Effects of Gibberellin Treatment on the Growth and Dry Weight of the Rice Plants

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Effects of Gibberellin Treatment on the Growth and Dry Weight of the Rice Plants[1]

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Summary

The effects of GA treatment on the growth and dry weight of rice are studied in this paper.

Plant height increased and tiller number decreased with GA, although the early GA treatment induced late active tillering. These degrees were greater in higher nitrogen levels. The increase in height was also reflected in the length of the culm and flag leaf of the main culm, while the changes of panicle length with GA were smaller.

The total dry weight increased with GA in the dwarf variety and decreased in the normal variety. The root weight tended to show a slight decrease in the normal variety and slight increase or almost no influence in the dwarf variety. The panicle and straw weight also decreased with GA in the former and increased in the latter types.

These findings suggest that there are close relationships among the effects of GA on the root (which absorbs mineral nutrition), straw (a photosynthetic organ) and panicle growth.

It is generally known that Gibberellin (GA) is a factor limiting the height of some plants and that GA application can result in the increase of height. Rice is not an exception to this; many tropical tall rice varieties showed a low GA response while short Japonica varieties showed a high response.[2] It is also shown that the GA application reduced the tiller number in the rice plants (1–5). However, the changes of dry weight with GA were widely different according to the variety and treatment (1–4). Hence, the experiment was designed to certify the effect of GA treatment on the dry weight of rice plants.

[1] Data were collected at The International Rice Research Institute, Los Baños, Laguna, Philippines.

[2] Harada, J. and Vergara, B.S., Unpublished data.

Materials and Methods

Experiment 1

The seeds, early short Peta (ESP)[3], were sown on July 12, 1967 and two plants per pot were transplanted on July 21 into porcelain pots containing 4 liters of culture solution. The nutrient levels were the same as that reported in the previous paper (4). The culture solution was renewed twice a week during this experiment. GA[4] was mixed into the culture solution giving a final concentration of 0.1 and 1 ppm twice a week starting from the 11th leaf (August 18) to flowering (September 29). The plants were harvested on October 20 and the plant height, tiller number, length of flag leaf, culm and panicle of the main culm and dry weight of each part were measured.

Experiment 2

Two varieties were used in this experiment: Fujisaka 5, a normal variety and Dwarf C[5], a dwarf mutant. The seeds were sown on August 15, 1967 and four plants per pot were transplanted into porcelain pots as mentioned above. The nutrient levels were the same as reported in the previous paper (4) up to September 25 and then the nitrogen levels were changed to 10, 40 and 120 ppm. The culture

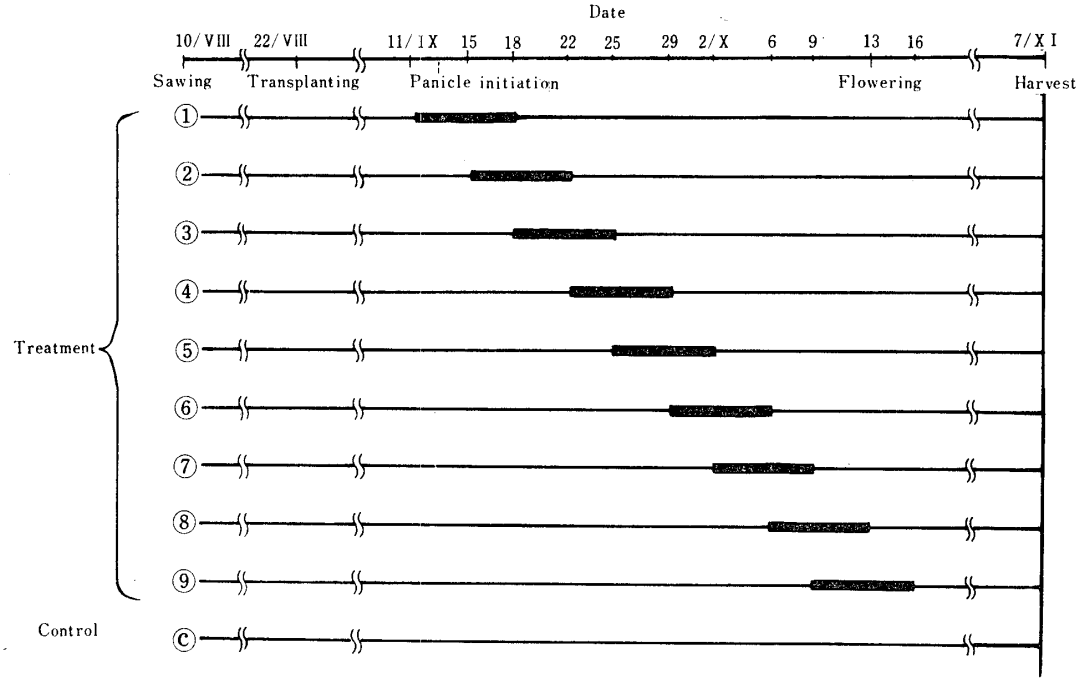

FIG. 1. Duration of GA treatments in Experiment 3.

[3] It is known as IR 262 A43-8-11-31-5.

[4] Gibberellin was kindly supplied by Kyowa Hakko Kogyo Co., Ltd., Tokyo, which contained at least 93% pure GA_3.

[5] It is known as "Waito C" in Japan.

solution was renewed twice a week up to flowering and once a week thereafter. GA treatments were done the same way as in Experiment 1, starting from September 25 to October 17 (flowering). The plants were harvested on November 7, then the size and dry weight of each part were measured.

