Split application of nitrogen can reduce biomass but maintain yield in maize in northern NSW

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Abstract

Four field experiments were conducted in the 2014-15 and 2015-16 seasons to compare interactions among nitrogen rates, application timing and maize hybrids. Two experiments were conducted at Gurley, south of Moree, under rain-fed conditions and two were conducted at Breeza, on the Liverpool Plains, under irrigated conditions. Nine nitrogen treatments were imposed in each experiment with seven treatment rates, ranging from 0 to 250 kg N/ha applied upfront at sowing, and two split treatments of 75:75 and 100:100 kg N/ha with half applied at sowing and half at the 6-8 leaf growth stage. Two medium maturity maize hybrids, Pac606 and Pioneer 1467 were selected for comparison. Biomass production was highest from the 100 kg N/ha and 75:75 split treatments in both hybrids, and the 150 kg N/ha treatment in Pac606. The lowest plant biomass was obtained from the 250 kg N/ha and 100:100 split treatment in both hybrids.

A positive linear yield response to N application was seen in both Pac606 and Pioneer 1467 with the highest yield obtained with the application of 250 kg N/ha. The 100:100 split application treatment reduced plant biomass when compared to 200 kg N/ha applied upfront but achieved similar yields. Kernel number had a strong correlation with grain yield but there was either no correlation or a weak association between plant biomass and grain yield with each of the hybrids. These results suggest splitting N application with 100 kg N/ha applied at sowing and 100 kg N/ha applied at the 6-8 leaf growth stage could be an appropriate strategy to maximise water use efficiency of maize under both rain-fed and irrigated production systems in northern NSW.

Keywords

Nitrogen management.

Introduction

Maize production in northern NSW continues to be a small but important summer rotation crop in both favourable rain-fed and irrigated cropping systems. Nitrogen (N) application has a major influence on maize yield and is a significant component of input costs. Maize production is generally focused on maximising yield to drive positive gross margin returns. Maize production has declined dramatically since the early 19th century. In 1924 production in Australia totaled 172,000 ha, in contrast by 2009 only 49,000 ha were under maize production (ABS 2009-10). In particular the area of dryland maize has reduced as grain sorghum and cotton have increased in area. Irrigated maize has maintained a small but reasonably stable area in northern NSW.

Dryland maize production in northern NSW is considered to be higher risk the further north and west production occurs. As such there is little dryland maize grown west of the Newell Highway. Maize is considered a higher risk summer crop option due to the need to synchronise the tasseling and silking growth stages to maximise kernel set. Yield can be very poor if these do not coincide or heat and water stress limit crop and/or grain development.

Nitrogen is required in large quantities for maize production and is typically the nutrient most limiting yield through impacts on plant growth and development (Uhart and Andrade 1995a). Nitrogen is also one of the largest input costs in maize production. As such, growers would prefer to minimise their production risk and costs by splitting the amount and timing of N application or reducing total overall application rates in unfavorable seasons.

Nitrogen uptake in maize escalates rapidly from the 8 leaf stage. Around fifty percent of the total crop requirement is taken up in the 30 days from 8 leaf stage to tasseling (Butzen 2017). Hence to maximize uptake and utilization within the crop, sufficient nitrogen needs to be supplied for uptake during this stage.

Typical recommendations are for application of nitrogen to occur either pre sowing or at sowing or through a split application method where a portion is also applied at the 6-8 leaf stage of crop development. Split application of N is employed as a risk management tool. In seasons where the climatic forecast is not favourable by the 6-8 leaf stage of development a decision can be made to not apply additional N. The challenge with this strategy, particularly in dryland situations, is being able to time N application with rain events to enable the N to move into the root zone for plant uptake.

Methods

Four experiments were conducted with two each in 2014-15 and 2015-16 at Gurley, south of Moree and Breeza, on the Liverpool Plains in northern NSW. The experiments at Gurley were managed under rain-fed (dryland) conditions, with plots four metres wide and eight metres long sown with a precision planter on 100 cm row spacing. The experiments at Breeza were sown on raised beds in a furrow irrigation system. Plots were 2 m by 8 m and were sown with a precision planter on 1 m row spacing.

The hybrids Pac606 and Pioneer 1467 were included in all experiments. Pac606 is a 114 corn relative maturity (CRM) hybrid suited for silage or grain production. Pioneer 1467 is a 114 CRM hybrid suited for silage or grain production. Analysis of all sites and seasons data for the nine nitrogen treatments was conducted. The treatments applied at sowing were 0, 50, 75, 100, 150, 200, 250 kg of N/ha and two split application treatments of 75:75 kg N/ha and 100:100 kg N/ha where half was applied at sowing and half was surface applied at the 6-8 leaf growth stage. All treatments were applied using urea.

