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The Maize with Multiple Ears and Tillers (MET)

III. Developmental Habit and Morphology of the Tillers***

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多蘗性 옥수수 硏究

III. 分蘗發生의 習性 및 形態***

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ABSTRACT

In order to investigate developmental habit and morphology of maize tillers, time and location of tiller development, number of tillers per plant, tiller angle, height and diameter of tillers and root systems of tillers were examined under field condition for maize with tillers. Materials used were mostly from Korean local lines and a few lines from other countries were also included for comparison. The time of the first tiller development was about 18 to 20 days after emergence when planted on May in Yusong. The second tiller appeared about 4 to 5 days after the first tiller appeared. The tiller number per plant varied with lines and hybrids and ranged from two to ten. The location of tiller development was usually basal nodes of the main stem. Each tiller appeared to have its own root system. The angle between tillers and main stem was variable depending upon the maizes and the tiller angle could be classified into three categories. The height of tillers was also variable and seemed to be under genetic control. The most productive tillers were found among the Korean local derivatives.

INTRODUCTION

It was formerly reported by Choe et al. that many Korean local maize lines have tillers, and that the most tillering Korean local maizes are often found among the lines from the areas where the magnitude of maize cultivation is rather small like Chun-nam-buk provinces (2, 3). It was also reported that some maize in the U.S. has habits of tillering (7, 11). Montgomery reported the effects of tiller removal on the grain yield of maize in 1918 (8). Some other maize genetists or breeders reported that some maizes in Mexico or in Central America are tillering (6, 12). Some of the recently bred sweet corn are also known to have tillers.

Even though there have been a number of reports about the maize tillers, all the hybrids grown by farmers todays do not have tillers at all. The question is why it is so. Some of the reasons may be speculated as follows. The first reason may be that early maize breeders might have failed in manifesting the heterosis in the maize with tillers. In other words, many of the maize breeders had wanted to have big maize plants with a big ear

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by hybridization, and they were unable to have such a plant from the tillering maize. The second reason may be that many maize breeders had considered maize tillers as suckers depleting the nutrition needed for main stem growth. The maize breeders also thought that the same effect of tillers might be obtained from the uniculm maize through the increase of the planting density. Lastly many maize breeders often considered the maizes with tillers as wild type or uncultivated ones (9, 10). Because of these reasons maizes with tillers have been discarded or ignored during breeding procedures by breeders. There have been no detailed reports of tillering behavior in maize. Hence the objectives of this study were to study closely the tillering behaviors of maize and its potential values in maize breeding.

MATERIALS AND METHODS

The inbreds and hybrids used in the study were from either locally developed or from other countries (Table 1). All the materials were common as far as they are tillered in a certain extent. Inbreds like IK or IRI, and hybrids like IK//IRI/Woolnungdo and IK/IRI were all developed by Choe and his coworkers at the Chungnam National University. The materials were planted in 1987 and 1988 at the farmer's farm near Yusung. The planting density was 60 cm by 30 cm in a row of five meters long. The planting dates were May 1 in both years. General field managements were followed by the standard procedures recommended by the Crop Experiment Station of the Rural Development Administration. The tillers were not removed during the investigation. The plant characteristics studied were time and location of tiller development, tiller numbers per plant, angle of tillers, root systmes of tillers, and height and diameter of main stem and tillers. The term of tillers in the study was defined as any branches developed from the main stem of maize.

RESULTS AND DISCUSSION

1. Time of appearance of the first tiller : The time of the first tiller appearance was almost same among inbreds and hybrids (Table 1). The first tiller leaf in inbreds appeared about 18 to 20 days after the emergence of the first leaf of main stem. The first tiller in hybrids appeared a few days earlier compared to the inbreds. The number of leaves of the main stem when the first tiller appeared were about 3 to 4. The second tiller appeared about 4 to 5 days later after the first

Table 1. Number of tillers per plant, days to the first tiller appearance, and effective tillers per plant of inbreds and hybrids with tillers.

Entries	Tillers per plant	Days to* 1st tiller	Effective tiller, %	Sources of seeds
Inbreds				
IK	2-3	20	90-100	Korea
IRI (upright)	2-3	20	90-100	Korea
Tlr	0-5	18	<10	US (Neuffer)
Cheyene Tribe	3-5	18	<70	Mexico (Wassom)
IRI/Bonghwa	3-4	20	80-90	Korea
Waesung	5-10	20	<60	Korea
Sinkihong	6-8	20	<70	Korea
Teosinte	0-5	20	0-100	Mexico (Wright)
Hybrids				
IK//IRI/B68	3-4	16	90-100	Korea & US
IK/IRI	3-4	17	90-100	Korea
IK//IRI/Woolnungdo	3-4	17	90-100	Korea

* After the first leaf appearance of main shoot.

