FIELD PERFORMANCE OF YOUNG COFFEE SEEDLINGS AND CUTTINGS INTERCROPPED WITH RUBBER

By

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Abstract

Coffee may be planted either using seedlings or cuttings. Anyhow, a comparative study of their field establishment and performance has not been made. In this study seedlings and cuttings of *Coffea canephora* intercropped with rubber were compared for their field establishment and growth. It is evident that there is no difference in the success of their field establishment. The dry matter yield determinants of plants, i. e. light intercept ion, conversion efficiency and rate of loss of dry matter, estimated by total leaf area, CO_2 assimilation rate and dark respiratory rate respectively, are also similar in both seedlings and cuttings. This is confirmed by the similar mean total dry weight of a seedling and a cutting. The partitioning of assimilates is more towards root development in the cuttings and is evident by the significantly high root dry weight and the root/shoot ratio. The % of assimilates partitioning towards the growth of aerial parts is less in the cuttings, i. e. 52 and 67% for cuttings and seedlings respectively. Despite of similar light levels, the CO_2 assimilation rates are lower in the afternoon in both seelings and cuttings. The % decline is 23.5 and 18.6% for seedlings and cuttings respectively.

Introduction

Though Coffee is planted mainly by using seedlings, cuttings could also be used for this purpose. This will help in maintaining genetic uniformity of the crop. Nevertheless, the field establishment and the growth rates of cuttings will have to be compared with those of seedlings before it could be practised. These may differ from that of seedlings due to the differences in root system and maturity.

Coffee adapts well to shade conditions (Friend, 1984). Further, it is reported that seedlings grown in shade produces more dry matter than those grown in full light (Venkatraman and Govindappa, 1987). Coffee when grown as a intercrop with rubber, receives almost full sunlight until rubber plants are ca. 18 – 24 months) old. The field establishment and growth rates of seedlings and cuttings, may differ under these conditions.

Differences in growth rates could be attributed to those of the dry matter yield determinants, i.e. light interception efficiency, conversion efficiency and rate of loss of dry matter produced (Kramer, 1986; Beadle *et al.,* 1985 and Nelson, 1988). These can be estimated by their leaf area, CO_2 assimilation rate and dark respiration rate.

CO_2 assimilation rate at any given light level is high earlier in the day than later, even though the light levels may be the same (Kuppers et al., 1986b). It is argued that ABA released due to water stress causes inhibition of CO_2 assimilation rates later in the day (Cornic and Miginiac, 1983; Raschke and Headrich, 1985). The ability to maintain high CO_2 assimilation rates later in the day will improve the productivity. The differences in the root system may cause seedlings and cuttings to differ in this aspect.

In this study, coffee seedlings and cuttings intercropped with rubber were compared for their field establishment and growth rates. The CO_2 assimilation rates were determined early and later in the day to study whether seedlings and cuttings differ in its diurnal variation.

Materials and Methods

Plant material

Cuttings of *Coffea canephora* (semi-green wood) with two nodes of Coffea canephora were allowed to sprout and root in a mist propagation unit. They were then transferred into polybags and when around 5 months, healthy cuttings were selected for planting in the field. Seedlings of *Coffea canephora* grown in polybags were obtained from a commercial nursery approved by the Department of Export Agriculture, Sri Lanka.

Coffee seedlings and cuttings of same age were intercropped with rubber, distributed randomly in an experimental area at the Rubber Research Institute, Agalawatte, South of Sri Lanka. Rubber plants were spaced at 9 x 2.4m. A single row of Coffee spaced at 2.4m within the row was planted in-between 2 rows of rubber. The size of a planting hole was 60 x 60 x 45cm. Management practises were as recommended by the Department of Export Agriculture, Sri Lanka. Measurements described late were made when both coffee and rubber plants were ca. 18 months.

CO_2 exchange measurements

The CO_2 assimilation rate (A) and dark respiration rate (Rd) measurements were made in the field using a portable photosynthesis system (Series L1 6200, Li-Cor Ltd., Nebraska, USA). The leaf chamber was covered with a black cloth when measuring dark respiration.

Ten plants each from both seedlings and cuttings were selected at random. From a selected plant 2 leaves were identified, one each from the 3rd and the 4th branch from the top. The measurements were made at 2 times of the day, i.e. 1000h and 1400h. The leaves were covered with black polythene for ca. 5h before the dark respiration rates were measured.

Estimation of leaf area

For each of the 10 seedlings and cuttings selected for the study, the specific leaf weight was determined using 12 leaves, sampled at different heights of the plant. Leaf area measurements were made using a portable leaf area meter (Series LI – 3000, Li – Cor Ltd., Nebraska, USA). Leaf dry weights were determined after oven drying them at 80 °C to a constant weight. Subsequently for each plant the total leaf dry weight was determined to estimate the total leaf area of a plant.

Dry matter yield

Each of the 10 seedlings and cuttings selected for the study were, uprooted and divided into its morphological units, i.e. roots, shoots, petioles and leaves. Dry weights of different morphological units wcr determined separately for each plant, after drying in an oven (maintained at 80°C) to constant weight. Root/shoot ratio, based on the dry weights were determined for each plant.

Results

CO_2 exchange rates

The mean daily CO_2 assimilation rates and dark respiration rates are similar in both seedlings and cuttings of *Coffea canephora* (Table 1).

Table 1. The mean daily CO_2 assimilation rates (A, umol m^{-2} s^{-1}) and dark respiration rates (Rd, umol m^{-2} s^{-1}) of *C. canephora* seedlings and cuttings. The measurements were made under field conditions. Each value is the mean of 20 observations.

