生物生産施設環境(J. Bio. Fac. Env.) 3(1) : 66～71, 1994

Relativeness Between Mineral Element of Soil and Occurrence of Tipburn in Chinese Cabbage

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土壤의 無機成分과 배추의 Tipburn 發生과 關聯性

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Summary

In order to understand the mechanism of the wide occurrence of tipburn phenomenon in Chinese cabbage grown under protected cultivation, Chinese cabbage cultivated in two experimental plots was analyzed based on the distribution of some mineral elements by region in the plant and in the soil. The following results were obtained:

1) The occurrence of tipburn is not related to the concentration of Ca in the soil.

2) The concentration of Ca by region in the plant increased in the order such as inner leaf < middle leaf < outer leaf and inner vein < middle vein < outer vein.

3) From this results the cause of occurrence of tipburn phenomenon in Chinese cabbage which occurred at fixed times in the growth and development of the plant can be controlled by modifying environmental factors in order to prevent excessive transpiration in the inner leaf.

Key words : chinese cabbage, tipburn, calcium
키 워 드 : 배추, 팁번, 칼슘

Introduction

Chinese cabbage is one of the most highly consumed vegetables in Korea. In a period of five years from 1986 to 1990, annual consumption of vegetable is 113.8kg/person and the average consimption of Chinese cabbage alone is 36.7kg which accounts for 32% of the total vegetable consumption[5]. Chinese cabbage is mainly processed and consumed as *kimchi*, and in recent years, the trend in making *kimchi* has gradually shifted from the traditional home－made preparation to mass production and commercialization. This is ascribed to become urbanization as well as a gradual change in the basic structure of the nuclear family and lifestyle of the consumers.

Because of these changes in trend for processing *kimchi*, there has been a high demand for fresh Chinese cabbage in the market throughout the year. Consequently, there has been a lot of studies on year－round cultivation of Chinese cabbage. In order to accomplish year－round production of

Chinese cabbage from summer and winter encompassing through spring, protected cultivation under greenhouse conditions has been mainly studied. In general, the problem that is normally encountered in summer cultivation of lowland Chinese cabbage is not only the heading due to high temperature but also the damage due to diseases and insect pest. Moreover in rainy season, the damage caused by soft rot comprise a considerable loss in production. Furthermore, in the case of continuous dry weather, virus infection may become so severe and may totally eliminate the crop. On the other hand, in protected cultivation of Chinese cabbage from winter to spring in which plants are subjected to thermal insulation under greenhouse conditions, a major problem is the occurrence of the so-called tipburn phenomenon which results in browning of the tip of the leaves. This may eventually lead to reduced marketability of Chinese cabbage cultivated under these conditions.

The tipburn phenomenon has been attributed to calcium deficiency in the plant. In general, several studies have shown that the tipburn phenomenon maybe directly or indirectly caused by the following:

1) absorption factor of calcium in the culture medium due to insufficient amount of calcium in the soil or medium itself, unbalanced cation and anion concentration, or unsuitable pH of the medium:

2) there is enough calcium in the soil or medium but the factors controlling transport of this mineral to the plant such as the presence of high salt concentration in the medium, the low level of oxygen concentration in the rhizosphere, daytime high humidity and dehydration, and high temperature are limitting;

3) calcium absorption as well as translocation within the plant is enough but the calcium supply in tissues or organs where required is insufficient or unbalanced as a result of water deficiency in tissues with very little transpiration or in tissues undergoing rapid growth and development.

In the present study, in order to clarify the mechanism of occurrence of tipburn phenomenon on Chinese cabbage under protected cultivation from winter to spring, two zones for protected cultivation were selected and the amount of mineral elements in the soil as well as the distribution of mineral elements associated with the development of Chinese cabbage were analyzed.

