Kor. Turfgrass Sci., 11(2), 117~124, 1997

The Study on the Growth and Branching of Stolon in Korean Lawn(*Zoysia japonica* Steud.)

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韓國 잔디의 匍匐莖 생장과 分枝에 관한 연구

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ABSTRACT

This study was carried out to investigate the growth and branching pattern of stolons at Korean lawn(*Zoysia japonica* Steud.) in the field condition.

The results were summarized as follows ;

1. About 80% of observed lawns had one primary stolon. Among the lawns with several primary stolons, 30% of them had two primary stolons, 63% had three, and 7% had four.
2. The angles between the primary stolon and the shoot were increased from 0° to 52° according to the node order from the terminal shoot apex, and reached maximum angle at the 7th node.
3. The internode length was the longest in the middle position of stolon, and its growing rate which depends on months was increased from May to September.
4. The branching angles between primary and secondary stolon were from 44° to 53° in each node. The average left branching angle was about 48.2°, right branching angle 47.8°, and the total average branching angle was 48.0°.
5. The rate of initial brabch was the highest at the 10th node in May, the 7th node in July and the 5th node in September. But, the initial branching rate at the 7th node in July was higher than any other that at the 10th node in May and the 5th node in September.
6. The distribution rate of secondary stolon in each node of primary stolon was the highest at the 7th node.
7. When the terminal shoot apex of primary stolon was damaged mechanically, the branching rate at the first node after the damaged region was highly increased to 62%.

The results of this study may be suggested that the secondary stolon begins to branch with the angle of 48° from the 7th node of the normal primary stolon, and those may be used as a basic data for the branching simulation in lawn.

Key words: Lawn, Stolon, Branching angle, Branching rate, *Zoysia japonica*.

INTRODUCTION

Korean lawn(*Zoysia japonica* Steud.) has a low ability in seed germination(Jeon, 1987), and usually proliferates by the growth of stolons and rhizomes. The branching of stolon can make up the lawn sod which is used in making a park, golf fields and so on. It was observed that the number and the length of stolon were increased by nitrogen treatment and clipping(Shim and Yun, 1987 ; McIntyre, 1964). Although the growth rate of stolon can be changed by nutrition and mowing(Madison, 1962), it is necessary to investigate the branching pattern of stolon in the field condition. If we can understand the principles for the branching pattern of stolon, it may be useful for the management and production of the lawn sod(Chang *et al.*, 1987).

It was reported that the branching architecture of the trees and herbaceous canopy plays an important role in sunlight interception for photosynthesis (Honda and Fisher, 1978 ; Chang *et al.*, 1984). In the studies on the canopy form and the branching pattern of trees in forests, the branch angles and lengths were the important factors(Honda, 1971 ; Whitney, 1976 ; Honda *et al.*, 1981 ; Fisher and Hibbs, 1982). This study was conducted to know the branching pattern of stolon in the field condition and to use as a basic data in the computer simulation to predict the proliferating process of lawn.

MATERIALS AND METHODS

This study was performed at lawn growing on bare ground of Nanjido, Seoul from May to September, 1996. We observed the growth pattern of stolon in *Zoysia japonica* and measured the natural branching angle between the primary stolon and secondary stolon as the study of Kim and Chang(1985). Branching angle and internode length were measured by protractor and ruler, respectively. We observed about 1,000 in the number of primary stolon and the results were presented at the mean values.

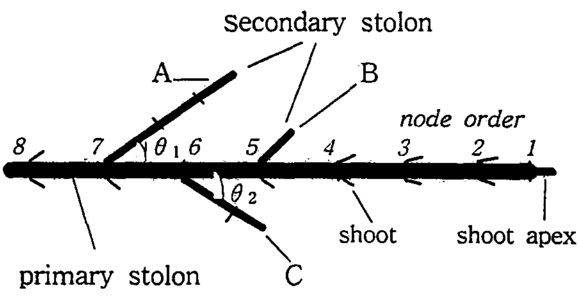

Fig. 1. Diagram and erminology of stolon in *Zoysia japonica*. (A, B, C : Secondary stolon. A, B : Right branch. B : Initial branch. C : Left branch. θ_1 : Right angle, θ_2 : Left angle).

