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Recommended Citation

Paynter, B H. (1991), *Development of procedures to determine the fertilizer requirements of annual pasture legumes grown in cereal cropping systems.*. Department of Primary Industries and Regional Development, Western Australia, Perth. Report.

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Development of procedures to determine the fertilizer requirements of annual pasture legumes grown in cereal cropping systems.

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Department of Agriculture and Food

TITLE: Development of Procedures to Determine the Fertilizer Requirements of Annual Pasture Legumes Grown in Cereal Croppings Systems

PERSONNEL: B.H. Paynter

DATE: 1991

TRIAL NUMBER: 88ME67, 88SC17, 90ME1, 90ME2, 89ME50, 89ME52, 89ME54, 89ME55, 89ME60, 89ME61, 90SC11

DOS FILENAME: Pay BH 91a.doc

Objective 1

To determine the phosphate (P) fertilizer requirements of burr medic on marginally acidic, medium textured soils and yellow serradella on acidic, light textured soils.

Design: 7 rates superphosphate x 2 species x 3 reps

Trials 1990: 88ME67, 88SC17, 90ME1 and 90ME2/5792 EX

Site Characteristics:

Table 1. Soil properties of < 2 mm fraction of the top 10 cm of untreated soil

Property	Experiment			
	88ME67	90ME1	90ME2	88SC17
Northcote	Dy 4.22	Dy 4.12	Dr 2.22	Uc 3.21
pH ($CaCl_2$)	5.1-5.5	5.5	5.0	4.6-4.8
pH (water)	6.0-6.4	6.4	6.0	5.1-5.4
Bicarbonate P (µg/g)	5-7	15	30	9-13
Total P (µg/g)	40	100	130	38
PRI (mL/g)	3.1	4.2	5.1	12.5

Methodology:

Experiments were sown early June (June 8-18) 1990 due to unfavourable seed bed conditions for germination. Before seeding a basal fertilizer (containing Cu, Zn, Mo, Mg, Mn and gypsum) was topdressed onto the soil surface. The pasture legume (at 50 kg/ha) was topdressed at 1 cm depth with light harrows following and the superphosphate treatments were hand topdressed after seeding. Dry matter in late July (42-46 DAS) and September (108-113 DAS) was assessed by visually rating 20 x 0.1 m^2 quadrats per plot. Grab samples of whole spring tops were analysed for %P and soil samples (0-10 cm) from each plot were analysed for bicarbonate extractable P levels. Growth data was fitted to Mitscherlich functions and is the only data presented in this summary.

Objective 1 Results:

Table 2. Regression co-efficients for the relationship between P applied (kg P/ha) and dry matter production (kg/ha); and the amount of P required for 90% maximum yield (kg P/ha)

Experiments and species	Mitscherlich parameters A (se)	B (se)	C (se)	r^2	P req (se) (kg P/ha)
a) Early growth					
88ME67 (46 DAS)					
Medic	207(8)	109(12)	0.089(0.023)	0.93	206(34)
Clover	171(8)	83(13)	0.126(0.041)	0.87	137(30)
90ME1 (42 DAS)					
Medic	201(6)	108(10)	0.131(0.025)	0.95	142(19)
Clover	154(6)	77(12)	0.196(0.064)	0.87	90(21)
90ME2 (46 DAS)					
Medic	69(3)	28(6)	0.227(0.113)	0.75	66(24)
Clover	61(2)	12(4)	0.192(0.142)	0.60	34(18)
b) Spring growth					
88ME67 (113 DAS)					
Medic	1,359(55)	759(65)	0.064(0.014)	0.96	298(41)
Clover	1,697(40)	780(55)	0.087(0.014)	0.97	194(21)
90ME1 (108 DAS)					
Medic	2,364(33)	702(39)	0.063(0.009)	0.98	189(15)
Clover	1,303(43)	600(74)	0.152(0.038)	0.91	111(19)
90ME2 (111 DAS)					
Medic	1,097(6)	309(11)	0.180(0.013)	0.99	63(3)
Clover	861(7)	94(14)	0.480(0.286)	0.88	2(3)
88SC17 (112 DAS)					
Serradella	1,006(28)	675(37)	0.063(0.010)	0.98	335(33)
Clover	636(28)	532(27)	0.041(0.006)	0.98	573(50)

Objective 1 Comments:

Differences in phosphate requirements between yellow serradella and sub. clover and between burr medic and sub. clover were again observed in 1990.