Materials and Methods

The experiment was conducted in two areas (refered here as Farm A and Farm B) of protected cultivation farm in Anseong Kun, Kyungki Do. Sowing was done in January 7, 1993, and transplanting was done in February 14. The Palgong variety(Kyung shin Seed Co.) of Chinese cabbage was used and the method of cultivation, fertilization and culture management followed the standard procedure of the National Horticulture Research Institute. The Farm A facilities consisted of a polythylene film house with a width of 4.8m, height of 1.9m and a total surface area of 420sq.m. Farm B also consisted of a polyethylene film house with a width of 5.0m, height of 2.0m and total surface area of 650 sq.m. Soil and plant analysis was done at ten days interval after transplanting and each replicate consisted of three samples. The experimental design used was the randomized block design with three replications. The leaves were collected for sampling and classified into three sections namely the inner leaf, the middle leaf and the outer leaf. The soil sample was detected using 1N NH_4OAC(pH 7), and the plant samples were analyzed by region after degrading in ternary solution consisting of HNO_3:H_2SO_4:$HClO_4$ at a ratio of 10:1:4. The samples were analyzed in an atomic extinction machine.

Results and Discussion

The changes in the concentration of Ca, K and Mg of the soil during the experimental period is shown in Fig. 1.

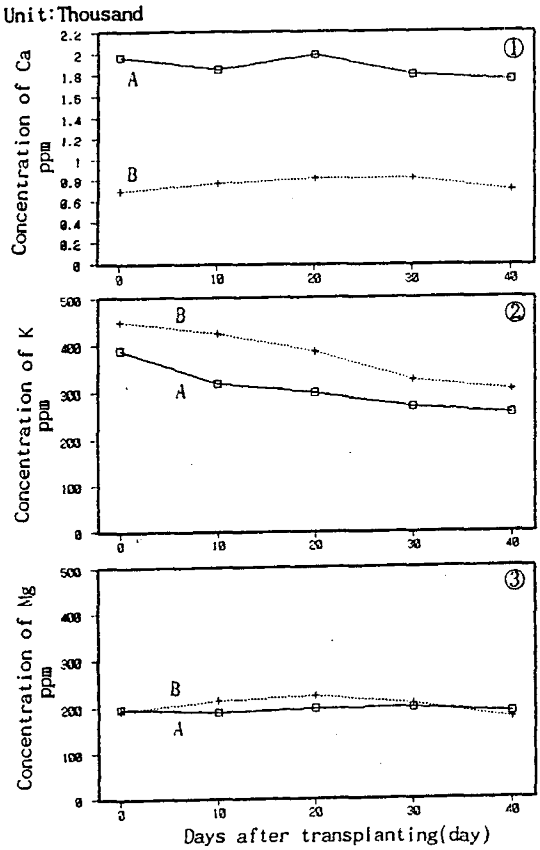

Fig. 1. Changes in calcium concentration①, potassium concentration②, magnesium concentration③ in soils. Each value is the mean of nine samples. Tipburn occurrence(A), Normal(B).

The tipburn phenomenon in Chinese cabbage was observed in Farm A. The concentration of Ca in the soil in The Farm A was higher than that in Farm B. However not much difference was observed in the concentration of K and Mg. This shows that the tipburn phenomenon may result directly from the Ca concentration in the soil more than the cultivation conditions and other factors related to the environment. Although the mechanism of physiological damage dur to tipburn is not yet well understood. Ca deficiency causes the young cells around the meristematic region of the leaves to stop growing resulting in the browning of the tip of the leaves[8].

Depending on the growing season, the concentration of Ca in the different regions of the leaf also varied in a order of the inner leaf < the middle leaf < the outer leaf. In the same manner the concentration of Ca in the leaf veins showed the same order as inner vein < middle vein < outer vein. The root however, showed a very low concentration of Ca. In particular the transpiration rate in the inner leaf was not as high[1] as the outer leaf and middle leaf and surrounding areas, so that the Ca concentration in the inner leaf was about 1/3 of the outer leaf. This trend was observed all throughout the growing period from 0−40 days after transplanting(Table 1).

There was no difference in the Ca concentration of the different plant parts in Farm A where a high incidence of tipburn was observed as compared with Farm B where normal growth was observed. However at 30−40 days after transplanting, the outer leaf as well as the outer veins in Farm A showed a highter Ca concentration as compared with outer leaves and veins in Farm B (Table 1).

