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EFFECT OF DIFFERENT LEVELS OF SUPPLEMENTAL NITROGEN ON CO_2 ASSIMILATION RATES AND PRODUCTIVITY OF *PUERARIA PHASEOLOIDES* (ROXB) BENTH. AND *DESMODIUM OVALIFOLIUM* (PRAIN) WALL. EX RIDLEY GROWN IN AGALAWATTA SERIES SOIL.

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ABSTRACT

Plant dry matter production is linked to CO_2 assimilation rates, respiratory losses and total leaf area. Experiments were undertaken to determine the effect of different levels of supplemental nitrogen given to legume cover crops, on their CO_2 assimilation rates and productivity. They were found to be highest for Pueraria phaseoloides *and* Desmodium ovalifolium *when given around 140 and 35 ppm of supplemental Nitrogen. Reciprocal of specific leaf area and leaf nitrogen content were also determined and they showed a positive linear relationship with supplemental nitrogen levels. How nitrogen could influence the CO_2 assimilation rates of cover crops studied are discussed.*

INTRODUCTION

Moderate applications of potassium and phosphorous fertilizers have relatively small effects on dry weights of different plant parts, including seed yield, but nitrogen (N) fertilizers markedly increases the yield of non-nodulating soybeans (Hanway and Weber, 1971). Decrease in CO_2 assimilation rates (A) due to lack of N was observed in *Oryza sativa* (Zelitch, 1971) *Zea mays* L., *Gossypium hirustum* L., and *Phaseolus vulgaris* L., (Ryle and Hesketch, 1969). Different A were observed in *Pisum sativam* when N inputs were varied by providing separate strains of *Rhizobium leguminosarum* (De Jong and Phillips, 1981). Boller and Heichel (1984) observed when *Medicago sativa* plants with effective and ineffective root nodules were given supplemental N (100 Kg/ha as NH_4 NO_3) it tended to reduce A per leaf area, but in *M. sativa* plants with ineffective root nodules a 50% increase in leaf area was observed increasing the A per ground area.

A close correlation was found between the A of *O. sativa* leaves and their total N content on a dry weight basis, which was regulated by quantity of N supplied (Zelitch, 1971). A increases linearly with increases in leaf N content up to values of 5-6% of dry weight in both C_4 and C_3 species. High levels of N (>3%) are normally obtained under intensive cultivation with high N application rates. Therefore, in natural environment most species would seem to be limited in their photosynthetic capacity by N (Brown, 1978). Since minerals are taken up by the root under mineral deficient conditions the minerals will be used in the root before they can reach the shoot. The relative amount of N in shoots and leaves increases when its available freely (Zelith, 1971).

P. phaseoloides and *D. ovalifolium* are commonly grown as ground covers in rubber plantations and they are important in preservation of fertility and soil conservation. These legume species can fix atmospheric N and mineralisation of organic N from decaying leguminous covers may provide some N to the rubber plants during first years of maturity. It may be possible that quantity of N fertilizer required under these conditions may be reduced (Yogaratnam and Samarappuli, 1983).

P. phaseoloides and *D. ovalifolium* were grown given different levels of suplemental N to study how supplemental N can effect their A, producitivity, leaf N content and reciprocal of specific leaf area (SLA-1). This study was carried out to see whether supplemental N is necessary for legume covers to show optimum growth, when grown under local conditions in Agalawatta series soil (Yogaratnam 1983).

MATERIALS AND METHODS

Plant material — The plants *P. phaseoloides* and *D. ovalifolium* were grown in plastic pots and were distributed randomly in a glass house. Five pots, each filled with 5 kg of Agalawatta series soil, were used for each treatment. The five treatments viz., 0,35,140,560 and 1,120 parts per million (ppm) of supplemental N as NH_4 NO_3 per pot, were added and two seedlings of uniform size were transplanted in a pot. The plants were watered regularly and fungicides were sprayed to prevent leaf diseases.

CO_2 assimilation rate A — Differential CO_2 measurements were done using an Infra Red Gas Analyser (Typer 225, Mark II, The ADC Ltd., England). The light source was a 1000 W halogen lamp. A 15 cm thick water jacket was placed between the light source and the leaf chambers to serve as a heat filter. Temperature of leaf chambers were maintained at 27°C. Light intensity was measured using a Li-Cor Quantum Sensor and was maintained at 600 $/^{u}Em^{-2}{}_{s}{}^{-1}$. The air flow rates through leaf chambers were 500 ml min^{-1}. The source of CO_2 was atmospheric air and to ensure a uniform supply of CO_2 to the leaf chambers the air was passed first into a 10 litre reservoir.

Five plants of similar growth stage from each treatment were selected. The centre leaflet of the fourth leaf from apex was used for A measurements. Five leaflets, one from each treatment were detached under water and A measurements were done simultaneously using a section of the detached centre leaflet as described by Nugawela and Aluthhewage (1984). This procedure was repeated five times according to a 5 × 5 lating square design. A measurements were also done using the fifth leaf from the apex.

