Proceedings *of the New* Zealand *Grassland* Association 54: *35-40 (1992)*

Summary of eleven long-term field trials with 'Longlife' phosphatic fertiliser

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Abstract

Longlife' phosphatic fertiliser is manufactured in New Zealand by mixing reactive phosphate rock (RPR) with single superphosphate (SSP) when the SSP is at an ex-den stage. Commercially produced Longlife (70:30 SSP:RPR) was evaluated in 6 field mowing trials in the North Island over 3 or4 years. Also, a 50:50 (SSP:RPR) Longlife-type product was examined in 5 field trials throughout New Zealand over 5 or 6 years. Longlife was compared against SSP and/or triple superphosphate (TSP) in all trials, and RPR treatments were included in 7 trials. In all trials with commercially produced Longlife, the pasture response to Longlife tended to be less than that to SSP or TSP in the first 2 years and was significantly different ($P<0.01$ in year 1, $P<0.07$ in year 2) for the average of all trials. Differences generally decreased over time. In the trials with RPR, Longlife tended to be intermediate between RPR and SSP. Thus, Longlife performed as expected from a simple non-interactive mixture of its components. This indicates that it is inappropriate for use where field conditions are unsuitable for RPR use (i.e. soil pH > 6.0 and/or rainfall <800 mm/year).

Keywords field trials, Longlife, phosphate, reactive phosphate rock, superphosphate

Introduction

'Longlife' has been produced by New Zealand fertiliser manufacturers since 1985 by mixing reactive phosphate rock (RPR) with single superphosphate (SSP) when the SSP was at an ex-den stage. The main commercial form of Longlife has been a 70:30 SSP:RPR mixture. During 1989 and 1990. a survey by MRL Research Group of farms indicated that Longlife constituted 20 and 26%, respectively, of the totalamountofphosphatic fertiliser applied on dairy and sheep/beef farms throughout New Zealand.

The only published field trials with Longlife (Mackay & Wewela 1990) were from 2 sites on a yellow-brown earth soil and involved comparison of Longlife (one rate) with 3 rates of RPR and SSP (all replicated twice) in the southern Ruahiies. Both sites responded to P but no significant difference was detected in total pasture production ova 2 years between any P fertilisers. However, at one site, legume production was stimulated more during the first 6 months from Longlife and SSP than from RPR.

The detection of real differences between phosphatic fertilisers which do not vary greatly in their P availability is very difficult in the field. Johnstone and Sinclair (1991) showed that to detect significant differences between products such as Longlife and SSP it is necessary to have a highly P responsive site and a high degree of replication; eg. 2 fertilisers with a 10% difference in P availability compared on a 100% responsive site may require about 40 replicates to ensure a 90% probability of detecting the difference between them. In practice. individual field experiments rarely meet these criteria. Clearly, conclusionsregarding the suitability of different phosphatic fertilisers are best made only after considering the collective results from a number of trials.

This paper summarises the results from 11 field trials which evaluated commercial Longlife or Longlife-type phosphatic fertiliser over 3 to 6 years.

Methods

Sites and experlmental procedure

Details of the 11 trial sites aregivein Table 1. Further details of sites 7-l 1 were given by Smith *et al.* (1991). In all trials, areas were selected and fenced to exclude animals for the trial duration. Pasture production was measured by mowing at 15 - 60 day intervals depending on pasture growth rate. All clippings (or 50% in trials 5 and 6, and 70% in trials 1 and 2) were evenly reapplied onto plots. Trials 1 to 6 had uniformity cuts taken prior to the first application of fertiliser. Basal dressings of sulphur, potassium and trace elements (some sites only) *were* applied regularly.

Longlife fertiliser

The commercial Longlife fertilisers used in trials 1 - 6 *were* manufactured from 70% SSP (made mainly from Nauru and Xmas Island PRs) and 30% RPR (North

Table 1 Summary of site and soil characteristics of Longlife field trials

	Location	Soil group	Rainfall (mm/year)	pH	Olsen P	Trial duration (years)
Commercial Longlife						
1.	Kaharoa	Yellow brown pumice	1600	5.6	23	3
2.	Taupo	Yellow brown pumice	1200	5.8	32	3
3.	Hamilton	Yellow brown loam	1250	5.7	17	3
4.	Hamilton	Yellow brown loam	1250	5.6	14	4
5.	Te Kuiti	Yellow brown loam	1450	5.6	6	4
6.	Te Kuiti	Yellow brown loam	1450	5.6	11	4
50:50 Longlife-type fertiliser						
7.	Te Kuiti	Yellow brown loam	1450	5.6	10	6
6.	Meremere	Yellow brown loam	1200	5.9	16	5
Q.	Winchmore	Yellow Qrey earth	770'	5.6	7	6
10.	Woodlands	Yellow brown earth	1040	5.9	13	6
11.	Gore	Yellow grey earth	890	5.6	14	6

[1] The site also received 500 mm In irrigation water

Carolina, unground) added ex-den. The 50:50 Longlife-typefertiliserusedintrials 7-11 was prepared from 50% SSP (made from a 50:50 mix of Nauru and Xmas Island PRs) and 50% RPR (North Carolina) by the former NZFMRA in a small-scale fertiliser plant with RPR being added to SSPex-den (A Braithwaite pers. comm.). Chemical analyses of these products are given in Table 2.

