

Responses of local varieties of rice to split application of nitrogen fertilizer

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SUMMARY

Nine local or village varieties of rice, of the 4—4½ months age class, were evaluated for their response to method of nitrogen fertilization. At each of three stations Maha Illuppallama, Karadian Aru and Labuduwa, three local varieties commonly grown in the area were compared with the hybrid variety H₄.

At Maha Illuppallama H₄ performed significantly better than local varieties when nitrogen was added all at tillering or in two split applications. When nitrogen was applied in three split applications H₄ was superior only to *Muthusamba*. Time of nitrogen application had no significant effect on yield of any variety.

Treatments had no significant effects on grain yields of any variety at Karadian Aru. Three split applications of nitrogen caused no significant differences in yield between H₄ and any of the three local varieties. Yields of some local varieties were adversely affected when all the nitrogen was applied at tillering or in two split applications.

At Labuduwa grain yields of H₄ were depressed when all nitrogen was applied at tillering. This variety, however, performed better than *Suramanian* and *Badiratawee*. Split application of nitrogen had a highly significant effect in increasing the yield of H₄, but not of the other three varieties. The mean yield of H₄ was superior to those of the other varieties at the 1 per cent. level of probability.

INTRODUCTION

Yields of crop species are known to vary according to the variety. In addition, a given variety of a crop species which gives a high yield under one set of field conditions does not necessarily perform similarly under all conditions (7). The importance of selecting crop plants for their efficiency in absorbing specific nutrients, has been stressed by Lawrence (9).

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As early as 1899 Bourcet (1) reported the differential intraspecific uptake of iodine by plants. In 1923 Hoffer and Carr (6) observed differential uptake of aluminium by maize, and these differences were related to the incidence of root rot. In 1928, Gregory and Growther (5) showed that varieties of barley responded differently to the major nutrient elements and made the noteworthy remark that it would be possible to develop varieties which would be suited to soils deficient in nutrients.

Many nutritional variants are known with rice and this is partly responsible for the wide range of edaphic adaptations of this plant. The large number of varieties of rice permits it to grow under varied soil, moisture and climatic conditions. Generally it is believed that the tall, leafy tropical varieties of rice do not respond appreciably to added nitrogen, or respond only at modest levels. According to Jennings and Beachall (8) the indica varieties of the tropics have been developed under less favourable environmental and cultural conditions in contrast to the japonica varieties from Japan and Taiwan which respond to high levels of nitrogen.

The hybrid selection H_4 derived from a cross between Murungakayan 302 and Mas was found to be strikingly resistant to blast than all other varieties, local and improved, in this country (2). It was therefore included among the four-months varieties recommended by the Department of Agriculture since 1957 (3). The multiplicity of varieties grown in the country was ascribed to high degree of local specialisation. Their performance was generally reported to be disappointing, their yields low and their genetic variability did not permit much advance selection (3). Therefore plant breeders of the Department of Agriculture endeavoured to progressively reduce the number of rice varieties under issue in Sri Lanka.

In 1967, probably as a consequence of the Food Drive launched by the Government, there was such interest in achieving self-sufficiency in rice at all levels of society. The policies of the Research Division of the Department of Agriculture were criticised for "writing off" local varieties of paddy as being non-responsive to chemical fertilizer.

The investigation was therefore carried out to make a comparative study of the response to nitrogen fertilization of some local or village varieties of rice and of the hybrid selection H_4 .

MATERIALS AND METHODS

The response of nine local or village varieties of rice, of the 4-4½ month age group, to time and method of nitrogen application was studied in field experiments of Maha Illuppallama, Karadian Aru and Labuduwa. At each station three local varieties usually grown in the area were compared with the hybrid variety H_4 .

The fertilizer treatments which consisted of three methods of nitrogen application were as follows :—

- (1) all nitrogen applied at tillering stage.
- (2) $\frac{1}{4}$ nitrogen applied at tillering stage and the balance at primordia initiation stage.
- (3) $\frac{1}{5}$ nitrogen applied at planting, $\frac{1}{5}$ at tillering and the balance at primordia initiation stage.