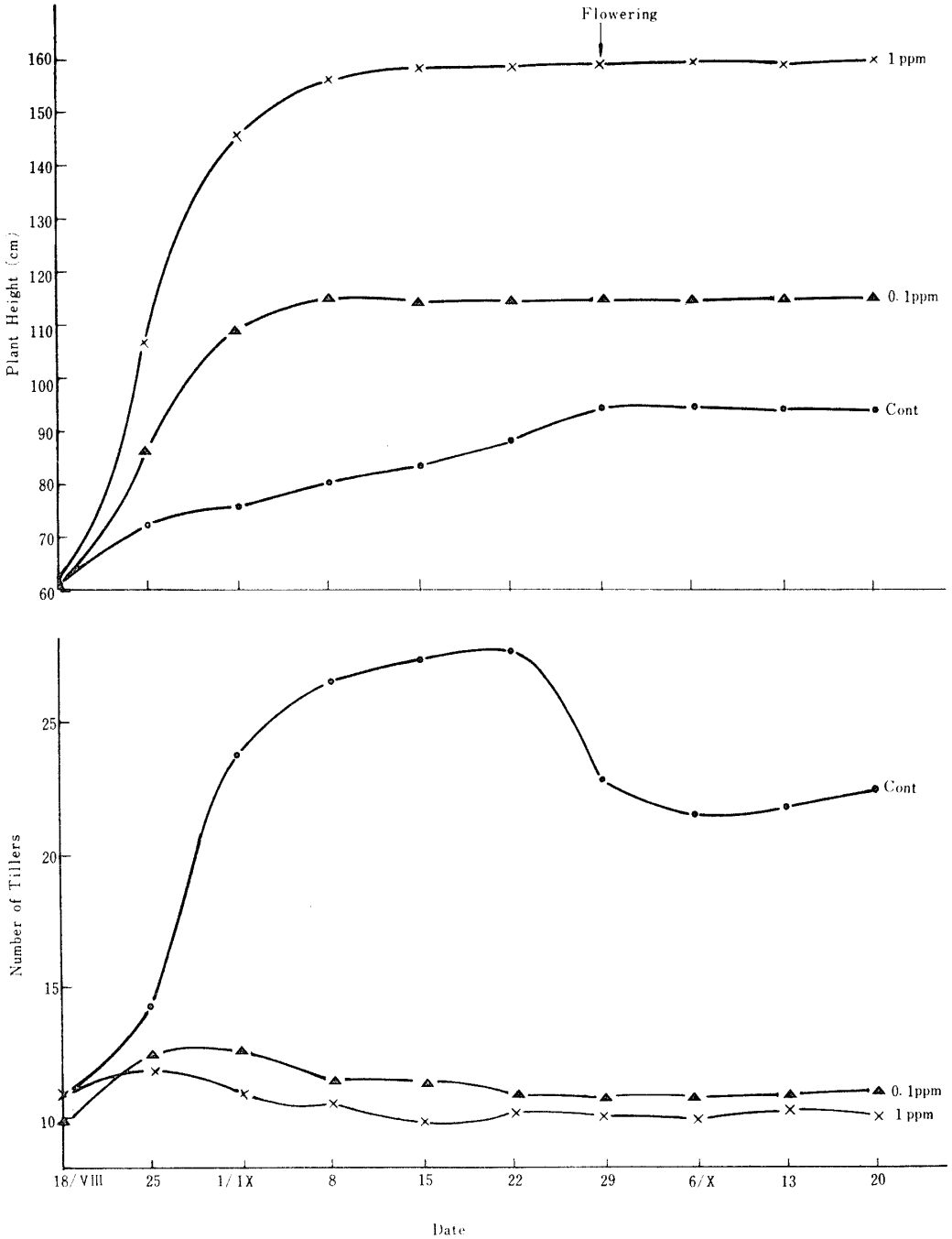

FIG. 2. Effect of GA plant height and tiller number of ESP.

Experiment 3

The seeds, variety Dwarf C, were sown on August 10, 1967. Four plants per pot were transplanted on August 22 and were cultured the same way as previously reported (4). GA was mixed into the culture solution, giving a final concentration of 0.5 ppm, twice a week at different stages as shown in Fig. 1. The plants were harvested on November 7, then the size and dry weight of each part were measured.

Results

Experiment 1

Fig. 2 shows the growth process of ESP treated with GA. The plant height increased and the tiller number decreased with the application of GA and the degree of increase or reduction was greater with higher GA concentration. The increase in height is also reflected in the length of the culm, panicle and flag leaf (Table 1).

TABLE 1. *Morphological Changes in ESP Treated with Gibberellin*

Conc. of GA (ppm)	Plant Height (cm)	No. of Tillers	Length of Flag Leaf (cm)		Length of Panicle (cm)	Length of Culm (cm)	Total Dry Wt. (g/plant)	Panicle/ Straw Ratio	Top/Root Ratio
			(Blade)	(Sheath)					
0	93.5	22.5	28.3	31.0	24.6	59.5	74.8	1.09	17.2
0.1	115.6	11.0	33.5	34.8	28.4	72.5	75.1	1.25	22.1
1	160.1	10.0	37.3	36.9	30.0	86.0	74.2	0.76	25.4

The longer culm length caused by the GA treatment was the result of longer internodes and not because of more elongated internodes. The lower internodes (IV, V and VI) responded more than the upper internodes (I, II and III) (Fig. 3). The total dry weight was almost the same in all treatments (Table 1). Although the control plants had more tillers and should weigh more, the height of the GA treated plants made up for the fewer tillers. A more detailed analysis of dry weight is shown in Fig. 4. The root weight decreased with a slight increase of shoot weight, therefore, top/root ratio increased with the GA treatment. The dry weight of the leaf sheath and culm increased, but the weight of the dead leaves and leaf blades decreased slightly. The panicle weight increased with 0.1 ppm GA but decreased with 1 ppm GA. So that the panicle/straw ratio is the biggest in 0.1 ppm and the smallest in 1 ppm GA-treatment.

Experiment 2

Plant height and tiller number tended to show higher value with high levels of nitrogen in both varieties and the former increased while the latter decreased with the application of GA (Figs. 5, 6 and Table 2). Internode length also increased with GA, the same way as in Experiment 1, in all levels of nitrogen. How-