RESULTS AND DISCUSSION

Diagram and terminology of stolon in lawn was presented at Fig. 1. The rhizome which was grown on the ground was named primary stolon. The branch stolon which was grown from the node of primary stolon was named secondary stolon according to the study of Shim and Yun(1987a). The node order at the stolon was numbered from the terminal shoot apex of the stolon.

The proliferation by stolons in lawn was accomplished mostly on the bare ground and lawn had mostly one primary stolon. About 80% of observed lawn had one primary stolon. Among the lawns with several primary stolons, 30% of them had two primary stolons, 63% had three, and 7% had four. It was similar to the study of Shim and Yun(1987) that the number of primary stolons per lawn organism was 2 or 3. Shim and Yun(1987b) observed that the number of secondary stolon was increased by nitrogen treatment. But this study was based on the natural field condition without additional nutrition treatment, and the soil of the observed site contained 0.34% of total nitrogen. Kim and Chang(1985) reported that the branch of stolon may be distributed to optimize the space for the sunlight interception of leaves and the proliferation of lawn. Therefore, it is considered that the number of primary stolon may depend on optimizing the ground space.

The angles between the primary stolon and the shoot at each node were increased from initial degree 0 to final degree 52 according to the node order and reached 52° at the 7th node(data not shown). It was similar to the study of Kim(1987). Therefore, it is considered that maximum effective angle for the light interception at shoot is about 52°.

The internode length was changed according to the months which have different environmental conditions. It was the longest in the middle position of the stolon, and decreased gradually with approaching first and last internodes(Fig. 2). The maximum

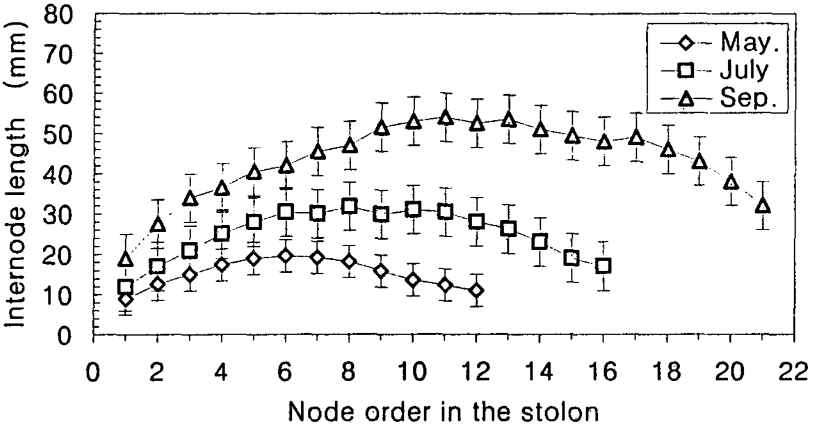

Fig. 2. The changes in the length of internode according to the months, May, July, September.

length of internode was about 55mm in September, 32mm in July, and 20mm in May at mean value. The growth rates of internode were increased from May to September, indicating that the stolon growth was affected by the weather in different season. Shim and Yun(1987a) reported that the stolon length was changed according to the clipping height of tillers and that the number of internodes was increased by nitrogen addition (Gary, 1967). Therefore, it is considered that the stolon growth depends on season, mowing and nutrients.

The branching angles between primary and secondary stolon were from 44° to 53° in each node(data not shown). The average left branching angle was about 48.2°, right branching angle 47.8°, and the total average branching angle was 48.0°. The difference between the right and left branch angles was not significant in each node.

