WEED CONTROL AND THE UPTAKE OF FERTILISER P FROM VARIOUS SOURCES BY YOUNG RADIATA PINE AT THREE SITES

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ABSTRACT

At two sites in the North Island (Tairua Forest on the Coromandel, and near Dargaville, at Mangakahia Forest), and one site in the South Island (Mariri Forest, Nelson) young radiata pine was subjected to weed control and P fertilisation. The P fertilisers varied from superphosphate (single and triple), phosphate rock (reactive) and partially acidulated reactive rock. The rate of P application was 75 kg/ha. The trials were installed, measured and sampled by members of the NZ Forest Nutrition Cooperative. NZ FRI staff completed the nutrient analyses, and managed the data. At the Tairua and Nelson sites, there were marked responses in basal area where the foliage analyses indicated that levels were <0.11% P. At Nelson, growth appeared to be on a divergent path, and trees treated with both fertiliser P alone, and P with weed control behaved similarly. At Tairua there were gains in basal area with fertiliser P alone (PARR>SSP), and further gains in the presence of weed control (SSP>PARR). At this site also, divergent growth was apparent. At Dargaville, although control trees where > 0.11% P, there was a slight, but not significant, increase in growth with fertiliser. The foliar P rise and fall scenarios were dependent on both P source, and site.

INTRODUCTION

Understanding the competition dynamics between radiata pine and understorey species for water and nutrients is crucial for making decisions on the effective use of fertilisers in plantation forestry. Phosphorus is one of the major nutrients consumed in forestry, and because of the immobility of P applied to most soils (the sands are the exceptions), competition for P by radiata and "weeds" can be intense in the surface soil horizon. On drier sites, soil moisture can further compound the effect of weeds in limiting the availability of P to the forest crop.

The aim of the work described in this report was primarily to ascertain the extent to which weed competition interfered with the uptake of P by radiata pine from single superphosphate (SSP) or triple superphosphate (TSP) at three sites contrasting in both soil P retention and soil moisture. A secondary objective was to better define the changes in foliar P levels following P fertilising to augment the CLAYSFERT growth model, where the rise in foliar P following fertilising is currently inadequately defined through too few observations.

MATERIALS AND METHODS

The trials were designed and installed by industry as in-kind contributions to the then NZ Forest Nutrition Cooperative and monitored by forest staff with some input by NZFRI staff. Four trials were initially installed but the fourth trial (at Topuni Forest) was accidentally sprayed with Grazon in very dry conditions.

The Sites

Mariri Forest (FR68/1)

The site is located in Compartment 93 Mariri Forest, in the Nelson District of Carter Holt Harvey Forests Ltd. (formerly Baigent Forest Industries Ltd). The site was burnt and windrowed, and planted to radiata pine in 1983. The soil type is Mapua hill soil. The site receives 1150 mm rainfall/year, has an average annual temperature of 9.5° C.

Tairua (FR68/2)

The site is located in Compartment 155 (Latitude 37° 14' S, 175° 48' W) in Tairua Forest (Carter Holt Harvey Forests Ltd) on the Coromandel Peninsula. The site slopes at 15° to the East, is at an altitude of 210 m and was formerly planted to Corsican pine (1939). Preparation of the site for planting was by burning, and planted with radiata pine at 4 m by 2 m spacing in 1985. The geology of the site is Whangamata Ash over Greywacke, and the soil is classified as Central Yellow Brown loams. The climate at the site is semi-tropical, receiving 2000 mm rainfall/year, and has an average annual temperature of 9.4° C.

Mangakahia (FR68/3)

The site is located in Loburns block in Mangakahia Forest (Carter Holt Harvey Forests, formerly NZ Forest Products Ltd.) in Northland. The site was prepared ex-pasture, and planted to radiata pine at 550 sph in 1984. The soil type at the site is a Waimatenui clay/Omu clay loam complex. The site receives 1600-1800 mm rainfall/year, has an average annual temperature of 9.2° C.

The trial designs

Mariri

The design compared 4 treatments:

- without weed control, no fertiliser P
- without weed control, fertiliser P as TSP

- without weed control, fertiliser P as TSP
- without weed control, fertiliser as P (TSP) and N (urea)
- with weed control, fertiliser P as TSP

The rate of P application was 75 kg/ha. All plots were broadcast fertilised with boron (6-8 kg B/ha as ulexite). The experiment was replicated 3 times in randomised blocks. The plots were 30 m x 30 m with inner measurement plots of 20 m by 20 m. The trial was established September 1988. The dominant weed species was gorse, and was controlled by slasher. Regrowth was controlled by spraying.

Tairua

The design compared 6 treatments:

- without weed control, no fertiliser P
- with weed control, no fertiliser P
- without weed control, fertiliser P as SSP
- without weed control, fertiliser P as PARR
- with weed control, fertiliser P as PARR
- with weed control, fertiliser P as SSP

The trial was established in November, 1988. The rate of P application was 75 kg/ha. The treatments were replicated twice as randomised complete blocks. The plots were 30 m x 30 m with inner measurement plots of 20 m x 20 m. The weed species were mainly shrubby hardwoods, ghania and pampas. Weeds were controlled by slashing and spraying with Roundup herbicide.

Mangakahia

The design compared 5 treatments:

- without weed control, no fertiliser P
- without weed control, fertiliser P as TSP

- with weed control, fertiliser P as TSP
- without weed control, fertiliser P as ground phosphate rock (GPR)
- without weed control, fertiliser P as PARR

P was applied at 75 kg/ha; the experiment was replicated 4 times in randomised blocks. The plots were 30 m x 30 m with inner measurement plots of 20 m x 20 m. The trial was established in December 1989.

RESULTS

Tree responses

Mariri

Over the first 4 years there was an accelerating difference between growth in the unfertilised plots, and growth (overall) in the fertilised plots (Fig. 1). After one year the difference was 37%, increasing to 54% and 57% in years 2 and 3. With the individual treatments the addition of P in the presence of weed control tended to slightly increase growth over the P and NP additions in the absence of weed control. The increase in growth to WC in the presence of fertiliser was not statistically significant.

In the absence of WC the P and NP additions significantly raised foliar P concentrations from acutely deficient (0.06 to 0.08%) over the measurement period (Fig. 2) to satisfactory (0.13 to 0.14%) by the second year, and marginal (0.10%) by the third year. However, in the weed controlled plots where P fertiliser was applied, foliar P concentrations remained in excess of 0.11% until the fifth year. The elevation of the foliar P concentrations in the presence of weed control is in line with the marginal improvement in BA growth described above.

Tairua

In the presence of weed control, basal area was improved in the order SSP> PARR (Fig. 3a), although the increase of 2.5 m^2/ha from 25 to 27.5 m^2/ha was not quite statistically significant (P.05). In the absence of weed control, the order of fertiliser effectiveness was reversed: PARR>SSP (Fig.3b); again the increase in BA from 27.5 m2/ha to 30 m^2/ha was not quite statistically significant (P.05). The combined data is shown in Fig. 3c.

Weed control did improve tree foliar P status by about 0.01%, but this was not sufficient to raise P status to satisfactory (Fig. 4a). In the absence of weed control the longer term effect seems to be for the PARR treatment to be more effective the SSP treatment in maintaining elevated foliar P concentrations (Fig. 4b). In the presence of weed control, SSP resulted in elevated foliar P concentrations over the PARR treatment, but the longer term trend may to be one of equivalence or "cross-over", with PARR> or = SSP (Fig. 4c). The combined data is shown in Fig. 4d.

Mangakahia

At this site the addition of P as TSP, either with or without weed control, had no effect of basal area (Fig. 5a). The addition of P as either GPR or PARR (both were applied in the absence of weed control) appears to have marginally, but not significantly (P.05) improved BA over the control by about 2 m^2/ha, with evidence of divergence.

The lack of a marked response to the P fertilisers can be attributed to the "adequacy" of P nutrition in the controls (Fig. 5b) where foliar P varied between 0.13% and 0.15% over the current duration of the trial. The improvement (although not statistically significant) in basal area with the PR fertilisers (applied in the absence of weed control) is associated with a tendency to a slightly higher level of P nutrition (Fig. 5c). The combined data is shown in Fig. 5d.

Foliar P rise and decline

Since foliage samples were not collected at the start of the experiments, and 1 year following application, the collected data is limited in value. However, by assuming that the control values for foliar P for all plots (0.08% at Mariri and 0.06% at Tairua) for the commencement of the trials, and straightening the data for year 1, the foliar P curves are shown in Figures 6a and b for Mariri and Tairua respectively.

At Mariri, little can be said about the nature of the rise, since the first year data is missing (Fig. 6a), but maximum values are reached by the second year, with declines to about 0.10 - 0.11% by the fifth year. At Tairua (Fig.6b) the first year data is probably approximately represented by the interpolation. The SSP treatment reaches maximum foliar P concentration (0.12%) by the fourth year and the PARR treatment continues to rise through to 0.11% by the fifth year.

