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EFFECT OF VARIOUS LIGHT INTENSITIES ON PHOTOSYNTHESIS AND NODULATION IN SOYBEAN

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Abstract

Influence of 5,000 and 10,000 lux light intensities on photosynthesis, leaf area, dry matter and nodulation in nodulated and non-nodulated soybean (*Glycine max* CV. Covernia-5) was investigated. High light intensity increased rate of photosynthesis, leaf area, dry weight matter and nodule formation. Carbon assimilation rate was higher in nodulated plants even under low light intensity as compared to non-nodulated plants. It is concluded that photosynthetic rate and biological N-fixation were linearly and positively correlated.

Introduction

Primarily light is the energy source for photosynthesis. Theoretically photosynthesis is possible at any light intensity, however, practically respiration dominates when light intensity is low and net assimilation will be zero at a light intensity of 50 lux (500 F.C) and minimum of 50-100 lux (500-1000 F.C) is required for effective rates of photosynthesis when the photosynthetic gas exchange is greater than the respiratory gas exchange (Blackman & Black, 1959). Wang (1963) found that with increasing light intensity photosynthesis of single leaf obeys the law of diminishing return. Extremely high ligh intensities may have an inhibitory effect on photosynthesis. On the contrary Wassinck (1954) reported that for optimal photosynthesis high light intensities are essential, and there is a linear relationship between light intensities and rate of photosynthesis (Stoughton, 1955). Different species of plants have different light requirements to perform their photosynthetic activities. In studies on the effect of light intensities on nodulation and nitrogen fixation supplementary light has been found to have a profound effect on nitrogen fixation activities in plants (Lawn & Brun, 1974). In the present investigation attempts were made to study the effect of 5000 and 10,000 lux light intensitities on the rate of photosynthesis and nodulation in soybean.

Materials and Methods

Soybean (*Glycine max* CV. Covernia-5) plants grown in a pot nursery were transferred to wide mouth bottles containing one litre of half-strength Hoagland's culture solution (Hewitt, 1966). The experiment was carried out at the department of Plant

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Table 1. Effect of various light intensities on rate of photosynthesis in soybean canopy.

Days after emergence	Crop	Light intensity (Lux) 5,000 Leaf Number 1	2	3	4	5	10,000 Leaf Number 1	2	3	4	5	6
							mg CO_2 dm^2 h^{-1}					
20	Nodulated	–	–	–	–	–	3.70	4.94	–	–	–	–
	Non-nodulated	–	–	–	–	–	3.15	5.04	–	–	–	–
30	Nodulated	–	3.20	4.53	4.26	–	–	2.90	5.58	6.40	–	–
	Non-nodulated	–	3.44	4.10	3.59	–	–	2.10	5.13	5.13	–	–
40	Nodulated	–	2.16	3.87	4.53	4.97	–	4.42	6.63	7.74	7.19	3.31
	Non-nodulated	–	2.10	3.33	3.33	3.79	–	4.14	5.53	4.42	2.21	–
50	Nodulated	–	4.24	3.88	3.89	4.55	–	2.48	6.08	7.19	8.29	–
	Non-nodulated	–	3.76	3.42	3.04	4.14	–	3.05	4.04	4.14	4.97	–
60	Nodulated	–	4.14	4.42	4.42	5.08	–	3.48	6.08	8.80	6.92	–
	Non-nodulated	–	3.76	4.30	3.87	4.44	–	1.93	4.14	2.21	4.42	–

Physiology, Agricultural Academy, Moscow. After first three trifoliate leaf formation the plants were inoculated with *Rhizobium japonicum* strain 646 obtained from Department of Microbiology, Agricultrure Academy, Moscow. Plants were kept under light intensities ranging from 5,000-10,000 lux at the surface of plants in a growth cabinet. The growth cabinet was illuminated with flourescent tubes and incandescent lamps in a ratio of 3:1 with a day temperature of 20°C followed by 18°C night temperature and 65-70% R.H. The culture solution was renewed every week and observations recorded at 10 days interval.

The photosynthesis rate was measured with the help of Infra-red gas analyser GIP_{10} MB_2 model. Leaf area was measured with the help of automatic leaf area meter. Five plants were removed from the bottles and nodules separated and counted. Plant samples were dried in hot air oven at 80°C until constant weight and used for dry matter determination.

Results and Discussion

The rate of photosynthesis varied with leaf position and increased acropetally in both nodulated as well as non-nodulated plants irrespective of light intensities (Table 1). High light intensity increased the rate of photosynthesis in both nodulated and non-nodulated plants (Fig. 1). However, the rate of photosynthesis was higher in nodulated than non-nodulated plants. This difference was detectable even at 500 lux.

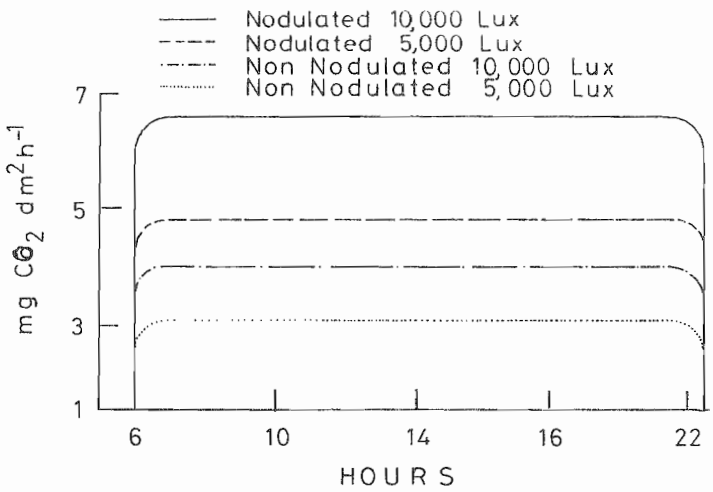

Fig. 1. Rate of photosynthesis in nodulated and non-nodulated soybean during illumination period at 5,000 and 10,000 lux.

