EFFECTS OF SPLIT APPLICATION OF FERTILIZER AND PLANTING DENSITY ON YIELD, COMPONENTS OF YIELD, AND OTHER AGRONOMIC CHARACTERS OF RICE (III)

by

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Experimental results obtained at Chiayi Agricultural Experiment Station proved that split application of nitrogen and potash fertilizers was generally effective in increasing grain yield in both the first and the second crops of rice (Chang and Yang, 1964a, b). A favorable effect of split application of potash fertilizer on rice was also observed by Shen and Yuen (1964), and Hong and Kuo (1965). However, split application of phoshoric fertilizer did not show any significant increase in grain yield of rice (Chang and Yang, 1964b). Mitsui (1954) also concluded that sufficient amount of phosphoric fertilizer applied as a basal dressing would be enough to cover the need for a maximum yield production.

The efficiency of fertilizer utilization by the rice plant can be improved if the timing of fertilizer application concurs with the periods of maximum plant uptake. Combinations of split fertilization should, therefore, be tried to evaluate their relative efficiency in relation to increase in grain yield. The relationship between split application of fertilizer and planting density is also worthwhile to investigate, since planting density is an important factor affecting nitrogen response of the rice plant (Matsuo, 1965).

This report presents a summary of the experimental results obtained at Chiayi Agricultural Experiment Station with the hope that the above-mentioned subjects could be better understood.

MATERIALS AND METHODS

Rice variety Chianung 242 was subjected to 4 applications of fertilizer as given in Table 1 and 2 planting densities, viz., 64 and 96 hills per 3.3 m^2. These were combined to make a factorial experiment with 8 treatments arranged in a randomized-block design with 4 replications. Ammonium sulphate, calcium superphosphate and potassium chloride were used as sources of N, P_2O_5, and K_2O, respectively. Application rates of fertilizers were 80, 40, and 40 for N, P_2O_5, and K_2O, respectively. Approximately 5 seedlings were transplanted for each hill. The distance between rows was 24 cm while that between hills within a row was 21.5 and 14.3 cm for 64 and 96 hills per 3.3 m^2, respectively. The plot was 2.5×4 m in

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Table 1. Treatments of fertilizer application*

Treatment	Element	Basal dressing	First top-dressing	Second top-dressing	Third top-dressing
Conventional	N	50	50	—	—
	P	100	—	—	—
	K	100	—	—	—
Splitting 1	N	40	30	30	—
	P	100	—	—	—
	K	67	—	33	—
Splitting 2	N	40	20	30	10
	P	100	—	—	—
	K	67	—	33	—
Splitting 3	N	30	20	40	10
	P	100	—	—	—
	K	50	—	25	25

* Basal dressing: one day before transplanting.
First top-dressing: Maximum tillering stage or 20 days (2nd crop) and 30 days (1st crop) after transplanting.
Second top-dressing: Panicle initiation stage or 32 days (2nd crop) and 60 days (1st crop) after transplanting.
Third top-dressing: Heading stage or 50 days (2nd crop) and 90 days (1st crop) after transplanting.

size which was equivalent to 10 m^2 or 1/1,000 ha.

Data taken included heading date, plant height, weight of panicle, length of panicle, number of panicles per hill, weight of 1,000 grains, number of grains per panicle, grain yield per hectare, length of internodes, lodging, and blast occurrence. All data were subjected to analysis of variance.

This experiment was conducted at Chiayi Agricultural Experiment Station in the second crop of 1964 and the first crop of 1965.

RESULTS AND DISCUSSION

Effects of Application of Fertilizer and Planting Density on Yield and Components of Yield.

The average yield, components of yield, and F values from the analysis of variance are given in Table 2.

