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Application of Ratoon Traits Obtained by Higher Cutting for Estimation of Percentage of Ripened Grains in Rice Plants

Masashiko Ichii and Noriyoshi Ogaya

Faculty of Agriculture, Kagawa University, Kagawa, 〒 761-07

The effect of the cutting height on the relationship between ratoon traits and the percentage of ripened grains of the uncut plant was investigated using 30 rice cultivars grown in a randomized block design with 2 replications. Variations from year to year of ratoon traits were also investigated. The plant was cut on the 10th day after heading at four different heights, i. e., at ground level, and at 5, 10 and 20cm above the ground. The percentage of missing hills increased as the cutting height decreased. The percentage of ratoon tillers and the ratoon height increased with the increase of the cutting height. The relationship between ratoon traits and the percentage of ripened grains of the uncut plant varied with the cutting height. Increased cutting heights gave significantly higher values for the correlation coefficients between the percentage of ratoon tillers and the percentage of ripened grains. However, the ratoon height was not significantly correlated with the percentage of ripened grains regardless of the cutting height. The year-to-year correlation of ratoon traits was significant and positive, although growth was different. The correlation coefficient was larger for the percentage of ratoon tillers than for the ratoon height. This suggests that the percentage of ratoon tillers obtained by cutting at 10 or 20cm above the ground may reflect the percentage of ripened grains of the uncut plant.

KEY WORDS : *Oryza sativa,* ratoon, cutting height, percentage of ripened grains.

Introduction

There have not been a useful selection measure for higher percentage of ripened grains since its heritability is lower. It was demonstrated in our previous investigation (Ichii and Kuwada 1981) that the ratoon traits could be used as the indicators of the percentage of ripened grains in the uncut plant, when the ratoon was obtained from the plant cut in the early stage of grain development. However, it is necessary to determine whether the values obtained vary with the cutting height. Ratoon traits are affected by the cutting height of the plant. According to Prasher (1970), the tiller number of the ratoon crop increases with the increase in the cutting height. Bahar and De Datta (1977) reported that the cutting height did not significantly affect the tiller number of the ratoon crop. Grain yield of the ratoon crop increased with increased cutting height, according to Bahar and De Datta (1977) and Mahiul Haque and Coffman (1980). Opposite results were obtained by Prasher (1970). Ishikawa (1964) and Balasubramanian *et al.* (1970) stated that the cutting height did not affect grain yield of the ratoon crop. These findings suggest that for the effective use of a ratoon trait as an indicator, the effect of the cutting height should be reexamined.

The current study was undertaken to determine to what extent the cutting height would affect the relationship between ratoon traits and the precentage of ripened grains of the uncut plant. Additional purpose of this research was to investigate yearly ratoon trait variations.

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Materials and Methods

The experiment was conducted at Kagawa University in 1980. Thirty rice cultivars (*Oryza sativa* L.), which were listed in our previous paper (ICHII and KUWADA 1981), were used. Thirty-four-day-old seedlings of each cultivar were transplanted with a single plant per hill spaced at 30×10 cm on June 6. The materials were grown in a randomized block design with 2 replications, each of which consisted of 125 plants. Basal fertilizer was applied at the rate of 1.0 kg N/*a*, 0.8 kg P_2O_5/*a* and 1.0 kg K_2O/*a*. No fertilizer was applied after cutting.

Two hundred plants for each cultivar were cut on the 10th day after heading at four different heights, i.e., at ground level, and at 5, 10 and 20 cm above the ground, the remaining plants being uncut. The percentage of ratoon tillers and ratoon height were recorded on the 40th day after cutting. The percentage of ratoon tillers was expressed by the following formula (Number of ratoon-plant tillers/Number of uncut-plant tillers)× 100. The ratoon height was measured from the cutting level. The percentage of ripened grains of the uncut plant was also recorded.

Additional purpose of this experiment was to show the variations from year to year of ratoon traits. Cultivars used, time of seeding and transplanting, experimental field and management practices in present experiment conducted in 1980 did not differ from those in the experiment in 1977.

Results

1. *Ratoon traits at different cutting heights*

A wide range of intervarietal variation was observed in the heading date of the untreated plants, and in the number of tillers and height of ratoon plants. Heading dates ranged from August 7 to September 2.

The results of variance analysis for the percentage of ratoon tillers and ratoon height are given in Table 1. There were significant variations associated with the cultivar, cutting height and cultivar×cutting height-interaction. Differences in the ratoon trait valuesr among the cultivars were significant, as shown by the results reported in our previous pape (ICHII and KUWADA 1981).