The form and quality of fertilizers applied were as follows :—

At Maha Illuppallama nitrogen was applied as ammonium sulphate at the rate of 2 cwt. per acre. The times and proportions of application were varied according to treatments. Phosphorous and potassium were applied before planting as concentrated super phosphate and muriate of potash at the rates of 1 cwt. and $1\frac{1}{2}$ cwt. per acre respectively.

Urea was the form of nitrogen used at Karadian Aru. The rate of application was 1 cwt. per acre. The times of application and quantities applied at a given time were varied according to treatments. Phosphorous and potassium fertilization were applied at the same rates and times as at Maha Illuppallama, with the same fertilizers.

At Labuduwa the form of nitrogen was urea, which was applied at the rate of $\frac{3}{4}$ cwt. per acre ; the times and proportions of application of which were varied according to treatments. The preplant fertilizer treatments included 1 cwt. of saphos phosphate and $\frac{1}{2}$ cwt. of muriate of potash.

At Maha Illuppallama the local varieties used were Vellai Illankalayan 28061, Muthusamba and Annakodai, and those at Karadian Aru were Perumkarruppan, Parawakuliyam and Motaisamba. The local varieties tested at Labuduwa were Kotahandiran, Suramanium and Bediratawee.

The experimental design was a 4×3 factorial. There were three replicates at each location. The internal dimensions of each treatment plot were 30 by $14\frac{1}{2}$ feet. Plots were separated from each other by 1 foot perimeter bunds and were row transplanted at 21-days of age at a spacing of 12 inches between rows and 6 inches within rows with three seedlings per hill.

CHARACTERISTICS OF THE SOILS

Important soil characteristics at the three stations are as follows :—

(1) Maha Illuppallama

Texture : clay loam

pH : 6.5–6.8

Total nitrogen : 0.16–0.18 per cent.

Available phosphorous : 20.3–30.5 lb. per acre

Exchangeable potassium : 0.20–0.25 m.e. per 100 gm. soil

Organic matter : 2.4–2.6 per cent.

(2) Karadian Aru

Texture : sandy loam

pH : 5.9–6.4

Total nitrogen : 0.07–0.12 per cent.

Available phosphorous : 11.4–54.7 lb. per acre

Exchangeable potassium : 0.06–0.26 m.e. per 100 gm. soil

Organic matter : 1.6–1.7 per cent.

(3) Labuduwa

Texture : sandy loam

pH : 5.0–5.2

Total nitrogen : 0.7–0.9 per cent.

Available phosphorous : 55.0–7.62 lb. per acre

Exchangeable potassium : 0.10–0.16 m.e. per 100 gm. soil

Organic matter : 11.2–15.0 per cent.

RESULTS AND DISCUSSION

1. Maha Illuppallama

The effect of treatments on yields of the four varieties tested at Maha Illuppallama are presented in Table 1. The variety H₄ was superior to all three village varieties the yield differences being significant at the 1 per cent. level of probability when all 39 lb. nitrogen were given in one application at tillering stage. It is clear that the local varieties performed less efficiently than H₄ even when the nitrogen was applied in two split doses, one third at tillering and the balance at the stage of primordia initiation. When however, the total quantity of nitrogen was given in three split doses, one-fifth at planting, one-fifth at tillering and the balance at the stage of primordia initiation the varieties H₄, Vellai Illankalayan and Annakodai performed equally well. The first two of these out yielded the variety Muthusamba at the 5 per cent. level of probability.

Table 2 presents the mean grain yields of the four varieties at this station. It will be noted that the variety H₄ was superior to all varieties at the 1 per cent. level of probability.

The superiority of the hybrid variety H₄ was as expected. The variety Vellai Illankalayan 28061 is one of the old selections of the Department of Agriculture which is one of the most adaptable and high yielding varieties. At one time it had been the most extensively grown improved variety in the country (4), and at present it is said to be grown in about 30 to 40 per cent. of the Anuradhapura District during the *Maha* season.

The variety Annakodai was not inferior to Vellai Illankalayan as revealed in the variance analysis. Annakodai which has a medium sized, light reddish brown grain is thought to be Dikwi, in which case it is also a selection of the Department of Agriculture.

Muthusamba is a variety which has a premium value due to the superior quality of the hulled grain. Its grains are short, rounded and white; like all *samba* varieties it is not a high yielder. In this investigation Muthusamba consistently yielded low in comparison to the other varieties.

