韓作誌(Korean J. Crop Sci.) 35(3) : 184～194(1990)

Effect of Plant Growth Regulator "*Hoe 78784*" on Lodging in Rice

Sang Chul Lee*, S.K. De Datta**

植物生長 調節劑 Hoe 78784가 벼 倒伏에 미치는 影響

李相哲* · 에스 케이 디 다타아**

ABSTRACT : This experiment was carried out at International Rice Research Institute (IRRI) farm to investigate the effect of plant growth regulators on lodging in rice and to determine plant characteristics when plant growth regulator applied at different concentrations and different times. The experimental plant growth regulator Hoe 78784 when applied at booting prevented lodging and significantly increased grain of IR 21820-154-3-2-3. However, they did not affect significantly the crop vegetative characteristics and yield component, except by decreasing plant height and internode elongation, and increasing the number of vascular bundles, and the thickness and diameter of the third and fourth internodes.

But when applied at 30 DT, it significantly decreased grain yield of all test varieties due to shortened panicle length and increased unfilled spikelet percentage. Hoe 78784 applied at heading did not increase yield nor did it prevent lodging.

The problem of lodging in cereals has received the attention of the plant breeders due to severity of damage caused to the crop and the consequent loss in yield and quality of the grain.

Grain yields considerably decrease when rice plants lodge during the ripening stage due to adverse environmental condition, the grain yield decrease is due to disturbance of the physiological activities and functions of the plants lodging, especially at assest dry matter synthesis, uptake, and nutrient assimilation, thus significantly reducing yield.

The use of growth regulators against lodging can be effective because culm elongation determine lodging, since the 1950s, a number of growth regulators on rice plants have been studied, but these are not sufficient, the number of chemically rather diverse compound, and their effects, has expanded considerably, but the most widely investigated retardants are known primarily for their "dwarfing" effects.

The fact that the decreased rate of stem growth induced by the retardants frequently could be overcome by exogenous GA3 suggested that in higher plants (Lang, 1970), the predominant action was an inhibition of Gibberellin biosynthesis.

Rademacher and Jung (1981) reported that of 60 different commercially available growth-regulating substances, only chlormequat chloride, mepiquat chloride and ethephon are used in cereal production. These growth retardants have not been intensively studied, but have shown variable results in rice. At present, many new growth regulators like BAS-106, PP-333, EL-500, S-3270, NTN-821 and CGR-811 have exhibited substantial success in lodging control (Nickell, 1983). Their applicaton increases plant resistance

* 慶北大學校 農科大學 (College of Agriculture Kyungpook National U., Taegu 702-010, Korea)

** 國際米作硏究所 (International Rice Research Institute, P.O. Box 933 Manila, Philippines)<'90. 2. 14. 接受>

to certain environmental stresses, controls crop height, increases tiller and enhances yield. These growth regulators are currently being evaluated in rice cropping systems.

Kwon and Yim (1986) reported that paclobutrazol application during tillering of transplanted rice does not seem to prevent lodging. But its application during the reproductive stage at low N levels more or less reduces culm length. At high rates, paclobutrazol tended to reduce grain yield by 5%. The meiotic stage is most vulnerable to lodging(Hou, 1983). At transplanting, seedlings treated with CCC, TLBA and NAA are shorter and have thicker stems than untreated seedlings. TIBA, NAA, and daminozide do not affect the culm lodging resistance (clr) value (IRRI, 1964), and plant height was reduced by 10% with CCC and 28% with TIBA. Yamada et al. (1962) reported that spraying TIBA effectively promotes tillering, suggesting that tillering in rice plants can be controlled by auxins or antiauxins.

The plant growth regulators have been used in crop production to determine if they can be used to control growth of rice plants and variable success has been achieved. This study sought to investigate lodging its prevention in rice using by new plant growth regulator Hoe 78784 and examine the relationship between lodging resistance and specific morphological characters when Hoe 78784 applied at different concentrations and different times.

METERIALS AND METHODS

The experiment was counducted in IRRI using IR36, IR42, IR64 and IR21820-154-3-2-2-3. The experiment was laid out in a split-plot design with four replications, with the rice variety as the main plot and application time as the subplot. Plots measured 5.5 x 3.75m with hill spacing at 20 x 20cm.

Defferent concentrations and application time of Hoe78784 are presented in Table 1.

Table 1. Treatments used to determine the effect of Hoe. 78784 plant growth regulator on lodging in rice.

Concentration (g ai/ha)	Application time
150	Booting
150	Heading
300	30 DT
300	Booting
300	Heading
Control	

Nitrogen fertilizer as urea, P as superposphate, and K as muriate of potash each at 60kg/ha were basal broadcast and incorporated (BB&I) using a power weeder. The remaining 30kg N/ha was topdressed at panicle initiation(PI).

Plots were flooded to a 2 to 3cm depth at 5 day after transplanting (DT) and maintained at 5 cm until ripening stage. Drainage was imposed at 12 days before harvesting(DBH).

Harvesting was done when more than 90% of the spikelets had ripened. Grains were harvested from a 5m^2 harvest area that was free from border effects. Four places, each measuring 0.02 m^2, were selected for plant sampling at harvest time. Internode length, leaf area, stem and leaf dry weight, bending index and degree of lodging were then measured.

Internode length was measured before harvest from the tip of the panicle to ground level of the main culm.

