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Physical and Chemical Properties of Coconut Coir Dust and Oil Palm Empty Fruit Bunch and the Growth of Hybrid Heat Tolerant Cauliflower Plant

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ABSTRAK

Penyelidikan yang dilaporkan dalam eksperimen ini memberi tumpuan terhadap ciri fizikal dan kimia habuk sabut kelapa (CD) dan tandan kosong kelapa sawit (EFB) berpotensi digunakan sebagai media pertumbuhan bagi kobis bunga hibrid di bawah rumah tanaman di tropika yang mempunyai kelembapan udara yang tinggi. EFB dan CD mempunyai ciri fizikal optimum untuk keperluan pertumbuhan tanaman pada awal penanaman. Walau bagaimanapun, kedapatan air tersedia bagi CD adalah 34% dibandingkan dengan 19% untuk EFB. Ruang rongga tersedia EFB , iaitu rongga yang melebihi 300 μm adalah tinggi dibandingkan dengan CD. Ciri kimia menunjukkan EFB adalah lebih alkali (pH 6.9) dibandingkan dengan CD(pH 5.3) dan rendah kekonduksian elektrik (EC) iaitu 1.3 dSm^{-1} dibandingkan dengan CD (1.9 dSm^{-1}). Keputusan juga menunjukkan CD mengandungi kepekatan nutrien yang tinggi dibandingkan dengan EFB. Walaupun EC asal CD lebih tinggi, jumlah bahan kering tanaman adalah tinggi dibandingkan dengan kobis bunga yang ditanam dalam EFB. Kedapatan fungi dan cendawan pada permukaan media EFB dan penguraian awal telah menyebabkan pertumbuhan tanaman yang kurang pada media EFB. Oleh itu, CD adalah media tanaman yang lebih sesuai dibandingkan dengan EFB untuk penanaman hibrid bunga kobis.

ABSTRACT

This research report is about the physical and chemical properties of coconut coir dust (CD) and oil palm empty fruit bunch (EFB), and their potential for use as growing media for hybrid cauliflower grown under humid tropical greenhouse conditions. The physical properties showed that both the EFB and CD provided optimum plant growth conditions at the start of the growing the period. However, the readily available water value for CD was 34% whereas that for EFB was 19%. The air filled porosity containing more pores larger than 300 μm were higher in EFB compared to CD. The chemical properties data suggested that EFB was more alkaline (pH of 6.9) than CD (pH of 5.3) and had lower electrical conductivity (EC) of 1.3 dSm^{-1} than CD (1.9 dSm^{-1}). The results also indicated higher nutrient contents in CD than in EFB. Despite a high initial EC value for CD than EFB, the hybrid cauliflower plant dry weights and total leaf area for CD grown plants were double those grown in EFB. The appearance of fungus and mushroom on the EFB medium surface and the early sign of decomposition may account for the lower plant growth in the EFB medium. Hence, CD is a more suitable growing medium for growing hybrid cauliflower compared to EFB.

INTRODUCTION

The principal difference in growing conditions between plants grown in other media and those raised in soil is the amount of space available for root development. In many cases the development of roots is restricted by the container, pot or holding medium in which the plants are raised (Carlile 1997). The root of plants must obtain sufficient water, oxygen and nutrients from the surrounding environment. The life processes of the root system excrete CO_2 and other gases that must disappear within a certain time from the root environment. The structure of the growing medium must be soft and porous enough so that roots can easily penetrate widely into the material and it must also provide anchorage and support for the plants. The well being of a plant is strongly dependent on the correct functioning of the root system. The physical, chemical and biological properties of a growing medium can be used as a basis of classifying the suitability of a growing medium in relation to the needs of the roots.

Understanding the physical environment surrounding roots in containers (relative volume of air, water, and solid) is based on the relationship between energy status and water content of the medium (Roberts *et al.* 1989). This relationship is a reflection of the pore size distribution of the medium. A plot of this relationship, i.e., a plot of volumetric wetness (q) vs. water potential is called moisture characteristic curve or moisture retention curve (De Boodt and Verdonck 1972).

Ever since Bunt (1961) first reported moisture retention curves for pot-plant media, there has been considerable effort to determine the utility of these curves in explaining plant growth, and the best way to quantify these data for both descriptive and predictive purposes (Roberts *et al.* 1989). The phase distribution (air, water and solid) of a medium is important for horticulture particularly at matric potentials between –1 cm and –100 cm water column (pF 2.0 = 10 kPa) (De Boodt *et al.* 1974; Michiels *et al.* 1993). Lower matric potentials will give rise to severe loses in growth rate. Air filled porosity (AFP) of the medium is the ability of the medium to retain air, hence is important to ensure sufficient oxygen supply to the roots. As far as the chemical properties are concerned the growing medium must have a suitable pH value range of about 5.0-6.5, an electrical conductivity that may not exceed a certain level and free of harmful elements and chemicals.

The physical and chemical properties of coconut coir dust (CD) from numerous sources have been found to be within acceptable ranges and suitable for use as growing medium (Evans *et al.* 1996). However significant differences were observed among coconut coir dust sources with respect to physical and chemical properties (Evans *et al.* 1996), and these may explain the differences in results (good and negative) obtained from previous studies (Reynolds 1973; Meerow 1994; Radjaguguk *et al.* 1983) when using CD as growing media. Yahya and Mohd Razi (1996) suggested that the variation in chemical and physical properties of the media and differences in plant sensitivity to a defined root environmental condition might have contributed to the marked differences in some ornamental plant development observed in their studies. Therefore, the properties of the growing medium affect the plant growth.