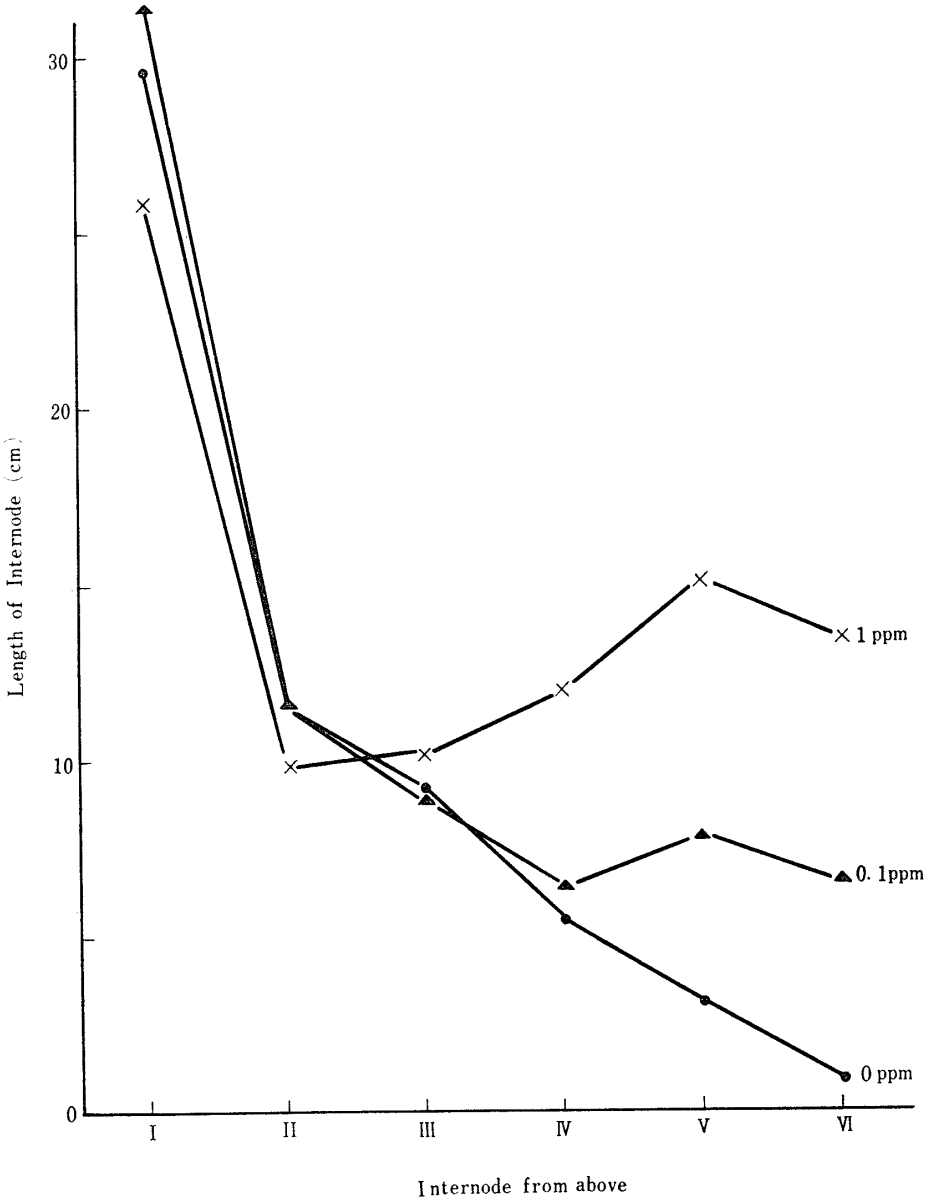

FIG. 3. Effect of GA on the length of internodes of ESP.

ever, the Dwarf C responded more than Fujisaka 5. Yet, the length of the panicle was not influenced with GA application (Fig. 7). The length of both leaf blade and leaf sheath increased with GA but the slight increase of the former and almost none in the latter were observed in Fujisaka 5. Increases of blade length with GA were slightly greater in higher nitrogen levels (Table 2).

The total dry weight of Dwarf C increased with applied GA in all nitrogen levels, while in that of Fujisaka 5, on the contrary it decreased (Fig. 8). The degree of such increase or decrease with GA was greater in high nitrogen levels. The dry weight of every part is as follows (Fig. 8): root weight of Dwarf C was more or less the same in all treatments, while that of Fujisaka 5 tend to show a slight

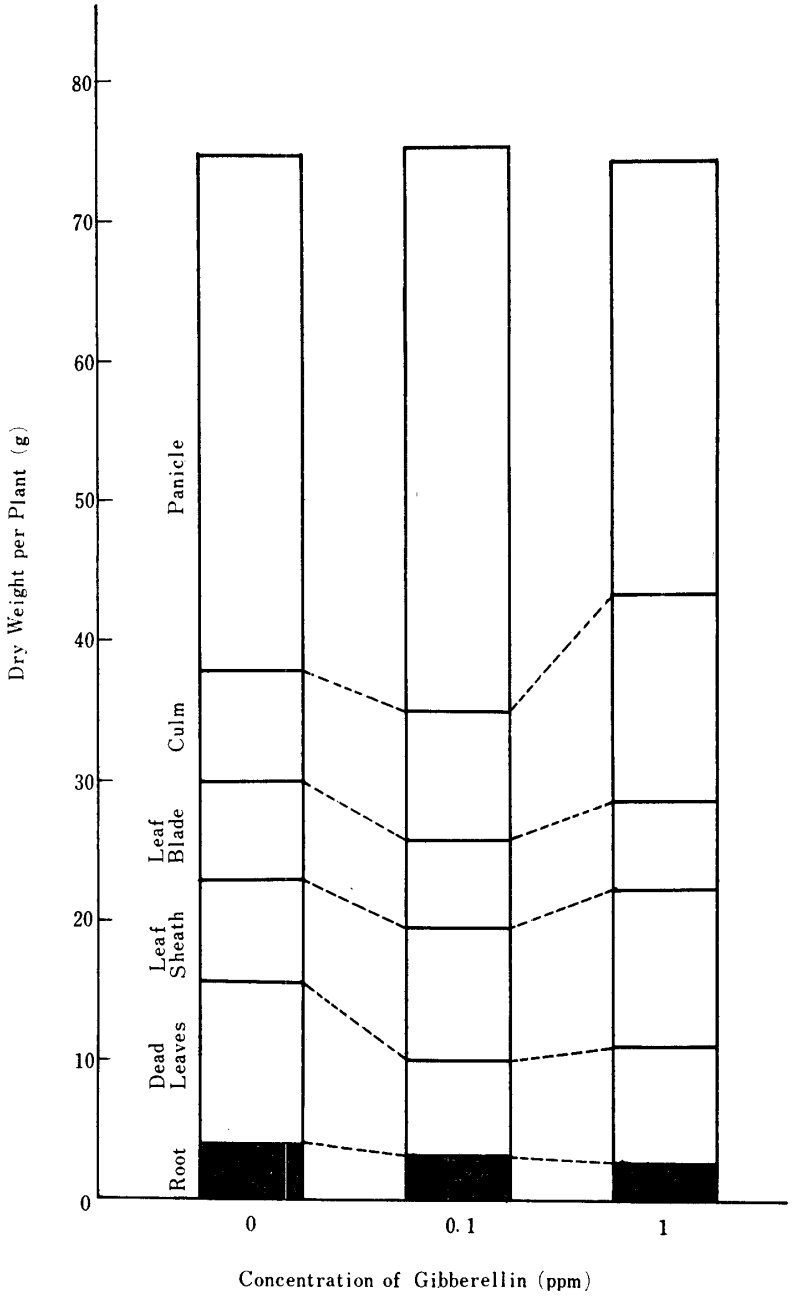

FIG. 4. Effect of GA on the dry weight of each part of ESP.

decrease with GA treatment. Dead leaves of Fujisaka 5 decreased with GA but changes of such with GA in Dwarf C were more complicated. Active straw weight of Dwarf C always increased with the application of GA, while in that of Fujisaka 5, it decreased slightly in 120 ppm nitrogen and was almost the same in other levels. The panicle weight of Dwarf C increased slightly with GA in 10 ppm nitrogen and considerably in others, while in that of Fujisaka 5, it always decreased considerably.

