[韓作誌(Korean J. Crop Sci.) 39(4) : 366~372(1994)]

Development of Small Vascular Bundles at Different Tillers as Affected by Nitrogen Levels in Rice Plants

Dong Jin Lee* · Benito S. Vergara** · Oscar B. Zamora*** · Ie Sung Shim****
Bong Ku Kim***** and Je Cheon Chae*****

窒素施用水準이 水稻 分蘖莖의 小維管束 發育에 미치는 影響

李東珍* · 베니토 에스 벨가라** · 오스카 비 자모라*** · 沈利星****
金鳳九***** · 蔡濟天*****

ABSTRACT : The experiments were conducted to evaluate the effect of nitrogen application on the development of small vascular bundle in the rice plants. Two cultivars, IR58, an indica type and Unbong 7, a japonica type were used in this study.

The number of small vascular bundles in peduncle of different tillers was increased with the increase of nitrogen level. In the main culm, number of small vascular bundles at higher nitrogen level was increased by 39% in IR58 and 24% in Unbong 7 compared with nitrogen free plot. The main culm had more small vascular bundles in the peduncle and number of small vascular bundle was decreased with later tiller order and tiller development.

The number and cross sectional area of small vascular bundles in flag leaf blade and sheath of main culm were increased with increasing levels of nitrogen.

The number of small vascular bundles in peduncle was highly correlated with the number of spikelets and grain weight per panicle.

Key word : Rice, Small vascular bundle, Peduncle, Nitrogen level

Grains are better filled in panicles with higher number and larger cross sectional area of vascular bundle(VB). The number of VB is proportional to the number of primary branches in the panicle. Grain yield potential can possibly be increased by having more and larger VB.

Nitrogen(N) is an important factor which influences the development of VB.[6] Nitrogen is a principal constituent of plant and accounts for at least one-half of the total number of ions absorbed.[8] It is a structural component of

* 農業遺傳工學研究所(Agricultural Biotechnology Institute, RDA, Suwon 441-707, Korea)
** 國際 벼 研究所(International Rice Reaearch Institute, P. O. Box 933, Manila, Philippines)
*** 필리핀大學校(University of the Philippines at Los Banos College, Laguna, Philippines)
**** 湖南作物試驗場(Honam Crop Experiment Station, RDA, Iri 570-080, Korea)
***** 檀國大學校(College of Agriculture, Dankook University, Cheonan 330-714, Korea)
〈'94. 7. 12 接受〉

chlorophyll, amino acids, enzymes, nucleic acids, plant membranes, plant growth hormones, and a large number of other metabolically important organic compounds within the plant.[2,7]

Lee et al[6] reported that both number and cross sectional area of VB in the internodes increased with N fertilization. Increased N fertilizer application resulted in increased number of VB, number of spikelets per panicle. Wada[9] reported that the number of VB were smaller in the kernels obtained under N probably due to the diminution of cell activity for differentiation into VB in the coleoptile.

This study sought to evaluate the effect of different levels of nitrogen on the development of small vascular bundle in the peduncle, leaf blade and sheath of rice plant.

Materials and Methods

The greenhouse experiment was conducted at International Rice Research Institute (IRRI), Los Banos, Laguna, Philippines in 1989-1990. Rice cultivars used were IR58, an indica type and Unbong 7, a japonica type.

Factorial in completely randomized design (CRD) with 3 replications were used for this experiment. Ammonium sulfate(21% N) was the source of nitrogen, and applied at 0, 2, 4, 8 g/pot containing 3. 5Kg Maahas soil. The nitrogen rate of 4g ammonium sulfate per pot is the standard for greenhouse study in the Plant Physiology Department, IRRI. Phosphorus (solophos) and potassium (muriate of potash) were applied at 2g each.

Tiller production was monitored and sampling was by tiller order. Peduncle, flag leaf blade and leaf sheath from the two cultivars were sampled for measuring small vascular bundle. For the leaf blade and leaf sheath the widest part of the middle region and the portion 1 cm from auricle were collected. The materials were fixed in 80% ethylalcohol solution. The free-hand transverse section were made. The number and cross sectional area of small vascular bundle were determined from peduncle, leaf blade and leaf sheath using a microscope.

