

THE NATURE OF FERTILIZER RESPONSE IN JAPONICA AND INDICA RICE VARIETIES

By

DR. NOBORU YAMADA *

(Chief Research Co-ordinator, Department of Agriculture, Ceylon)

WITH the object of elucidating the different types of fertilizer response in rice varieties, growth and yield components of three Japonica and two Indica varieties were examined under three levels of fertilizer application, during the Yala season of 1959.

MATERIALS AND METHODS

1. Varieties used :

Japonica type :

Norin No. 1, *Taichung* No. 65 and *Kanan* No. 8.

Indica type :

Murungakayan 302 and H-4.

2. Nitrogen levels :

Using 1 ft. square concrete pots, containing 30 Kg of soil each, the treatments shown in Table 1 were given :

Table 1.—Fertilizer Treatments

Fertilizers	Levels (gm/pot)			Time applied
	Low (N ⁰)	Medium (N ¹)	High (N ²)	
Ammonium sulphate (Basal dressing)	0	0.5	2.0	11 July
(Top do.	0	1.0	4.0	18 Aug.
Superphosphate	0	1.0	4.0	11 July
Potassium sulphate	0	0.5	2.0	11 July

On 14th July, seedlings (26 days old) were transplanted in the pots at a spacing of 6" x 6" with three seedlings per hill, and four hills per pot.

*Expert from Japan under the Colombo Plan.

RESULTS AND DISCUSSION

1. Yield and yield components in relation to fertilizers

Grain yields and yield components for individual varieties are given in Table 2 and Fig. 1.

All varieties used showed remarkable increase in grain yield as the fertilizer application was increased, with the exception of *Murungakayan* 302. Percentage increase in grain yield of N_2 against N_0 was about 50 per cent. with three Japonica varieties and 70 per cent. with H-4, but no increase was observed with *Murungakayan* 302. The yield increase of *Norin* No. 1 was almost entirely caused by the increase of panicle number per hill. As shown in fig. 2, yield of N_2 is 153 per cent. of that of N_0 , and panicle number of N_2 is 148 per cent. of that of N_0 , but the weight of individual panicles is not affected by the fertilizer levels, showing only 4 per cent. increase at N_2 . Therefore, the yield increase of 53 per cent. of this variety was caused by the increase of panicle number by 48 per cent. and by the increase of panicle weight by 4 per cent. This class of variety in which yield increase is obtained mainly by the increase of panicle number and not by the increase of weight of a panicle is designated "the panicle number type" in Japan.

On the other hand, response of *Kanan* No. 8 was manifested more markedly in the increase of weight of individual panicles than in an increase in panicle numbers (fig. 1 and 2). Yield increase of 44 per cent. resulted from the 25 per cent. increase in panicle weight and 15 per cent. increase in panicle number. Average weight of a panicle is much higher than in *Norin* No. 1 and increases with the application of fertilizer. This is an example of the so-called "panicle weight type".

Taichung No. 65 is an "intermediate type" with a response intermediate between *Norin* No. 1 and *Kanan* No. 8.

H-4, the hybrid selection recently produced by Mr. H. Weeraratne, at the Central Rice Breeding Station, Batalagoda, from a cross between M 302 and *Mas*, is shown to be "panicle number type". The yield at N_2 was 171 per cent. of that N_0 and this yield increase can be accounted for mainly by the increase of panicle number by 59 per cent. and partly by the increase of panicle weight by about 7 per cent. (figs. 1 and 2). It is very interesting that this variety, H-4, is able to produce very heavy panicles in spite of its being essentially a "panicle number type" (fig. 1). Thus, as it combines the characteristics of the "panicle number type" with heavy panicle weight, H-4 can give very high yields under fertilizer application. The performance of this variety might be superior to that of *Norin* 1, one of the leading varieties of Japan.