The emergencing rates of initial branch at each node of the primary stolon were examined. The first branch after the terminal shoot apex at the primary stolon was named initial branch(Fig. 1.). The positions of the initial branch depended on months. There was little difference between the right and left initial branching rates(data not shown). The initial branching rate was 27% at the 10th node, 16% at the 11th node in May, 38% at the 7th node, 19% at the 8th node in July, and 25% at the 5th node, 13% at the 6th node in September(Fig. 3.). Therefore, it was the highest at the 10th node of the primary stolon in May, the 7th node in July, and the 5th node in September. It means that the position of initial branch was moved from the hind to the fore part of the primary stolon, depending on seasonal conditions. It was similar to the study on the distribution of terminal daughter branch in crabgrass(Kim and Chang, 1985). The initial branching rate at the 7th node in July was higher than any other that at the 10th node in May and the 5th node in September. Although the position of initial branch depends on the months, the distri-

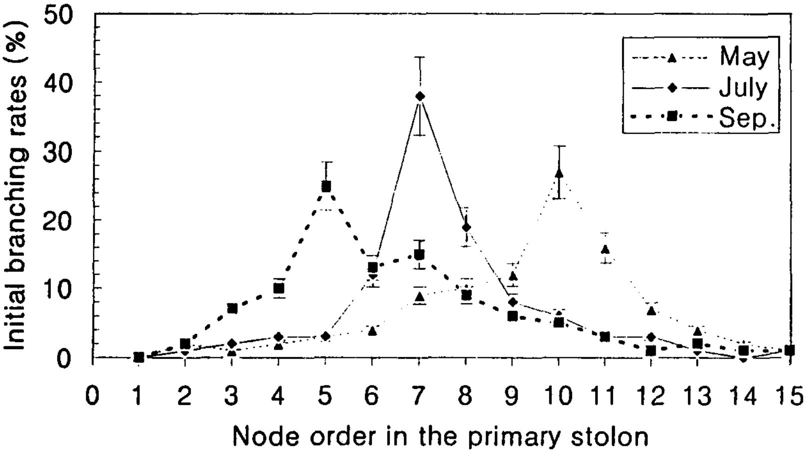

Fig. 3. The distribution of the initial secondary stolon in the primary stolon according to the months, May, July, September.

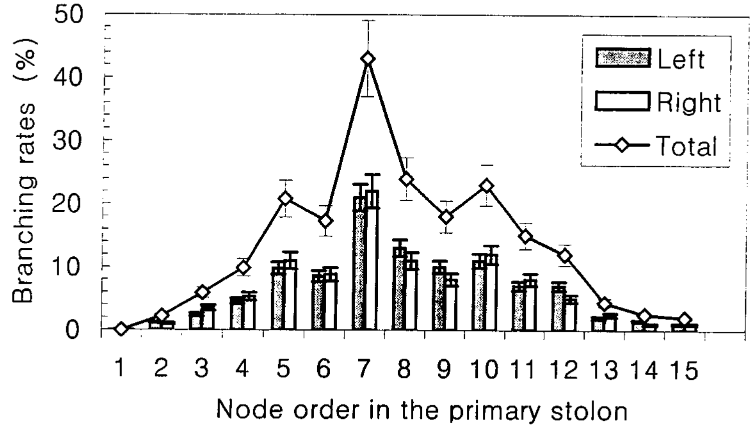

Fig. 4. The distribution of secondary stolon at each node of the primary stolon in September.

bution of the first branch which shows the higest branching rate at the 7th node would suggest that the secondary stolon begins to branch at the 7th node of the primary stolon.

The distribution of secondary stolon in each node of primary stolon was examined in the beginning of September(Fig. 4). Secondary stolon was mostly produced at each node between the 4th node and the 12th node of primary stolon. There were little differences between the right and left branching rates. Total distribution rates of secondary stolon were 43% at the 7th node of the primary stolon, 24% at the 8th node, 18% at the 9th node. Therefore, it was the highest at the 7th node of the primary stolon.

When we consider the distributions of the initial branch(Fig. 3), the total branch(Fig. 4) and the branching angles, it may be concluded that the secondary stolon begins to branch with the angle of 48° from the 7th node of the normal primary stolon.