Table 2 Chemical analyses of Longlife and other P fertilisers used in the field aids

Trial No.	Total P(%)	Citric-soluble P (as % Of total P)	Water-soluble P (as % Of total P)
Commercial Longlife			
1,2	10.4	67	46
3	10.8	62	44
4	10.3	65	50
5.6	10.3	63	41
mean	10.4	64	46
50:50 Longlife-type fertiliser			
7 - 11	11.4	54	
SSP			
3	9.3	97	96
4	9.1	66	81
5, 6	9.5	66	77
7 - 11	9.4	66	77
TSP			
1, 2	18.4	66	71
7 - 11	20.6	94	91
North Carolina RPR			
5, 6	i2.6	30	
7 - 11	12.6	32	

Design of trials

Trials 1 and 2. Treatments (on a total P basis) were 0, 10, 20, 35, 50 and 80kgP/ha/year of triple superphosphate (TSP) and 20. 35 and 50kgP/ha/year of commercial Longlife. There were 5 replicates in arandomised block design.

Trial 3. Treatments (on a total P basis) were 0, 22, 44 and 66kgP/ha/year of SSP and of commercial Longlife. There were 4 replicates in a randomised block design.

Trial 4. Treatments (on a total P basis) were 0, 22.5, 30 and 60kgP/ha/year of SSP and of commercial Longlife. There were 4 replicates in a randomised block design.

Trials 5 and 6. Treatments were 0, 15, 30 and 45kgP/ha/year of Longlife (based *on* 9.6% 'available' P) and SSP (based on 2% citric-soluble P), and 15 and 30kgP/ha/year of North Carolina RPR (on a totalPbasis).There were 4 replicates in a randomised block design.

Trials 7 - 11. Treatments (on a total P basis) included annual applications of 0, 0.5, 0.75, 1.0 and 2.0 x maintenance (M) P rate of TSP (see Smith et al. 1991 for details). These 5 trials also had SSP (from 50% Nauru and 50% Xmas Island PRs), a 50:50 Longlife-type fertiliser (made from 50% Nauru/Xmas SSP and 50% North Carolina RPR), and North Carolina RPR, all applied at 0.75 M. All treatments were replicated thrice.

Calculations and data analysis

Analysis of variance was done on data from all trials and the LSD (5%) was estimated. Thesubstitutionvalue (Ψ) was calculated (Johnstone & Sinclair 1991) for all trials. This is the ratio of total P in SSP or TSP to total P in

Longlife required to give the same pasture yield over a specified time interval (eg., 1 kg $P_{Longlife}$ = Ψ kg P_{SSP}).

Results

Commercial Longlife trials

In all years and for all trials there was a significant response to added P, which averaged 7-10% in year 1 and 9-24% in year3 for SSP or TSP (Table 3). In all trials the response to P generally increased over all rates applied and therefore data is presented as the mean of the 3 rates. for the sake of brevity (Table 3).

In the first year, over all trials Longlife was lower yielding ($P<0.01$) than SSP or TSP, with an average relative response of 76%. although differences were not statistically significant in any one trial. This continued into year 2. although the relative difference between responses to Longlife and SSP or TSP had decreased ($P<0.07$; relative response of 8 1%). In year 2. Longlife was lower yielding ($P<0.05$) than SSP in trial 6 with the effect reaching significance due to therelatively large P response (+28% to SSP). In 5 trials, there was a trend for the response from Longlife relative to SSP or TSP to increase over time, but in trial 3 the reverse trend occurred.

Trials 5 and 6 included RPR which was lower yielding ($P<0.05$) than SSP in year 1. but increased in relative effectiveness over time (Figure 1). Overall, there was a trend for Longlife to be intermediate between RPR and SSP in all years.

Estimates of the substitution value (Ψ for all trials averaged 0.66.0.75 and 0.79 in years 1.2 and 3 respectively (Table 4). This indicates that the pasture yield from Longlife at a given rate of total P could have been obtained with a lower rate (from Ψ) of total P as SSP or TSP.

