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Effect of Grain Specific Gravity on Seedling Growth and Vascular Bundle Development of Two Rice Cultivars

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벼種子의 比重差異가 幼苗生長 및 維管束 發達에 미치는 影響

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ABSTRACT : High density (HD) grains is associated with seedling vigor. Studies were conducted on the relationship of different grain densities and vascular bundle (VB) development and seedling growth. IR58 (indica type) and Unbong 7 (japonica type) were used in this experiment. HD grains had more and bigger VB in the leaf blade and sheath than poor density grain at seedling stage. IR58 had more large VB at the leaf compared with Unbong 7. Higher development of VB in seedling of HD grains can increase transport of assimilate and growth rate. Plant height, leaf number, root growth and dry weight increased with increasing grain density from poor to high.

The total area of large VB in the leaf blade and sheath was highly correlated with the dry weight. Higher number and larger area of VB and dry weight can be obtained by using HD grains and these initial advantages can contribute to high yield potential.

Key words : Rice, Specific gravity, Vascular bundle, Development, Seedling growth

The better seedling growth of high density (HD) grains may result in more or bigger vascular bundles (VB) which in turn may result in better growth. Higher VB development can means more efficient transport of assimilates from the leaf to the developing organs. The vigor of rice seeds in terms of seedling growth rate is closely related to specific gravity of the seed[6].

HD grains have not only higher volume and weight[8] but also higher seedling vigor[1]. By using HD grains, seedling growth can be increased by 25 to 50%[1]. Grain density is highly correlated with dry weight of rice seedling[2]. Seedling from heavy seeds tillered more rapidly and produced more and larger panicles and heavier grains and higher yield than light seeds[7].

An understanding of the development of the VB system and the role of HD grains in producing a better VB system can contribute to the general effect of increasing further the grain yield potential of rice. However, little is known on the effect of HD grains on

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the development of VB.

This study assess the effect of grain density on VB development and relationship between VB development and seedling growth.

MATERIALS AND METHODS

Seeds of IR58 (indica type) and Unbong 7 (japonica type) were graded according to their specific gravity as proposed by Venkateswarlu et al.[9]: very poor density grain (< 1.00), poor density grain (1.00~1.06), average density grain (1.08~1.14), good density grain (1.16~1.20), and HD grain (>1.20). Germinated seeds were sown in 4-liter pots containing 3.5kg puddled Maahas clay soil mixed with 4g ammonium sulfate (21% N), 2g of solophos (18% P_2O_5) and 2g of muriate of potash (60% K_2O). The plants were grown in the Internationl Rice Research Institute (IRRI) green house.

The widest part of the leaf blade and sheath (1cm from the auricle) were sampled when the 6th leaf emerged. The materials were fixed in FAA solution (50ml ethyl alcohol, 10ml formaldehyde, 5ml acetic acid and 35ml distilled water). The materials were fixed for 24 to 48 hours. The air from the fixing fluid and samples was drawn out with a vacuum pump. After fixing, they were washed in running tap water for 5 to 6 minutes each and free-hand transverse sections were made. Hematoxylin were used for staining and the samples were mounted with canada balsam. Number and cross sectional area of large vascular bundles (LVB) in leaf blade and sheath, plant height, leaf number, root number, root length and dry weight were recorded. The experiment was conducted in two factorial design (2 cultivars and 5 grain densities) in CRD with 3 replications.

RESULTS AND DISCUSSION

1. Development of vascular bundle

The number of LVB in the 5th leaf blade of the seedling HD grains was significantly higher than the seedling from very poor density grains (Table 1). Although not statistically significant, the seedling from HD grains of IR58 had the highest number of LVB. The cross sectional area of LVB as well as its components phloem and xylem was larger in heavier grains than in lower density grains. IR58 generally had more and bigger area of VB then Unbong 7.

