A STUDY OF OXALATE CONCENTRATION IN FIVE GRASSES IN THE WET TROPICS OF QUEENSLAND

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ABSTRACT

Total oxalate concentration was examined in five tropical grasses in a wet tropical environment of north-eastern Queensland. One grass, Setaria splendida *CPI 15899, contained maximum levels in excess of 5.0 per cent. Common guinea grass* (Panicum maximum) *contained more oxalate than did* P. maximum *cv. Makueni. Signal grass* (Brachiaria decumbens) *contained negligible quantities of oxalate.*

In S. splendida *the oxalate concentration of leaf blades was much higher than in stems and declined rapidly in both parts with increasing age. The oxalate concentration in leaf plus stem was significantly correlated with sward growth rate (negative); percentage leaf (positive); and nitrogen concentration (positive, spring/summer only). Oxalate concentrations were highest in autumn and winter when sward growth rates were lower.*

INTRODUCTION

Since the recorded death from oxalate poisoning of cattle grazing *Setaria anceps* (*S. sphacelata*) cv. Kazungula (Jones *et al.* 1970, Seawright *et al.* 1970) it has been confirmed that several *Setaria* species and cultivars contain high oxalate levels (Jones *et al.* 1970, Jones and Ford 1972a, Smith 1972, Hacker 1974, Ndyanabo 1974, Roughan and Warrington 1976). While *Setaria* spp. have been shown to contain higher oxalate levels than other grasses, the results of Mathams and Sutherland (1952), Garcia-Rivera and Morris (1955) and Jones and Ford (1972a) prompted the last authors to suggest that some of the larger leaved forms of *Panicum maximum* may also be high in oxalate.

The investigation reported here examined the oxalate concentrations of the main commercially used grasses grown in a high fertility and high rainfall situation in the wet tropics of north-eastern Queensland. We studied pangola grass (*Digitaria decumbens*), signal grass (*Brachiaria decumbens*), and two guinea grasses (*Panicum maximum*), one of which (cv. Makueni) is relatively larger leaved and more robust than the common guinea grass used in north Queensland (Middleton and McCosker 1975). *Setaria splendida* CPI 15899, with a high yield potential in the wet tropics (Harding 1972, Middleton and McCosker 1975) and with a known high oxalate concentration (Jones *et al.* 1970, Jones and Ford 1972a, Hacker 1974) was also included in the study.

MATERIALS AND METHODS

The experiment was located at South Johnstone Research Station, Lat. 17°35'S, Long. 146°00'E and A.A.R. 3 217 mm, in the tropical lowlands of coastal north-eastern Queensland.

Climate of the region is detailed in a report by the Commonwealth Bureau of Meteorology (Anon. 1971). The fertility of the soil, derived from alluvium, (Um 6.34, Northcote 1971) has been detailed by Teitzel and Bruce (1971, 1973).

The factorial experiment with two blocks incorporated three cutting frequencies (3, 6 and 12 weeks) and five grasses. The grasses included three erect, tufted types, *Panicum maximum* (guinea grass), cv. Makueni, common guinea and *Setaria splendida* CPI 15899, and two stoloniferous grasses, *Digitaria decumbens* (pangola

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grass) and *Brachiaria decumbens* (signal grass) cv. Basilisk. Plot size was 3.1 m × 1.25 m. Grasses were planted in a prepared seedbed on December 8, 1972 with a basal fertilizer application of 500 kg ha^{-1} superphosphate and 125 kg ha^{-1} potassium chloride. A further application of superphosphate (250 kg ha^{-1}) and potassium chloride (125 kg ha^{-1}) was applied on September 13, 1973, 24 weeks after sampling commenced. Nitrogen in the form of ammonium nitrate was applied at 75 kg N ha^{-1} on March 29, 1973 and thereafter at 12-week intervals.

