STUDIES ON PRODUCTIVITY OF COFFEE III-DIFFERENCES IN PHOTOSYNTHESIS BETWEEN FOUR VARIETIES OF COFFEE

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SUMMARY

Net photosynthesis was measured in plants of four coffee varieties (two of *Coffea arabica* and two of *Coffea canephora (robusta)*) at several temperature and light conditions.

It was observed that light saturation occurred at approximately 0.11 cal cm^{-2} min^{-1}, whereas net photosynthesis decreased with increasing temperatures above 20 °C (approximately 7 % per °C). The *arabica* selection S288–23 showed the highest net photosynthesis and the lowest percentual decrease with excessive temperatures. The results are in good agreement with field experiments of plants of the same groups.

The method used, may be applied for a comparison of potential dry matter production between varieties under different environmental conditions.

1. INTRODUCTION

In previous publications (NUNES *c.s.* 1968; BIERHUIZEN *c.s.*, 1969) the influence of some environmental factors on vegetative growth, photosynthesis and transpiration of Coffea arabica were reported. The results obtained stress the relevant unfavourable effect of excessive temperatures, giving a more fundamental basis for the interpretation of some practical problems. Such a temperature effect has been already recognized by coffee growers (COSTE 1955).

Considering the impressive variation of ecological conditions where coffee can be grown and produce valuable crops (WELLMAN 1961), large differences in physiological behaviour between varieties are to be expected in dependency of the main climatic factors. Quick methods to detect such ecological preferences may be used as a guide in breeding programs, in case production is directly or indirectly involved. Bean production is highly dependent on the vegetative growth according to ALVIM 1958; MACHADO 1952; GUISCAFRE-ARRILAGA & GOMEZ 1942 and MONTOYA *c.s.*, 1961. The temperature effect on growth and on net photosynthesis is quite similar (NUNES *c.s.*, 1968). The authors believe therefore that measurements of net photosynthesis are useful for a rapid investigation of the potential production of varieties under different ecological conditions.

The present paper reports the differences in photosynthesis between two varieties of *Coffea arabica* and two of *Coffea canephora (robusta)*.

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2. MATERIAL AND METHODS

The material mentioned in *table 1*, obtained from the department of Tropical Crop Husbandry of the Agricultural University at Wageningen, was used.

Cuttings of plants, 9 months old, were grown together for about four weeks in a controlled room with natural day light, at a day/night temperature of 24 to 28°/20° C and at a relative humidity of approximately 70%.

Table 1. Material used

Plant	Origin
Coffea arabica	
'Gimma'	Collected in the region of Gimma, district of Kaffa (Ethiopia) at 1720 m altitude
S288–23	Selection from 'Coffee Research Station' Balehonur, Mysore India
Coffea canephora (robusta)	
BP42 y809	Yangambi seed selection from Java material
SA34	Java

The plants were grown in plastic 10 liter pots, the soil being a mixture of clay, sand and old rotten leaves (2:1:1 by volume). Care was taken to keep the soil at field capacity (33% water content by volume) throughout the experiment.

Measurements of net photosynthesis were made in a small controlled cabinet equiped with artificial light from three HPLR Philips 400 watt lamps. By using thermostat control and changing the distance between the lamps and the plant, several environmental combinations of light and temperature were produced. The net photosynthesis of each plant was measured at four light intensities during the day at a certain temperature, the measurements being repeated at a higher temperature the next day according to the scheme of *table 2*.

Table 2. Sequence and conditions of the measurements

Day	Temperature	Light (cal cm^{-2} sec^{-1})			
Monday	20°C	0.05	0.11	0.15	0.42
Tuesday	25°C	0.05	0.11	0.15	0.42
Wednesday	30°C	0.05	0.11	0.15	0.42

A closed gas circuit was used in the photosynthesis measurements. A detailed description of this method including calculations and equipment has been given previously (NUNES *c.s.*, 1968). Only calculated data of net photosynthesis at a CO_2 concentration 300 p.p.m. are given here.

3. RESULTS AND DISCUSSION

Fig. 1 gives the effect of light and temperature on photosynthesis.

