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GREEN PANIC-LUCERNE SWARD RESPONSE TO NITROGEN, PHOSPHORUS AND SULPHUR ON THE DARLING DOWNS

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SUMMARY

A rain-grown green panic (*Panicum maximum* var. *trichoglume* cv. Petrie)–lucerne (*Medicago sativa* cv. Hunter River) pasture was established in 1962 on a dark brown clay soil on the eastern Darling Downs. This received annual spring applications of nitrogen, phosphorus and sulphur from 1966 to 1970.

Sulphur increased dry matter yield of green panic and naturally occurring burr medic (*Medicago polymorpha*). Dry matter yield response of green panic to nitrogen was dependent on the presence of sulphur. Lucerne yields were little affected by fertilization.

Following five annual applications of sulphur, basal cover of the pasture was higher and that of native grasses lower compared with treatments receiving no sulphur.

The only effect of phosphorus was a minor increase in the basal cover of green panic.

I. INTRODUCTION

On the basaltic heavy clay soils of the eastern Darling Downs the productivity and density of green panic (*Panicum maximum* var. *trichoglume* cv. Petrie) pastures rapidly decline with consequent reinvasion by native species. After 3 years, the green panic is pale-coloured and unthrifty. A similar condition in a green panic pasture on a similar soil at Brian Pastures pasture research station near Gayndah had responded to a combined application of nitrogen and sulphur fertilizers (Young and Hirst 1964). Sulphur responses on the heavy clay soils of the Darling Downs had been shown in pot experiments by Andrew, Kipps and Barford (1952) and in a field experiment on lucerne (*Medicago sativa*) by Littler and Price (1967).

This paper reports the results of a field experiment laid down in a 4-year-old green panic-lucerne pasture at Nobby. Burr medic (*Medicago polymorpha*) was also present as a volunteer constituent. The aim of the experiment was to measure the response of these three pasture components to application of nitrogen, sulphur and phosphorus. The results were to serve as a guide in formulating commercial fertilizer recommendations. The phosphorus treatment was included as an insurance that this nutrient was not limiting to plant growth (Lloyd 1970).

II. MATERIALS AND METHODS

The green panic-lucerne sward was sown in February 1962 on a Purrawunda clay (Thompson and Beckmann 1959), with a history of approximately 60 years of cultivation and annual cropping. Fertilizer treatments were applied on 8 September 1966 in a 3 x 2^2 complete factorial design in three randomized blocks with plots of 4 m x 5 m. Treatments were—

1. Nitrogen (N), as ammonium nitrate, at 0, 67 and 135 kg N ha^{-1}.
2. Phosphorus (P), as monosodium-dihydrogen-phosphate, at 0 and 22 kg P ha^{-1}.
3. Sulphur (S), as flowers of sulphur, at 0 and 34 kg S ha^{-1}.

Fertilizer treatments were applied each spring up to and including 1970. However, commencing with the 1968 application, the rates of P and S were reduced to 11 and 22 kg ha^{-1} of element respectively.

For pasture yield sampling, three 1·00 m x 0·40 m randomly selected quadrats per plot were cut to approximately 2 cm above ground level. The harvested material was dried for 16 hours at 80°C to provide estimates of dry matter yields of pasture components. Sub-samples of dried forage, bulked by treatments, were taken for Kjeldahl nitrogen determination. Following sampling, plots were mown to a 2 cm stubble height and the cut material was removed from the experimental area.

On 29 August 1971, 300 points per plot were recorded using a 10 point frame with points 55 mm apart, to determine percentage basal cover of green panic, native grasses, burr medic seedlings and toal basal cover of pasture.

Monthly and annual rainfall from October 1967 to Sepember 1968 inclusive, together with average monthly and annual rainfall for Nobby (27° 52′ S, 151° 54′ E), are shown in Table 1.

TABLE 1

MONTHLY AND TOTAL RAINFALL (mm) FROM OCTOBER 1967 TO SEPTEMBER 1968, AND THE 30-YEAR (1940–1969) AVERAGE FOR NOBBY

—	Oct 1967	Nov	Dec	Jan 1968	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1967–68	75	111	16	120	36	68	42	41	10	82	80	21	700
30-year average	73	66	99	102	93	79	38	38	48	38	33	33	739

III. RESULTS

Data for pasture yields and nitrogen content are presented from harvests made on 18 January, 4 June and 10 October 1968. Values obtained from subsequent samplings showed similar trends in treatment effects.