On March 29, 1973 the grasses were cut back to sampling height (10 cm for signal and pangola and 20 cm for the three tufted grasses). Plots were cut (between 8 a.m. and 3 p.m.) with dagging shears at 3, 6 and 12 week intervals according to treatment over the following 48 weeks. The whole plot, excluding a 15 cm border, was sampled. An accurate cutting height was achieved by use of an adjustable height sampling quadrat. One sub-sample was dried and analyzed for total nitrogen while a second sub-sample was separated into leaf lamina and stem (including leaf sheath) and dried for oxalate analysis. Oxalate concentration for leaf + stem was calculated from the dry weight and % oxalate for each plant component.

Total oxalate was determined by the titrimetric method of Moir (1953). The oxalate was expressed as per cent anhydrous oxalic acid in the dry material.

Analysis of variance was carried out to determine the effect of treatments on oxalate concentrations. In addition linear regressions were fitted to the data to determine the extent to which variation in plant oxalate concentration could be accounted for by sward growth rate (i.e. average daily yield increment), percentage leaf and plant nitrogen (leaf + stem) concentration. These regressions were done on the consecutive 3-weekly samplings as we considered the shorter sample intervals would reflect response to the environment more closely than 6 or 12 week intervals.

TABLE 1

Rainfall and temperature registrations at South Johnstone March 1973 to February 1974

Month	Rainfall mm		Temperature °C Maximum		Temperature °C Minimum	
	Recorded	Mean*	Recorded	Mean*	Recorded	Mean*
March	1019	641	30·5	29·1	21·9	20·8
April	575	396	28·5	27·5	21·1	19·4
May	389	244	27·1	25·9	19·3	17·9
June	228	170	25·9	24·0	18·9	15·5
July	117	91	25·3	23·5	15·5	13·9
August	24	83	26·3	24·8	17·3	14·4
September	145	83	27·2	26·6	18·1	15·8
October	90	80	28·9	28·4	18·8	18·1
November	284	117	29·9	30·1	21·7	19·1
December	1049	195	29·7	31·0	22·6	20·9
January	542	525	30·4	30·5	22·8	21·5
February	765	592	29·3	30·6	23·2	21·7
TOTAL	5227	3217				

* Long term January-December mean.

RESULTS

Climate

Growing conditions were generally favourable throughout the 48-week period. Rainfall was about 60 per cent above normal and winter (May-September) minimum temperatures were 2 to 3° above normal (Table 1).

Cultivars

The oxalate concentrations of the grasses are shown in Tables 2 and 3. *S. splendida* was the only grass with high oxalate levels, the levels in leaf, stem and whole plant being significantly higher than those of other grasses, at all regrowth ages and harvest periods. The only exception was in 12-week material on December 4 and February 26, when the levels were similar to those in common guinea. Signal grass contained very low oxalate concentrations. Common guinea was consistently higher in leaf and stem oxalate than Makueni, although the differences were not always significant.

TABLE 2

Whole plant oxalate concentration of 3, 6 and 12 week regrowth of five grasses at 4 periods of the year

Harvest date*	Regrowth age (weeks)	Oxalate (% o.d.m.)					L.S.D. 5%
		Spl.	Com.	Mak.	Pan.	Sig.	
June 19	3	5·83	1·77	1·30	1·34	0·41	
	6	4·62	1·63	1·20	0·94	0·57	0·38
	12	1·88	1·12	0·67	0·44	0·37	
Sept. 12	3	5·27	1·87	1·28	1·01	0·25	
	6	4·47	1·73	1·11	0·82	0·23	0·30
	12	3·11	1·63	1·06	0·62	0·29	
Dec. 4	3	4·12	1·11	0·38	1·10	0·29	
	6	3·18	0·98	0·45	0·51	0·20	0·61
	12	1·11	0·91	0·39	0·57	0·14	
Feb. 26	3	3·82	1·29	0·83	1·13	0·26	
	6	2·92	1·05	0·77	0·68	0·16	0·58
	12	0·73	0·71	0·35	0·28	0·29	
Mean	3	4·76	1·51	0·95	1·15	0·30	
	6	3·80	1·35	0·88	0·74	0·29	0·37
	12	1·71	1·09	0·62	0·48	0·27	

* 75 kg N ha^{-1} was applied 12 weeks prior to each harvest date.
Spl. (*S. splendida*), Com. (common guinea), Mak. (Makueni guinea), Pan. (Pangola), and Sig. (signal).