Although CD and its mixture with other components have been widely and successfully used in different parts of the world as an environment friendly peat substitute for growing plants in containers (Meerow 1994, 1995), its basic properties and utilization in crop production in Malaysia is rather scarce (Yahya and Mohd Razi 1996). Another potential medium is oil palm empty fruit bunch (EFB). It is one of the solid wastes generated from the oil palm industry. Even though direct mulching using EFB on soil can improve soil structure, aeration and moisture capacity (Megat Johari *et al.* 1990) there has been little interest on utilisation of EFB as growing medium for containerized plants.

The objective of this study was to determine the differences in physical and chemical properties between the local CD and EFB, and their effect on the growth and nitrogen content in the hybrid cauliflower when used as growth media. In many cases the properties of CD were manipulated to prepare suitable coir based media for containerized plant (Handreck 1993; Meerow 1994, 1995; Yahya *et al.* 1997). However, in this study no manipulation was done to improve the basic properties of the medium by mixing with other organic and inorganic components.

MATERIALS AND METHODS

Experiment 1: Determination of Physical and Chemical Properties

Coconut coir dust (CD) obtained locally from Perak and freshly shredded oil palm empty fruit bunch fibres of mean gross length 9.10 ± 3.40 cm obtained from Kapar Klang were used in this study. Oil palm fibres were cut to a mean gross length of 3.46 ± 1.26 cm by an impact type cutter at a cutting speed of 2 kg/min. Short fibres were then ground through 5.0-mm sieve and air-dried. The products are referred to as oil palm empty fruit bunch (EFB). Both CD and EFB were analysed for physical and chemical properties. Bulk density (g cm^{-3}) was determined using modified methods of De Boodt *et al.* (1974). The cylinder used was a brass ring, 4.0-cm in height and 7.60 cm (internal diameter), with internal volume of 181 ml. The bottom of the ring was fitted with iron gauze and rubber ring and the whole assembly were weighed. Another ring was then placed on top of the above-mentioned ring and stacked vertically. The rings were filled with a medium and gently tapped against a laboratory table at a height of ≈ 10.0 cm a sufficient number of times to obtain a certain bulk material in the bottom ring. The top ring was discarded. The bottom ring filled with medium was weighed and then seated on to the porous plate and saturated with water for 48 hours. The mass was determined after drying the medium in the oven at 105° C for 24 hours.

The particle density of the substrates was determined by using a pycnometer bottle (Blake and Hartge 1986). All determinations were replicated five times. The total pore space (volume %) and volumetric shrinkage (volume %) were calculated following the methods of Michiels *et al.* (1993).

The moisture retention curves of both coconut coir dust and oil palm empty fruit bunch were determined using the method of De Boodt *et al.* (1974). The moisture content was measured after equilibrating the samples on the pF equipment at matric potentials of –10, -50, –100, -300 cm water column and 15 bar (pF 1, 1.7, 2.0, 2.5 and 4.2). From this curve, the air volumes, readily available water, water buffer capacity, less readily available water and pore size distributions were calculated (Michiels *et al.* 1993).

The pH and electrical conductivity (EC) of the coconut coir dust and oil palm empty fruit bunch were determined using air-dried samples to water ratio of 1:2 (v/v). The samples were stirred with a glass rod and allowed to equilibrate for 4 hours. For pH measurement, the samples were stirred again immediately before measuring the pH using a calibrated pH meter. For EC measurement, the solution was then filtered through a Whatman No.41 filter paper and the extract was collected in a small beaker. The EC of the extract was measured using the EC probe with calibrated conductivity meter.

Total nitrogen was determined using Semi-Micro Kjedahl., potassium (K^+) contents using flame photometer and calcium (Ca^{2+}), magnesium (Mg^{2+}) and zinc (Zn^{2+}) contents using absorption following HNO_3-H_2O_2 digestion of the coconut coir dust and oil palm empty fruit bunch in the microwave. Phosphorus concentration (P) was determined colorimetrically by vanadium molybdate measured at 410 nm with a spectrophotometer.

Five replications were tested for each medium (coconut coir dust and oil palm empty fruit bunch). A t-test for two independent samples (two tailed test, a = 0.05) was done to determine if the medium significantly affected the measured physical and chemical properties.

Experiment 2: Growth Comparison of Hybrid Cauliflower Grown in Coconut Coir Dust and Oil Palm Empty Fruit Bunch

a. Plant Materials, Growth Conditions and Treatments

White polyethylene bags of 6 L volume were used as growing bags. A 10 cm circular opening was made at the top of each bag after filling with 6 L of growing medium (100% coconut coir dust or 100% empty fruit bunch) to plant the hybrid cauliflower seedling. Slits were made at the bottom of each bag to allow for drainage. The coconut coir dust or oil palm empty fruit bunch was then thoroughly wet with water and allowed to drain before seedling transplanting. Each bag was placed on a perforated square plastic basket fitted with 6 legs of 4 cm high from the greenhouse floor.

Seeds of hybrid heat tolerant cauliflower were germinated in germination trays filled with 100 % coconut coir dust or 100% oil palm empty fruit bunch and watered daily with tap water. Two weeks after germination, uniform sized seedlings were transplanted, one seedling per bag, into the 6 L growing bags filled with coconut coir dust or oil palm empty fruit bunch.

