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Properties of cocopeat-based growing media and their effects on two annual ornamentals

(Sifat medium penanaman yang berasaskan cocopeat dan kesannya terhadap dua tanaman hiasan semusim)

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Key words: cocopeat, growing medium, air-filled porosity, wettability, annual ornamentals

Abstrak

Sifat fizikal lima medium penanaman (100% cocopeat, 2 cocopeat: 1 pasir, 1 cocopeat: 1 pasir, 1 cocopeat: 1 tanah gambut, dan 100% tanah gambut) telah dikaji. Keupayaan menyerap air bagi 100% cocopeat paling tinggi dan nilainya berkurangan apabila kandungan cocopeat dalam campuran medium dikurangkan. Penambahan kandungan pasir dalam cocopeat menghasilkan kesan yang kecil pada keupayaan menyerap air bagi cocopeat. Tanah gambut paling sukar dibasahkan. Medium yang terdiri daripada 100% tanah gambut mempunyai nilai keliangan yang dipenuhi udara yang paling tinggi. Mencampurkan tanah gambut dengan cocopeat membaiki tahap pengudaraan cocopeat. Medium yang terdiri daripada 100% cocopeat mempunyai keupayaan menyimpan air yang paling tinggi manakala keupayaan 100% tanah gambut paling rendah. Penambahan kandungan pasir mencepatkan kehilangan air medium iaitu daripada 1.8% setiap jam bagi 100% cocopeat kepada 2.6% dan 6.2% setiap jam apabila kandungan pasir dalam cocopeat bertambah daripada 33.3% kepada 50.0%. Celosia dan marigold yang ditanam di medium yang dikaji memberikan respons yang berbeza bergantung pada kandungan medium.

Abstract

The physical properties of five growing media (100% cocopeat, 2 cocopeat: 1 sand, 1 cocopeat: 1 sand, 1 cocopeat: 1 peat, and 100% peat) were characterized. The medium water absorbing capacity (or wettability) was highest in 100% cocopeat and the value was reduced proportionately as the composition of cocopeat in the media decreased. Increasing the sand content in cocopeat produced little effect on medium wettability. Pure peat was most difficult to wet. The medium composed of 100% peat had the highest air-filled porosity. Incorporation of peat into cocopeat improved the aeration status of cocopeat. The medium containing 100% cocopeat had the highest container moisture capacity while 100% peat the least. Increasing the sand content in the media aggravated moisture loss; from 1.8% hourly in 100% cocopeat to 2.6% and 6.2% hourly of their initial moisture capacity as the proportion of sand increased from 33.3% to 50.0%. Celosia and marigold plants responded differently to the changing composition of the growing media.

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Introduction

Difficulty in getting good top soil and variations in its quality promote the use of soilless materials in the production of horticultural crops. One of the soilless materials widely available in the tropics is coconut coir dust or commercially known as cocopeat. Cocopeat is actually an industrial waste after the extraction of fibre from the coconut husk. Unlike peat, use of cocopeat is considered environmentally sustainable and has attracted interest among research scientists and horticulturists worldwide (Verdonk et al. 1983; Meggelen-Laagland 1995; Martinez et al. 1996; Prasad 1996). As a growing medium, cocopeat can be used to produce a number of crop species with acceptable quality. However, the responses of crops to a specific mixture of cocopeat-based medium vary depending on plant species (Yahya and Mohd Razi 1996).

Variation in chemical and physical properties of the media and differences in plant sensitivity to a defined root environmental condition may have contributed to the marked differences in plant development observed earlier (Yahya and Mohd Razi 1996). Among the critical properties are aeration, moisture, nutrition, pH and electrical conductivity. Understanding of the medium properties in relations to crop growth is vital before the medium can be used successfully as this would determine the cultural practices, especially fertilizer and irrigation requirement, and scheduling.

In this study, interest was focussed on aeration (measured as air-filled porosity, AFP) and moisture availability (measured as container moisture capacity, CMC). The properties of a growing medium are often determined at a fixed point of water potential by a given method without plants in the laboratory, and always reported as a property of the growing media. However, what is more important to the horticulturists is the actual AFP and CMC of the medium during the growing period. This paper reports some physical properties of cocopeat-based growing media, and the growth and flowering of celosia *(Celosia plumosa)* and african marigold *(Tagetes erecta)* grown on them.

