**Forage production and nitrogen uptake of forage sorghum, grain sorghum and maize as affected by cutting under different nitrogen levels**

M. Rahman, S. Fukai and F.P.C. Blamey

School of Land and Food Sciences, University of Queensland, St. Lucia, Qld.

## ABSTRACT

Nitrogen (N) requirements of forage crops may differ in single cut and multicut situations because of their differences in leaf to stem ratios. A field experiment was conducted at Redland Bay, southeast Queensland to study the effect of N fertiliser on forage yield and N content of single cut and multicut forage sorghum, grain sorghum and maize. Under single cut conditions, biomass yield increased significantly with 120 kg N ha $^{-1}$ but there was no further increase at higher N rates in any crop. However, the total N content of the each crop increased significantly with the increase in N rate, up to the highest N rate of 240 kg N ha$^{-1}$. Biomass yields were significantly decreased under the multicut regime, but this effect was not as marked with 240 N ha $^{-1}$ applied at sowing or as a split application of 120+60+60 kg N ha $^{-1}$. Total N content of the crop was much higher in the multicut than in the single cut especially with higher N rates.

**Key words**

Forage production, cutting, nitrogen, sorghum, maize.

## INTRODUCTION

Forage sorghum is widely grown in eastern Australia as an annual summer forage to supplement pasture production for sheep, beef and dairy cattle. It is used as grazing, as silage or green chop, or as hay (3). Grain sorghum and maize also have the potential to be used as silage in Australia (4,9). As forage, sorghum may be cut only once (single cut) or several times (multicut) because of its regrowth habit, whereas maize can be cut only once. Havilah and Kaiser (1992) also grouped sorghum as single cut (sweet sorghum and grain sorghum) and multicut (hybrid forage sorghum and Sudan grass) for silage making. One of the major production constraints of these forage crops is low soil N availability. In most areas of southeast Queensland, soil N has been exhausted due to exploitative crop production. Moreover, the N requirement of the crop may differ depending on cutting management. Response to N by grain sorghum, maize and the regrowth of forage sorghum has previously been studied (1,5,8). However, little work has been done on the comparative productivity of single cut and multicut forage and grain sorghum, and maize under different N fertiliser levels. This study aims to examine the effect of N on biomass yield and N content of single cut and multicut forage sorghum, grain sorghum and maize.

## MATERIALS AND METHODS

A field experiment was conducted at The University of Queensland Research Farm, Redland Bay, latitude 27$^0$37'S longitude 153$^0$19'E, in the coastal region of south-east Queensland during 1998/99-summer season. The trial was arranged in a split plot design with three replications. The main plot treatment was four plant types [grain sorghum cv. MR Buster, single cut forage sorghum cv. Agfeed, multicut forage sorghum cv. Agfeed and maize cv. 31 MIO]. The subplot treatment was six levels of N. Four N treatments were common to all crops: 0, 60, 120, 240 kg N ha $^{-1}$ at sowing. The other two N treatments were applied to forage sorghum and maize: split application of 60+60 and 120+60+60 kg N ha $^{-1}$, with the initial application at sowing. The split N was applied at 51 days after sowing (DAS) and 92 DAS. For grain sorghum, the two N treatments were 60 and 120 kg N ha $^{-1}$ applied at sowing to allow a multicut harvest. In multicut forage sorghum, the additional N was applied after cutting. The seeds were sown on 14 December 1998 in 50-cm rows and 2 weeks after sowing seedlings were thinned to16 sorghum and 8 maize plants m$^{-2}$. The crop was irrigated twice a week during crop establishment and once a week thereafter. Multicut forage sorghum was cut at 51, 92 and 155 DAS. Maize was cut for silage when the

milk line was half way down the grain (98 DAS). Single cut sorghum was cut for silage at milky dough stage (81 and 102 DAS for grain sorghum and forage sorghum, respectively). In the latter two N treatments, grain sorghum was cut at 51 DAS and then allowed to regrow until maturity (155 DAS). In all multicut treatments, the crop was cut 10-15 cm above the ground and all material was removed from the field. Tissue analysis was done for N at each harvest with selective N treatments only.

