PROFITABLE USE OF NITROGEN FERTILISER TO SUSTAIN PRODUCTION WHERE RAINFALL IS UNRELIABLE

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Summary. For the sequence of wheat crops between 1987 and 1994, at Warra on the Western Downs, Queensland, financial returns were increased with increasing level of applied N to each crop, up to 75 kg/ha.crop. Increased profit was derived from increases in yield and grain protein concentration and were affected largely by the price on offer for high protein grains, particularly during the dry seasons of the 1990's. There was evidence that nitrate residues did accumulate in fertilised (75 kg/ha.crop) soil except after crops in 1988 or 1989. With the exception of these crops (1988 and 1989), which received high (>200 mm) incrop rainfall, 75 kg/ha.crop provided ample supplementary N for this sequence of wheat crops. Higher fertiliser N applications (100-150 kg/ha) did increase profits in 1988 but reduced profits in 1989.

INTRODUCTION

A major impediment to the sustainability and profitability of cropping in the northern cereal belt is the decline in soil fertility which is experienced where cropping continues without periods of pasture ley. Although the fertility decline may impact on almost all essential plant nutrients, nitrogen (N) and phosphorus (P) appear to be those which most frequently limit crop production in northern Australia. In many northern cropping systems supplies of N and P are supplemented by the application of fertilisers. Moreover, some growers are concerned that due to unreliable in-crop rainfall, extremes in crop response to N will lead to low profitability or even to a financial loss.

Fertilisation strategies need, therefore, to be trialed in this environment over several years to test possible residual N fertiliser effects on returns derived from grain yield and protein. The yield and protein content of almost all cereal grains grown in the region impacts either directly (wheat, barley) or indirectly (sorghum) on financial returns. Profitable and sustainable production fertilisation strategies were evaluated over the period 1987-1994 at a site on the Western Downs, Queensland. The following soil and crop information demonstrate marked residual effects on crop production and increased profitability by adopting a N fertilisation strategy in which soil nitrate was found to accumulate during a sequence of wheat crops between 1987 and 1994.

MATERIALS AND METHODS

Experimental site is located at Warra (26?47?S, 150?53?E), 125 kilometre west of Toowoomba, Queensland. The soil is representative of a large area, (≈ 0.7×10^6 ha) of cultivated brigalow lands of eastern Australia, and has been described in detail by Dalal *et al.* (1). Briefly the soil had a clay content of 55%, organic C 0.7%, total N 0.07% and pH 8.5 in the top 0.1 m layer.

Rate of N (0-150 kg/ha) experiments were conducted each year when wheat was sown between 1987 and 1994 on zero tilled (ZT) and conventionally tilled (CT) soil. These experiments were conducted on a site (≈ 1 ha) adjacent to that where various management options were compared to sustain the productive capacity of the fertility-degraded vertisol. Urea was applied at sowing in bands (0.5 m apart) at the centre of every other interrow space (0.25 m) 7 cm deep. A cone distributor was used to apply a weighed quantity of fertiliser over a plot 12.5 m long and 2.25 m wide.

Wheat seeds, variety Hartog (25/m), were sown in rows 12.5 cm on either side of each fertiliser band 5 cm deep. Crops were sown on 30 May 1987, 26 May 1988, 20 June 1989, 3 July 1990, 26 May 1992, 22 July 1993 and 17 June 1994. Phosphate fertiliser (≈ 8.4% P) fortified with Cu (0.9%) and Zn (0.85%) was applied with the seed at the rate of 10 kgP/ha.

During the fallow (December to April) two to four tillage (CT) operations were carried out with tined implements to about 100 mm for weed control. Except for the sowing operation ZT treatments were not tilled. Weeds were controlled by herbicide spray (1.2 L/ha glyphosate and 1.2 L/ha 2,4D amine) 2-4 times during the fallow.

At maturity, crop from the inside 7 rows was machine harvested and grain yield estimated from a measured plot length (≈ 10 m) with adjustment to 12% water content. Grain was analysed for N concentration in Kjeldahl digests using automated NH_4-N analysis (2).