Among these varieties Annakodai was the most susceptible to leaf diseases like bacterial leaf blight and brown spot disease due to *Helminthosporium oryzae*. Compared to H₄, the local varieties all lodged.

2. Karadian Aru

At Karadian Aru the performance of H₄ was not so outstanding in comparison to the local varieties (Table 3). When all 39 lb. nitrogen were applied at tillering stage the varieties H₄ and Parawakuliyana were significantly superior to the varieties Perumkaruppan and Motaisamba. When the nitrogen was given in two split applications only Motaisamba performed poorly.

Split applying the total quantity of 39 lb. nitrogen at these stages of growth showed no differences in yield between any of the varieties tested at this station.

Table 4 presents the mean grain yields of four varieties tested at Karadian Aru. It will be observed that the variety H₄ was superior to the varieties Perumkaruppan and Motaisamba. The variety Parawakuliyana which is a selection of the Department of Agriculture was as good as the variety H₄ as far as mean grain yields are concerned, viz. treatment numbers 1 and 3. The drop in yield of Parawakuliyana when nitrogen was applied in two-split applications cannot be explained.

3. Labuduwa

The effect of time of nitrogen application on yield of rice at Labuduwa is seen from data in Table 5. The grain yields of all varieties at this wet zone station were very much lower than those of the two dry zone stations discussed earlier. Nitrogen application at various times as dictated by treatments had no significant effect on grain yields of these local or village varieties, viz. Kotahandiran, Suramanian and Bediratawee. According to these results a single application of the nutrient at tillering stage is as good as two or three split applications. Obviously therefore the single application would be preferred due to the additional labour and the difficulty of application if fertilizer is to be applied in two or three split doses. In contrast, the hybrid variety H₄ responded differently to the split application of nitrogen. Application of the full quota of nitrogen at tillering stage to this variety resulted in a significant depression of yield compared to two or three split applications of the nutrient.

The mean grain yields of the four varieties used at Labuduwa are presented in Table 6, where it will be seen that the variety H₄ was superior to the local or village varieties. The yield differences were highly significant. The variety H₄ out-yielded the next best variety Kotahandiran by 25 bushels per acre. The variety Suramanian recorded the lowest mean yield.

Thus it is clear from the above results that the variety H₄ out-yielded all the local varieties tested at each of the locations. These results confirm those obtained during the 1957 to 1959 period when H₄ was first introduced to farmers. This hybrid selection has been reported to out-yield varieties of the four months age class used up to the late 1950's, and to satisfy the demand for a variety in the 4 to 5 months age class (2, 3). Yamada (11) who studied the fertilizer response manifested by H₄ at Peradeniya found clear evidence that a yield potential of over 160 bushels per acre was possible with this indica hybrid on studies in a better part of the field, the of average yield of the whole field being 120 bushels per acre. In a study of the varietal differences in response to nitrogen fertilizer using H₄, Murungakayan 302 and Murungan Samba 3081, Thenabadu and Gunawardena (10) found the variety H₄ to be superior to the other two varieties. Grain yields of H₄ and Murungan Samba 3081 increased with each increment of nitrogen but that of Murungakayan 302 increased only up to 30 lb. nitrogen per acre and decreased at the higher level.

The optimum amount of nitrogen differs with the variety or genotype. If this amount is exceeded, grain yields decrease. Depending on the varietal characteristics even the quality of the grain decreases in relation to grain fertility and the number of fully ripened kernels. Excess nitrogen would also induce lodging and increase the plant's susceptibility to disease and pests.

CONCLUSIONS

From the data obtained in these three experiments conducted at three stations in the island it is clear that local or village varieties of rice generally exhibit a low yield potential compared to the variety H₄. Further it could be said that, in general, application of nitrogen fertilizer does not encourage these local varieties to produce higher grain yields.