Spikelet number per panicle, fertility and 1,000 grain weight were determined. Grain weight per panicle was at 14% moisture content. Data were analyzed by ANOVA and the Least Significant Difference(LSD) or Duncan's Multiple Range Test(DMRT).

Results and Discussion

Rice plants were grown in four levels of nitrogen:0g(NO), 2g (N1), 4g (N2) and 8g/pot (N3). The vascular bundle of the rice plant links the leaf, stem and panicle, and is the complex tissue through which organic material, water, and nutrients are transported.[3] There are two types of vascular bundles : small vascular bundle(SVB) are located near the epidermis and often referred to as outer vascular bundle while the large vascular bundle(LVB) or inner vascular bundle are located towards the center.[4] In both IR 58 and Unbong 7, the number of small vascular bundles in peduncle was significantly increased with the increase in nitrogen(N) level (Fig. 1). In the main culm(M) of IR 58, the number of SVB was increased by 39% from 16.0 at N0 to 22.3 at N3. Likewise, in Unbong 7, the number of SVB was increased by 24% from 22.0 at N0 to 27.3 at N2. This result agree with earlier report of Lee et al.[6] that number of VB in internodes was increased with nitrogen fertilization. The maximum in-

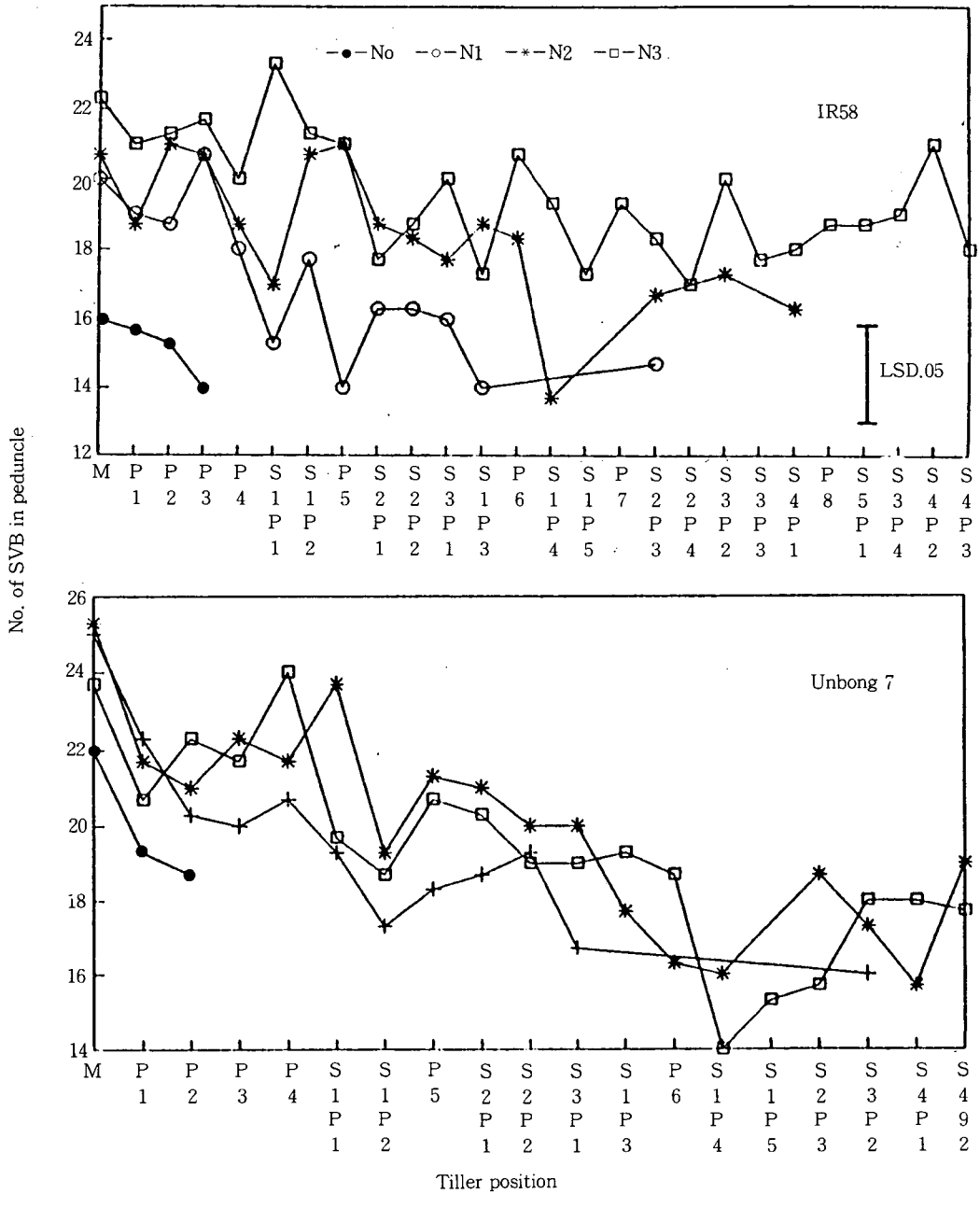

Fig. 1. Number of small vascular bundles(SVB) in the peduncle at different tillers(arranged in development order) as affected by four levels of nitrogen in IR58 and Unbong 7. Vertical bars indicate LSD at P.05 to compare all treatment means.

crease in SVB was at N2 and N3 in the main culm and in early initiated tillers. At N0 level, the few tillers developed had SVB ranging from 14.0 to 16.0 in IR 58 and 18.7 to 22.0 in Unbong 7. The numbers of SVB in the main culm, primary and secondary tillers were sig-

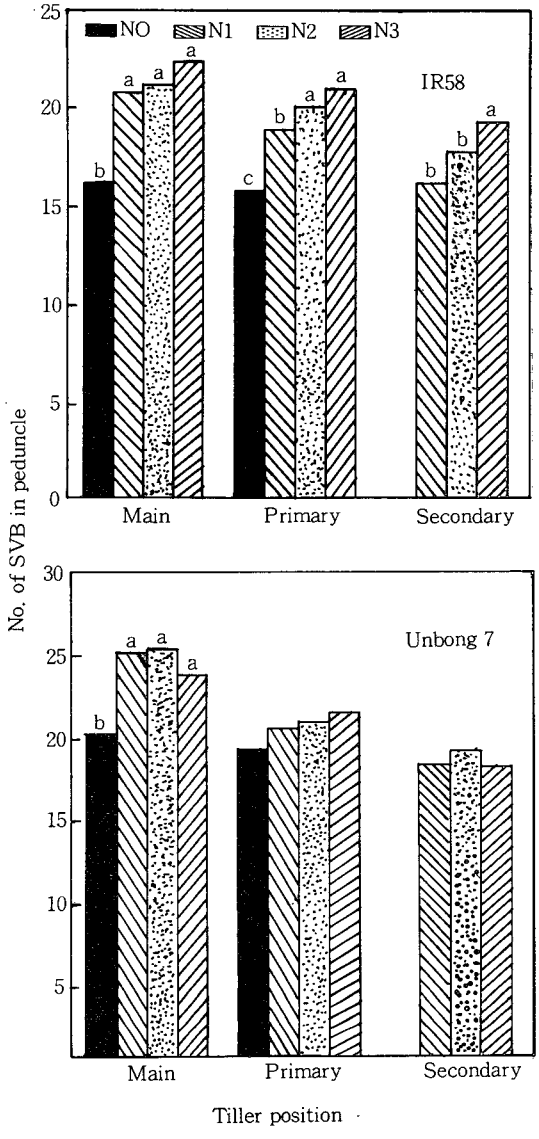

Fig. 2. Number of small vascular bundles (SVB) in the peduncle at different tiller positions as affected by four levels of nitrogen in IR58 and Unbong 7. Means with the same letter within a tiller position is not significantly different at the 5% level by DMRT.

nificantly increased with increasing N level in IR 58 but Unbong 7 was significantly increased in main culm with increasing N level(Fig 2).

