Jl. Rubb. Res. Inst. Sri Lanka (1992) 72, 15-26

CLONAL DIFFERENCES IN ROCK PHOSPHATE UTILIZATION BY *HEVEA*

D M A P Dissanayake, T Dissanayake, R Gunasekera and
Surani Jayasekera

ABSTRACT

Genotypic variability in utilization of rock phosphates including the local source **Eppawela** was evaluated using *Hevea* clones during the early immature phase. All the clones responded to P fertilization; and the responses were related to the source of fertilizers and other soil characteristics. Plants of clone RRIC 121 utilized Eppawela rock phosphate efficiently, both in Matale and Boralu soils. But, plants of clone RRIC 110 were able to use both rock phosphate sources only in Matale soils. However, response to rock phosphates from plants of RRIC 100 was comparatively low in relation to P uptake and dry matter production. The necessity of testing these clones for the locally available phosphate source in the field scale is also discussed.

INTRODUCTION

Phosphorus is one of the most limiting nutrients for crop production in tropical soils. Besides being deficient in total and extractable P, some of the tropical soils have high P sorption capacities. Adequate P fertilization is therefore essential and it is becoming more and more important to use the most suitable, effective and economic phosphatic fertilizers available (Silva *et. al.,* 1978; Sivasubramanium *et. al.*, 1981; Mullar *et. al.*, 1986).

The need of fertilizers both for immature and mature rubber is well established (Yogaratnam and de Mel, 1985). Nevertheless, the use of chemically treated highly soluble fertilizers to correct P deficiency is a costly process and therefore cheaper alternatives should always be considered where possible. With the discovery of low grade new phosphate deposit, Eppawela, in Sri Lanka, this has become even essential.

Rubber under current plantation practices requires a period of about 5-6 years to attain a `tappable' 50 cm girth and the extent of this unproductive phase is mainly governed by the inherent clonal characteristics, the soil and the nature of agronomic and management inputs (Sivanadyan *et. al.*, 1973). At present a number of new *Hevea* clones have been introduced in Sri Lanka and they vary in their growth pattern and yield potential.

In addition to the soil borne factors, the effective usage of rock phosphates can also be influenced by plant borne factors. Crops capable of yielding satisfactorily may also utilize phosphate rock efficiently but may vary in their ability in utilization of rock phosphate fertilizers under different soil conditions (Van Rajj & Van Diest, 1979: Diest *et.al.*, 1971; Marais *et.al.*, 1970; Bekele *et.al.*, 1983). This has been related to the nutritional characteristics, differences in the extensiveness of root systems and P absorption characteristics of such crops. Nevertheless as these factors have not been properly evaluated in relation to rubber. The experiment reported here investigated the clonal variations of immature rubber with regard to phosphate utilization from rock phosphate.

MATERIALS AND METHODS

Soils

Two types of Sri Lankan rubber growing soils, namely Matale and Boralu were used. Some physico – chemical characteristics of these soils are given in Table 1.

Table 1. *Some physico-chemical characteristics of Matale and Boralu soils.*

Soil	Texture	Organic C%	pH	AER-P (mg/kg)	(AER+CER) -P(mg/kg)	AAE-Ca (mg/kg)
Matale	Silty clay	2.50	4.55	5.57	6.68	65.00
Boralu	Gravelly	1.20	3.91	4.21	5.50	10.50

AER-P – Anion Exchangeable Resin P
(AER+CER)-P – Anion and cation exchangeable resin P
AAE -Ca – Acetic acid extractable P

Fertilizers

Eppawela rock phosphate (ERP) and a rock phosphate fertilizer imported to Sri Lanka from Egypt (IRP) were tested with Triple Super Phosphate (TSP) and no

P fertilizer treatments. Details of the fertilizers are given in Table 2.

Table 2. *Phosphorus contents of fertilizers.*

Fertilizer	Total P_2O_5 content%	Citric acid soluble P%*	Water soluble P%*
ERP	11.50	10.10	0.04
IRP	28.50	30.00	0.05
TSP	53.80	81.35	0.07

* Expressed as a percentage of the total P content.

Experiment

Clones RRIC 100, RRIC 110 and RRIC 121 which are currently cultivated in rubber plantations in Sri Lanka were used in this experiment.

