Queensland Journal of Agricultural and Animal Services Vol. 42 (2), 71-77 (1985)
Published by the Queensland Department of Primary Industries

The response of rice to time and rate of application of nitrogen fertiliser in the Burdekin Valley

J. E. Barnes

Summary

Five experiments were conducted over three seasons (1970 to 1972) in the Lower Burdekin Valley on drill sown rice (cv. Bluebonnet 50). Nitrogen rates of 66, 88, 110 or 132 kg N/ha as ammonium sulphate were applied (1) at sowing, (2) after permanent flooding, (3) at panicle initiation, (4) half at sowing and half at panicle initiation. Split application gave the highest grain yield followed in order, by application at sowing, at permanent flooding and at panicle initiation. The highest yield was obtained at 132 kg N/ha in three experiments but in others N rate had no significant effect on yield.

Rates of nitrogen had no effect on maturity, 1000 grain weight, panicle number, panicle weight or the nitrogen and phosphorus contents of the plant or grain. Generally dry matter yield increased with nitrogen rates.

Time of nitrogen application had no significant effect on grain number per panicle, panicle number, or nitrogen and phosphorus contents of the plant or grain at harvest. Application of all nitrogen at panicle 3 initiation delayed maturity, decreased 1000 grain weight and dry matter yield.

INTRODUCTION

Rice is grown in the Lower Burdekin Valley (119° 30′S 147° 30′E) under irrigated 'paddy' conditions. The crop (cv. Bluebonnet 50 and more recently Starbonnet) is drill sown into dry contour bays which are then irrigated to germinate the crop and later permanently flooded to a depth of 20 to 150 mm. This depth of water is maintained from early tillering until grain ripening, a period of 90 to 110 days depending on the season.

Nitrogen is the major nutrient used by rice in the Lower Burdekin. It is generally applied as ammonium sulphate at rates up to 88 kg/ha at sowing (J. B. Greenaway, pers. comm. 1970). This practice gives variable results. Often crops lodge because of excessive vegetative growth, while at times other crops become nitrogen deficient before maturity. Long grain rice cultivars have often responded to nitrogen rates greater than 88 kg/ha and split application of nitrogen also may be beneficial, (Wells and Johnston 1970; Yang *et al.* 1968; Chang and Yang 1966). Bluebonnet 50 is known to respond well to split applications of nitrogen (Sims *et al.* 1967; Hall *et al.* 1968).

The object of this work was to evaluate the effects of rate and time of application of nitrogen fertiliser on growth and yield of rice on the Oakey soils of the Lower Burdekin Valley.

MATERIALS AND METHODS

Altogether five experiments were conducted; two (Experiments 1 and 3) at Claredale in the summer or 1970–71 and winter of 1971 respectively and the other three (Experiments 2, 4, and 5) in the 1970–71 summer, 1971 winter and 1971–72 summer at Millaroo Research Station. The soils were Oakeys described by Reeve *et al.* (1960). All are inherently low in nitrogen (less than 10 ppm N in 0–20 cm).

Nitrogen was applied as ammonium sulphate at 66, 88, 110 or 132 kg N/ha in combination with three stages of growth (1) at sowing, (2) early tillering after permanent flooding, (3) at panicle initiation. In a fourth combination, half the nitrogen was applied at sowing and half at panicle initiation.

At sowing, nitrogen fertiliser was drilled separately with a combine to a depth of 75 mm into a fine seedbed. At other stages of growth the fertiliser was hand broadcast into the standing water following which water flow in or out of the bay was prevented for at least four days.

Treatments were replicated four times and completely randomised within blocks. Plot size ranged from 22 to 28 m² in different seasons. Each trial was analysed as a randomised complete block, with the embedded factorial structure of the treatments as set out above. An analysis over seasons was also carried out. Phosphorus (10 kg P/ha) as superphosphate was drilled together with the rice seed (cv. Bluebonnet 50) at 120 kg/ha, to a depth of 20 mm in rows spaced 175 mm apart. Seedling densities of 300 to 400 plants per m² were achieved.

The rice bay was flushed (once for summer crops and twice for winter crops) to germinate the seed. When the seedlings were about 150 mm high the field was sprayed with propanil at 15 L/ha to control weeds. Permanent water was applied one day later and maintained at a maximum depth of 120 mm until rice reached physiological maturity, when the field was drained for harvest. The plots were machine harvested and yields determined from areas of 14 to 19 m². Grain moisture content and 1000 grain weights were recorded and samples taken for nitrogen and phosphorus analysis. At harvest a one square metre sample was taken from each plot to measure dry matter yield and panicle number. Representative subsamples were dried, ground and analysed for nitrogen and phosphorus.