TABLE 3

Leaf and stem oxalate concentration of 3, 6 and 12 week regrowth of five grasses (mean of harvests on June 19, Sept. 12, Dec. 4 and Feb. 26)

Plant part	Regrowth age (weeks)	Oxalate (% o.d.m.)					L.S.D. 5%
		Spl.	Com.	Mak.	Pan.	Sig.	
Leaf	3	5·46	1·53	1·07	1·80	0·46	
	6	4·84	1·38	1·03	1·41	0·49	0·43
	12	3·15	1·59	1·07	1·22	0·58	
Stem	3	3·39	1·18	0·40	0·45	0·07	
	6	2·57	1·11	0·37	0·38	0·10	0·33
	12	1·02	0·57	0·16	0·15	0·10	
Mean	Leaf	4·85	1·50	1·06	1·48	0·51	0·19
	Stem	2·33	0·95	0·31	0·33	0·09	0·19

Plant parts

In all grasses the oxalate concentration in the leaf was always higher than in the stem (Table 3).

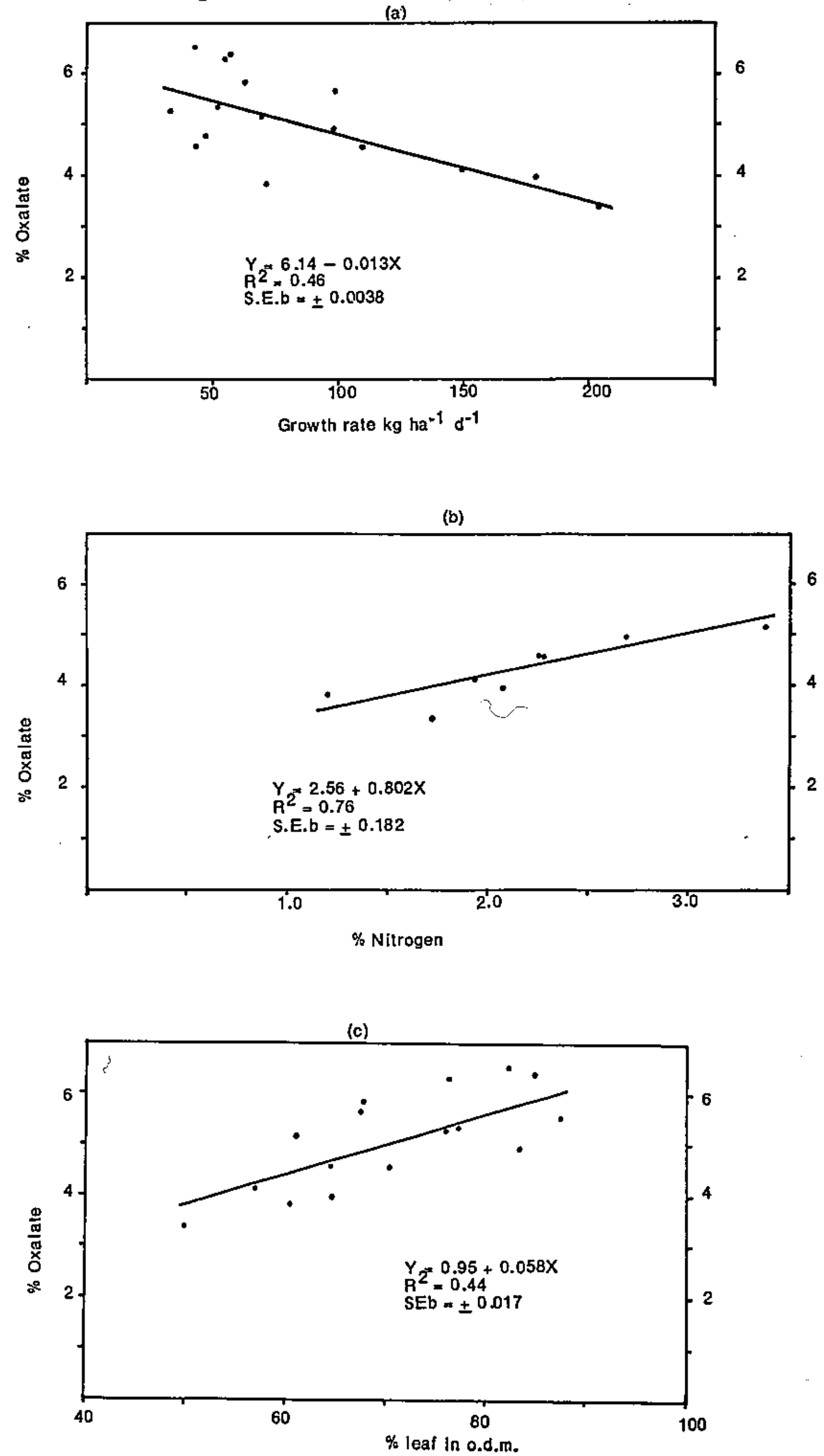

FIGURE 1

Linear regressions of total oxalate in leaf plus stem at 3-weekly cuts of *S. splendida* on (a) sward growth rate, (b) nitrogen concentration (spring/summer only) and (c) % leaf (o.d.m.).

