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Nitrogen and phosphorus fertiliser requirements of irrigated wheat at Emerald, Queensland

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Summary

The nitrogen and phosphorus fertiliser requirements of irrigated wheat were studied on three soil types at Emerald, Queensland in 1975 and 1976.

The optimum rates of fertiliser application were found to be 100 kg N/ha and 25 kg P/ha for a yield goal of 4500 kg/ha and 150 kg N/ha and 25 kg P/ha for a yield goal of 6000 kg/ha. At high yield levels, the low values for available nitrogen and phosphorus in the soil prior to planting were found to be of little importance in the determination of the optimum rates of nitrogen and phosphorus fertiliser application.

No significant yield responses to nutrients other than nitrogen and phosphorus were obtained, although low levels of extractable zinc and sulphur were recorded on some sites.

INTRODUCTION

Early in the development of the Emerald Irrigation Area (EIA), the maximum yield of wheat (3600 kg/ha) was achieved with less than 100 kg N/ha (Keefer and McAllister 1970). Subsequent to this, the yield potential was increased by the release of semi-dwarf varieties (Syme 1969, 1970) and better irrigation practices (Salter and Goode 1967; Keefer and Younger 1971). It was therefore appropriate to reassess the nitrogen requirements of irrigated wheat in the EIA.

Phosphorus has been identified as a limiting nutrient for wheat production on many of the soils of central Queensland (Strong *et al.* 1977). Similar soils also occur in the EIA, many having bicarbonate extractable P levels less than the minimum critical value of 15 ppm (Strong *et al.* 1980).

This paper reports the grain yield responses to N and P of wheat grown under optimum irrigation regimes on three soil types in the EIA.

MATERIALS AND METHODS

Three sites were selected on soils representative of the majority of farms in the EIA. Trial site descriptions for the three sites and two seasons are presented in Table 1.

In the first season, each experiment consisted of five rates of nitrogen as urea (0, 20, 40, 80 and 160 kg N/ha) and four rates of phosphorus as double superphosphate (0, 8, 28 and 50 kg P/ha) in an incomplete randomised blocks design with two replicates. The two intermediate P rates were applied only at the lowest and highest N rates. In the second season, the design was reduced to randomised complete blocks incorporating five rates of nitrogen (0, 50, 100, 150 and 200 kg N/ha) and two rates of phosphorus (0 and 25 kg P/ha) with three replicates. The fertilisers were applied in bands 18 cm apart approximately four weeks prior to sowing. Plots 100 m in length were used to permit mechanical harvesting.

Two additional treatments incorporating dressings of all other nutrients were included in the 1976 experiments, in conjunction with the 100 kg N/ha, 0 kg P/ha and 100 kg N/ha, 25 kg P/ha treatments respectively. The mixture consisted of the following elements applied at the rates shown in kg/ha: K 107, Zn 45, Mn 27, Mg 10, Cu 8, S 121, B 2, and Mo 0.5.

The semi-dwarf cultivars Oxley or Kite were planted (Table 1). Furrow irrigation was applied at planting, mid-tillering, boot, flowering and early grain expansion to minimise moisture stress at critical stages of growth. Grain was mechanically harvested at maturity.

Table 1. The classification and description of the soil types studied, their natural vegetation, and some details of the management and nutritional status of the individual sites studied in 1975 and 1976

Soil type[1] and classification[2]	Soil and natural vegetation description[3]	Season	Cultivar	Planting date	Planting rate (kg/ha)	Avail–N 0–60 cm (kg/ha)	Bicarb–P 0–10 cm (ppm)	Avail–Zn 0–10 cm (ppm)	Avail–S 0–10 cm (ppm)	pH 0–10 cm
Downs										
BUg	moderately deep dark basaltic cracking clay	1975	Kite	7 Jun	40	55.0	17.8	0.3		7.8
Ug 5.12	grassland with bloodwood	1976	Oxley	27 May	45	54.0	9.2	0.7	26.5	7.3
Scrub										
Tb Ug	deep dark basaltic cracking clay	1975	Kite	11 Jun	40	55.0	17.9	0.5		8.0
Ug 5.16	brigalow yellowood belah	1976	Oxley	24 Jun	45	42.0	12.8	0.8	36.5	8.1
Alluvial										
AUg	deep dark grey alluvial cracking clay	1975	Oxley	12 May	60	37.0	22.7	0.4		8.2
Ug 5.16 Ug 5.24	brigalow yellowwood	1976	Oxley	15 Apr	60	56.0	8.2	0.7	4.5	8.1