The growing bags were placed in a greenhouse under natural photoperiod and irradiance with day temperature ranging between 28°C and 38°C and minimum night temperature of 25°C. The seedlings were irrigated via drip emitter (2 L h^{-1}) with tap water for the first 3 days and a complete Cooper (1979) nutrient solution thereafter. Nitrogen was applied as KNO_3 at a concentration of 200 ppm N. The nutrient solution was adjusted to pH ranging from 5.5 to

5.8 with either dilute KOH or H_2SO_4. The electrical conductivity of the solution was 2.4 dS m^{-1}. Initially plants were irrigated twice daily for 15 minutes but as the environmental conditions promoting evapotranspiration increased and the plants grew larger fertigation was increased to three times/day. The experimental design was a randomized complete block design with the two growth medium as treatments each replicated five times.

b. Plant Samplings, Growth Parameters and Chemical Analysis

Plants were harvested at 21, 42 and 65 days after transplanting (DAP). The plants were cut just below the first leaf node, which was less than 1 cm from the growing medium surface. Five plants of each treatment were harvested at each harvesting time and separated into stem plus petioles, leaves and curd at final harvest. After weighing, the plant samples were dried in a forced air oven at 70° C for 96hr and weighed. The dried samples were ground through a 2 mm sieve for total N analysis.

RESULTS

The physical and chemical properties of coconut coir dust were evaluated as potential growing medium for containerized plants and compared to oil palm empty fruit bunch. The bulk density of oil palm empty fruit bunch (0.075 g cm^{-3}) was significantly higher than that of coconut coir dust (0.177 g cm^{-3}) as shown in Table 1. Oil palm empty fruit bunch also showed a significantly higher particle density (1.321 g cm^{-3}) compared to 0.758 g cm^{-3} for coconut coir dust. The total pore space for organic medium included the open, interconnecting and closed pores. Data in Table 1 show that coconut coir dust had significantly higher total pore space (96.26 %vol.) than oil palm empty fruit bunch (92.80% vol.). No significant difference was found in volumetric shrinkage values between coconut coir dust and oil palm empty fruit bunch. The volumetric shrinkage values for the coconut coir dust and oil palm empty fruit bunch were 11.21% and 10.13% respectively.

The moisture retention curves for coconut coir dust and oil palm empty fruit bunch are shown in *Fig. 1.* As suction was gradually increased more water was drawn out of the oil palm empty fruit bunch compared to the coconut coir dust, resulting in the low amount of water retained in oil palm empty fruit bunch as compared to coconut coir dust. Increasing suction will result in the progressive emptying of the pores of different sizes until at high suction values where only the narrow pores retain water. Hence, the shape of the moisture retention curve of a medium reflects its pore size distribution (Michiels *et al.* 1993).

From the moisture retention curves obtained for coconut coir dust and oil palm empty fruit bunch, its pore distributions were calculated. *Fig. 2* shows the distribution of pore size for oil palm empty fruit bunch and coconut coir dust. It is clear that oil palm empty fruit bunch contained relatively larger pores (> 300 μm diameter) than coconut coir dust, and once these large pores are emptied at a given suction, only small amounts of water remained.

This is reflected in the results as only 45% water was retained in oil palm empty fruit bunch at 1 kPa suction compared to 71% water retained in coconut coir dust as shown in *Fig. 1.* The air filled porosity (AFP) represented by relatively larger pores > 300 mm in oil palm empty fruit bunch was 47% whereas the AFP in coconut coir dust was only 25% (*Fig. 2*).

The coconut coir dust contained more pores of sizes between 60 mm and 300 mm than oil palm empty fruit bunch which resulted in a

TABLE 1

Physical properties of coconut coir dust and oil palm empty fruit bunch

Property	Coconut coir dust	Oil palm empty fruit bunch	t- value
Bulk density (g cm^{-3})	0.074	0.177	3.790**
Particle density (g cm-^{3})	0.758	1.321	2.659*
Total pore space (% vol)	96.264	92.796	2.932**
Shrinkage (% vol)	11.206	10.129	0.729^{NS}

The figures are means of 5 replications.

^{ns}, *, ** Non significant or significant at p< 0.05 or 0.01, respectively.