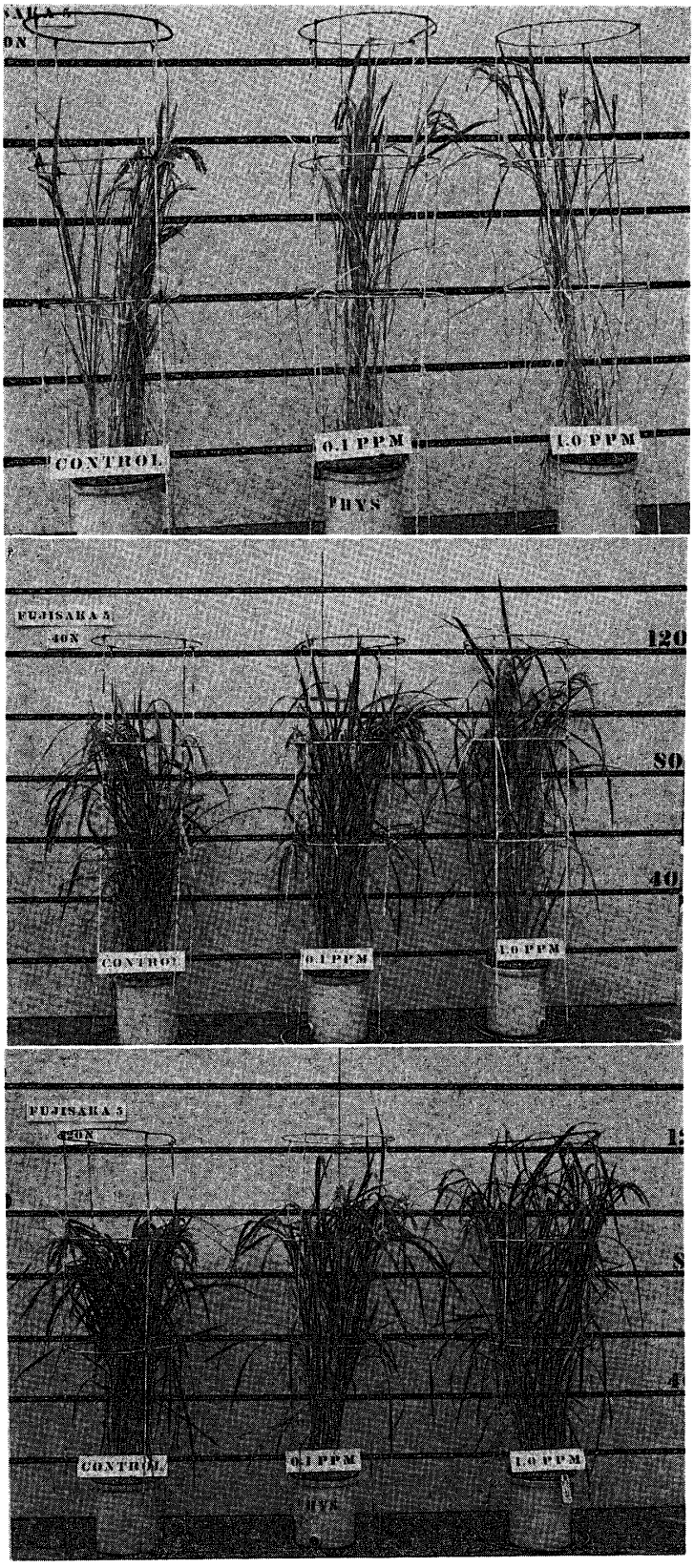

FIG. 5. Effect of GA on the growth of Fujisaka 5 in different nitrogen levels.

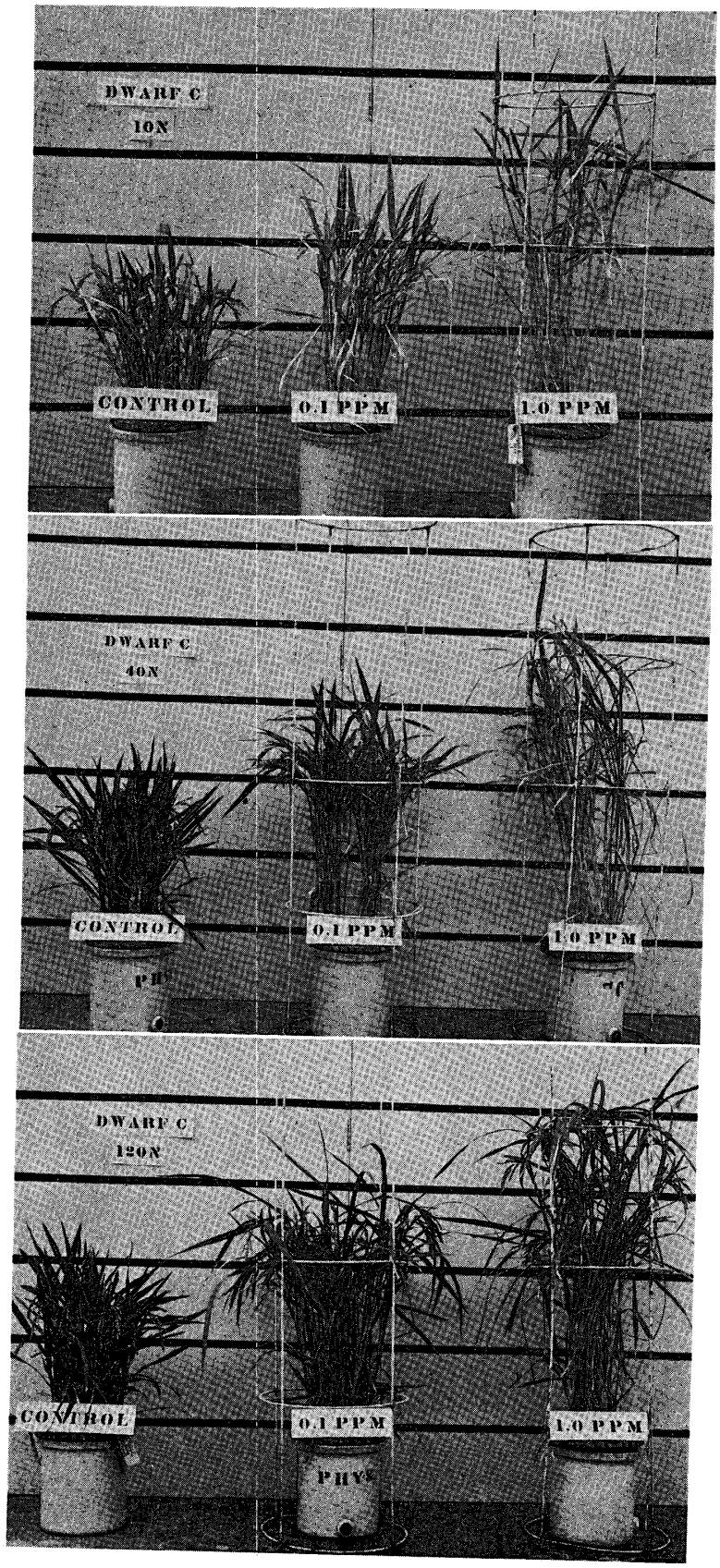

FIG. 6. Effect of GA on the growth of Dwarf C in different nitrogen levels.