Regrowth age

The oxalate concentration of leaf, stem (Table 3) and whole plant (Table 2) of *S. splendida* declined significantly with increasing age. A similar trend was apparent in pangola grass while in both guinea grasses and signal grass the decline in oxalate with age was small and inconsistent.

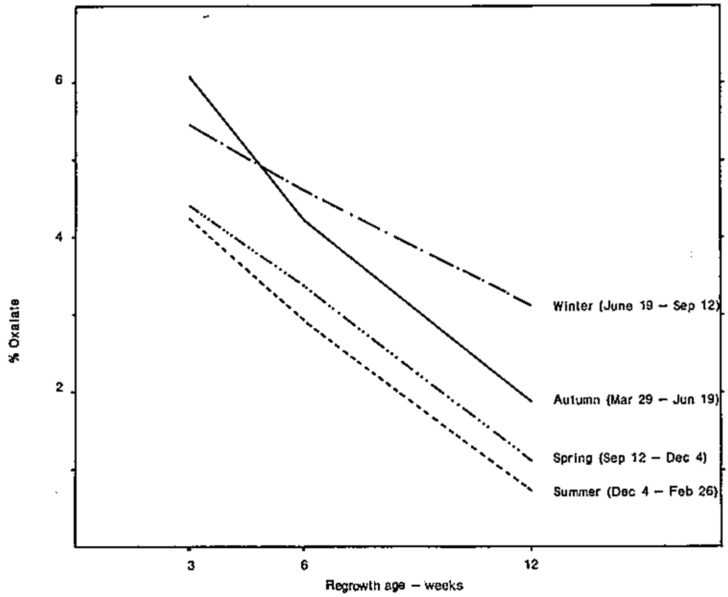

FIGURE 2

Season and regrowth age effects on the total oxalate concentrations in leaf plus stem of *S. splendida.*

Association between oxalate and other variables

Linear regressions of oxalate concentration on growth rate, percentage leaf (o.d.m.) and nitrogen concentration of *S. splendida* (spring/summer only) were significant (Figure 1).

