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Growth Pattern of Tall and Short Lines of Rice and their Response to Gibberellin

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ABSTRACT

The growth pattern of two types of dwarfness in rice was studied. The difference in height of the tall and short *Peta* plants was apparent even at the seedling stage. In the dwarf and in the normal *Century Patna* 231 the difference in height was apparent only after panicle initiation. The four lines had the same number of elongated internodes, with the taller lines having longer internodes.

The application of gibberellin resulted in increased plant height, longer internodes, blades and leaf sheaths, and decreased tiller number. *Century Patna* 231-*dwarf* showed the least, and short *Peta* the greatest, response to gibberellin application.

INTRODUCTION

Previous experiments using 119 rice cultivars and lines showed the contrasting plant height of two pairs of lines: *Century Patna* 231-*normal* (CPN) versus *Century Patna* 231-*dwarf* (CPD) and *Early Tall Peta* (ETP) versus *Early Short Peta* (ESP). The CP lines represent a type in which the difference in height between the dwarf and normal is apparent only at flowering, while the *Peta* lines represent a type in which the difference in height is apparent even before flowering. CPD was obtained by irradiation. ESP and ETP were obtained by crossing *Peta* with *Taichung* (*Native*) *1* and then backcrossing the progenies to *Peta* three times. *Peta* is the tall, and *Taichung* (*Native*) *1* the short, variety.

A previous paper (Harada and Vergara, 1971) showed that the CP lines did not differ in their response to gibberellin (GA) at the seedling stage, which was generally low. CPD is therefore an exception, as GA was found to have no effect on the growth of the second leaf sheath. On the other hand, the *Peta* lines, particularly ESP, gave a much higher response to GA than the CP lines. This paper presents the results of a study to determine whether the response of the four lines to GA at the later growth stages is similar to, or different from, that at the early stages.

The two types of dwarfness provide excellent material for studying plant height and internode elongation. However, before detailed physiological and biochemical studies can be made, a knowledge of the growth pattern of these four lines is essential. An experiment, therefore, was conducted and the results are presented in this paper.

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METHODS

Experiment 1

The four lines—CPN, CPD, ETP, and ESP—were sown on a wet seedbed and transplanted after 14 days (29 December 1966) to a field plot at 20×25 cm spacing, with one plant per hill. Before transplanting, 60, 40, and 40 kg ha^{-1} of nitrogen, phosphorus (P_2O_5), and potassium (K_2O) respectively, were applied to the field.

The extent of leaf emergence, the total number of leaves on the main culm, and the length of the blade, leaf sheath, and the elongated internodes of the main culm were measured weekly.

Experiment 2

The four lines used in Expt. 1 were also used in this glasshouse experiment. The seeds were sown on 2 February 1967 and four plants were transplanted to each pot on 15 February. The porcelain pots contained 4 l of complete culture solution. The nutrients used were 40 ppm nitrogen (as NH_4NO_3), 10 ppm phosphorus (as NaH_2PO_4), 40 ppm potassium (as K_2SO_4), 2 ppm iron (as Fe-citrate), and 0·5 ppm manganese (as $MnCl_2$). Calcium, magnesium, and other essential elements were not added since the tap water used contained sufficient quantities of these elements. The culture solution was renewed once a week for 3 weeks and twice a week thereafter.

Gibberellin[1] was mixed with the culture solution (giving a final concentration of 0·1 and 1 ppm) twice a week starting from the 11th-leaf stage to flowering. Each treatment was duplicated.

Plant height, tiller number, length of flag leaf and leaf sheath, and length of internodes were measured at harvest (ESP and ETP, 18 May; CPD and CPN, 24 May).

RESULTS

Experiment 1

Plant height and tiller number. The difference in height between ETP and ESP was apparent even at the seedling stage (Fig. 1), and became greater after panicle initiation. At harvest ETP was 125 cm tall while ESP was 74 cm, a difference of 51 cm. The CP lines showed a different pattern: both had the same height up to panicle initiation, after which they started to differ. At harvest CPN was 125 cm tall and CPD 85 cm, a difference of 40 cm.

ESP always had more tillers than ETP. The CP lines, on the other hand, had the same tiller number and tillering pattern.