tiller appeared. The third tiller was appeared about 3 to 4 days after the second tiller. When the number of tillers per plant were more than ten, the duration of tiller development tended to be shortened as plant grows(1). The development and growth of tillers follow a pattern identical with that of the main shoot. The observation of tiller development was done fully under the field conditions. The factors influencing the tiller development were partly studied by Duncan and Hesketh (5) and by Stevenson and Goodman (10). Duncan and Hesketh found that tillering of 22 maize races was not correlated with temperature. However, Stevenson and Goodman reported that low temperature was effective in tiller production. The one thing clear was that the materials used in the study was quite different from those used by either Duncan and Hesketh and Stevenson and Goodman. According to the past observation made by Choe et al. (4), the habits of tillering of IK and IRI inbreds and IK/IRI or IK//IRI/Woolnung-do did not show great variation under the field condition. From the field observation it was found that the first tiller became most productive compared to the later tillers. Some later tillers died and couldn't contribute to silage or grain yield.

The tiller development was also influenced by the location where the tiller develops. For instance, the time of tiller development was irregular in inbred Tlr where some tillers developed from above ground nodes of the main stem.

2. Number of tillers per plant : Montgomery (8) indicated that maize tillers are largely dependent upon the environment such as soil condition or temperature. He also reported that tendency to tiller is somewhat hereditary, as certain flint and sweet corn produce well-developed ear bearing tillers. Choe et al. (3) also indicated that the MET material he has selected out from Korean local lines tended to tiller regardless of the planting density in Korea and that tillers of the MET material is under genetic control. As shown in Table 2, all the materials used in the study showed a great range of tiller numbers per plant. The tiller number of inbreds like IK and IRI was two to three and they were not variable in tiller number per plant, while inbred like Waesung had more than five tillers per plant. The number of tillers of hybrids was three to four and they seemed to be quite consistent under the various environments. From the study it was found that as the number of tillers per plant increased, the ratio of effective tiller number per plant decreased. Under the environment studied, the tillers of IK and IRI were all effective bearing harvestable ears. However, tillers of Waesung and other lines from Mexico and teosinte relatives were partly effective in bearing ears. The tillers

Table 2. Height and diameter of main stem and tillers of inbreds and hybrids of maize with tillers.

Character	Height, cm					Diameter, mm				
Inbred No.*	1	2	3	4	5	1	2	3	4	5
Main stem	166	210	127	135	175	16	18	17	16	17
Tiller 1	160	211	130	136	165	16	20	11	14	18
Tiller 2	160	211	113	130	115	16	18	5	13	15
Tiller 3	-	-	65	120	-	-	-	4	13	-
Tiller 4	-	-	55	100	-	-	-	3	3	-

Hybrid No.**	1	2	3	1	2	3
Main stem	308	312	300	26	25	24
Tiller 1	292	282	283	22	20	20
Tiller 2	290	270	282	21	19	18
Tiller 3	282	270	277	19	18	18

* 1.IK, 2.IRI (upright), 3.Tlr, 4.Cheyene Tribe, 5.IRI/Bonghwa

** 1.IK//IRI/B68, 2.IK/IRI, 3.IK//IRI/Woolnungdo of hybrids used in the study were all effective since they borne a few harvestable ears. It is assumed, therefore, that the most economical number of tillers per plant should not be greater than two under normal plant densities, 60 cm by 30 cm. From the study it was also found that the tiller number per plant can be controlled by breeding procedures.

3. Location of tiller development : Time and location of tiller appearance are important factors in determining the number and vigor of productive tillers which, in turn, govern the yields of maize. Most materials used in the study developed tillers from the underground basal nodes of the main stem (Figure 1). Only exception was observed in the Tlr inbred which produced a few tillers from the above ground nodes of the main stem (Figure 2). It was found that the way of tillering habits of maize was different from other grass family like rice, wheat or barley which produce normally secondary tillers from tillers.

4. Tiller angle : As the number of tillers per plant, the angle between tillers and main stem is important for imporving plant canopy. From the study the maize plants could be classified into three categories according to the angles between tillers and main stem. The first group of maize (Figure 3) shows that there is no or less angle between tillers and main stem. Inbred Waesung belongs to the first group. The second group of

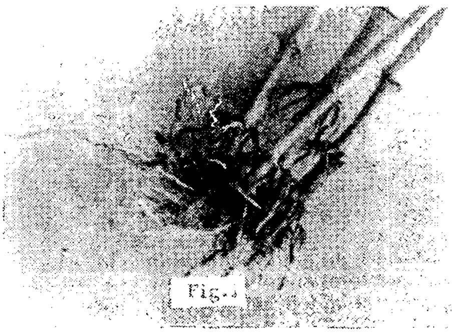
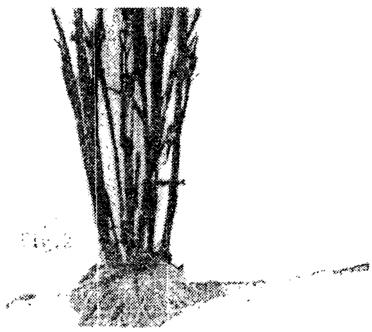