1. McDonald (1975) and Tucker *et al.* (1980). 2. Northcote (1979). 3. Keefer *et al.* (1977).

RESULTS

Grain yield responses to applied P at two levels of N (0 and 160 kg N/ha) at three sites in 1975 are presented in Figure 1. At high rates of N application, phosphorus application significantly increased yields at the Downs and Scrub sites. There was no P response on the Downs soil in the absence of applied N. No response was achieved on the Alluvial soil, regardless of N application. At the highest P rate, yields did not significantly exceed those at 28 kg P/ha. Bicarbonate extractable phosphorus values were 17.8, 17.9 and 22.7 ppm for the Downs, Scrub and Alluvial sites respectively (Table 1). Maximum yields of 4800 kg/ha were obtained on the Downs and Scrub soils. A maximum yield of only 3000 kg/ha was obtained on the Alluvial site, where free water remained at the soil surface following each irrigation.

Phosphorus application significantly increased yields at all sites in 1976, with this effect not being significantly altered by nitrogen rate (Figure 2). In 1976, values were 9.2, 12.8 and 8.2 ppm for the Downs, Scrub and Alluvial sites respectively (Table 1).Maximum yields of 6000 kg/ha and 5200 kg/ha were obtained on the Downs and Alluvial soils. Hail damage at the Scrub soil site resulted in the maximum yield recorded being 3200 kg/ha.

Nitrogen application significantly increased yields at all sites in both years (Figures 2 and 3). Available soil nitrogen averaged 50 kg N/ha over all locations (Table 1). Yield asymptotes were not achieved in 1975 at the highest rates of nitrogen studied (160 kg N/ha), although the highest yields attained did not significantly exceed those at 80 kg N/ha on the Downs site or those at 40 kg N/ha on the other two sites. In 1976, a yield asymptote was obtained only on the Downs site. The maximum yields recorded did not significantly exceed those at 100 kg N/ha on the Downs and Scrub sites. Yield response at the Alluvial site was linear, but still the maximum yield did not significantly exceed that at 100 kg N/ha.