55kg of air dried soil (<6mm) was thoroughly mixed with ERP, IRP, and TSP separately and filled into plastic pots (18" diameter and 20" height). Urea, muriate of potash and kieserite were also thoroughly mixed with these soils to provide N,K and Mg. Fertilizers required for the 9 months were applied according to the current fertilizer recommendations of the Rubber Research Institute of Sri Lanka (Yogaratnam, 1983). Accordingly, 88g of IRP, 80.9g of ERP and 54.5g of TSP were added as treatments and 46g of urea, 41g of muriate of potash and 75g of kieserite were added as an uniform application.

Budded stumps of different clones were planted in pots and they were buried in soil in the field according to a fully randomized design. Prior to placing of pots in holes, washed sand was added at the bottom of holes to make 1 foot thick layer to prevent nutrient absorption from soils outside the pot. Pots were watered during dry days, and weeded when ever necessary.

After a period of 9 months, plants were harvested. Leaf blades, petioles, bark and feeder roots were separated, oven dried and dry weights were recorded. Sub-samples of ground plant materials were subjected to acid digestion and P in the extract was determined by an automated colorimetric method with molybdate/vandate reagent. Ca was determined using atomic absorption spectrophotometer.

Soils were air dried, sieved thorough 2 mm sieve and resin exchangeable P was analyzed (Dissanayake, 1992). Soil pH was determined using 0.01 M $CaCl_2$ solution (1:2.5 ratio).

Analysis of variance for different assessments and contrast analysis were carried out. Mean comparisons between treatments were performed using Duncan's Multiple Range Test.

RESULTS

Clonal differences in P uptake

The different clones varied in their behavior in phosphate uptake as measured in various parts of the rubber plants. There was a significant interaction between soils and clones on P uptake in leaf petioles ($P<0.01$) and bark ($P<0.05$). But P uptake by roots and leaves was not different between clones. The clone RRIC 121 showed higher uptake of phosphorus in leaf petioles and bark compared with clones RRIC 100 and 110. But this clonal difference was observed only in Boralu soil. In Matale soil, all the clones behaved in a similar manner in relation to P uptake in leaf petioles. But the bark P uptake was significantly lower in plants of RRIC 100 compared with clone RRIC 110 (Table 3).

Table 3. *Phosphorus uptake by three clones grown in Boralu and Matale soils*

Clone	P uptake (mg/pot)			
	Leaf Petioles		Bark	
	Boralu	Matale	Boralu	Matale
RRIC 121	43.04^{A}	34.46^{A}	19.57^{A}	23.97^{AB}
RRIC 110	14.89^{B}	36.74^{A}	10.24^{B}	31.01^{A}
RRIC 100	15.90^{B}	38.04^{A}	9.12^{B}	18.43^{B}

Similar results were observed in P uptake by shoots, and when the whole plant was considered. Clone RRIC 121 performed well in Boralu soil compared with other two clones as shoot P uptake and total P uptake were significantly higher than RRIC 100 and 110. But all clones behaved in a similar way showing no differences among them when they grew in Matale soils (Table 4).

Table 4. *Phosphorus uptake in shoots and in total plants of different clones grown in Boralu and Matale soils.*

Clone	Shoot P uptake(mg/pot)		Total P uptake (mg/pot)	
	Boralu	Matale	Boralu	Matale
RRIC 121	229.09^{A}	196.43^{A}	265.94^{A}	305.08^{A}
RRIC 110	113.58^{B}	280.99^{A}	165.02^{B}	370.86^{A}
RRIC 100	101.13^{B}	220.47^{A}	141.60^{B}	298.03^{A}

Clonal differences in dry matter production

A significant interaction was observed between soils and clones on dry matter production in leaf (P<0.05) and bark (P<0.05). Dry matter production in both leaves and bark was higher in plants of clone RRIC 121 than in RRIC 100 and 110 when they were grown in Boralu soil. However, these clones did not vary in their ability for dry mater production when grown in Matale soils (Table 5).