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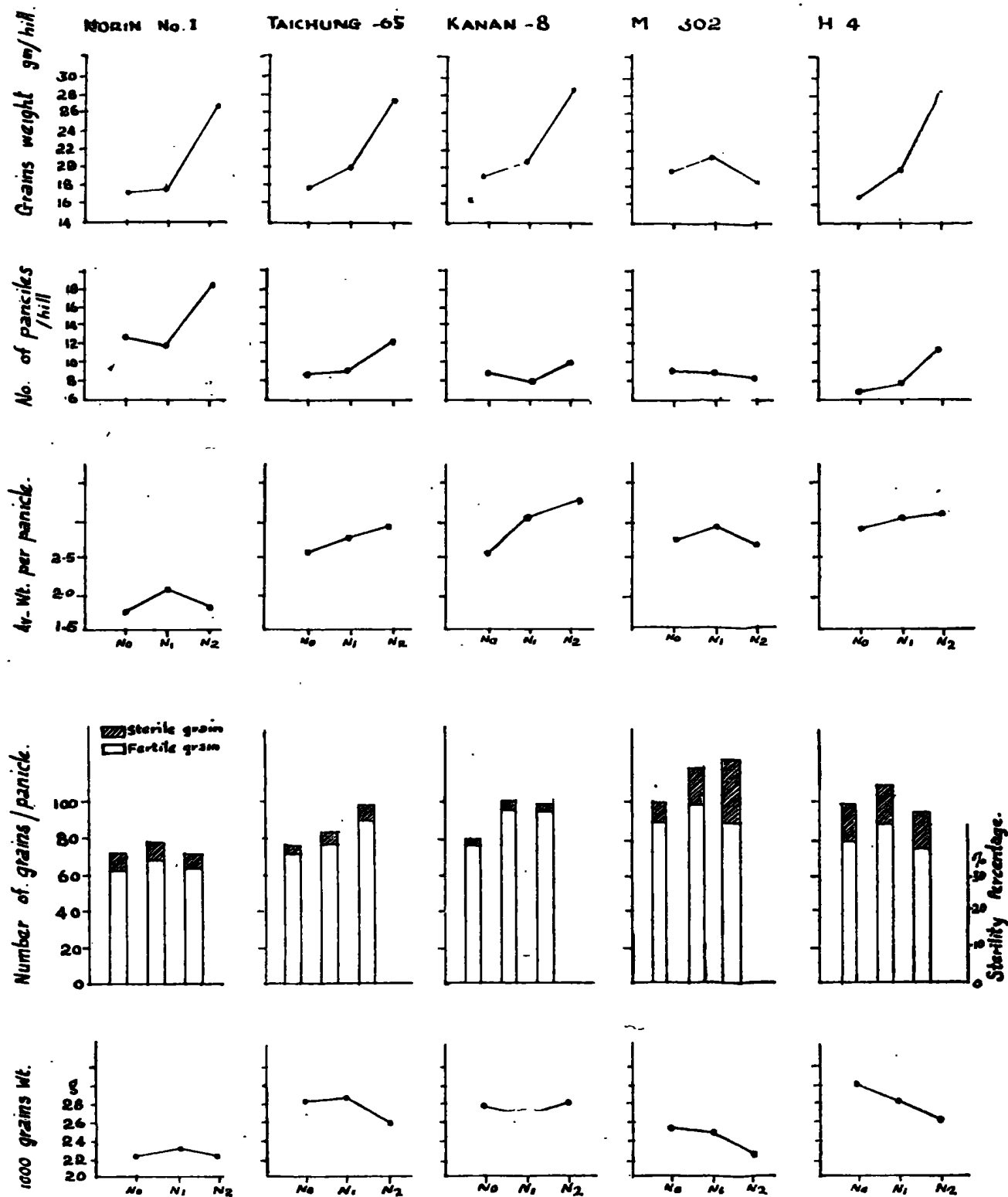