Table 2 shows that, although not statistically significant, split fertilizations generally yielded better than conventional one in both rice crops. Split Fertilization 3 produced 346 kg or 6.36% and 352 kg or 5.69% more grain yields per ha than conventional fertilization in the second and the first crops, respectively. The highest yield increases previously recorded for split fertilization were 6.75% in the second crop of 1963 (Chang and Yang, 1964a) and 10.75% in the first crop of 1964 (Chang and Yang, 1964b). It appears probable, therefore, that 5 to 6% yield increase could reasonably be expected in both crops when fertilizers are properly splitted.

Table 2. Means and F values of grain yield and components of yield of rice variety Chianung 242 subjected to methods of fertilization and planting densities

Treatment	Grain yield (kg/ha)		Number of panicles per hill		Number of grains per panicle		weight of 1,000 grains (g)	
	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965
Fertilization								
Conventional	5,437	6,177	9.9	11.5	153	121	29.8	30.8
Splitting 1	5,599	6,527	9.8	11.9	170	128	28.7	31.4
Splitting 2	5,561	6,364	9.6	10.1	176	130	29.1	31.9
Splitting 3	5,783	6,529	9.1	10.5	179	131	29.0	31.3
F value	2.10	1.47	1.0	4.1*	10.7**	2.2	13.0**	2.1
LSD 5%	—	—	—	1.3	10.5	—	0.4	—
Planting density								
64 hills	5,592	6,359	10.8	12.6	172	133	29.0	31.3
96 hills	5,598	6,440	8.4	9.4	167	122	29.3	31.4
F value	0.01	0.35	49.8**	57.5**	1.	11.1**	8.9**	0.1
LSD 1%	—	—	1.0	1.2	—	9	0.3	-
Fertilization × planting density								
F value	3.11*	1.10	1.78	0.47	0.9	1.7	1.7	1.7

* Difference significant at 5% level.
** Difference significant at 1% level.

Split Fertilization 1 yielded better than Split Fertilization 2 in both crops, indicating spltting ratio of 4:3:3 for nitrogen fertilizer in Split Fertilization 1 was more effective than that of 4:2:3:1 in Split Fertilization 2. Suzuki (1958) also reported that 4:3:3 splitting ratio for nitrogen fertilizer gave the best result. The higher productivity of Split Fertilization 1 may be attributable to the heavier dosage of nitrogen applied at first top-dressing or maximum tillering stage which eventually results in a larger number of panicles per hill.

Split Fertilization 3 outyielded Split Fertilization 1 in the second crop but both fertilization gave almot the same yield in the first one. The higher efficiency of the former may be due probably to heavier dosage of nitrogen applied at second top-dressing or panicle initiation stage. Smaller ratio of potash fertilizer used as basic dressing in Split Fertilization 3 may also have contributed to the increase of grain yield, as suggested by Hong and Kuo (1965). Chang and Yang (1964b) also found that for potash fertilizer, splitting ratio of 6:4 gave better grain yield than that of 6.7:3.3.

The analysis of yield components shows that split fertilizations substantially increased number of grains per panicle and weight of 1,000 grains which may be the factors responsible for the yield increase. The number of panicles per hill was considerably decreased by split applications of fertilizers except Split Fertilization 1 which appeared to have almost the same number of panicles per hill as that of conventional one.

High planting density consistently outyield low one in both rice crops, the percentage of yield increase being greater in the first crop. The yield increase of high planting density was caused largely by the increase of panicles per unit area. The results were similar to those of previous experiments (Chang and Yang, 1964a, b).

It was noted that conventional fertilization and Split Fertilization 1 gave high yield in low planting density while Split Fertilization 2 and 3 yielded better in high planting density in the second crop. In the first crop, the situation was just the opposite. The interaction between fertilization and planting density was significant at 5% level in the second crop but failed to reach a significant level in the first one. Since rice plant appeared to produce larger and heavier panicles with more grains per panicle in the second crop, third top-dressing of nitrogen at heading stage or so-called "grain fertilization" may be quite effective especially to plots of high planting density. The effect of nitrogen fertilization at milk ripe stage was also noted by Matsuwura (1962). In the first crop, however, heavier dosage of nitrogen applied at first top-dressing or maximum tillering stage seems necessary to prevent a drastic decline of effective tillers, especially in the plots of high planting density where competition for nitrogen may be more serious at the early stage of growth. Therefore, it seems reasonable to suggest that nitrogen splitted less than three times with heavier dosage applied at the early stage of growth may be more favorable in the first crop while in the second crop, nitrogen