DISCUSSION

The oxalate levels of the grasses we examined in a wet tropical environment are generally comparable to those recorded for the same species elsewhere. Only young leaf material of *S. splendida* was high in oxalate, ranging from 4.5 per cent (Feb. 26) to 6.7 per cent (June 19) for 3-week regrowth. These values fall within the range of those recorded on the same accession of *S. splendida* grown in the south-eastern Queensland sub-tropics (Jones *et al.* 1970, Hacker 1974).

Our results with *S. splendida* show that leaf blades contain at least 50 per cent more oxalate than does the stem plus leaf sheath. Jones and Ford (1972b) demonstrated large differences in oxalate between plant parts with *S. anceps* (cv. Nandi and Kazungula). However, comparison with their results is difficult since they used a range of nitrogen fertilizer levels which affected the ratio of leaf to stem oxalate. Also, their results are expressed in soluble oxalate which accounts for about 90 per cent of total oxalate in *Setaria anceps* (Jones *et al.* 1970). At approximately similar nitrogen fertilizer levels our results appear comparable to those of Jones and Ford (1972b).

The data we have presented show a rapid decline in oxalate concentration with plant age. This is shown clearly in *S. splendida* where the decline occurred at all periods of the year (Table 2) and in both leaf and stem (Table 3). Much of this decline could be due to a dilution effect caused by higher growth rate and yield as the defoliation interval was lengthened. However, the decline of whole plant oxalate (leaf and stem) with age, would also be enhanced by an increasing proportion of stem (Jones and Ford 1972b) as the proportion of leaf (mean of all harvests) we measured for 3-, 6- and 12-week regrowth was 56 per cent, 44 per cent and 21 per cent ($P_{0.01}$ = 6.8 per cent) respectively.

Regression analysis demonstrated that sward growth rate is negatively correlated and percentage leaf is positively correlated with oxalate concentration. It is probable that the reduction of oxalate levels in the whole plant with increasing growth rate was largely due to the corresponding reduction in the percentage leaf.

It is of interest to note that spring and summer oxalate levels in *S. splendida* (Figure 2) were substantially lower than those recorded in autumn and winter. In the other four grasses with relatively low absolute oxalate levels this seasonal trend was less apparent. For example, while Makueni and common guinea appeared to follow a similar pattern to that of *S. splendida*, pangola and signal grass exhibited no clear seasonal trend. The marked seasonal effect shown in *S. splendida* is consistent with seasonal differences in growth rate (Jones and Ford 1972b) and its effect on percentage leaf. The autumn/winter growth rates we recorded were approximately one half those of the spring/summer period while mean percentage leaf figures (3-week regrowth) were 77 per cent and 64 per cent respectively for autumn/winter and spring/summer.

We found a positive correlation between oxalate concentration and nitrogen concentration in *S. splendida*, but in the spring and summer period only. Jones and Ford (1972b) found a similar correlation in *S. anceps*. The poor relationship between oxalate and nitrogen in autumn and winter may have been attributable to the narrow range in values of both oxalate and nitrogen as a direct consequence of less variable growth rate changes in autumn/winter than in spring/summer.

The oxalate levels we recorded in common guinea were similar to those recorded by Mathams and Sutherland (1952) and Garcia-Rivera and Morris (1955) and Ndyanabo (1974) but lower than those recorded for a broadleaf guinea grass by Garcia-Rivera and Morris (1955). The levels of oxalate in common and Makueni were both substantially higher than those recorded for fine-leaf types of *P. maximum* (cvv. Gatton, Petrie and Sabi) by Jones and Ford (1972a). However, of the two guinea grasses we examined, common guinea contained more oxalate than did the broader-leaved, more robust Makueni.

The leaf plus stem oxalate levels we recorded for pangola grass at 6 and 12 weeks of age are consistent with levels recorded by Garcia-Rivera and Morris (1955) and Jones and Ford (1972a). However young (3-week regrowth) leaf material exceeded 2.0 per cent oxalate in 8 of the 16 samplings, reaching 2.7 per cent on two occasions in the first sampling after nitrogen fertilizer was applied.