Within the plant, Ca passes through the sieve tube, but there was no shifting so that it was transported via vessel translocation resulting in reduced level of transported Ca[1,2,3,8]. Transpiration occurred faster in actively growing regions such as the outer leaf resulting in partitioning, however Ca is partially partitioned and shows the physical partitioning of Ca in the plant.

In plants, studies on physiological properties of Ca included the role of this element in cell wall rigidity maintenance of intetgrity strength of the cell membrane[6,7], controlling in water permeability of

Table. 1. Concentrations of calcium of mineral element in dry matters of outer leaves, middle leaves, inner leaves, outter veins, inner veins and roots of Chinese cabbage. Each value is the mean of nine plants. Tipburn occurrence(A), Normal(B).

(unit: %)

Days after transplanting	0	10	20	30	40
Outer leaf (A)		1.4±0.08	1.4±0.1	2.7±0.2	2.8±0.1
Middle leaf	1.7±0.1	1.0±0.1	1.1±0.08	1.1±0.1	1.4±0.2
Inner leaf		0.3±0.04	0.6±0.04	0.7±0.05	0.6±0.08
Outer vein		1.2±0.05	1.2±0.01	1.9±0.1	2.0±0.1
Middle vein	1.4±0.08	1.0±0.07	0.0±0.1	1.0±0.01	1.3±0.06
inner vein		0.3±0.02	0.6±0.04	0.7±0.01	0.5±0.02
Root	0.08	0.2±0.08	0.5±0.04	0.6±0.03	0.7±0.09
Outer leaf (B)		1.2±0.06	1.5±0.06	2.3±0.2	2.2±0.2
Middle leaf	1.3±0.1	1.1±0.06	1.3±0.04	1.1±0.2	1.1±0.2
Inner leaf		0.4±0.01	0.7±0.2	0.6±0.1	0.7±0.08
Outer vein		1.2±0.07	1.1±0.1	2.0±0.1	1.5±0.2
Middle vein	1.2±0.07	1.1±0.09	1.0±0.07	1.1±0.1	1.0±0.07
Inner vein		0.4±0.02	0.7±0.06	0.6±0.04	0.6±0.08
Root	0.06	0.2±0.02	0.5±0.04	0.7±0.1	0.7±0.09

the cell membrane[11], adjustment of translocation of photosynthate[10] and regulation of senescence. In particular the decrease in physiological activity of aging organs accompanied by an increase in the concentration of Ca[4,9] suggest the complexity in the translocation and accumulation of Ca. The major cause of the occurrence of tipburn phenomenon in Chinese cabbage grown under protected cultivation from winter to spring can be attributed to the environmental factors preventing the translocation of Ca around the growing point of the young cells of the middle leaf. Furthermore, this can also be attributed to distinctive environmental factors in this cropping period such as the severe diurnal variatione, high humidity, lack of ventilation, although the direct interaction of these phenomena is not yet well established.

There was no difference in the concentration of K and Mg, which are translocated through the vessels and the sieve tube (Table 2,3)

The K concentration in the plant was ablut 5% which was 5 times higher than the average concentration of Ca in the plant. However the Ca concentration in the soil was about 2−3 times higher than the K concentration. This shows that Ca absorption in the rhizosphere did not proceed as smoothly as K absorption in the rhizosphere. Furthermore the absorbed Ca in the plant is distributed depending on the inside physiological metabolism and outside environment that may have resulted in unequal partitioning in the different parts of the plant[1].

Therefore, tipburn which results from Ca dificiency can be prevented, first, by ensuring that the Ca which is incorporated in the soil or culture medium is properly regulated to attain maximum absorption from the underground parts. Secondary, the proper content of Ca to be absorbed should be incorporated at the appropriate time so that

Table. 2. Concentrations of potassium of mineral element in dry matters of outer leaves, middle leaves, inner leaves, outter veins, inner veins and roots of Chinese cabbage. Each value is the mean of nine plants. Tipburn occurrence(A), Normal(B).