On the other hand, the numbers of SVB in flag leaf blade and sheath of the main culm were increased with increasing N level in both cultivars(Table 1). In IR 58, the number of SVB in the main leaf blade was increased from 46.0 to 61.3, while in Unbong 7 was increased 47.3 to 57.7. The increased rate of SVB number in leaf sheath of main culm at N1, N2 and N3 compared to N0 was 7, 18 and 23% for IR 58 and 9, 13 and 18% for Unbong 7, respectively. IR 58 had more SVB in the main leaf blade and sheath than Unbong 7.

Table 1. Number of small vascular bundles in the leaf blade and sheath of the main culm as affected by four levels of nitrogen in IR58 and Unbong 7

N-level	No. of small vascular bundles			
	Leaf blade		Leaf sheath	
	IR58	Unbong 7	IR58	Unbong 7
N0	46.0 b	47.3 b	18.7 b	17.7 b
N1	58.7 a	54.7 a	20.0 b	19.3 ab
N2	61.0 a	57.7 a	22.0 a	20.0 a
N3	61.3 a	56.7 a	23.0 a	20.0 a
F-value Cultivar	5.60*		22.22**	
F-value N-level	27.88**		17.85**	
F-value Interaction	1.46ns		2.22ns	

*, ** means are significantly different at 5% and 1% level, respectively. Means followed by a common letter in a column are not significantly different at the 5% level by DMRT.

The cross sectional areas of the SVB in the peduncle of the main culm, leaf blade and leaf sheath were significantly increased with increasing levels of N in IR 58 and Unbong 7 (Table 2). The cross sectional area of SVB in the peduncle of the main culm increased in IR 58 (1.66 to 2.74$\times10^{-3}$mm^2) and in Unbong 7(1.76 to 2.16$\times10^{-3}$mm^2) as the level of N was increased. However, the significant increase was only from N0 and N1 to N2 and N3. Increasing the N level also increased the cross sectional area of SVB in the leaf blade of the main culm (0.65 to 0.97$\times10^{-3}$mm^2) in IR 58 and (0.34 to 0.79$\times10^{-3}$mm^2) in Unbong 7. In

Table 2. Cross sectional area of small vascular bundle in the peduncle, leaf blade, and leaf sheath of the main culm as affected by four levels of nitrogen in IR58 and Unbong 7

Cultivars	N-level	Total area of vascular bundle ($\times 10^{-3}mm^2$)		
		Peduncle	Leaf blade	Leaf sheath
IR58	N0	1.66 c	0.65 b	1.33 b
	N1	2.01 b	0.84 a	1.46 a
	N2	2.54 a	0.97 a	1.49 a
	N3	2.74 a	0.88 a	1.48 a
Unbong7	N0	1.76 b	0.74 b	0.92 c
	N1	2.52 a	0.75 b	1.14 bc
	N2	2.61 a	0.79 a	1.21 ab
	N3	2.55 a	0.76 ab	1.39 a
F-value	Cultivar	2.39^{ns}	0.72^{ns}	25.01^{**}
	N-level	29.09^{**}	8.51^{**}	5.66^{**}
	Interaction	3.24^{*}	5.22^{*}	1.43^{**}

*, ** means are significantly different at 5% and 1% level, respectively. Means followed by a common letter in a column are not significantly different at the 5% level by DMRT.

the leaf sheath of main culm, cross sectional area of SVB showed 1.33 to 1.49($\times 10^{-3}mm^2$) for IR 58 and 0.92 to 1.39($\times 10^{-3}mm^2$) for Unbong 7, respectively. IR 58 had bigger SVB than Unbong 7. Higher nitrogen levels increased the number and cross sectional area of VB in the peduncle, leaf blade and sheath. The higher number and larger cross sectional area of VB would be the advantage of modern high yielding cultivars. The advantage probably lies in the more efficient transport of assimilates from the leaf and stem to the developing reproductive organs.