Plant height was measured at harvest from the base of the plant to the tallest panicle. Tillers were counted from 8 designated hills/plot and converted to tiller number per hill. Grain yield was determined from 125 hills at the center of each plot and converted to tons per hectare at 14% moisture content. Eight hills were sampled outside the 5m^2 harvest area to determine yield components using the procedures described by Gomez(1972). The third and fourth internodes from top downwards selected for anatomical observations. Portions 2cm long from each internode were sliced using a razor blade to a thickness of 20-30 microns. Diameter of culm, number of vascular bundles and culm thickmess were determined microscopically, and values reduced to fractions. Thickness of culm wall was obtained by measuring the average distance from the periphery of a cross section to its inner boundary. The number of vascular bundles was ascertained by counting those which appeared in a cross section of the clum. Culm diameter was obtained by measuring the longest and shortest diameter of the eight samples using a calibrated microscope and computing for the average.

RESULTS AND DISCUSSION

Lodging Reaction

IR42 and IR64 did not show any indication of lodging regardless of growth regulator used(Table 2). The lodging in IR36 was significantly higher in the control and at heading, regardless of concentration of growth regulators. In contrast, 150g ai/ha 300g ai/ha Hoe 78784 effectively controlled lodging when applied at booting and at 30 DT at 300g ai/ha. Similarly, IR21820-154-3-2-2-3 severely lodging in the control plot but not with Hoe 78784 applied at a high concentration(300g ai/ha) at 30 DT. However, Hoe 78784 applied at 30 DT in high concentrations(300g ai/ha) decreased grain yield.

The period from 45 to 30 days before heading was responsive to lodging prevention by PP-333(Kohli, 1984), but because of adverse effects on yield associated with this timing, attention has recently focused on the period from 20 to 10 days before heading.

Another new plant growth regulator, CGR-811 was reported to increase lodging resistance when applied a day before transplanting. CGR-811, NTN821, PP-333 and S3307 have been found to be very effective in reducing culm length, thus preventing lodging. When properly used, yield reduction is not a problem(Shirakawa et al., 1984).

Bending Resistance

In general, IR21820-154-3-2-2-3 had the least bending resistance in both treatments(Fig 1). Bending resistance of IR36, IR42 and IR64 was greatest when the growth regulators were applied at 30 DT, and least when applied during heading at 300 ai g/ha. This however, was not significantly different from the control.

Lodging resistance increases after soil treatment with PCP on the 30th day before heading (Hashizme and Yamagishi, 1969).

Grain Yield

Grain yields of each variety were significantly influenced by concentration and application time of growth regulator.

Grain yields varied from 2.8 to 4.7 t/ha(Table 3). Hoe 78784 at 150g ai/ha applied at booting significantly decreased grain yield (3.3 t/ha) in IR36. This was due to shortened panicle length, light panicle weight and low filled spikelet percentage. In contrast, yields of IR42 decreased when concentration was 300g ai/ha. Similar observation were recorded in resistant variety IR64, although IR42 yield higher than did IR64.

Chemical treatment at heading produced no

Table 2. Lodging percentage of test rices as affected by Hoe 78784 application in different concentrations and timing.

Concentration (g ai/ha)	Application Time	Lodging(%)[a]			
		IR36	IR42	IR64	IR21820-154-3-2-2-3
150	Booting	0 a	0	0	8 bc
150	Heading	20 b	0	0	16 bc
300	30 DT	0 a	0	0	0 a
300	Booting	0 a	0	0	4 ab
300	Heading	16 b	0	0	18 c
Control		20 b	0	0	40 d

[a] In a column, treatment means having a common letter(s) are not significantly different at the 5% level by DMRT.

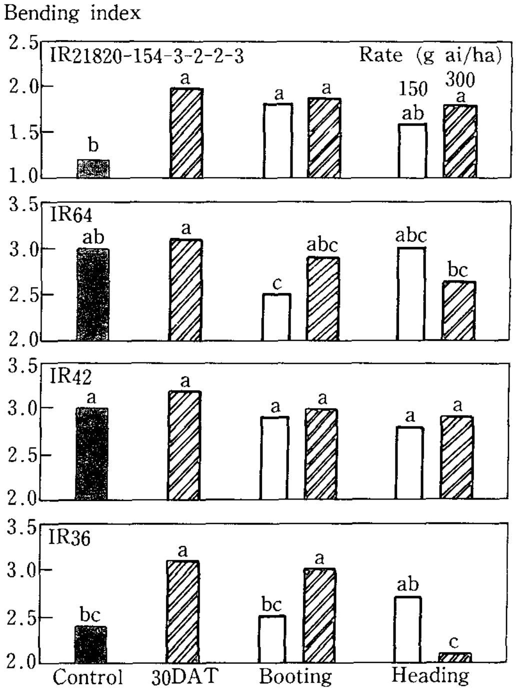

Fig. 1. Bending resistance of four rices as affected by Hoe 78784 application in different concentrations and timing. Within a variety or line, bars with a common letter(s) are not significantly different at the 5% level by DMRT.

significant difference in grain yield between all varieties and the control.

Yields were lower in IR42 with Hoe 78784 application at 30 DT due to shortend panicle lengths which decreased lodging. Treatment at booting stage significantly produced higher yield.

Yield Components

Varietal yield components difference with application time and concentration. In IR36, Hoe 78784 applied at 30 DT gave significantly shorter panicles than those in the control. When applied at heading (300g ai/ha), it produced panicles not significantly different from those of the other treatments(Table 4). Hoe 78784 increased panicle weight in all treatments except when applied at 30 DT. Panicle weights of IR36 were highest with 300g ai/ha application during heading, and lowest at 30 DT. No significant difference in 100-grain weight and spikelet fertility was observed among treatments. However, Hoe 78784 at any rate produced the highest spikelet fertility when applied at heading. The lowest percentage of filled spikelets was recorded with Hoe 78784 application at 30 DT at high concentrations.