Starting soil N levels were measured prior to sowing to a depth of 1.2 m and calculated to be 145 and 105 kg N/ha at the Breeza and Gurley sites respectively in 2014 -15 and 72 and 73 kg N/ha at the Breeza and Gurley sites in 2015 -16 .The application rates were budgeted to provide sufficient soil and applied N to achieve 5 t/ha in the rain-fed experiments near Moree and 12 t/ha in irrigated experiments at Breeza

Dry matter production was measured through cutting samples from an area of two metres of row at the early kernel fill stage. Plant, tiller and cob numbers were recorded from these samples. Samples were dried in a dehydrator at 60°C for seven days and then weighed. Grain yield and quality was determined by mechanical harvesting. A sub sample was collected from each plot for determination of screenings; thousand kernel weight and kernel number.

Results

Dry matter production was higher for Pac606, compared to Pioneer 1467 across all N rates. However, the N response trends for the two hybrids were very similar. The highest plant biomass was produced from the 50, 100, 150, 200 and 75:75 split treatments. The lowest biomass was obtained from the 250 and 100:100 split treatments (Table 2).

Table 1. Interaction between nitrogen rate and hybrid and the impact on plant dry matter and cob production – mean of four site/ years analysis.

	Dry matter production (t/ha)		Cobs/ plant	
Nitrogen rate (kg/ha)	**606**	**1467**	**606**	**1467**
0	8.55	7.45	0.97	0.96
50	10.91	9.09	1.06	0.95
75	9.23	6.21	1.09	1.06
100	11.22	9.38	1.01	1.06
150	10.55	8.87	1.00	1.02
200	9.62	10.23	1.07	1.02
250	6.10	6.40	1.10	1.01
75:75 Split	11.54	10.71	1.01	0.96
100:100 Split	5.80	6.84	1.08	0.89
Lsd (P=0.05)	1.47		0.10	

Differences in plant growth were measured through tiller and cob counts. Hybrid differences were evident when comparing across all N treatments, with Pioneer 1467 producing more tillers per plant (0.15 vs 0.04) and per square metre (0.67 vs 0.26) than Pac606. However, the interaction between hybrid and nitrogen rates was not significant for tillers per plant, tillers per square metre or cobs per square metre (data not shown).

The application of N resulted in crops with more cobs per plant for Pac606 but there were no differences among the various N application rates or timings (Table 2). Pioneer 1467 produced a similar number of cobs per plant to Pac606. Pioneer 1467 did not respond to N application rates or timings except the 75 and 100 kg N treatments which produced more cobs per plant than the 50 kg and 100:100 kg N/ha treatments.
There was a significant interaction between hybrid and N rate for grain yield. Higher yields were obtained from Pioneer 1467 at almost all treatment levels, except the 75:75 split.

Grain yield increased in line with increasing N application rate, up to the highest rate of 250 kg N/ha, which was three times more than the yield produced from the nil treatment (Figure 1). The lowest yields were obtained from the nil N treatment. The application of 250 kg N/ha up front produced the highest yield for both hybrids. The 75:75 split treatment produced yields equal to applying 150 kg N/ha up front for Pioneer 1467. In contrast the 75:75 split applications produced significantly higher yields than the 150 kg N/ha upfront treatment for Pac606. The 100:100 split produced yields equal to the 200 kg N/ha upfront treatment.

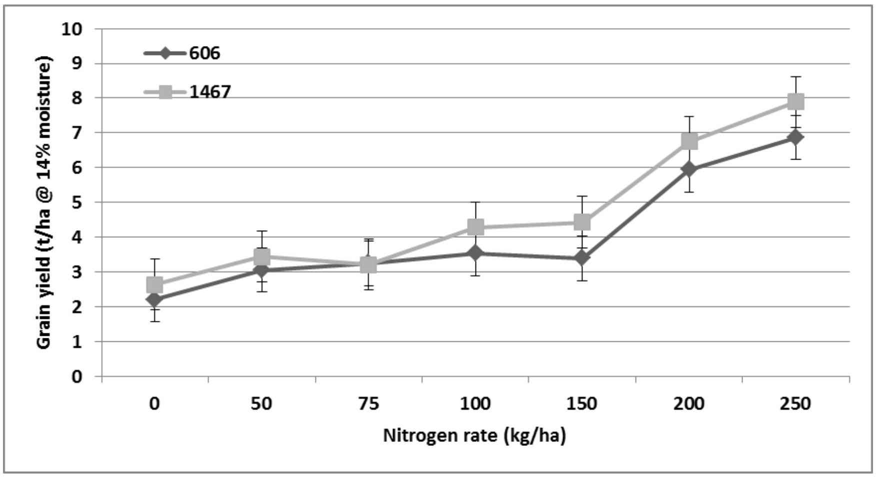

Figure 1. Impact of varying nitrogen rate on maize grain yield - across sites analysis.

Plant biomass, collected at early grain fill, was compared to grain yield to assess if there was a useful correlation between those values (Figure 2). While the relationship between dry matter and grain yield was better for Pac606 than Pioneer 1467. It can be seen that dry matter was not a useful indicator of yield in these experiments.

