PHOTOSYNTHETIC RATE IN NODULATING AND NON-NODULATING LINES OF *ARACHIS HYPOGAEA* L.

M. L. LODHA, N. D. SHARMA, V. ARUNACHALAM, R. P. JOHARI and S. L. MEHTA
Division of Biochemistry, Indian Agricultural Research Institute, New Delhi 110 012, India.

ABSTRACT

Photosynthetic rates in field-grown nodulating and non-nodulating lines of groundnut (*Arachis hypogaea* L.), were similar. However, *in vivo* nitrate reductase activity was significantly higher in leaves of the non-nodulating line compared to that its nodulating parental lines. It has been suggested that in the absence of nodule sink, diversion of photosynthates towards nitrate assimilation may to some extent relieve feedback control on photosynthesis.

INTRODUCTION

Several studies have indicated that high rates of translocation are important in maintaining high photosynthetic rates in plants[1,2]. Reduced demand for photosynthates is also known to result in a reduction in the net photosynthetic rate in some cases[1]. In two varieties of soybean, net photosynthetic rate was reduced approximately one-third by partial depodding[3]. In addition, partial inhibition of photosynthesis by vegetative and reproductive sink removal has been demonstrated in another soybean variety[4]. The basis of sink-limited photosynthesis is some kind of end-product inhibition due to the accumulation of soluble carbohydrates in leaves[2]. In groundnut, in which nodules are a more powerful sink for carbohydrates than in other legumes[5], the effect of source–sink manipulation on photosynthetic rate is not known. Therefore, in the present investigation, photosynthetic rate and nitrate reductase activity have been studied in nodulating and non-nodulating lines of groundnut with a view to finding out the effect of increased source/sink ratio on photosynthesis.

MATERIALS AND METHODS

Groundnut nodulating genotypes NC 17 (Virginia Runner) and the rust-resistant PI 259747, and a non-nodulating derivative from their cross, were obtained from the IARI Regional Station, Hyderabad. These lines were grown at the Institute Farm during the monsoon season under the recommended agronomic practices. Nodulating lines were grown under natural infection of native rhizobia without N-fertilizer application, while the non-nodulating line was grown with 80 kg N/ha fertilization and also without N-fertilizer application.

Dry weight of leaves and photosynthetic rate by $^{14}CO_2$-feeding were determined using whole plant canopy according to Lodha *et al*[6]. Net photosynthetic rate was also determined by using an infrared gas analyser (IRGA)[7] in another experiment conducted during the second year. In this experiment, leaflet of the third leaf from the top was used.

In vivo assay of nitrate reductase in leaf, root and nodule samples was done as described by Lodha *et al*[8].

The results reported are averages of 2 or 3 determinations except in the case of net photosynthetic rate where 6 determinations were averaged.

RESULTS AND DISCUSSION

Table 1 shows that dry weight of leaves of the parental nodulating lines and the fertilized non-nodulating line did not differ much at 70 and 85 days after sowing (DAS). Nitrogen fertilization increased leaf weight in the non-nodulating line by about 25%.

As regard leaf photosynthetic rate (mg CO_2 fixed/g dry wt/h), differences between nodulating and non-nodulating lines were non-significant at

Table 1 *Dry weight of leaves in nodulating and non-nodulating lines of groundnut*

Groundnut line	Characteristics	Dry wt (g/plant) 70 DAS	85 DAS
NC 17 (male parent)	Nodulating	17.0	25.2
PI 259747 (female parent)	Nodulating	12.9	28.5
NC 17 × PI 259747	Non-nodulating	10.4	20.9
NC 17 × PI 259747 (with N-fertilization)	Non-nodulating	12.9	26.1

Table 2 *Leaf photosynthetic rate of nodulating and non-nodulating lines of groundnut as measured by $^{14}CO_2$ feeding*

Groundnut line	mg CO_2 fixed g dry wt h	
	70 DAS	85 DAS
NC 17	15 0	5 1
PI 259747	15 9	10.5
NC 17 × PI 259747	21 2	5.8
NC 17 × PI 259747 (with N-fertilization)	16.7	7 4

both 70 and 85 DAS (table 2). When net photosynthetic rate was measured using IRGA and the results expressed on leaf area basis, the photosynthetic rate at vegetative stage (50 DAS) of the fertilized non-nodulating line was not different from that of the parental female line, but was significantly lower than that of the other parental line NC 17 (table 3). However, at 85 DAS no difference was observed in the photosynthetic rates of nodulating and non-nodulating lines.

