mean leaf length between IK//IRI/B68 and Jinjoo Ok. But the mean leaf width of IK//IRI/B68 was about 2 cm narrower than that of Jinjoo Ok. The mean leaf area of the IK//IRI/B68 was also smaller than that of Jinjoo Ok due to the narrower leaf width. There were not significant differences in mean leaf characteristics between main stem and tillers of IK/IRI/B68. The longest leaf was the leaf below the ear-bearing node and the widest leaf was the leaf just above the ear-bearing node. Mean length, width and area of leaf on main stem and tillers were similar. Coefficients of variation calculated for individual leaf indicated that the leaves near the ear-bearing node were more uniform than others. The leaf area measured was significantly greater than that estimated by formular, length x width x 0.75. New constant to estimate leaf area of tillering maize was derived as 0.8.

INTRODUCTION

A number of experimental multi-tillering corn hybrids have been developed at the Canada Dept. of Agr. Research Station, Ontario[1]. These hybrids are reportedly known to produce more dry matter than the recommended single stalked plants[8]. Tsotsis indicated that maize tillers may be used for future breeding purposes[10]. Sprague and Welhausen also indicated that maize tillers may be used under certain conditions (personal comm. 1988). However, it is true that most maize breeders considered the maize tiller as one of the undesirable characters and they have discarded them during their breeding programs. Therefore, the maize hybrids that have been grown nowdays are characterized by no or few tillers.

The fact that there are very few research reports on maize tillers has attracted our attention some years ago. So far with our very limited research facilities and financial supports from various sources, we have studied genetic and morphological characteristics of the maize tillers[2,3,4,6,7]. We have also developed a few inbred

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lines as well as a few hybrids that all have tillers[5]. During our research on maize tillers we had questions about the leaves of the tillering maize, since the maize with tillers had more leaves per plant than the ordinary nontillering maize. One of the questions that we have had was if length, width and area of leaves of with tillers are similar with those of nontillering maize. The other question was if characteristics of the main stem leaves of the tillering maize are the same as those of the tiller leaves. In order to answer the questions we have conducted the present research.

MATERIALS AND METHODS

Up to now there is no single maize hybrid with tillers grown for commercial purpose in Korea. However, we have developed a few tillering hybrids and they are being subjected to performance trials. The hybrid, IK//IRI/B68 is one of the hybrids with tillers that we have developed. The general performance including fresh and dry weight per unit area was found to be acceptable under certain environmental condition[4]. The IK//IRI/B68 hybrid was grown for our research in alternative row with Jinjoo Ok, which is nontillering and recommended to Korean farmers.

The plant space was 60 cm by 30 cm in five meter row. The general farm management including fertilizer application was conducted following the standard practices recommended by the Crop Exp. Station of the Rural Development Administration in Suweon, Korea. The soil and weather conditions were not so bad during growing season and there wasn't any serious physiological stress to the both hybrids.

The leaves to measure were sampled about 40 days after silking stage from each plant. When leaves were sampled, they were numbered according to their positions. The leaf of the ear node was numbered as 1 and the first leaf above the ear node was numbered as 2. The first leaf below the ear node was -2. The flag leaf was numbered as 6. A total of nine leaves in average were sampled from each plant or tiller. We assumed that the leaves sampled for our study were mostly active ones in terms of photosynthetic capacity for the final production. The sampled leaves were measured for their length, width and area by the leaf analyzer of T & J. Crump Inst. Leaf area was also estimated by the Montgomery's formular; length x width x 0.75[9]. The research approaches included comparison of leaf characters between IK//IRI/B68 and Jinjoo Ok, comparison of leaf characters among leaves with the same plant or tiller, comparison of measured and estimated leaf areas, variation of each leaf at each node, and derivation of mathematical model to measure leaf area of tillering maize if there is any.

RESULTS AND DISCUSSION

Two inbreds, IK and IRI, in IK//IRI/B68 hybrid were developed at the Chungnam National University as tillering lines. The tillering habits of the lines were so unique that the hybrids which were derived from IK should be distinguished from the ordinary hybrids in the respects of tillering habits.

The average length, width and area of leaves of the two hybrids are shown in Table 1. The average length of the main stem leaves of IK//IRI/B68 was not significantly different from that of Jinjoo Ok, although the leaves of IK type (IK//IRI/B68) seemed to be longer than Jinjoo Ok (74 cm vs 76 cm). The average width of leaves of IK type hybrid was narrower than that of Jinjoo Ok. The average leaf width of IK type was 6.6 cm and was about 2 cm narrower than that of Jinjoo Ok.