The leaf sheaths had more LVB than the leaf blade (Table 2). The number and cross sectional area of LVB had similar pattern as those in the leaf blade. The higher number of LVB and larger cross sectional area both leaf blade and sheath indicate a better transport

Table 1. Number and cross sectional area of large vascular bundles (LVB) in the 5th leaf blade

Grain density	No. of LVB		Area of LVB (10^3mm^2)	
	IR58	Unbong 7	IR58	Unbong 7
Very poor	6.3b	5.3b	1.93c	1.77c
Poor	7.0ab	6.3b	2.36b	2.03b
Average	7.0ab	7.0a	2.37b	2.36a
Good	7.0ab	7.0a	2.48ab	2.36a
High	7.3a	7.0a	2.68a	2.37a

Means followed by a common letter in a column are not significantly different at the 5% level by DMRT

Table 2. Number and cross sectional area of large vascular bundles

Grain density	No. of LVB		Area of LVB ($10^{-3}mm^2$)	
	IR58	Unbong 7	IR58	Unbong 7
Very poor	8.0c	7.7b	2.23c	2.57b
Poor	9.0b	8.3b	2.99b	2.76b
Average	9.3b	8.3b	3.46ab	2.95ab
Good	10.0a	8.7b	3.65a	2.98ab
High	10.0a	9.3a	3.67a	3.46a

Means followed by a common letter in a column are not significantly different at the 5% level by DMRT

Table 3. Dry weight of seedlings at different grain density in 5th leaf stage

Grain density	Dry weight (mg/plant)			
	IR58	(%)	Unbong 7	(%)
Very poor	47c	(100)	42c	(100)
Poor	65b	(138)	47bc	(112)
Average	76ab	(162)	56ab	(140)
Good	77ab	(164)	59a	(133)
High	80a	(170)	66a	(157)

Means followed by a common letter in a column are not significantly different at the 5% level by DMRT

system for photosynthetic assimilation to the growing point and sink[10].

The higher number and cross sectional area of LVB with higher grain density can affect the subsequent growth of the rice seedling. The HD grains more VB compared to the poor density grains probably as a result of more nutrients available from the endosperm and the efficient enzymatic action which are needed for the development of VB.

2. Seedling growth characters

With increasing grain density, plant height significantly increased 23.3~29.0cm and 27.6~37.5cm for IR58 and Unbong 7, respectively (Fig. 1). These results agree with the report that seedlings raised from good and HD grains were significantly taller than those from poor dentisty grains[5].

The leaf number of IR58 and Unbong 7 increased with increasing grain density indicating that the plastochron interval is shorter in HD grains. The number of roots increased as grain density increased but was not statistically significant expect in the very poor density grains. Total root length was significantly longer in both cultivars with increase in grain density. All these findings generally agree with the earlier report[1] that plant height, leaf number, root number and root length had heigher in HD grains than in low density grains.

Dry weight of the two cultivars significantly increased with increasing grain density (Table 3). IR58 had higher dry weight than Unbong 7. The increase in dry weight from very poor to average, good and HD grains compared to very poor was 38, 62, 64 and 70% for IR58 and 12, 33, 40 and 57% for Unbong 7, respectively. Arain[1] reported that the average increase in dry weight was 73% higher in HD grain than lower density grain 20 days after seedling emergence.