Reciprocal of specific leaf area (SLA^{-1}) — From the remaining lateral leaflets (after using centre leaflet for A measurements) leaf discs were punched and were dried in an oven at 75°C for 24h. SLA^{-1} was calculated as below;

$$SLA^{-1} = \frac{\text{Dry weight of leaf disc sample}}{\text{Area of leaf disc sample}}$$

Dry matter production — The plants were harvested after three months of growth. The dry weights of leaves and other plant parts were obtained separately after oven drying the material for 24 h at 75°C.

Leaf N content—Oven dried leaf samples from different treatments were grown separately and 0.2 g sample per treatment was used to determine leaf N from micro kjeldhal digestion.

RESULTS

CO_2 assimilation rates of P. *phaseoloides* and *D. ovalifolium* responded to changes in supplemental N levels in a similar pattern. P. *phaseoloides* exhibited highest A when soil was supplemented with around 140 ppm of N, but D. *ovalifolium* required only 35 ppm of N to show highest A.

Table 1. *A (μ mol CO_2 $m^{-2}s^{-1}$) of P. phaseoloides* (X) *and D. ovalifolium* (Y) *supplemented with different levels of N. Experiment 1 and 2, A determined using 4th and 5th leaf* from *apex respectively.*

				Nitrogen levels (ppm)				
Cover crop	Expt.	0	35	140	560	1120	LSD	Significance
X	1	4.372	4.541	5.518	4.625	2.227	2.342	•
	2	4.003	4.485	4.998	4.347	1.313	1.336	•••
Y	1	4.047	5.717	4.870	3,716	2.270	0.851	•••
	2	4.798	6.249	5.298	3.159	3.215	0.651	•

°°° $P < 0\ 001$, ° $P < 0\ 05$

Total dry matter production of *P. phaseoloides* and *D. ovalifolium* varied with supplemental N levels in a similar way to their A. In *P. phaseoloides* and *D. ovalifolium*, a positive linear relationship between supplemental N levels and leaf N content ($r = 0.9760$ and 0.9779, respectively) and SLA $^{-1}$ ($r = 0.974$ and 0.9462, respectively) were observed (Table 2).

Table 2. *Total dry matter production, leaf N content and SLA $^{-1}$ of P. phaseoloides (X) and D. ovalifolium (Y) grown in pots with different levels of supplemental N.*

	Dry matter yield (g per pot)		% leaf N content		SLA $^{-1}$ (g/cm^2)	
N levels (ppm)	X	Y	X	Y	X	Y
0 ...	7.58	6.47	3.46	2.89	.0011	.0010
35	7.92	13.30	3.93	2.69	.0012	.0014
140	8.14	12.82	4.01	2.71	.0012	.0014
560	6.74	8.43	4.47	3.40	.0013	0025
1120	4,93	3.14	5.93	4.35	.0016	.0028
Significance of treatment differences	***	***	***	***	**	**
LSD	1.64	3.14	0.41	0.32	.000133	.000457

*** $P < 0.001$ ** $P < 0.01$

DISCUSSION

Initial increases in supplemental N levels increased the A per unit leaf area in *D. ovalifolium* and *P. phaseoloides*. This agrees with the work of Ryle and Hesketch 1969), Zelitch (1971) and Ingernarsson et. *al* (1984) with other crops. N at optimum levels might favour A due to improved structure and enzymatic activity of organelles concerned (Zelitch, 1971) and lower mesophyll and stomatal resistance to CO_2 transfer (De Jong and Phillips, 1981). Stomatal aperture is related to the capacity of the mesophyll tissue to fix carbon and it can regulate internal CO_2 concentration when the capacity of the mesophyll tissue to fix CO_2 is altered by various means (Reschke 1975; Wong *at. al*, 1979; De Jong and Phillips 1981).

Further increases in N levels above 140 ppm for *P. phaseoloides* and 35 ppm for *D. ovalifolium* resulted in the A to decrease gradually. It increased the leaf N content and this might have toxic effects to the plant. Higher levels of soil N may interfere with the uptake of other essential nutrients such as potasium and magnesium creating a nutrient imbalance. SLA^{-1} increased with increasing levels of supplemental N, probably due to accumulation of photosynthetic assimilates due to poor translocation. This could contribute to lower A through source sink relationships.

Increase in A and dry matter production shown with initial increase in supplemental N, also suggests the soil lacks N for optimal growth of the test plants and are unable to obtain balance through N fixation. The root nodule formation is in close relation with the addition of supplemental N in both *P. phaseoloides* and *D. ovalifolium* (Jayasinghe 1984).

The productivity of crops where the entire aerial portions are harvested is dependent almost entirely on the total quantity of CO_2 assimilated less that lost by respiration (Zelitch, 1971). For both *P. phaseoloides* and *D. ovalifolium* the A and total dry matter production (productivity) are closely related and respond similarly to changes in N levels (Fig. 1 & 2). Hence high A results in high productivity. *D. ovalifolium*, which has a greater A than *P. phaseoloides* shows a higher dry matter production. *D. ovalifolium* exhibits its highest A at a lower levels of supplemental N. It may be that this plant has a lower N requirement. If not it could be more efficient in fixing atmospheric N or utilising soil N.