Table 3. Means and F values of certain agronomic characters of rice variety Chianung 242 subjected to treatments of fertilization and planting density

Treatment	Heading date (days)		plant height (cm)		Panicle weight (g)		Panicle length (cm)		leaf blast (%)	
	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965
Fertilization										
Conventional	63	87	116	105	4.4	3.7	24.3	21.9	15.8	25.6
Splitting 1	64	87	116	106	4.4	3.9	24.3	23.6	16.3	20.5
Splitting 2	64	87	118	106	4.9	4.1	24.9	24.0	17.6	18.4
Splitting 3	63	87	118	105	4.8	4.0	25.2	24.1	14.7	18.4
F value	0.7	0.5	1.7	0.1	3.5*	3.5*	3.7*	14.0**	1.2	15.0**
LSD 5%	—	—	—	—	0.4	0.3	0.7	0.8	—	2.6
Planting density										
64 hills	63	88	119	107	4.6	4.1	24.3	23.6	14.2	20.5
96 hills	63	87	116	104	4.6	3.8	25.0	23.2	18.0	21.0
F value	0	11.0**	14.1**	9.3**	0	11.5**	6.9*	2.6	11.5**	0.34
LSD 1%	—	0.3	1.6	1.9	—	0.3	0.5	—	2.4	—
Fertilization × planting density										
F value	0.8	0.3	0.2	1.3	1.0	1.2	1.1	0.4	1.7	0.23

* Difference significant at 5% level.
** Difference significant at 1% level.

could be splitted more than three times with more emphasis placed at the latter stage of growth, if maximum yield production is to be obtained.

No significant interaction between ferilization and planting density was found in components of yield.

Effects of Fertilization and Planting Density on some Agronomic Characters.

A summary of the data and F values computed on these characters are presented in Table 3.

Heading date was not affected by either fertilizations or spacings in both crops. However, in the first crop, rice plant headed significantly earlier in plots of high planting density. Plant height was generally higher when fertilizers were split-applicated, while high planting density significantly shortened the plant height in both crops. Split fertilizations produced larger and heavier panicles than conventional one, the differences being statistically significant, indicating that panicle fertilization was highly effective. High planting density generally produced shorter and lighter panicles. The percentage of leaf blast occurrence was considerably lower in plots of split fertilizations especially in the first crop, suggesting that blast disease could be controlled to some extent by proper application of nitrogen fertilizer. Leaf blast was generally more serious in plots of high planting density. In all characters analyzed, interactions between fertilization and planting density failed to reach a significant level. These observations were generally similar to those of the previous experiments (Chang and Yang, 1964a, b).

Effects of Fertilizer Application and Planting Density on the Length of Internodes and Lodging.

The average length of internodes, the percentage of lodging and F values are summarized in Table 4.

It was found that the third, fourth, and fifth internodes were considerably shortened by split fertilizations in comparison with those of conventional one, the difference in the third internode being highly significant in the first crop. However, the first and second internodes of rice plant in plots of split fertilization were longer than those of conventional one, differences being significant at 1% level in the first crop for the first internode and in the second crop for the second internode. From a standpoint of plant type, rice plant with longer internodes at upper culm and shorter internodes at lower part of the culm would appear to be the most productive one. Hosika (1961) reported that the length of the first internode was associated with the yielding ability of rice plant, the longer the first internode, the higher the yield. Furthermore, shorter basal internodes are necessary for lodging resistance, as suggested by Matsuwura (1962). Since the percentage of lodging was relatively low in both crops, no attempt was made to associate lodging with the length of internodes. However, lodging seems highly likely when longer internodes are accompanied with larger and heavier panicles.