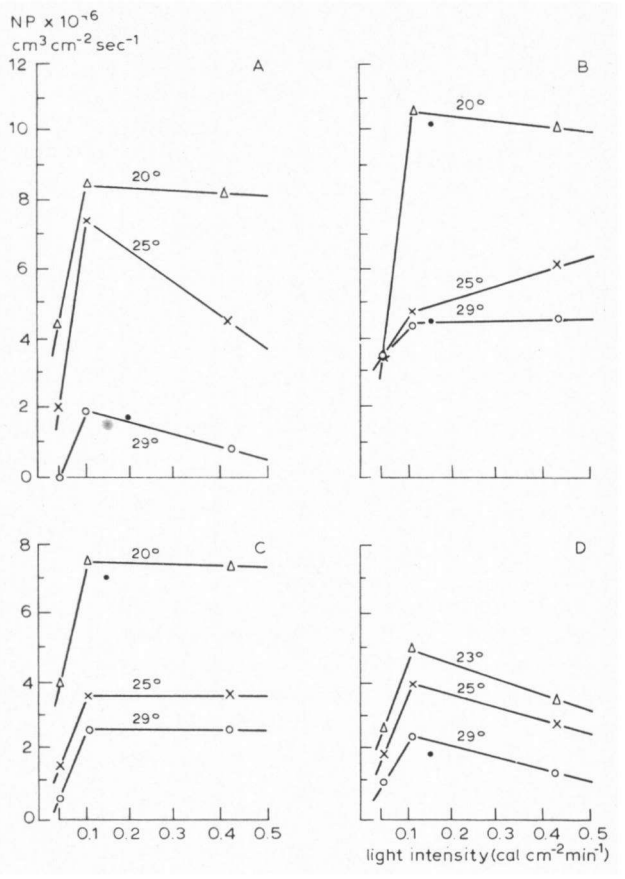

Fig. 1. The effect of light (cal cm^{-2} min^{-1}) and temperature on net photosynthesis (cm^3 cm^{-2} sec^{-1}) in plants of *Coffea arabica* from a high altitude in the region of Gimma, Ethiopia (A) and from a selection S288-23, India (B), and in plants of *Coffea canephora* (*robusta*), from BP42 y 809 a selection obtained in Yangambi starting from Java material (C) and from selection SA34 from Java (D).

3.1. Light effect

Light saturation occurs at approximately 0.11 cal $cm^{-2}sec^{-1}$. At a light intensity of 0.42 cal $cm^{-2}sec^{-1}$, which was the highest intensity studied, the photosynthesis rate was the same or even slightly lower than that at 0.11 cal $cm^{-2}sec^{-1}$. The inhibitory effect of the highest light intensity was more pronounced in *Coffea arabica* collected at high altitude in the Gimma region (fig. 1A) and in *Coffea canephora* SA34 from Java (fig. 1D). The decrease in net photosynthesis of SA34 might be ascribed to the higher temperature (23°C). It may be suggested that this reaction represents an indirect effect of light through an increase of leaf temperature and thus of an increase of internal CO_2 content of the tissues (NUNES *c.s.* 1968).

3.2. Temperature effect

In all cases, the lowest temperature, corresponded to the highest net photosynthesis. The decline due to the increase of temperature from 20°C to 29°C was about 75% in plants from the Gimma region, 67% in both plants SA34 and BP42 y809 and only 60% in plants from selection S288–23. It was evident that the *arabica* from the high altitude Gimma was highly susceptible to excessive temperatures in contrast with the tolerance of selection S288–23. The two *robusta* varieties, however, behaved very similarly and their tolerance was in between the two *arabica* specimen.

Comparing maximum net photosynthesis rate between plants, the most productive one was that from the selection S288–23 from India, followed by 'Gimma' from Ethiopia, both belonging to the *Coffea arabica* species. The first one belongs to a selection which has been referred to as a tree with the most vigorous growth at Luna – Philippines trials (Thirteenth Annual Report of the Research Department of the Coffee Board) and the highest adaptability to a wide range of climatic conditions in India. (NARASIMHASWAMY 1960). Because of this, plants of selection S288–23 recently have been spread in regions of India, where formerly only robusta varieties were grown. Our results are in good agreement with this.

The results are also in fair agreement with previous results concerning the influence of some environmental factors on photosynthesis of coffee (NUNES *c.s.*, 1968; BIERHUIZEN *c.s.* 1969). In experiments described in this paper, however, the internal CO_2 content of the tissues was higher in almost every measurement, in spite of the low temperature. For this reason the plants did not reach the high levels of photosynthesis reported earlier. It is possible that preconditioning to the growth environment may have influenced net photosynthesis as well.

Although the present results should be regarded as preliminary, it is clear that the method employed may be useful for the comparison of ecological preferences between varieties, whereas it may be applied as a test for potential dry matter production in breeding programs.

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