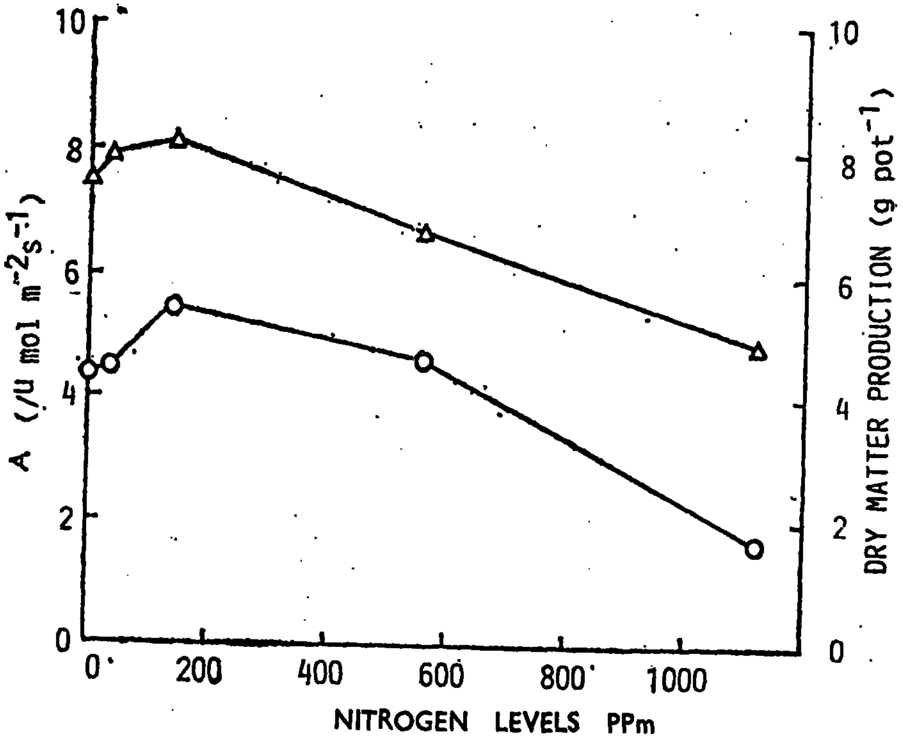

Fig. 1. Effect of supplemental N on A (o) and dry matter production (Δ) in P *phaseoloides*

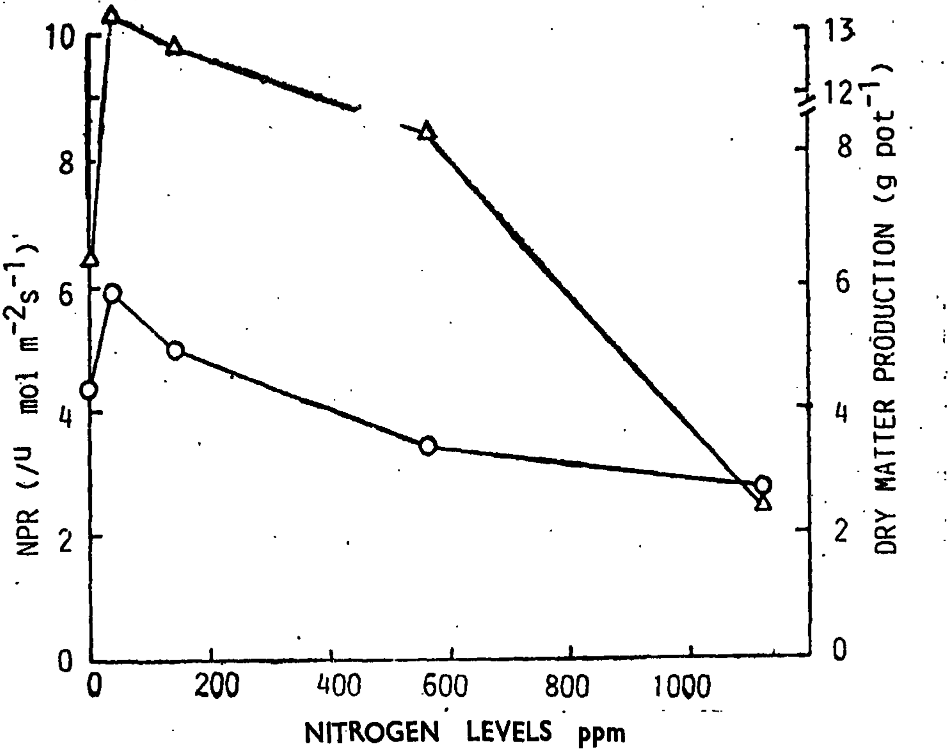

Fig- 2. Effect of supplemental N on A (o) and dry matter production (Δ) in *D. ovalifolium*

Results of the experiment carried out show that although *P. phaseoloides* and *D. ovalifolium* have the capacity to fix atmospheric N, requires supplemental N for optimum A and dry matter production when grown in Agalawatta series soil.

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