In vivo nitrate reductase activity in the unfertilized non-nodulating line was about 90% and 190% higher in leaf, and about 80% and 60% lower in root compared to the activity in female and male parental lines respectively (table 4). As a result of N-fertilization, leaf and root nitrate reductase activity increased by 1.5-fold and 3.2-fold respectively in the non-nodulating line. Very high activity of nitrate reductase was observed in nodules of the parental lines (table 4).

The nodule is an important sink demanding translocation of photosynthates for N_2 fixation and to some extent for NO_3^- assimilation. In non-nodulating lines such a demand does not exist, and end-product inhibition of leaf photosynthesis is expected[2]. However, in the non-nodulating line of groundnut no such inhibition was apparent (tables 2 and 3). Similar observations have also been made in

Table 3 *Net photosynthetic rate of nodulating and non-nodulating lines of groundnut as measured by IRGA*

Groundnut line	μg CO_2 fixed/min/dm^2	
	50 DAS	85 DAS
NC 17	328 ± 11	479 ± 29
PI 259747	265 ± 12	474 ± 13
NC 17 × PI 259747 (with N-fertilization)	270 ± 17	482 ± 45

Table 4 *In vivo activity of nitrate reductase in nodulating and non-nodulating lines of groundnut* at 85 DAS*

Groundnut line	nmol NO_2 formed/g fresh wt/h		
	Leaf	Root	Nodule
NC 17	203 ± 20	79 ± 5	1471 ± 187
PI 259747	307 ± 39	142 ± 29	1595 ± 360
NC 17 × PI 259747	588 ± 27	30 ± 6	Nodules absent
NC 17 × PI 259747 (with N-fertilization)	884 ± 44	97 ± 16	Nodules absent

* Composite sample of three plants analysed in triplicates.

field-grown soybean where the source/sink ratio was increased by depodding[9]. It is possible that in the non-nodulating line, diversion of photosynthates towards nitrate assimilation in leaf may play an important role in relieving end-product inhibition of photosynthesis. This is further substantiated by the finding that nitrate reductase activity in leaves of the non-nodulating line was higher compared to that in the nodulating lines.

ACKNOWLEDGEMENT

The authors thank Mr O. P. Yadav for technical assistance.

2 June 1988

1. Geiger, D. R., *Can. J. Bot.*, 1976, **54**, 2337.
2. Wardlaw, I. F., *The biology of crop productivity*, (ed.) P. S. Carlson, Academic Press, New York, 1980, p. 297.
3. Lawn, R. J. and Brun, W. A., *Crop. Sci.*, 1974, **14**, 11.
4. Mondal, M. H., Brun, W. A. and Brenner, M. L., *Plant Physiol.*, 1978, **61**, 394.
5. Williams, J. H., *Rhod. J. Agric. Res.*, 1979, **17**, 49.
6. Lodha, M. L., Johari, R. P., Sharma, N. D. and Mehta, S. L., *Biochem. Physiol. Pflanzen.*, 1985, **180**, 337.
7. Long, S. P. and Hallgren, J. E., *Techniques in bioproductivity and photosynthesis*, (eds) J. Coombs, D. O. Hall, S. P. Long and J. M. O. Scurlock, Pergamon Press, Toronto, 1985, p. 67.
8. Lodha, M. L., Sharma, N. D., Johari, R. P. and Mehta, S. L., *Indian J. Exp. Biol.*, 1984, **22**, 615.
9. Wittenbach, V. A., *Plant Physiol.*, 1983, **73**, 121.