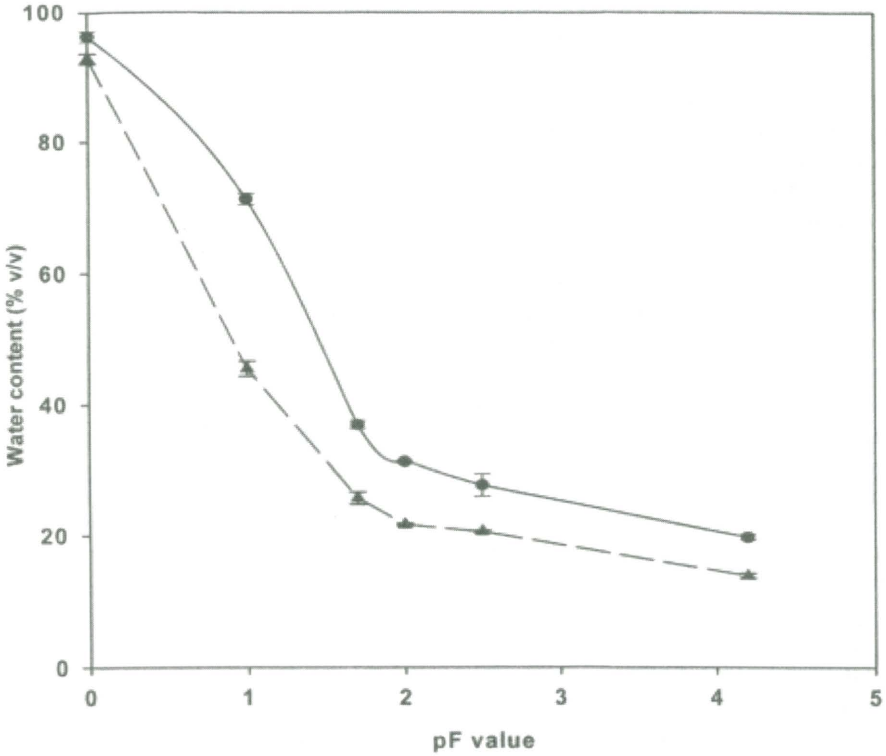

Fig. 1: Moisture characteristic curve for coconut coir dust ● *and oil palm empty fruit bunch* ▲

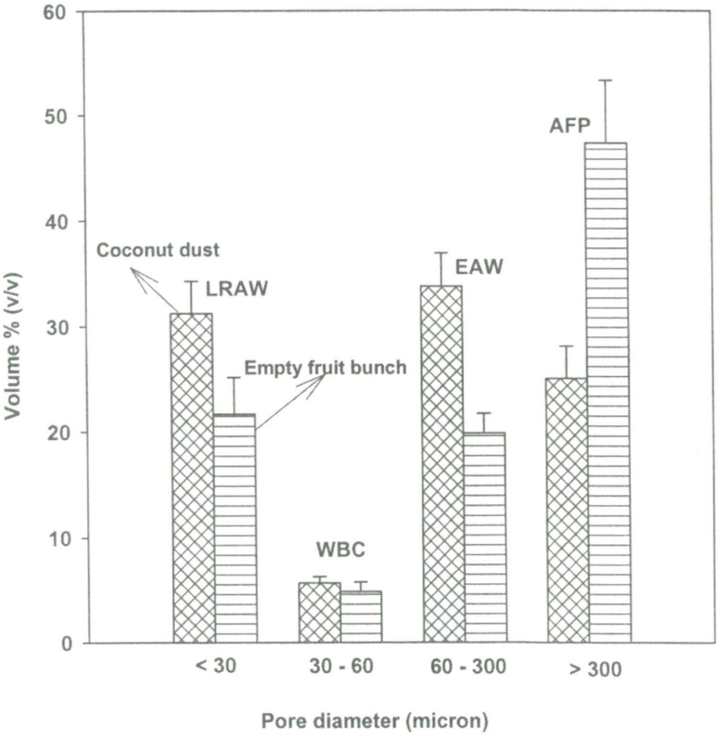

Fig. 2: Air filled porosity (AFP), Easily available water (EAW), Water buffer capacity (WBC) and Less readily available water (LRAW) for coconut coir dust and oil palm empty fruit bunch at different pore size distribution. The values are means of 5 replications and standard errors are shown

higher readily available water (RAW) value of 34% compared to 20% for oil palm empty fruit bunch.

However, both coconut coir dust and oil palm empty fruit bunch showed almost similar values of pore size between 30 mm and 60 mm which decreased the water buffer capacity. The water buffer capacity for coconut coir dust and oil palm empty fruit bunch was 6% v/v and 5% v/v, respectively. Narrow pore sizes of < 30 mm was also high in coconut coir dust than oil palm empty fruit bunch, hence coconut coir dust retained more less readily available water (LRAW) of 31% compared to 22% for oil palm empty fruit bunch.

There was a marked difference between the growing media with respect to chemical properties (Table 2). One factor indirectly affecting plant growth is the pH of the growing medium. The pH differed significantly between coconut coir dust and oil palm empty fruit bunch samples (Table 2) with pH ranging from 5.3 to a high value of 6.9 respectively. The recommended pH range for an ideal substrate was between 5.2 and 6.3 (Abad *et al.* 1989). Therefore, the pH value of oil palm empty fruit bunch was higher than the established limits for an ideal substrate whilst coconut coir dust was within the range.

The EC level of the coconut coir dust (1.96 dSm^{-1}) was high though within the range for ideal substrate as compared to the EC of 1.30 dSm^{-1} for oil palm empty fruit bunch. The amount of naturally–occurring nutrients in coconut coir dust was significantly higher than oil palm empty fruit bunch with potassium (K^+) content of 2.39%, being the highest for all nutrients measured. The concentration of P and Ca^{2+} in coconut coir dust was 0.41 and 0.18% respectively and for oil palm empty fruit bunch 0.23 and 0.08%. Hence, the high EC value of coconut coir dust as compared to oil palm empty fruit bunch observed in the present study could be due to the higher concentrations of these nutrients in coconut coir dust compared to that in the oil palm empty fruit bunch. Coconut dust contained 0.11% magnesium (Mg^{2+}), which was significantly different from the 0.05% Mg^{2+} content in oil palm empty fruit bunch. The Mg^{2+} content was lowest in both coconut coir dust and oil palm empty fruit bunch in comparison to other nutrients. Total nitrogen (N) was slightly higher in oil palm empty fruit bunch compared to that in coconut coir dust. Since the nutrients content in both media is low, the nutrient requirements of plants growing in these media may be supplied by fertigation (liquid feeding) during plant growth.