Yields and nitrogen concentrations of individual pasture components at each sampling date are shown in tables 2, 3 and 4.

Dry matter yields of green panic on 18 January reveal a significant interaction between nitrogen and sulphur (table 2). Sulphur significantly increased dry matter yields at each of the three levels of nitrogen, but nitrogen alone did not improve dry matter yields. Dry matter yields tended to increase with increasing rates of nitrogen in the presence of sulphur. This interaction, however, was significant at the first harvest only.

Nitrogen level in green panic dry matter tended to increase with increased rates of nitrogen fertilizer in the absence of sulphur (table 2). Plant nitrogen and dry matter yield tended to be inversely related.

Fertilizer treatments had little effect on lucerne yield (table 3). However, at the June 1968 sampling, a small but significant reduction in yield occurred at 67 kg N ha^{-1} compared with the nil nitrogen rate.

Burr medic was present as a volunteer winter-spring annual component. Sulphur application significantly increased dry matter yield of burr medic at the sampling on 8 October (table 4). Nitrogen concentration increased where sulphur was applied, particularly at the nil and 67 kg ha^{-1} rates of nitrogen addition.

Yield of pasture at each sampling date is shown in table 5.

The combined yields of green panic and lucerne on 18 January reflect the interaction of nitrogen and sulphur seen earlier for green panic in table 2. Nitrogen alone did not improve dry matter yield but in the presence of sulphur significantly increased it. Application of sulphur at each of the three levels of nitrogen produced significantly greater pasture yield (table 5).

Pasture yield on 4 June revealed a significant positive interaction between nitrogen and phosphorus, resulting from a decrease in yield due to phosphorus in the absence of nitrogen and an increase in yield where phosphorus was applied in conjunction with 67 kg ha^{-1} of nitrogen. The main effect of sulphur in improving pasture yield was again evident (table 5).

Increased burr medic growth due to sulphur fertilization (table 4) is reflected in pasture yield on 8 October (table 5).

Mean yields of individual components and total pasture for all three samplings are shown in table 6.

The pasture as a whole responded to the application of 34 kg S ha^{-1}, and to nitrogen in the presence of sulphur. There was no yield response to nitrogen fertilizer applied alone.

Basal cover estimates made in 1971 are shown in table 7.

Phosphorus and sulphur application resulted in a significant increase in basal cover of green panic while nitrogen had no effect. Native grasses (predominantly *Dichanthium* spp.) had significantly less basal area where sulphur was applied. Burr medic seedling basal cover showed a significant increase due to application of sulphur fertilizer. Basal cover of lucerne was negligible and the data are not presented.

TABLE 2

MEAN DRY MATTER YIELDS (kg ha^{-1}) OF GREEN PANIC ON 18 JANUARY AND 4 JUNE 1968, FOR THREE NITROGEN LEVELS AND TWO LEVELS EACH OF PHOSPHORUS AND SULPHUR, WITH PLANT NITROGEN CONCENTRATION EXPRESSED AS PERCENTAGE OF OVEN DRY MATERIAL SHOWN IN PARENTHESIS

Nitrogen (N) (kg ha^{-1})		0				67				135			
Phosphorus (P) (kg ha^{-1})		0		22		0		22		0		22	
Sulphur (S) (kg ha^{-1})		0	34	0	34	0	34	0	34	0	34	0	34
Sampling Date	Factor												
18 Jan 68	NPS	514 (1·65)	1 028 (1·80)	551 (1·80)	1 100 (2·00)	723 (2·60)	1 933 (1·85)	514 (2·40)	1 576 (1·85)	489 (2·95)	2 779 (2·45)	236 (3·00)	2 581 (2·15)
	NP	770		826		1 328		1 045		1 634		1 408	
	NS	532	1 063			618	1 754			361	2 680*		
	N	798c†				1 186b				1 521a			
	PS	574	1 912	434	1 753								
	P	1 243a		1 093a									
	S									503b	1 832a		
4 Jun 68	NPS	650 (1·35)	860 (1·75)	616 (1·30)	690 (1·45)	654 (1·75)	687 (1·50)	842 (1·75)	805 (1·30)	636 (1·80)	827 (1·55)	694 (1·95)	850 (1·60)
	NP	756		652		670		823		732		773	
	NS	633	775			749	746			666	836		
	N	704a				747a				752a			
	PS	648	791	717	781								
	P	720a		750a									
	S									683b	786a		

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.