Table 3 Average pasture production (kg DM/ha/year) from nil P, Longlife and SSP or TSP in 6 field trials (see Table-l for site details). Fertiliser data are the average of 3 P rates estimated for equivalent rates of total P applied.

Trial No.	nil P	Longlife	SSP or TSP	LSD (5%)
Yearl:				
1	9770	10550	10595	540
2[b]	5125	5625	5800	410
3	7790	8680	8830	420
4	8310	9150	9540	420
5	8210	8690	8920	430
6	9720	10180	10440	390
Mean	8154	8813	9021	122**
Year 2:				
1	11420	12510	12600	425
2	11660	13200	13810	650
3	6720	7570	7880	490
4	8690	9690	9490	500
5[b]	6040	7340	7770	460
6[b]	5600	6770	7160	380*
Mean	8355	9513	9785	301t
Year 3:				
1	7030	8060	8035	210
2	9640	10385	10435	410
3	6420	7300	7760	600
4	8830	10270	10260	500
5	6030	7230	7470	450
6"	6330	7680	7790	470
Mean	7380	8488	8625	195
Year 4:				
4	7650	9910	10010	760
5[b]	4300	6530	6790	540
6	6390	9100	9430	660

[a] For comparison between fertilisen; t, 'and "Indicate 10, 5 and 1% level of significance.
[b] Lessthanl year

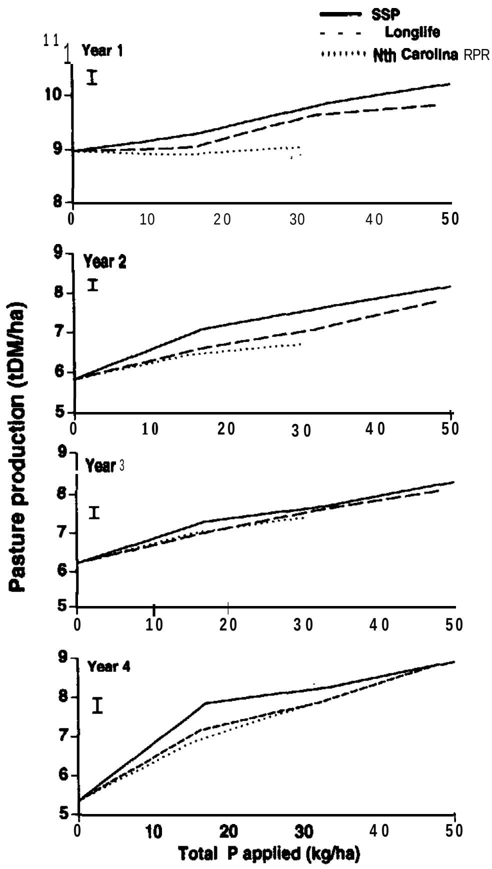

Figure 1 Effect of P fertilisers on pasture production over 4 years. Data are the average for trials 5 and 6. Bars represent SEDs.

50:50 Longlife-type fertiliser trials

There was little response to soluble P fertiliser over the control treatment in the first year of these trials, averaging 4% from 0.75 M SSP. but thereafter it increased to an average of 17% in year 5 (Figure 2). Longlife was not significantly different to SSP, although it tended to be slightly lower producing in all years. There was little response to RPR in the fit 2 years but it increased over time to near that from Longlife and SSP in years 4 and 5.

The response from Longlife averaged 75 - 78% of that from SSP in the fiit 3 years and increased to 85% by the fifth year, whereas the response from RPR relative to SSP was 0 in year 1 and increased to 78% in year 5.

The Ψ values (calculated relative to TSP) had relatively large errors due mainly to the use of only one rate of P for the various fertilisers. Nevertheless, the Ψ for Longlife tended to be intermediate between that for SSP and RPR for the duration of the trials.

Discussion

The pasture response to commercially produced Longlife was less than that from SSP or TSP when averaged over all trials in the first 2 years, but the difference decreased over time. Associated measurements with RPR (Figures 1 and 2; and Sinclair 1990) also showed an initial lag in effectiveness and overall the difference

Table 4 Substitution values (Ψ) for Longlife and other P fertilisers in 11 field trials. Ψ is the ratio of total P in a standard (TSP or SSP) to total P in the fertilisers for the same pasture production. Bracketed values are standard errors.

