Effect of Drainage on CO₂ Exchange and Some Characters Related to Grains Yield of Rice Plant*

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In the previous paper³⁾ dealing with growth conditions of rice plant in ill-drained paddy field, the author described a problem on the increased grains yield caused by drainage treatment. He pointed out that the apparent photosynthesis per plant in drained plot dropped for a while by drainage, but after re-irrigation it became higher than that in water-logged plot. Thus, number of ripened grains per panicle, percentage of ripened grains, and weight of 1000 kernels were increased by drainage treatment.

It is the purpose of the present investigation to make clear why the apparent photosynthesis increases by re-irrigation.

MATERIALS AND METHODS

In this experiment, a water-logged condition and two drainage treatments were designed. Two drainage treatments were divided into earlier drained plot and later drained one, the former meant a drainage from the end of the valid tillering time until the panicle primordium differentiation time, and the latter did a drainage from the panicle primordium differentiation time till heading time.

Murata's apparatus⁵⁾ was applied in this experiment to measure the photosynthesis and respiration of each leaf-blade in different order using a rice-variety of Hokuriku-No. 52.

RESULTS AND DISCUSSION

1. Relationship between photosynthesis and respiration

As illustrated in Fig. 1, drainage treatment increased photosynthetic activity, but decreased respiration in each leaf-blade of the same order both at heading time and at ripening stage.

In other words, the ratio of photosynthetic activity to respiration rate (P/R) was higher in both drained plots than in water-logged plot.

2. Dry weight of leaf-blade

Previously, Takeda and Maruta⁷⁾ reported that the weight of each green leaf-blade at ripening stage increases for a time, and then decreases gradually with the progress of maturation.

In this experiment, as shown in Table 1, the dry weight of each leaf-blade per unit area increased even two weeks after heading. Further, drainage treatment before heading showed a helpful

Fig. 1. Relation between photosynthesis and respiration of rice plant

Note.	Top leaf (flag)	1st leaf from Top	2nd leaf from Top
Water-logged	①	②	③
Earlier drain.	△	△	△
Later drain.	□	□	□

effect of holding the leaf-blade weight during ripening stage.

3. Effect of artificial defoliation on grains yield

Artificial defoliations by cutting off leaf-blades with scissors were made at heading time to investigate the functions of photosynthetic organs in producing grains during the ripening stage. The results are shown in Table 2.

Each leaf-blade in the same order of drained plots was superior in the activity of dry matter production to that of water-logged plot.

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Table 1. Dry weight of each leaf-blade per unit area (mg/100 cm²)

	Heading time			Ripening stage		
	B ₁	B ₂	B ₃	B ₁	B ₂	B ₃
Water-logged	.649	.606	.533	.668	.652	.632
Earlier drain.	.646	.608	.578	.707	.674	.644
Later drain.	.641	.601	.532	.688	.667	.645

Note. B₁: leaf-blade of flag leaf. B₂: leaf-blade beneath B₁. B₃: leaf-blade beneath B₂.

Table 2. Hulled rice amount per hill

	Untreated	Defoliated		
		except B ₁ +B ₂	except B ₁	all blades
Water-logged	31.5 ^g	30.3 ^g	24.3 ^g	15.9 ^g
Earlier drain.	33.2	31.9	25.4	16.3
Later drain.	33.6	32.2	25.7	16.3

Table 3. Average weight of one hulled grain and roles played by photosynthetic organs

	Average weight of one hulled grain				Roles* played by photosynthetic organs			
	Untreated	Defoliated			B ₁	B ₂	Blades below B ₂	Organs other than leaf-blades**
		except B ₁ +B ₂	except B ₁	all blades				
Water-logged	18.5 ^{mg}	17.8 ^{mg}	14.5 ^{mg}	9.3 ^{mg}	5.2 ^{mg}	3.3 ^{mg}	0.7 ^{mg}	9.3 ^{mg}
Earlier drain.	19.9	19.0	15.1	9.6	5.5	3.9	0.9	9.6
Later drain.	19.5	18.5	15.0	9.4	5.6	3.5	1.0	9.4

Note. * These values were calculated by the values of the left column.

** These organs consist of leaf-sheaths and husks etc.

4. Effect of artificial defoliation on the average weight of one hulled grain

Average weight of one hulled grain is given in Table 3. It is recognized to be larger in drained plots than in water-logged plot in case of either defoliation or not.