TABLE 3

MEAN DRY MATTER YIELDS (ka ha^{-1}) OF LUCERNE ON 18 JAN 68, 4 JUN 68 AND 8 OCT 68 FOR THREE NITROGEN LEVELS AND TWO LEVELS EACH OF PHOSPHORUS AND SULPHUR, AND PLANT NITROGEN CONCENTRATION, EXPRESSED AS PERCENTAGE OF OVEN DRY MATERIAL, SHOWN IN PARENTHESIS

Nitrogen (N) (kg ha^{-1})		0				67				135			
Phosphorus (P) (kg ha^{-1})		0		22		0		22		0		22	
Sulphur (S) (kg ha^{-1})		0	34	0	34	0	34	0	34	0	34	0	34
Sampling Date	Factor												
18 Jan 68	NPS	336 (2·10)	560 (2·30)	384 (2·00)	396 (2·65)	431 (2·00)	673 (1·95)	664 (2·15)	536 (2·20)	320 (2·70)	540 (2·15)	358 (2·90)	440 (1·95)
	NP	449		390		550		600		431		400	
	NS			360	479			548	606			340	490
	N	420a†				577a				414a			
	PS									363	592	479	457
	P									477a		463a	
	S											416a	525a
4 Jun 68	NPS	96 (4·50)	129 (4·20)	57 (4·15)	76 (4·35)	58 (4·75)	50 (4·55)	36 (4·95)	60 (4·65)	52 (5·36)	70 (4·35)	85 (5·70)	60 (4·30)
	NP	110		65		55		48		61		71	
	NS			76	101			47	54			69	66
	N	90a				51b				66ab			
	PS									69	84	69	66
	P									76a		61a	
	S											64a	75a
8 Oct 68	NPS	546 (3·35)	700 (3·35)	801 (3·40)	423 (3·50)	504 (3·30)	507 (3·30)	658 (3·25)	778 (3·50)	696 (3·55)	631 (3·40)	487 (3·75)	321 (3·50)
	NP	624		614		506		718		662		404	
	NS			674	562			580	642			591	477
	N	616a				611a				535a			
	PS									581	612	659	507
	P									597a		579a	
	S											615a	560a

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.

TABLE 4

MEAN DRY MATTER YIELD (kg ha^{-1}) OF BURR MEDIC ON 8 OCT 68 FOR THREE NITROGEN LEVELS AND TWO LEVELS EACH OF PHOSPHORUS AND SULPHUR, AND PLANT NITROGEN CONCENTRATION, EXPRESSED AS PERCENTAGE OF OVEN DRY MATERIAL, IS SHOWN IN PARENTHESIS

Nitrogen (N) (kg ha^{-1})		0				67				135			
Phosphorus (P) (kg ha^{-1})		0		22		0		22		0		22	
Sulphur (S) (kg ha^{-1})		0	34	0	34	0	34	0	34	0	34	0	34
Sampling Date	Factor												
8 Oct 68	NPS	313 (1·90)	1 353 (2·85)	456 (2·40)	1 586 (3·00)	489 (2·35)	1 282 (3·00)	517 (2·20)	1 227 (3·00)	488 (2·60)	1 406 (2·85)	584 (2·80)	1 642 (2·90)
	NP	833		1 021		886		872		947		1 113	
	NS	385	1 470			503	1 255			536	1 524		
	N	927a†				879a				1 030a			
	PS									430	1 347	519	1 485
	P									889a		1 002a	
	S											475b	1 416a

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.