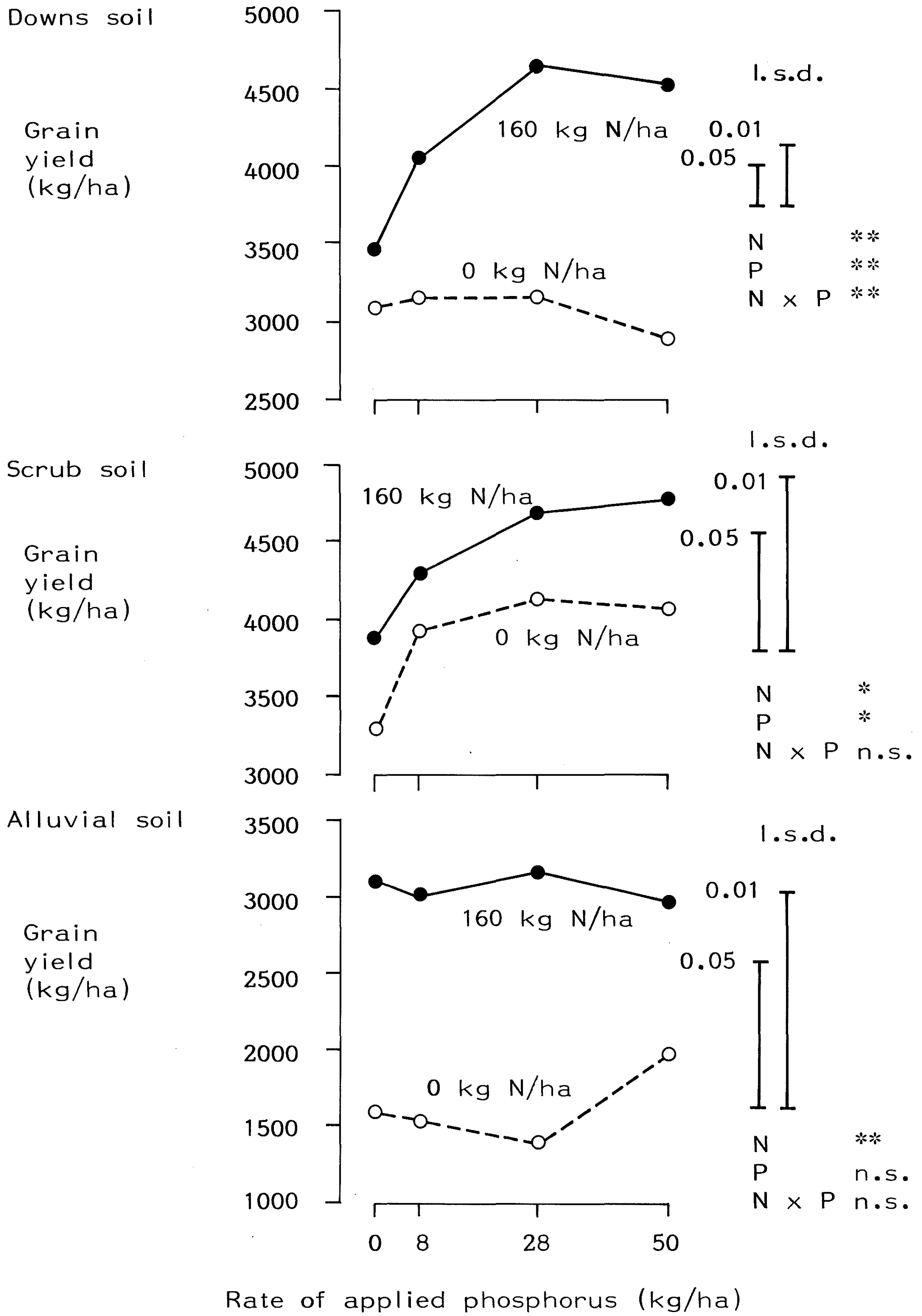

Figure 1. Wheat grain yield responses to applied phosphorus at two rates of nitrogen for three soils in 1975.