Burr medic tends to show a larger absolute response to applied P, requires more applied P for both early and late in the year to achieve 90% of its maximum yield and responds to P applications at higher soil test values than sub. clover. Yellow serradella, on the other hand, is a relatively P efficient species and has a lower requirement for applied P than sub. clover. Agronomically, the different pasture legumes have different P response surfaces, but economically, this is not yet known and is subsequently being determined. This also requires some knowledge of their response to residual P and the yield boosts achievable from differing levels of pasture productivity. Both of which some measurements have been made. As a rough guess, it is likely that yellow serradella pastures will have a lower recommended level of P application than sub. clover pastures; while burr medic pastures are likely to be a few units of applied P higher than sub. clover pastures, but not much higher.

Future Trials 1991: No.

Objective 2

Determine the response of yellow serradella and burr medic to residual phosphate and freshly applied phosphate.

Design: 2 P placements x 7 rates P 1989 x 3 rates P 1990 x 3 reps.

Trials 1990: 89ME52, 89ME55 and 86ME61/5792 EX

Site Characteristics:

Table 3. Soil properties of < 2 mm fraction of the top 10 cm of untreated soil

Property	Experiment		
	89ME52	89ME55	89ME6
Northcote	Dy 2.23	Dy 2.85	Uc 5.32
pH ($CaCl_2$)	5.0	5.6	4.5
pH (water)	5.8	6.6	5.2
Bicarbonate P (µg/g)	14	9	12
PRI (mL/g)	2.3	2.5	69.0

Methodology:

Experiments were sown on the June 7, 1990. The pasture legume (at 50 kg/ha) was topdressed at 1 cm depth with light harrows following and the fresh superphosphate treatments were hand topdressed after seeding in a split-plot design. Each split-plot was assessed for dry matter production in late September by visually rating 8 x 0.1 m^2 quadrats per plot. Grab samples of whole tops were analysed for %P and soil samples (0-10 cm) from each split plot were analysed for bicarbonate extractable P levels. Growth data was fitted to Mitscherlich functions.

Objective 2 Results:

Table 4. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on dry matter (kg/ha) of burr medic (cv. Serena) at 115 DAS and bicarbonate P (µg/g) levels from 0-10 cm in 89ME52. Values are means of 3 replicates (split-plot analysis)

Measurement:		Dry matter (kg/ha)			Bicarbonate P (µg/g)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
Drilled	0	1,040	1,872	2,640	16	17	24
	2.28	1,253	2,105	2,838	19	23	27
	4.55	1,630	2,299	3,029	19	25	28
	6.82	1,707	2,431	3,076	22	25	33
	9.10	1,887	2,571	3,100	24	28	34
	18.20	2,059	2,519	3,157	23	27	38
	36.40	2,283	2,618	3,159	34	32	36
Topdressed	0	972	1,617	2,359	14	16	23
	2.28	1,064	1,774	2,594	15	21	27
	4.55	1,159	1,828	2,699	15	23	26
	6.82	1,302	1,927	2,739	17	26	26
	9.10	1,334	2,143	2,878	16	29	33
	18.20	1,662	2,298	2,847	19	33	37
	36.40	1,895	2,407	2,899	29	33	36

	Dry matter	Bicarbonate P
P placement (PP)	**	**
P rate 1989 (PR89)	**	**
PP x PR89	n.s.	n.s.
P Rate 1990 (PR90)	**	**
PP x PR90	n.s.	*
PR89 x PR90	**	n.s.
PP x PR89 x PR90	n.s.	n.s.
LSD (0.05) =	329 kg/ha	7 µg/g
LSD (0.05)* =	273 kg/ha	8 µg/g

[* At same level of PP and PR 89.]