Fig. 1. YIELD AND YIELD COMPONENTS

TABLE 2—YIELD AND YIELD COMPONENTS

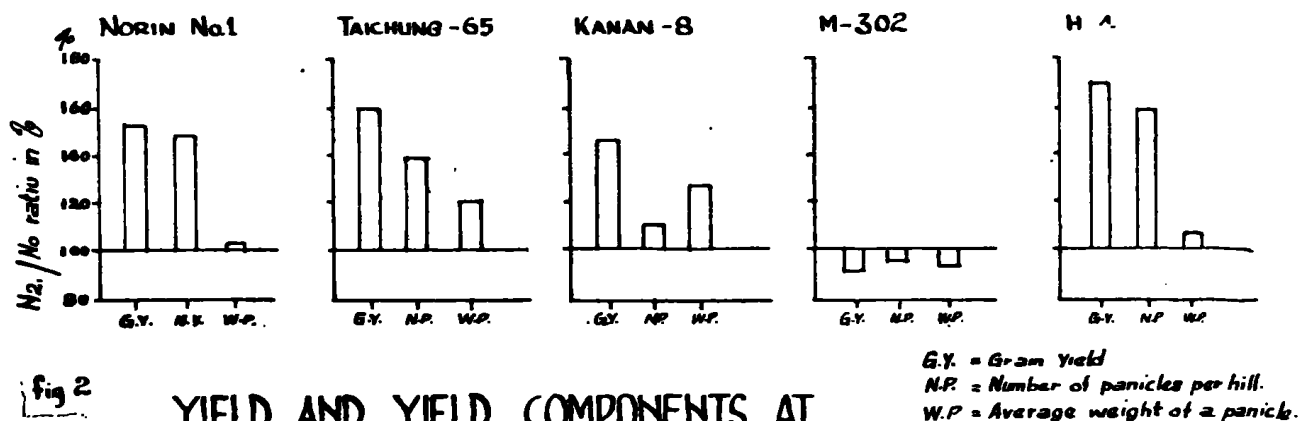
Variety	Fertilizer level	Grain Weight g/hill	Number of panicles per hill	Average Weight of a panicle	Number of grains per panicle	Percentage of sterility	Weight of straw g/hill	Grain total weight %	Dry Wt. top roots g/hill	Days sowing to harvest	Dry Wt. production per day
Norin-1	N ₀	17.5 ..	12.5 ..	1.40 ^g ..	69.3 ..	12.7 ..	18.6 ..	48.5 ..	38.4 ..	122 ..	0.314 ^g
	N ₁	17.7 ..	11.0 ..	1.63 ..	76.0 ..	10.9 ..	17.8 ..	49.8 ..	36.6 ..	121 ..	0.302
	N ₂	26.8 ..	18.5 ..	1.45 ..	69.5 ..	11.4 ..	23.1 ..	53.7 ..	52.2 ..	123 ..	0.421
Taichung-65	N ₀	17.2 ..	8.3 ..	2.06 ..	76.4 ..	5.1 ..	18.6 ..	48.0 ..	38.1 ..	131 ..	0.291
	N ₁	19.6 ..	8.5 ..	2.30 ..	85.5 ..	5.7 ..	18.0 ..	52.2 ..	39.3 ..	133 ..	0.296
	N ₂	27.5 ..	11.5 ..	2.49 ..	99.8 ..	6.8 ..	27.6 ..	49.9 ..	57.2 ..	132 ..	0.433
Kanan-8	N ₀	18.3 ..	8.5 ..	2.16 ..	81.5 ..	3.7 ..	23.4 ..	43.9 ..	44.8 ..	138 ..	0.324
	N ₁	19.8 ..	7.8 ..	2.56 ..	103.9 ..	5.3 ..	22.9 ..	46.4 ..	45.0 ..	139 ..	0.324
	N ₂	26.4 ..	9.8 ..	2.70 ..	101.1 ..	3.9 ..	35.3 ..	42.8 ..	64.6 ..	140 ..	0.462
Murungakayan-302..	N ₀	19.7 ..	8.8 ..	2.25 ..	100.0 ..	12.5 ..	33.7 ..	36.9 ..	55.3 ..	147 ..	0.376
	N ₁	21.8 ..	8.8 ..	2.49 ..	116.3 ..	15.8 ..	45.4 ..	32.4 ..	70.7 ..	147 ..	0.481
	N ₂	18.5 ..	8.5 ..	2.17 ..	120.0 ..	30.0 ..	57.1 ..	24.4 ..	80.2 ..	149 ..	0.538
H-4	N ₀	16.5 ..	6.8 ..	2.44 ..	100.2 ..	23.0 ..	27.3 ..	37.7 ..	46.9 ..	145 ..	0.323
	N ₁	19.9 ..	7.8 ..	2.56 ..	109.8 ..	21.2 ..	33.4 ..	37.3 ..	55.6 ..	147 ..	0.378
	N ₂	28.2 ..	10.8 ..	2.62 ..	95.5 ..	26.1 ..	43.9 ..	39.1 ..	75.6 ..	152 ..	0.498

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Contrary to this, *Murungakayan* 302 shows increase in neither panicle number nor in panicle weight and accordingly no increase in yield under fertilizer application. But under N_0 condition (without fertilizer), this variety shows highest yield among all varieties used. So that this variety is characterized by high yield without fertilizer, and no response to the fertilizer. It should, however, be mentioned that the experimental land was extremely fertile and the nutrient status of the soil even at N_0 would have been very high.