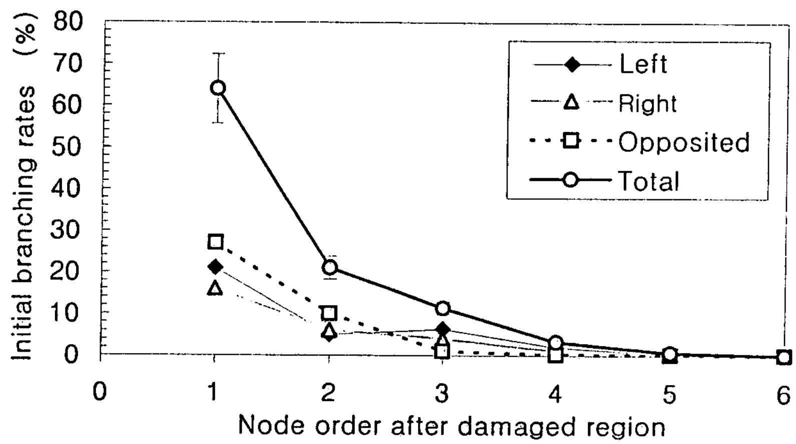

Fig. 5. The distribution of initial branch in primary stolon which was damaged on the terminal shoot apex.

Kim and Chang(1985) studied the mathematical and simulation model for branching geometry in spreading herbs. The results of this study may be used as basic data for the simulation model which can predict the growth pattern of stolon in the ideal environmental conditions.

When the terminal shoot apex of primary stolon was damaged mechanically, the secondary stolon was distributed differently. As the shown in Fig. 5., the rate of right branch at the first node after the damaged region was 21%, the left branch 16%, and the opposite branch 23%, therefore, total branching rate was 62%. Although the branching rate has little difference between the opposite and alternate branch, it was highly increased at the first node after damaged region.

The change of branching pattern after damage may be considered as a result of wound effect or apical dominance(McIntyre, 1971). And it means that lawn has an adaptability for the proliferation in the individual level of the organism. Several studies reported that the rhizomes of lawn, which were involved in guerilla type having a low interaction between ramets, have a growth pattern changed by environments(Leaky and Chancellor, 1977 ; Cleg, 1978 ; Lovet-Doust, 1981 ; Choung, 1988). Therefore, it may be considered that the branching pattern of stolons in lawn, which was specifically determined by the genetic character, was expressed by using the temporal and spatial resources. To reveal the branching mechanism in the molecular level, it may be necessary to study the hormonal effects on the growth of stolon.

적 요

한국 잔디의 匍匐莖 생장과 分枝 형태를 야외 조건에서 직접 조사한 연구 결과는 다음과 같다.

1. 잔디의 약 80%가 1개의 原匍匐莖을 가지며, 여러개의 原匍匐莖을 가진 것 중에서 30%가 2개, 63%는 3개, 7%는 4개의 原匍匐莖을 가진다.
2. 匍匐莖과 側芽 사이의 각은 포복경의 頂芽로부터의 마디 순서에 따라 0°에서 52°까지 증가하며, 7번째 마디에서 최대각에 도달하였다.
3. 節間 길이는 匍匐莖의 중간 지점에서 가장 길게 나타났으며, 계절에 따라 다른 節間 길이의 생장율은 5월부터 9월까지 증가하였다.
4. 原匍匐莖과 1次 匍匐莖 사이의 分枝角은 44°에서 53°사이이며, 왼쪽 분지각의 평균은 48.2°, 오른쪽 분지각의 평균은 47.8°로서, 평균 분지각은 48°를 이루었다.
5. 原匍匐莖에서 초기의 1次 匍匐莖이 나타나는 위치는 5월에는 10번째 마디, 7월에는 7번째 마디, 9월에는 5번째 마디에서 가장 높게 나타났으며, 그 중에서도 7월의 7번째 마디에서 초기 分枝率이 가장 높았다.
6. 原匍匐莖의 각 마디에서 1次 匍匐莖을 가지는 비율은 다양하게 나타났지만 7번째 마디에서 가장 높았다.
7. 原匍匐莖의 頂芽가 손상되었을 때, 손상된 부위 다음의 첫 번째 마디에서 分枝를 이루는 비율이 62%로 크게 증가하였다.

본 연구의 결과들은 정상적인 원포복경의 7번째 마디에서 1차 포복경이 48°의 각을 이루며 생

장하기 시작한다는 것을 제안하며, 잔디의 分枝 시뮬레이션을 위한 기초 자료로 사용될 수 있을 것이다.

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