An attempt was made to evaluate the potential of these two substrates for use as growing media by planting hybrid cauliflower on both media and supplying both with complete nutrient solution including nitrogen at 200 ppm in a subsequent experiment.

Differential growth responses were observed between the two growing media studied (*Figs. 3* and *4*). Plants grown in coconut coir dust exhibited higher morphological growth than oil palm empty fruit bunch. Leaf and stem dry weight were 49% and 42% less in oil palm empty fruit bunch respectively compared to coconut coir dust at 21 DAP (*Fig. 3a*). These resulted in

TABLE 2
Chemical properties of coconut coir dust and oil palm empty fruit bunch

Property	Coir dust	Oil palm empty fruit bunch	t- value
pH	5.3	6.9	3.751**
Electrical conductivity ($dS\ m^{-1}$)	1.96	1.30	3.973**
Total nutrient (%):			
Total nitrogen	0.39	0.42	2.870*
P	0.41	0.23	3.406**
K^+	2.39	1.56	2.507*
Ca^{2+}	0.18	0.08	2.499*
Mg^{2+}	0.11	0.05	2.859*

The figures are means of 5 replications.
*, **, Significant at $P<0.05$, or 0.01 respectively.

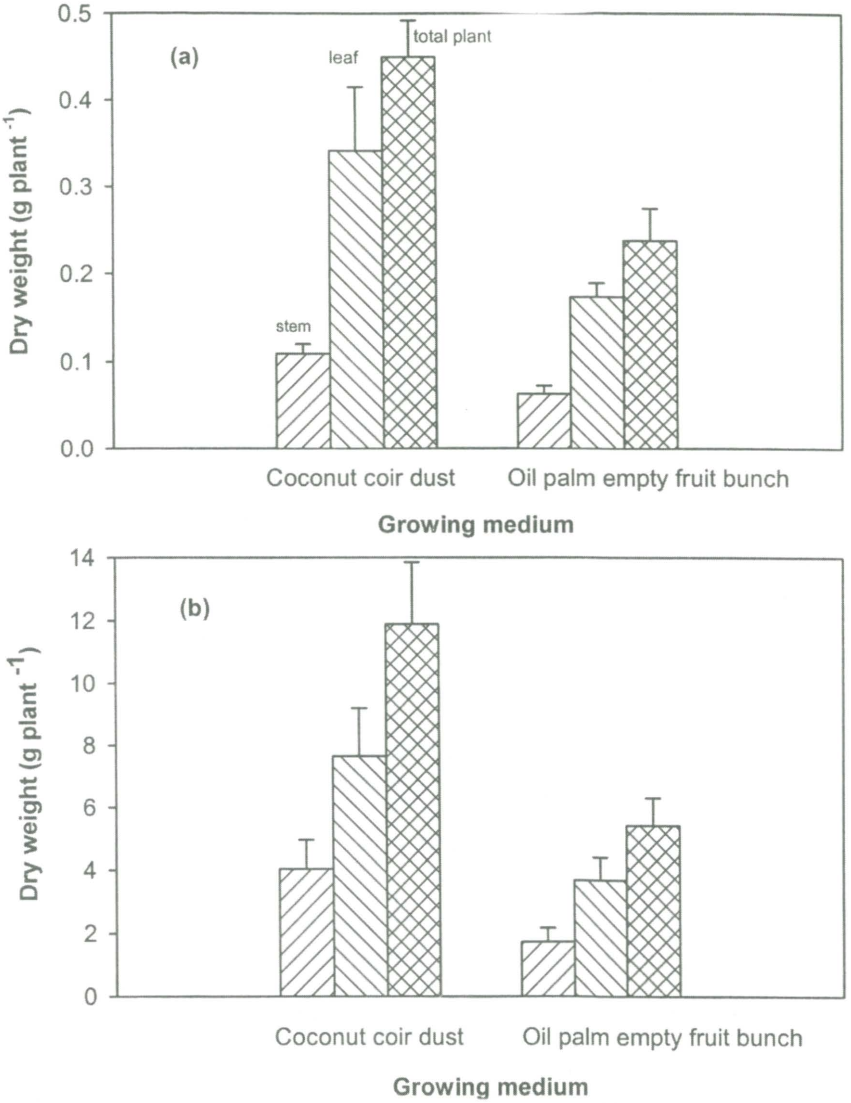

Fig. 3: Growth of hybrid cauliflower in coconut coir dust or oil palm empty fruit bunch at (a) 21 and (b) 42 DAP with 200 ppm N. The values are means of 5 replications and standard errors are shown. Note the different scales of Y axes

a significantly ($p<0.01$) higher above-ground total plant dry weight of plant grown in coconut coir dust compared to oil palm empty fruit bunch (*Fig. 3a*). Total leaf area for coconut coir dust plant was higher than that in oil palm empty fruit bunch at 21 DAP (*Fig. 4*).

The growth rates for hybrid cauliflower plants grown in either coconut coir dust or oil palm empty fruit bunch did not show any distinct dissimilarly. However differences were observed in dry weight accumulation. There was significantly higher dry weight accumulation in stem and leaves of plants grown in coconut coir dust compared to those grown in oil palm empty fruit bunch at 42 DAP (*Fig. 3b*). These results suggest greater plant growth response to coconut coir dust compared to oil palm empty fruit bunch growing medium. Total plant dry weight and total leaf area for plant grown in coconut coir dust were double that grown in oil palm empty fruit bunch (*Fig. 3b*).

