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Influence of Environmental Conditions on Harvest Index of Rice[1]

Fu-Hsiung Lin[2]

Summary

Monthly plantings of two rice cultivars throughout the year (1975) showed that harvest index was affected by planting date. January and February plantings gave highest grain yield and highest harvest index, and July planting also gave higher harvest index than plantings in other summer months.

The application of nitrogenous fertilizers brought about increases in grain yield and total dry weight, but a decrease in harvest index in the first crop season. This was because the rate of grain yield increase in response to nitrogen was lower than that of total dry weight. These relations were not observed clearly in the second crop season as harvest index did not change much in response to nitrogen application.

In general, harvest index, grain yield and total dry weight increased with an increase in population density, but harvest index showed smaller differences due to planting density than those in grain yield and total dry weight.

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Influence of Environmental Conditions on Harvest Index of Rice

Fu-Hsiung Lin

Introduction

The ratio of grain yield to biological yield (excluding root weight) is defined as harvest index. The harvest index in cereal crops is sensitive to environmental conditions as is grain yield.

The influence of growing season on harvest index has been recorded in rice production in the Philippines. Chandler (1969) noted that the harvest index in an old cultivar, Peta was as low as 0.22 during the cloudy monsoon but was as high as 0.47 in the sunny dry season. The relationship of the yield of cereals to population density has been broadly elucidated. Grain yield increases to a maximum value which is realized at an optimum density and declines as density is further increased. Harvest index showed a progressive decline at densities above the optimum (Scarsbrook and Doss 1973; Puckridge and Donald 1976).

The application of nitrogen to cereals commonly give an increase in biological yield combined with a decrease in harvest index. McNeal et al. (1971) who studied spring wheat in Montana showed that the harvest index fell from 0.43 to 0.39 with nitrogen application and a negative correlation occurred between harvest index and grain yield. Similar relationships occurred among rice genotypes (Langfield 1961). Where a marked difference in the response of biological yield to nitrogen was accompanied by an inverse response of harvest index. These studies indicated a notable interaction between soil fertility, genotype and harvest index.

In Taiwan, rice is grown in the first (winter) and second (summer) crop seasons, which greatly differ in climatic conditions. Although many of rice cultivars have been selected so as to be adaptive in both seasons, the second crop usually gives a singificantly lower yield than the first crop, as accompanied by a lower harvest index. This has suggested to the author the necessity of examing the pattern of variations in harvest index as influenced by genotypes and environmental conditions and the significance of its variation in breeding programs. The objectives of this study were to examine the influence of environmental factors on harvest index of rice.

Materials and Methods

To study the effect of planting date on harvest index, two rice cultivars; Kaohsiung 140 (Japonica) and Chianung sen 11 (Indica) were planted throughout the year at one-month intervals. For each planting, seedlings raised in nursery trays were transplanted in the field when they expanded three leaves. The plot area for each variety was 5m². Conventional management practices were adopted throughout the test; at maturity 20 plants were harvested at ground level and were measured for total dry weight, grain yield and harvest index.

The relationship of harvest index to nitrogen level and population density was examined in the 1981 second crop and 1982 first crop, with four cultivars, i.e., Kaohsiung sen 7 (Indica), Tainan 5 (relatively tall and medium-late Japonica), Kaohsiung 140 (relatively short and medium-late Japonica), and Kaohsiung 141 (early maturing Japonica). Three nitrogen levels were 60kg, 120kg and 180 kg/ha of nitrogen. The planting densities were 27cm x 27cm, 27cm x 13.5cm and 13.5cm x 13.5cm. Forty percent of the total nigrogen was applied as basal dressing, and the remaining 30%, 20% and 10% as first, second, and third (panicle initiation stage) top dressings, respectively. The experiment followed a split-plot design with four replications, taking varieties as sub-plots and nitrogen levels or spacings as main-plots. Five plants from each plot were sampled at maturity stage. The plants were dried at 75°C for 48-72 hours. The total dry weight, grain yield and harvest index were recorded for analysis.

Results and Discussion

a) Effect of planting date

Effect of monthly planting on the variation of harvest index, grain yield and total dry weight were examined throughout the year of 1975 and the results are given in Fig. 1. It was shown that the rice planted in January and February gave higher harvest index which accompanied by higher grain yields. The another peak for high harvest index was observed in the July planting. Both of them are to coincide with the planting time of local first and second crops, respectively. Planting in other months gave lower harvest index and grain yield as compared to the two peaks. The September and October plantings were not harvested due to transitory yellowing disease damage.

