RESPONSE OF SOME SPECIES OF *AESCHYNOMENE* TO APPLICATION OF PHOSPHORUS IN EASTERN HIGHLANDS PROVINCE, PAPUA NEW GUINEA

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ABSTRACT

A glasshouse experiment was conducted at Menifo Sheep Research Centre (1405 m a.s.l.) for a period of 28 weeks commencing in July 1996 to determine the responses of two cultivars of Aeschynomene americana, *cv. Lee and cv. Glen, and two other species,* A. villosa *(CPI 93621) and* A. brasilliana *(CPI 92519) to application of phosphorus. Both fertiliser treatments and genotypic differences had an effect on leaf dry-matter yield. Application of phosphorus significantly improved ($P<0.01$) the relative leaf dry-matter yield by 32-47% and A. villosa (S3) produced a significantly higher ($P<0.05$) leaf dry matter yield. There was no effect of phosphorus on stem dry-matter yield but between genotypes,* A. americana, *cv. Lee and* A. villosa *had significantly higher ($P<0.05$) stem dry matter yield. Phosphorus had a significant effect ($P<0.05$) on root growth. Phosphorus also significantly improved ($P<0.05$) relative dry-matter yield in all genotypes by 40.52%. Leaf/stem and shoot/root ratios were not sensitive to application of phosphorus.* A. brasilliana *had a significantly high ($P<0.05$) leaf/stem ratio compared to* A. americana, *cv. Lee, cv. Glen and* A. villosa. *Conversely* A. villosa *had a significantly higher ($P<0.001$) shoot/root ratio followed by* A. americana, *cv. Lee while difference between* A. americana *cv. Glen and* A. brasilliana *was small. In terms of forage quality,* A. brasilliana *was more efficient on these soils. This study showed that phosphorus efficient species are valuable in reducing fertiliser requirements and can improve the returns obtained from application of moderate fertiliser.*

KEYWORDS*: Aeschynomene,* Soils, Eastern Highlands, Phosphorus.

INTRODUCTION

Most soils in the highlands are inherently low in available phosphorus (P) for legume growth (Sivasupiramanian *et al.* 1986). Increasing grazing pressure and stocking rates due to economic and social pressure further aggravates this. To alleviate this deficiency, application of P fertilisers is a standard practise. However the high cost and the amount of fertiliser required to increase the availability for legume growth (Parfitt & Mavo 1983), prevents the use of fertilisers and as a consequence, P deficiency in pastures is becoming evident. Various cost efficient options are available particularly for soils low in available P. This includes amongst others, the use of species and cultivars that are P efficient.

This experiment examines the effect of phosphorus on the growth of *Aeschynomene* species and accessions which are known to tolerate poor conditions. As genetic diversity exists both within and between species (Bishop and Hilder 1993), this offers the opportunity for exploitation to suit soils low in available P.

MATERIALS AND METHODS

A glasshouse experiment was conducted at Menifo Sheep Research Centre (1405 m a.s.l.) for a period of 28 weeks, commencing in July 1996 to determine the response of *Aeschynomene* species to application of P.

The soils were collected from a semi-commercial sheep farm in Napamogona near Goroka which represent one agro-ecological zone for sheep farming in the Eastern Highlands Province. Soil samples were taken from an area that was previously grazed with sheep and cattle, and during the time when corn (*Zea mays*) was planted. No inorganic fertilisers were used in the area. The samples were taken at random to a depth of 30 cm, bulked and a composite sample air-dried. The chemical status of the soil is given in Table 1. The air-dried soil was sieved through a 5 mm screen to remove plant materials and a sub-sample collected for potting. The pots had a surface area of 165.05 cm² and were filled with 1.0 kg of air-dried soil and well consolidated. Plastic lining was used inside the pots to avoid leaching.

Table 1. **Chemical analysis of soils from Napamogona, Eastern Highlands Province, Papua New Guinea**

Soil property	Method of determination	Value
pH	1:2.5 soil:distilled water	6.1
Extractable bases me. 100g	Ammonium acetate	
Ca		12.6
Mg		4.96
K		0.56
Na		0.03
Cation exchange capacity	Kcl extraction	23.9
Base saturation %		76
P mg/kg	Olsen extraction	6
Organic Carbon %	Walkey and Black	23
Total N %	Kjeldahl	0.19
C/N ratio	Walkey and Black	12

Treatment seeds were scarified and germinated in sacks and transferred to pots. After sixteen days, the fully emerged seedlings were trimmed to 3 plants per pot and materials left on the soil surface. All pots were watered daily to maintain moisture content at field capacity and weeds checked and left in the respective pots. After 28 weeks, all the plants were harvested and separated into leaf and edible stems (6 mm in diameter), stem and root (including nodules) fractions. The components were then dried in an air forced draught oven at 70°C for 48 hours to determine dry-matter yield (DMY).