Table 5. *Dry matter production of different clones grown in Boralu and Matale soils (g/pots).*

Clone	Leaves		Bark	
	Boralu	Matale	Boralu	Matale
RRIC 121	71.78^{A}	62.37^{A}	10.94^{A}	19.96^{A}
RRIC 110	35.98^{B}	80.19^{A}	5.48^{B}	14.33^{A}
RRIC 100	32.75^{B}	72.26^{A}	6.35^{B}	13.70^{A}

Application of phosphate fertilizers significantly enhanced P concentration in bark (P<0.01), petioles (P<0.01), leaves (P<0.05) and roots (P<0.05) of rubber plants. Higher P concentration was observed in roots only when plants were fed with IRP, and not when they were fed with ERP (P<0.01).

With regard to vegetative growth of plants, phosphate fertilization significantly influenced dry matter production in bark (P<0.05) and leaves (P<0.01), but not in roots. The ability to take up P and produce dry matter by each clone varied in relation to different phosphate fertilizers. Dry matter production of plants was highly correlated with P uptake in both Boralu and Matale soils (Fig. 1,2,3). The clone RRIC 110 showed its ability to utilize both ERP and IRP effectively only in Matale soil as bark, leaf and total P uptake was comparatively high. However, this particular clone produced high amount of dry matter in the plant when they were fed with ERP compared to IRP in Boralu soil. The ability to utilize ERP by the clone RRIC 121 was higher in Matale soil compared with its ability to utilize IRP in the same soil as dry matter production was more in bark, leaf and the total plant when plants were fed with ERP. But this clone produced the lowest amount of dry matter when they were fed with IRP. However, RRIC 121 plants showed their ability to utilize both ERP and IRP in Boralu soil as dry matter production was comparatively high with these two fertilizers. Also, these plants showed the highest P uptake in Boralu soil when fertilized with ERP.

Total P uptake in plants of clone RRIC 100 was probably low, which led to the production of low amounts of dry matter with IRP in Matale soil than with other fertilizer sources. But, utilization of both rock phosphates by plants of this particular clone was fairly satisfactory in Boralu soil.

Effect of different clones on soil P content

A significant interaction ($P<0.05$) between clones and soils was observed on available soil P. Irrespective of P sources, plants of clone RRIC 121 showed their ability to influence the soil P content than by plants of clone RRIC 100 especially in Boralu soil. However, the behavior of both RRIC 100 and 110 was similar in this soil in relation to available P content. But these two clones behaved differently in Matale soil. However, plants of clones RRIC 100 and RRIC 121 showed similar effects in Matale soil on available P content (Table 6).

Table 6. *Effect of different clones on absorbing soil phosphate content*

Clone	(AER+CER) – p mg/kg	
	Boralu	Matale
RRIC 121	39.23^{A}	29.52^{AB}
RRIC 110	32.75^{AB}	25.16^{B}
RRIC 100	23.72^{B}	34.41^{A}

(AER+CER)–P – Anion and cation exchangeable resin P

DISCUSSION

It was reported that plant species and even varieties of the same species differ in their ability to grow on soils low in P and thereby varying in their ability to utilize rock phosphate (Freid, 1953; Fohse *et.al.*, 1988). In relation to rubber, this was highlighted and clonal differences in P utilization ability of *Hevea* from rock phosphates appear to exist.

All clones responded to P fertilization which indicated that P was indeed limiting growth of the immature rubber plant although this is generally not the case for mature rubber plants (Yogaratnam *et al*,1984). In general, clones varied in their ability to use P and it was related to the source of fertilizer and other soil characteristics. It is known that the clones RRIC 110 and 121 show vigorous growth during the first four years than RRIC 100 (RRISL, 1984 & 1985). This makes it possible to explain the effective utilization of rock phosphates by the two clones RRIC 110 and RRIC 121 during their growth at the early stages, as fast growing plants are known to show a high P uptake (Khasawneh & Doll, 1978). In RRIC 110 and 121, their total P uptake was higher than in RRIC 100. It is also known that both RRIC 110 and 121 produce higher amounts of latex yield than RRIC 100 over a period of seven years after tapping commences. RRIC 121 initially starts with a lower yield and it increased at a higher rate as the tree matures and also showed a greater yield potential than clone RRIC 110 (Jayasekera, personal communication). In this study also the clones RRIC 121 and 110 recorded higher dry matter production than clone RRIC 100.