DISCUSSION

At Mangakahia, soil P fertility was adequate to maintain satisfactory growth, and fertiliser P may not be required. The slight differences in basal area between the TSP and the PR treatments could be continued to be monitored for growth divergence.

At the other two sites (Mariri and Tairua) soil P fertility was catastrophically low as shown by the foliar P status of trees in the unfertilised plots. At these two sites there were significant responses to P and to the practice of weed control. The effects of fertilisation on growth appear to be diverging.

The data gathered suggests that the PARR type fertilisers may have an advantage over the soluble superphosphates in maintaining foliar P levels above the critical level in the

longer term. At Tairua, the performance of trees fertilised with SSP has been superior to the PARR fertilised tress to date in the presence of weed control. This is to be expected since these trees were acutely deficient at the start of the trial, and would respond more quickly to immediately available P from SSP. With time it would be it is possible that the SSP treated trees will decline in foliar P status more rapidly than the PARR treated trees, since the effectiveness of P from SSP may be limited (depending of soil P retention capacity) compared with PARR. The lack of effect of weed control on PARR performance may be explained in terms of supply of P from this fertiliser source being more "balanced" between weeds and pine i.e fast enough for radiata pine, but not fast enough to supply for the growth of weeds.

Early data on the rise and fall in foliar P concentrations suggests an interaction between sites i.e. differences in behaviour of the "change" function with time. These trials should continue to be monitored to follow longer term changes in P nutrition.
As these trials are now at canopy closure and require thinning, they should be permanently marked for to be able to be relocated for foliage sampling.

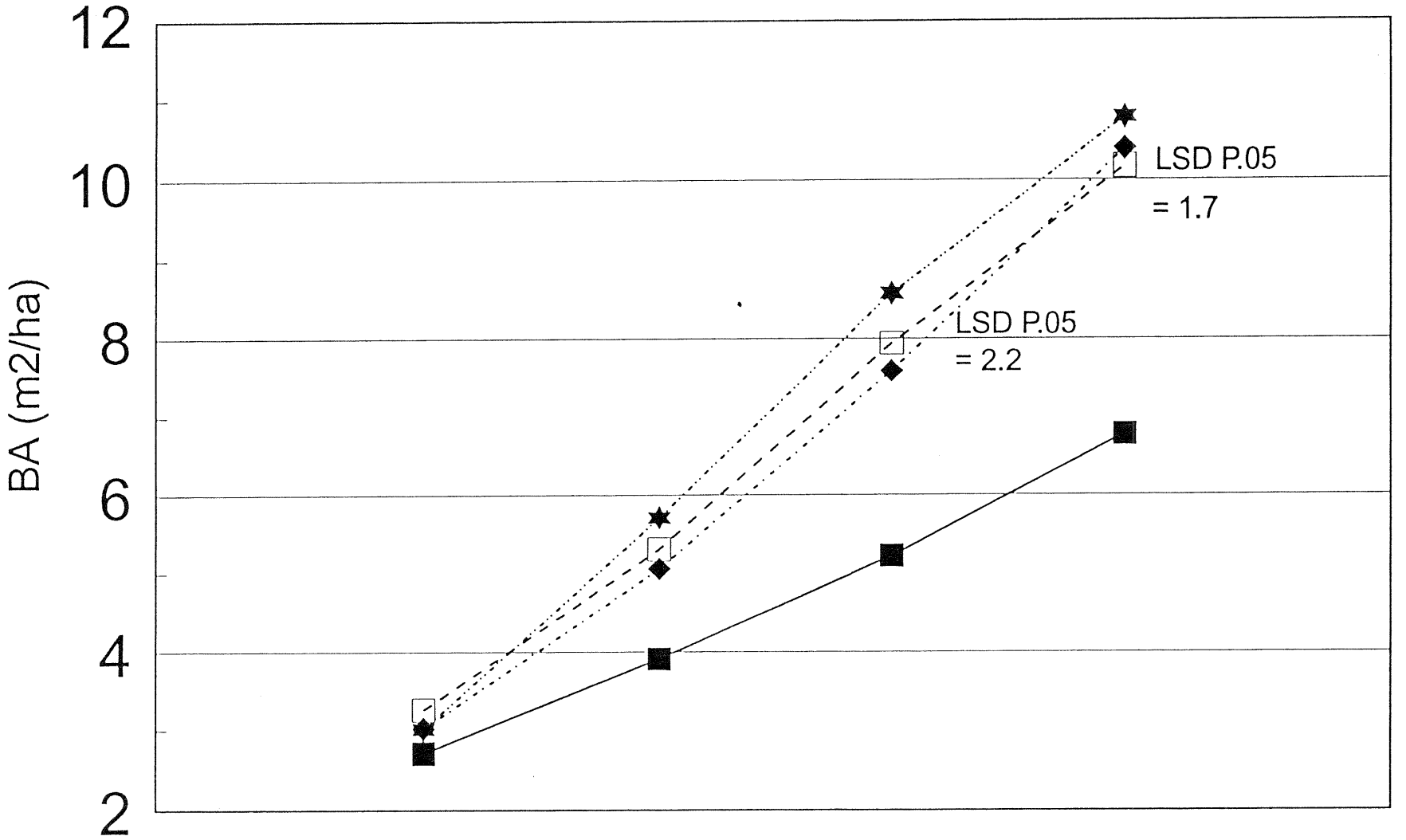
CONCLUSIONS

At two P responsive forest sites there were clear effects of weed control and fertilisation at improving the early P nutrition of young radiata pine. At both sites growth trends suggest divergence in response. The improvement in P nutrition with the PR fertilisers is slower than with the soluble superphosphates, and the studies should continue to compare fertiliser source effectiveness. Evidence is presented for differences between sites in the foliar P "rise and fall" functions

ACKNOWLEDGMENTS

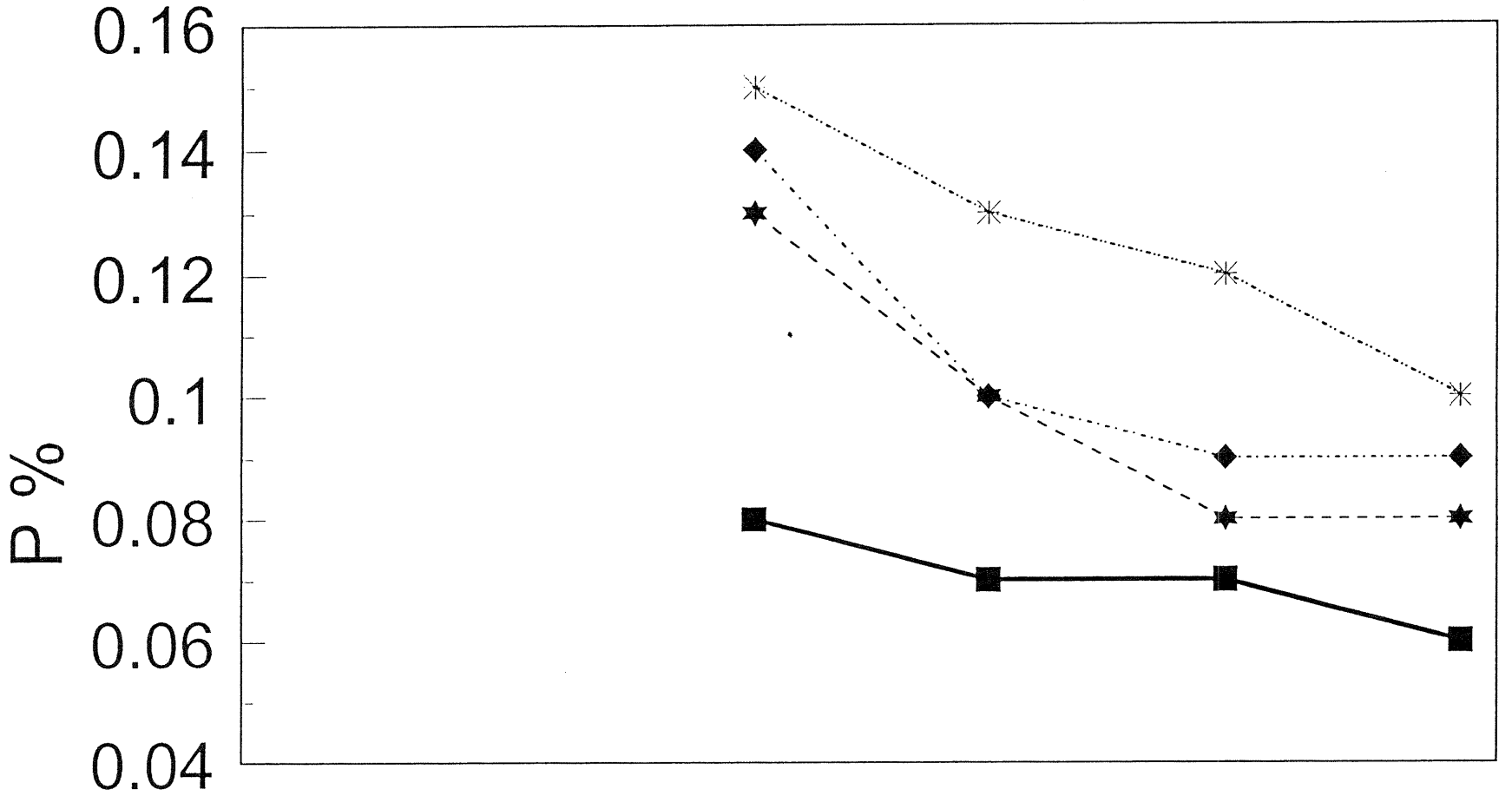
The authors gratefully acknowledge the contribution made by each forest company in the installation, fertilising, weed control, measurement and foliage sampling of the trials, and especially thank Paul Smale, Hank Phibbs and Grant Spencer.