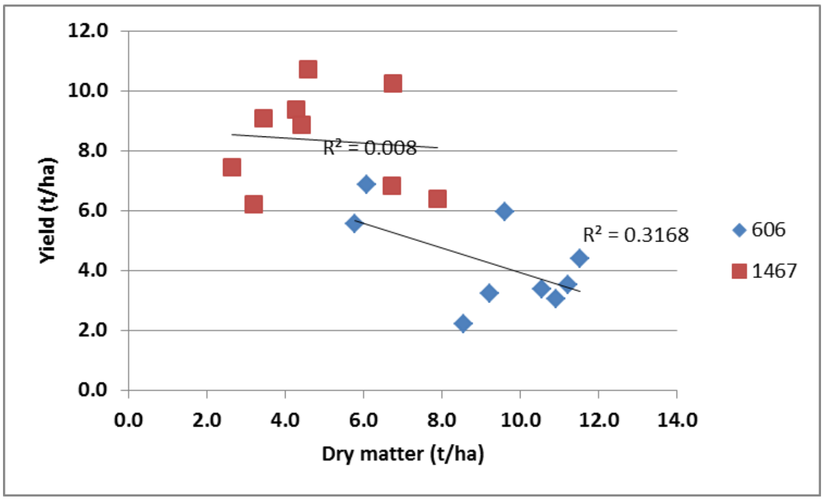

Figure 2. Correlation between dry matter production and maize yield.

Kernel number was calculated (1000/m^2) for both hybrids and regressed against grain yield (Figure 3). Both hybrids showed a strong relationship between grain yield and kernel number indicating that the more kernels set the higher the resultant yield (Figure 3). The relationship between kernel number and yield were not significantly different between the two hybrids (that is the slopes are the same). In contrast the number of cobs per plant did not prove to be a good indicator of yield (data not shown).

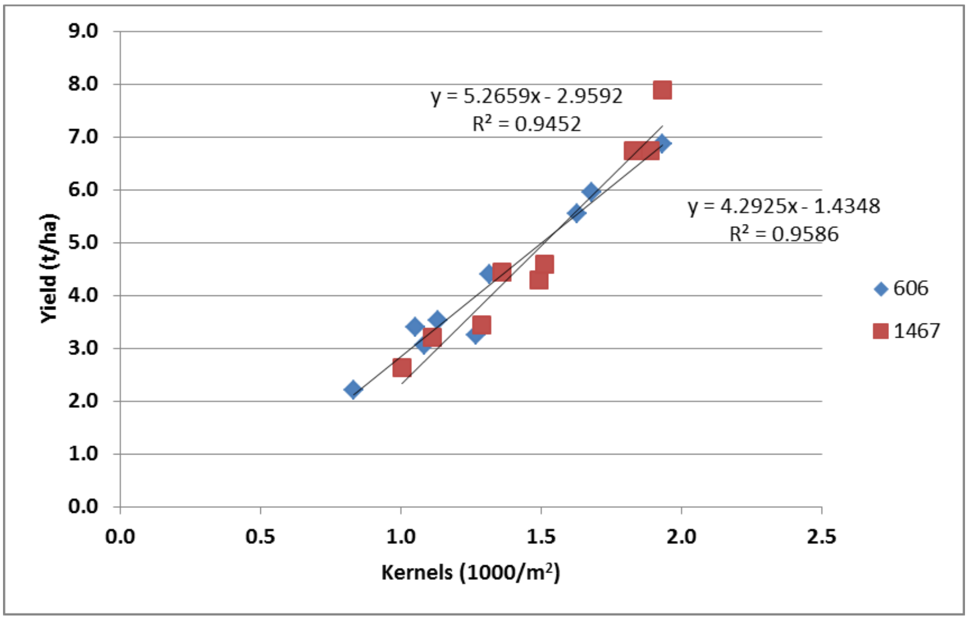

Figure 3. Relationship between maize grain yield and kernel number.

Conclusion

Nitrogen rate had a positive linear relationship with grain yield for both maize hybrids utilised in these experiments. The highest yields were obtained from applying 250 kg N/ha at sowing. The split application of 100 kg N/ha at sowing and 100 kg N/ha at the 6-8 leaf growth stage showed merit in that it reduced plant biomass compared to applying 200 kg N/ha at sowing but still achieved similar grain yield.

This approach could be a useful risk management tool for growers as it then delays the need for additional expenditure on N until further into crop development, allowing a better evaluation of the likely seasonal conditions. The 75:75 split N application did not provide as conclusive evidence of its merit as a potential risk management tool to maximise maize production. The starting soil nitrogen levels of these experimental sites would also have had an impact on this outcome. Plant biomass, derived from dry matter cuts at early kernel fill was not a useful indicator of final maize yield, even though typically only 20-30 % of the total nitrogen uptake for the crop occurs between this growth stage and crop maturity.

References

ABS Australian Bureau of Statistics (2009-10). Historical Selected Agriculture Commodities, by State (1861 to Present). Cat. no. 7124.0.

Butzen S (2017). Nitrogen Application Timing in Corn Production. (https://www.pioneer.com/home/site/us/agronomy/library/nitrogen-application-timing/).

Uhart SA and Andrade FH (1995). Nitrogen deficiency in maize: I. Effects on crop growth, development, dry matter partitioning, and kernel set. Crop Science 35, 1376-1383.