Table 1 shows that the average leaf area of nine leaves on the main stem of IK type was much smaller than that of Jinjoo Ok. The mean leaf area of IK type was 405 cm^2, while that of Jinjoo Ok was 537 cm^2. Table 1 also shows the individual leaf characteristics. The similar differences between both hybrids were found among leaves of the same leaf number. The length of

Table 1. Comparison of leaf length, width and area at each leaf position between main stem of IK//IRI/B68 and Jinjoo Ok.

Leaf	Leaf length, cm		Leaf width (cm)		Leaf area $(cm)^2$	
No.	IK type	Jinjoo Ok	IK type	Jinjoo Ok	Ik type	Jinjoo Ok
6	41±6.4a	43±2.4	4.2±0.8	5.3±0.2	144±34	181±24
5	50±6.9	60±2.4	5.8±0.6	7.3±0.2	238±45	343±16
4	62±6.0	68±3.0	6.6±0.4	8.8±0.3	337±51	477±24
3	72±4.6	77±3.9	7.4±0.4	9.7±0.2	437±47	589±31
2	82±3.1	85±4.8	8.0±0.3	10.2±0.3	500±33	662±40
1	88±1.6	87±4.6	7.8±0.5	10.0±0.0	534±26	702±40
-2	92±1.3	90±4.3	7.2±0.4	10.0±0.5	542±17	685±36
-3	90±2.4	89±4.0	6.8±0.5	9.2±0.3	493±28	626±38
-4	87±3.2	84±2.6	6.2±0.2	8.2±0.3	423±40	572±34
Mean	74±2.1	76±1.8	6.6±0.1	8.7±0.2	405±15	537±19
t(0.05, df=16)	2.775		0.254*		3.13**	

a : Mean±SE

*, ** : Significant at 5% and 1% level, respectively.

flag leaf was 41 cm for IK type and 43 cm for Jinjoo Ok. The average width of flag leaf was 4.2 cm and 5.3 cm for IK type and Jinjoo Ok, respectively. The flag leaf was the smallest among the leaves measured as the area was 144 cm^2 and 181 cm^2 for IK type and Jinjoo Ok, respectively. The main reason for greater leaf area of Jinjoo Ok over IK type was due to wider leaf of Jinjoo Ok comparing to that of IK type.

Comparisons of length and width of leaves between main stem and tillers of IK type were shown in Table 2. The longest leaf was the leaf numbered -2, while the widest leaf was found in the leaf numbered 2. The leaf at ear node, which is numbered 1 seemed to be located in the middle between the longest leaf and the widest leaf of a plant. The results show that the leaf at the ear node is the most stable indicator for length and width of leaves. Table 2 also shows that there is no significant differences between main stem and tillers in average leaf length and width. In other words, length and width of the same numbered leaf of tillers were similar with those of the main stem. In the previous report it was also indicated that the length of tillers of IK type hybrid was the same as the length of main stem at the harvesting time[4]. Therefore, our presumption that the maize tillers are inferior to the main stem in length and in leaf characteristics may be wrong at least in IK type hybrids.

The area of each leaf was also compared in Table 2. The largest leaf was the leaf numbered 1 and -2 on main stem and on tillers. The

Table 2. Leaf length, width, and area of main stem and tillers of IK//IRI/B68.

Leaf	Main	Leaf length (cm)		
No.	stem	Tiller 1	Tiller 2	Tiller 3
6	40.6±6.4	42.8±5.8	45.0±6.0	–
5	50.4±6.9	50.6±6.5	47.7±9.8	43.5±6.5
4	62.0±6.0	61.6±5.9	61.7±9.9	54.5±6.5
3	72.0±4.6	70.0±5.6	68.7±8.4	68.5±2.5
2	82.0±3.1	78.0±4.6	78.7±6.4	75.7±2.5
1	88.2±1.6	87.0±3.2	82.0±8.2	87.0±0.0
-2	91.6±1.3	92.8±2.1	96.3±0.9	88.0±3.0
-3	90.4±2.4	92.0±1.5	98.7±3.0	98.5±0.5
-4	86.8±3.2	87.4±2.2	96.3±5.8	93.5±6.5
Mean	73.8±6.3	73.6±6.2	75.0±6.8	76.1±7.5
t*	–	0.028NS	0.133NS	0.250NS
6	4.2±0.8	5.3±0.8	5.5±1.2	–
5	5.8±0.6	5.6±0.6	6.0±1.0	6.0±0.5
4	6.6±0.4	6.6±0.5	7.3±0.7	7.0±0.2
3	7.4±0.4	8.0±0.4	8.0±0.6	8.0±0.5
2	8.0±0.3	8.2±0.5	9.0±0.6	7.9±0.4
1	7.8±0.5	7.8±0.4	8.3±0.3	8.0±0.2
-2	7.2±0.4	7.4±0.4	8.0±0.6	6.9±0.3
-3	6.8±0.5	6.8±0.4	7.0±0.0	6.9±0.6
-4	6.2±0.2	6.0±0.5	6.0±0.0	6.1±1.3
Mean	6.6±0.4	6.9±0.4	7.2±0.4	7.1±0.3
t*	–	0.358NS	1.014NS	0.88NS