Dry weight. The growth curves for the *Peta* and CP lines, based on dry weight, were essentially the same (Fig. 2). All lines had a final dry weight of about 50 g per hill.

Lengths of blade and leaf sheath. The blade length increased from the first to the 13th leaf in the *Peta* lines and from the first to the 12th leaf in the CP lines (Fig. 3). CPN and CPD had about the same blade length, while ETP had longer blades than ESP.

[1] Gibberellin, which contained at least 93 per cent pure GA_3, was supplied by the Kyowa Hakko Kogyo Co. Ltd., Tokyo.

The length of the leaf sheath increased from the first to the last leaf in all lines. The CP lines did not differ in the length of their leaf sheaths while the *Peta* lines did, with ETP having longer leaf sheaths than ESP.

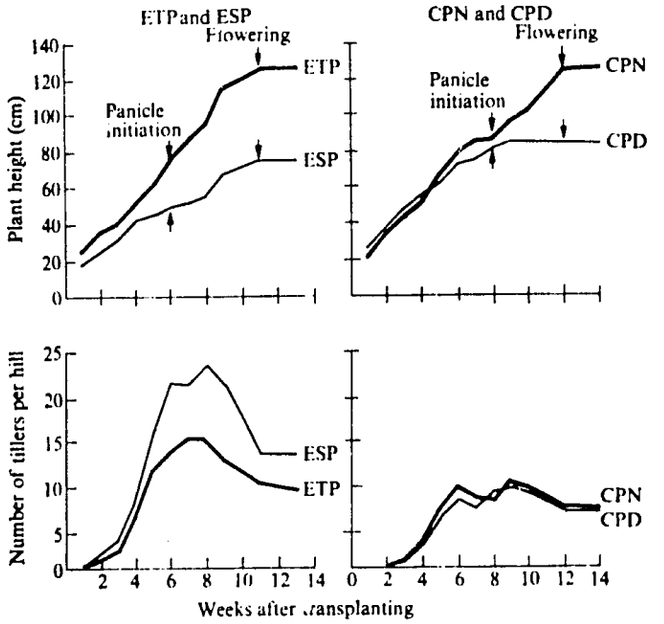

FIG. 1. Changes in plant height and tiller number of the *Century Patna* (CPN, CPD) and *Peta* (ETP, ESP) lines during growth.

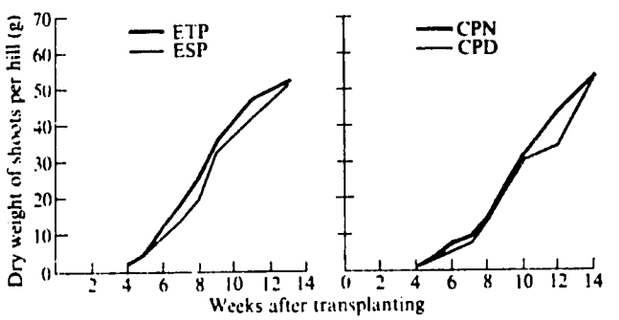

FIG. 2. Dry weight of the shoots of the *Century Patna* (CPN, CPD) and *Peta* (ETP, ESP) lines.

Internode length and number. Rapid internode elongation started at panicle initiation, with at least the top five internodes of all lines elongating (Fig. 4). The major difference in the height of the lines resulted not from the number of elongated internodes but from the length of the internodes. The tall lines (ETP and CPN) had longer internodes than their corresponding short lines (ESP and CPD).