In addition, plant growth in oil palm oil palm empty fruit bunch experienced damage due to fungal and mushroom growth in the medium at about 30 to 35 DAP (*Figs. 6a, 6b* and *6c*). The experiment was terminated after 42

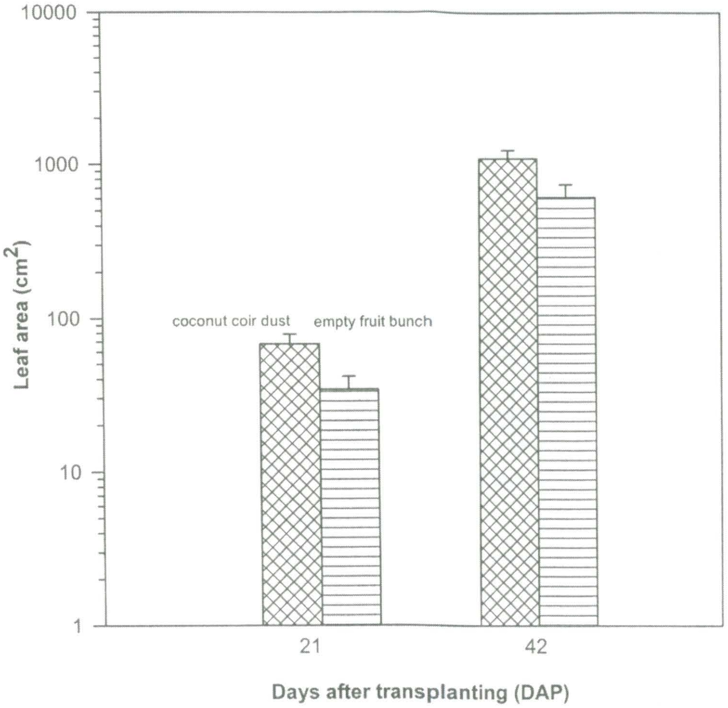

Fig. 4: Total leaf area of cauliflower grown in coconut coir dust or oil palm empty fruit bunch at 21 and 42 DAP supplied with 200 mg l^{1}N. The values are means of 5 replications and standard errors are shown

DAP due to excessive fungal and mushroom problems in the oil palm empty fruit bunch-growing medium. Therefore data at 65 DAP was not available.

The results in *Figs. 5a* and *5b* show that the total N uptake in the leaf of hybrid cauliflower plants was affected by the growing medium. Total N uptake in the leaf at 21 and 42 DAP was significantly higher in plants grown in coconut coir dust than in plants grown in oil palm empty fruit bunch. Total N uptake in the leaf per plant ranged between 10.0 to 20.0 mg dry weight for plants grown in oil palm empty fruit bunch and coconut coir dust respectively. Total N uptake in the stem per plant was lower than in the leaf for all plants grown whether in coconut coir dust or oil palm empty fruit bunch. However, total N uptake was 30% higher in the stem of plants grown in coconut coir dust than that in oil palm empty fruit bunch.

The high dry weight accumulation in the plant grown in coconut coir dust (*Fig. 3a* and *3b*) resulted in double the total N uptake in the plants grown in coconut coir dust as com-pared to the plants grown in oil palm empty fruit bunch at both 21 and 42 DAP.

DISCUSSION

During the growing period, the physical properties of the substrate cannot be changed whereas the chemical properties can be kept unchanged or varied by adding nutrients. Therefore, at the start of the growing period, the physical properties of the substrates have to be in an optimal condition (Ulrich 1996).

Both coconut coir dust and oil palm empty fruit bunch were evaluated as lightweight materials with bulk density varying between 0.074 g cm^{-3} and 0.180 g cm$^{-3,}$ respectively (Table 1). The values were lower than the range for ideal substrates (Abad *et al.* 1989). However, the coconut coir dust bulk density was within the range (0.04 to 0.08g cm^{-3}) reported by Evans *et al.* 1996 for five coconut coir dust sources from the Philippines and by Patricia *et al.* (1997) for coconut coir dust from Mexico (0.075g cm^{-3}) and Sri Lanka (0.056g cm^{-3}). The advantage of the light weight material is that it allows ease of handling and transport, which is a very important commercial or economic consideration during handling and transport. Despite their low bulk density, both coconut coir dust and oil palm