Table 2 continued -

Leaf No.	Main stem	Leaf length (cm)		
		Tiller 1	Tiller 2	Tiller 3
6	144±34	184±48	138±57	−
5	238±45	244±51	198±68	178±38
4	337±51	345±54	296±85	289±39
3	437±47	426±92	435±92	411±57
2	500±33	506±59	494±80	449±31
1	534±26	561±49	581±68	550±30
-2	542±17	552±26	601±30	572±39
-3	493±28	503±20	559±37	572±77
-4	423±40	434±34	494±62	515±100
Mean	405±46	417±45	422±57	442±51
t*	−	1.84NS	0.22NS	0.53NS

* : t values were calculated between main stem and tillers

individual leaf area became smaller as the leaf position goes up or down from the ear-bearing node. The average leaf area of main stem was also simlar to that of tillers, as far as the leaf position was the same. The total leaf area including tiller leaves of individual plant of IK type was compared with that of Jinjo Ok (Table 3).

Table 3. Comparison of total leaf area per plant between IK//IRI/B68 and JinJoo Ok.

	Leaf Area (cm^2)	
	IK//IRI/B68	Jinjoo Ok
Main stem	3648±46*	4837±58
Tiller 1	3755±45	−
Tiller 2	3796±57	−
Tiller 3	3536±51	−
Total	14735	4837

* Mean ±SE

Although the average leaf area of the main stem of IK type was smaller than that of Jinjoo Ok, the total leaf area of a whole plant of IK type was about three times greater than that of Jinjoo Ok. Greater leaf area of IK type is due to the tillers of IK type. As shown in Table 3, each tiller of IK type had similar leaf area as the main stem. Greater leaf area per plant of IK type was previously reported in terms of leaf area index[3]. Choe *et al*. reported that leaf area indices of IK type hybrids with tillers were greater than 9, while the leaf area of ordinary nontillering hybrids was around 5[3]. In this study the average total leaf area of nine leaves of IK type was 14,735 cm^2 against 4,837 cm^2 of Jinjoo Ok.

Environmental variations of leaf length, width and area of both hybrids were shown in Table 4. Regardless of main stem or tillers, leaves positioned at near the ear bearing node have lower coefficients of variation than the leaves at upper or lower nodes. Especially the leaves, number 4, 5 and 6 were very variable in length, width and area. Therefore, it is assumed that more reliable data would be obtained from the leaves positioned at near the ear-bearing node. Figure 1 shows that Jinjoo Ok had more uniform and smaller coefficient of variation in leaf area than IK type for all leaves on main stem.

The leaf areas measured and estimated by the formular, length x width x 0.75, were compared in Table 5. Without exception the mean leaf area

Table 4. Coefficient of variation for length, width and area of leaves at different leaf positions of IK// IRI/B68, %. (Values of Jinjoo Ok hybrid is shown in paranthesis).

Leaf No.	Main stem			Tiller 1			Tiller 2		
	Length	Width	Area	Length	Width	Area	Length	Width	Area
6	35(14)	43(10)	52(33)	27	29	45	30	30	59
5	30(10)	23(7)	42(12)	29	24	47	36	29	59
4	22(11)	14(9)	34(12)	21	17	35	31	16	50
3	14(12)	12(5)	24(13)	18	13	29	21	13	36
2	8(14)	9(7)	15(15)	13	13	26	14	11	28
1	4(13)	14(0)	11(14)	8	11	19	17	7	20
-2	3(12)	12(13)	7(13)	5	12	11	2	13	9
-3	6(11)	16(8)	13(15)	4	12	9	5	0	12
-4	18(8)	7(18)	21(15)	6	20	17	10	0	22
-5	-(12)	-(12)	-(20)	−	−	−	−	−	−

Table 5. Comparison of leaf area measured and estimated by factor, 0.75 of main stems and tillers of IK//IRI/B68 and Jinjoo Ok. (unit:cm²)