The averages of percentage of ratoon tillers and the ratoon height at four cutting heights of 30 culitvars are shown in Fig. 1. The values of both traits increased with increased cutting

Table 1. Analysis of variance of ratoon traits

Trait	Source	d. f.	Mean Square
Percentage of ratoon tillers	Cultivar (C)	29	1118.79**
	Cutting height (H)	3	17336.32**
	C×H	87	112.22*
	Error	120	80.88
Ratoon height	Cultivar (C)	29	209.06**
	Cutting height (H)	3	7000.90**
	C×H	87	76.18**
	Error	120	33.69

*, ** : Significant at 5 and 1% level, respectively.

height, though the values obtained at 10 and 20 cm cutting height were not significantly different. In one-third of the cultivars used, most of the hills cut at ground level did not produce ratoons. But such missing hills significantly decreased when the cutting height was 5 cm above the ground, and they were not observed in the plants cut at a height of 10 cm above the ground.

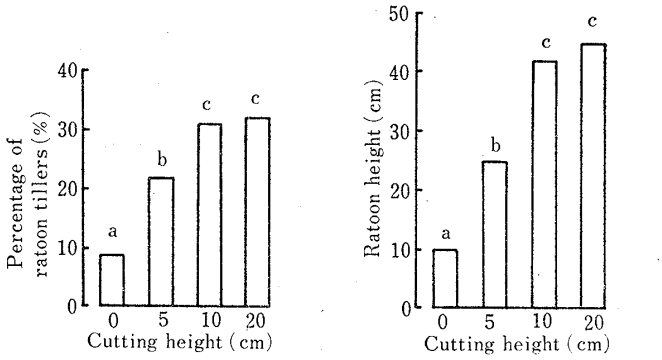

Fig. 1. Percentage of ratoon tillers and ratoon height at four differnnt cutting heights.
The respective means followed by the same letter are not significantly different at 5% level according to Dancan's Multiple Range Test.

We found (Ichii and Kuwada 1981) that in varietal comparison the percentage of ratoon tillers and ratoon height were closely related to the percentage of ripened grains in the uncut plants when the plant was cut at the height of 5 cm. Terefore, the above result suggests that the relationship between the two ratoon traits and the percentage of ripened grains also varies with the cutting height of the plant. In Table 2, the phenotypic correlation coefficients between the ratoon traits and the percentage of ripened grains in the uncut plant are shown for four cutting heights. As seen in this table, the correlation coefficients between the percentage of ratoon tillers and the percentage of ripened grains increased with the cutting height, and became significant at a height of 10 and 20cm above the ground. Ratoon height, on the other hand, showed no obvious relationship with the percentage of ripened grains regardless of the cutting height.

Heritability estimates in the broad sense for the percentage of ratoon tillers and ratoon height were estimated from the results of variance analysis. These are listed in Table 3. The estimates for the percentage of ratoon tillers were high and constant irrespective of the cutting height, while those for the ratoon height widely differed with the cutting

Table 2. Phenotypic correlation coeffecients between ratoon traits and the percentage of ripened grains of uncut plant

Cutting height (cm)	Percentage of ratoon tillers : Percentage of ripened grains	Ratoon height : Percentage of ripened grains
0	−0.03	−0.03
5	0.16	0.04
10	0.38*	0.09
20	0.52**	−0.03

*, ** : Significant at 5 and 1% level, respectively.

Table 3. Broad sense heritability (%) of ratoon traits at four different cutting heights

Cutting height (cm)	Percentage of ratoon tillers	Ratoon height
0	85.4	90.7
5	78.7	51.3
10	88.7	51.9
20	84.5	82.7

Table 4. Comparison of ratoon traits between 1977 and 1980

Year	Percentage of ratoon tillers (%)	Ratoon height (cm)
1977 (A)	36.7	36.5
1980 (B)	24.5	24.8
A−B	12.2**	11.7**

** : Significant at 1% level.

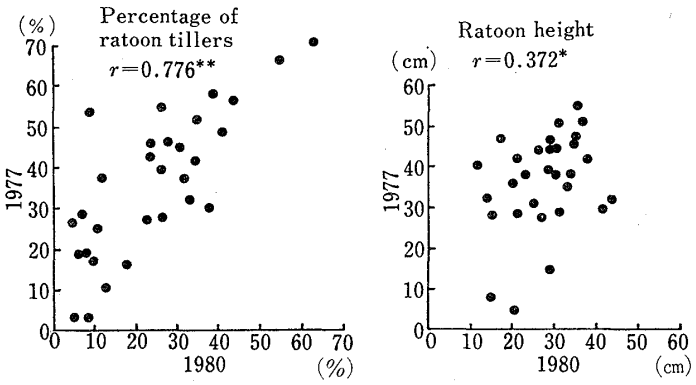

Fig. 2. Year-to-year correlation of ratoon traits.
*, ** : Significant at 5 and 1% level, respectively.

height, ranging from 51 to 91%. The estimates at the cutting of ground level were unexpectedly high. The fact can be explained by the increase of missing hills, which reduces the variation associated with replications of the experiment.