The number of SVB was highly correlated with the number of spikelets and grain weight per panicle (Fig. 3). This findings agree with report of Chae et al.[1] that the number of small and large vascular bundles in peduncle was highly correlated with the number of spikelets. Lee et al.[6] reported that the number of large vascular bundles in peduncle was highly correlated with the number of primary and secondary branches and spikelet number. Joarder and Eunes[5] reported that one large vascular bundle was needed to form one primary branch. This results implied that higher number of SVB in peduncle can be produced more spikelet number and grain weight per panicle. Although higher SVB number is generally a cultivar characteristics, cultural factors such as nitrogen management can improve the development of vascular bundle. Optimum nitrogen management increase the number of SVB in IR58 and Unbong 7. Small VB is responsible for the transport of assimilates. Higher number of SVB can produce higher spikelets which in turn resulted in increase grain yield potential.

摘 要

本 實驗은 窒素施用 水準이 水稻의 이삭줄기, 葉身 및 葉鞘의 小維管束 發育에 미치는 影響을 究明하여 收量을 增大시킬 수 있는 方案을 모색하기 위하여 '89~'90년에 國際벼硏究所 (IRRI)에서 印度型인 IR 58과 日本型인 운봉 7을 供試하여 修行하였다.

1. 分蘖莖의 穗首節間에 發達된 小維管束數는 窒素施用 水準이 增加할수록 有意하게 增加되는 傾向이었으며, 主稈의 경우 窒素 無施用區에 비하여 窒素施用區에서 IR 58은 39% 및 운봉 7은 24% 增加하였다.
2. 主稈 및 일찍 出現된 1, 2次 分蘖莖의 發育 順序로 小維管束數가 많이 發育되어 있었으며, 分蘖莖의 出現이 늦을수록 維管束의 發育이 低下 되었다.
3. 主稈의 穗首節間, 葉身및 葉鞘의 小維管束發育은 窒素 無肥區 및 小肥區에 비하여 窒素 增施區에서 다소 增加하는 傾向이었다.
4. 穗首節間의 小維管束數는 이삭당 穎花數 및 粒