## RESULTS

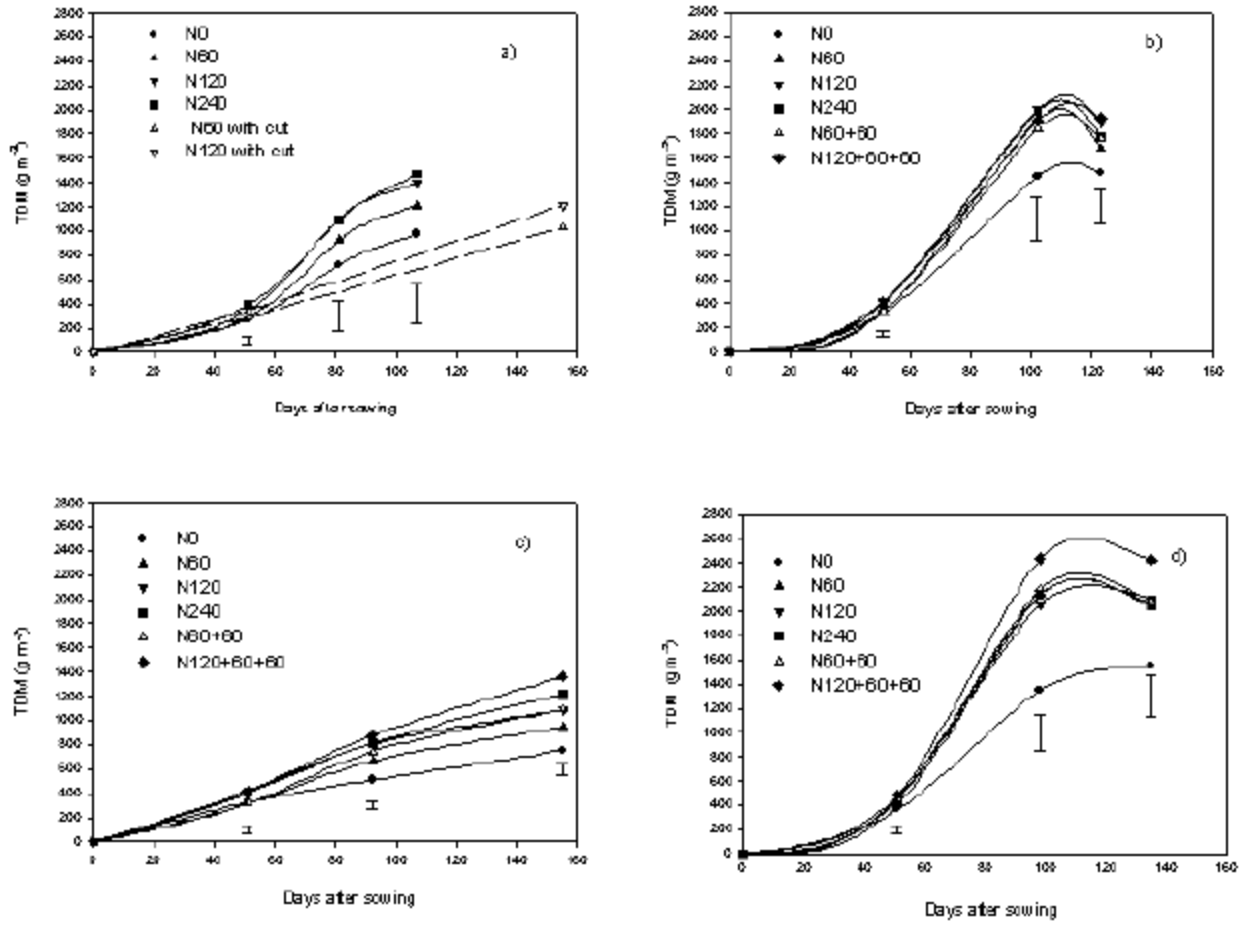
### Grain sorghum

Biomass yield increased as N levels increased to 120 kg N ha $^{-1}$ at 51 DAS. But at silage stage harvest, there was no significant increase in biomass yield at above 60 kg N ha $^{-1}$(Fig.1a). At silage stage the highest biomass yield (1105 g m$^{-2}$) was obtained with the application of 120 kg N ha $^{-1}$ and was 53% higher than the control (723 g m$^{-2}$). A similar trend was observed at maturity. In multicut treatments, the cumulative biomass yield was not significantly affected due to cutting 51 DAS. The effect of N on total N content was more pronounced than that of biomass yield. Total N content increased progressively with each increase in N level and multicut treatments gave higher total N content than the corresponding single cut N levels (Table 1).