Table 5. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on P concentration (%P) and P content (kg P/ha) of whole tops at 115 DAS in 89ME52. Values are means of 3 replicates (split-plot analysis)

Measurement:		P concentration (%P)			P content (kg P/ha)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
Drilled	0	0.15	0.17	0.22	1.56	3.18	5.73
	2.28	0.15	0.18	0.23	1.83	3.86	6.49
	4.55	0.15	0.18	0.22	2.50	4.04	6.75
	6.82	0.16	0.20	0.25	2.74	4.87	7.59
	9.10	0.15	0.18	0.24	2.77	4.71	7.32
	18.20	0.16	0.21	0.26	3.37	5.20	8.21
	36.40	0.18	0.25	0.26	4.06	6.62	8.20
Topdressed	0	0.14	0.18	0.22	1.39	2.98	5.28
	2.28	0.15	0.17	0.21	1.60	3.15	5.62
	4.55	0.16	0.19	0.25	1.85	3.38	6.75
	6.82	0.16	0.19	0.26	2.08	3.78	7.22
	9.10	0.17	0.20	0.24	2.23	4.58	6.99
	18.20	0.16	0.19	0.27	2.66	4.25	7.79
	36.40	0.17	0.20	0.27	3.13	4.80	7.85

	P concentration	P content
P placement (PP)	n.s.	**
P rate 1989 (PR89)	**	**
PP x PR89	n.s.	n.s.
P rate 1990 (PR90)	**	**
PP x PR90	n.s.	n.s.
PR89 x PR90	n.s.	n.s.
PP x PR89 x PR90	n.s.	n.s.
LSD (0.05) =	0.04 %P	1.32 kg P/ha
LSD (0.05)* =	0.04 %P	1.33 kg P/ha

[* At same level of PP and PR89.]

Table 7. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on P concentration (%P) and P content (kg P/ha) of whole tops at 95 DAS in 89ME55. Values are means of 3 replicates (split-plot analysis)

Measurement:		P concentration (%P)			P content (kg P/ha)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
	0	0.16	0.21	0.26	1.54	3.28	5.02
	2.28	0.16	0.22	0.28	1.78	3.41	5.79
	4.55	0.18	0.23	0.28	2.23	3.96	6.11
Drilled	6.82	0.18	0.20	0.26	2.42	3.66	5.69
	9.10	0.18	0.20	0.27	3.06	3.87	6.19
	18.20	0.21	0.23	0.29	3.75	4.78	6.93
	36.40	0.21	0.24	0.28	3.91	5.56	6.99
	0	0.16	0.20	0.25	1.44	2.93	5.22
	2.28	0.17	0.22	0.28	1.77	3.27	5.78
	4.55	0.17	0.22	0.28	1.85	3.26	5.52
Topdressed	6.82	0.19	0.21	0.27	2.38	3.44	5.58
	9.10	0.18	0.24	0.26	2.55	4.01	5.31
	18.20	0.19	0.22	0.30	3.05	4.12	6.77
	36.40	0.25	0.25	0.30	4.44	5.18	6.34

	P concentration (%P)	P content (kg P/ha)
P placement (PP)	n.s.	n.s.
P rate 1989 (PR89)	**	**
PP x PR89	n.s.	n.s.
P rate 1990 (PR90)	**	**
PP x PR90	n.s.	n.s.
PR89 x PR90	n.s.	n.s.
PP x PR89 x PR90	n.s.	n.s.
LSD (0.05) =	0.04 %P	1.07 kg P/ha
LSD (0.05)* =	0.04 %P	0.98 kg P/ha

[* At same level of PP and PR89.]