As illustrated in fig. 1, with varieties of the panicle weight and intermediate types, the increase of panicle weight caused by fertilizer application is accompanied by increase in grain number per panicle, i.e., the weight of a panicle is raised by increasing grain number per panicle. But, with the panicle-number varieties, such as *Norin* No. 1 and H-4, no increase of either panicle weight nor of grain number per panicle takes place. It is interesting to note that *Murungakayan* 302 behaves like a panicle-weight variety, showing increase in grain number per-panicle. But the sterility percentage shows a marked rise and consequently the number of fertile grains is rather reduced in spite of the total increase in grain number per panicle.

In general, sterility percentage is higher with indica varieties than with Japonica varieties, and *Murungakayan* 302 particularly showed a striking increase in the sterility percentage under fertilizer application.



2. Dry matter production and distribution between grain and straw

The total dry matter of grains and straw per hill at the time of harvest is illustrated in Fig. 3. In general, the Indica varieties are able to produce more dry matter than Japonica varieties. Of course, the

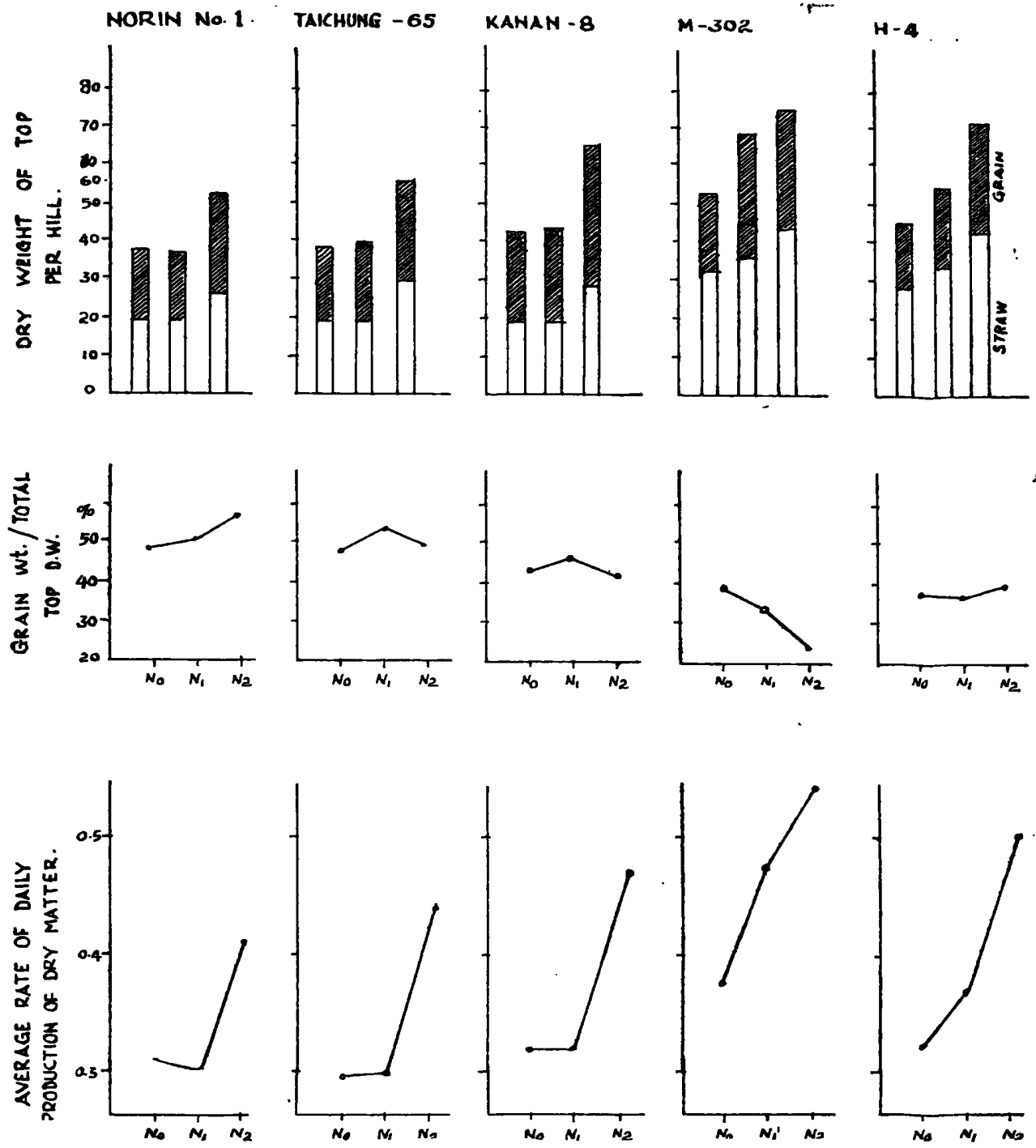


fig.3 DRY MATTER PRODUCTION AND DISTRIBUTION BETWEEN GRAINS AND STRAW.