It is evident from Fig. 1 that the harvest index was affected by planting date. In southern Taiwan, the first crop season generally gave higher harvest index than the second crop season. This difference caused the lower yield in the second crop. Plantings in April to June gave lower grain yields and lower harvest indices than in July planting or the second crop. This trend is generally observed in monthly planting experiment conducted in Taiwan and is attributed to the inadaptibility of the varieties tested to the intermediate season between the first and second crops for an unknown reason.

The harvest indices in the first and second crops were uncorrelated (r = 0.087). This indicate that harvest index is affected by the growing seasons greatly. Probably, genotypes with a high harvest index can be selected in the second crop season in which the variance for harvest index was larger.

b) Effect of nitrogen application

The application of nitrogen in the first crop season generally resulted in an increase in the total dry weight and grain yield, but a decrease in harvest index, as the grain yield increased in response to nitrogen application with a lower rate than the increase in total dry weight. This trend was not so clear in the second crop season as harvest index did not change much in response to nitrogen application (Fig. 2). An application of 120 kg/ha of nitrogen brought about a slight increase in both total dry weight and grain yield, but 180 kg/ha of nitrogen brought about a slight decrease in grain yield (Table 1). As is well known, nitrogen application is more effective in the first crop than in the second crop.

The varieties tested can be classified into two groups differing in the response of harvest index to nitrogen application. Kaohsiung sen 7 and Tainan 5 belong to one group in which harvest indices decreased with nitrogen application in both crop seasons. Kaohsiung 140 and Kaohsiung 141 belong to the other group which showed a decrease in harvest index with nitrogen application in the first crop season but an increase in the second crop season (Table 1). The interaction between cultivar and nitrogen level was significant only in the second crop. This suggests that genotypes with high harvest index may be selected in the second crop with a high level of nitrogen application (Table 2).

c) Effect of planting density

In general, the data showed that harvest index, grain yield and total dry weight increased with the increasing population density, but harvest index showed smaller differences between low and high planting densities than those in grain yield and total dry weight (Fig. 3).

It was reported in wheat (Puckridge and Donald, 1976) and cron (Hanway and Russell, 1969; Fairboum et al, 1970) that the harvest index declined after the maximum yield was reached at optimum density. They considered such decrease to be caused by poor light utilization among plants in dense planting. The present experiment did not show such trend with the increase of planting density from 27 cm x 27 cm to 13.5 cm x 13.5 cm. This indicated that the four cultivars used in the experiment were adapted to dense planting conditions.

The response to planting densities differed among the four cultivars tested. Kaohsiung sen 7 produced at 13.5 cm x 13.5 cm almost the same amount of total dry weight in both the first and second crops, but a lower harvest index and lower grain yield in the second crop than in the first crop. Kaohsiung 140, a short

Japonica, produced at dense planting almost the same total dry weight and harvest index as well as grain yield in the two crop seasons. Kaohsiung 141, an early maturing Japonica, produced at dense planting less total dry weight and harvest index in the second crop than in the first crop and the grain yield in second crop of this variety was significantly lower (Table 3). These results indicated the response to dense planting conditions varied with variety and a genotype which could produce high total dry weight and harvest index may benefit to grain yield under dense planting conditions for the both crop seasons.

Significant differences were observed for the harvest index, total dry weight and grain yield among different population densities (Table 4). The significant interaction between cultivar and population density in harvest index revealed that genotypes with a high harvest index may be selected by comparing between different planting densities.