TABLE 2. *Effects of GA on the Plant Height, Tiller Number and Length of Flag Leaf of Fujisaka* 5 *and Dwarf C in Different Nitrogen Levels*

	Treatment		Plant Height (cm)	No. of Tillers	Length of Flag Leaf (cm)	
	N (ppm)	GA (ppm)			Blade	Sheath
Fujisaka 5	10	0	109.0	5.9	40.1	30.3
	10	0.1	109.1	4.1	39.5	30.8
	10	1	134.3	4.1	43.4	31.7
	40	0	113.4	9.7	42.3	32.6
	40	0.1	121.0	5.3	46.5	31.4
	40	1	138.4	5.4	49.9	30.4
	120	0	109.1	12.9	43.6	32.6
	120	0.1	124.8	6.6	50.4	33.5
	120	1	142.9	6.8	53.8	33.3
Dwarf C	10	0	43.9	7.3	14.0	16.4
	10	0.1	66.8	6.3	20.7	18.8
	10	1	99.3	6.0	29.6	23.5
	40	0	50.0	11.8	17.8	17.3
	40	0.1	86.4	9.1	25.9	21.3
	40	1	108.4	7.8	32.8	23.6
	120	0	50.3	14.0	18.6	17.8
	120	0.1	89.9	8.4	29.6	23.1
	120	1	114.2	7.7	39.3	25.9

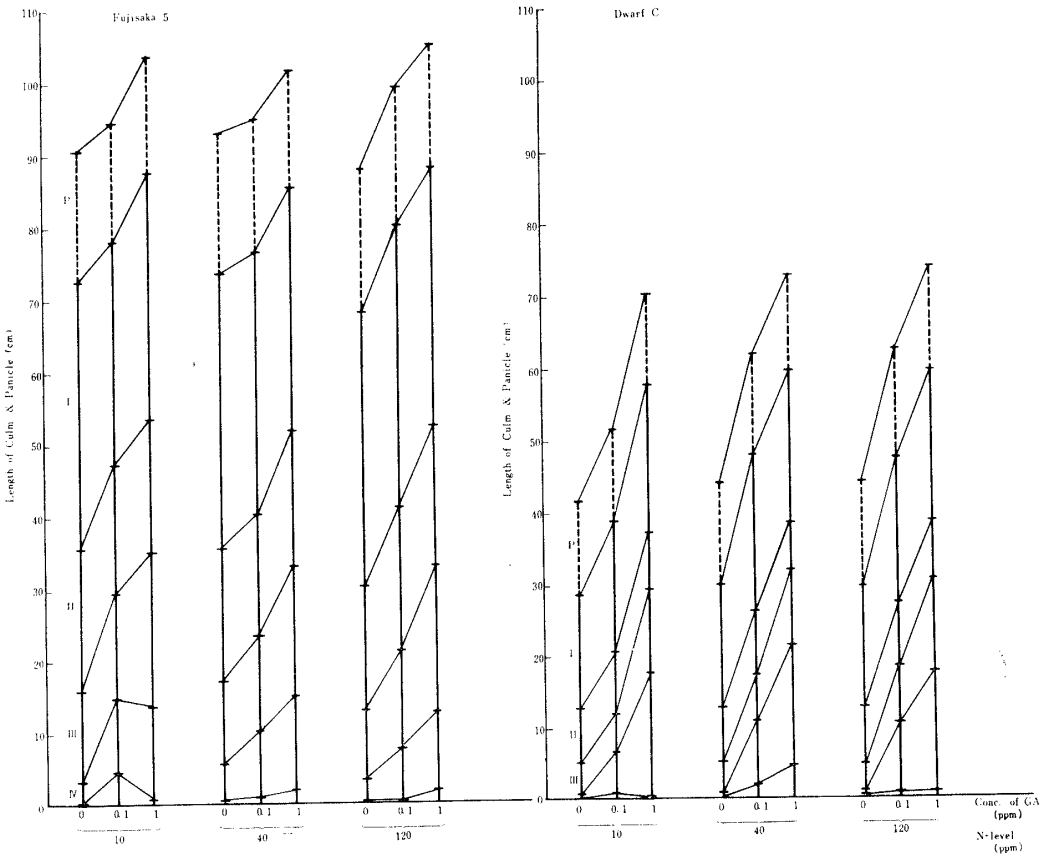

FIG. 7. Effect of GA on the internodes and panicle length of Fujisaka 5 and Dwarf C in different nitrogen levels.

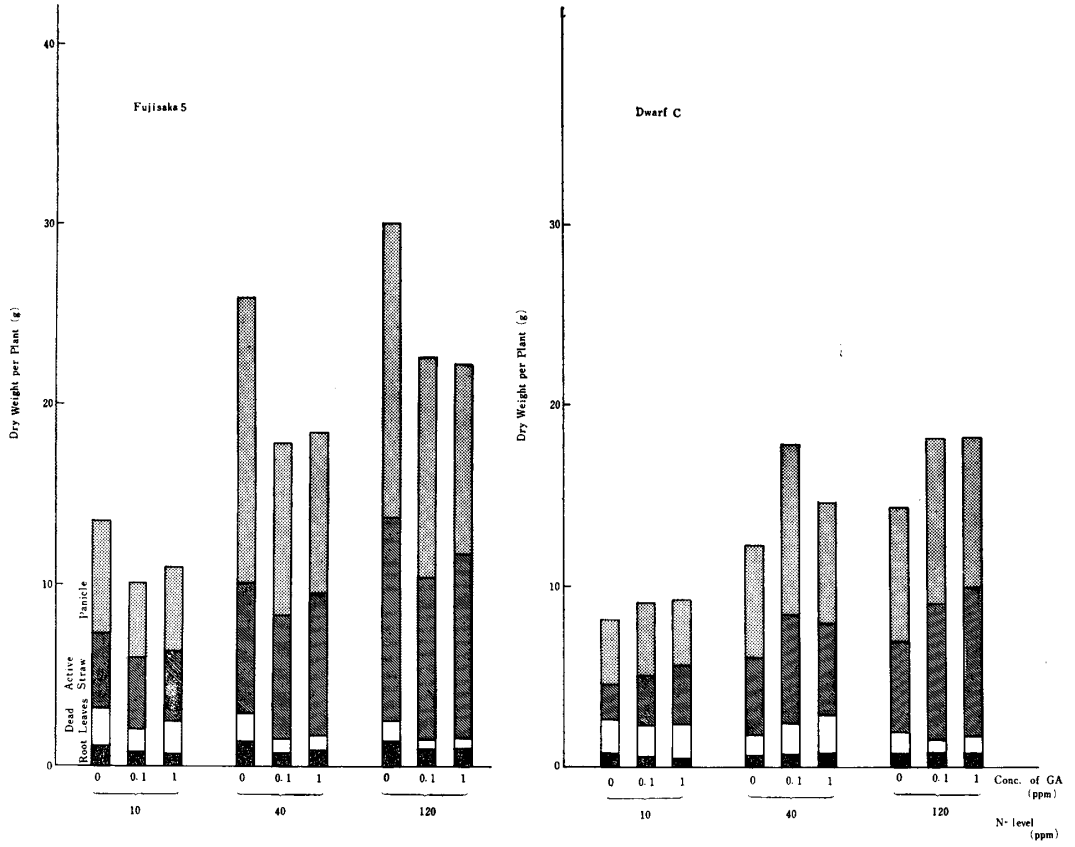

FIG. 8. Effect of GA on the dry weight of each part of Fujisaka 5 and Dwarf C in different nitrogen levels.