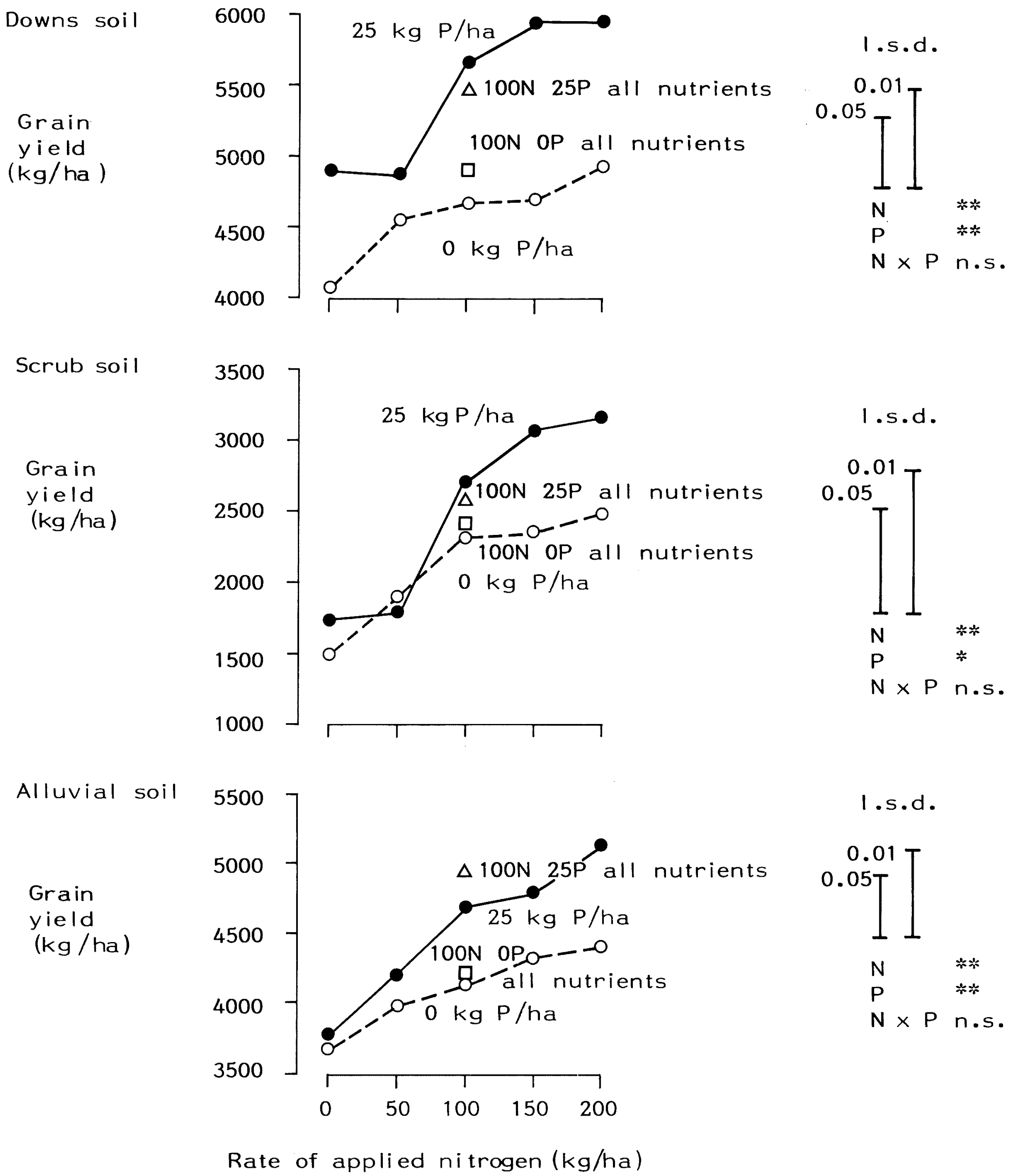

Figure 2. Wheat grain yield responses to applied nitrogen at two rates of phosphorus for three soils in 1976.