RESULTS

Dry matter production and nitrogen uptake increased with increasing N rate except in Experiment 4 (Table 1). There was also a significant response to nitrogen in grain yields in Experiments 3, 4 and 5, but not in Experiments 1 and 2 (Figure 1). Nitrogen rate had no effect on grain moisture, 1000 grain weight, panicle number, grain number per panicle, and phosphorus uptake at maturity.

Table 1. Effect of rates of nitrogen on dry matter yields at harvest and plant nitrogen uptake

Nitrogen rate kg/ha	Experiment 1		Experiment 2		Experiment 3		Experiment 4		Experiment 5	
	Dry matter kg/ha	Plant N kg/ha	Dry matter kg/ha	Plant N kg/ha	Dry matter kg/ha	Plant N kg/ha	Dry matter kg/ha	Plant N kg/ha	Dry matter kg/ha	Plant N kg/ha
66	10 218*a**	59.8*a*	9 755*b*	80.1*b*	7 785*b*	51.6*b*	7 348*b*	54.6*c*	7 834*b*	54.6*b*
88	10 360*a*	60.6*a*	10 155*b*	86.0*b*	8 498*b*	57.4*b*	8 335*b*	61.8*bc*	9 605*a*	62.5*ab*
110	11 115*a*	66.8*a*	11 351*ab*	102.6*a*	8 451*b*	56.6*b*	9 613*a*	72.1*a*	10 144*a*	64.9*ab*
132	11 332*a*	66.1*a*	11 897*a*	108.3*a*	9 901*a*	69.4*a*	9 531*a*	65.2*ab*	10 540*a*	69.8*a*
l.s.d. P=0.05	1 325	9.1	1 651	16.1	892	8.3	1 182	10.9	1 719	10.8

* Treatments followed by the same letter are not significant.

Split application of N was superior to a single application at sowing only in Experiments 1 and 2. Application of all N at permanent flooding or at panicle initiation resulted in lower grain yield than split application in Experiments 1, 2, 3 and 5 (Figure 2). Dry matter production was not conclusively changed by application at sowing, permanent flooding, or split applications but was significantly lower than all other treatments when applied at panicle initiation in Experiments 1 and 5 (Table 5). Timing of N application had no significant effect on grain number per panicle or panicle number. Plant uptake of N and P was reduced when all N was applied at permanent flooding compared to applications at sowing or applications at panicle initiation except in Experiment 4 (Table 2).