Fig.1. The effect of treatment on basal area at Marirl Forest (FR68/1)



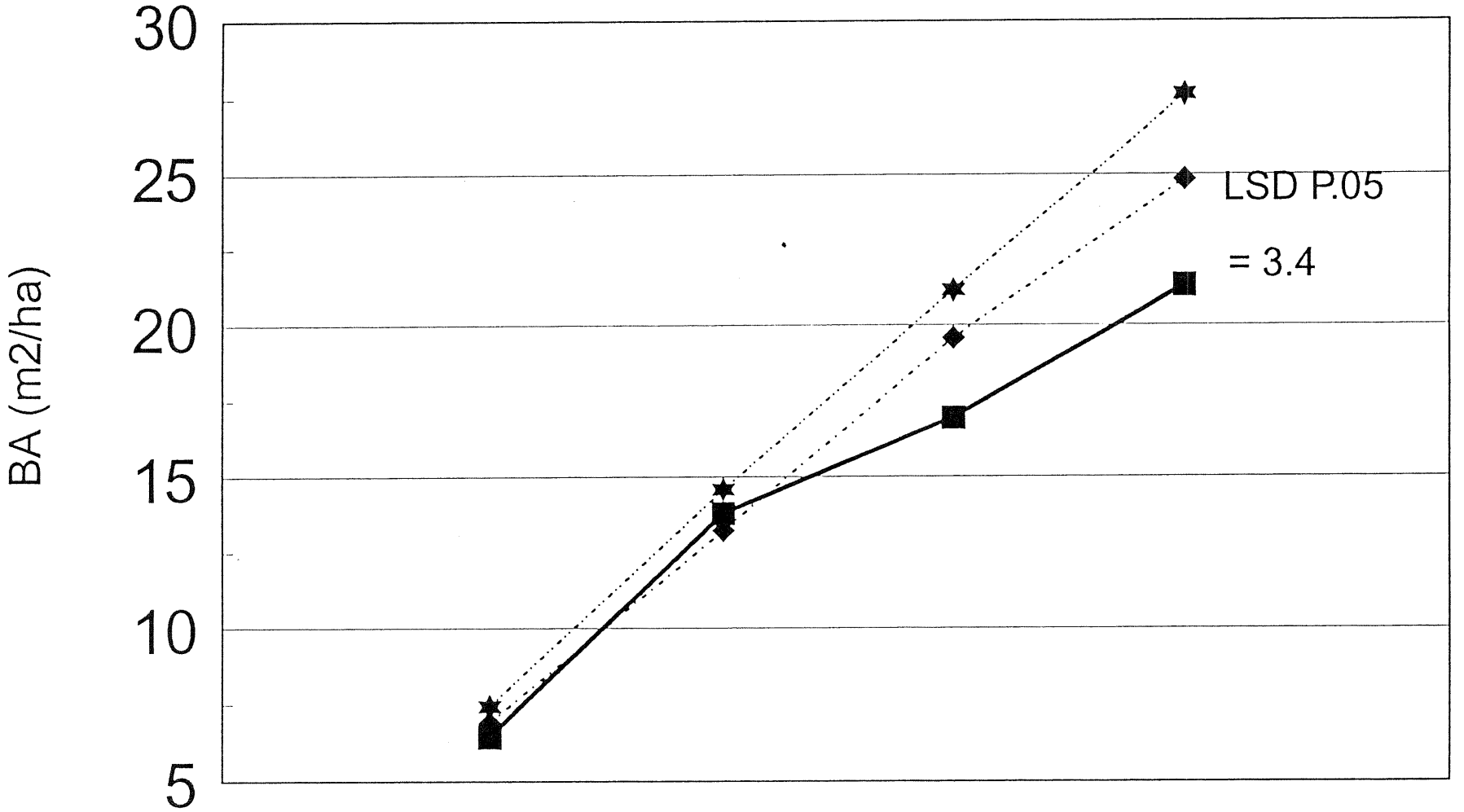
	1988	1989	1990	1991	1992	1993
control ■		2.71	3.91	5.22	6.78	
P ◆		3.02	5.06	7.59	10.39	
P + wc ✸		3.01	5.71	8.58	10.78	
NP ⊟		3.26	5.31	7.94	10.17	

Fig. 2. The effect of treatment on foliar P % at Marlri Forest (FR68/1)



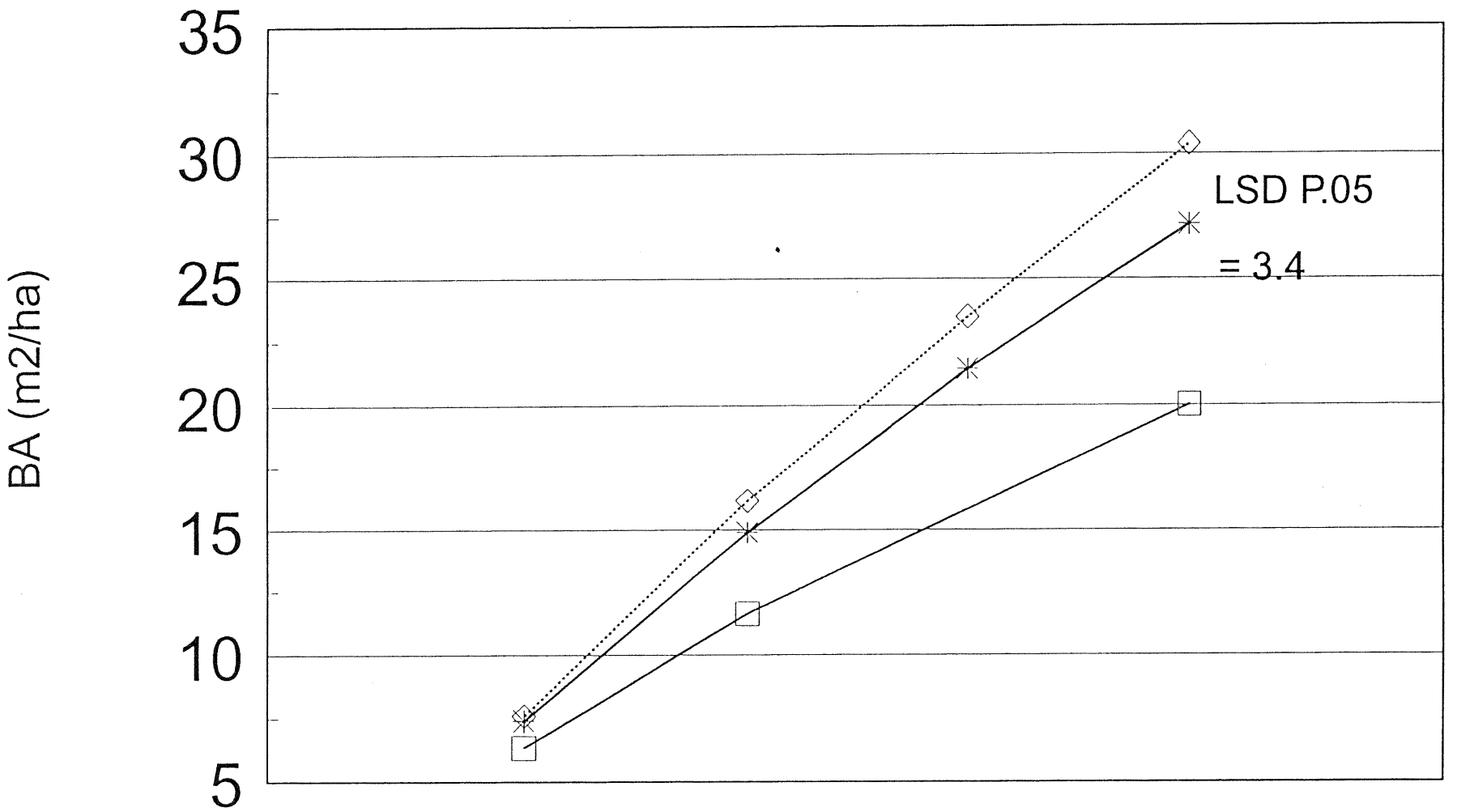
	1988	1989	1990	1991	1992	1993
control ■			0.08 a	0.07 a	0.07 a	0.06 a
P ◆			0.14 b	0.10 b	0.09 b	0.09 b
P + wc ✳			0.15 c	0.13 c	0.12 c	0.10 c
NP ✸			0.13 d	0.10 a	0.08 d	0.08 d

