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Studies on Photosynthesis in the Coconut Palm : Rate of Apparent Photosynthesis*

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Rate of apparent photosynthesis in coconut palm has been studied using Warburg manometric technique. Most recently matured frond (the youngest fully opened leaf) exhibits significantly higher photosynthetic rate than the fronds showing increasing maturity. Five leaf discs of 7 mm diam. show significantly higher O_2 output. Temperature variation from 32° to 42°C in the water bath has no influence on the rate of O_2 output. O_2 output is significantly higher at 3000 lux light intensity than at 2500 or 4500 lux.

STUDY of photosynthetic efficiency, a direct measure of dry matter production in green plants, has attained great significance in recent times. Results of studies on photosynthetic process in crop plants in relation to productivity have been adequately reviewed[1-4]. However, in coconut no such studies have been conducted so far, and the present study relates to the determination of apparent photosynthesis.

Twenty adult coconut palms of the same age group belonging to the West Coast Tall variety were used. In every palm, fronds of desired maturity were marked. Four leaflets, 2 each from either side of the middle region of the midrib, were sampled. Small discs (7 mm diam.) cut from the mid region of all the 4 leaflets were pooled together and representative samples drawn from this were used for determination of rate of apparent photosynthesis. Rate of apparent photosynthesis was determined following the method described by Forsyth and Hall[5], using a Photowarburg apparatus.

Desired number of leaf discs was placed in the main compartment of the manometer reaction flask with their upper surface facing the light source. The side arm of the reaction flask contained 0.4 ml distilled water, to prevent dessication of the leaf discs. The centre well of the flask contained 0.6 ml Pardee's CO_2 buffer[6]. A folded filter paper was placed in the centre well to increase surface of the buffer, exposed to flask atmosphere. The light source was tungsten lamps of different light intensities for standardization and the intensity was maintained at 3000 lux using 40 watt lamps throughout rest of the study. The reaction flasks were not shaken as the discs were not suspended in the fluid. Ten to 15 min. equilibration, after switching on the lights, preceded the commencement of gas output measurements. Throughout the study, the reaction flasks were immersed up to the neck in water in the waterbath of the equipment. Other manometric procedures followed were as described by Umbreit[6].

Manometric readings were recorded at 10 min intervals and results expressed at μl O_2 evolved/cm^2 leaf tissue/hr. For each sample 3 replicates were run simultaneously and the mean of the nearest two values were taken for the calculation of O_2 evolved.

Optimum conditions—In order to determine the optimum light intensity at which O_2 evolution is maximum the effect of three light intensities (2500, 3000 and 4500 lux) was studied. The results (Table 1) show that O_2 evolution is significantly higher at 3000 lux than at 2500 and 4500 lux. To determine the optimum quantity of tissue to be used, the rate of O_2 output was measured using 5, 7 and 10 leaf discs, respectively. The data presented in Table 1 show that O_2 is significantly higher when 5 discs are used.

Since the temperature of the water bath in which the reaction flasks were suspended varied from 32° to 42°C during the experimental period of 1 hr it was examined whether this influences the O_2 output. The results (Table 1) show that the rate of O_2 output is not influenced due to variation in temperature from 32° to 42°C.

Photosynthesis in relation to maturity of leaves—Photosynthetic rate was determined in the three whorls of the crown of coconut, representing 3 stages of maturity, viz. (i) youngest fully opened leaf (inner whorl), (ii) N/2 or $\frac{N+1}{2}$ leaf (where N is total number of leaves, representing the middle whorl of leaves and (iii) oldest living leaf (outer whorl), the physiological maturity increasing from the youngest unfolded leaf> middle leaf> oldest leaf.

Variation in the rate of O_2 output is significant between the three whorls of leaves (Table 2). The rate is significantly higher in the youngest fully opened leaf than in others. A decrease in the rate in relation to increasing maturity of leaf tissue is also noted.

TABLE 1 — RATE OF APPARENT PHOTOSYNTHESIS IN RELATION TO DIFFERENT LIGHT INTENSITIES, NUMBER OF LEAF DISCS AND TEMPERATURE

Light (lux)	Photo. (a)	No. of discs	Photo. (a)	Temp. °C	Photo. (b)
2500	69. 0	5	105. 6	32	16. 4
3000	85. 2	7	86. 3	34	19. 3
4500	56. 0	10	80. 5	36	20. 0
Mean	70. 1		90. 5	38	19. 8
SE	7.56		12.41	40	15. 0
F ratio	37.41*		11.52*	42	17. 9
CD (5% level)	7.11		11.65	SE	6.16
				F ratio	1.07†

(a) = μl O_2/cm^2/hr
(b) = μl O_2/cm^2/10 min
* P=0.01
† Not significant

TABLE 2 — RATE OF APPARENT PHOTOSYNTHESIS IN RELATION TO MATURITY OF LEAF

Leaf maturity	Rate of app. photosynthesis μl O_2/cm^2 /hr	
	Mean	CV, %
Youngest fully opened	105.8	24.13
Middle frond	82.8	25.52
Oldest frond	78.4	24.41
F ratio	24.60*	—
CD (5% level)	8.22	—

*P = 0.001

*Paper forms Part I of the series

RP-S

Warburg's manometric technique had been used earlier to determine photosynthetic rates in several terrestrial plants[7–10]. In all these studies, the leaf discs were suspended in buffer in the reaction flasks. However, it was observed later that separation of leaf discs from buffer during measurements would give better accuracy[11]. In the present study leaf discs were separated from the buffer completely[5].

The principal requirement of correct manometric measurement of photosynthetic O_2 output, is the maintenance of constant CO_2 partial pressure in reaction flasks, and hence the proportionality between the surface of sample and gas exchange rate is to be ascertained[11]. In the present experiment this has been checked using different number of leaf discs of the same surface area. The findings that higher rate of O_2 output is obtained with 5 discs than with 7 or 10 discs establishes that smaller leaf area is perhaps essential to maintain the proportionality.

Photosynthetic rates are known to be influenced by temperature variations; however, such large differences in the rates are known to be reflected only at temperatures below 20°C. Adaptability of plants to environmental temperature in relation to their photosynthetic rates is known[3,12]. In the present study very little variation is seen in the photosynthetic rates of coconut leaf within the range 32° to 42°C. The temperature variability in the West Coast of Kerala during summer months is more or less within this range.

Photosynthetic rates are known to be greatly affected by the age of the leaf tissue. A decline in the rate with the increasing maturity of leaf tissue has been reported [13–15]. A similar trend has been noted in the present study also.

Photosynthetic rates of coconut leaf tissue obtained using this technique are comparable to similar studies in other crops[5,7]. While discussing the merits of the use of leaf tissue samples for studying the characteristics of the photosynthetic apparatus Nätr[16] has pointed out that the characteristic of the sample must reflect the characteristic of the intact plant. The correctness of the assumption that the photosynthesis of the leaf discs can be considered as a measure of photosynthetic capacity of the plant has been proved in several crop plants[17]. As has been mentioned by Semikhatova[11], although the rate of apparent photosynthesis obtained by employing this method may not be compared with productivity measurements of mass culture, this method is useful to understand the maximal efficiency of the photosynthetic process.

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