The experimental design was a randomised block in a split plot arrangement with three replicates. The main plots were five levels of P. P as 19.9% $NaH_2PO_4 2H_2O$ was applied at rates equivalent to 0 (PO), 20(P20), 70 (P70) and 120 (P120) kg/ha of P on a surface area basis. The sub-plots were two cultivars of *Aeschynomene americana* cv. Lee (S1) and cv. Glen (S2), and one accession each of *A. villosa* CPI 93621 (S3) and *A. brasiliana* CPI 92519 (S4). All yield data was subjected to an analysis of variance and differences between means were tested for significance using the *t*-test.

RESULTS

As the analysis of variance (Table 2) showed no interaction between different genotypes and rates of P application, the results are presented as main effects only. Both fertiliser treatments and genotypic differences had an effect on leaf DMY. Application of P fertiliser significantly ($P<0.01$) improved relative leaf DMY by 32-47%, however the differences between the added rates were not significant. The correlation between increasing P rates and leaf DMY was significant (r^2-=0.81, $P<0.05$) (Table 3). S3 produced significantly ($P<0.01$) higher leaf DMY relative to S1, S2 and S4. There was no effect of P on stem DMY (Table 3), however between genotypes, S3 had significantly higher ($P<0.01$) stem DMY compared to S1, S2 and S4 (Table 4).

P had a significant effect ($P<0.01$) on root growth of all genotypes. Maximum root growth was achieved at 50 kg/ha (Table 5) and the correlation between P rates and root growth was not significant ($r^2=0.33$, $P<0.05$). The response of total DMY was similar to that of the leaves. Application of P also significantly improved ($P<0.5$) relative total DMY in all genotypes by 40-52% (Table 5) but the correlation between increasing P levels and total DMY was not significant ($r^2=0.53$, $P<0.05$).

The relative increase in leaf DMY was greater than the roots and leaf DMY continued to increase with increasing levels of P above the level at which there was no increase in root DMY. When the other growth indices were considered, leaf/stem

Table 2. **Summary results of analysis of Variance on dry-matter yield (g/pot) of different components.**

		Mean square values of yield components					
Source of Variation	df	Leaves	Stems	Roots	Leaf/Stem	Shoot/Root	Total
Phosphate level (P)	4	0.76**	0.68	1.77**	0.40	1.07	4.51*
Main plot error	8	0.06	0.10	0.16	0.18	0.37	0.82
Species (S)	3	0.41**	0.58**	0.26	0.65**	10.48**	0.74
P x S	12	0.09	0.06	0.11	0.18	0.45	0.40
Sub-plot error	30	0.07	0.11	0.17	0.21	0.64	0.69

*P<0.05, **P<0.01

Table 3. **Effect of Phosphorus on leaf dry-matter yields (g/pot) of four different *Aeschynomene* genotypes**

	Species				
Phosphate levels	S1	S2	S3	S4	Mean
PO	0.49	0.69	1.10	0.88	0.77
P20	1.39	1.01	1.24	1.03	1.17
P50	1.18	1.06	1.19	1.12	1.14
P70	1.20	1.11	1.55	1.24	1.28
P120	1.53	1.01	1.89	1.38	1.46
Mean	1.16	0.98	1.38	1.13	

LSD to compare S means at 5% - 0.20, LSD to compare S means at 1% - 0.27
LSD to compare P means at 5% - 0.23, LSD to compare P means at 1% - 0.34

Table 4. **Mean dry-matter yield (g/pot) of plant components of four different *Aeschynomene* genotypes**

	Plant components		
Species	Stem	Leaf/Stem	Shoot/Root
S1	0.88	1.55	2.89
S2	0.67	1.70	1.70
S3	1.04	1.42	3.65
S4	0.62	1.94	2.27
Lsd 5%	0.25	0.34	0.60
1%	0.33	0.46	0.80

Table 5. **Effect of phosphorus on root and total dry-matter yield (g/pot) of *Aeschynomene* genotypes**

	Plant components	
Phosphate levels	Roots	Total
P0	0.50	1.72
P20	0.86	2.89
P50	1.06	2.91
P70	0.84	3.05
P120	1.00	3.56
Lsd 5%	0.38	0.85
1%	1.24	1.24

and shoot/root ratios were not sensitive to application of P. S4 had a significantly high ($P<0.05$) leaf/stem ratio compared to S1, S2 and S3 (Table 4) and conversely, S3 had a significantly higher ($P<0.01$) shoot/root ratio followed by S1 whilst any difference between S2 and S4 was small (Table 4).