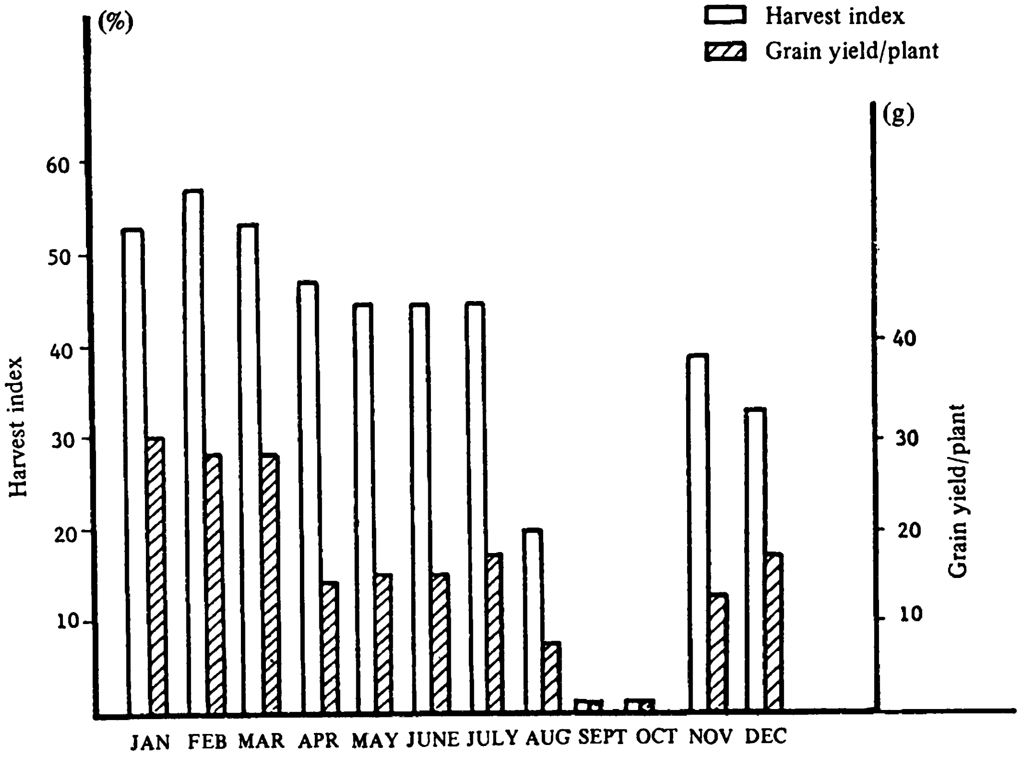

Fig 1. Effect of monthly planting on harvest index and grain weight at Pingtung (mean for two rice varieties 1975/76).

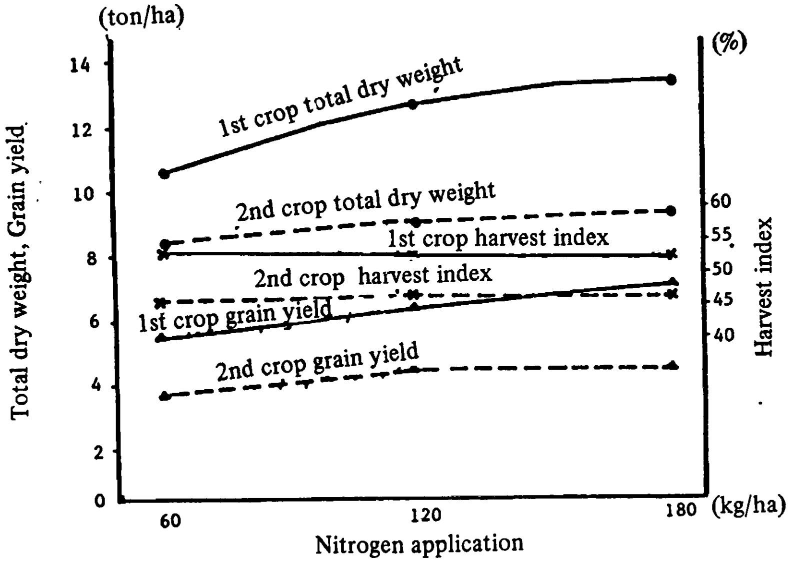

Fig 2. The influence of nitrogen on total dry weight, grain yield and harvest index

Table 1. Effect of nitrogen level on total dry weight, harvest index and grain yield in four selected rice varieties

		Nitrogen levels								
Variety	Crop	60kg N/ha			120kg N/ha			180kg N/ha		
		T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)	T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)	T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)
Kaohsiung sen 7	1	9.6	56.3	5.4	11.8	55.6	6.5	12.8	55.2	7.0
	2	8.8	46.4	4.1	9.9	44.1	5.4	10.2	42.9	4.4
Tainan 5	1	11.8	53.4	6.1	13.6	52.3	7.0	14.5	50.4	7.3
	2	8.9	48.9	4.3	8.3	46.3	3.8	8.8	43.3	3.8
Kaohsiung 140	1	10.9	54.4	5.8	12.4	51.0	6.4	13.4	50.7	6.8
	2	7.9	45.1	3.6	8.0	49.2	3.9	8.9	52.0	4.6
Kaohsiung 141	1	10.3	53.2	5.5	12.6	51.6	6.5	13.3	52.3	6.9
	2	8.3	43.9	3.6	9.4	47.5	4.4	8.8	49.3	4.3
Mean	1	10.7	54.2	5.7	12.6	52.6	6.6	13.5	52.2	7.0
	2	8.5	45.8	3.9	8.9	49.4	4.4	9.2	46.7	4.3

Table 2. Analysis of variance for grain yield, harvest index and total dry weight of rice varieties under different nitrogen levels in the first and second rice crops, as shown by the significance of mean

Source of Variation	df	Harvest index		Grain yield		Total dry weight	
		I	II	I	II	I	II
Replication	3						
Nitrogen	2	*	ns	*	ns	*	ns
Error (a)	6						
Variety	3	**	*	ns	ns	**	**
N. x Variety	6	ns	**	ns	*	ns	*
Error (b)	27						

*, ** : Significant at the 5% and 1% levels, respectively.

ns : Non-significant.