production of dry matter depends upon the growth duration and the rate of daily photosynthetic production. So that a late variety can accumulate more dry matter than an early variety, even though the daily rate of production of the former may be less than that of the latter. The total dry weight of plant (including dry weight of roots) divided by the number of days from sowing to harvest gives the average daily rate of dry matter production. As shown in Fig. 3, Indica varieties possess a higher daily rate of dry matter production than Japonica varieties. It is evident from these results that the efficiency of dry matter production is higher with Indica varieties than Japonica varieties; *Murungakayan* 302 particularly has a very high daily rate of dry matter production and the rate rises with fertilizer application.

However, the Japonica varieties are able to utilize about 50 per cent. of the total dry matter in grain production, while Indica varieties can utilize less than 40 per cent. of the total dry matter for the same purpose. Although *Murungakayan* 302 possesses the highest rate of dry matter production, the ratio of dry matter appropriated in grain formation to the total dry matter is the lowest, and the proportion decreases considerably with fertilizer application. At the N_2 level only 25 per cent. of the total dry matter can be used in grain production, and 75 per cent. is diverted to straw.

From the physiological point of view the distribution of dry matter between grain and straw appears to be determined by varietal differences in nitrogen and carbohydrate metabolism. The low rate of distribution of dry matter to grain is possibly due to the following physiological causes :—

- (1) Nitrogen absorption is possibly high, in nitrogen assimilation a large quantity of the photosynthetic product, glucose, is consumed.
- (2) Moreover glucose is utilized to produce cell-wall substances, such as cellulose, hemicellulose, &c.
- (3) The result is the vigorous growth of vegetative organs, and the depressed accumulation of starch before heading as well as the low production of starch after heading.

In short, the problem lies in the chemical components of the dry matter; starch production and accumulation in relation to nitrogen level is the most crucial factor in determining dry matter distribution. The problem continues to be actively investigated in my laboratory.

3. Type of fertilizer response

In the present experiment, *Murungakayan* 302 showed no response to fertilizer application. But according to the fertilizer experiments hitherto undertaken at several places, this variety had shown considerable response. The soil used in the present study was very fertile, and this is the reason why this variety did not show fertilizer response. On poor soil, deficient in nutrients, this variety can respond to fertilizer application. Therefore, the difference in the response between this variety and others, including H-4, can be explained as shown in Fig. 4.

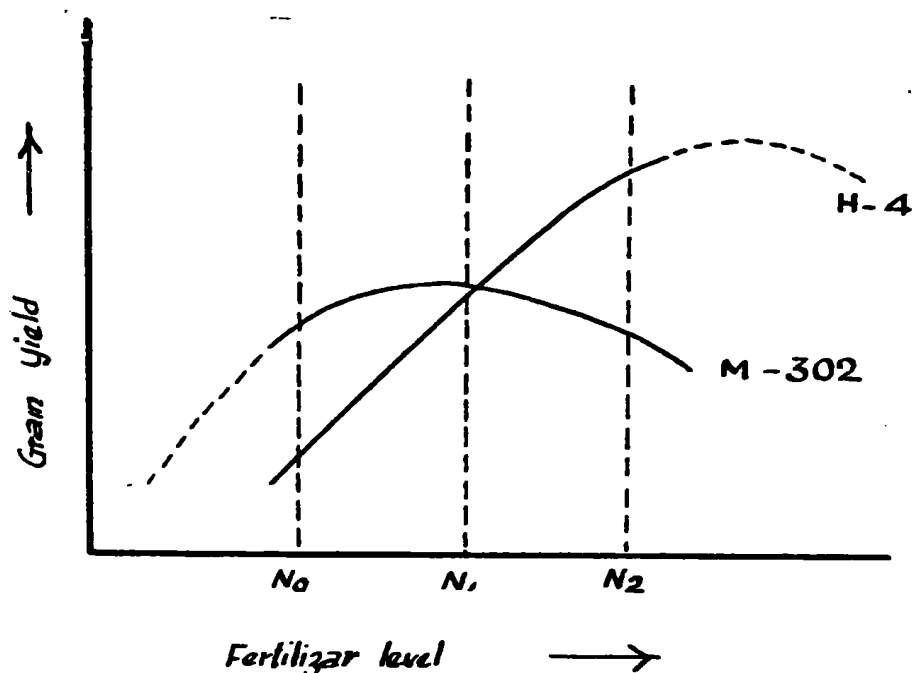


fig: 4.