DISCUSSION

Despite the high base saturation and exchange capacity (Table 1), P unfortunately reacts rapidly with soil constituents to produce relatively insoluble P compounds resulting in its low availability in soil solution for plant growth. Under this condition, the extent of response by the genotypes to application of P was depended on the requirements of different plant components and their efficiency to utilize P.

The high correlation between increasing P levels and leaf DMY observed here demonstrates that P has a greater effect than N, K and S in stimulating early growth of seedlings (Whiteman 1977). This can be explained on the basis of increase in leaf growth rates as a subsequent effect of P on rapid development and growth of nodules and increase in assimilation of N by the whole plant (Gates 1974), and translocation of assimilates to the tops. This is evident in the continued increase in leaf yield relative to root yield. As genetic diversity exists between species (Bishop and Hilder 1993), the genotypes are at variance in their ability to take up and utilise P rather than to differences in internal requirements (Stem 1984). S3 produced more leaves and stems, however in terms of fodder quality, S4 appear to be more efficient in these soils as demonstrated by high leaf/stem ratio followed by S2, S1 and S3 respectively. S1 and S3 had a high propotion of stems and lower root growth compared to S2 and S4 which had a higher root growth relative to shoot growth. The high root growth in S2 and S4 demonstrates their ability to explore a volume of soil to recover P which tends to diffuse over very short distances (Lewis and Quirk 1967) and this may have enhance their efficiency of utilisation under such circumstances. Other responses of herbaceous legumes such as *Stylosanthes humilis* (Andrew 1996) and *Stylosanthes guianensis* cv. Endeavour (Chantkam 1978) have shown that species differ in their ability to absorb P at low solution concentration. The linear increase in root growth at the lower P rate (20 kg/ha) may be explained on the basis of inherently low P status and a critical root concentration was reached at 50 kg/ha as indicated by the curvilinear response. Beyond that, luxury consumption of P in roots inhibited cation absortion. Legumes which are adapted to low fertility conditions such as *Stylosanthese* species and *Trifolium subterraneum* are known to be susceptible to high P rates (Rossiter 1955, Asher and Loneragan 1967). These species however have special attributes that enabled them to perform best under different environments (Bishop and Hilder 1993).

Application of P fertilisers improved the total DMY of the genotypes, however, the response due to P was marginal (69%). Variation due to genotype accounted for only 31%, which implies that despite a lack of significant correlation, the introduction of suitable genotypes cannot substitute for the effect of fertiliser at the level of P input. The lack of any significant differences between added P rates suggests that either the genotypes were susceptible to high P rates or that the initial P requirements of these genotypes were just above maintenance (Winks 1973, Shaw and Andrew 1979) and can be achieved at a minimum rate of 20 kg/ha. The two latter attributes are adaptive features of nutrient efficient species. Similar responses were observed with *A. facalta* which persisted on poor sandy soils and responded to moderate application of superphosphate (Dicker and Garden 1985). These attributes may also explain the lack of interaction on all measured variables. P concentration in the leaves were however not determined to verify if such low P tolerant species contain sufficient P in the edible portions to sustain growth performance of grazing animals.

The native pastures in the highlands are generally low in N and P and this has become the focus of pasture improvement. The effect of P fertiliser for increasing pasture growth and also to improve forage concentration of essential elements to satisfactory levels for adequate growth performance of grazing animals is becoming more important. This study demonstrated that P efficient species in terms of P required/quantity of DM produced are valuable in reducing fertiliser requirements and can improve the returns obtained from application of moderate fertiliser. In terms of forage quality, S4 is more efficient on these soils. However caution should be exercised here as low yielding genotypes also have other desirable characteristics such as persistence (Bishop and Hilder 1993) and their suitability will be determined under a cutting regime to simulate the effects of grazing.

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