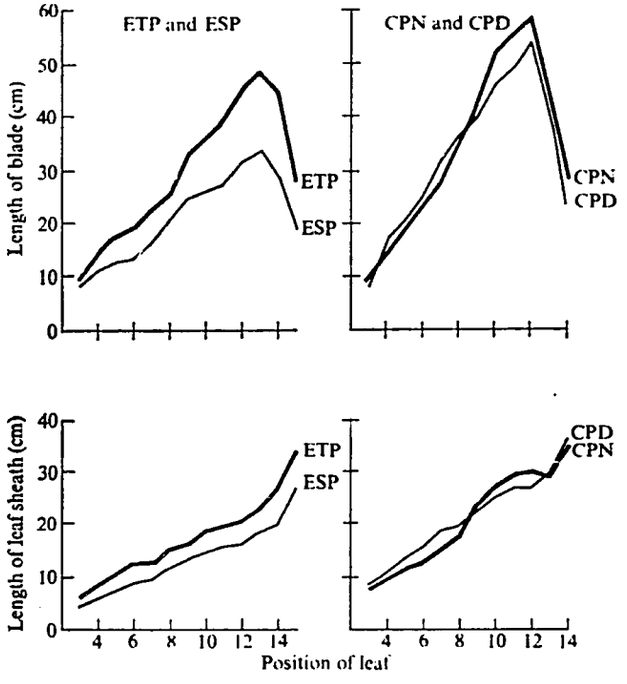

FIG. 3. Changes in the length of the leaf sheath and blade of the *Century Patna* (CPN, CPD) and *Peta* (ETP, ESP) lines.

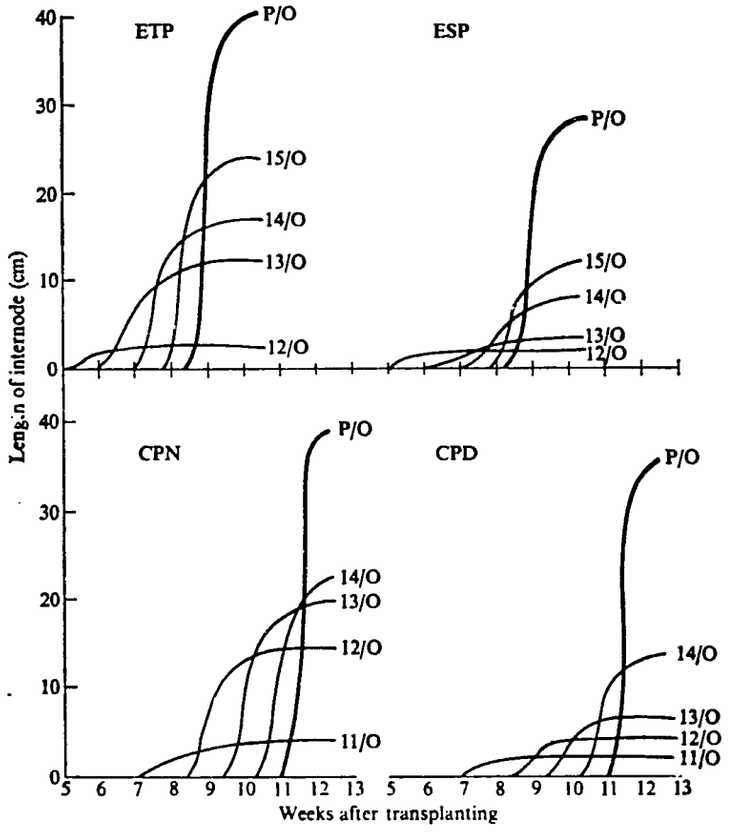

FIG. 4. Elongation pattern of the internodes of the *Century Patna* (CPN, CPD) and *Peta* (ETP, ESP) lines. (P/O is the internode just below the panicle; numbers refer to the position of the leaf above each internode on the main culm.)

Experiment 2

Plant height. Plates 1 and 2 show the response of the four lines to GA. Comparatively, ESP showed the largest response, while CPD gave a small response.

A more detailed analysis of the response to GA is shown in Table 1. The application of GA, especially at a higher concentration (1 ppm), increased the height of the plants.

TABLE 1. *Morphological changes in the plants treated with gibberellin (data obtained at harvest)*

		Plant height (cm)	No. of tillers	Length of flagleaf* (cm)		Dry weight (g/plant)		Length of culm (cm)	No. of elongated internode
				Blade	Sheath	Shoots	Roots		
	Control	133·5	11·3	39·3	36·8	50·4	4·9	92·5	5·3
ETP	0·1 ppm	153·5	7·1	41·0	38·3	47·2	3·8	110·7	5·6
	1 ppm	193·3	5·3	45·2	41·3	40·8	3·0	131·8	5·9
	Control	78·0	16·4	28·1	25·9	38·3	4·5	43·2	5·1
ESP	0·1 ppm	109·0	8·6	32·3	32·6	42·4	3·5	63·2	5·1
	1 ppm	181·8	7·5	42·1	39·3	39·0	3·4	116·2	5·1
	Control	126·9	6·9	34·3	34·6	50·1	7·7	85·1	5·8
CPN	0·1 ppm	149·1	4·6	36·7	36·6	46·8	3·6	104·8	6·4
	1 ppm	197·9	4·0	42·9	36·7	40·4	2·8	146·6	6·5
	Control	98·9	8·3	29·1	33·2	50·9	5·3	43·5	5·0
CPD	0·1 ppm	104·0	6·0	36·1	34·4	39·5	3·3	51·4	5·8
	1 ppm	122·3	5·1	37·9	34·8	46·5	2·9	66·2	6·0