Plant type	A	Rd
Seedlings	9.0	1.28
Cuttings	8.8	1.08
Significance	n.s.	n.s.

n.s. = $p < 0.05$

Nevertheless, the CO2 assimilation rates determined early and later in the day are significantly different in both seedlings and cuttings (Table 2). It is lower later in the day. Anyhow the incident light levels were also slightly lower later in the day. The % decrease in A during the latter part of the day is 23.5 and 18.6 for seedlings and cuttings respectively. This difference is statisticaly not significant.

Table 2. The CO_2 assimilation rates (A, umol m^{-2} s^{-1}) of *C. canephora* seedlings, cuttings and the mean light levels (Q, umol m^{-2} s^{-1}) early and later in the day. Measurements were made under field conditions. Each value is the mean of 10 observations.

Time of measurements	Mean Q	Plant Type: Seedlings	Plant Type: Cuttings
1000h	825	10.2	9.7
1400h	715	7.8	7.8
	Significance	*	*
	L. S. D. (5%)	1.6	1.2

* = $p < 0.05$

The dark respiratory rates were similar early and later in the day in both seedlings and cuttings (Table 3).

Table 3. The dark respiratory rates (Rd, umol m^{-2} s^{-1}) of *C. canephora* seedlings and cuttings determined early and later in the day. Measurements were made under field conditions. Each value is the mean of 10 observations.

Time of measurements		Plant Type: Seedlings	Plant Type: Cuttings
1000h		1.30	1.05
1400h		1.25	1.12
	Significance	n.s.	n.s.

n.s. = $p < 0.05$

Leaf area estimation

The mean total leaf area per plant is 3.0 (±0.52) and 2.9 (±0.31) m^{-2} for seedlings and cuttings respectively. The difference is not significant.

Dry matter yields

The total dry weight of a plant is similar in a seedling and a cutting (Table 4). Nevertheless, the root dry weight is significantly high in the cuttings. Thus the amount of dry matter partitioned for root growth is relatively high in the cuttings. This is also evident by the significantly high root/shoot ratio in the cuttings. Though not significant the dry weights of the aerial parts are less in the cuttings (Table 4). The % of the total dry matter partitioned for the growth of aerial parts is 52 and 67% for cuttings and seedlings respectively. This differecnce is statisticaly significant.

Table 4. The total dry weight (Tw, g^{-1}), the root/shoot ratio (R/S) and dry weights of shoots (Sw, g^{-1}), roots (Rw, g^{-1}) and leaves (Lw, g^{-1}) in cuttings and seedlings. The dry weights were determined after oven drying at 80 °C to constant weight. Each value is the mean of 10 observations.

Plant type	Tw	R/S	Sw	Rw	Lw
Seedlings	1427	0.53	957	469	395
Cuttings	1632	0.95	853	780	329
Significance	n.s.	***	n.s.	**	n.s.
L. S. D. (5%)	–	0.16	–	132	–

Discussion

The success of field establishment of the *Coffea canephora* seedlings and cuttings are comparable. The dry matter yield determinants of seedlings and cuttings were compared when they were ca. 18 months. Mean daily CO_2 assimilation rate is similar in both seedlings and cuttings (Table 1). Anyhow, as reported for other species (Tenhunen et al., 1985; Kuppers et al., 1986a; Gollan et at., 1985) the CO_2 assimilation rates were high earlier in the day than later even though light levels are only slightly different (Table 2). The % decline in CO_2 assimilation rate, later in the day is similar in both seedlings and cuttings, 23.5 and 18.6 respectively. The decrease in A, later in the day is attributed to water stress by some workers, eg. Burshka et al., 1985; Kuppers et al., 1986a and 1986b. Thus, though the seedlings and cuttings differ in their root system, both plant types seems to be capable of maintaining their water status. The root/shoot ratio is significantly high in the cuttings (Table 4) suggesting that more assimilates are being partitioned towards root growth. It is reported that more dry matter is partitioned towards root growth when sweetgum and pinus seedlings are grown under water stress (Tolley and Strain, 1984). A relatively higher amount of dry matter being partitioned for root growth in the cuttings could be to overcome the disadvantages of not having a tap root system. This will also result in an increased root surface area for water and mineral absorption. Though not significant, the lower shoot and leaf dry weights in cuttings suggests that increased root growth is at the expense of shoot and leaf growth. Infact, the % of total dry matter partitioned towards the aerial part of the plant is significantly low in the cuttings. Less aerial parts in a plant may also minimise transpiratory water loss. Also, it could be that shallow soil, ca. 45cm, in the experimental area may have retarded the growth of the tap roots in the seedlings.

The rate of dry matter loss, estimated from the dark respiratory rates are similar for both seedlings and cuttings (Table 1). Further dark respiratory rates do not vary with time of day as evident in CO_2 assimilation rates (Table 3). Similar observations have been made with *Hevea brasiliensis* (Nugawela, 1989).

The toatl leaf area, an estimation of light interception capacity is also similar in both seelings and cuttings.

There is evidence to show that the dry matter yield determinanats, i.e. light interception, conversion efficiency and rate of loss of dry matter of *C. canephora* seedlings and cuttings are similar. Thus, we could expect them to have similar growth rates. Infact, the mean total dry matter yield of a seedling and a cutting is similar (Table 4). Further, we could expect a similar economic yield, unless differences in the harvest index, branching and economic life cycle exist. Economic life cycle of the seedlings and cuttings could differ due to the observed differences in their root growth. Thus, it could be concluded that *C. canephora* seedlings and cuttings are alike in their field establishment and also in field performance during their early growth stages.

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