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Table 1. Effect of split application of nitrogen on grain yields of four varieties at Maha Illuppallama

Nitrogen treatments	Variety	Yield (Bush/acre)
(1) 39 lb/N/acre applied at tillering ..	(1) H ₄ ..	95.0
	(2) Vellai Ilankalayan ..	79.0
	(3) Muthusamba ..	75.5
	(4) Annakodai ..	77.2
(2) 9.7 lb/N/acre applied at tillering and 29.3/ lb/N/acre applied at primodia initiation stage	(1) H ₄ ..	92.0
	(2) Vellai Ilankalayan ..	76.6
	(3) Muthusamba ..	67.5
	(4) Annakodai ..	77.4
(3) 7.8 lb/N/acre applied at planting : 7.8 lb/N/ acre applied at tillering and 23.4 lb/N/acre applied at primodia initiation stage	(1) H ₄ ..	86.7
	(2) Vellai Ilankalayan ..	80.7
	(3) Muthusamba ..	67.5
	(4) Annakodai ..	78.0
		L. S. D. at 5% = 11.1 bush./acre
		L. S. D. at 1% = 15.0 bush./acre
		C. V. = 8.22%

Table 2. Mean grain yields of four varieties at Maha Illuppallama

Variety	Mean Yield (bush./acre)
(1) H ₄ ..	91.2
(2) Vellai Ilankalayan ..	78.8
(3) Muthusamba ..	70.2
(4) Annakodai ..	77.5
L. S. D. at 5% = 6.4 bush./acre	
L. S. D. at 1% = 8.6 bush./acre	

Table 3. Effect of split application of nitrogen on grain yields of four varieties at Karadian Aru

Nitrogen treatment	Variety	Yield (bush./acre)
(1) 39 lb/N/acre applied at tillering ..	(1) H ₄ ..	75.9
	(2) Perumkarruppan ..	57.4
	(3) Parawakuliyam ..	73.7
	(4) Motaisamba ..	55.7
(2) 9.7 lb/N/acre applied at tillering and 29.3 lb/ 2/N/acre applied at primodia initiation stage	(1) H ₄ ..	73.4
	(2) Perumkarruppan ..	66.4
	(3) Parawakuliyam ..	64.5
	(4) Motaisamba ..	56.3
(3) 7.8 lb/N/acre applied at planting ; 7.8 lb/N/ acre applied at tillering and 23.4 lb/N/ acre applied at primodia initiation stage ..	(1) H ₄ ..	71.9
	(2) Perumkarruppan ..	60.2
	(3) Parawakuliyam ..	71.8
	(4) Motaisamba ..	65.2
		L. S. D. at 5% = 13.0 bush./acre
		C. V. = 11.59%

Table 4. Mean grain yields of four varieties at Karadian Aru

Variety	Mean Yield (bush./acre)
(1) H ₄ ..	73.7
(2) Perumkarruppan ..	61.3
(3) Parawakuliyam ..	70.0
(4) Motaisamba ..	59.1
	L. S. D. at 5% = 7.5 bush./acre
	L. S. D. at 1% = 10.2 bush./acre

Table 5. Effect of split application of nitrogen on grain yields of four varieties at Labuduwa

Nitrogen treatments	Variety	Yield (bush./acre)
(1) 39 lb/N/acre applied at tillering ..	(1) H ₄ ..	36.0
	(2) Kotahandiran ..	25.4
	(3) Suramanian ..	16.8
	(4) Bediratawee ..	19.3
(2) 9.7 lbs/N/acre applied at tillering and 29.3 lbs/N/acre applied at primodia initiation stage	(1) H ₄ ..	56.1
	(2) Kotahandiran ..	24.1
	(3) Suramanian ..	17.6
	(4) Bediratawee ..	24.5
(3) 7.8 lbs N/acre applied at planting; 7.8 lbs N/acre applied at tillering and 23.4 lbs N/acre applied at primodia initiation stage	(1) N ₄ ..	54.2
	(2) Kotahandiran ..	22.0
	(3) Suramanian ..	18.6
	(4) Bediratawee ..	20.4
		L. S. D. at 5% = 11.1 bush./acre
		L. S. D. at 1% = 15.1 bush./acre
		C. V. = 23.49%

Table 6. Mean grain yields of four varieties at Labuduwa

Variety	Mean Yield (bush./acre)
(1) H ₄ ..	48.8
(2) Kotahandiran ..	23.8
(3) Suramanian ..	17.7
(4) Bediratawee ..	21.4
	L. S. D. at 5% = 6.4 bush./acre
	L. S. D. at 1% = 8.7 bush./acre.