Leaf No.	Main stem				Tiller 1		Tiller 2		Tiller 3	
	IK type		Jinjoo Ok		IK type		IK type		IK type	
	M	E	M	E	M	E	M	E	M	E
6	144	128	181	169	184	170	138	186	178	196
5	238	219	343	327	244	213	198	215	289	286
4	337	307	477	451	345	305	296	338	411	411
3	437	400	589	558	426	420	435	412	449	447
2	500	492	662	648	506	480	494	531	550	522
1	534	516	702	655	561	509	581	511	572	455
-2	542	495	685	677	552	515	601	578	572	510
-3	493	461	626	614	503	469	559	518	515	428
-4	423	404	572	517	434	393	494	433	—	—
-5	—	—	470	493	—	—	—	—		
Mean	405	380	531	511	417	386	421	414	442	406
t	6.1**		2.9*		6.6**		0.5		2.1	

M : measured E : estimated
* : Significant at 0.05 probability level
** : Significant at 0.01 probability level

Table 6. Comparison of leaf factors between 0.75 as a population mean and 0.8 estimated by [area/(length x width)] of IK//IRI/B68.

Leaf No.	Main stem	Tiller 1	Tiller 2	Tiller 3
6	0.84	0.81	0.56	0.68
5	0.81	0.86	0.69	0.76
4	0.82	0.85	0.66	0.75
3	0.82	0.76	0.79	0.75
2	0.76	0.79	0.70	0.79
1	0.77	0.83	0.85	0.94
-2	0.82	0.80	0.78	0.84
-3	0.80	0.80	0.81	0.90
-4	0.79	0.83	0.85	—
Mean	0.80	0.81	0.75	0.80
t value	6.15**	6.18**	0.21	1.67
df	8	8	8	7
t(.01, df)	3.36	3.36	3.36	3.50

** : Significant at 1% level.

measured was greater than that estimated. Leaf area at each node also indicated that individual leaf area measured by machine was greater than that estimated by formular. We couldn't find the reason for the discrepancy. Under the assumption that leaf area measured by leaf area meter is accurate, we could derive a factor to estimate leaf area of IK type by dividing leaf area by leaf length x leaf width. The factor obtained is shown in Table 6 and compared with the constant, 0.75,

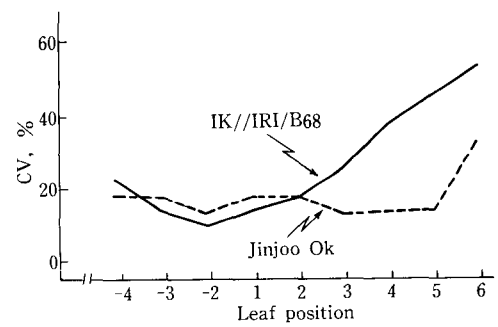

Fig. 1. Environmental variation of leaf area at each leaf position of IK//IRI//B68 and Jinjoo Ok.

which is previously reported. Table 6 indicated that the newly obtained factor, 0.8 should be used in estimating the leaf area of the IK type of hybrid.

摘 要

분얼하는 옥수수 교잡종 (IK//IRI/B68)의 잎이 분얼하지 않는 옥수수(진주옥)의 잎과 길이나, 폭 또는 면적에 있어서 차이가 있는지의 여부를 알기 위해 주경 또는 분얼경의 止葉으로 부터 아래로 9개 잎을 收穫期에 취하여 엽장, 엽폭, 엽면적을 측정하였다.

1. 개체당 주경의 평균 葉長은 IK형(IK//IRI/

B68)이나 진주옥이 거의 같았으나 평균 葉幅은 IK형이 진주옥보다 약 2cm 좁았다. 평균 엽면적 역시 IK형이 적었는데 그 이유는 엽폭이 좁았기 때문이었다.

2. IK형 옥수수에서 主莖과 分葉莖간의 잎특성(長, 幅, 面積)은 서로 비슷하였다.
3. IK형 옥수수는 着穗節 바로 아래 節의 잎이 가장 길었고 着穗節 바로 위의 잎이 가장 넓었다.
4. IK형 옥수수 잎의 節位別 變異係數를 비교한 결과 着穗節을 포함한 着穗節 근처 잎이 변이계수가 가장 낮았고, 着穗節에서 멀리 떨어진 잎일수록 變異係數의 값이 컸다. 특히 止葉의 變異係數는 다른 잎들보다 훨씬 컸다. 이같은 경향은 주경과 분얼경의 잎이 모두 같았다.
5. 기존의 公式(長 x 幅 x 0.75)에 의해 추정한 엽면적보다는 직접 측정한 엽면적이 컸다. 따라서 IK형 옥수수의 엽장과 엽폭에 의한 엽면적 추정은 기존의 0.75 대신에 0.80을 이용하는 것이 보다 타당할 것으로 생각된다.

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