2. *Yearly variation in ratoon traits.*

Two ratoon traits, the percentage of ratoon tillers and ratoon height, observed in 1980 were compared with those in 1977. Temperature, solar radiation and rainfall in the experimental field during the period from May to October in 1977 were nearly normal compared to the averages of the 10 year period from 1966 to 1975. But, in the period from July to August in 1980, temperature and solar radiation were 2°C and 20–30% less, respectively, than the average, and rainfall was twice as much. Therefore, the year 1980 was considered as a year of cool-weather damage.

In Table 4, the two ratoon traits observed in 1977 and 1980 are compared. They were obtained at 40 days after cutting, in the ratoons whose plants were cut at 5 cm above the ground on the 10th day after heading. Percentage of ratoon tillers was 12.2% less and ratoon height was 11.7cm less in 1980 than in 1977, and all of these differences were significant. Figure 2 illustrates the between-year correlations in the two ratoon traits. In this figure, significant positive correlations in both of the traits were observed, and the correlation coefficient was larger in the percentage of ratoon tillers than in the ratoon height.

Discussion

Although the total available carbohydrate (TAC) content of the stem base was higher than that in the upper part of culm at the early stage of grain filling in rice plants (YOSHINO and MURAYAMA 1960), the amount of TAC contained in stubbles may be affected by the cutting height. According to ICHII and SUMI (1983), growth of rice plant ratoons on the amount of nutrients contained in the stem base. These results may account for

the fact that ratoon height and the percentage of ratoon tillers increased with an increase in the cutting height. Ono *et al.* (1968) and Watanabe *et al.* (1969) reported that dry matter yield in the regrowth of orchardgrass increased with the cutting height. Prasher (1970) showed in his investigation concerning double-cropping through ratooning of paddy rice that the tillering of the ratoon crop increased with the cutting height of the plant. According to Mahiul Haque and Coffman (1980), grain yield of rice ratoon plants increases with the cutting height of the plant, and in this study rtaoon height increased as the cutting height increased. Bahar and De Datta (1977) showed in their investigation using rice plants that the cutting height of the plant did not significantly affect the tiller number in the ratoon crop, though it affected the grain yield and the percentage of missing hills in the ratoon crop. In this experiment, the reduction of the cutting height caused a significant increase in the percentage of missing hills. Missing hills may be caused by rotting of the resting buds, as Harnaez (1958) and Ichii (1983) reported. Vigorous growth of ratoon plants is very important in double-cropping by ratooning and soiling in rice.

In the present experiment, which was conducted in 1980, the percentage of ratoon tillers exhibited a significant correlation with the percentage of ripened grains in the uncnt plant when the cutting was performed at 10 or 20cm above the ground, but never at 0 and 5cm. While ratoon height showed no correlation with the percentage of ripened grains regardless of the cutting height. In the experiment carried out in 1977 (Ichii and Kuwada 1981), however, both the percentage of ratoon tillers and ratoon height exhibited significant correlation with the percentage of ripened grains though the cutting height was 5cm. Judging from the results of these two experiments, it is suggested that the precentage of ratoon tillers observed at 10 or 20cm cutting height can be used as the indicator of the percentage of ripened grains.

Percentage of tillers and height of ratoon plant were significantly lower in 1980 than in 1977. These differences may primarily be attributed to the differences in temperature and solar radiation. Temperature and solar radiation in the summer of 1980 were both abnormally lower than in the usual year. Such low temperature and low solar radiation in 1980 most probably resulted in a low accumulation of nutrients in the stem base of rice plants, and adversely affected the growth of ratoons, as shown by Ichii and Sumi (1983).

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Literature Cited

Bahar, F. A. and S. K. De Datta 1977. Prospects of increasing tropical rice production through ratooning. Agron. J. **69** : 536-540.