The role played by each leaf-blade of the same order in feeding up each grains was increased by drainage treatment.

Effects of drainage on photosynthetic organs other than leaf-blades were not so clear in 'later drained plot' as in 'earlier drained plot'.

5. Effect of defoliation on the rate of well-ripened grains

As shown in Table 4, the rate of well-ripened hulled grains to total grains in number, decreased by defoliation treatment in either plot. The decrease of the rate due to defoliation was, however, lesser in drained plots than that in control plot.

6. Effect of drainage on the number of spikelets

As given in Table 5, drainage effect on the number of flowered spikelets was not clear namely, later drain.>control>earlier drain. However, the diminutions in the degeneration of secondary rachis and of spikelets per panicle were distinctly

recognized by the drainage treatment.

From the results mentioned above, it seems reasonable to assume that the yield increase due to the drainage treatment may be attributed to promotion in the photosynthetic activity and to relative reduction in respiration during ripening stage.

Baba and Tajima¹⁾ observed the increase of useless respiration by supplying excessive amount of ferrous iron.

Further, they²⁾ found a considerable decrease in the rate of photosynthesis to respiration by H₂S-treatment.

And, Murata et al.⁶⁾ recognized recently the decrease in the ratio of *P/R* by applying either ferrous iron or H₂S in gravel culture of rice plant.

In the present experiment, the occurrence of H₂S was not confirmed both in water-logged plot and in drained plots. However, high holding in Eh_h value in soil was recognized even after re-irrigation in drainage plots.

Therefore, successive effect of maintaining soil in oxidative by drainage treatment seems to diminish the injury of ferrous iron during ripening stage in these drained plots, and to maintain *P/R*

Table 4. Percentage ratio of well-ripened hulled grains to total number of grains produced

	Untreated	Defoliated		
		except B ₁ +B ₂	except B ₁	all blades
Water-logged	78.1 %	72.5 %	58.9 %	42.8 %
Earlier drain.	82.5	75.6	62.5	47.0
Later drain.	84.8	74.0	63.2	48.2

Note. Well ripened hulled grains mean those that are more than 17 mm in thickness.

ratio high.

SUMMARY

The author investigated the roles played by leaf-blades in producing grains with reference to drainage treatment.

1. Each leaf-blade in the same order of drained plot showed higher capacity in producing dry matter, than that of water-logged plot.

2. Drainage treatment was apt to promote the photosynthetic activity, but to reduce respiration. Consequently it made *P/R* ratio increase.

3. Drainage treatment showed a favorable effect on holding the leaf-blade weight high during ripening stage.

4. Drainage treatment decreased the degeneration in secondary rachises and spikelets in panicles, and increased not only the grains weight but also percentage of well-ripened grains.

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Table 5. Effect of drainage on the number of spikelets

	A	B	C	D
Water-logged	1703	70.0	16.8	7.6
Earlier drain.	1667	69.5	11.6	5.4
Later drain.	1724	73.7	10.8	5.6

Note.

A: number of flowered spikelets per hill

B: number of flowered spikelets per panicle

C: degenerated number of spikelets per panicle

D: degenerated number of secondary rachis branch per panicle

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〔和 文 摘 要〕

中干が水稻のガス代謝および収量決定要素におよぼす影響

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前報において、落水処理による収量の増加は、登熟期の見掛けの同化量の増加による事を報告したが、収量に対する真の同化作用と呼吸作用との関係、とくに、葉位別の問題については明らかになし得なかった。

本試験では、常時湛水区を対照として、早期中干区(栄養生長の後期の落水)と晚期中干区(幼穂の發育する期間)の二つの落水区を設け、主として、登熟期の葉身の機能と、登熟との関係について調査した。

1. 各葉位の葉身のはたらきを、ガス代謝と剪葉法による稔実調査の両面から検討したところ、大体、同様な傾向が認められ、常時湛水区に比べ、中干区では、各葉位とも葉身の乾物生産能力が高められていた。

2. 中干区では、葉身単位面積当りの真の光合成作用が高いとともに、呼吸作用が低く、したがって P/R 比が高い傾向を示した。また、登熟のある時期まで、葉の充実度もまさっていた。

3. これらのことが、中干区で退化穎花数を減少させ、1粒重を増加し、上米歩合を高め、収量の増加を来したものと考えた。