TABLE 5

MEAN TOTAL DRY MATTER YIELD (kg ha^{-1}) OF PASTURE ON 18 JAN 68, 4 JUN 68 AND 8 OCT 68 FOR THREE NITROGEN LEVELS AND TWO LEVELS EACH OF PHOSPHORUS AND SULPHUR FERTILIZERS

Nitrogen (N) (kg ha^{-1})		0				67				135			
Phosphorus (P) (kg ha^{-1})		0		22		0		22		0		22	
Sulphur (S) (kg ha^{-1})		0	34	0	34	0	34	0	34	0	34	0	34
Sampling Date	Factor												
18 Jan 68	NPS	850	1 588	935	1 496	1 154	2 606	1 178	2 112	809	3 319	594	3 021
	NP	1 219		1 216		1 878		1 645		2 065		1 808	
	NS			892	1 542			1 166	2 360			701	3 170*
	N	1 218b†				1 763a				1 935a			
	PS									937	2 504	904	2 210
	P									1 720a		1 556a	
	S											919b	2 357a
4 Jun 68	NPS	746	989	673	766	712	737	878	865	688	897	779	910
	NP	866		717		725		871		793		844*	
	NS			709	876			796	800			735	902
	N	794a				798a				818a			
	PS									717	875	786	847
	P									796a		811a	
	S											747b	861a
8 Oct 68	NPS	859	2 053	1 257	2 009	993	1 789	1 175	2 005	1 184	2 037	1 071	1 963
	NP	1 457		1 635		1 392		1 590		1 609		1 517	
	NS			1 059	2 032			1 083	1 897			1 127	2 001
	N	1 543a				1 490a				1 565a			
	PS									1 011	1 959	1 178	1 992
	P									1 486a		1 581a	
	S											1 090b	1 976a

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.

TABLE 6

MEAN DRY MATTER YIELDS (kg ha^{-1}) OF GREEN PANIC, LUCERNE, BURR MEDIC AND TOTAL YIELD FOR PERIOD 18 OCT 67 TO 8 OCT 68 FROM THREE SAMPLING DATES (18 JAN 68, 4 JUN 68 AND 8 OCT 68) FOR THREE NITROGEN LEVELS AND TWO LEVELS EACH OF PHOSPHORUS AND SULPHUR FERTILIZERS

Nitrogen (N) (kg ha^{-1})		0				67				135			
Phosphorus (P) (kg ha^{-1})		0		22		0		22		0		22	
Sulphur (S) (kg ha^{-1})		0	34	0	34	0	34	0	34	0	34	0	34
Component	Factor												
Green panic	NPS	1 164	1 888	1 167	1 790	1 377	2 620	1 356	2 381	1 125	3 606	930	3 431
	NP	1 526		1 478		1 998		1 868		2 366		2 181	
	NS			1 165	1 838			1 367	2 500			1 027	3 516*
	N	1 502c†				1 933b				2 273a			
	PS									1 222	2 703	1 151	2 534
	P									1 963a		1 843a	
	S											1 186b	2 618a
Lucerne	NPS	978	1 389	1 242	895	993	1 230	1 358	1 374	1 068	1 241	930	821
	NP	1 183		1 069		1 111		1 366		1 154		875	
	NS			1 110	1 142			1 175	1 302			1 000	1 033
	N	1 126a				1 239a				1 015a			
	PS									1 013	1 288	1 177	1 030
	P									1 150a		1 103a	
	S											1 095a	1 160a
Burr medic	NPS	313	1 353	456	1 586	489	1 282	517	1 227	488	1 406	584	1 642
	NP	833		1 021		886		872		947		1 113	
	NS			385	1 470			503	1 255			536	1 524
	N	927a				879a				1 030a			
	PS									430	1 347	519	1 485
	P									889a		1 002a	
	S											475b	1 416a
TOTAL	NPS	2 455	4 630	2 865	4 271	2 859	5 132	3 231	4 982	2 681	6 253	2 444	5 894
	NP	3 542		3 568		3 995		4 106		4 467		4 169	
	NS			2 660	4 450			3 045	5 057			2 563	6 073*
	N	3 555b				4 051a				4 318a			
	PS									2 665	5 338	2 847	5 049
	P									4 002a		3 948a	
	S											2 756b	5 194a

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.