In IR42, no significant differences in panicle length, panicle weight, filled spikelet percentage and 100-grain weight occurred with Hoe 78784 applied at any concentration or timing. IR64 and IR21820-154-3-2-2-3 also showed no significant difference in all yield components except with panicle length. In IR64, panicle length was significantly shorter with Hoe 78784 applied at 30 DT and at booting. In IR21820-154-3-2-2-3 panicle length was shortest when treated at booting with 150g ai/ha.

Vegetative Characteristics

Significant differences in plant height at harvest occurred in all test rices as a result of different

Table 3. Grain yield of test rices as affected by Hoe 78784 application in different concentrations and timing.

Concentration (g ai/ha)	Application time	Grain yield(t/ha)[a]			
		IR36	IR42	IR64	IR21820-154-3-2-2-3
150	Booting	3.3 a	4.5 ab	3.5 b	4.0 a
150	Heading	3.2 ab	4.7 a	3.8 a	3.9 ab
300	30 DT	2.8 b	3.8 c	3.4 b	3.5 b
300	Booting	3.1 ab	4.0 c	3.7 ab	4.1 a
300	Heading	3.1 ab	4.2 bc	3.8 a	3.8 ab
Control		3.1 ab	4.2 bc	3.7 ab	3.5 b

[a] In a column, means having a common letter(s) are not significantly different at the 5% level by DMRT.

Table 4. Yield components of test rices as affected by Hoe 78784 application in diffecent concentrations and timing.

Concentration (g ai/ha)	Application time	Panicle length[a] (cm)	Panicle weight[a] (g/m^2)	Filled spikelet[a] (%)	100-Grain weight[a] (g)
			IR36		
150	Booting	18 ab	460 ab	74 a	2.2 ab
150	Heading	18 ab	413 abc	73 a	2.2 ab
300	30 DT	17 b	343 c	69 a	2.2 ab
300	Booting	18 ab	400 abc	66 a	2.1 b
300	Heading	20 a	482 a	75 a	2.2 ab
Control		20 a	384 bc	68 a	2.3 a
			IR42		
150	Booting	21 a	394 a	86 a	2.1 a
150	Heading	21 a	473 a	86 a	2.2 a
300	30 DT	21 a	444 a	85 a	2.3 a
300	Booting	21 a	425 a	82 a	2.3 a
300	Heading	21 a	476 a	81 a	2.3 a
Control		21 a	413 a	81 a	2.2 a
			IR64		
150	Booting	21 b	347 a	74 a	2.6 a
150	Heading	22 ab	369 a	77 a	2.6 a
300	30 DT	20 b	356 a	77 a	2.6 a
300	Booting	20 b	340 a	83 a	2.5 a
300	Heading	23 a	410 a	79 a	2.7 a
Control		21 b	419 a	77 a	2.6 a
			IR21820-154-3-2-2-3		
150	Booting	22 b	450 a	73 a	2.1 a
150	Heading	24 ab	529 a	75 a	2.3 a
300	30 DT	22 ab	495 a	76 a	2.2 a
300	Booting	22 ab	495 a	73 a	2.1 a
300	Heading	23 ab	488 a	71 a	2.3 a
Control		24 a	485 a	73 a	2.2 a

[a] In a column, treatment means having a common letter(s) are not significantly different at the 5% level by DMRT.

Table 5. Plant height and tiller number[a] of test rices as affected by Hoe 78784 application in different concentrations and timing.

Concentration (g ai/ha)	Application time	IR36		IR42		IR64		IR21820-154-3-2-2-3	
		Plant height (cm)	Tiller count (no./hill)	Plant height (cm)	Tiller count (no./hill)	Plant height (cm)	Tiller count (no./hill)	Plant height (cm)	Tiller count (no./hill)
150	Booting	74 ab	14 a	87 ab	12 a	80 bc	11 a	91 ab	12 a
150	Heading	78 a	14 a	91 a	12 a	89 a	11 a	90 abc	11 a
300	30 DT	61 c	15 a	83 b	13 a	73 c	12 a	84 c	11 a
300	Booting	69 c	15 a	86 ab	12 a	77 c	11 a	86 bc	11 a
300	Heading	80 a	14 a	90 ab	12 a	86 ab	11 a	91 abc	13 a
Control		81 a	14 a	91 a	13 a	87 a	11 a	95 a	13 a

[a] In a column, treatment means having a common letter(s) are not significantly different at the 5% level by DMRT.

timing and concentration of growth ratardants (Table 5). In all test varieties, highest plant height was recorded in the control plots. No difference was observed between concentrations at heading. However, with 300g ai/ha Hoe 78784 application at 30 DT, plant height significantly decreased in both susceptible and resistant varieties. Suzuki et al. (1981) measured the levels of endogenous GA1 and GA19 in the shoots of rice at various stages of internode elongation and found decreasing values from maximum tillering stage to heading. Hoe 78784 probably inhibited gibberellic acid biosynthesis at 30 DT, accounting for the significant reduction in plant height.

Tiller number varied from 11 to 15/hill (Table 5). IR36 and IR64 recorded the highest and the lowest tiller count, respectively. Tiller number significantly differed among varieties but not among treatments. Nonsignificance among treatments does not agree with Nakata and Nakai (1977) who reported that application of growth retardant B9 to rice leaves at transplanting inhibits leaf emergence rate and promotes tiller growth.