* Flagleaf is the 15th or 14th leaf in both lines.

This increase in height was also reflected in the length of the culm. Longer culms resulted from longer internodes and not from more elongated internodes. In the case of the *Peta* lines, several of the internodes of both ETP and ESP at 1 ppm GA were longer than those of the control (Fig. 5). Internode III of ESP gave the biggest response. On the other hand, the dwarf CP had a relatively very small response, in fact, the taller line (CPN) gave a higher response (Fig. 6).

Tiller number, dry weight and length of blade and sheath. GA reduced the tiller number, especially at higher concentrations (Table 1), and increased the length of the blade and sheath of the flagleaf, with the increase in the sheath being comparatively smaller. The dry weight of the shoots and roots generally decreased with GA application.

DISCUSSION

The CP lines and the *Peta* lines had about the same dry weight throughout their growth from transplanting to harvest. The apparent morphological differences between these two groups of lines were in the number of tillers per hill and in the length of the blade and sheath. The CP lines had fewer tillers than the *Peta* lines. CPD and CPN had the same tiller number, while ESP had more tillers than ETP. The corresponding blades and leaf sheaths of the CP lines were longer than those of the *Peta* lines.

Weekly measurements revealed that the tall and the short *Peta* lines differed in height even at an early growth stage, while the CP lines differed only after panicle initiation. Thus, the phenomena responsible for the difference in height between the

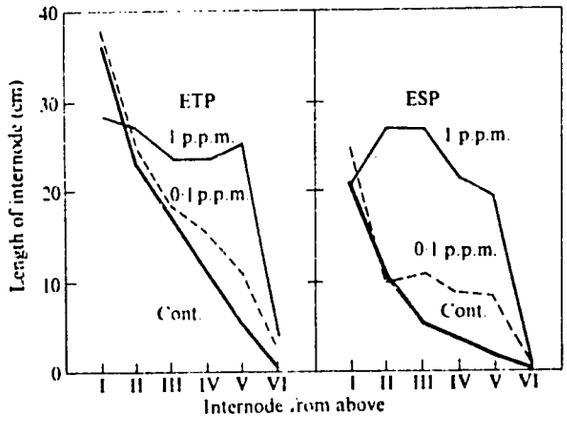

FIG. 5. Effect of the gibberellin treatment on the length of the internodes of *Peta* lines.

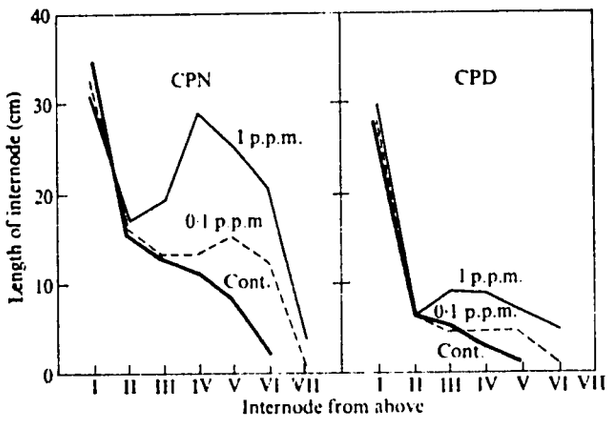

FIG. 6. Effect of the gibberellin treatment on the length of the internodes of *Century Patna* lines.

tall and short lines differed in the CP and *Peta* lines. All lines had at least five elongated internodes, with the tall lines having longer internodes than their corresponding short lines.

The differences in the response of the CP and *Peta* lines to GA during the seedling stage is further proof of the difference in the mechanism involved. Both CP lines had a low response to GA at the seedling stage (Harada and Vergara, 1971).