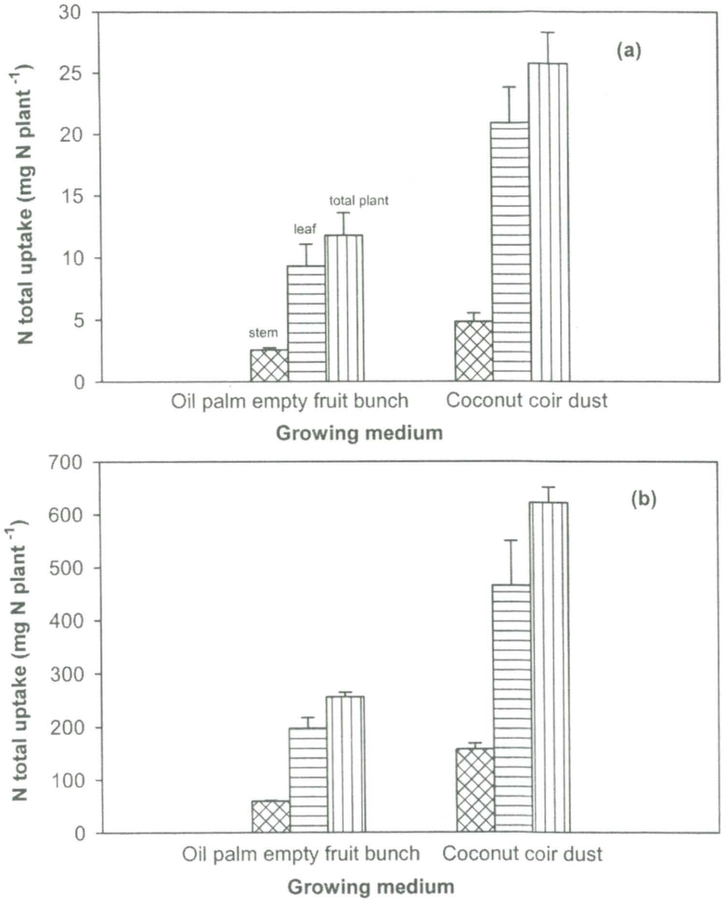

Fig. 5: Total nitrogen uptake in the leaf, stem and total plant of hybrid cauliflower plant grown in coconut coir dust or oil palm empty fruit bunch at 21 (a) and 42 (b) DAP supplied with 200 ppm N. The figures are means of 5 replications and standard errors are shown. Note the different scales of Y axes

empty fruit bunch did not show any problems to anchor of cauliflower plants.

Both the particle and bulk densities of oil palm empty fruit bunch were significantly higher than coconut coir dust (Table 1). These could be attributed to the different material composition of the two media. For most organic substrates, however the particle density is the parameter with the least quantum with respect to limitations on plant growth (Michiels *et al.* 1993).

The total pore space, which can be filled with water and air for both coconut coir dust and oil palm empty fruit bunch, was characteristically high (Table 1). Therefore both media should have sufficient amounts of air and available water for plant growth. The value obtained for coconut coir dust was 96 vol % which was close to the 95.3 vol % obtained by Prasad (1997) and between 95.1 to 96.3 vol % by Patricia *et al.* (1997) for coconut coir from Mexico and Sri Lanka. Furthermore, the total pore space has been reported to show small changes over time for black, white peat and sphagnum (Michiels *et al.* 1993) when using those substrates in an ebb/flood irrigation system.

Air filled porosity (AFP), readily available water (RAW), water buffer capacity (WBC) and less readily available water (LRAW) are the physical properties that have a direct effect on plant growth. It is usually recommended that air filled porosity (AFP) for growing medium in horticulture should be above 10-20% (De Boodt and Verdonck 1972; Bugbee and Frink 1986). The air content of the medium is particularly important when plants are grown for long periods of time in containers. In this study, the AFP was estimated to be above 25% in both coconut coir dust and oil palm empty fruit bunch (*Fig. 2*) and thus sufficient for growing hybrid cauliflower plant which has a long maturity period of 65 - 70 days. The AFP of the oil palm empty fruit bunch which contains more pores of size > 300 μm was however, much higher than coconut coir dust with difference of 47% (*Fig. 2*).

The results showed that the optimal values of RAW were 34% for coconut coir dust and 19% for oil palm empty fruit bunch. The water buffer capacity (WBC) values obtained for both coconut coir dust and oil palm empty fruit bunch are adequate (Bunt 1988). Hence, it is expected that plants grown in these media will not be prone to drastic wilting if there is a sudden increase in transpiration when the watering regime is not adjusted. Based on the results of this study and other evidence adduced so far, it is reasonable to suppose that the physical properties of both coconut coir dust and oil palm empty fruit bunch are optimum at the start of growing period.

The results for chemical properties of both coconut coir dust and oil palm empty fruit bunch indicate wide differences between the two growing media (Table 2). The pH, through its effect on the availability of major and minor nutrients from growing medium, is of considerable importance to plant growth. The results shown in Table 2 indicate that oil palm empty fruit bunch is more alkaline (pH of 6.9) compared to coconut coir dust (pH of 5.3). This would favour coconut coir dust as a more suitable growing medium than oil palm empty fruit bunch since the optimal pH for plant growth in most substrates is 5.0–5.5 (Carlile 1997). On the other hand, high electrical conductivity (1.9 dS m^{-1}) for coconut coir dust may pose a problem by retarding plant growth. Fewer problems may occur with oil palm empty fruit bunch with its lower EC value of 1.3 dS m^{-1}.

Earlier (Evans *et al.* 1996; Meerow 1995) and recent studies (Abad *et al.* 2002) on coconut coir dust naturally occurring nutrients were reported to be low in mineral nitrogen (N), calcium (Ca^{2+}) and magnesium (Mg^{2+}) and can be improved by using fertilisers such as calcium nitrate, magnesium nitrate, magnesium sulphate or gypsum. These researchers also reported high levels of phosphorus (P) and potassium (K^+) content in coconut coir dust tested. Other researchers have also reported low levels of N, Mg^{2+} and P but high K^+ content in oil palm empty fruit bunch (Megat Johari *et al.* 1990). The results, however, indicated higher nutrient contents with the exception of total nitrogen in coconut coir dust compared to oil palm empty fruit bunch (Table 2).