### Forage sorghum (single cut)

At 51 DAS, the highest biomass yield was obtained with 120 kg N ha $^{-1}$, which was significantly higher than at all other N levels except 240 kg N ha $^{-1}$ (Fig.1b). At silage stage (102 DAS), there was no significant response to >60 kg N ha $^{-1}$. A similar trend was observed at maturity. At silage stage, the highest biomass yield (2000 g m$^{-2}$) was obtained with 120 kg N ha $^{-1}$, which was 38% higher than the control. However, there was no advantage of split N application. The crop was lodged at silage stage in all N treatments and there was no increase in biomass yield from silage stage to maturity. In contrast with biomass yield, the highest total N content was obtained by applying N at 120+60+60 kg ha $^{-1}$, which was significantly higher than all other N treatments (Table 1).

**Fig. 1. Changes in total biomass yield (TDM) with time in a) grain sorghum, b) single cut forage sorghum, c) multicut forage sorghum and d) maize fertilised with 6 rates of N. In (a) & (c) TDM is expressed as cumulative biomass production in multicut treatments.**




**Forage sorghum (multicut)**

At 51 DAS, the biomass yield was the same as single cut forage sorghum. At 92 DAS, the highest biomass was obtained with 120+60+60 kg N ha $^{-1}$. This was not different from the yield with 240 and 60+60 kg N ha $^{-1}$, but differed significantly from all other N levels (Fig.1c). The second application of N had a significant beneficial effect on biomass production; both 60+60 and 120+60+60 kg N ha $^{-1}$ producing significantly higher yields compared with 60 and 120 kg N ha $^{-1}$ treatments, respectively. In the last cut, 120+60+60 kg N ha $^{-1}$ (which had additional N after the second cut) gave the highest yield (468 g m$^{-2}$), which was similar to the yield attained with 240 kg N ha $^{-1}$, but differed significantly from all other N treatments. This indicated that there was no residual effect of N after the second cut with the lower N levels. Only 240 kg N ha $^{-1}$ treatment had a residual effect after the second cut. The cumulative biomass yield was also highest with 120+60+60 kg N ha $^{-1}$, which was similar to the yield attained with 240 kg N ha $^{-1}$, but significantly higher from all other N levels. A similar trend was observed for total N content (Table 1).

**Maize:** Crop responsiveness to N was significant for all harvests. At silage stage, the highest biomass yield (2435 g m$^{-2}$) was obtained with the application of N at 120+60+60 kg ha $^{-1}$ and the lowest (1348 g m$^{-2}$) with no N applied (Fig.1d). However, the rate of increase was higher with the initial increment of N application (60 kg ha $^{-1}$) and the response was less after that level. There was no green leaf at maturity stage due to wind damage and biomass yield did not increase after silage stage. The effect of N on total N content was also significant at each harvest, although there was no increase in total N content from silage stage to maturity. At maturity, the highest total N content was obtained with 120+60+60 kg N ha $^{-1}$, which was significantly higher than all other N treatments (Table 1).

Table 1. Total N content and leaf to stem ratio of single cut and multicut forage sorghum and, total N content of grain sorghum and maize.

| N levels (kg $ha^{-1}$) | Grain sorghum N content (g $m^{-2}$) | | Single cut forage sorghum | | *Multicut forage sorghum | | Maize N content (g $m^{-2}$) |
|---|---|---|---|---|---|---|---|
| | Single cut | Multicut* | N content (g $m^{-2}$) | Leaf to stem ratio | N content (g $m^{-2}$) | Leaf to stem ratio | |
| 0 | 8.08 c** | - | 9.67 c | 0.19 | 11.62 d | 0.65 | 8.23 c |
| 60 | 11.08 bc | 15.40 ab | 13.29 bc | 0.19 | 17.26 c | 0.61 | 17.25 b |
| 120 | 16.14 ab | 18.77 a | 14.68 ab | 0.18 | 20.36 b | 0.63 | 21.08 b |
| 240 | - | - | - | 0.18 | 24.57 a | 0.57 | - |
| 60+60 | - | - | 14.53 ab | 0.20 | 19.76 b | 0.59 | - |
| 120+60+60 | - | - | 17.70 a | 0.21 | 25.36 a | 0.56 | 26.40 a |

*With multicut treatment, N content was the cumulative of all cuts.