Fig.1



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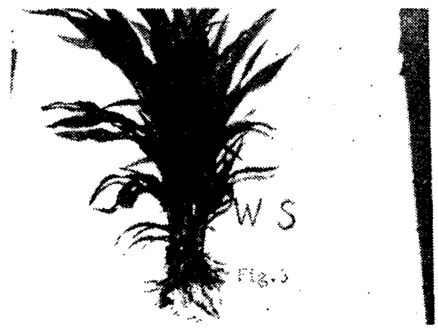

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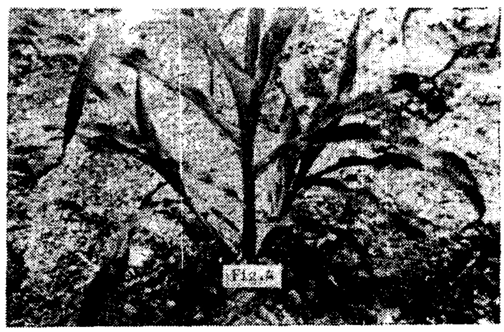


Fig.4

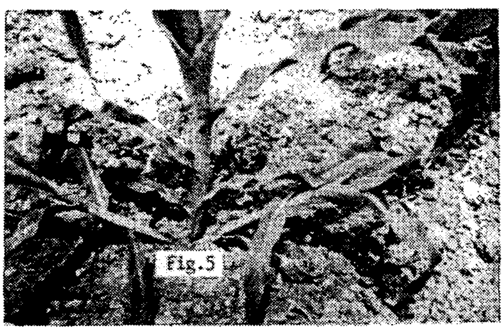
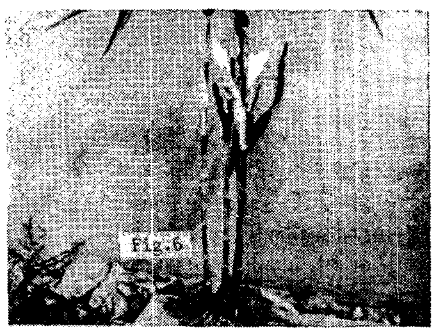


Fig.5



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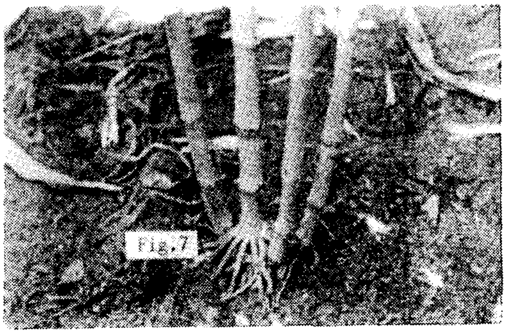