Materials and methods

Five growing media with notable differences in their physical charateristics were used in the study. The media were 100% cocopeat (T & H Coconut Fibre Sdn Bhd), 100% peat [Peat Tech (Malaysia) Sdn Bhd], 2 parts cocopeat: 1 part sand, 1 part cocopeat: 1 part sand, and 1 part cocopeat: 1 part peat. During the preparation of the media, 2 kg of ground magnesium limestone and 10 kg of compound fertilizer 14 N: 14 P_2O_5: 14 K_2O were incorporated into every one metre cube of each medium. Two plant species, namely celosia *(Celosia plumosa)* cv. Geisha Carmine Red and marigold (*Tagetes erecta*) cv. Inca Yellow, were grown in 12 cm plastic containers containing 950 mL of each medium. The plants were raised under acrylic shelters (approximately 70% light transmissibility). The plants were irrigated at 0900 h and 1530 h daily using an overhead micro-sprayer. There was no additional fertilizer added during the growing period. The treatments were arranged in a split plot design with media as main plots and plant species as sub-plots. Each treatment was replicated five times and each sub-plot contained four plants.

Data on various aspects of medium characteristics and plant growth were collected. Medium wettability was measured by soaking the pots filled with 950 mL medium (without plant) in standing water (2 cm deep). The water level was adjusted to the required depth when necessary. The increase in medium moisture content which indicates the degree of wettability, was monitored hourly by weighing the media using an electronic balance. The initial moisture content of the media was 4%.

The CMC of the media was measured by weighing the container at 0, 2 and 6 h after irrigation at 20 days after planting, and their values were adjusted for the plant weight. The CMCs were calculated as [(transient mass – dry mass)/dry volume]. A day after the determination of CMC, the AFP was estimated using saturation and drainage method (Bunt 1988) at 2 h and 6 h after irrigation.

The growth and flowering of celosia and marigold were monitored by the measurement of plant fresh weight, plant height, date of flower emergence, length of plumes (for celosia) and flower number (for marigold) at 40 days after planting.

Results

Wettability

The capacity of each medium to absorb water is represented by its wettability as shown in *Figure 1*. Water absorbing capacity was highest in 100% cocopeat and the capacity reduced proportionately as the composition of cocopeat in the media decreased. Pure peat was the most difficult to wet. Incorporation of peat into cocopeat reduced medium wettability. After 2 h of treatment, the moisture content of cocopeat was 29.1% and the corresponding values for peat and peat-cocopeat mixture were 4.4% and 13.8%.

Increasing the sand content in cocopeat even up to 50% produced little effect on its initial wettability. At 24 h after the start of treatment, moisture contents of the media were 54.0, 28.5, 50.3, 42.8 and 40.4% for 100% cocopeat, 100% peat, 2 cocopeat: 1 sand, 1 cocopeat: 1 sand, and 1 cocopeat: 1 peat respectively.

Air-filled porosity

The 100% peat medium had the highest aeration status as shown by the highest AFP value *(Figure 2)*. Its AFP was significantly higher (p <0.0001) than those in other media except for 1 cocopeat: 1 peat mixture. Adding sand to cocopeat did not improve aeration of the cocopeat as shown by no marked increase in AFP in 2 cocopeat: 1 sand and 1 cocopeat: 1 sand compared with those in 100% cocopeat.

The AFP values in all media tested increased proportionately with time. Generally, the increased rate of AFP was greatest for 100% peat and it was smallest in 1 cocopeat: 1 peat. The respective values were 10.3% and 6.8% hourly.