TABLE 7

PERCENTAGE BASAL COVER OF GREEN PANIC, NATIVE GRASSES (PREDOMINANTLY *Dichanthium* spp.) BURR MEDIC SEEDLINGS AND TOTAL BASAL COVER (ALL PASTURE COMPONENTS) ON 29 JUL 71

Nitrogen (N)		0				67				135			
Phosphorus (P)		P_0		P_1‡		P_0		P_1		P_0		P_1	
Sulphur (S)		S_0	S_1§	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
Component	Factor												
Green panic	NPS	1·1	2·9	2·2	5·2	1·5	3·2	2·1	5·3	1·1	4·7	1·0	5·2
	NP	2·0		3·7		2·4		3·7		2·9		3·1	
	NS			1·7	4·0			1·8	4·3			1·1	4·9
	N		2·8a†				3·0a				3·0a		
	PS									1·2	3·6	1·8	5·2
	P									2·4b		3·5a	
	S											1·5b	4·4a
Native grasses	NPS	3·1	1·0	2·7	0·9	3·8	1·0	2·4	2·1	1·9	0·4	2·4	0·0
	NP	2·1		1·8		2·4		2·3		1·2		1·2	
	NS			2·9	0·9			3·1	1·6			2·2	0·2
	N		1·9a				2·3a				1·2a		
	PS									2·9	0·8	2·5	1·0
	P									1·9a		1·7a	
	S											2·7a	0·9b
Burr medic	NPS	0·1	0·9	0·3	0·8	0·1	0·7	0·3	0·5	0·2	0·8	0·4	0·5
	NP	0·5		0·6		0·4		0·4		0·5		0·5	
	NS			0·2	0·8			0·2	0·6			0·3	0·7
	N		0·5a				0·4a				0·5a		
	PS									0·1	0·8	0·4	0·6
	P									0·5a		0·5a	
	S											0·3b	0·7a
TOTAL	NPS	4·9	7·6	6·7	7·7	6·3	6·3	5·3	8·8	5·3	7·2	4·9	7·1
	NP	6·2		7·2		6·3		7·1		6·3		6·0	
	NS			5·8	7·6			5·8	**7·6**		5·1	7·2	
	N		6·7a				6·7a				6·1a		
	PS									5·5	7·0	5·6	7·8
	P									6·3a		6·7a	
	S											5·6b	7·4a

* Indicates that interaction is significant when tested at the 5% level of significance.
† Means for main effects within each row with a letter in common do not differ when tested at the 5% level of significance.
‡ P_1 was 22 kg ha^{-1} for 1966 and 1967 spring fertilizer application and at an annual rate of 11 kg ha^{-1} subsequently.
§ S_1 was 34 kg ha^{-1} for 1966 and 1967 spring fertilizer application and at an annual rate of 22 kg ha^{-1} subsequently.

IV. DISCUSSION

A significant positive interaction between nitrogen and sulphur occurred in six of seven samplings of green panic dry matter during the period 1966 to 1971, the exception being at 4 June 1968 (table 2). The magnitude of the interaction increased with higher rainfall.

Nitrogen concentration of green panic increased with higher rates of nitrogen fertilizer in the absence of sulphur. Mathematical conversion of nitrogen concentration to crude protein percent could be misleading. Anderson and Spencer (1950) and Andrew, Kipps and Barford (1952) showed non-legumes to exhibit increased concentration of non-protein nitrogen and total nitrogen when sulphur-deficient.

The small reduction in lucerne yield shown on 4 June 1968 following the application of 67 kg ha^{-1} of nitrogen is of little importance when viewed in the light of yields at other sampling dates (table 3) and total lucerne yield (table 6).

Medic has proved to be a compatible and significant component of sown pastures on the eastern Downs. Jones (1970) has reported increased medic yields where sulphur was applied. As well as responding in dry matter yield to sulphur application when other pasture components were dormant, the nitrogen content of medic was increased. Anderson and Spencer (1950) showed that dry matter yields and percent nitrogen of subterranean clover (*Trifolium subterraneum*) were reduced by sulphur deficiency.

The low basal cover of the pasture in the control treatment in 1971 echoes the degeneration of sown grasses and increase in native species usually experienced in the district. Sulphur application produced more vigorous growth of green panic, restricted the encroachment of native species and prolonged the effective life of the sown pasture.

Commercial green panic pastures on the basaltic soils of the eastern Downs have exhibited poor production and persistence even with application of nitrogen as urea or ammonium nitrate. This investigation emphasizes the importance of sulphur for pasture production and persistence.

The only effect of phosphorus in this experiment was a minor increase in the basal cover of green panic.

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