

RESPONSE OF RICE TO FERTILIZERS IN A RICE-VEGETABLE CROP ROTATION IN THE MATALE DISTRICT

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ABSTRACT

Rice-vegetable rotation is a widespread practice in the Matala district in recent years. Generally, a high NPK fertilizer rate is used for vegetables. An experiment was conducted in 2 locations during the 1984—86 period in Tenna, Matala to determine the fertilizer response of a 3½-month rice variety (Bg 94—1) in fields that had been cropped with vegetables in the previous season.

Soil analysis prior to crop establishment showed very high levels of Olsen P (60—84 ppm) and moderately high levels of exchangeable potassium (0.27—0.31 me/100g soil). No significant yield response to basal fertilizer (NPK) application was observed in any of the locations. There was also no response to either P or K fertilizer. It appears that high rice yields can be obtained by applying the recommended amount of nitrogen only. Increases in grain yield resulted mainly, due to increases in panicle numbers and grains per panicle rather than grain weight.

KEY WORDS: Crop rotation, Fertilizer recommendation, Rice, Vegetable

INTRODUCTION

Rice-vegetable crop rotation in rice fields has become a widespread practice in the Matala district as it provides more benefits than two rice crops a year. The vegetable growing season of a particular field varies with the availability of irrigation water for rice production. In the vegetable season, the farmers usually grow bush beans and capsicum planted in the same hill at higher plant densities than recommended. The recommended levels of NPK fertilizer mixtures are 0.7 t/ha for bush beans and 0.85 t/ha for capsicum, but investigations carried out in this area revealed that farmers use about 2—2.5 t/ha NPK fertilizer for the vegetable crop. The source of fertilizer used which can vary with the individual farmer includes basal paddy fertilizer mixture V(NPK), top dressing paddy fertilizer mixture TDM (N & K), urea or various commercial vegetable fertilizer mixtures available in the market.

These fertilizer applications have been used as a means of obtaining immediate increase in vegetable yields without considering the fertilizer use efficiency (Joseph *et al.*, 1986). It is somewhat reasonable to expect that these fertilizer applications would increase immediate soil fertility by increasing the nutrient pool, but their long term effects on the soil environment are not known. Accumulation of certain elements due to continuous use of high levels of fertilizer may create toxicities and nutrient imbalances in the soil which can adversely affect crop growth. On the other hand, the residual effects of some of the nutrients applied to the vegetable crop could contribute to increased yield in the subsequent rice crop, but no direct measurements have been made under this kind of cropping system. The effects of heavy applications of N, P and K fertilizers for extended periods on crop growth have not been studied under local conditions. The objective of this study was to determine the response of a 3½-month rice variety to fertilizer, in fields that have been cropped with vegetables in the previous season.

MATERIALS AND METHODS

Three experiments (in two locations) with rice were conducted during the period 1984—86 at Tenna (Matale) in rice fields where mixed vegetables (bush beans and capsicum) were grown during the previous season and to which 2—2.5 t/ha NPK fertilizer had been applied. In location 1 (Table 1) experiment was carried out in maha 84/85 (29 Oct. 84—8 Feb. 85) and maha 85/86 (8 Nov. 85—18 Feb. 86). In maha 84/85, the fertilizer recommendation of the Department of Agriculture (DR), DR without basal fertilizer, DR without first top dressing fertilizer and DR without second top dressing fertilizer were tested against a no fertilizer control (Table 2). During maha 85/86 in the same location (after a vegetable crop in yala 85) the treatment, DR without basal fertilizer was omitted and two new treatments, namely, DR without P fertilizer and DR without K fertilizer, were included (Table 2). These 6 treatments were also tested in location 2 but during yala 85 (10 June 85—16 Sept. 85; Table 2).

