STUDIES ON THE INTERRELATIONSHIPS AMONG PLANT CHARACTERS IN RICE

I. Effect of varietal difference and environmental condition on the correlation between characters*

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Synopsis Environmental correlation between plant characters takes different values according to variety. It even appears that environmental correlation between certain two characters takes positive value in one variety while it takes negative value in another.

Genetic correlation also varies when the environmental condition under which genotypes are grown differs.

Plant characters, such as grain yield, are generally assumed as a compound character of which the main components are the number and weight of panicles. It is well known that there exist some associations among some characters in rice where these characters change connectedly with each other when grown under different environmental conditions. This association is expected to occur always in a relation between a compound character and its component. Concept of the distinction between the so-called "panicle number type" and the "panicle weight type" suggests that the relationship of grain yield with other plant characters varies among varieties. The question arises as to how great the effect of genotype on the relationship among plant characters is.

The effect of environmental factors is so great that the majority of an agronomic character is influenced by it. It seems, therefore, highly probable that genetic correlations among plant characters are also under the influence of environmental factors. Again the question arises: Through what kind of developmental processes is the genetic correlation induced and how is it affected by the environmental factors? In this series of study, the

general feature of correlated characters in rice plant will be studied both physiologically and genetically.

In this report examples will be presented to show the effect of genotype on the environmental correlation and of the environmental

Fig. 1 Peta; above, Taichung Native-1; below

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Table 1. Measurements of Peta and Taichung N-1 under each cultural condition.

Variety	Date of trans-planting	Spacing (cm) and N level (kg/ha)	LAI at flowering	No. of tillers per m ² (max.)	Plant ht (cm)	Grain/wt total wt ratio (%)	Panicle wt (g)	Yield (ton/ha)
Peta	7/1/63	30 0	3.45	200	178	31.3	2.55	3.25
	"	30 100	6.50	408	210	22.4	2.06	2.19
	12/20/63	30 0	2.50	191	131	39.4	2.95	4.12
	"	30 150	7.05	354	182	27.5	2.36	2.79
	12/21/63	15 0	1.86	239	108	44	2.70	4.05
	"	15 150	6.62	467	157	35	2.42	3.44
	7/2/64	20 0	2.63	247	148	35.2	2.66	3.28
	"	20 30	3.59	303	160	30.6	2.45	3.29
	"	20 60	4.81	426	165	30.7	2.51	3.50
	"	20 90	6.20	471	172	27.1	2.40	2.88
	"	20 120	6.88	559	192	27.1	2.52	3.02
T-N-1	7/1/63	30 0	2.36	175	101	51.4	2.80	4.13
	"	30 100	3.89	389	108	41.1	2.65	5.35
	12/20/63	30 0	1.50	178	84	50.0	2.35	3.35
	"	30 150	6.00	390	106	48.2	2.51	6.07
	12/21/63	15 0	1.67	256	76	54	2.02	3.53
	"	15 150	7.63	517	121	47	2.12	6.05
	7/2/64	20 0	1.99	262	81	44.8	2.00	4.02
	"	20 30	2.55	316	88	47.9	2.17	4.84
	"	20 60	4.27	419	90	49.2	2.08	5.27
	"	20 90	3.84	445	93	46.8	2.18	5.79
	"	20 150	6.49	563	104	44.8	1.96	5.68

condition on the genetic correlation in the characters of rice plant.

Materials

Two varieties, i.e., Peta and Taichung Native-1 (Fig. 1), were used. They are similar in tillering ability and leaf area index, but Peta is taller in stature and longer in growth duration by two to five weeks than Taichung Native-1. They were planted under various conditions as listed in Table 1 during 1963-1965 at The International Rice Research Institute, Los Banos, Laguna, Philippines.

Data were collected by sampling more than 100 plants for grain yield and more than 10 plants for other characters. All experiments contained more than two replications. The methods of collecting data were the same as those described in the previous report (TANAKA and KAWANO, 1966).

Result

Generally speaking, Peta showed negative nitrogen response in grain yield while Taichung Native-1 showed positive response (Table 1).

Peta was taller and its ratio of grain weight

to total weight was smaller than that of Taichung Native-1. The varietal differences in LAI, number of tillers, and panicle weight were not consistent.

In Peta, LAI at flowering was negatively correlated with grain yield, while in Taichung Native-1 the correlation was positive as far as the cultural conditions in these experiments were concerned (Fig. 2). A similar trend was observed in the relation between the maximum tiller number and the grain yield (Fig. 3). Taller stature was associated with

Fig. 2. Relation between LAI and grain yield in Peta and Taichung N-1.

Fig. 3. Relation between tiller number and grain yield in Peta and Taichung N-1.

Fig. 5. Relation between grain wt./total wt. ratio and grain yield in Peta and Taichung N-1.

Fig. 4. Relation between plant height and grain yield in Peta and Taichung N-1.

Fig. 6. Relation between panicle weight and grain yield in Peta and Taichung N-1.

grain yield in Taichung Native-1 (Fig. 4). The variation in plant height was larger in Peta than in Taichung Native-1.

In Peta, there was a close correlation between the ratio of grain weight to total plant weight and grain yield, while in Taichung Native-1 there was no close correlation (Fig. 5).

A close correlation existed between the average panicle weight and the grain yield in Peta while no correlation existed in Taichung Native-1 (Fig. 6).