The growth retardant TIBA, which is capable of counteracting the action of auxin (Galston, 1947), promotes tillering (Yamada et al., 1962). Tillering in rice plants can be controlled by auxins or anti-auxins.

Hoe 78784 applied at 30 DAS reduced internode length in IR36 from the first to the third internode, but no response was observed with

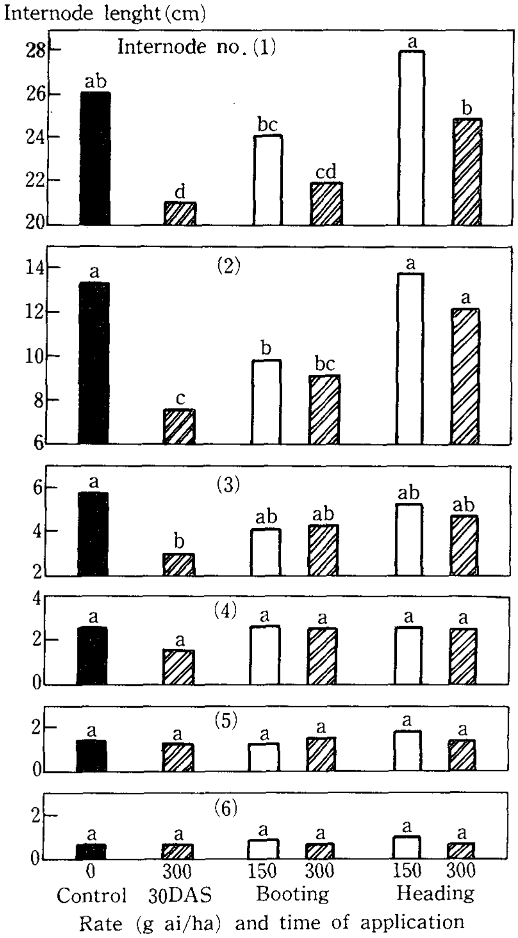

Figure 2. Internode length of IR36 as affected by Hoe 78784 application in different concentrations and timing. Within an internode, bars with a common letter (s) are not significantly different at the 5% level by DMRT.

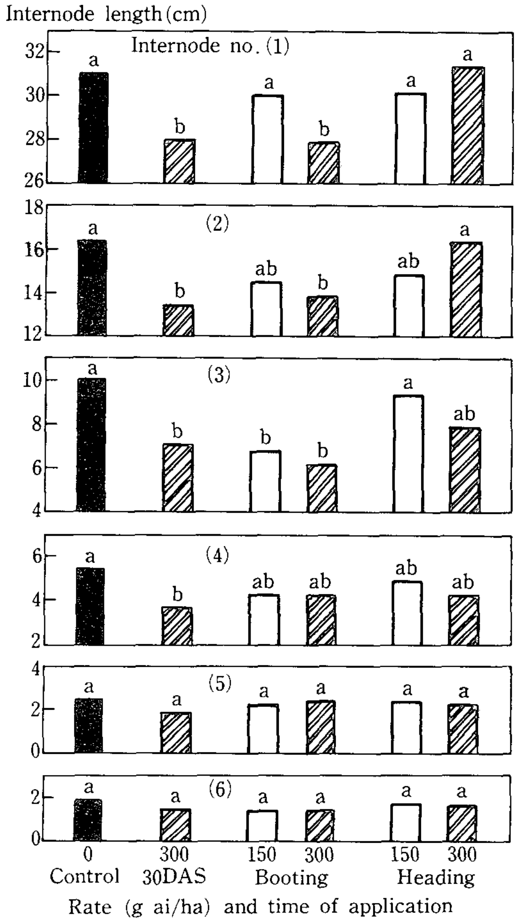

Figure 3. Internode length of IR64 as affected by Hoe 78784 application in different concentrations and timing. Within an internode, bars with a common letter (s) are not-significantly different at the 5% level by DMRT.

application at heading(Fig. 2). Increasing concentration further reduced internode length regardless of application time. In IR64, internode reduction extended only up to the fourth internode(Fig. 3).

Early application of growth regulators greatly shortened internode length. Hoe 78784 applied at booting effectively controlled culm elongation. Tall rices IR21820-154-3-2-2-3 and IR42 had a significant reduction up to the fourth internodes, respectively(Fig. 4 and 5).

Hoe 78784 application at 30 DT increased number of vascular bundles and thickness and diameter of the third and fourth internodes in all varieties(Fig. 6-11). The control and heading groups showed lower number of vascular bundles, thickness and diameter of culm in the third and fourth internodes.

No explanation can be given for the increase in thickness and diameter of culm with Hoe 78784 application. However, Seko(1962) observed that in lodging-susceptible plants, the lower internodes are long and slender, culm wall is thin, Weight per unit length of culm is small, development of culm mechanical tissues is inferior and breaking strength of the first to the third internode is small. Ramiah and Dharmalingam(1934) associated a thicker schlerenchyma and culm wall and a