The effective utilization of IRP in Boralu soil and ERP in Matale soil by RRIC 121 and 110 respectively could be expected because these two sources displayed a greater dissolution rate in these soils (Dissanayake, 1992). Although, the clone RRIC 121 showed its ability to utilize both sources of rock phosphates in Boralu inspite of the fact that ERP was less soluble in this soil. Clone RRIC 121 is capable of uptaking higher amount of P than other two clones in Boralu soil where phosphate fixation was reported to be high (Silva *et.al.*, 1978). The clone RRIC 110 was capable of utilizing P from IRP in Matale soil effectively although IRP was reported to be less soluble in this soil (Dissanayake, 1992). But, the clone RRIC 100 responded poorly to application of rock phosphates although P uptake was recorded to be high in Matale soil. These results clearly show that the ability of clones to utilize rock phosphate fertilizers varied with the soil and the source of P. Rubber under current plantation practices requires a period of about 6 to 9 years to reach the standard tappable girth of 50 cm. This immature period amounts to about 20%–33% of the trees life cycle. The drag of this unproductive period is governed mainly by the inherent clonal characteristics other than the soil and management practices.

But, only very little information available on rubber clones used in this study. This is mainly because they were introduced very recently to the rubber industry in Sri Lanka. On the otherhand, under the conditions of rubber growing areas, P is not limited and therefore not a problematic element for the functions of the mature rubber tree and less attention has therefore been given previously to phosphate nutrition. However, after discovery of the rock phosphate deposit, ERP, in Sri Lanka there is considerable interest in investigating the suitability of this source for rubber.

Findings of this study may therefore be useful in exploring the possibility of introducing ERP as a P source especially for clones RRIC 121 and 110 for economy reasons as IRP which is imported from Egypt is the only source currently recommended for immature rubber.

ACKNOWLEDGEMENT

It is with pleasure we place on record our sincere gratitude and grateful thanks to Dr N Yogaratnam, Deputy Director Research for his constant help, guidance and encouragement throughout this study.

REFERENCES

Bekele, T; Cino, B J; Ehklert, P A I; Van Der Mass, A A and Van diest, A (1983). An evaluation of plant – borne factors promoting the solubilization of alkaline rock phosphates. *Plant and Soil* **75**: 361–378.

Diest, J; Marais, P G; Harry, R B A and Heyns, C F G (1971). Relative availability of rock phosphate to different plant species. *Agrochemophysica* **3**: 35–40.

Dissanayake, D M A P (1992). Plant and soil factors influencing the availability of phosphorus from natural phosphate sources, PhD Thesis, University of Aberdeen, Scotland, United Kingdom.

Fohse, D N Claasen and Jungk, A (1988). Phosphorus efficiency of plants I. External and internal P requirement and P uptake efficiency of different plant species. *Plant and soil* **110** : 101 –109.

Freid, M (1953). The feeding power of plants for phosphates. *Soil Sci. Am.* **17**: 357–359.

Khasawneh, F E and Dall, E C (1978). The use of phosphate rock for direct application to soils. *Advances in Agronomy* **30**: 159–206.

Marais, P J; Diest, J; Harry, R B A and Heyns, C F G (1970). Availability of different plant species to absorb phosphate. *Agrochemophysica* **2**: 7–12.

Mullar, S O Hagemann and Ansorge, H (1986). The effect of various phosphorus fertilizers on yields. Phosphorus uptake by plants and conversion of phosphorus fertilizers in long term experiments on different soils. *Fertilizer Research* **10**: 231– 236.

RRISL (1984, 1985) Annual Reviews Rubber Research Institute of Sri Lanka

Silva, C G S; Kumarakulasuriyar, S and Wickremasinghe, L J (1978). The efficient use of phosphatic fertilizer in relation to the phosphorus fixing capacities of the rubber soils. *J. Rub. Res. Inst. Sri Lanka* 54 (1) No. 2; 263–269.

Sivanadyan, K; Said, M B M; Khee, W Y; Kwi, S N and Pushparajah, E (1973). Agrononomic practices towards reducing period of immaturity, *RRIM Planters' Conference, Rub. Res. Inst. Malaya.*

Sivasubramaniam, S; Wickremasinghe, K N and Ayadurai, S (1981). The use of Eppawela apatite for tea in Sri Lanka. *Tea quarterly* **50** (1), 4–10.

Van Rajj, B and Van Diest (1979). Utilization of phosphate from different sources by six plant species. *Plant and Soil* **51**; 577 –589.