The treatments (5 in maha 84/85 and 6 in yala 85 and maha 85/86) were in a randomized complete block design with three replicates. The plot size was 3m × 4m and each plot was separated by a 30 cm bund. The rates and times of fertilizer application recommended by the Department of Agriculture for a 3½-month variety are as follows: (a) basal fertilizer at planting

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(V mixture)—7kg N/ha, 60kg P_2O_5 /ha and 20kg K_2O /ha, (b) first top dressing fertilizer at 2 weeks after transplanting (WT)—42kg N/ha and (c) second top dressing fertilizer (TDM) at 6WT—37kg N and 25kg K_2O /ha. Nitrogen, P and K were given in the form of urea, triple superphosphate and muriate of potash respectively. In all three experiments, 21-day old rice seedlings (variety Bg 94—1) raised in wet-bed nurseries, were transplanted at a spacing of 15 cm $\times$ 15 cm.

Soil samples taken prior to planting and basal fertilizer application, were analysed for pH, organic matter content, total N, available (Olsen) P and exchangeable K. Ten randomly selected rice hills were marked at 9 days after transplanting (DT) and tiller counts taken at 2—3 weeks intervals. Grain yields were recorded from the centre plots after discarding two border rows around each plot. Number of panicles/m², grains/panicle and 1000 grain weight were determined on 10 hills.

RESULTS AND DISCUSSION

Soil analysis

The soil analysis data for the two experimental locations are presented in Table 1. In both locations the available P is very high while exchangeable K is moderately high. In location 1, the available P level was 60 ppm just before maha 84/85 rice crop and 82 ppm just before the maha 85/86 rice crop. Likewise, exchangeable K also increased between these two seasons (0.27—0.31 me/100g soil). This increase must be due to the residual and cumulative effects of P and K fertilizers applied to the maha 84/85 rice crop and yala 85 vegetable crop.

It therefore appears that the observed high P and K levels in these rice soils at Matala are due to the heavy NPK fertilizers applied to the vegetable crops. Most of these fertilizers are applied on to the soil surface and no incorporation into the soil is done by the farmers due to high labour costs and possible damages to the closely-spaced vegetable crop. Since P is relatively immobile in the soil (Brady, 1974), any surface-applied P not taken up by the vegetable crop will remain on the surface until the soil is prepared for rice cultivation.

Grain yield

Grain yield data for the different fertilizer treatments in the two locations are given in Table 2. In location 1 during maha 84/85, no signifi-

cant response to the basal NPK fertilizer was obtained (Treatments 1 and 2). Omission of any one of the top dressings also resulted in decreased yields compared to the Departmental recommendation (DR) (Treatments 1, 3 and 4). In location 1 (maha 84/85) and location 2 (yala 85), the treatment which did not receive the second N top dressing yielded significantly more than the one where the first N top dressing was omitted. But these two treatments gave similar yields during maha 85/86 in location 1. This may be associated with the small differences in the amounts of N received by these two treatments (49 vs 44 kg N/ha) or differences in the times of N application.

In location 1, the maha 85/86 experiment has shown that there is no response to P or K (even as top dressing) which was also observed in yala 85 in location 2 (Table 2—Treatments 1, 6 and 7). It is also relevant to note that reasonably high yields (3.75 to 5.48 t/ha) were obtained even without any fertilizer application reflecting perhaps the residual fertility of these soils.

Tiller production and yield components

During the yala 85 season (location 2) tiller counts were taken at regular intervals and are presented in Fig. 1. At the first two sampling dates (9 and 16 DT) no treatment differences were observed. At 24 DT tiller numbers increased rapidly and treatment differences were observed. All treatments which received nitrogen as 1st top dressing at 2 WT produced higher number of tillers/m² over the treatments which did not receive the 1st top dressing (Treatments 1, 4, 6, 7 vs 3, 5). No differences were observed among the nitrogen top dressed treatments even though their basal fertilizer applications were different. With soil P and K not limiting as discussed earlier, the nutrient that caused differences in tiller production at this stage was nitrogen.

The crop reached the maximum tillering stage at 33 DT and tiller numbers declined after this day. Tiller counts taken at 50 DT of treatments which received the 2nd top dressing at 6 WT showed a temporary halt in tiller number decline (Treatments 1, 3, 6 and 7). This temporary halt in decrease in tiller number could be due to two reasons. One being the emergence of new tillers with the application of N at 6 WT and the other being the delay in tiller deaths due to increased supply of nitrogen. However, this was a temporary effect and tiller numbers thereafter decreased with time.