Table 6. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on dry matter (kg/ha) of burr medic (cv. Serena) at 95 DAS and bicarbonate P levels (µg/g) from 0-10 cm in 89ME55. Values are means of 3 replicates (split-plot analysis)

Measurement:		Dry matter (kg/ha)			Bicarbonate P (µg/g)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
Drilled	0	940	1,528	1,912	8	12	24
	2.28	1,148	1,565	2,012	9	14	27
	4.55	1,246	1,734	2,197	9	16	30
	6.82	1,361	1,808	2,223	11	16	29
	9.10	1,639	1,891	2,274	13	16	32
	18.20	1,829	2,082	2,374	16	22	32
	36.40	1,862	2,287	2,468	25	27	36
Topdressed	0	873	1,445	2,072	7	12	22
	2.28	1,016	1,603	2,089	8	12	24
	4.55	1,099	1,513	1,975	8	14	28
	6.82	1,251	1,600	2,094	10	16	28
	9.10	1,427	1,677	2,039	13	19	36
	18.20	1,601	1,876	2,240	13	19	29
	36.40	1,750	2,035	2,069	20	25	37

	Dry matter	Bicarbonate P
P placement (PP)	**	n.s.
P rate 1989 (PR89)	**	**
PP x PR89	n.s.	n.s.
P rate 1990 (PR90)	**	**
PP x PR90	n.s.	n.s.
PR89 x PR90	**	n.s.
PP x PR89 x PR90	n.s.	n.s.
LSD (0.05) =	287 kg/ha	7 µg/g
LSD (0.05)* =	240 kg/ha	6 µg/g

[* At same level of PP and PR89.]

Table 8. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on dry matter (kg P/ha) of yellow serradella (cv. Madeira) at 122 DAS and bicarbonate P levels (µg/g) from 0-10 cm in 89ME61. Values are means of 3 replicates (split-plot analysis)

Measurement:		Dry matter (kg/ha)			Bicarbonate P (µg/g)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
Drilled	0	351	601	773	5	5	14
	2.28	480	695	855	4	7	16
	4.55	546	721	943	5	8	16
	6.82	560	836	1,047	4	8	19
	9.10	698	918	1,102	7	10	18
	18.20	910	1,334	1,328	10	13	21
	36.40	1,029	1,572	1,543	14	16	25
Topdressed	0	311	543	797	4	6	12
	2.28	369	573	824	5	7	14
	4.55	401	626	886	6	8	15
	6.82	467	699	916	6	8	15
	9.10	539	730	979	6	10	20
	18.20	700	850	1,031	7	10	20
	36.40	1,140	1,102	1,173	13	17	19

	Dry matter	Bicarbonate P
P placement (PP)	**	*
P rate 1989 (PR89)	**	**
PP x PR89	n.s.	n.s.
P rate 1990 (PR90)	**	**
PP x PR90	*	*
PR89 x PR90	n.s.	n.s.
PP x PR89 x PR90	n.s.	n.s.
LSD (0.05) =	204 kg/ha	3 µg/g
LSD (0.05)* =	181 kg/ha	3 µg/g

[* At same level of PP and PR89.]

Table 9. Effect of phosphate placement in 1989, P applied 1989 and P applied 1990 on P concentration (%P) and P content (kg P/ha) of whole tops at 122 DAS in 89ME61. Values are means of 3 replicates (split-plot analysis)

Measurement:		P concentration (%P)			P content (kg P/ha)		
P placement 1989	P applied 1989 (kg P/ha)	P topdressed 1990 (kg P/ha)			P topdressed 1990 (kg P/ha)		
		0	9.1	36.4	0	9.1	36.4
Drilled	0	0.16	0.17	0.18	0.55	1.02	1.38
	2.28	0.17	0.17	0.19	0.81	1.22	1.66
	4.55	0.17	0.18	0.20	0.95	1.32	1.90
	6.82	0.16	0.19	0.20	0.88	1.61	2.10
	9.10	0.18	0.20	0.21	1.26	1.81	2.27
	18.20	0.21	0.23	0.22	1.87	3.05	2.89
	36.40	0.22	0.24	0.27	2.30	3.79	4.11
Topdressed	0	0.14	0.15	0.17	0.43	0.81	1.38
	2.28	0.15	0.15	0.16	0.57	0.85	1.33
	4.55	0.15	0.16	0.17	0.61	1.03	1.45
	6.82	0.16	0.16	0.18	0.73	1.12	1.61
	9.10	0.15	0.16	0.18	0.83	1.19	1.73
	18.20	0.17	0.18	0.19	1.17	1.50	1.96
	36.40	0.19	0.19	0.20	2.20	2.07	2.39
P placement (PP)			**			**	
P rate 1989 (PR89)			**			**	
PP x PR89			n.s.			**	
P rate 1990 (PR90)			**			**	
PP x PR90			n.s.			**	
PR89 x PR90			n.s.			n.s.	
PP x PR89 x PR90			n.s.			**	
LSD (0.05) =			0.02 %P			0.46 kg P/ha	
LSD (0.05)* =			0.04 %P			0.37 kg P/ha	