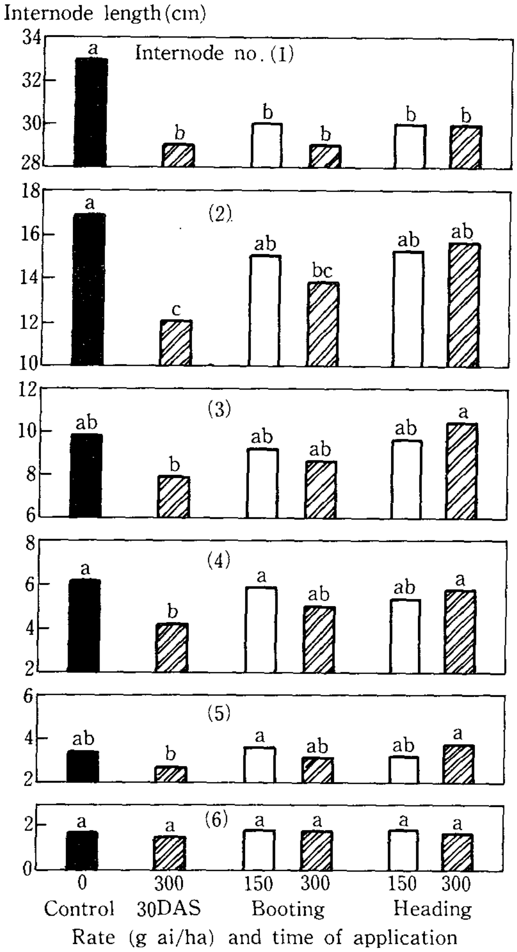

Figure 4. Internode length of IR21820-154-3-2-2-3 as affected by Hoe 78784 application in different concentrations, bars with a common letter(s) are not significantly different at the 5% level by DMRT.

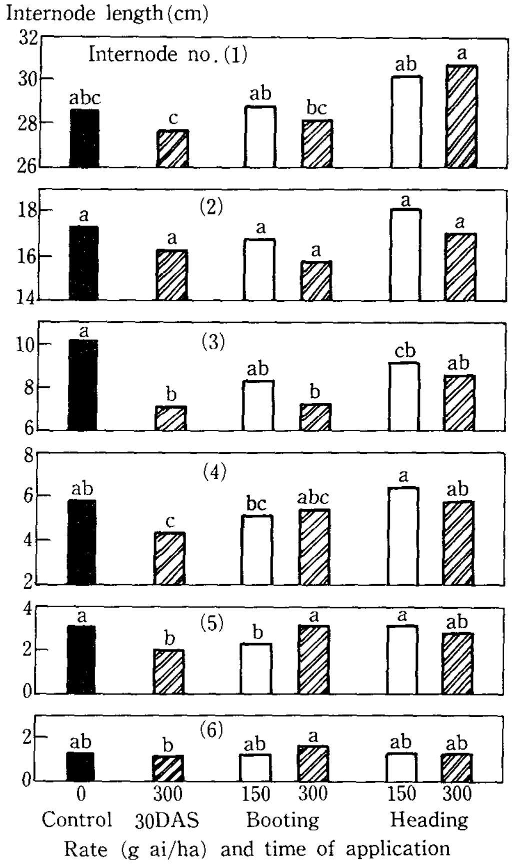

Figure 5. Internode length of IR42 as affected by Hoe 78784 application in different concentrations and timing. Within an internode, bars with a common letter (s) are not significantly different at the 5% level by DMRT.

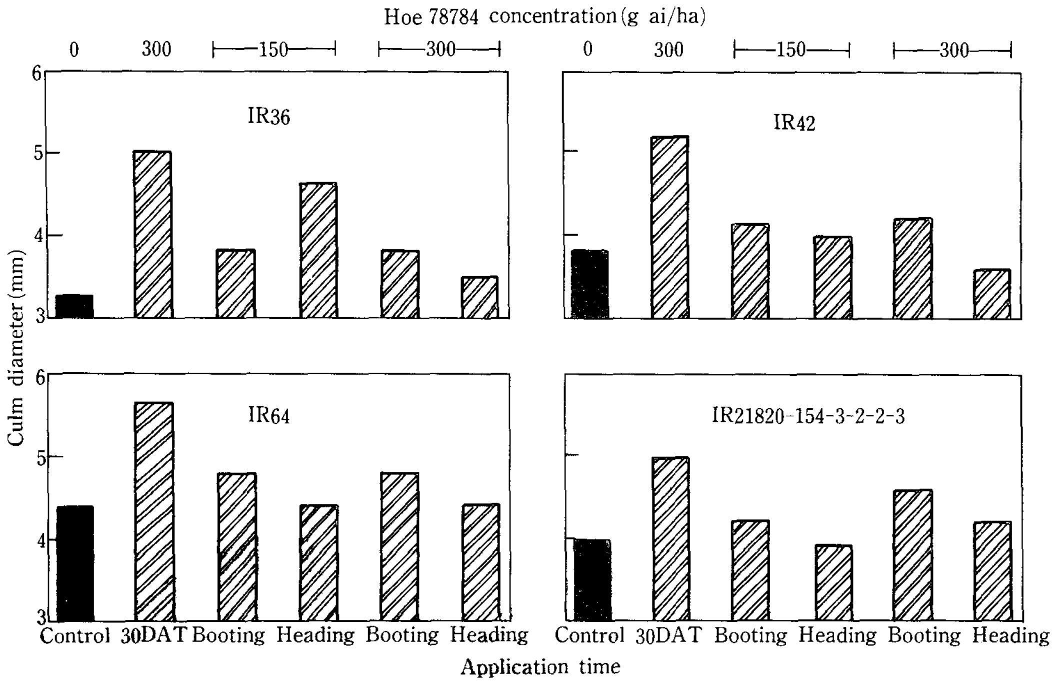

Figure 6. Culm diamenter of third internode of four rices as affected by Hoe 78784 application in different concentrations and timing.