Discussion

Peta is a typical variety responding negatively to nitrogen application, while Taichung Native-1 responds positively. When these two varieties are grown without nitrogen application, both yield relatively high and the yield difference between the two varieties is not highly apparent. Under heavy nitrogen application, however, Peta yields poorly while

Taichung Native-1 does much higher so that the yield difference between these two varieties usually increases with the rate of nitrogen application. In growth duration, Peta is longer by about two weeks in dry season (usually from December to May) and about five week in rainy season (usually from June to November) than Taichung Native-1. When Peta is grown with a heavy nitrogen application, it bears large LAI with a big extinction coefficient (K) which gives rise to serious mutual shading. In varieties of long growth duration, large LAI at the time of flowering is not associated with a high dry matter production after flowering or grain yield while in those of short growth duration, it is usually associated with a high dry matter production after flowering (KAWANO and TANAKA, 1968).

It seems, therefore, reasonable that in Peta the vigorous growth which is partly measured in LAI and tiller number results in poor yield.

The negative correlations of LAI and tiller number with grain yield in Peta are understood in this sense.

Low light intensity in crop community caused by mutual shading must have accelerated an elongation of culm, especially in Peta. Consequently, a negative correlation existed between plant height and grain yield in Peta.

The ratio of grain weight to total weight and the average panicle weight tended to be small at high nitrogen level in both varieties. Since Peta is a negative-nitrogen-response variety, positive correlation would be seen between these two characters and grain yield in this variety as a result.

In Taichung Native-1, on the other hand, vigorous growth usually results in high grain yield. Positive correlations of LAI at flowering, maximum tiller number, and plant height with grain yield in this variety are more simply understood than in Peta. The reason why no apparent correlation existed between the ratio of grain weight to total weight or average panicle weight and grain yield in this variety is not clearly known.

In case of Peta and Taichung Native-1, varietal differences in growth duration and leaf character seem to be the main factors of varietal differences in environmental correlations of some characters with grain yield. It may then be inferred that the varietal differences in environmental correlation among plant characters are caused by genetic difference which could be considered as more basic in the course of development. This type of genetic differences, through their influences upon many other characters, would have an important meaning in understanding how the compound characters are physiologically and genetically built up and correlated with each other. Before solving the problems with compound characters and correlated characters, physiological aspects of genetic factors which are fundamental in plant growth itself seem first to be studied.

It is at any rate apparent that environmental correlation between plant characters differs among varieties. In some cases, environmental correlation between certain two characters is a positive value in one variety, while it is a negative value in another. In some other

cases, there exists an environmental correlation between certain two characters in one variety, while no correlation exists between the same in another.

MONSI and SAEKI (1953) proposed the following formula on the light penetration of plant community: $I/I_0 = e^{-K \cdot LAI}$, where I , I_0 , e , and K represent the light intensity at the bottom, at the top of the plant community, base of natural logarithm, and extinction coefficient of the community, respectively. SAEKI (1960) further proposed that a big K value is desirable for higher dry matter production of the community when LAI is small, and a small K value when LAI is big.

If individual plants within each population are genetically identical and each population has different K values, positive genetic correlation will be expected between dry matter production and K when LAI is small, and negative genetic correlation when LAI is big. The authors (1965) showed that length of leaf was negatively related to K in rice community, and varietal correlation between the length of leaf and grain yield was positive at low nitrogen levels and negative at high nitrogen levels. This result seems reasonable since LAI of rice populations is highly influenced by the nitrogen level under which plants are grown and grain yield is highly influenced by dry matter production of the population.

This suggests that the effect of environmental condition on the genetic correlation is sometimes great enough to change its value from negative to positive.

Summary

Two rice varieties, Peta and Taichung Native-1, were planted under various environmental conditions at Los Banos, Laguna, Philippines. In Peta, LAI at flowering, maximum tiller number, and plant height were negatively correlated with grain yield, while in Taichung Native-1 these characters were positively correlated with grain yield. The ratio of grain weight to total weight and average panicle weight were positively correlated with grain yield in Peta, while no clear correlation existed between the same in Taichung Native-1 as far as the conditions in this report were concerned. These suggest

that environmental correlation between plant characters greatly differs among varieties.

It is also discussed that genetic correlation between plant characters varies when environmental condition is different. The possibility that genetic correlation takes positive and negative values under different environmental conditions is suggested.

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稲における形質間相関に関する研究

I. 品種間差および二三環境条件が形質間相関に及ぼす影響

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二つの水稻品種、ペタと台中在来一号、をフィリピン国、ラグナ州、ロスパニョスにおいて種々の条件の下で栽培した。

ペタでは、開花時葉面積指数、最高分げつ数、および地上部長が収量と何れも負の相関々係にあつたのに対し、台中在来一号では、これら形質は収量と正の相関々係を示した。籾わら比及び一穂重は、ペタにおいては収量と正の相関々係にあつたが、台中在来一号においては、少なくとも本試験の条件内では、特別な関係は認められなかつた。

一方著者らの以前の結果より、形質間遺伝相関々係が環境の影響を受ける事が考察され、遺伝相関の価がある環境下では正の、また他の環境下では負の価をとる可能性のある事が指摘された。

従つて一般的に次の事がいえよう。即ち形質間環境相関は、品種により明らかに異り、その価が品種により正から負に逆転する事もありうる。遺伝相関は環境条件の影響を受け、環境条件により、その価が正から負に逆転する事もありうる。