Fig. 3a. The effect of treatment on basal area at Tairua Forest (FR68/2)
No Weed control, SSP, PARR



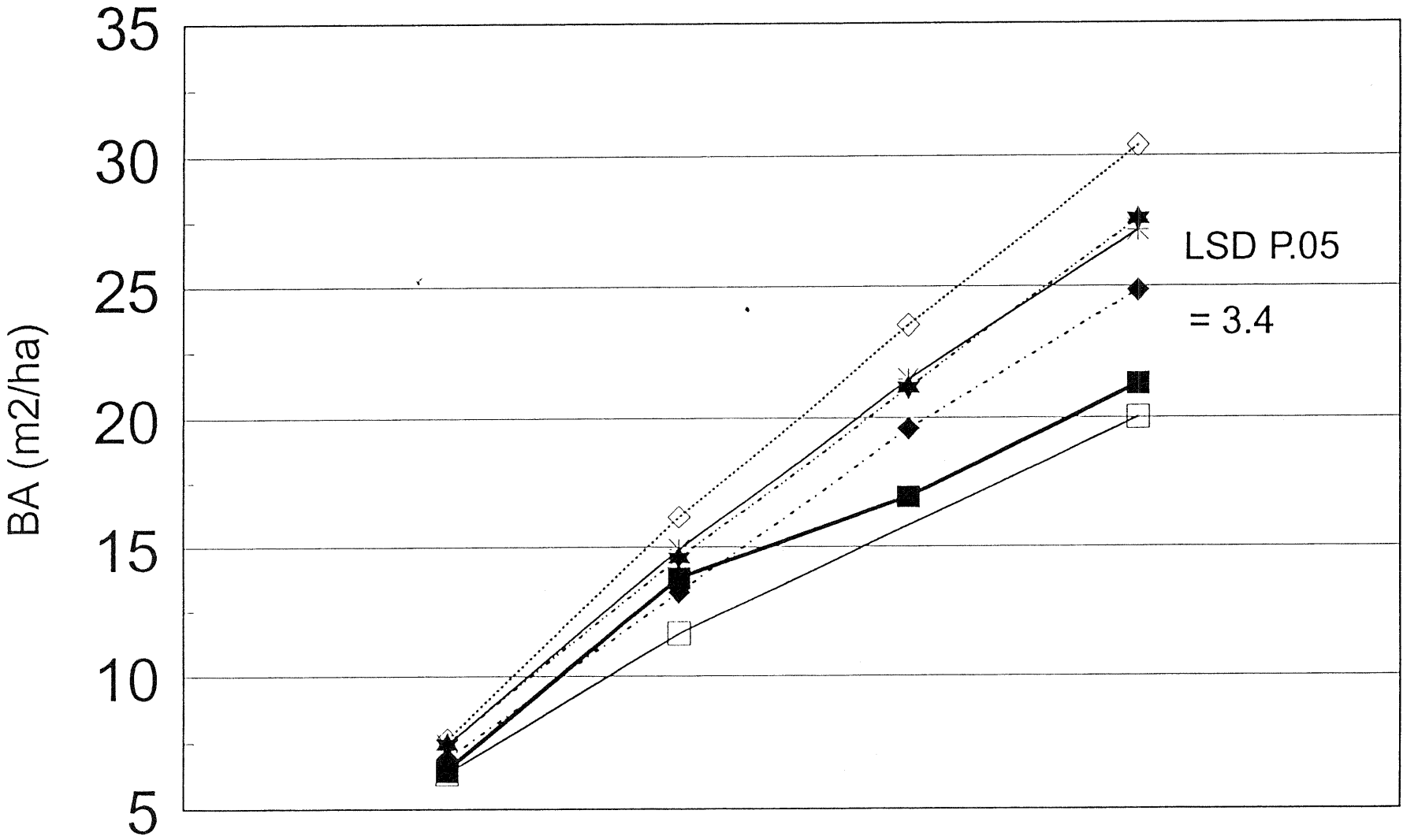
	1988	1989	1990	1991	1992	1993
control		6.46	13.78	16.94	21.29	
super		6.90	13.22	19.58	24.83	
parr		7.44	14.57	21.14	27.61	

Flg. 3b. The effect of treatment on basal area at Talrua Forest (FR68/2)
Weed control, SSP, PARR



	1988	1989	1990	1991	1992	1993
wc		6.35	11.63		20.01	
wc+super		7.61	16.17	23.51	30.39	
wc+parr		7.42	14.90	21.46	27.18	

Flg. 3c. The effect of treatment on basal area at Talrua Forest (FR68/2)