[* At same level of PP and PR89.]

Objective 2 comments

Trial 89ME52

(1) Phosphate drilled was more effective for plant growth than P topdressed. Plots in which the phosphate was drilled had higher soil test values for bicarbonate extractable P than plots in which the P was topdressed.

(2) Increasing the level of P applied in 1989 or 1990 increased the P concentration and P content of whole tops. There was an interaction between the level of P applied in 1989 and 1990 on plant growth, but not on P concentration or P content.

Trial 89ME55

(1) Phosphate drilled was more effective for plant growth than P topdressed. Plots in which the phosphate was drilled had similar soil test values for bicarbonate extractable P than plots in which the P was topdressed.

(2) Increasing the level of P applied in 1989 or 1990 increased the P concentration and P content of whole tops. There was an interaction between the level of P applied in 1989 and 1990 on plant growth, but not on P concentration or P content.

Trial 89ME61

(1) Phosphate drilled was more effective for plant growth than P topdressed. Plots in which the phosphate was drilled had slightly higher soil test values for bicarbonate extractable P and P concentrations of whole tops than plots in which the P was topdressed.

(2) Increasing the level of P applied in 1989 or 1990 increased the P concentration and P content of whole tops. There was no interaction between the level of P applied in 1989 and 1990 on plant growth, P concentration and P content; but there was an interaction between P placement, P applied 1989 and P applied 1990 on P content.

Future Trials 1991: Yes, 89ME50 and 89ME60.

Objective 3

To measure the influence of different levels of pasture productivity (generated by different levels of P supply) and the different pasture legumes on subsequent wheat crops.

Basic Design: Pasture productivity 1988/89 x rates of N 1990 x 3 reps.

Trials 1990: 89ME50, 89ME54, 88ME67, 88SC17, 89ME60/6106/7EX.

Site Characteristics:

Table 10. Soil properties of < 2 mm fraction of the top 10 cm of untreated soil

Property	88ME67	89ME50	89ME54	88SC17	89ME60
Northcote	Dy 4.22	Uc 5.32	Uc 5.31	Uc 3.21	Uc 3.21
pH ($CaCl_2$)	5.1-5.5	5.2	5.4	4.6-4.8	4.6
pH (water)	6.0-6.4	5.9	6.3	5.1-5.4	5.5
NO_3- (µg/g)	3	5	3	3	4
NH_4+ (µg/g)	4	5	3	4	5

Methodology:

Before sowing, 36.4 kg P/ha (as superphosphate) was topdressed onto each plot. Experiments were direct drilled mid-May (May 16-23) 1990 sowing wheat (cv. Gutha) at 50 kg/ha and 36.4 kg P/ha as superphosphate at 5 cm depth with light harrows following onto non-legume and previous legume plots. Nitrogen (as Agran) was hand topdressed after seeding. Spring dry matter was assessed by cutting either 4 or 8 x 0.25 m^2 quadrats per plot and grain yields determined using an experimental harvester. Whole top samples and grain samples were analysed for %N. Pre-seeding soil samples (0-10 cm) from each plot were analysed for NO_3- and NH_4+. Yield boost in this summary (expressed as N equivalents) represents the amount of applied N required for wheat after a non-legume to produce the same level of yield as wheat after a legume pasture in the absence of N fertilizer.