Yogaratnam, N (1983). Fertilizing of rubber and associated cover crops. *A Hand Book of Rubber Culture and Processing*. Ed. by O S Peries and D M Fernando, RRISL, 85–98.

Yogaratnam, N; Silva, F P W and Weerasuriya, S M (1984). Recent developments in the nutrition of *Hevea* in Sri Lanka. *Proceedings of the Int. Rub. Conference, Colombo.*

Yogaratnam , N and de Mel, J G (1985). Effect of fertilizers on leaf composition of NPK in some *Hevea* cultivars. *J. Rub. Res. Inst. Sri Lanka* **63**: 17–25.

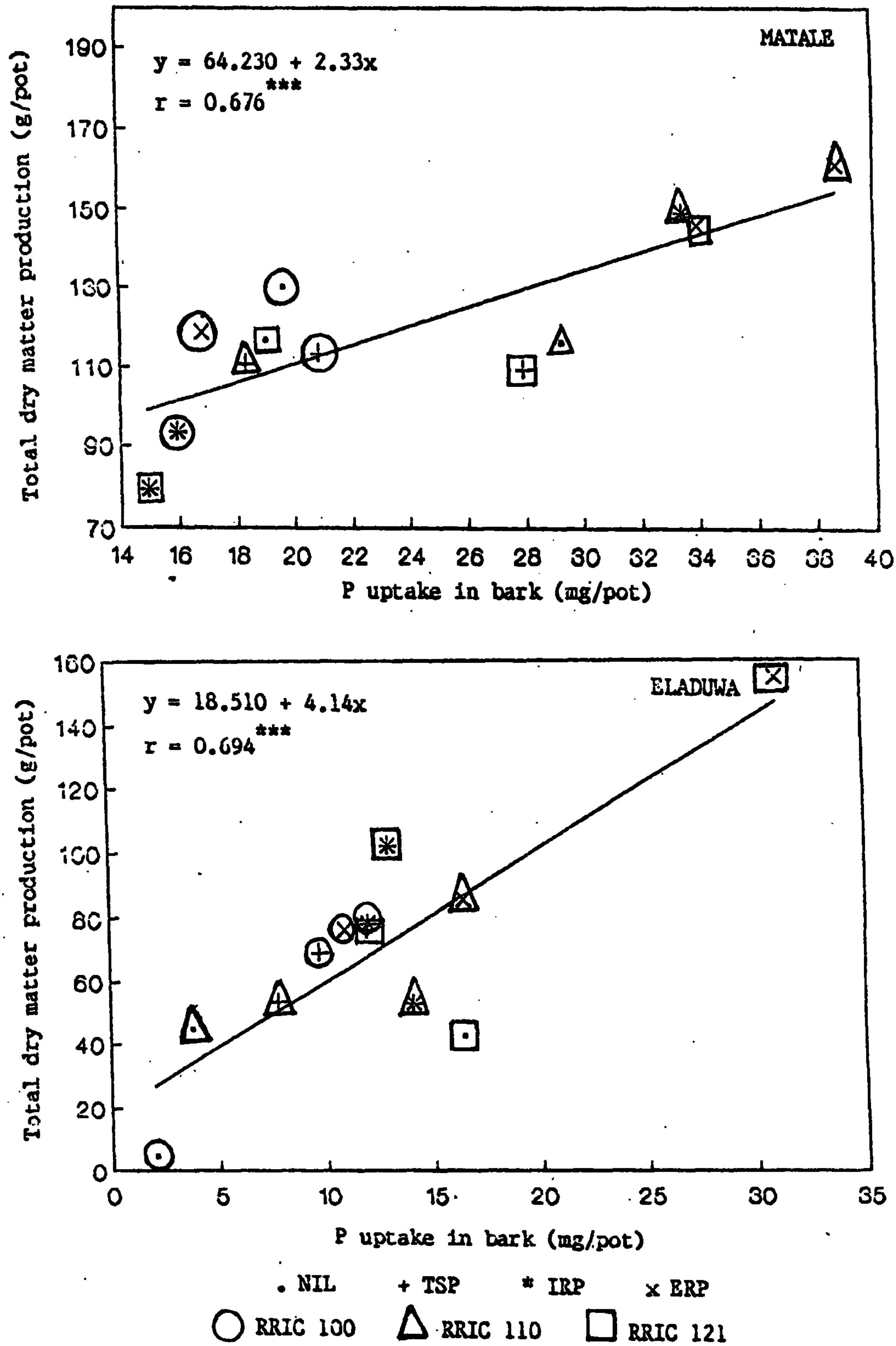

Fig. 1 Relationship between P uptake in bark and total dry matter production in plants of different clones that received P fertilizers in Matale and Eladuwa soils