Balasubramanian, B., Y. B. Morachan and R. Kaliappa 1970. Studies on ratooning in rice. I. Growth attibutes and yield. Madras Agric. J. **57** : 565-570.

Harnaez, A. 1958. Some facts on rice ratooning. Plant Ind. Digest **21** : 7, 22.

Ichii, M. and H. Kuwada 1981. Application of ratoon to a test of agronomic characters in rice breeding. I. Variation in ratoon ability and its relation to agronomic characters of mother plant. Japan. J. Breed. **31** : 273-278.

——— and Y. SUMI 1983. Effect of food reserves on the ratoon growth of rice plant. Japan. Jour. Crop Sci. **52** : 15–21.

——— 1983. The effect of water management of ratoon ability of rice plant. Tech. Bull. Fac. Agr. Kagawa Univ. **34** : 123–128.

ISHIKAWA, T. 1964. Studies on the ratoon of rice plant in early cultivation. Bull. Fac. Agric., Univ. Miyazaki, Japan **10** : 72–78.

MAHIUL HAQUE, M. and W. R. COFFMAN 1980. Varietal variation and evaluation procedures for ratooning ability in rice. SABRAO Journal **12** : 113–120.

ONO, S., H. NAKASHIMA and K. EHARA 1966. Physiological and ecological studies on the regrowth of herbage plants. VIII. Effect of cutting treatments on the original tiller regrowth and new tiller development of orchardgrass. J. Japan. Grassl. Sci. **14** : 10–19.

PRASHER, C. R. K. 1970. Paddy ratoons. World Crops **22** : 145–147.

WATANABE, K., I. KATSURA, S., S. SEKIMURA and H. OIZUMI 1969. Effect of cutting height and growth season on the regrowth of orchardgrass, *Dactylis glomerata* L. J. Japan. Grassl. Sci. **15** : 16–20.

YOSHINO, M. and N. MURAYAMA 1960. Studies on metabolism of rice plant during the ripening period. (Part 4) Movement of carbohydrates in stem during the ripening period. J. Sci. Soil Manure, Jpn. **31** : 17–20.

イネの登熟歩合推定のための高刈りによる再生茎形質の利用

一井真比古・鋸谷　智吉

（香川大学農学部，木田郡三木町，〒761-07）

稲体の地上部を生育後期に剪除したときに見られる再生茎の形質が非剪除株の登熟歩合の推定に利用しうることをすでに報告した．しかしながら再生茎の特性は地上部の刈取り高さによって変異すると思われる．そこで再生茎形質と登熟歩合との関係に及ぼす刈取り高さの影響を明らかにしようとした．また既報の結果を加え，再生茎形質の年次間変異についても検討した．

水稲 30 品種を供試し，出穂後 10 日に地際より 0，5，10 および 20cm で地上部を刈取り，刈取り後 40 日に再生茎率（(再生株の茎数/非剪除株の茎数)×100）および再生草丈（再生株における刈取り面からの草丈）を調査した．非剪除株の登熟歩合を成熟期に調べた．

再生茎率および再生草丈は品種固有の特性であり，かつこれらの形質は刈取り高さによって顕著に異なることが明らかになった（Table 1）．高く刈取るほど再生茎率および再生草丈は増大したが，20cm 刈りは 10 cm 刈りと有意に異ならなかった（Fig. 1）．なお，0 cm 刈りでは再生しない株が多く見られたが，高く刈るほど再生しない株の頻度は減少し，10cm 刈りではすべての株が再生した．再生茎形質と登熟歩合との関係は刈取り高さに伴って変異し，高く刈取るほど再生茎率と登熟歩合との相関は高くなり，かつ有意であった（Table 2）．しかしながら再生草丈は刈取り高さにかかわりなく登熟歩合と有意な相関を示さなかった．再生茎率の遺伝率（広義）は刈取り高さにかかわりなく，かつほぼ一定であったが，再生草丈のそれは刈取り高さによって大きく変異した（Table 3）．

本実験（1980）および既報（1977）の結果から，再生茎形質の年次間変異を検討した．1980 年における再生茎率および再生草丈は 1977 年のそれらに比べ有意に小さかった（Table 4）．また再生茎形質の年次間相関をみると，両年次における 7 月および 8 月の気温および日射量が顕著に異なったにもかかわらず，それらは有意で，かつ正であった（Fig. 2）．再生茎率の年次間相関は再生草丈のそれより顕著に高かった．

以上の結果から，地上 10～20cm で地上部を刈取ったときの再生茎率は登熟歩合を推実するための有効な手段となりうると思われる．