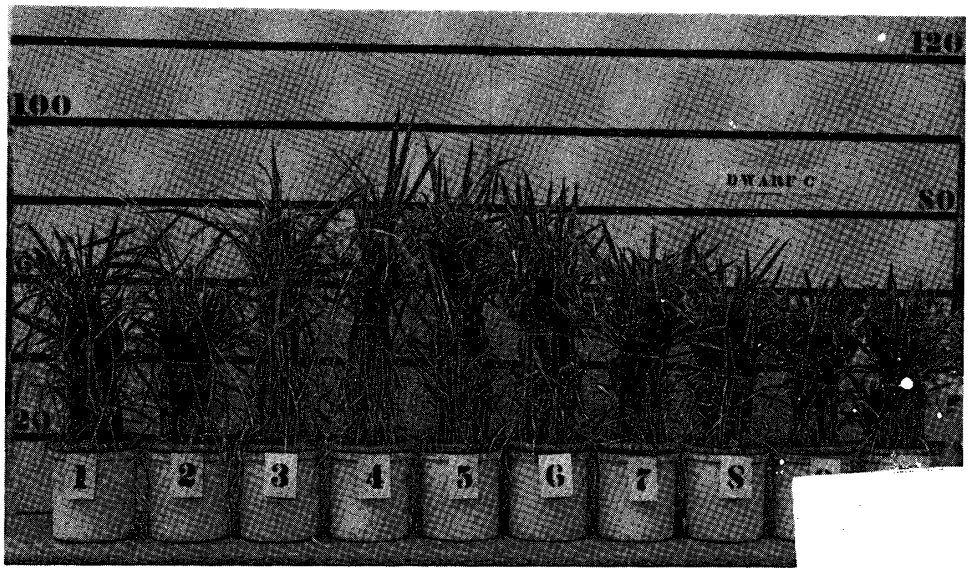

FIG. 9. Effect of GA treatment at different stages of the growth numbering of treatments corresponds to the one used in Fig. 1.

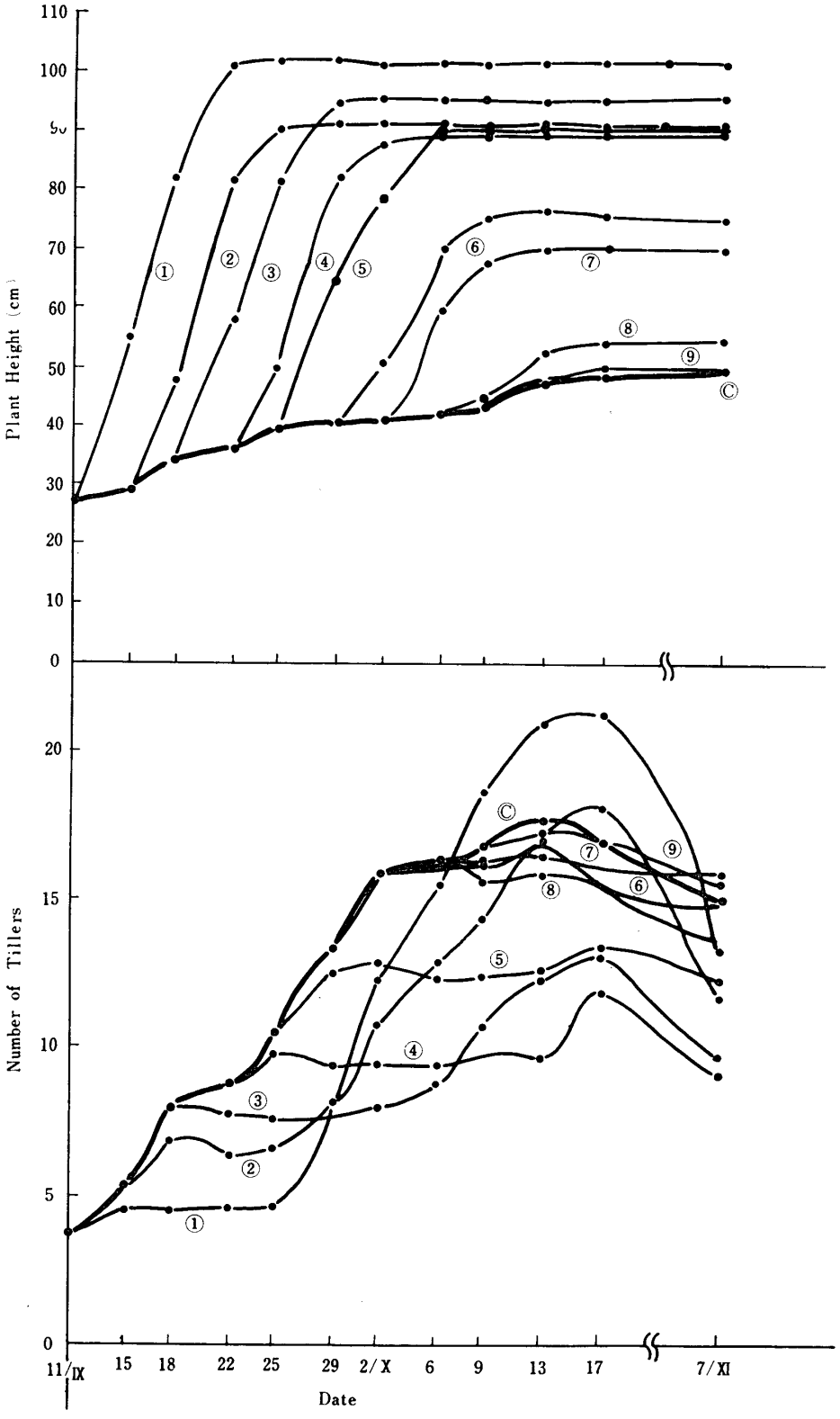

FIG. 10. Effect of GA treatment at different stages on the plant height and tiller number in Dwarf C. The numbering of treatments corresponds to the one used in Fig. 1.