The application of GA at the later growth stages gave the same comparative results as application at the seedling stage. ESP responded more than ETP while the CP lines, particularly CPD, gave a smaller degree of response. Generally, GA was

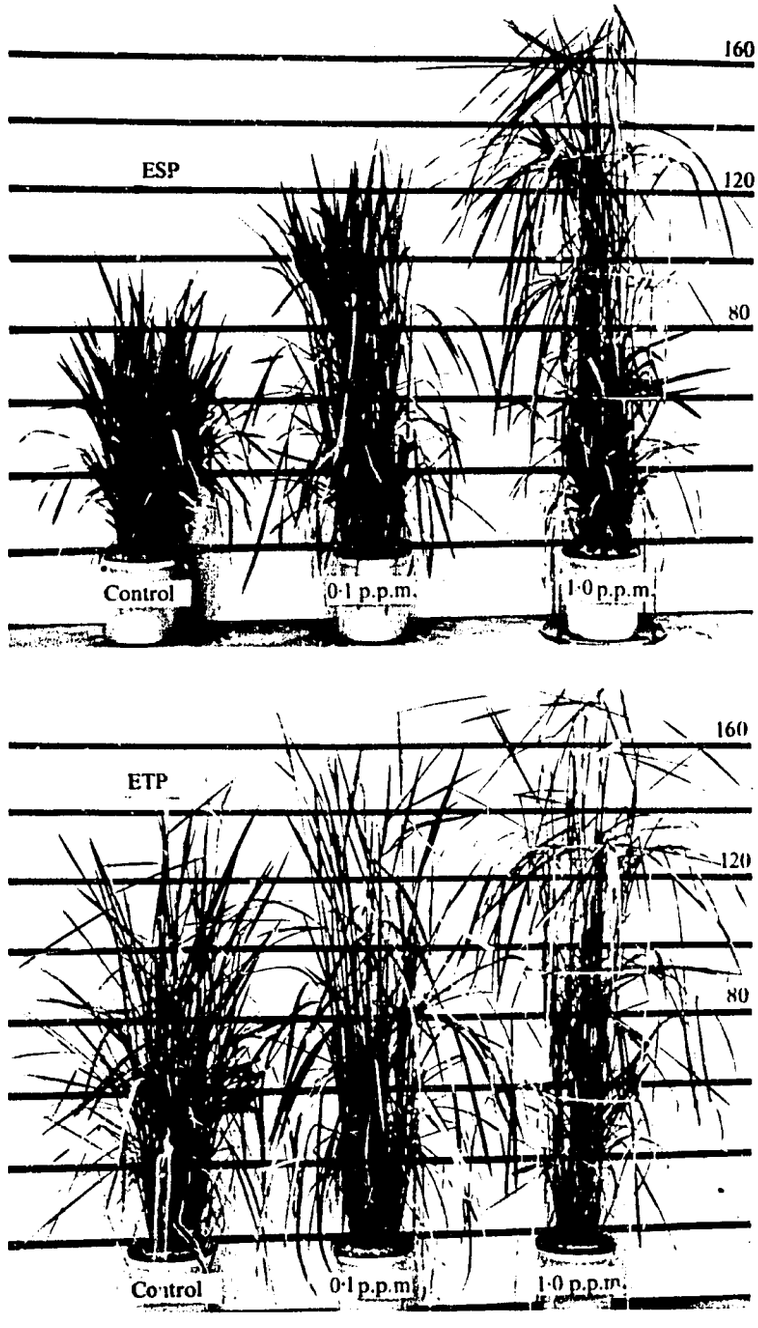
160
ESP
120
80
Control
0·1 p.p.m.
1·0 p.p.m.
160
ETP
120
80
Control
0·1 p.p.m.
1·0 p.p.m.