** Means with the same letter are not significantly different within each of four crops

Comparison between crops: Under single cut conditions, forage sorghum and maize were more productive than grain sorghum irrespective of N levels. At silage stage, the highest biomass yield was 2435, 2000 and 1105 g $m^{-2}$ for maize, forage sorghum and grain sorghum, respectively (Fig.1). The effect of N on total biomass yield was significant at each harvest in all crops, but the response curves differed. Although the response to N was different between crops, there was no significant interaction between crop and N on total biomass yield. Under single cut conditions, the response was higher with 60 kg N $ha^{-1}$, and the response was less after that level in all crops. The response to application of > 120 kg N $ha^{-1}$ was not significant and there was no benefit of an additional N application. At silage stage, the highest biomass yield increase over the 0N treatment was 81, 53 and 38% in maize, grain sorghum and forage sorghum, respectively. In contrast with biomass yield, total N content increased significantly with the increase in N application up to the highest rate in all crops. Maize gave the highest total N content of ** kg N $ha^{-1}$. The biomass yield of forage sorghum was significantly decreased under the multicut regime compared to single cut (** vs ** kg N $ha^{-1}$), but this affect was not as marked with 240 kg N $ha^{-1}$ or a split application of 120+60+60 kg N $ha^{-1}$. Although the total biomass yield was reduced in multicut forage sorghum, the total N content was much higher in multicut due to a higher proportion of the biomass being leaf compared to single cut (36% vs.12%). The responsiveness of biomass to N was also higher with multicut forage sorghum than single cut forage sorghum. With multicut forage sorghum, the highest biomass increase was 80% at 120+60+60 kg N $ha^{-1}$, whereas in single cut the biomass increase was only 31% with the same N level.

**DISCUSSION**

Under single cut conditions, forage sorghum and maize showed higher productivity than grain sorghum. Muchow (1989) also reported higher productivity of maize over grain sorghum and pearl millet. At silage stage, the highest biomass yield was 2435 and 2000 g $m^{-2}$ for maize and forage sorghum, respectively. This is comparable with maximum yields of 2100-2300 g $m^{-2}$ previously recorded for sorghum x Sudan grass hybrids and maize in a single cut under irrigated condition (7). The response to N was highest in maize and lowest in forage sorghum under single cut conditions. Muchow and Davis (1988) also observed a higher N response in maize compared with grain sorghum. The lower responsiveness of forage sorghum is probably due to higher proportion of stem in total biomass. Due to higher stem proportion, the requirement of N was less and as a consequence the response to N was also less. Total

N content was increased significantly with the application of N up to the highest level in all crops and the highest amount was obtained in maize with the highest N level (Table 1). This result differs from the findings of Muchow and Davis (1988) who observed a similar N uptake in maize and grain sorghum at a given rate of applied N. However, in the present trial, total N content was similar in grain sorghum and forage sorghum, although total biomass was higher in forage sorghum. As a consequence N use efficiency was higher in forage sorghum compared with grain sorghum. Higher N use efficiency in forage sorghum was due to higher stem proportion as N concentration was lower in stem than in leaves.

Under multicut conditions, the cumulative biomass yield was significantly reduced compared with single cut irrespective of N levels, but the reduction was less with high initial N rate or split application of N. The highest cumulative regrowth biomass for forage sorghum was 71% of single cut biomass with the application of 120+60+60 kg N $ha^{-1}$. However, total N content was much higher in multicut than single cut. Muldoon (1985a) also reported lower biomass yield of sorghum x Sudan grass hybrids in multicut than single cut under well irrigated and fertilised conditions and the regrowth was 73% of single cut biomass. Although biomass yield was lower under multicut, the response to N was higher in multicut than single cut. Birch and Stewart (1989) also observed a large response of multicut forage sorghum to N fertiliser. But, in their trial, there was only a limited residual effect of N on the subsequent regrowth even with the application of 340 kg N $ha^{-1}$ at planting. The contrast between the data from the present trial and results of Birch and Stewart (1989) was probably due to lower biomass yield at the first cut and shorter cutting cycles in the present experiment

## CONCLUSIONS

Under single cut conditions, a higher biomass yield of grain sorghum, forage sorghum and maize can be obtained with a moderate N rates, although total N content increases with higher N rates. However, for multicut forage sorghum, higher N application is essential to increase both the biomass yield and total N content.

## ACKNOWLEDGEMENTS

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