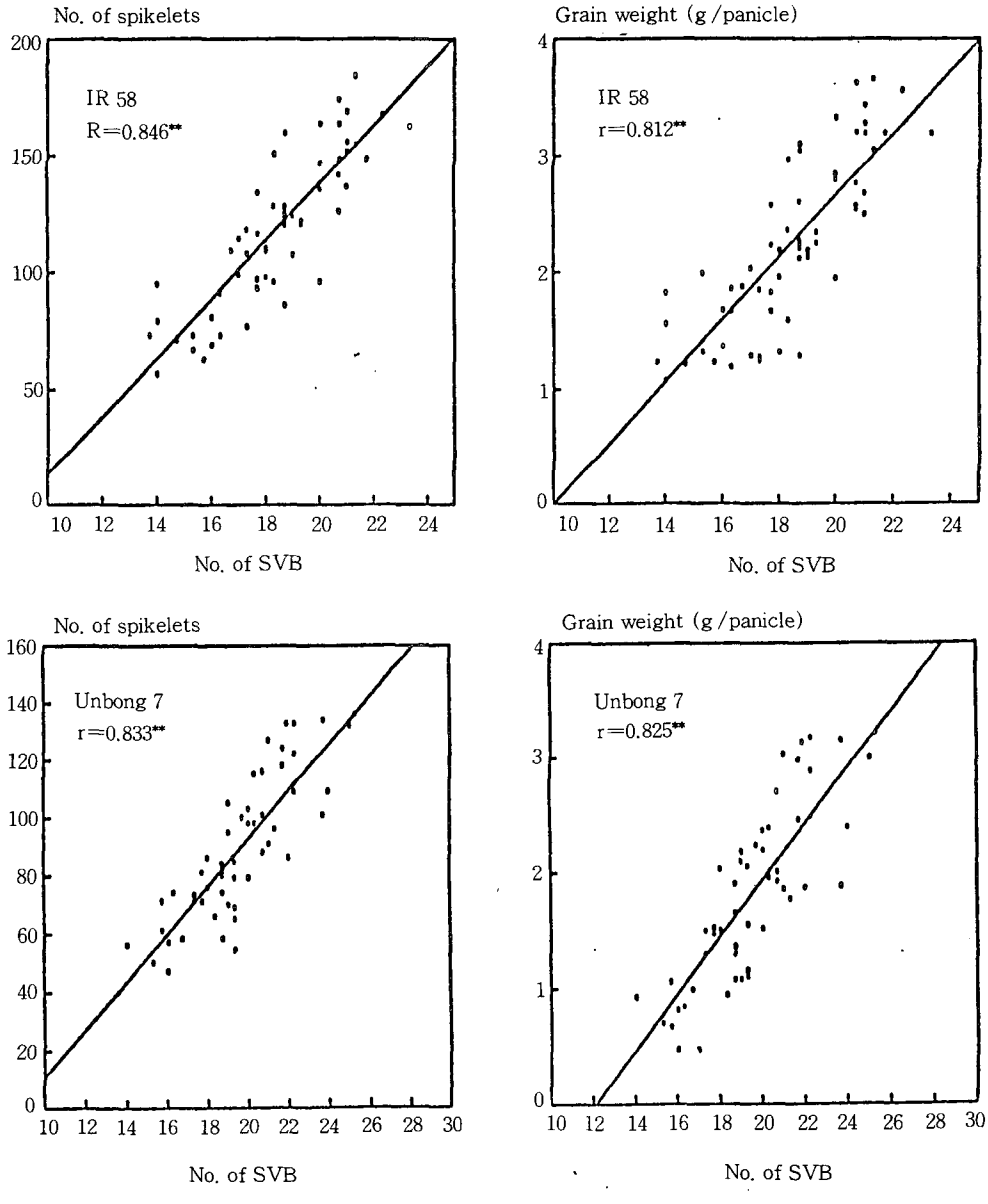

Fig. 3. Correlation coefficients between number of small vascular bundles (SVB) and number of spikelets and grain weight per panicle in IR58 and Unbong 7.

重과 밀접한 正의 相關關係를 나타냈으며, 이는 줄기에 發達된 小維管束이 穎花數의 分化와 깊은 聯關性을 가지고 있으며, 發達된 維管束을 통해 養水分 轉流가 원할히 이루어져서 결국 이삭당 粒重도 增加되는 結果를 보였다.

Literature Cited

1. Chae, J.C., B.K. Kim and D.J. Lee. 1984. A study on the development of internodal vascular bundles and air spaces, and its

realtionships to panicle characteristics of rice varieties. Korean J. Crop Sci. Soc. 29 (4):356-361.
2. Devlin, R.M. 1975. Plant physiology. New York: D. Van Nostrand Company. 600 p.
3. Esau, K. 1977. Anatomy of seed plants. John Wiley and Sons, New York. 550 p.
4. Hoshikawa, T. 1989. The growing rice plant: An anatomical monograph. Tokyo, Nosan Gyoson Bunka Kyokai. 310 p.
5. Joarder, N. and A.M. Eunus. 1980. Correlation of vascular bundle and panicle characters in rice. Kalikasan, Phillip. J. Biol. 9:93-95.
6. Lee, D.J., K.J. Kim, J.H. Lee, B.K. Kim and J.C. Chae. 1985. The effect of nitrogen fertilization on vascular bundles and air space development in the internodes of several rice varieties and the relationship between the histological structure and panicle characteristics. Korean J. Crop Sci. Soc. 30:107-115.
7. Meyer, B.S., B.B. Anderson and R.H. Bohning. 1973. Introduction to plant physiology, London: D. Van Nostrand Company. 565 p.
8. Reisenauer, H.M. 1978. Absorption and utilization of ammonium nitrogen by plants. In nitrogen in the environment (Nielsen, R. and J.G. MacDonald, eds.). 2:157-170.
9. Wada, K. 1954. Observations on the occurrence of highly-numbered vascular bundles in coleoptile of rice plant. Proc. Crop Sci. Soc. Japan 23(1):6-9.