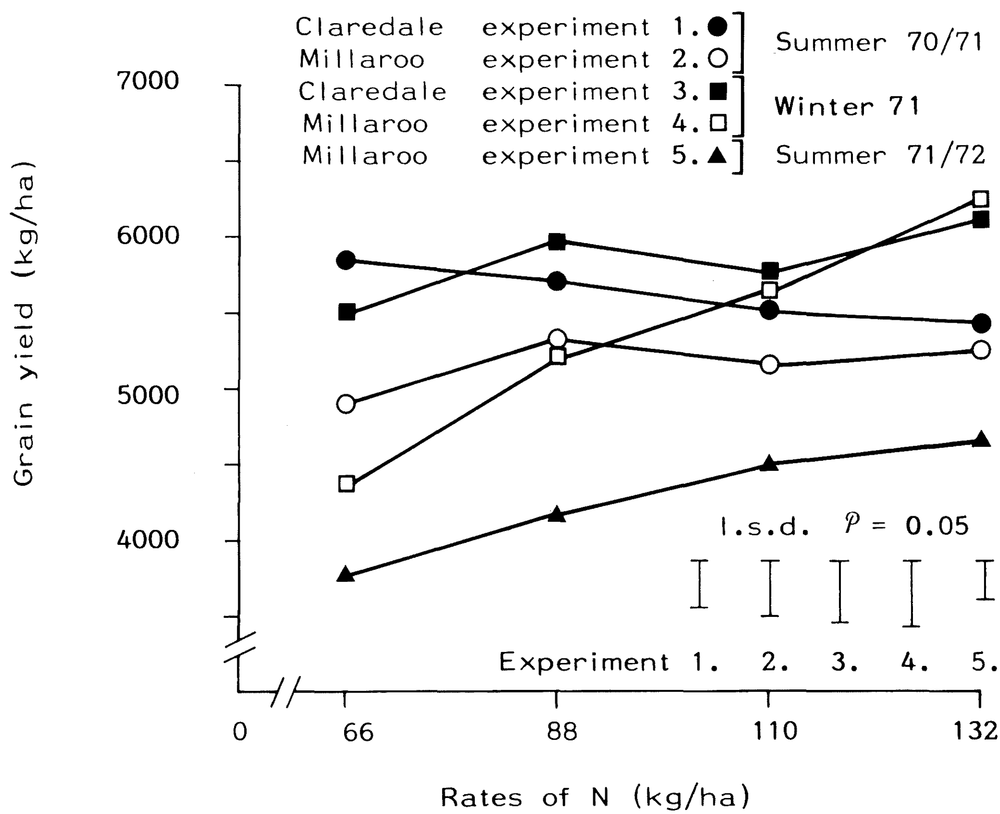

Figure 1. Effect of rates of nitrogen on grain yield.

Table 2. Effect of time of application of nitrogen fertiliser on plant uptake of nitrogen and phosphorus

Time of application of nitrogen fertiliser	Uptake of nitrogen and phosphorus (kg.ha)									
	Experiment 1		Experiment 2		Experiment 3		Experiment 4		Experiment 5	
	N	P	N	P	N	P	N	P	N	P
All at sowing	69.9*a**	14.6*a*	101.3*a*	21.8*a*	70.6*a*	10.7*ab*	55.4*c*	12.3*b*	70.2*a*	11.9*a*
All at permanent flood	53.0*b*	11.3*bc*	87.6*a*	16.3*b*	46.7*b*	9.9*b*	67.5*ab*	13.7*ab*	46.9*b*	8.6*b*
All at panicle initiation	65.8*a*	14.1*a*	95.8*a*	20.1*ab*	70.2*a*	12.1*a*	58.7*bc*	12.7*b*	67.9*a*	12.8*a*
½ sowing+½ panicle initiation	64.6*a*	13.6*ac*	92.3*a*	19.7*ab*	47.5*b*	10.0*b*	72.0*a*	15.6*a*	66.8*a*	13.9*a*
l.s.d. *P*=0.05	9.1	2.9	16.1	3.9	8.3	1.9	10.9	2.4	10.8	2.7

* Treatments followed by the same letter are not significant.