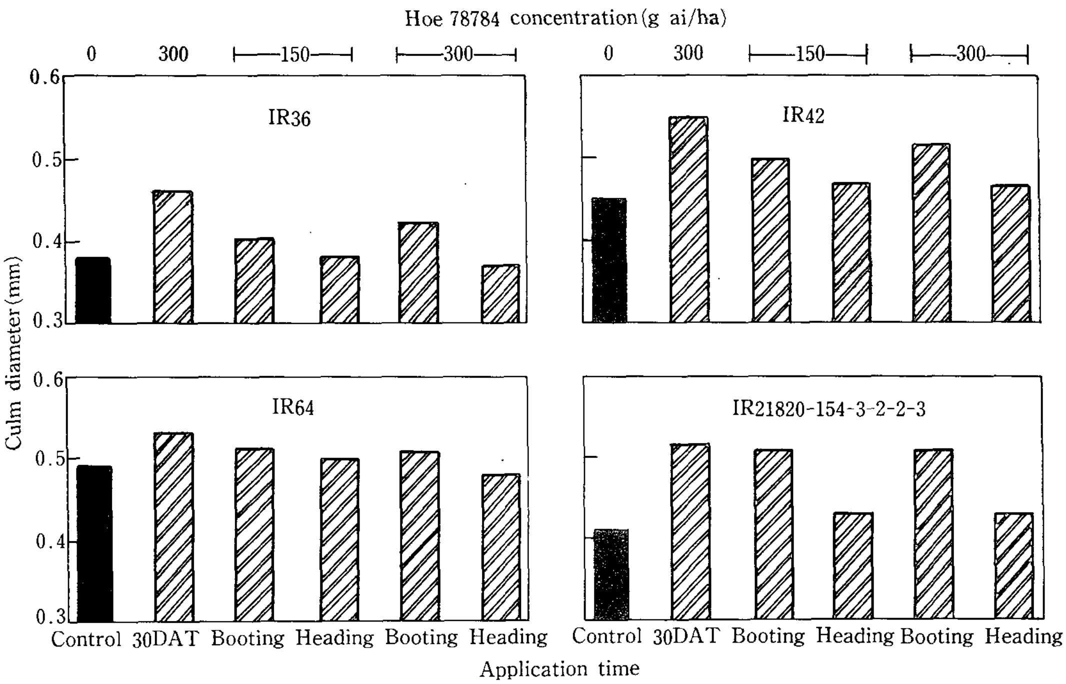

Figure 7. Culm thickness of third internode of four rices as affected by Hoe 78784 application in different concentrations and timing.

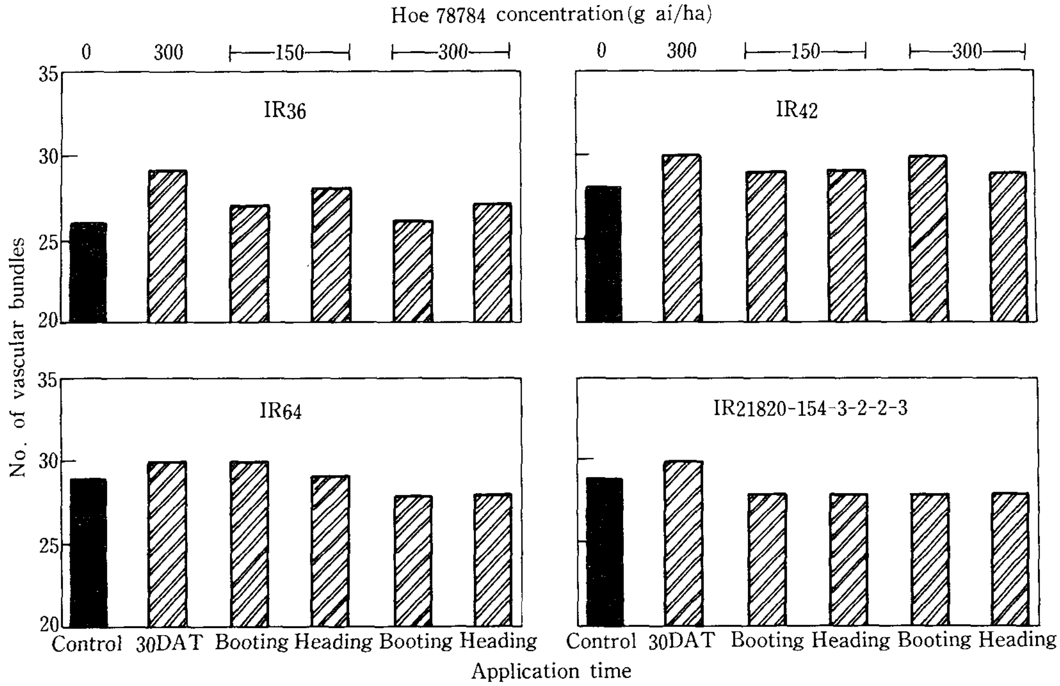

Figure 8. Number of vascular bundles of third internode of four rices as affected by Hoe 78784 application in different concentrations and timing.