	1988	1989	1990	1991	1992	1993
control		6.46	13.78	16.94	21.29	
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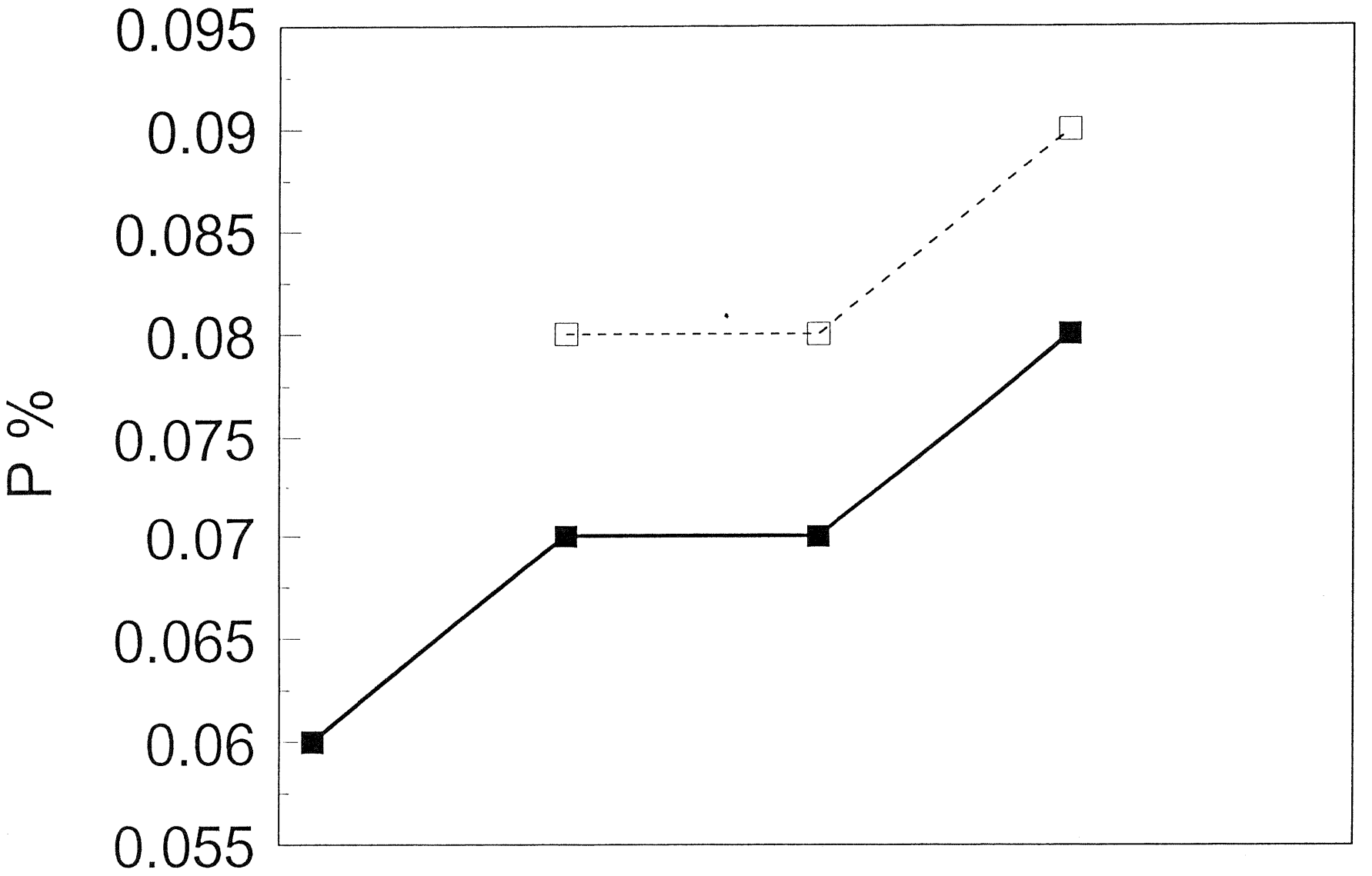
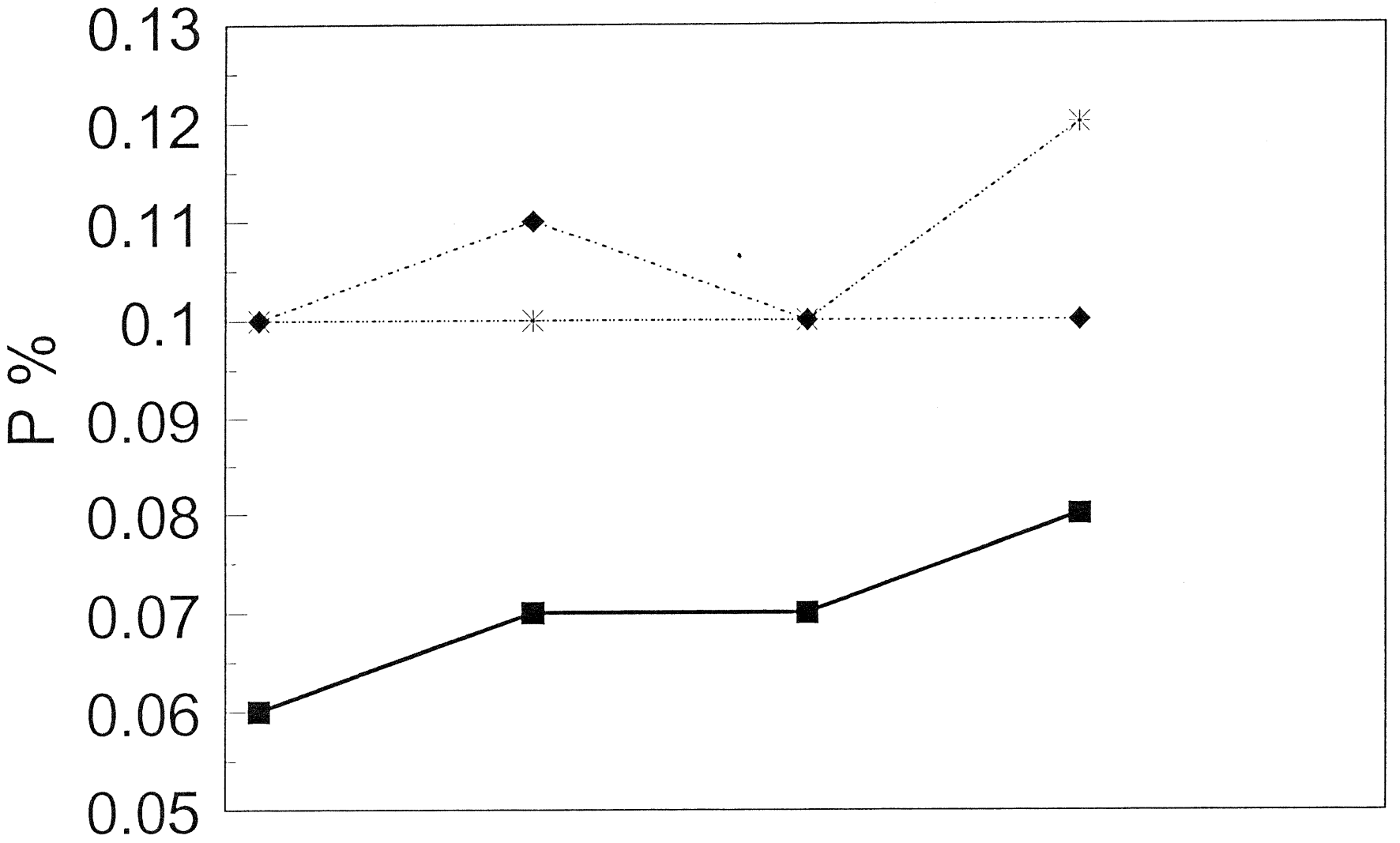
wc+super		7.61	16.17	23.51	30.39	
wc+parr		7.42	14.90	21.46	27.18	

Fig. 4a. The effect of weed control on foliar P % Tairua Forest (FR68/2)



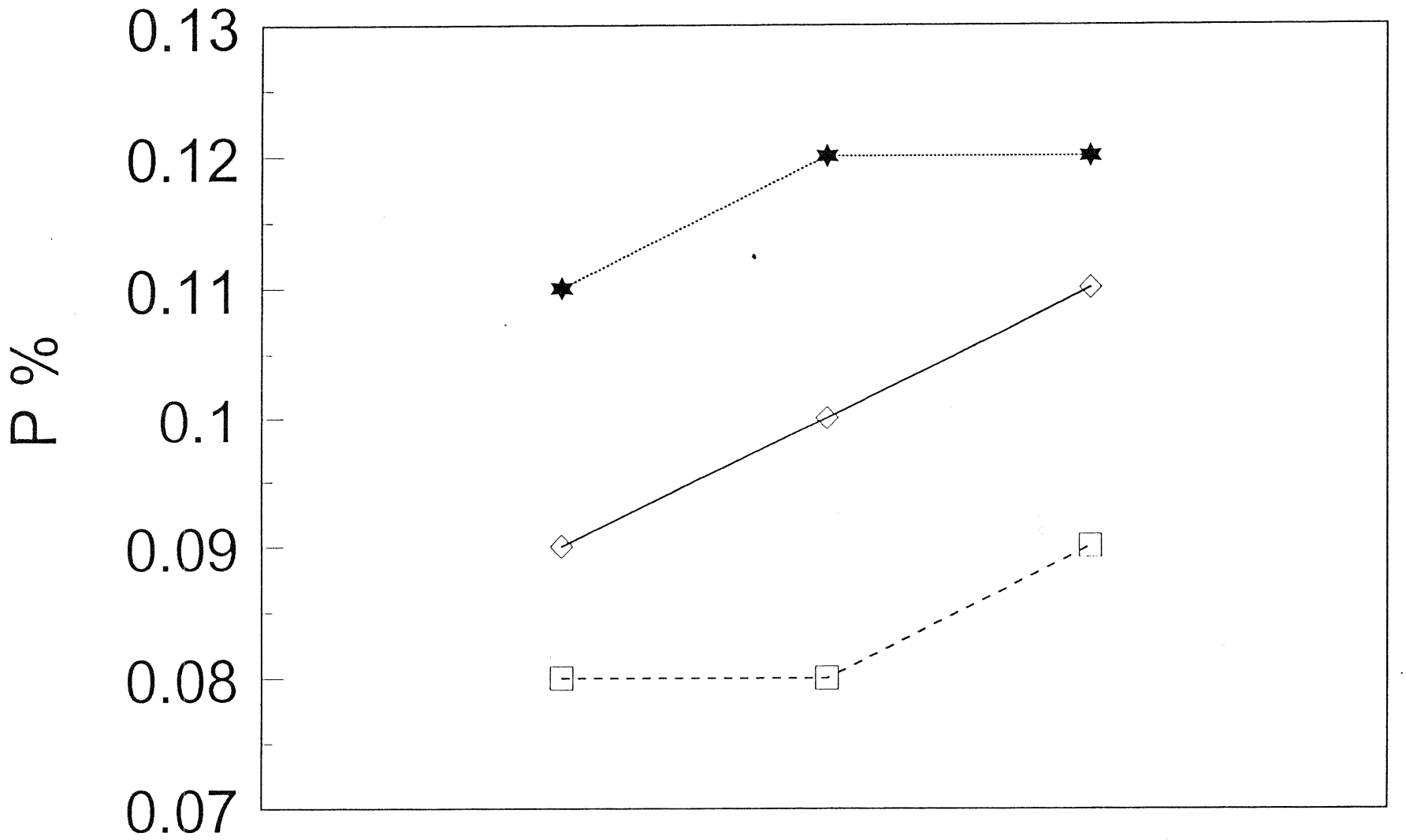
	1990	1991	1992	1993	1994
control ■	0.06	0.07 a	0.07 a	0.08 a	
wc ⊟		0.08 d	0.08 c	0.09 d	