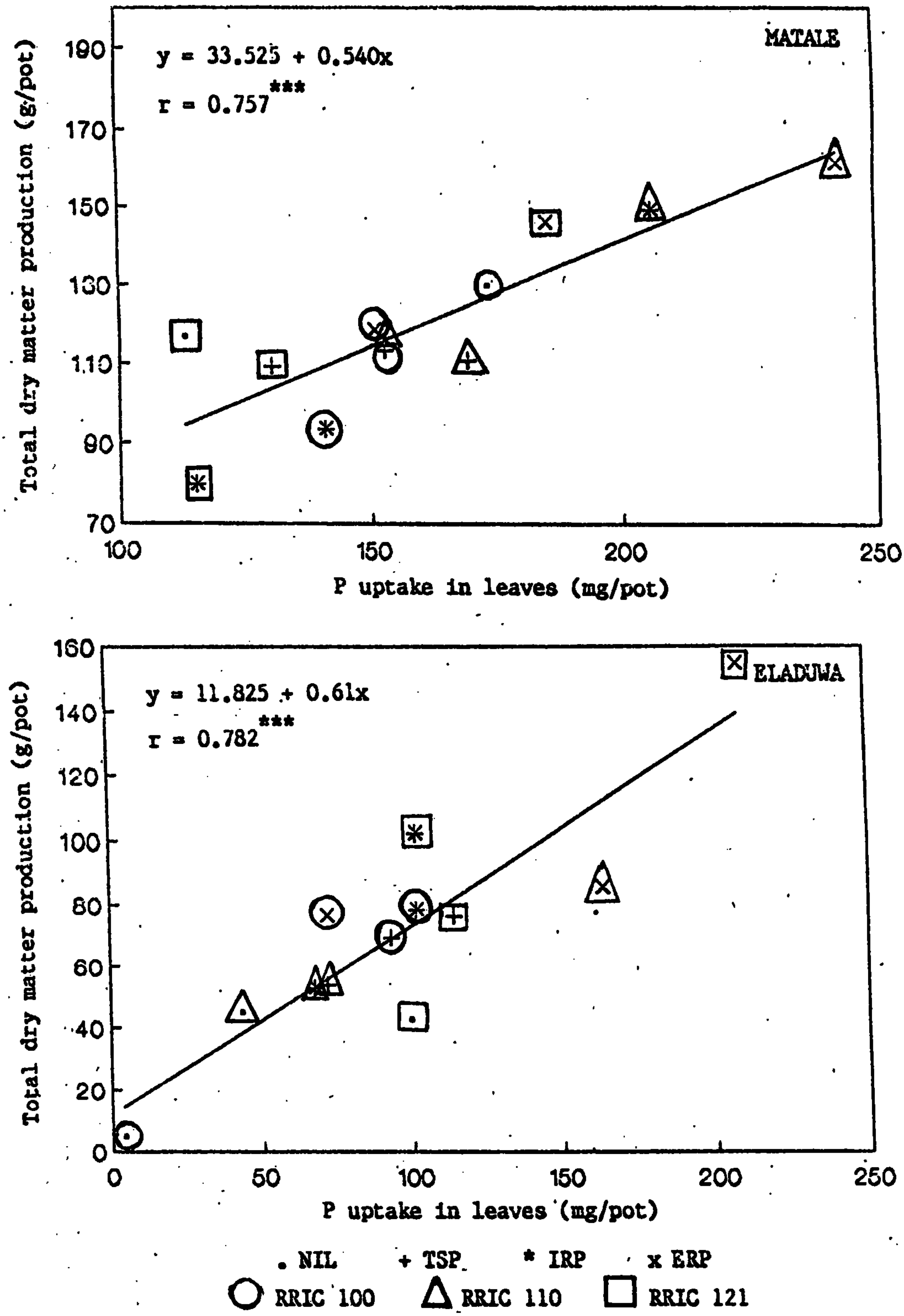

Fig. 2 Relationship between leaf P uptake and total dry matter production in plants of different clones that received P fertilizers in Matale and Eladuwa soils