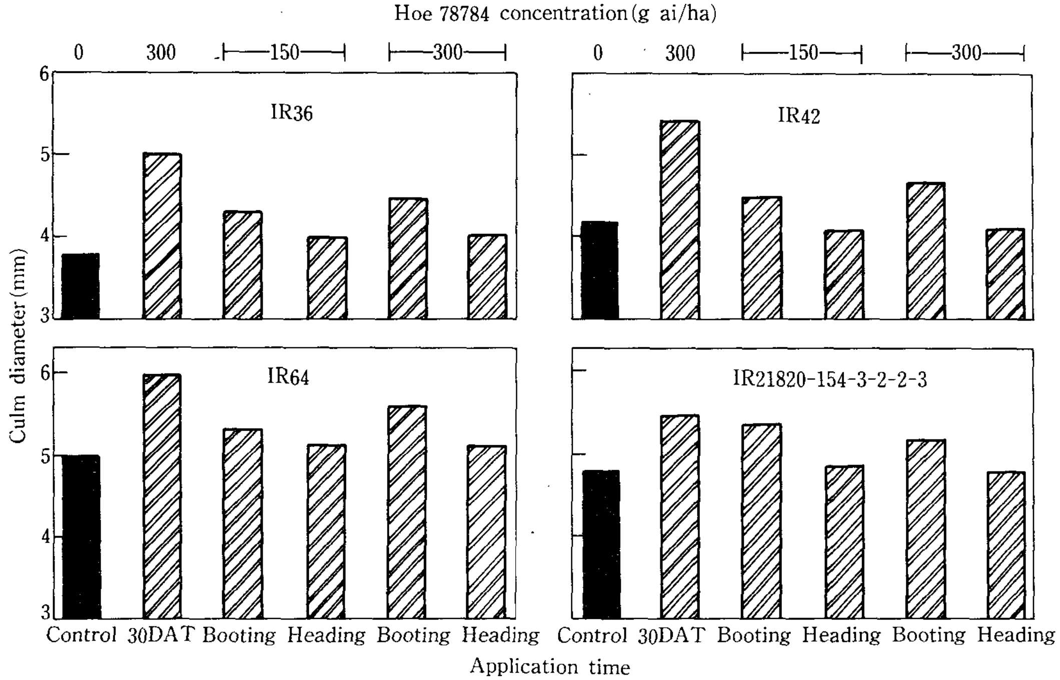

Figure 9. Culm diameter of fourth internode of four rices as affected by Hoe 78784 application in different concentration and timing.

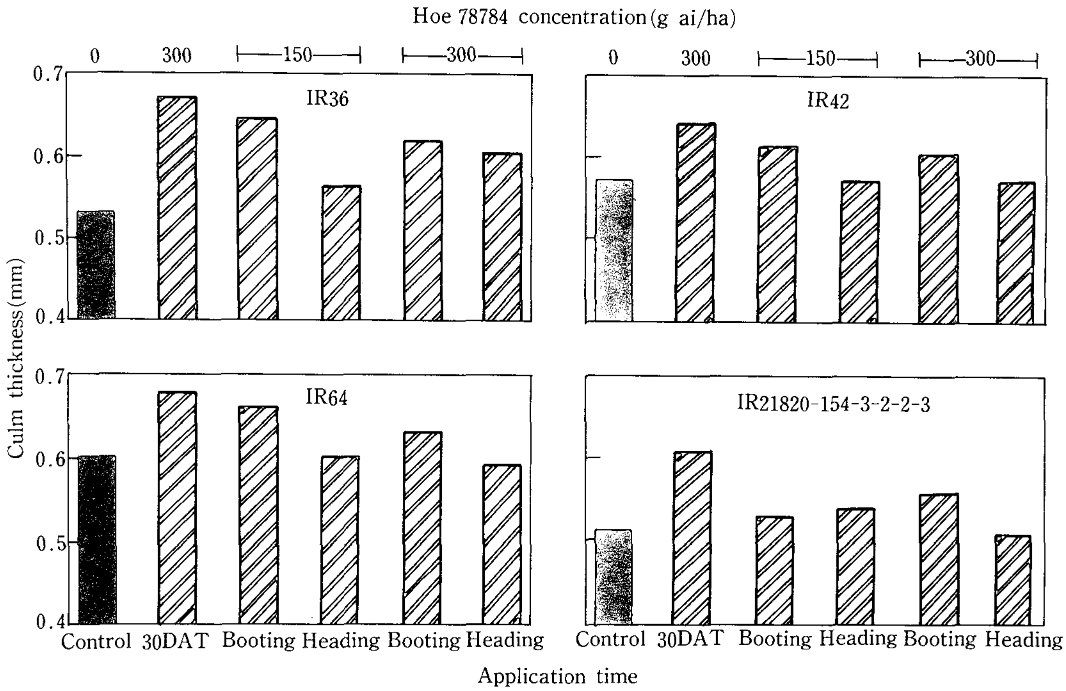

Figure 10. Culm thickness of fourth internode of four rices as affected by hoe 78784 application in different concentrations and timing.