Fig. 4b. The effect of treatment on foliar P % Talrua Forest (FR68/2)
No weed control, SSP, PARR



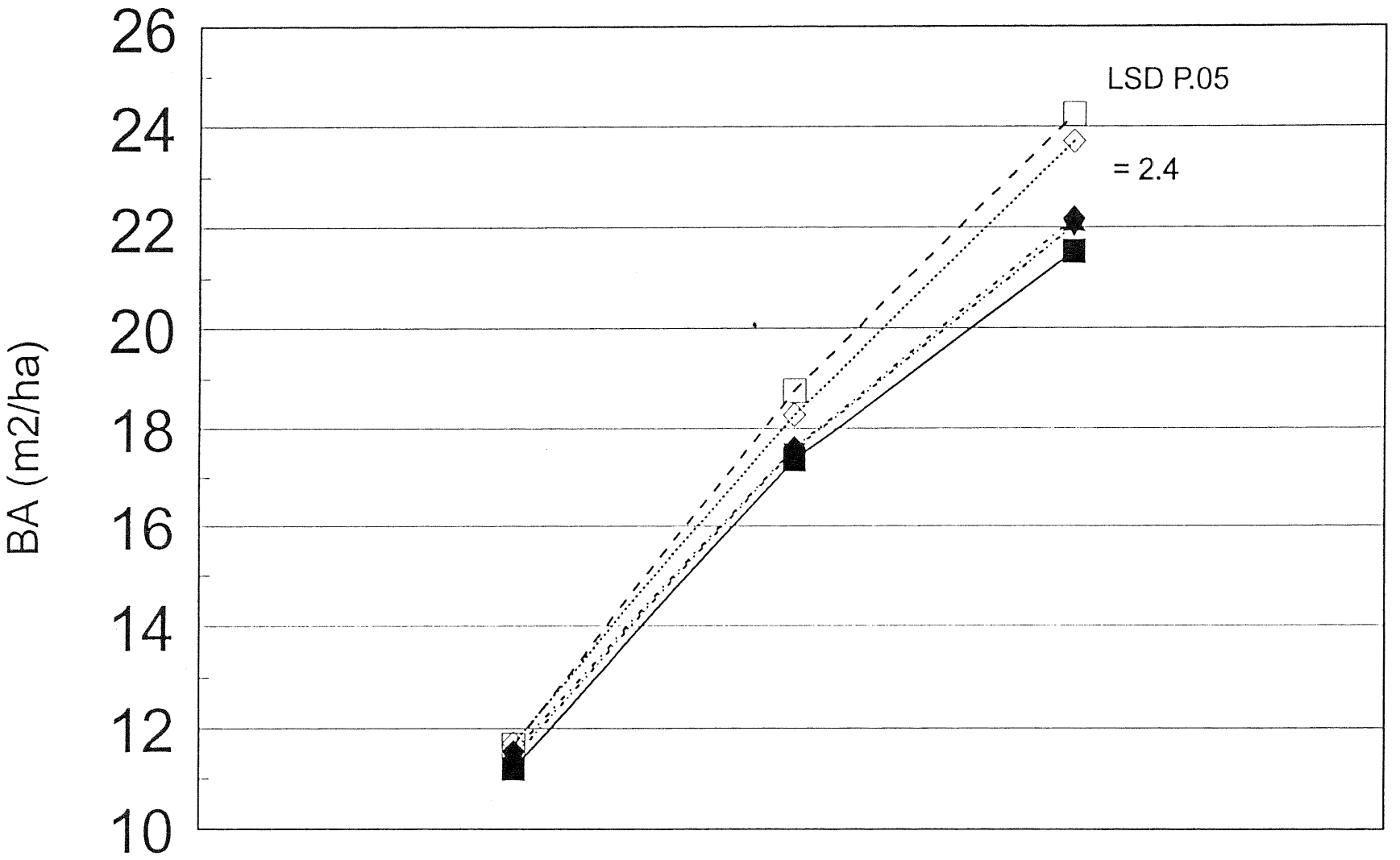
	1990		1991		1992		1993		1994
control ■	0.06	a	0.07	a	0.07	a	0.08	a	
super ◆	0.10	b	0.11	b	0.10	b	0.10	b	
parr ✳	0.10	b	0.10	c	0.10	b	0.12	c	

Fig. 4c. The effect of treatment on foliar P % Tairua Forest (FR68/2)
Weed control, SSP, PARR



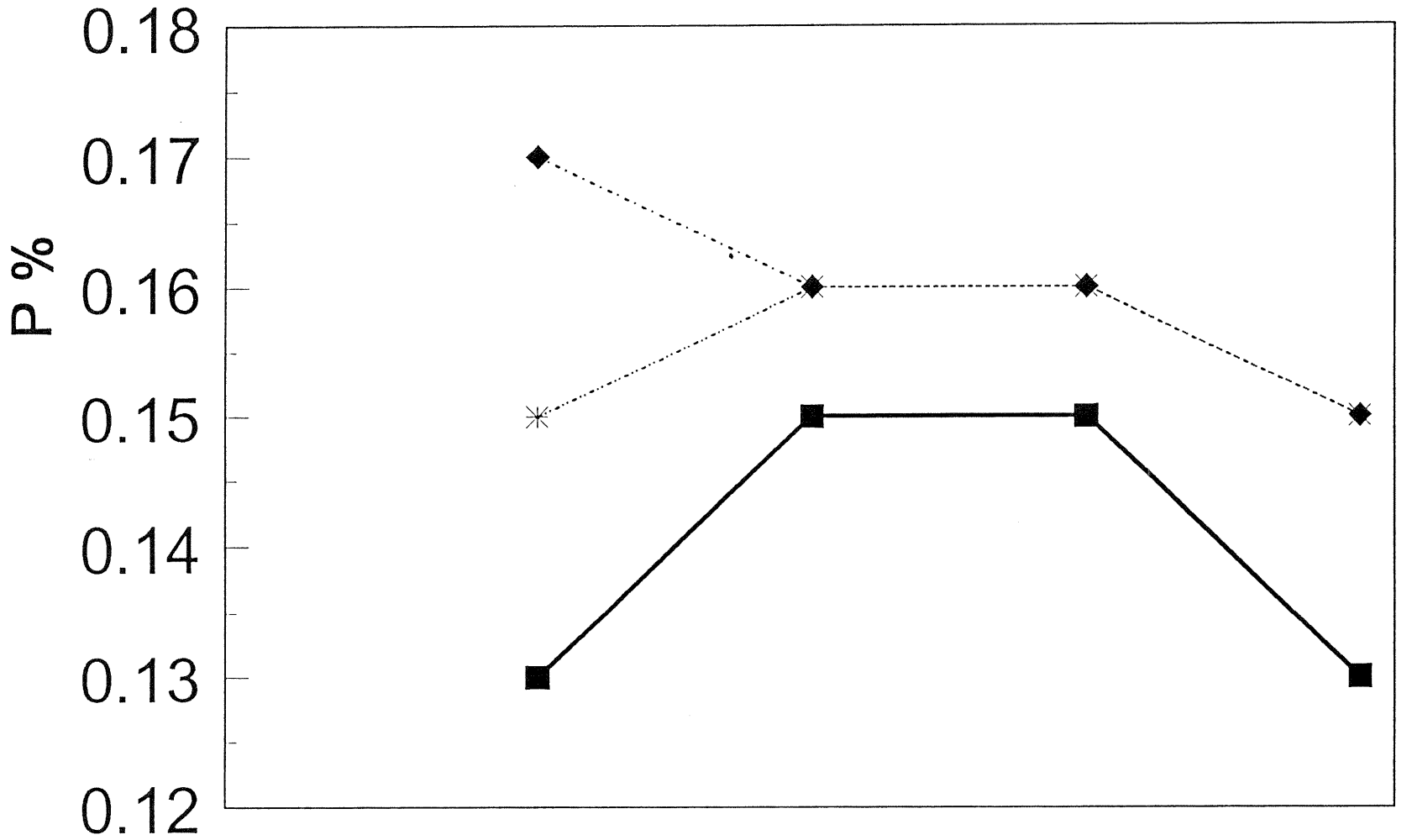
	1990	1991		1992		1993		1994
wc		0.08	d	0.08	c	0.09	d	
wc+super		0.11	b	0.12	d	0.12	c	
wc+parr		0.09	e	0.10	b	0.11	e	

Fig. 5a. The effect of treatment on basal area at Mangakahia Forest (FR68/3)