Internodes of rice plants were shorter in plots of high planting density than

Table 4. Means and F values of internode length and lodging percentage of rice variety Chianung 242 subjected to methods of fertilization and planting density

Treatment	Length of Internodes (cm)										Lodging (%)	
	1st		2nd		3rd		4th		5th			
	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965	2nd crop 1964	1st crop 1965
Fertilization												
Conventional	43.3	38.5	22.3	21.2	15.6	13.6	9.6	6.0	3.3	0.7	26.7	0
Splitting 1	43.6	41.7	22.9	21.5	15.5	11.8	8.6	5.2	3.0	0.7	29.0	8.5
Splitting 2	44.7	41.5	23.1	21.5	14.9	12.0	8.5	5.7	3.1	0.7	29.3	0.3
Splitting 3	43.6	43.0	23.4	21.8	15.1	10.7	8.1	4.6	2.8	0.5	33.4	2.1
F value	1.9	27.5**	5.7**	0.7	2.6	8.4**	2.4	2.9	0.9	0.2	0.1	4.1*
LSD 5%	—	1.1	0.6	—	—	1.2	—	—	—	—	—	3.5
Planting density												
64 hills	43.4	41.3	22.8	21.6	15.5	12.4	9.5	5.6	3.3	0.6	33.7	0.5
96 hills	44.2	41.0	23.0	21.4	15.0	11.6	7.9	5.2	2.7	0.8	25.6	2.9
F value	2.7	0.5	0.8	0.2	6.2*	3.2	14.6**	1.4	10.4**	0.4	1.0	2.4
LSD 5%	—	—	—	—	0.4	—	0.84	—	0.4	—	—	—
Fertilization × planting density												
F value	1.3	1.6	5.1**	0.5	2.0	2.5	0.5	2.0	0.4	1.6	0.2	5.6**

* Significant at 5% level.
** Significant at 1% level.

those of low one, differences in the third, fourth, and fifth internodes being significant in the second crop. Interactions between fertilization and planting density were not significant in most of internodes.

SUMMARY

The effects of 3 split applications of nitrogen and potash fertilizers and 2 planting densities on yield and some agronomic traits evaluated in the second crop of 1964 and the first crop of 1965 at Chiayi Agricultural Experiment Station are reported.

Split fertilizations generally outyielded conventional one in both crop. The yield increase appeared to be due largely to the increase in either number of grains per panicle or grain weight. Grain yield was also increased by close spacing which was attributable to increase in the number of panicles per unit area. An evidence of interaction between fertilization and planting density was detected for grain yield in this experiment.

The weight and length of panicles were significantly increased by split fertilizations but decreased by close spacing. Heading date and plant height were not significantly affected by split fertilizations. Rice plant was shorter and headed earlier in plots of high planting density.

Split fertilization increased the first and second internodes but decreased the other three indernodes at the lower part of the culm. All internodes were shorter in plots of high planting density. Lodging was relatively light in this experiment.

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水稻肥料分施與栽植密度對產量，產量構成因子及其他主要農藝性狀之效果(三)

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摘　要

本文係報告嘉義農業試驗分所在民國53年第2期作及54年第1期作舉辦三種氮、鉀素肥料分施法及兩種栽植密度對水稻產量、產量構成因素及其他農藝性狀效果之試驗結果。

肥料分施在第1、2期作產量其產量均較慣行法爲佳，其增產原因爲每穗粒數及（或）千粒重之增加。密植亦能增產，其產量之提高乃得自單位面積總穗數之增加。產量在肥料分施與栽植密度之間，有顯著之交感作用。

穗長、穗重皆因肥料分施而顯著增加，但隨栽植密度之增加而減少，生育日數與株高受肥料分施之影響較少。密植可縮短生育日數及減低株高。

稻莖第1及第2節間長度均因肥料分施而增加，惟其餘3節則見縮短。在密植區之稻莖各節之節間長度均較疏植區者爲短，稻田只發生輕微之倒伏，故其與稻莖節間之關係無法詳予考察。