RESULTS AND DISCUSSION

Reliability of crop responses and financial returns from N application

In spite of the modest and erratic rainfall received during winter periods (Table 1), wheat responded by an increase in grain yield and/or grain protein content to N applied at sowing (1987-1993). Yield response to applied N was naturally highest in that year (1988) with highest incrop effective rainfall received before flowering (Fig. 1). In years of more moderate effective winter rainfall, grain yield responses were achieved with N rates up to 75 kg/ha. In years of more moderate rainfall grain protein levels were also increased by N fertiliser application.

Table 1. Pre-flowering and post-flowering rainfall (mm) at the Warra site for each year of wheat cropping between 1987 and 1994.

Year	Rainfall (mm)		
	Pre-flowering	Post-flowering	Total
1987	66	51	117
1988	169	43	212
1989	99	118	217
1990	66	68	134
1992	76	32	108
1993	108	35	143
1994	11	86	97

Crop returns ($/ha), net of the cost of fertiliser N, were usually increased by N fertiliser application in the year of application between 1987 and 1993 (data not shown). Returns from the application of higher N rates (75-150 kg/ha) were further increased by the following wheat crop due to response to N residues in soil fertilised for the previous crop. At these N rates crop returns were increased dramatically in the year after fertiliser application for all except those applied in 1988 or 1989. Crops fertilised in those years were

more responsive to applied N than crops fertilised in other years. Thus, there would appear to be considerable financial compensation for applying fertiliser N, even when crop responses are only modest in the year of the application.

Figure 1. Grain yield and protein response in the years of N application and in successive unfertilised crops in a sequence (1987-1994) of wheat crop at Warra, Queensland; data are means of CT and ZT for years tillage had no significant ($P < 0.05$) effect.

Wheat on the adjacent site received N fertiliser applied with each successive crop over the same cropping period. Increases in financial returns by the regular application of N to crops between 1987 and 1994 (Table 2) averaged between $87/ha and 137/ha for applications of N (25, 50 or 75 kg/ha.crop).

Table 2. Increases in crop returns ($/ha net of fertiliser cost) on an adjacent site where N (0, 12.5, 25, 50, 75 kg/ha) was applied to each successive wheat crop over the period

N rate	Cost of	Increased crop returns ($/ha)[1]	
(kg/ha.crop)	Fertiliser($/ha)	Tillage (CT)	Zero tillage (ZT)
12.5	(63)[2]	306	
25	(126)	794	608
50	(253)	867	
75	(380)	867	962

Cumulative Returns of $2933/ha (CT) and $2901/ha (ZT) for seven wheat crops, 1987, 1988, 1989, 1990, 1992, 1993 and 1994.

[1] Increased returns ($/ha) net of fertiliser costs shown in text.

[2] Investment ($/ha) in fertiliser N over seven wheat crops.

Accumulated nitrate in fertilised soil, 1987-1994

Soil nitrate was determined (kg/ha) to a depth of 1.5 m by core sampling in May, before wheat was sown, and in November, after crop harvest, on an adjacent site where fertiliser N was applied in an identical manner at rates of 0 or 75 kg/ha to each crop. There is evidence (Fig. 2) that nitrate did accumulate in fertilised soil during this sequence of crops. In November, following all crops, there was negligible nitrate in unfertilised soil, but in fertilised soil, nitrate residues were evident following all crops except those of 1988 and 1989. The 75 kg/ha rate for each crop appeared therefore to provide ample supplementary N from 1987 to 1994 except for crops which received high (>200 mm) incrop rainfall.

Although application at a higher N rate (100 kg/ha CT and 150 kg/ha ZT) did increase profits in 1988, higher N rates (125 kg/ha CT and 150 kg/ha ZT) in 1989 reduced profits below that of a 75?kg/ha application.

Figure 2. Soil nitrate accumulation in May (before sowing) and November (after wheat harvest) in unfertilised soil (shown as an area) and for fertilised (75 kg N/ha.crop) soil on an adjacent and identically treated site; data shown are means of ZT and CT treatments.

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