I, II : First and second crops, respectively.

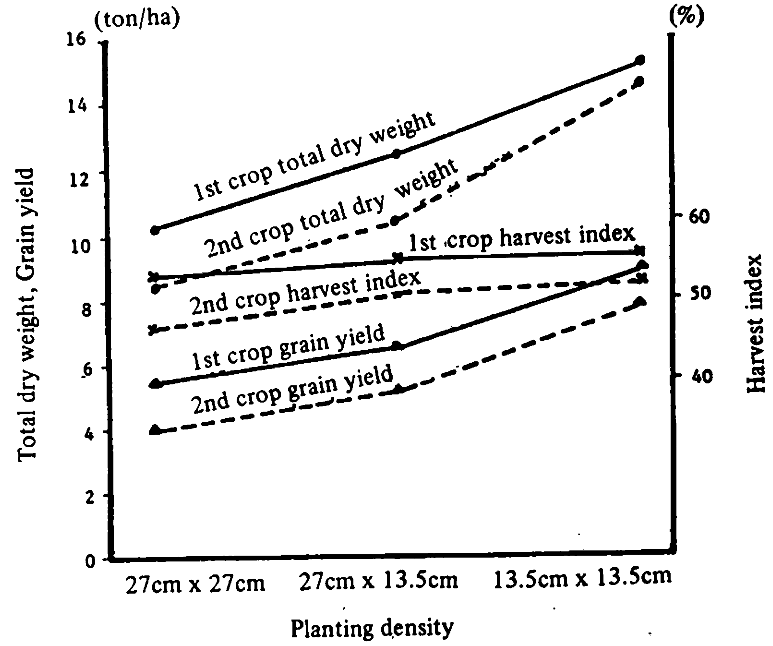

Fig 3. The influence of planting density on total dry weight, grain yield and harvest index

Table 3. Effect of population density on total dry weight, harvest index and grain yield in four selected rice varieties

Variety	Crop	Spacing								
		17cm x 27cm			27cm x 13.5cm			13.5cm x 13.5cm		
		T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)	T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)	T.D.W. (t/ha)	H.I. (%)	G.Y. (t/ha)
Kaohsiung sen 7	1	9.4	55.0	5.1	10.4	56.3	5.8	15.4	54.8	8.4
	2	9.5	44.2	4.2	11.2	47.9	5.4	15.5	50.4	7.8
Tainan 5	1	11.7	52.4	6.1	12.6	53.7	6.7	14.7	55.0	8.1
	2	8.5	47.6	4.1	10.2	53.0	5.3	13.9	53.9	7.5
Kaohsiung 140	1	9.9	52.1	5.2	12.5	55.3	6.9	14.8	55.7	8.2
	2	8.3	48.4	3.8	10.0	51.4	5.1	15.0	55.8	8.1
Kaohsiung 141	1	10.3	54.7	5.6	11.7	56.5	6.6	16.2	56.4	9.1
	2	8.4	46.0	3.9	10.4	50.6	5.2	12.7	49.5	6.3
Mean	1	10.3	53.6	5.5	11.8	55.5	6.5	15.3	55.5	8.5
	2	8.7	46.6	4.0	10.5	50.7	5.5	14.5	52.4	7.4

Table 4. Analysis of variance for grain yield, harvest index and total dry weight of rice varieties under different population densities in the first and second rice crops as shown by the significance of mean squares

Source of Variation	df	Harvest index		Grain yield		Total dry weight	
		I	II	I	II	I	II
Replication	3						
Density	2	*	*	**	**	*	**
Error (a)	6						
Variety	3	**	**	ns	ns	*	*
Density x Var.	6	*	ns	ns	ns	ns	ns
Error	27						

*, ** : Significant at the 5% and 1 % levels, respectively.

ns : Non-significant.

I, II : First and second crops, respectively.

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環境條件對水稻收穫指數之影響[1]

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摘要

水稻收穫指數對環境因素很敏感。本試驗利用不同種植月份，氮肥及密度進行探討，其結果顯示二品種經周年種植，其收穫指數受種植月份之影響。一月份及二月份種植區產量及收穫指數均最高，而七月份種植時其收穫指數亦較夏季其他月份要高。

增施氮肥使谷產量及總乾物量均增加，但使第一期作之收穫指數減低，此因谷產量因增施氮肥而增加之速率比總乾物量增加速率較低。此種關係在第二期作則不明顯，因爲第二期作之收穫指數受氮肥用量影響小。

一般而言，收穫指數、谷產量及總乾物量均隨族群密度增加而增加，但收穫指數對密度之反應較谷產量及總乾物量小。

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[1] 花蓮區農業改良場研究報告第 33 號。

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