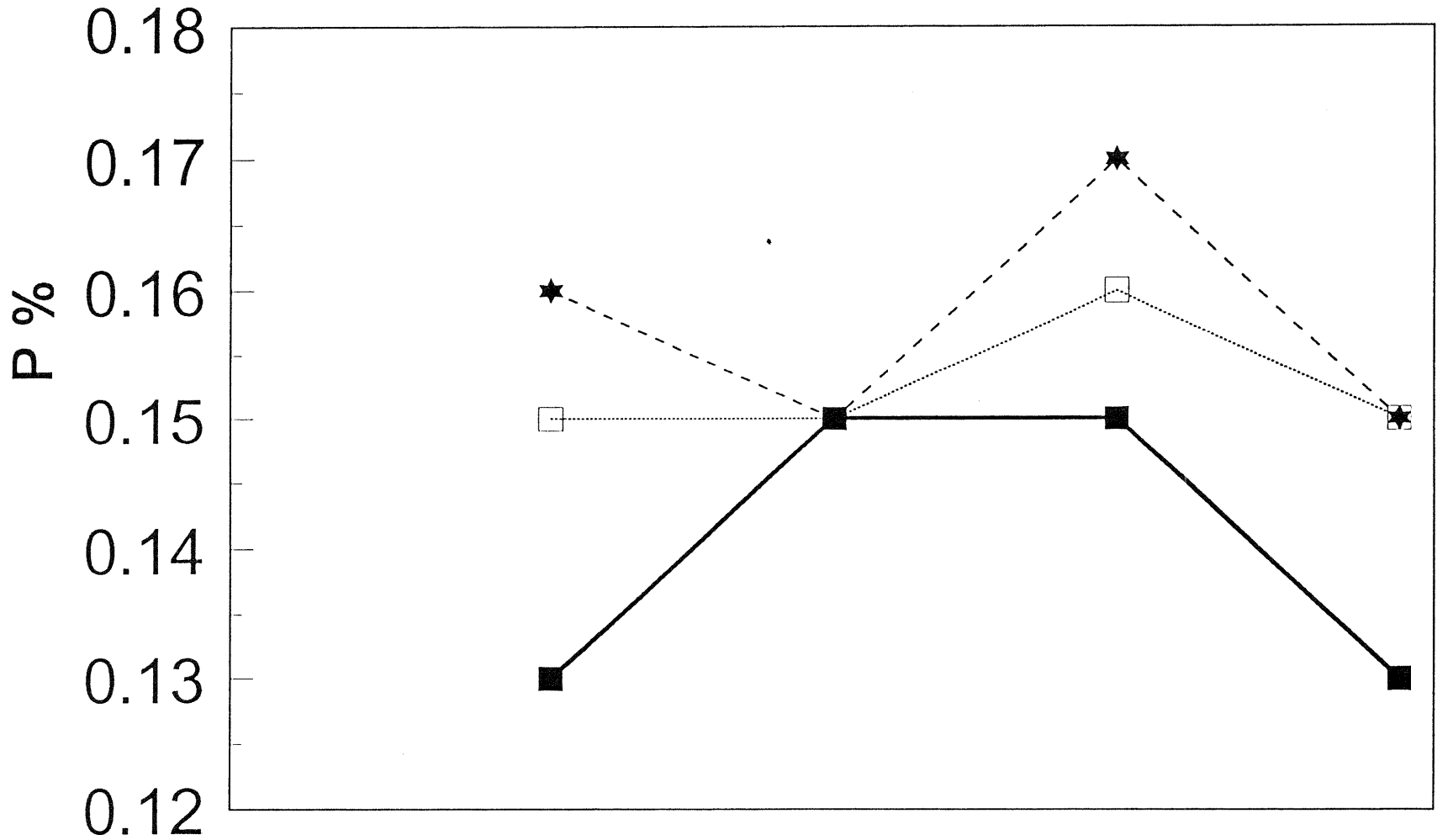
	1989	1990	1991	1992	1993
control ■		11.20	17.36	21.53	
triple ◆		11.55	17.62	22.19	
triple+wc ✸		11.43	17.58	22.04	
GPR ⊟		11.67	18.77	24.25	
PARR ◈		11.71	18.28	23.71	

Fig. 5b. The effect of treatment on foliar P % at Mangakahla Forest (FR68/3)
Weed control, TSP, TSP+WC



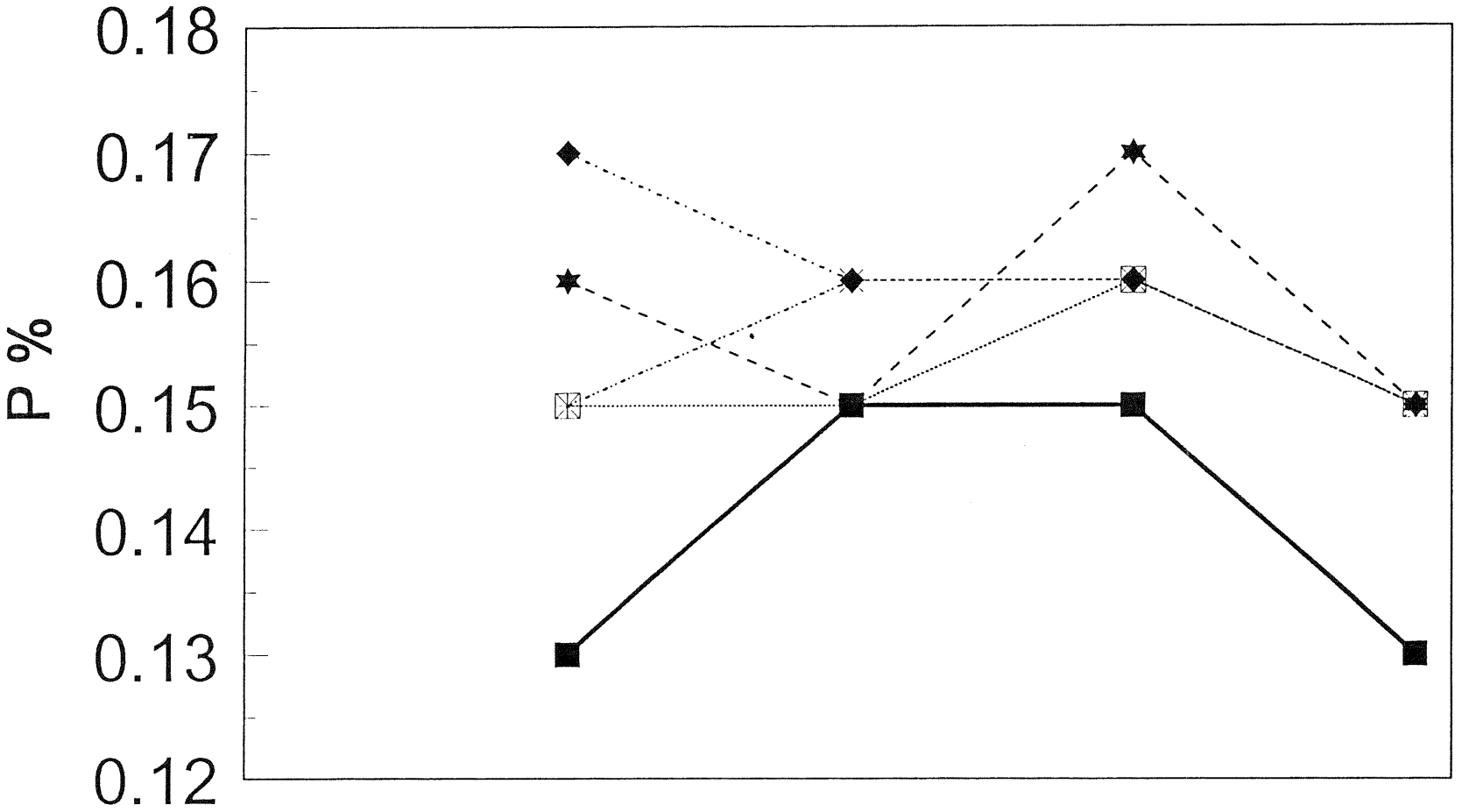
	1990	1991	1992	1993	1994
control		0.13 a	0.15 a	0.15 a	0.13 a
triple		0.17 d	0.16 b	0.16 b	0.15 b
triple+wc		0.15 b	0.16 b	0.16 b	0.15 b

Fig. 5c. The effect of treatment on foliar P % at Mangakahla Forest (FR68/3)
Control, PR, PARR