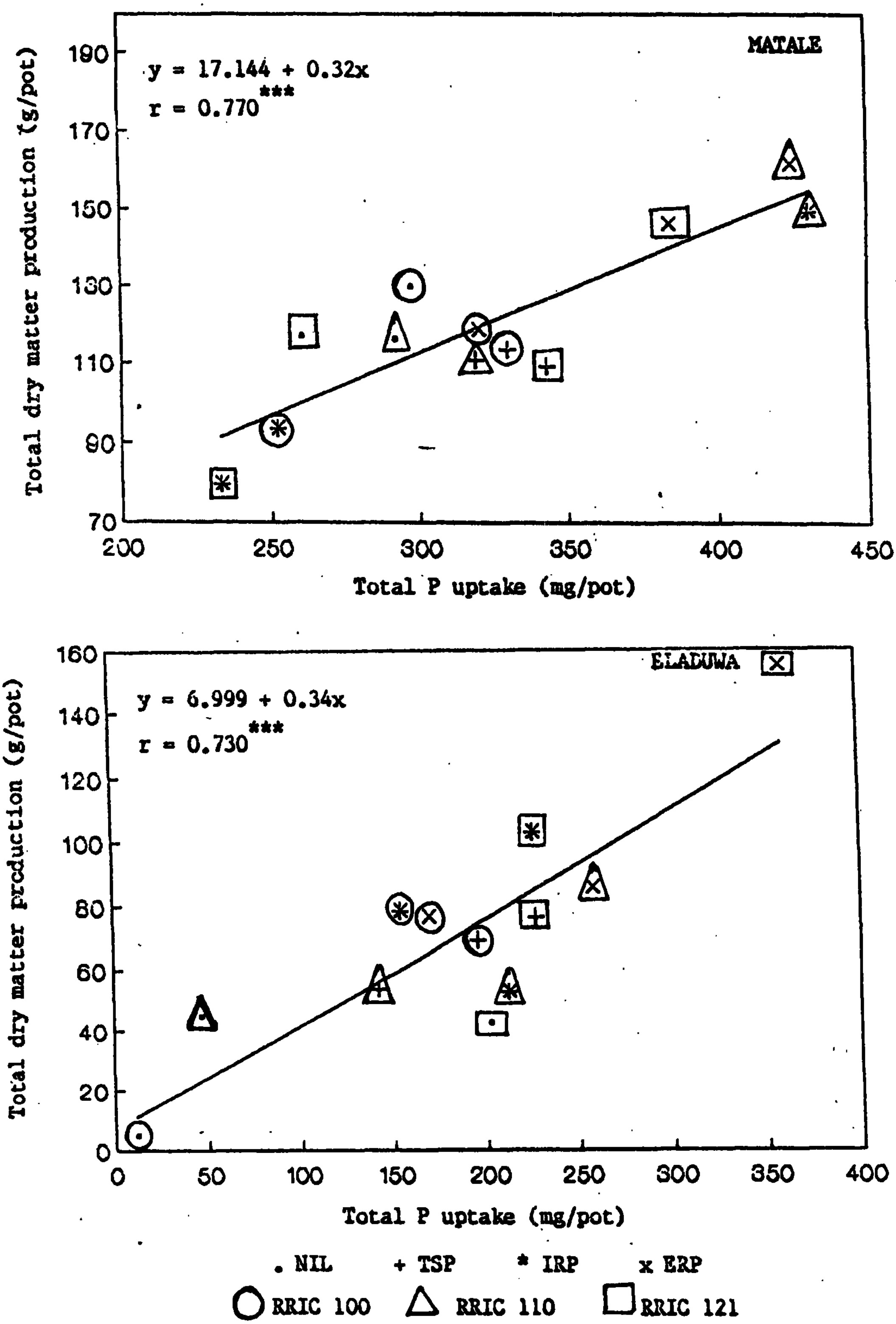

Fig.3 Relationship between total P uptake and total dry matter production in plants of different clones that received P fertilizers in Matale and Eladuwa soils