(unit: %)

Days after transplanting	0	10	20	30	40
Outer leaf(A)		5.0±0.2	5.4±0.2	5.6±0.7	6.2±0.3
Middle leaf	6.0±0.1	5.6±0.7	5.5±0.07	5.6±0.7	5.6±0.3
Inner leaf		3.2±0.9	5.2±0.2	5.0±0.2	4.9±0.5
Outer vein		8.6±0.9	8.5±0.1	9.2±0.4	9.4±0.3
Middle vein	7.0±0.04	8.5±0.3	7.6±0.5	7.6±0.3	8.2±0.3
Inner vein		7.4±0.4	5.6±0.2	6.2±0.3	7.6±0.2
Root	2.3	1.8±0.1	4.5±0.3	4.1±0.2	4.7±0.3
Outer leaf(B)		3.4±0.1	5.2±0.3	5.5±0.2	5.5±0.1
Middle leaf	5.6±0.4	3.4±0.1	6.0±0.3	5.3±0.1	4.9±0.5
Inner leaf		3.5±0.2	5.8±0.3	5.6±0.7	5.2±0.2
Outer vein		8.9±0.5	8.6±0.1	9.4±0.3	9.5±0.9
Middle vein	7.8±0.7	7.9±0.4	8.2±0.3	7.6±0.1	7.8±0.4
Inner vein		6.6±0.3	7.0±0.1	5.8±0.2	7.6±0.4
Root	2.8	2.1±0.2	3.2±0.2	4.2±0.4	4.2±0.1

Table. 3. Concentrations of magnesium of mineral element in dry matters of outer leaves, middle leaves, inner leaves, outter veins, inner veins and roots of Chinese cabbage. Each value is the mean of nine plants. Tipburn occurrence(A), Normal(B).

(unit: %)

Days after transplanting	0	10	20	30	40
Outer leaf(A)		0.5±0.02	0.7±0.02	0.6±0.02	0.6±0.01
Middle leaf	0.4±0.04	0.3±0.04	0.4±0.03	0.3±0.02	0.3±0.05
Inner leaf		0.2±0.02	0.3±0.02	0.2±0.01	0.2±0.04
Outer vein		0.4±0.06	0.6±0.02	0.4±0.01	0.4±0.04
Middle vein	0.3±0.04	0.4±0.01	0.3±0.05	0.2±0.01	0.3±0.02
Inner vein		0.3±0.01	0.3±0.02	0.2±0.01	0.2±0.01
Root	0.2	0.3±0.02	0.3±0.02	0.2±0.01	0.2±0.01
Outer leaf(B)		0.5±0.02	0.8±0.02	0.7±0.04	0.8±0.02
Middle leaf	0.5±0.03	0.3±0.05	0.5±0.03	0.4±0.01	0.3±0.02
Inner leaf		0.2±0.03	0.4±0.04	0.2±0.02	0.2±0.01
Outer vein		0.3±0.02	0.5±0.06	0.4±0.02	0.5±0.01
Middle vein	0.3±0.01	0.3±0.01	0.4±0.04	0.3±0.01	0.3±0.03
Inner vein		0.2±0.01	0.3±0.02	0.2±0.01	0.2±0.01
Root	0.3	0.3±0.04	0.3±0.04	0.2±0.03	0.2±0.02

translocation around the growing regions of the inner leaf with the environmental controlling of the above-ground part can be maximized.

적 요

겨울부터 봄에 걸친 배추의 施設保溫栽培에서 많이 發生되는 Tipburn現象의 原因을 究明하기 위하여 배추재배 試驗區의 土壤과 배추의 部位別 無機成分 分析을 했다. 實驗結果는 다음과 같다.

1. Tipburn現象의 發生과 土壤의 칼슘농도와는 關係가 없었다.

2. 배추部位別 칼슘濃度는 內葉<中葉<外葉이었고, 內葉脈<中葉脈<腦葉脈의 順이었다.

3. 以上의 結果로 Tipburn現象의 發生原因은 배추生育의 一定時期에 배추內葉으로부터 蒸散作用을 抑制시키는 어떤 環境要因에 의해 1次的으로 發生된다고 생각된다.

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