3. Relationship between development of LVB and growth characters

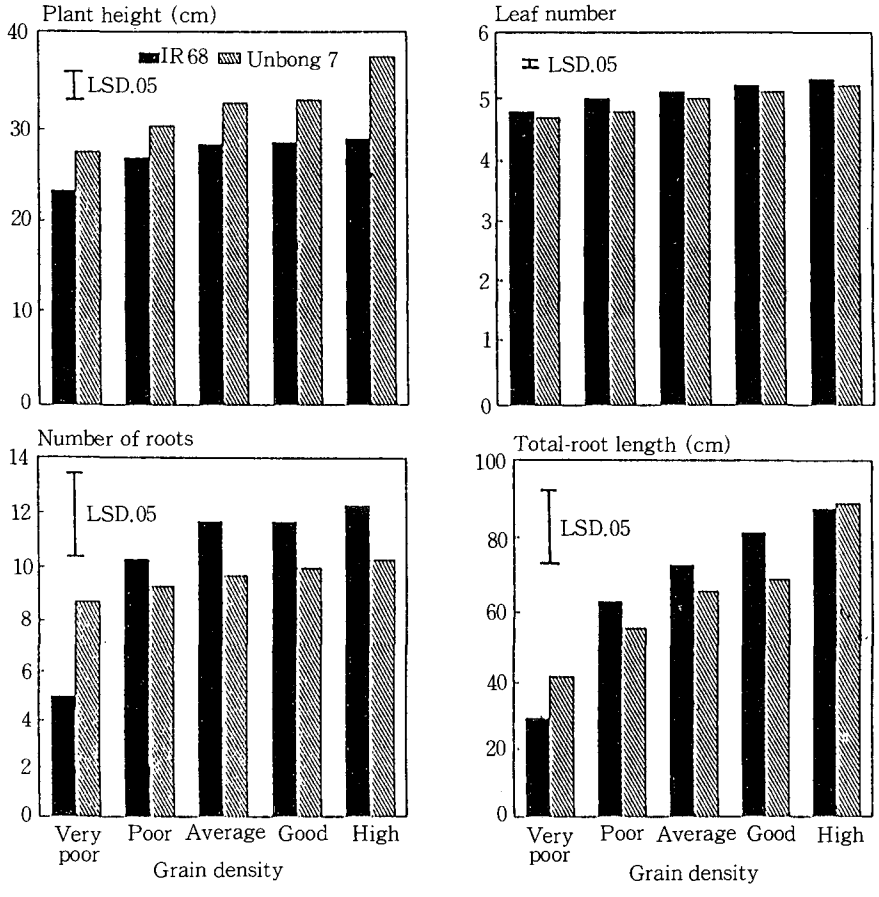

Fig. 1. Morphological characteristics of shoot and root at different grain density.

Dry weight was significantly correlated with the development of vascular bundle in the 5th leaf blade and sheath(Table. 4) Increasing the total cross sectional area of LVB can increase dry weight since LVB is responsible for the transport of assimilates.

The number of LVB of the leaf blades was closely correlated with the width of the leaf blades (Table 5). In IR58, the width of leaf blade was significantly correlated with the number of VB in the 4th and 5th leaves but from the 3rd to the 5th leaf in Unbong 7. Th-

Table 4. Correlation coefficients between the total dry weight and number of large (LVB) and small (SVB) vascular bundles in leaf blade and sheath

	Leaf blade		Leaf sheath	
Cultivars	No. of LVB	No. of SVB	No. of LVB	No. of SVB
IR58	5.559*	0.707**	0.799**	0.723**
Unbong 7	0.630**	0.644**	0.651**	0.704**

* : Significant at the 5% level
** : Significant at the 1% level

Table 5. Correlation coefficients between the number of large vascular bundles (LVB) and width of leaf in IR58 and Unbong 7

Cultivars	No. of LVB in leaf blade			
	2nd	3rd	4th	5th
IR58	0.428ns	0.331ns	0.838**	0.586*
Unbong 7	0.378ns	0.600*	0.515*	0.612*

ns : Non significant
* : Significant at the 5% level
** : Significant at the 1% level

is indicates that wider leaves have more VB development.

In screening rice breeding materials for higher VB to increase the number of primary branches in the panicle and increase efficiency of assimilate transport[10], the wider leaves at seedling stage may be used as criteria. The consistently higher LVB of IR58 at seedling stage was also reflected in higher development of VB at flowering and among tiller orders compared to Unbong 7[4]. The seedling traits show the importance of HD grains in producing better seedling. HD grains result in more and larger area of LVB. This high number and large area of LVB is maintained at all growth stages, it may higher grain yield potential. The number of LVB is correlated with the number of panicle branches and number of spikelets[3] The use of HD grains can provide an early start for higher VB development.

摘 要

本 實驗은 比重選으로 種子密度를 5 等級으로 細分한 뒤 각 等級別 幼苗의 維管束 發達 및 生育特性에 미치는 影響을 究明하기 위하여 인디카型인 IR58과 자포니카型인 雲峰7號를 供試하여 遂行한 結果는 다음과 같다.

1. 種子의 密度가 1.00 以下에서 1.20 以上으로 높아질수록 幼苗의 葉身과 엽초에 發達된 維管束數와 크기가 增加하는 傾向이었다. IR58은 雲峰7號보다 維管束數와 크기가 良好하게 發達하였다.
2. 幼苗의 生育特性인 草長, 葉數, 根數 및 根長은 種子의 密度가 1.20以上까지 높아질수록 增加하였다.
3. 葉身과 엽초에 發達된 維管束數는 乾物重과 高度로 有意한 正의 相關關係를 나타냈으며, 第4, 5 葉身의 大維管束數는 葉身幅과 有意한 正相關을 보였다.
4. 種子의 密度가 높아질수록 幼苗의 維管束 發育을 좋게 하며 養水分의 원활한 이동으로 인하여 生育이 良好하여 건묘육성에 바람직하였다.

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