Objective 3 Results:

Table 11. Regression co-efficients for the relationship between spring pasture yield (= X) in 1989 (kg/ha) and wheat grain yields (= y) in 1990 (kg/ha) with no N applied; and the increase in grain yields with every extra 500 kg/ha of legume pasture produced

Trial	Equation		Every extra 500 kg/ha legume pasture worth
89ME50	$y = 1428 + 0.271x$	$r^2 = 0.99$	135 kg grain/ha
89ME54	$y = 2064 + 0.159x$	$r^2 = 0.94$	80 kg grain/ha
88ME67	$y = 850 + 0.155x$	$r^2 = 0.85$	78 kg grain/ha
89ME60	$y = 1424 + 0.235x$	$r^2 = 0.93$	118 kg grain/ha
		Average	= 103 kg grain/ha

Table 12. Yield boost expressed as N equivalents after 1 or 2 years of legume pasture with varying levels of productivity in 88ME67

Pasture productivity	Yield boost (kg N/ha) 1 year pasture	2 years pasture
Poor pasture	8	10 kg N/ha
Average pasture	19	26 kg N/ha
Good pasture	32	41 kg N/ha

Table 13. Yield boost expressed as N equivalents after 2 years of serradella pasture in 88SC17 with varying levels of pasture productivity

Pasture productivity	Yield boost (kg N/ha)
Poor pasture	10
Average pasture	26
Good pasture	46

Table 14. Wheat grain yields after non-legume or burr medic (cv. Serena) pasture in 89ME54 with increasinig levels of N applied and P non-limiting

N applied (kg N/ha)	Wheat yield (kg/ha) after Non-legume	Burr medic
0	864	2,149
30	1,633	2,736
80	2,502	3,411

Yield boost equivalent to 60 kg N/ha.

Table 15. Wheat grain yields after non-legume or yellow serradella (cv. Madeira) pasture in 89ME60 with increasing N applied and P non-limiting

N applied (kg N/ha)	Wheat yield (kg/ha) after Non-legume	Yellow serradella
0	654	1,433
30	1,068	2,166
80	1,729	2,504

Yield boost equivalent to 58 kg N/ha.

Objective 3 Comments:

(1) A productive legume pasture can either reduce N input costs or increase grain yields. This yield boost measured either way is dependent upon the level of pasture productivity; the poorer the pasture the lower the yield boost, the better the pasture legume the larger the yield boost. Not only is the presence of a pasture legume and the level of its productivity important, the length of the pasture phase is also important.

(2) For similar levels of pasture productivity burr medic and sub. clover pastures provide similar yield boosts.

(3) These flow-on effects on wheat growth need to be included when making decisions on the economics of fertlising legume pastures in the eastern wheatbelt.

Future Trials 1991: Yes, 89ME61

Miscellaneous Objective

Response of pasture legumes to deep placed superphosphate.

Design: 6 P rate-placement treatments x 2 species x 4 reps.

Results:

Table 16. Spring dry matter (October 8, 1990 - 140 DAS) of yellow serradella (cv. Madeira) and burr medic (cv. Santiago) with differing levels of superphosphate drilled with the seed or deep placed 7.5 cm below the seed

P treatment		Yellow serradella		Burr medic	
Placement	P applied (kg/ha)	Yield (kg/ha)	% Increase	Yield (kg/ha)	% Increase
Drilled	0	3,337		1,164	
	9.1	3,825	(14%)	1,779	(53%)
	36.4	4,008	(20%)	2,170	(86%)
+ Deep cultivation	36.4	4,035	(21%)	2,186	(87%)
banded	9.1	3,980	(19%)	1,939	(67%)
	36.4	4,202	(26%)	2,335	(101%)
Species	**				
P rate	**				

Comment:

(1) No effect of deep banding, but response to P application rate.

(2) No cultivation response.

Future Trials 1991: Yes, regenerating.