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During the two maha seasons in location 1, the treatments which received the 1st top dressing produced higher number of panicles/m² over the control and the treatment which received no 1st top dressing (Table 3; Treatments 1, 2, 4, 6, 7). No significant differences were observed among these nitrogen treatments even though their basal fertilizer applications were different. During the yala 85 season too, this trend was observed except in treatment 4. It is therefore clear that application of nitrogen as first top dressing is important to produce sufficient number of panicles/m² and the differences found among treatments with regard to this yield component was directly responsible for the yield differences among treatments.

Significant differences were observed with regard to the grains/panicle yield component (Table 3). However, it is difficult to attribute the differences found among treatments as direct treatment effects, because this yield component does not appear to be directly related to panicle/m² yield component. Therefore, any differences found among treatments could be due to both direct treatment effects and the interaction between treatment effects and panicles/m² yield component. No treatment effects were observed with regard to seed weight yield component.

From these results it is clear that basal fertilizer application which consists mainly of P and K, could be omitted for the subsequent rice crop in view of the possible build-up of these nutrients in the soil resulting from their addition to the preceding vegetable crop. With regard to the application of K as 2nd top dressing (TDM) no significant response was observed. Even though the availability of this nutrient was high initially and no yield response was observed, yet the availability of this nutrient may not remain high at the later stages of a rice crop growth in certain situations. Therefore, as a precaution it is advisable to apply the 2nd top dressing of K until further investigations confirm the availability of this nutrient at the later stages. The importance of nitrogen fertilization both as 1st and 2nd top dressings is however, very clear.

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Table 1. Selected properties of the experimental soils (0—15 cm depth) prior to establishment of rice crop*

<i>Experimental location</i>	<i>pH (H₂O) 1 : 1</i>	<i>Organic matter (%)</i>	<i>Total N (%)</i>	<i>Olsen's P (ppm)</i>	<i>Exch. K (me / 100g soil)</i>
Location 1 (maha 84 / 85)	4.9	2.2	0.16	60.0	0.27
Location 1 (maha 85 / 86)	4.4	2.3	0.13	82.0	0.31
Location 2 (yala 85)	4.1	2.1	0.14	84.2	0.30

*Mean of 3 replicates

Table 2. Effect of fertilizers on grain yield of rice variety Bg 94—1 in fields cropped with vegetables in the previous season

Treatment No.	Treatment			Grain yield (t / ha)*		
	Basal mixture V (NPK)	1st Top dressing (N) (2 WT)	2nd Top dressing TDM (NK) (6 WT)	Location 1 (maha 84 / 85)	Location 1 (maha 85 / 86)	Location 2 (yala 85)
1**	YES	YES	YES	6.30 a	7.84 a	6.25 a
2	NO	YES	YES	6.39 a	NT	NT
3	YES	NO	YES	5.43 c	6.84 b	4.74 c
4	YES	YES	NO	5.74 b	6.53 b	5.53 b
5	NO	NO	NO	4.42 d	5.48 c	3.75 d
6	Only N & K No P	YES	YES	NT	7.81 a	6.41 a
7	Only P & N No K	YES	Only N No K	NT	7.80 a	6.66 a
CV %				3.3	4.3	7.0

* Values followed by the same letter within columns are not significantly different at 5% according to DMRT

** Treatment 1 received fertilizers according to the recommendation of the Department of Agriculture

NT=not tested

Table 3. Effect of fertilizers on yield components of rice variety Bg 94 — 1 in fields cropped with vegetables in the previous season