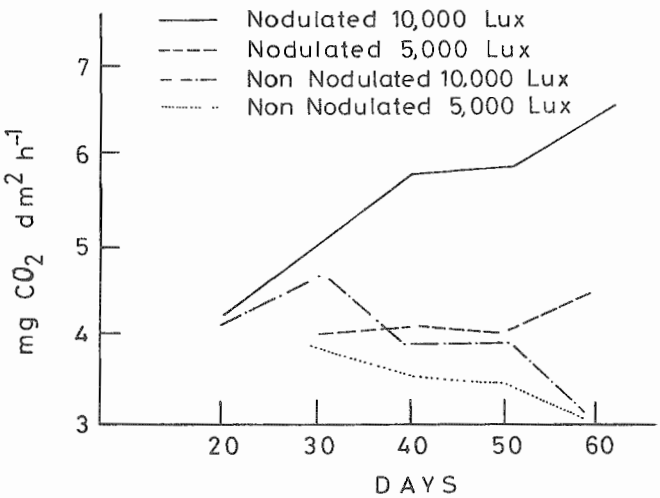

Fig. 2. Rate of photosynthesis during growth period of nodulated and non nodulated soybean at 500 and 10,000 lux light intensities.

The rate of photosynthesis gradually increased in nodulated soybeans irrespective of the light intensity with passage of time whereas in non-nodulated soybeans decreased with the passage of time under both light intensities (Fig. 2). The leaf area increased at each subsequent sampling date irrespective of light intensity or nodulation (Table 2). Leaf area increased when light intensity increased from 5,000 lux to 10,000 lux in both nodulated and non-nodulated plants, however, the rate of leaf area accumulation was

Table 2. Effect of light intensities on leaf area per plant in soybean.

Days	Crop	Light intensity (Lux) 5,000	10,000
		Leaf area (Cm^2)	
20	Nodulated	–	132
	Non-nodulated		120
30	Nodulated	279	285
	Non-nodulated	272	280
40	Nodulated	309	414
	Non-nodulated	300	312
50	Nodulated	400	421
	Non-nodulated	396	410
60	Nodulated	396	415
	Non-nodulated	394	400

Each value is mean of 5 plants.

Table 3. Effect of light intensities on weight of nodules in soybean.

Days	Light intensity (Lux) 5,000	10,000
	Weight of nodule mg/plant	
20	–	–
30	6	8
40	5	19
50	50	110
60	52	120

Each value is mean of 5 plants.

higher in nodulated than non-nodulated plants. Fresh weight of nodules increased with time under both light intensities. Weight of nodules increased under higher light intensity (Table 3). The dry matter accumulation increased with the duration of time in nodulated and non-nodulated plants under both light intensities and was more under 10,000 lux than 5,000 lux (Table 4) but the dry matter content remained higher in nodulated plants.

The acropetal increase in rate of photosynthesis with increase in light intensity (Table 1) was also noticed by Johnson *et al.*, (1969). This could be due to the fact that upper surface of the leaves had greater exposure to light than lower surface which increased the rate of photosynthesis. Our results are in accordance with those of Wassinck (1954), Wheeler (1971), Lawn & Bruns (1974).

Increase in the rate of photosynthesis at the same light intensity in nodulated plants over non-nodulated plants (Fig. 1) indicates that nitrogen fixation in nodulated plants increased the supply of nitrogen which in turn increased photosynthetic rate and growth rate in these plants. From these findings it is inferred that nodulation and rate of nitrogen fixation are positively correlated with photosynthesis as also shown by Maque & Burries (1972), Mishustin (1973), Hardy & Havelka (1976) and Hatam & Hume (1976). Tritikov *et al.*, (1982), also noticed that increased light intensity increased nodulation and rate of photosynthesis in leguminous plants.

An increase in leaf area (Table 2) and dry matter accumulation (Table 4) with an increase in light intensity and still greater increase of these parameters in nodulated plants than non-nodulated as observed in the present investigation is in accordance with the findings of Ashaur (1969), Lie (1971) and Tritikov *et al.*, (1982). Increase in leaf area and dry matter accumulation could also be attributed to nitrogen fixation in nodulated plant. It would suggest that rate of photosynthesis increased with increasing light intensity and photosynthetic rate in turn can be correlated with biological nitrogen fixation.

Table 4. Effect of light intensities on dry matter accumulation in soybean.

Parts of plant	Crop	Light intensity (Lux)									
		5,000					10,000				
		Days after emergence									
		20	30	40	50	60	20	30	40	50	60
		Gram per plant					Gram per plant				
Leaf	Nodulated	–	0.37	0.90	0.90	1.00	0.22	0.50	0.93	0.95	1.20
	Non-nodulated	–	0.35	0.90	0.77	0.90	0.20	0.45	0.80	0.92	1.10
Stem	Nodulated	–	0.20	0.50	0.60	0.80	0.18	0.25	0.52	0.62	1.10
	Non-nodulated	–	0.15	0.45	0.60	0.70	0.16	0.22	0.50	0.62	1.10
Root	Nodulated	–	0.18	0.35	0.50	0.60	0.10	0.15	0.40	0.50	0.70
	Non-nodulated	–	0.10	0.34	0.40	0.40	0.14	0.13	0.40	0.48	0.60
Pods	Nodulated	–	–	0.09	0.10	0.50	–	–	0.20	0.25	0.80
	Non-nodulated	–	–	0.01	0.05	0.40	–	–	0.03	0.10	0.50

Each value is mean of 5 plants.

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