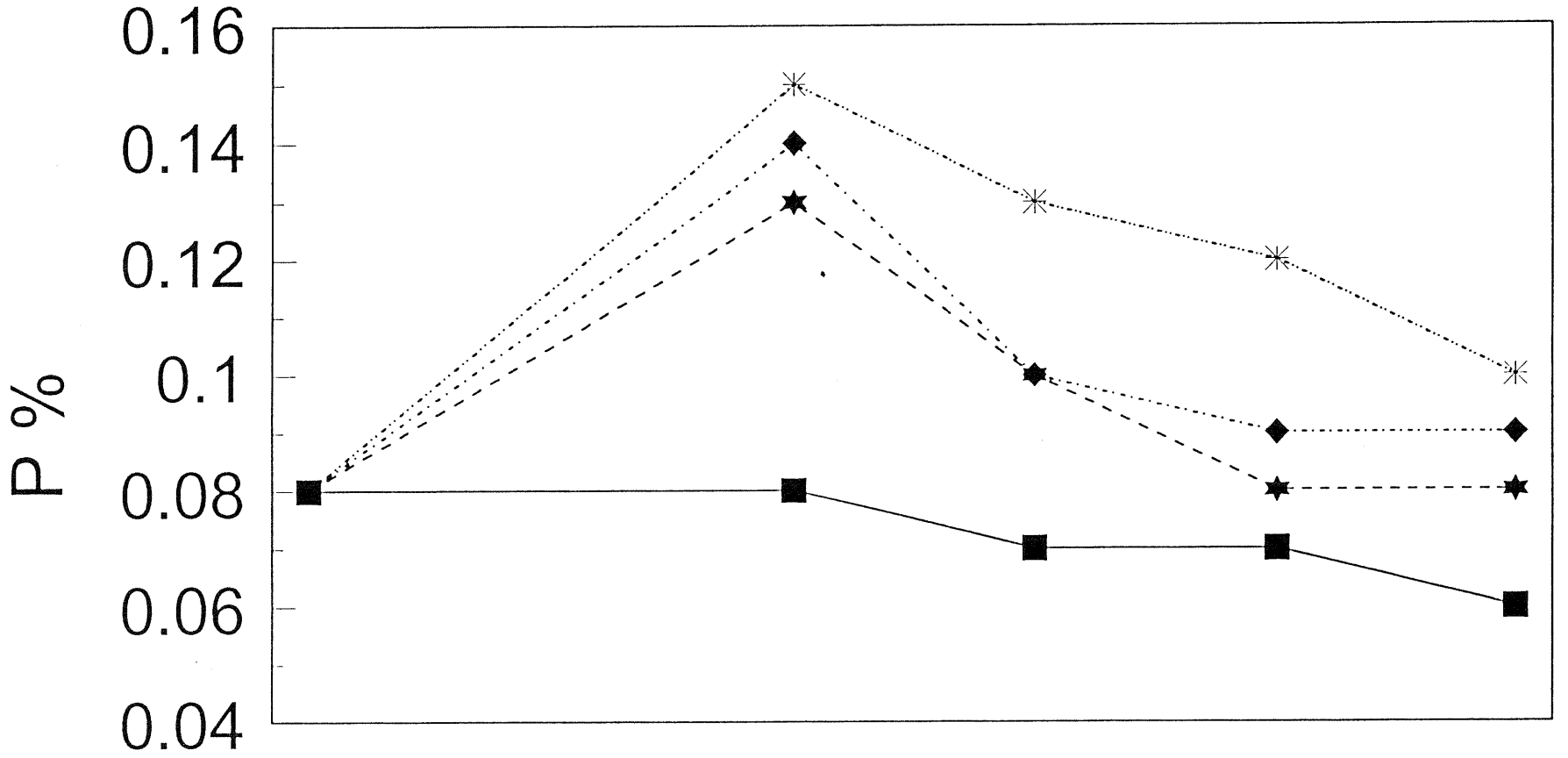
	1990	1991	1992	1993	1994
control		0.13 a	0.15 a	0.15 a	0.13 a
GPR		0.16 c	0.15 a	0.17 c	0.15 b
PARR		0.15 b	0.15 a	0.16 b	0.15 b

Fig. 5d. The effect of treatment on follar P % at Mangakahia Forest (FR68/3)



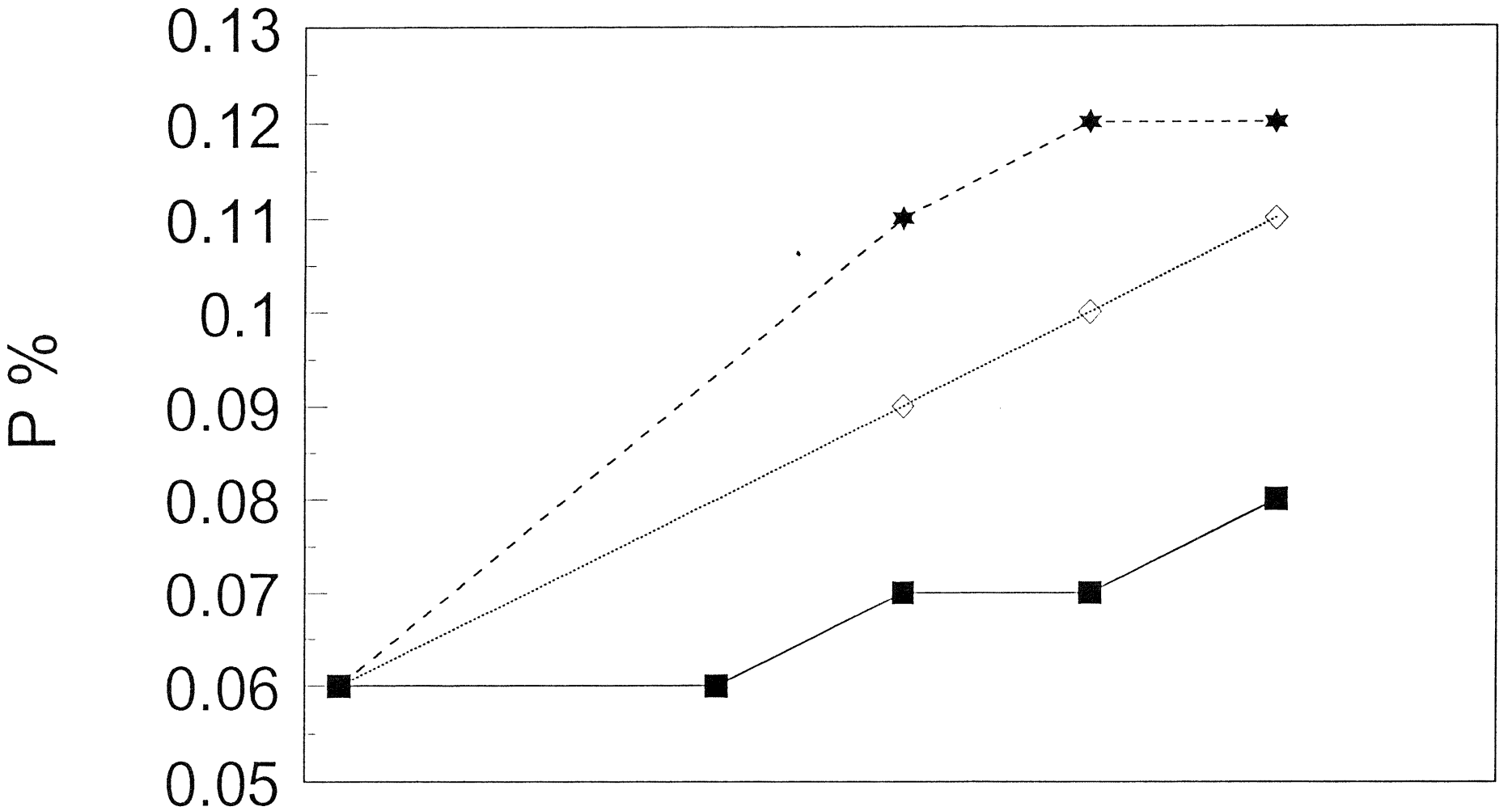
	1990	1991	1992	1993	1994
control		0.13 a	0.15 a	0.15 a	0.13 a
triple		0.17 d	0.16 b	0.16 b	0.15 b
triple+wc		0.15 b	0.16 b	0.16 b	0.15 b
PR		0.16 c	0.15 a	0.17 c	0.15 b
PARR		0.15 b	0.15 a	0.16 b	0.15 b

Figure 6a. Estimated changes in foliar P levels with soluble P at FR 68/1 (Mariri Forest)



	1988	1989	1990	1991	1992	1993
control ■	0.08		0.08 a	0.07 a	0.07 a	0.06 a
P ◆	0.08		0.14 b	0.10 b	0.09 b	0.09 b
P + wc ✳	0.08		0.15 c	0.13 c	0.12 c	0.10 c
NP ★	0.08		0.13 d	0.10 a	0.08 d	0.08 d

Figure 6b. Estimated changes in foliar P levels with P source (in presence of WC) at FR68/2 (Tairua)



	1988	1989	1990	1991	1992	1993	1994
control	0.06		0.06	0.07	0.07	0.08	
wc+super	0.06			0.11	0.12	0.12	
wc+parr	0.06			0.09	0.10	0.11	

COOPERATIVE CHARTER