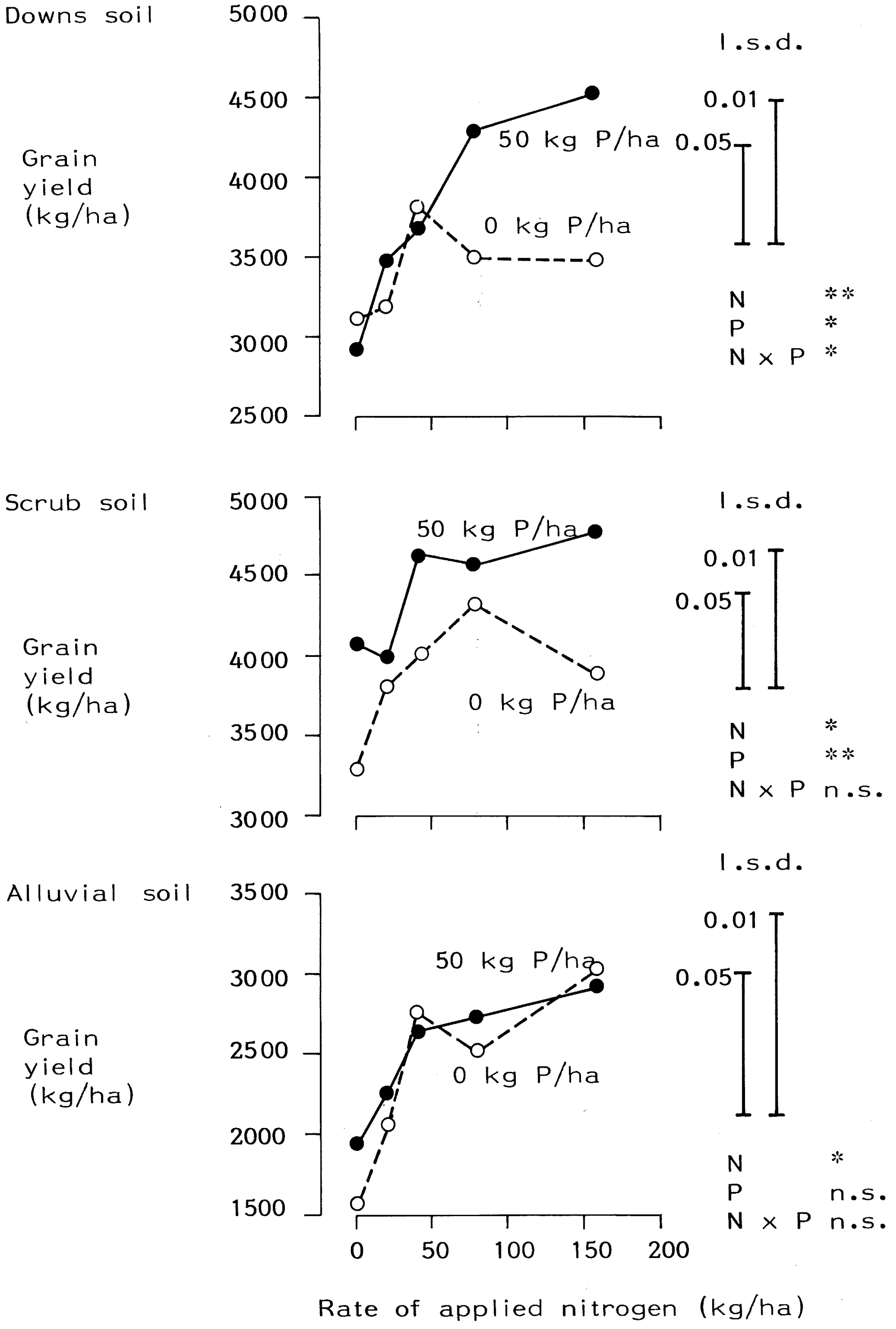

Figure 3. Wheat grain yield responses to applied nitrogen at two rates of phosphorus for three soils in 1975.

Site characterisation analyses were conducted, but only the data for zinc and sulphur are presented in Table 1. Levels of available zinc from 0.3 to 0.5 ppm were recorded at soil pH levels of 8.0 at all sites in 1975. In 1976, levels of available zinc of 0.7 to 0.8 ppm were recorded at soil pH levels from 7.3 to 8.1. The level of available sulphur at the Alluvial site was 4.5 ppm. No symptoms of nutritional disorders were observed in the field in either season.

Grain yield responses to the complete nutrient dressings in 1976 are shown in Figure 2. These responses were not statistically significant.

DISCUSSION

Phosphorus application resulted in significantly increased yields on the Downs and Scrub sites in 1975 and on all sites in 1976. The Alluvial site, with a slope less than 0.1%, was new cultivation in 1975, and irregularities in slope resulted in ponding of water for long periods following irrigation. Emergence and plant growth were reduced, presumably as a result of waterlogging. The Alluvial site was land planed prior to the 1976 study, and a significant P response was recorded in the second season.

The application of 25 to 28 kg P/ha significantly increased yields on all soils, with no additional yield resulting from higher rates of application. The sufficiency of a dressing of 25 to 28 kg P/ha for the attainment of high yields of irrigated wheat was supported by the 1976 data, in which yields up to 6000 kg/ha were obtained at high rates of nitrogen application at levels of bicarbonate extractable soil phosphorus of 9.2 ppm. At high yield levels, the low soil analysis data reported were of little importance to the determination of the optimum rate of phosphorus fertiliser application. Thus it is concluded that a dressing of phosphorus is warranted on all soils tested.