The very low levels of oxalate we recorded in signal grass agree with the findings of Jones and Ford (1972a). However, higher levels (1.1 per cent total oxalate in leaf) have been recorded in Uganda (Ndyanabo 1974).

From a practical view point we conclude that of the grasses we examined in a high rainfall tropical situation only *S. splendida* accumulated high oxalate levels. High oxalate levels ($>$ 5.0 per cent) were restricted to young, leafy regrowth. Slower grass growth in autumn/winter resulted in a higher percentage of leaf and hence higher oxalate concentrations than in spring and summer. Since oxalate is rapidly detoxified in the rumen (Morris and Garcia-Rivera 1955, Watts 1957, Dodson 1959) the chance of harmful effects on beef cattle being caused by *S. splendida* does not appear high. In any case, the level of oxalate and its intake can be restricted by adoption of the management precautions outlined by Jones *et al.* (1970), Seawright *et al.* (1970), Jones and Ford (1972b) and Anon (1972). We have not observed any problems with beef cattle grazing *S. splendida* in association with legumes at South Johnstone Research Station nor are we aware of any problems elsewhere.

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ATRAZINE TOLERANCE IN FIVE TROPICAL PASTURE GRASSES

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ABSTRACT

Five glasshouse experiments were carried out to investigate the effect of different rates of atrazine on plants at four stages of development. Two were pre-emergence treatments and three were designed to study the effect of applying atrazine at 3, 5 *and* 9 *weeks after sowing.*

Pre-emergence application of atrazine at 1 *and* 4 *kg* ha^{-1} *caused mean reduction in seedling emergence of grasses grown in one of two clay soils. However the effect on individual grasses was not significant.*

Mortality of emerged Panicum coloratum, Chloris gayana *and* Cenchrus ciliaris *on both soils was increased by atrazine at* 4 *kg* ha^{-1}.

Root and shoot yields $plant^{-1}$ *of* C. gayana *only were significantly reduced by pre-emergence atrazine application. Root/shoot ratios were not significantly affected.*

Root and shoot yields pot^{-1} *of* C. gayana *and* C. ciliaris *were significantly reduced by pre-emergence atrazine. On one soil atrazine at* 4 *kg* ha^{-1} *significantly reduced shoot yields* pot^{-1} *of* P. maximum *and* P. coloratum.

Post-emergence application of atrazine at 1 *and* 4 *kg* ha^{-1} *at the* 2- *to* 4-*leaf stage* (3 *weeks after sowing) and beyond had no significant effect on plant survival or shoot yield.*

Overall, the decreasing order of atrazine tolerances was: Bothriochloa insculpta, P. maximum, P. coloratum, C. ciliaris *and* C. gayana.

INTRODUCTION

Atrazine (2-chloro-6-ethylamino-4-isopropylamino—1,3,5—triazine) has been recommended to effectively control many annual grass and broadleaved weeds when applied pre-plant or pre- or post-emergence depending on the particular situation (Swarbrick 1976).

One of the most troublesome broadleaved weeds in spring- and summer-sown tropical grass pastures on the Darling Downs in south-eastern Queensland is *Salvia reflexa* (mintweed). Felton and Strang (1974) and Rawson *et al.* (1976) recommend low atrazine rates (0.5 to 1.0 kg ha^{-1}) for its control.

Little information is available on the susceptibility of the important pasture grasses to atrazine.

Brachiaria decumbens and *Panicum maximum* have a high degree of tolerance to pre-emergence application of atrazine whereas *Paspalum plicatulum* and *Setaria anceps* are susceptible to this herbicide (Hawton 1976).

Thompson (1972) showed that for weed grasses within the genera *Setaria* and *Panicum* selectivity patterns of atrazine for several species and/or varieties are related to differential rates of detoxification of the herbicide.

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