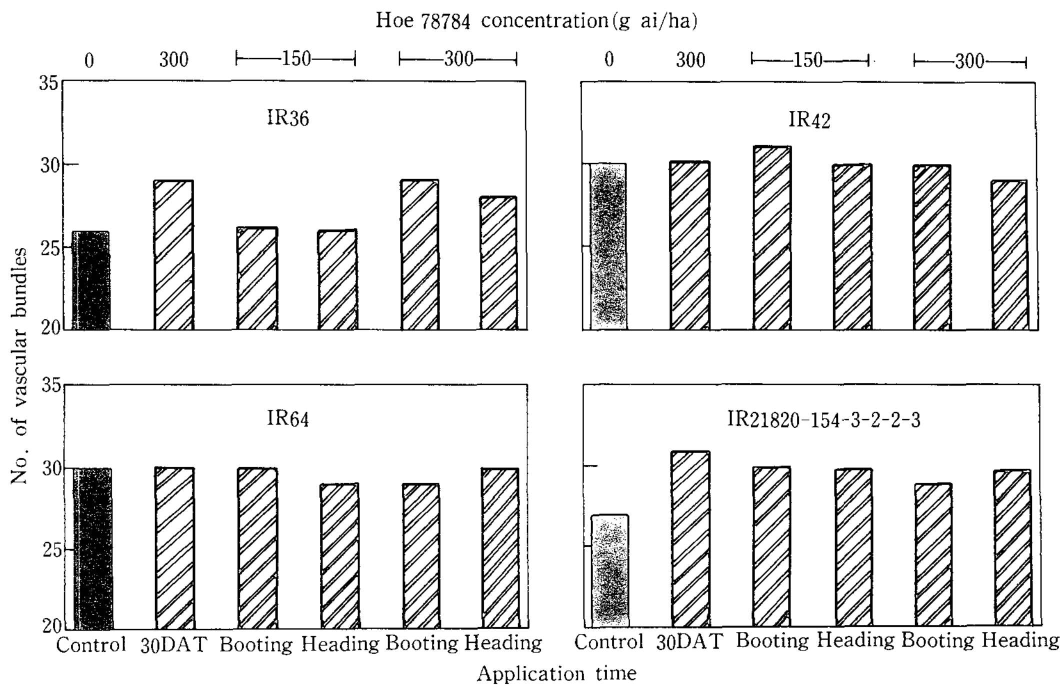

Figure 11. Number of vascular bundles of fourth internode of four rices as affected by Hoe 78784 application in different concentrations and timing.

broader culm diameter to the presence of schlerenchyma around the air cavity in resistant varieties.

摘 要

本 實驗은 植物生長 調節劑 Hoe 78784를 處理하여 水稻의 倒伏 防止效果를 調査하고, 本 植物生長 調節劑의 濃度와 處理 時期를 각기 달리하였을 때 水稻의 營養生長, 形態的 特性 및 收量에 미치는 效果를 究明하기 爲하여 實施하였던 바 몇가지 結果를 얻어 報告하는 바이다.

Hoe 78784를 水稻 伸張期에 處理하였을 때 供試된 品種에서 倒伏 防止效果가 크게 나타났으며, 特히 倒伏性 品種인 IR21820-154-3-2-3에 있어서는 收量을 크게 增加시켰다.

生長 調節劑 Hoe 78784는 草長 및 節間의 伸張을 抑制시켰고, 特히 形態學的 特徵으로서는 Hoe 78784를 處理함으로써 세째 및 네째 마디 稈의 두께와 直徑을 增加시켰으며, 또한 줄기속에 유관속의 數도 增加시켜서 倒伏 防止效果를 나타낸 것으로 思料되며, 營養 生長機官 및 收量構成 要素에 크게 影響을 미치지 못하였다.

處理 時期와 濃度별로 볼 때 Hoe 78784를 移秧後 30일날 處理하였을 때는 倒伏 防止效果가 뚜렷하였으며 穗長 및 收量構成 要素에 影響을 미쳐 收量을 크게 減少시켰다. 그러나 出穗期때 Hoe 78784 處理는 濃度에 관계없이 倒伏 防止效果를 나타내지 않았고, 기타 諸形質에도 影響을 미치지 못했다.

REFERENCES

1. Galston, A. W. 1947. Effect of 2.d.5-Tiba on growth and flowering of soybeans. Am. J. Bot. 34 : 356-360.
2. Hashizume, A. and A. Yamagishi. 1969. Studies on growth regulation of rice plants by soil treatment with pentachlorophenol (PCP). Proc. Crop Sci. Soc. Japan 38(3) : 388-395.
3. Hou, F. F. 1983. Effect of plant growth regulators and herbicide on weed community composition, sprouting development and grain yield of main and ratoon rice. M.S. Thesis. University of the Philippines at Los Banos, Philippines. 173p.
4. IRRI(International Rice Research Institute). 1964. p 37-49. In Annual report for 1963. IRRI, Los Banos, Philippines.
5. Kohli, A. 1984. Paclobutrazol, a versatile new plant growth regulator as an effective tool in crop management. Imperial Chemical Industries Japan Ltd. Bull. 15p.
6. Kwon, Y. W. and K. O Yim. 1986. Paclobutrazol in rice. p 128-137. In plant growth regulators in agriculture. Food and Fertilizer Technology Center for the Asian-Pacific Region.
7. Lang, A. 1970. Gibberellins : Structure and metabolism. Annual Rev. Plant Physiol. 24 : 571-598.
8. Nakata, K. and H. Nakai. 1977. Effect of B9 on growth and yield of rice plant. Bull. Univ. Educ. Nat. Sci. 26(2) : 125-142.
9. Nickell, L. G. 1983. The role of growth regulators and hormones in enhancing food production. p 601-606. In chemistry and world food supplies : the new frontiers. Chemrawn 2. Pergamon Press.
10. Rademacher, W. and J. Jung. 1981. Comparative potency of various synthetic plant growth retardants on the elongation of rice seedlings. Z. Ackerfllanzenb. 150(5) : 363-371.
11. Ramiah, K. and S. Dharmalingam. 1934. Lodging of straw and its inheritance in rice. Indian J. Agr. Sci. 4 : 880-894.
12. Shirakawa, N., M. Endo and H. Tomioka. 1984. Studies on a plant growth regulator CGR 811. Proc. Crop Sci. Japan Extra Issue No. 1 : 116-117.
13. Suzuki, Y., S. Kurogochi, N. Marofushi, Y. Ota and N. Takahashi. 1981. Seasonal changes of GA and HBA in three rices. Plant and Cell physiol. 22(6) : 1085-1093.
14. Yamada, N., H. Suge, and H. Nakamura. 1962. Chemical control of plant growth and development. Proc. Crop Sci. Soc. Japan. 31 : 258-262.