SCHEMA OF RESPONSE OF M-302 AND H-4.

Murungakayan 302 shows very high activity in the absorption of nutrients even from the less fertile soil and accordingly it absorbs too much nitrogen under fertile conditions; absorption of too much nitrogen in relation to starch production results in decreased yield. The failure of this variety to show increase at all in panicle number when fertilizers are applied must be a morphological limiting factor to increasing yield.

The solution culture experiment conducted at Peradeniya, demonstrated very clearly that the concentration of nitrogen recommended as adequate for Japonica varieties and therefore called a standard

concentration* is too high for the Indica varieties, causing striking retardation of root development especially with *Murungakayan* 302. Moreover, even with the reduced concentration of nitrogen, *Murungakayan* 302 showed a strikingly high percentage of sterility and straight head when nitrogen was supplied up to heading time. H-4, however, did not suffer by the supply of nitrogen at this reduced concentration. These results clearly indicate that the optimum concentration of nitrogen is different between Japonica and Indica varieties, and between *Murungakayan* 302 and H-4.

To revert to Fig. 4, the results of the present experiment may be regarded as expressing the relative yield of *Murungakayan* 302 and H-4 at N_0 and N_2 levels in the two response curves.

Finally, it is clear from the results and interpretation presented above, that there are different types of fertilizer response in paddy varieties. Some varieties have a low optimum fertilizer level, and others a high optimum range. With some varieties yield increase is entirely due to the rise in the number of panicles per hill; with others, increase in weight of individual panicle is mainly responsible for the yield increase. Some other varieties behave as intermediate between these two groups. A knowledge of the characteristics of varieties is essential for the adoption of correct cultural and breeding techniques. For example, it is now evident that *Murungakayan* 302 is not suitable for transplanting and for conditions of very heavy fertilization; this variety performs satisfactorily when broadcast and when the soil is unfertilized or when the application of fertilizer is not excessive. On the other hand, H-4 can produce high yields under transplanting with wide spacing and heavy applications of fertilizer. Tillering capacity and panicle number assume importance in the breeding of varieties for conditions of transplanting.

SUMMARY

For the purpose of elucidating the different types of fertilizer response in rice varieties, growth and yield components of three Japonica and two Indica varieties were examined at three levels of fertilizer application in pot soil culture during Yala of 1959 at Peradeniya.

* Standard concentration of N in culture solution is $C = 20\text{ppm}-N$; during the tillering stage: C, 2C; from end of tillering period: $\frac{1}{2}C$, $\frac{3}{4}C$; before and after heading: $\frac{1}{2}$, $\frac{1}{4}C$; from 2 weeks after heading: 0.

Reduced concentration used was 20 ppm—N during only the active tillering stage, and later the concentration was reduced to less than C, as indicated above.

All varieties, except *Murungakayan* 302, showed striking yield response to fertilizers. The process by which this yield increase was obtained, however, differed with variety. Yield increase in *Norin-1* was entirely caused by the increased number of panicles per hill (panicle—number type), while *Kanan-8* showed more marked increase in the weight of the individual panicle than in the number of panicles (panicle—weight type). *Taichung-65* behaved as an intermediate type.

The response of the Ceylon hybrid H-4 was that characteristic of the panicle—number type. *Murungakayan* 302, on the other hand, belongs to the panicle—weight type: grain number per panicle was increased by fertilizer application. But, because the optimum range of fertilizer levels for this variety is not very high, percentage sterility rose considerably with heavy fertilization and resulted in a reduced weight of panicle.

Indica varieties, as exemplified by *Murungakayan* 302, by reason of their very high daily rate of dry matter production, are capable of producing more dry matter than Japonica varieties, but the distribution of this dry matter to grain is less efficient; a high sterility percentage and a low ratio of grain to total dry matter result.

Murungakayan 302 is suitable for broadcasting on unfertilized soils or at moderately high fertility levels. H-4, on the other hand, can produce very high yields under transplanting with wide spacing and at high intensities of fertilizer application.