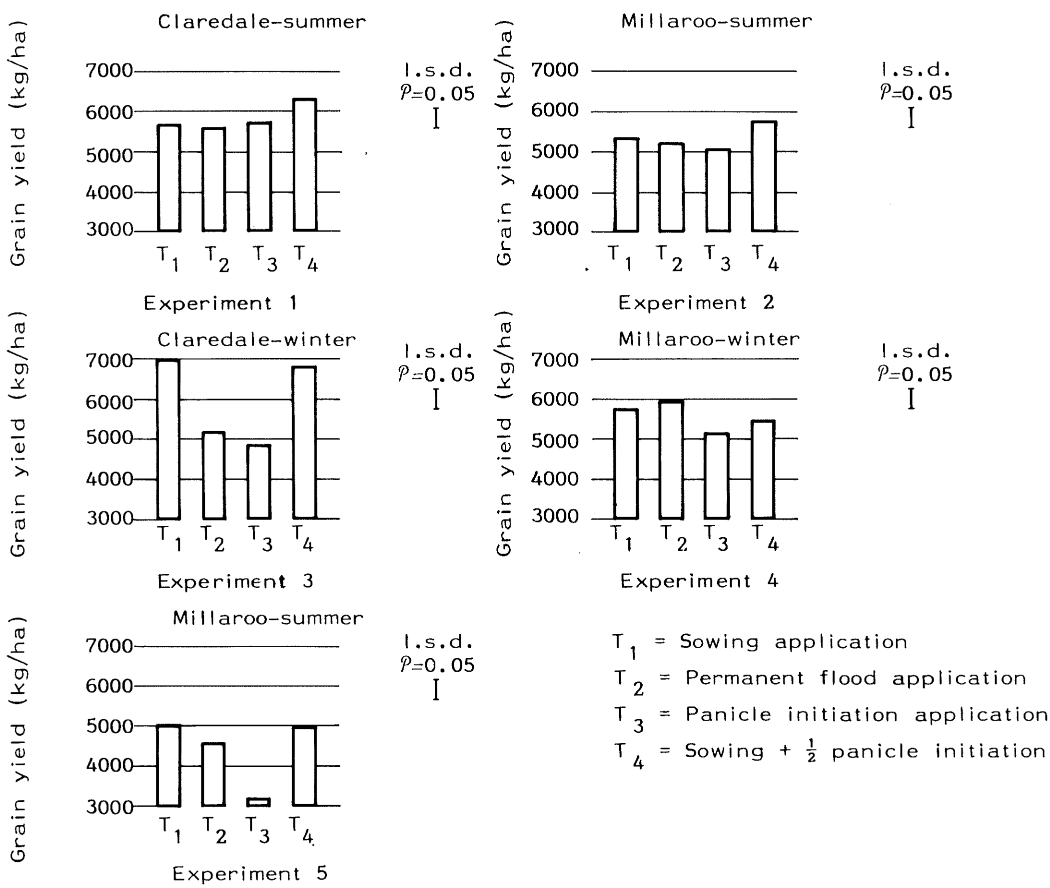

Figure 2. Effect of time of application of nitrogen on grain yield.

Application of all N at panicle initiation increased grain moisture and decreased 1000 grain weight over all other treatments except in Experiment 3. (Tables 3 and 4 respectively).

Delaying N application until later in the crop cycle caused maturity to be delayed as can be seen from the grain moisture levels (Table 3). In four of the five experiments, application of N at panicle initiation significantly delayed maturity, and split applications delayed maturity in two experiments.

Table 3. Effect of time of application of nitrogen on grain moisture

Time of application of N	Grain moisture %				
	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
All at sowing	19.11*b**	15.00*c*	10.14*a*	10.63*bc*	11.23*c*
All at permanent flood	18.96*b*	15.71*bc*	10.33*a*	10.36*c*	11.58*bc*
At panicle initiation	22.49*a*	23.19*a*	11.33*a*	11.39*a*	15.65*a*
½ sowing+½ panicle initiation	19.07*b*	16.98*b*	10.68*a*	10.89*b*	12.14*b*
l.s.d. P=0.05	0.93	1.53	1.22	0.51	0.89

* Data followed by the same letter are not significant.

There were no significant interactions and analysis over seasons showed each experiment should be treated separately.

Table 4. Effect of time of application of nitrogen on 1000 grain weight

Time of application of N	1 000 grain weight g at 16% moisture				
	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
All at sowing	27.004*a**	27.54*a*	28.857*b*	28.909*a*	27.500*a*
All at permanent flooding	27.278*a*	27.69*a*	30.048*a*	28.947*a*	27.666*a*
All at panicle initiation	23.963*b*	24.75*b*	28.615*b*	26.788*c*	25.615*c*
½ sowing+ ½ panicle initiation	27.139*a*	28.11*a*	30.195*a*	28.272*b*	26.728*b*
l.s.d. P=0.05	0.731	0.84	1.088	0.584	0.594

* Treatments followed by the same letter are not significant.

Table 5. Effect of time of application of nitrogen on dry matter production at harvest

Time of application of N	Dry matter kg/ha				
	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
All at sowing	12 689*a*	12 326*a*	10 613*a*	7 796*b*	10 988*a*
All at permanent flooding	10 159*bc*	11 411*ab*	7 558*b*	10 869*a*	9 785*a*
All at panicle initiation	8 903*c*	9 153*c*	6 698*b*	8 634*b*	7 243*b*
½ sowing+½ panicle initiation	11 903*c*	10 267*bc*	9 766*a*	7 527*b*	10 106*a*
l.s.d. P=0.05	1 325	1 651	892	1 182	1 719

* Data followed by the same letter are not significant.

DISCUSSION

The response in grain yield to N levels up to 132 kg N/ha in three experiments is consistent with results obtained elsewhere (Wells 1970; Wells 1972; Kumar and George 1972; Yang *et al.* 1968). In Experiment 4 no levelling of the response was noticed even at 132 kg N/ha and the reason for this is not clear.

The response to split application was similar in nature to that found by other workers (Sims *et al.* 1967; Hall *et al.* 1968; and Kumai *et al.* 1972). Since at least one and up to three wetting and drying cycles occur in a rice crop before permanent flooding, it would be expected that some nitrogen would be lost through nitrification–demitrification from plots fertilised at sowing. It could be expected that in winter crops which have a greater number of wetting and drying cycles this effect would be greatest. The analysis over seasons does not confirm this and more recent work (Maltby, J. E. and Barnes, J. E. pers. comm. 1984) shows that the largest portion of nitrogen is lost on the first flush. The lack of response to split application compared to application at sowing in Experiments 3, 4, and 5 cannot be explained from this data. The yields obtained from applying all nitrogen at sowing were higher than those generally achieved by the industry using a similar practice but this could be due in part to the fact that depth of placement was 7.5 cm. At this depth ammonium ions convert more slowly to nitrate ions than surface applied N, reducing potential losses of N due to demitrification after reflooding (Ponnamperuma 1964). A positive response to increasing depth of placement of N fertiliser has already been achieved on these soils (J. Barnes, unpub. data 1972).