<i>Treatment No.**</i>	<i>Location 1 (maha 84 / 85)*</i>			<i>Location 1 (maha 85 / 86)*</i>			<i>Location 2 (yala 85)*</i>		
	<i>No. of panicles per m²</i>	<i>Grains per panicle (no.)</i>	<i>1000 grain weight (g)</i>	<i>No. of panicles per m²</i>	<i>Grains per panicle (no.)</i>	<i>1000 grain weight (g)</i>	<i>No. of panicles per m²</i>	<i>Grains per panicle (no.)</i>	<i>1000 grain weight (g)</i>
1	396 a	60 ab	26.5 a	442 a	66 a	27.0 a	334 a	67 a	29.3 a
2	390 a	64 a	25.5 a	—	—	—	—	—	—
3	326 b	61 ab	27.2 a	387 b	66 a	26.6 a	290 b	54 b	30.0 a
4	393 a	54 b	27.2 a	440 a	55 b	26.7 a	296 b	60 ab	31.1 a
5	304 b	56 b	26.2 a	388 b	51 b	27.2 a	243 c	53 b	29.0 a
6	—	—	—	447 a	64 a	27.1 a	332 a	65 a	29.5 a
7	—	—	—	437 a	66 a	27.3 a	334 a	67 a	29.2 a
CV%	5.3	7.0	6.6	5.0	5.9	1.6	5.6	8.5	4.3

* Values followed by the same letter within columns are not significantly different at 5% level according to DMRT

** Details of treatments as in Table 2

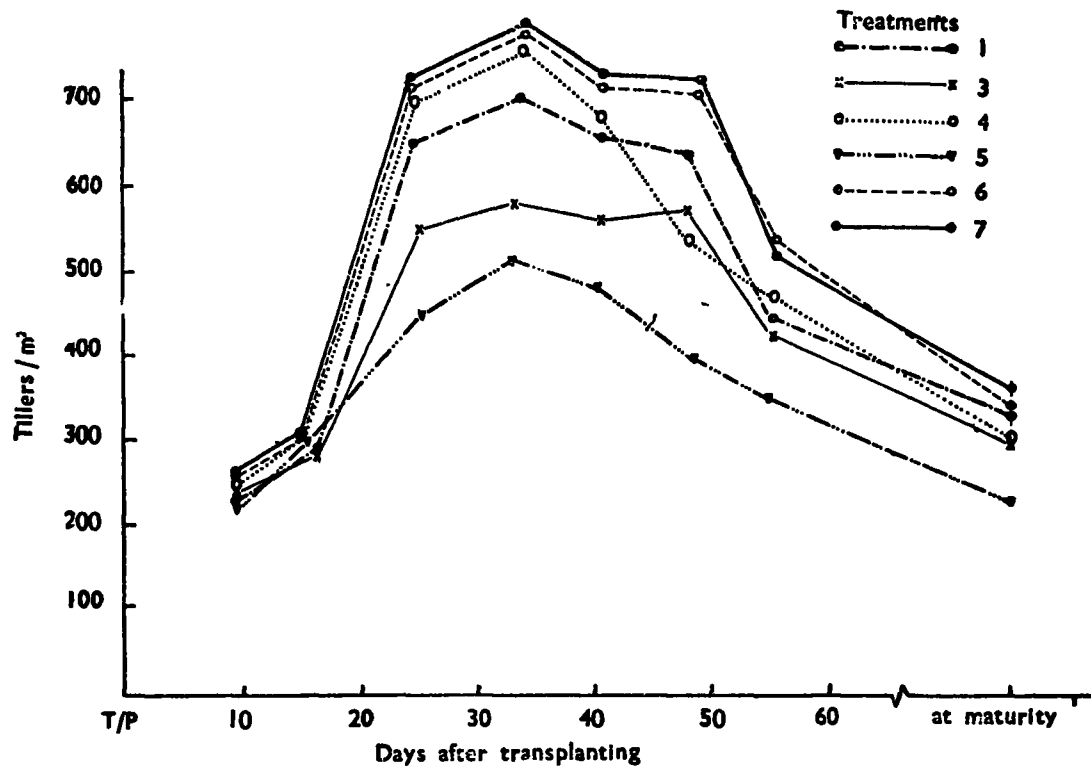


Fig. 1. Effect of different fertilizer treatments on tiller production — yala 1985