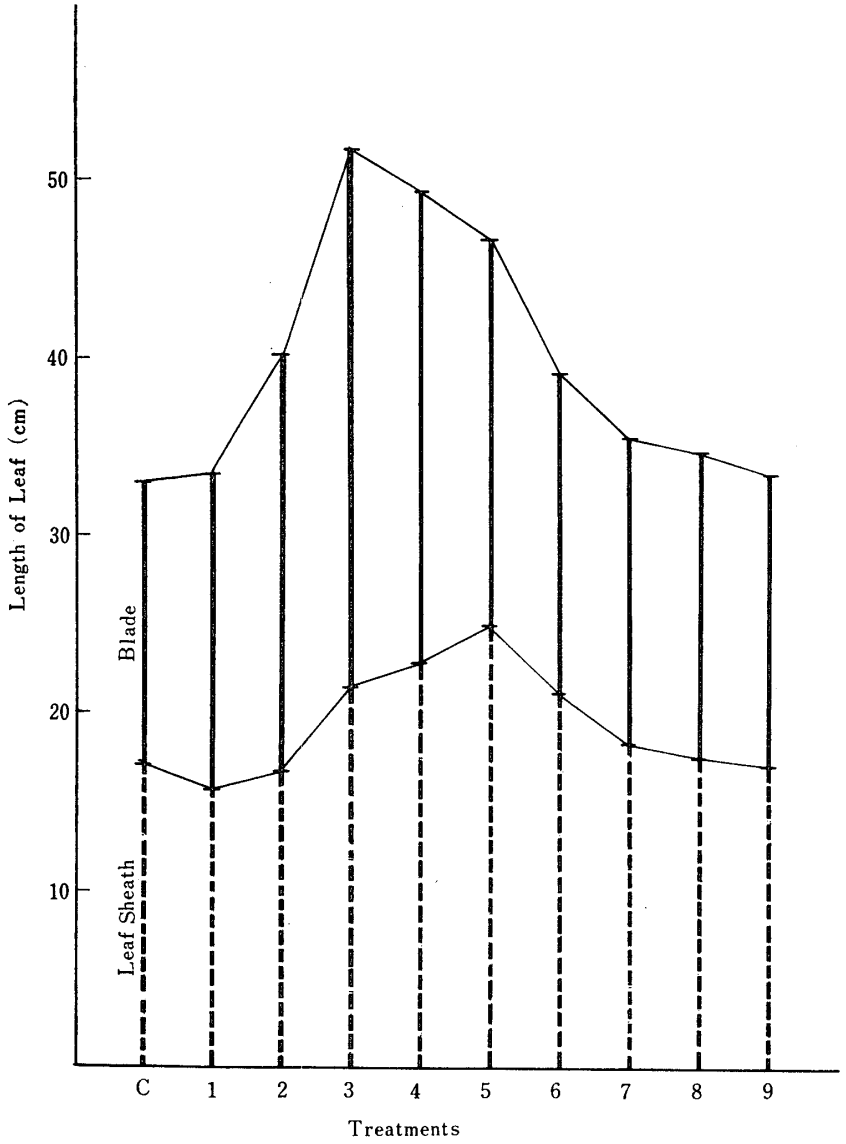

FIG. 11. Effect of GA treatment at different stages on the length of the flag leaf (13th~14th leaf) in Dwarf C. The numbering of treatments corresponds to the one used in Fig. 1.

Experiment 3

Plant height increased with GA in all stages of the treatment (Figs. 9, 10). The increase of tiller number was inhibited at least during early stages of the treatment with some and thereafter in others. In 1 and 2, GA treatment at early stages induced extremely late tillering (Fig. 10). The length of the leaf blade and leaf sheath of the flag leaf also increased with GA and the degree of increase of the leaf blade was greater in treatments 3 and 4. However, the leaf sheath was bigger in 4 and 5 than in the others (Fig. 11). The length of the culm increased considerably with GA in treatments 3, 4 and 5 and slightly in 7, 8 and 9; while the panicle length was more or less the same in all treatments (Fig. 12). The

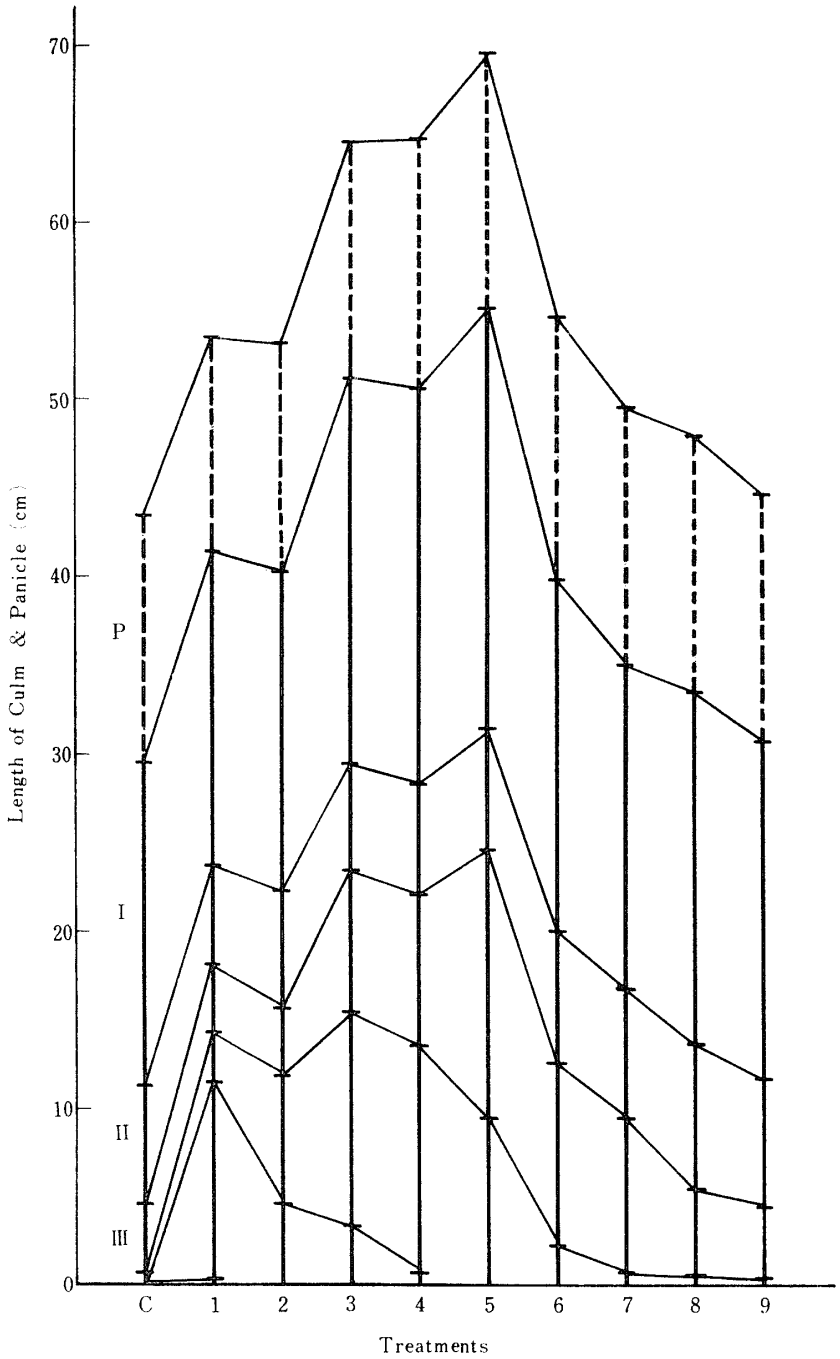

FIG. 12. Effect of GA treatment at different stages on the internodes and panicle length in Dwarf C. The numbering of treatments corresponds to the one used in Fig. 1.