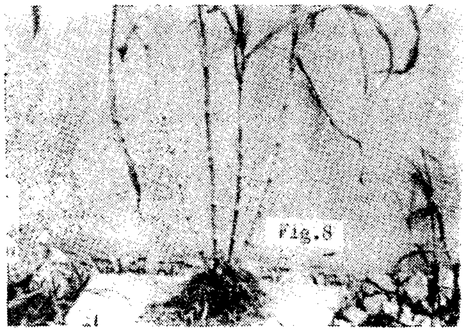

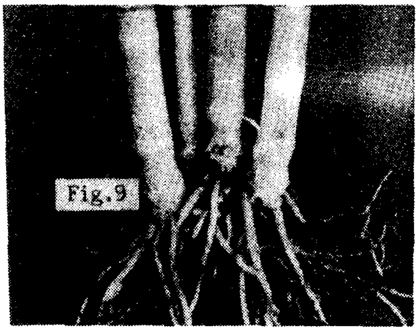

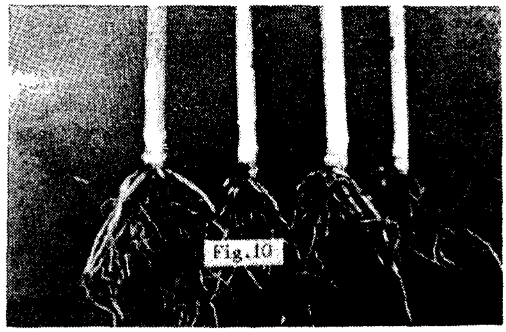

Fig. 1. All tillers were developed from the basal nodes of the main stem.
Fig. 2. A few tillers were developed from the above nodes of the main stem in Tlr.
Fig. 3. There was no or less angle between the tillers and the main stem (The first group in text).
Fig. 4. The angle between the tillers and the main stem were about 45° (The second group in text).
Fig. 5. The angle between the tillers and the main stem were greater than 45° (The third group in text).
Fig. 6. The tiller angle of the first group in the early season of the growth were maintained until the late season of the growth.
Fig. 7. The tiller angles of the second group in early season of the growth were maintained until the late season of the growth.
Fig. 8. The tiller angle of the third group in early season of the growth were maintained until the late season of the growth.
Fig. 9. The root systems of the tillers before tillers were separated.
Fig. 10. The root systems of the tillers after tillers were separated.

maize (Figure 4) shows about 45 degrees of angle between tillers and main stem. Inbred IK and IRI belong to this group. The last group is the maize showing more than 45 degrees of angle between tillers and main stem. Inbred IRI/Bonghwa and hybrid IK//IRI/Woolnungdo belong to the last group (Figure 5). It was also interesting to note that the angle between tillers and main stem fixed in early stages of growth was maintained throughout the whole growing season without big disturbances in angles. Figures 6, 7, and 8 show the plant type of inbreds and hybrids in later part of growing season.

5. Height and diameter of main stem and tillers : The maize tillers should be high and big enough to be economically important. The height and diameter of tillers and main stem are shown in Table 2. Usually the height of main stem was higher than that of tillers. However, the height of tillers of inbred IK and IRI was almost as high as the height of the main stem. Choe et al. (4) previously reported that the tillers of the IK and

IRI lines show synchronized growth pattern of the main stem. In other lines which produce many tillers per plant, the height and diameter of tillers decreased gradually as the time of tiller occurrence is belated. The absolute height of the tillers is also important. From the study it was found that the height of tillers of inbred lines like Cheyene Tribe, Tlr, and Waesung was much lower than that of inbred IK or IRI.

In order to grow maize hybrids with tillers, the tillers of the hybrids should be high enough to produce harvestable good ears. As shown in Table 2 the tiller height of three hybrids used in the study were shorter than those of main stem. The diameter was also small in tillers. This will be one of the differences that we can find between maize tillers and tillers of other grass family like rice or wheat. For practical use of maize with tillers new breeding procedures and cultivation practices will be required to improve the height and diameter of the tillers.

6. Root systems of tillers : The root systems of maize with tillers have not been fully understood. We assumed that the maize with tillers should have different root systems from the ordinary non-tillering maize. Dr. Wellhausen (personal com.) has also mentioned about the possible different root systems of maize with tillers. In order to find if the maize with tillers has different root systems, we examined the roots of maize with tillers, and found that each tiller of tillered maize has its own root system as shown in Figures 9 and 10.

摘　要

分蘖하는 옥수수에서 分蘖의 發生時期 發生部位, 個體當分蘖數, 分蘖角, 根系, 크기等에 對해 調査 報告된바가 없기에 이들 特性을 알기 위해 國內 在來種에서 純系分離한 自殖系統 및 交雜種을 中心으로 1987年과 1988年에 圃場調査한 것을 다음과 같이 要約한다.

1. 一次分蘖時期는 忠南의 儒城에서 5月 11日頃 播種時 主莖의 第一本葉이 地上에 出現後 18日 내지 20日이었고, 第二次分蘖은 一次分蘖이 있은 後 4~5日 後였다. 自殖系統들 사이와 交雜種들 사이에는 分蘖의 發生時期에 큰 差異가 없었고 交雜種은 自殖系統보다 2日 程度 빨랐다.

2. 分蘖들의 發生部位는 거의 모든 供試系統들이 主莖의 地下節에서 였다.(例外 : Tlr 系統)

3. 個體當 分蘖數는 栽植密度에 關係없이 系統 및 交雜種에 따라 달랐다. IK나 IRI같은 自殖系統은 個體當 分蘖數가 2~3個로 定해졌으나 倭城과같은 系統은 5내지 10個가 되기도 하였다. (IK×IRI)F_1은 3~4個였다.

4. 主莖과 分蘖이 가지는 分蘖角도 遺傳的 特性으로 大略 3個로 區分할 수 있었다. 1群은 分蘖角이 없거나 매우 적은것, 2群은 分蘖角이 45° 程度 되는것, 3群은 分蘖角이 45° 以上되는 것들이다.

5. 各 分蘖은 各各의 固有 根系를 가지고 있었다.

6. 分蘖의 크기(길이, 直徑)는 有効莖 如否를 決定하는데 重要한데 大部分 在來種 系統이나 이들로 만들어진 交雜種은 60cm×30cm의 栽植密度下에서 有効莖 比率이 90% 以上되었다.

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