Significant responses to applied nitrogen were obtained on all sites in both seasons. Higher yields and statistically significant responses to higher rates of nitrogen were obtained in 1976 than in 1975, although yields were reduced by hail damage on the Scrub site in 1976. In the first season, yields from the Scrub and Downs sites may have been reduced by late planting (Goyne 1972), by low seeding rate (Keefer and Younger 1971), and by the use of the earlier maturing cultivar Kite which has been reported to yield 7% less on average than the later maturing cultivar Oxley (Shepherd *et al.* 1983). The lower yields at the Alluvial site were discussed earlier.

Ulrich (1952) proposed that the nutrient concentration within a specified plant part is related to plant growth, and that growth is not affected until the nutrient concentration decreases to a critical value, considered to be the concentration at 95% of the maximum yield. Using the yield goal modification of this technique for fertiliser responses in the field (Dahnke *et al.* 1981), the optimum rate of nitrogen application was taken as that at 95% of the maximum yield in each case. Since available soil nitrogen levels were similar in all locations, no adjustment was made for soil nitrogen. On this basis, the application of 150 kg N/ha was considered optimal for all three soils using the 1976 data, for which the fertiliser responses were not constrained by other agronomic factors. At the lower yield levels attained in 1975, the application of 100 kg N/ha was sufficient to optimise yields. At high yield levels, the low soil analysis figures reported were of little importance to the determination of the optimum rate of nitrogen fertiliser application.

The extent of the response to nitrogen was dependent on the level of phosphorus only at the Downs site in 1975. However, significantly higher yields at the optimum rate of applied nitrogen were attained in the presence of a dressing of phosphorus on all sites in 1976 in the absence of other limitations. Consequently dressings of both nitrogen and phosphorus should be applied.

The optimal rate of applied N determined from the 1976 experiments corresponds with the conclusions of Strong (1981), who found that 150 kg N/ha was necessary to optimise the yields of irrigated wheat planted on 1 June on similar soils on the Darling Downs. Delay in planting after that date and the level of residual nitrate nitrogen in the soil at planting both had strong negative effects on the optimal applied nitrogen rate. Bicarbonate extractable soil phosphorus and number of irrigations also affected grain yields in his studies, but neither had any effect on the optimal rate of fertiliser nitrogen. Strong (1981) developed a relationship between delay in planting time, level of residual nitrate N in the soil at planting and the optimal rate of applied nitrogen. A similar relationship would be expected at Emerald. With delayed planting in central Queensland, however, the decline in yield potential and the associated decline in fertiliser nitrogen requirements would be more severe, as the crop would flower and mature in higher temperatures (Goyne 1972; Woodruff and Tonks 1983).

The levels of available zinc were less than or similar to the critical level of 0.8 ppm (Whitehouse 1973) on all sites in both seasons. The level of available sulphur on the Alluvial soil in 1976 was less than 8 ppm, which was considered to be the critical level by White *et al.* (1981) from limited evidence. However, no deficiency symptoms were observed in either season, and no significant yield responses to the complete nutrient dressings were obtained in 1976.

CONCLUSION

The optimum rate of nitrogen application is dependent upon the maximum yield obtained in the experiment or upon the yield goal selected. On the basis of these studies the following nitrogen and phosphorus fertiliser recommendations are made.

Yield goal of 6000 kg/ha

1. The attainment of such high yields would necessitate a high standard of agronomy.

2. The application of 150 kg N/ha and 25 kg P/ha to ensure the nutritional requirements of the crop.

3. The selection of a semi-dwarf cultivar of high yield potential planted at the optimum time (May) and at a suitable planting rate (70 kg/ha).

4. The selection of an irrigation regime designed to stimulate the development of effective secondary roots and to provide favourable conditions during the critical four week period around flowering.

Yield goal of 4500 kg/ha

1. The application of 100 kg N/ha and 25 kg P/ha should be sufficient to ensure the attainment of this yield goal.

2. The selection of a semi-dwarf cultivar is still essential.

3. For other management factors, a slightly lower standard of agronomy should still result in satisfactory yields.

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