lower internodes responded more to the application of GA at early stages. The total dry weight increased considerably with GA treatment at the middle stages, 5, 6 and 7. However, it was reduced slightly at early stages in 1 and 2, and was not affected in the treatment 8 at later stage (Fig. 13). Most of the root weights increased. The straw weight increased in all treatments, although the degree was greater in the treatments at middle stages. The panicle weight reduced in the

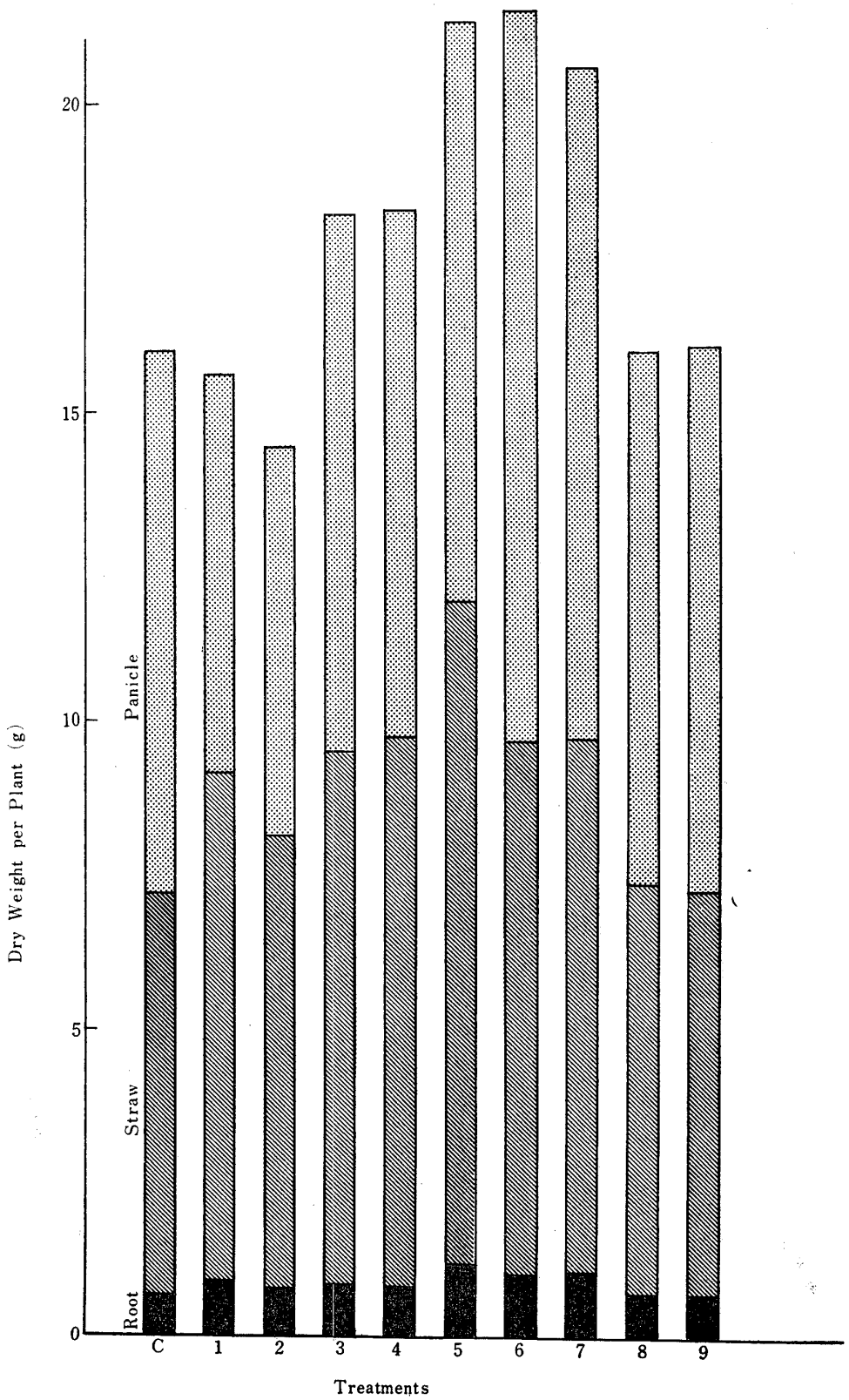

FIG. 13. Effect of GA treatment at different stages on the dry weight of Dwarf C. The numbering of treatments corresponds to the one used in Fig. 1.

early stage treatments and was not affected in the later stage treatments. However, it increased considerably in the middle stage treatments of 6 and 7.

Discussion

Plant height increased and the tiller number decreased with GA, although the GA treatment at the early growth stage induced later active tillering as reported in the previous paper (3). An extreme increase of plant height with the early stage treatment of GA was based on the leaf blade elongation and not on the culm length. The increase in height was also reflected in the length of the culm and flag leaf of the main culm. The longer culm length caused by GA was the result of longer internodes and not because of more elongated internodes. The same case applies to the difference between the two isogenic lines: ESP, a short line with low content of GA and ETP, a tall line with high GA content, as reported before.[6] From this point, GA seems to affect only the elongation of each internode. As a general tendency, lower internodes responded more compared to the upper internodes as previously reported (4). The reason for such may be that the competition for mineral nutrition and carbohydrate does not occur between the panicle and culm during the lower internode growth. Changes of the panicle length with GA were irregular among varieties and treatments and the degrees were smaller.

The total dry weight of Dwarf C increased with GA in most treatments except in the early growth stage. On the other hand, it always decreased with Fujisaka 5. In the former variety, root weight increased or was not influenced with GA and in such cases, the straw and panicle weight also increased. However, in the latter, it all decreased. These results suggest that the normal growth of dwarf mutant will occur when GA is supplied to the plants. Moreover, it is suggested that the excess growth of shoots with GA affects the root growth through the competition for nutrients; root growth affects the straw through the absorption of the mineral nutrition, and that straw growth is reflected again in the root growth through the photosynthesis. These may also be reflected in the panicle weight.

Acknowledgement

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The authors would like to thank Kyowa Hakko Kogyo Co. Ltd., Tokyo, for supplying gibberellin samples.

[6] Harada, J., "Gibberellin content of tall and short lines of rice and their response to gibberellin." A paper presented at the Saturday Seminar, The International Rice Research Institute, Los Baños, Laguna, Philippines, on February 3, 1968.

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