PLATE 1

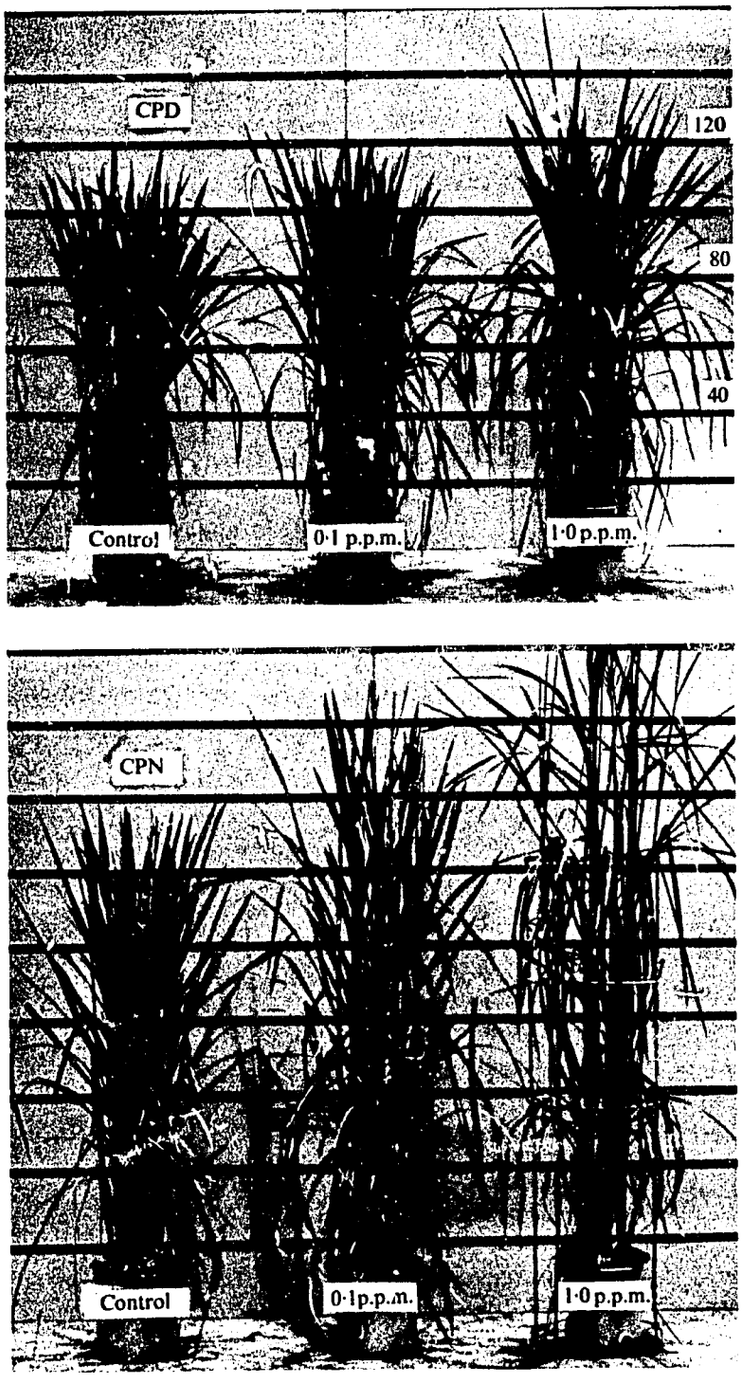

PLATE 2

effective in increasing the height of the dwarf cultivars (Hayashi and Murakami, 1958). In the case of CPD, GA is apparently not the factor limiting its elongation. The non-response of the dwarf lines to GA has also been reported in other plants (Kamata and Kishimoto, 1960; Nagamatsu, Omura, and Tsuzuki, 1964; Harada and Wada, 1968).

The present experiment supports earlier findings (Hayashi and Murakami, 1958; Ishizuka and Hirose, 1961; Shimizu, 1965) of a general increase in plant height, internode length, and flagleaf blade and sheath, and a decrease in tiller number as a result of GA application.

The similarity in the growth and in the response to GA of CPN and CPD before panicle initiation indicates that the difference in height and internode elongation of these lines is most probably the result of a reaction occurring only at panicle initiation. On the other hand, the factors responsible for the greater height and longer internodes of ETP are present immediately after germination.

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EXPLANATION OF PLATES

PLATE 1. Response of ESP and ETP to 0·1 and 1·0 ppm GA. Pictures were taken at flowering (18 April 1967).

PLATE 2. Response of CPD and CPN to 0·1 and 1·0 ppm GA. Pictures were taken at flowering (5 May 1967).