Trial Number	Time (years) 1	2	3	4	5	6[a]	Total[b]
Commercial Longlife							
1	0.77 (0.28)	0.88 (0.11)	1.00 (0.17)				
2	0.62 (0.16)	0.44 (0.08)	0.73 (0.14)				
3	0.73 (0.17)	0.62 (0.17)	0.34 (0.14)				
4	0.50 (0.23)	1.33 (0.52)	0.98 (0.18)	0.95 (0.15)			
5[c]		0.59 (0.08)	•	0.85 (0.10)			
8	0.67 (0.04)	0.88 (0.12)	0.89 (0.13)				
Mean	0.68	0.75	0.79				
50:50 Longlife-type fertiliser							
7-11							
SSP[d]	0.89 (0.88)	0.92 (0.54)	1.03 (0.47)	0.80 (0.33)	0.91 (0.38)	1.16 (0.34)	0.91 (0.32)
Longlife[d]	0.86 (0.56)	0.62 (0.42)	0.69 (0.37)	0.63 (0.29)	0.71 (0.32)	0.93 (0.29)	0.87 (0.27)
RPR[d]	-0.27 (0.49)	0.25 (0.31)	0.43 (0.31)	0.70 (0.31)	0.67 (0.31)	0.75 (0.25)	0.45 (0.22)

[a] Excluding trial 8
[b] Based on total production for years I-5
[c] Missing values where unsuitable response curves occurred
[d] All values relative to TSP

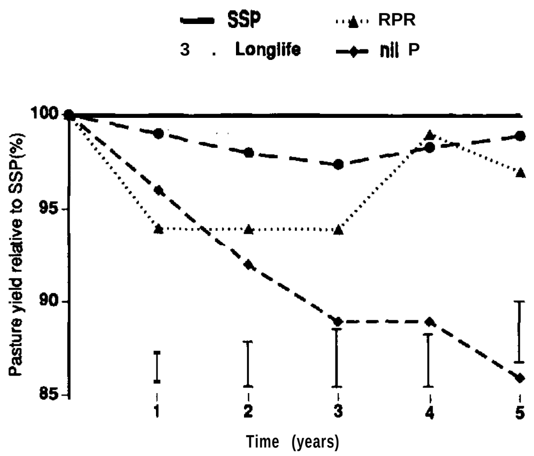

Figure 2 Effect of P fertilisers on annual pasture production expressed as % relative to SSP. Bars represent SEDs.

between RPR and SSP or TSP tended to be greater than that for Longlife. Thus, the results are consistent with Longlife performing agronomically as expected from a non-interacting mixture of its components (eg. 70% SSP and 30% RPR in most commercial Longlife).

Bolan et *al.* (1987) measured the chemical reactions that occurred in the preparation of Longlife in a laboratory and found that when RPR was added to SSP ex-den. residual free acid preferentially consumed the RPR and this resulted in reduced acidulation of the unreactive PR used for the SSP. However, they noted that in a commercial works the den temperature is higher than in their laboratory study and that this would favour greater acidulation of the unreactive PR. A significant increase in unreactive PR (from which little P becomes plant-available) in Longlife compared to SSP would mean reduced agronomic effectiveness in the long term, but this was not evident in the field trials. In practice. there is less likelihood of this being an issue because SSP is being manufactured using an increasing component of PRs of higher reactivity than in the past,

Longlife may not be an appropriate phosphatic fertiliser for all situations. The field trials indicated that it functioned as a simple mixture of its components and this suggests that it is inappropriate in field conditions unsuitable for RPR. It is currently recommended that RPRs should not be used on soils with a pH above 6.0 and/or where rainfall is less than 800 mm (Sinclair 1990). These conditions may also be appropriate for Longlife, and in such conditions soluble P fertiliser (eg. SSP or TSP) should be used.

Results from these trials should not be extrapolated to partially acidulated PRs (PAPRs) because PAPRs are manufactured differently from Longlife. Indeed, in the MAF National Series of P trials (Smith et *al.* 1991) PAPR made using phosphoric acid was as effective as SSP or TSP in all conditions. In the 5 trials from the National Series described in this paper, the Ψ for PAPR relative to TSP over 5 years was 1.09 whereas it was 0.67 for the 50:50 Longlife. However, in some situations (eg. low level of acidulation, different acid, or hard granules) PAPRs have also been initially less effective than SSP or TSP (Rajan *et al.* 1993).

Conclusions

1. Longlife phosphatic fertiliser appears to function as expected from a non-interacting mixture of its components (commonly 70% SSP and 30% RPR).
2. When Longlife is first used, there may be a small lag in pasture response compared to that from SSP.
3. Soluble P fertiliser (eg. SSP. TSP) is more appropriate than Longlife when conditions are unsuitable for RPR (soil pH exceeding 6.0 and/ or rainfall less than 800 mm).

ACKNOWLEDGEMENTS

The conduct of trials 7 - 11 by AgResearch scientific staff throughout New Zealand was greatly appreciated. We also thank M. Hawke.T. Gee, M. Boyes and K. Jones for technical assistance with trials 1 to 6 and C. Smith and J. Waller for statistical analyses. BOP Fertiliser Ltd provided financial assistance for trials 1 and 2.

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