Although there were no significant grain yield responses to split application in three out of five experiments, compared to application at sowing, split application of N eliminated lodging in all experiments whereas the plots receiving either 110 or 132 kg N/ha at sowing generally lodged in all experiments. In some experiments, plots receiving 88 kg N/ha at sowing also lodged.

In four of the five experiments, N application at permanent flood resulted in significantly less grain yield than split application (Table 4). However, the fertiliser was applied after permanent flood and may have been trapped by the soil near the surface. Nitrification in the oxidized surface layer could lead to nitrate formation and subsequent leaching and denitrification in the lower reduced zones of the soil profile. The large and rapid uptake of nitrogen that occurs at panicle initiation (Bacon pers. comm. 1984) would not occur in this situation as the plants were at an early stage of development (10 to 75 cm high), and would not have developed a large root system as occurs at panicle initiation.

The lack of a significant relationship between yield components and N response may have been due to the small sample size and the high degree of plot variability. However, Broadbent and Mikkelsen (1968) found no effect of split applicaion of N on tiller and panicle numbers although other yield components were not measured. When all N was applied at panicle initiation the only significant effect was the decrease in 1000 grain weight.

The positive benefits of split N application and higher rates on rice yields and the reduced lodging, has resulted in the adoption of this practice by farmers.

ACKNOWLEDGEMENTS

The author wishes to thank Mr H. Morris and the staff at Millaroo Research Station, for their assistance in the carrying out of the trial and Miss E. Goward, Mr P. O'Rourke and Mr R. Shepherd, Biometry Branch for the statistical analysis and Agricultural Chemistry Branch for the analysis of the plant samples.

References

Broadbent, F. E. and Mikkelsen, D. S. (1968), Influence of placement on uptake of tagged N by rice, *Agronomy Journal* **60** (**6**), 674.

Chang, W. L. and Yang, S. C. (1966), Effects of split application of fertiliser on planting density on yield, and other agronomic characters of rice, *Journal Taiwan Agricultural Research* **15**, 1–7.

Hall, V. L., Sims, J. L. and Johnston, T. H. (1968), Timing of nitrogen fertilisation of rice. II. Culm elongation as a guide to optimum timing of applications near midseason, *Agronomy Journal* **60** (5), 540.

Kumar, C. R. M. and George, C. M. (1972), Studies on the effect of top dressing with nitrogen at distinct phases of rice, *Agricultural Research Journal of Kerala* **10** (2), 93.

Ponnamperuma, F. N. (1964), Dynamic aspects of Flooded Soils and the Nutrition of the Rice Plant, in *Mineral Nutrition of the Rice Plant*, Proceedings Symposium at International Rice Research Institute, 1964.

Reeve, R., Hubble, G. D. and Thompson, C. H. (1960), *The Laboratory Examination of soils from the Lower Burdekin Valley North Queensland*, CSIRO Divisional report 7/59 March 1960.

Sims, J. L., Hall, V. L. and Johnston, T. H. (1967), Timing of N fertilisation of rice. 1. Effect of applicaitons near midseason on varietal performance, *Agronomy Journal* **59** (1), 63.

Wells, B. R. (1970), *Performance of long grain rice grown on clay soils as related to rate and timing of N fertiliser*, Report Arkansas Agricultural Experiment Station Serial, **187**, 12.

Wells, B. R. (1972), Response of Starbonnet to nitrogen fertilisation in Arkansas, *Rice Journal* **75** (4), 10.

Wells, B. R. and Johnston, T. H. (1970), Differential response of rice varieties to timing of midseason N applications, *Agronomy Journal* **62** (5), 608.

Yang, P. L., Wang,Y. P. and Chiang, M. H. (1968), Effect of split fertilisation on rice production, *Journal Agriculture and Forestry* 16 and 17, Taiwan Provincial Chung-Hsing Univ.

(Accepted for publication 15 October 1985)

Mr Barnes is an officer of Agriculture Branch Queensland Department of Primary Industries, Kingaroy Q. 4610.