The results on hybrid cauliflower plant growth in coconut coir dust or oil palm empty fruit bunch suggest that coconut coir dust is a more suitable growing medium than oil palm empty fruit bunch (*Figs. 3a, 3b* and 4). Despite the high initial EC value of coconut coir dust, no indication of growth retardation in hybrid cauliflower plant was observed. Under these conditions, plant dry weight and total leaf area were double in plants grown in coconut coir dust compared to those grown in oil palm empty fruit bunch. High yields have also been reported for *Calceolaria* grown in different mixtures of compost with commercial substrates (1:2 ratio) having higher EC values of 5.60 and 4.95 dS m^{-1} (Gomez *et al.* 2002). These researchers suggested that the cations and anions contributing to the EC in commercial substrate were mainly nutrients such as K^+ and NO_3^-N, and thus had a beneficial effect of over compensating for the osmotic effect.

Recently, Noguera *et al.* (2000) reported that the excess soluble salts is easily and effectively leached from the coconut coir dust material under customary irrigation regimes when used for ornamental plants in containers or 'growing bags' for tomatoes, flowers, etc., in garden greenhouses. In this study, it has been suggested that frequent fertigation applied to the medium may effectively leach out the excess soluble salt in coconut coir dust. Nevertheless, a high K^+ content in coconut coir dust as seen in Table 2 may contribute to a high EC but not to excess salinity, which may have caused an osmotic imbalance.

From the results of this study, it is postulated that the lower growth response of hybrid cauliflower plant to oil palm empty fruit bunch at 21 DAP could be due to high rates of immobilisation of soluble N by micro-organisms in the oil palm empty fruit bunch medium. This is reflected in lower total N uptake in the leaf and stem of plants grown in oil palm empty fruit bunch in comparison to those grown in coconut coir dust (*Figs. 5a* and *5b*). Thus, it was assumed that the liquid feed of 200 ppm N applied to the oil palm empty fruit bunch medium was not enough to compensate for a consistently high rate of N immobilisation.

Since both coconut coir dust and oil palm empty fruit bunch are organic materials, the properties of both media may change due to decomposition of organic matter in the substrate during the growing period. A high pH level of 5.9 to 6.9 resulting from applying large amounts of lime was shown to increase the decomposition rate of sphagnum peat, which finally reduced plant growth in comparison to the low pH between 4.4 and 5.2 (Anon 1997). The same phenomenon may have occurred with oil palm empty fruit bunch which was characterised with a high pH of 6.9 (Table 2) and lower plant growth response at 42 DAP when compared to coconut coir dust as shown in *Fig. 3b.*

Visual observations during this study indicated that after 30 DAP the growing bags containing oil palm empty fruit bunch medium flattened out and started to show early signs of decomposition. In contrast, the coconut coir dust medium stayed fluffy. This shows that the changes in properties of the oil palm empty fruit bunch are more rapid than the coconut coir dust growing medium, which indicates a lack of bio-stability in the oil palm empty fruit bunch.

Lemaire (1995) reported that lack of bio-stability may cause severe volume loss resulting in compaction, reductions in air volume, readily available water, porosity, particle size alteration, increases in pH and salinity due to mineralization and also change in the gaseous phase composition due to carbon dioxide production. These changes in properties may finally reduce the plant growth (Lemaire 1995). Thus the low hybrid cauliflower plant growth in the oil palm empty fruit bunch observed in this study may be due to the changes in the properties during the growing period.

High content of lignin, between 37% and 50% dry weight, was reported by Abad *et al.* (2002) in the coconut coir dust from different sources whilst lower values of 22% and 25% in the oil palm empty fruit bunch were reported by Zainon *et al.* 1998 and Megat Johari *et al.* 1990. Lignin is resistant to microbial degradation. Thus coconut coir dust is most likely to be more bio-stable than oil palm empty fruit bunch due to CD's higher lignin content. Evidence of a very high bio-stability index of 100 for coconut coir dust, which related to high C/N ratios, and high lignin content in the coconut coir dust has also been reported by Lemaire (1997).

Other factor that account for the low hybrid cauliflower plant growth in the oil palm empty fruit bunch was the appearance of fungus and mushroom on the medium surface. In contrast there was no fungal and mushroom growth in coconut coir dust even until 42 DAP.

It is expected that a high pH of 6.9 for the oil palm empty fruit bunch may be suitable for strong development of certain fungi and mushroom observed in the present study (*Figs. 6a, 6b* and *6c*). This is in agreement with other studies using peat medium which provide optimal growth of mushroom like fungi, cup fungi (*order Pezizales*) and agarics (*order Agaricales*) in the processed peat medium at high pH values of between 6.5 and 7.5 and temperature above 20° C (Schlechte 1997). The mycelium of these fungi and mushroom grow vigorously in the substrates which may become hardened, impervious to water and deficient in nutrients such as nitrogen and potassium (Schlechte 1997). Hence the hybrid cauliflower plant grown in oil palm empty fruit bunch with thick coverings of the mycelium in the growing bag showed retarded growth (*Fig. 3*).

CONCLUSIONS

The results presented show that the physical properties of both coconut coir dust and oil palm empty fruit bunch are optimum at the start of the growing periods. However, differences in chemical properties between the two media were more obvious compared to other properties. Under these conditions and with continuous liquid feed high in N content, the hybrid cauliflower grew better in 100 % coconut coir dust than 100% oil palm empty fruit bunch. Moreover, coconut coir dust was free from fungi and mushroom-like fungi during the growing period of cauliflower. It can be concluded that coconut coir dust can be used directly as growing medium whereas oil palm empty fruit bunch has to be composted, to achieve biostability. Hence, coconut coir dust is a more suitable growing medium for growing hybrid cauliflower than oil palm empty fruit bunch.

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