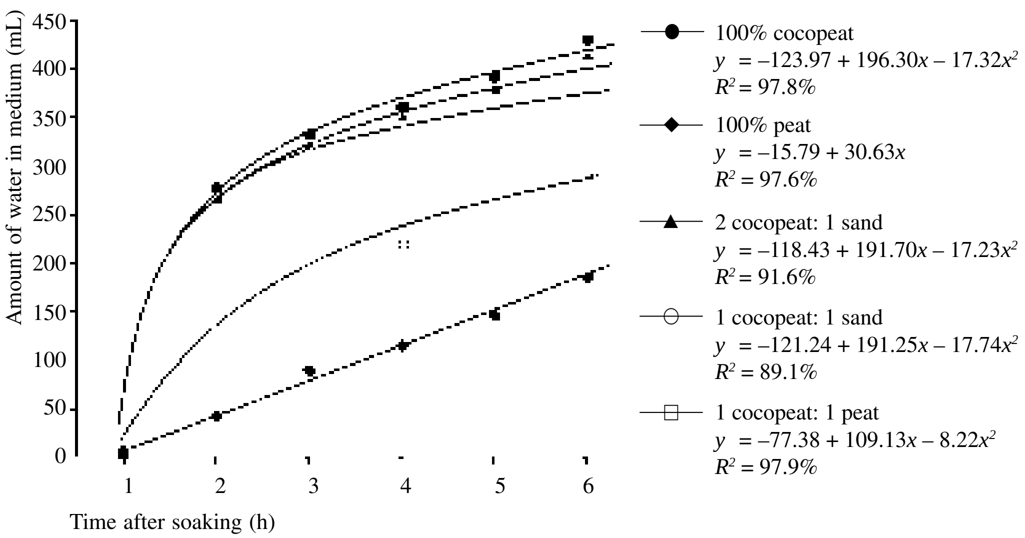
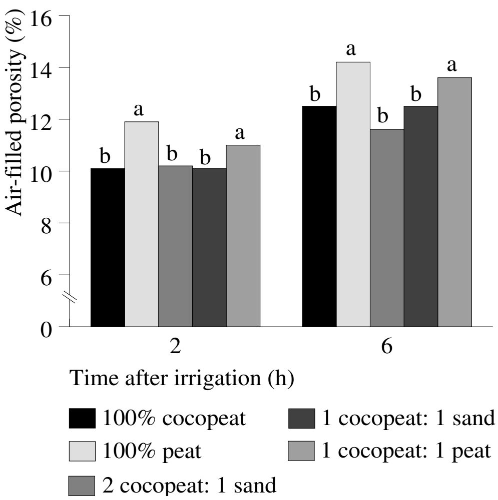
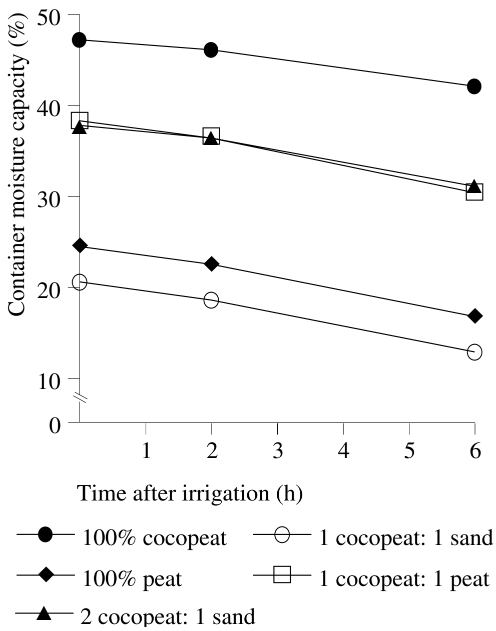


Figure 1. Wettability of five combinations of cocopeat-based growing media



Values in each hour group with same letter are not significantly different at $p < 0.05$ according to DMRT

Figure 2. Changes in air-filled porosity of five growing media.



LSD 0.05 (pooled) = 0.37%

Figure 3. Changes in container moisture capacity of five growing media

Container moisture capacity

The container moisture capacities (CMC) of various growing media are shown in *Figure 3*. Among the media tested, pure cocopeat had the highest CMC ($p < 0.0001$). The CMC of 100% cocopeat was 47.2, 46.1 and 42.1% respectively at 0, 2 and 6 h after irrigation. The CMC of 100% peat was the lowest and the corresponding values were 24.5, 22.5 and 16.8%.

The rate of moisture loss varied significantly among media. Increasing the sand content in cocopeat increased the rate of water loss; from 1.8% hourly in 100% cocopeat to 2.9% and 6.2% hourly of their initial moisture capacities as the proportion of sand increased from 33.3% to 50.0%.

Plant growth and floral development

Celosia The growth and flowering of celosia on various media are presented in *Table 1*. The plants were the tallest when grown on 100% peat and on medium containing equal proportion of cocopeat and peat ($p < 0.0001$). Plants grown on 100% cocopeat were the shortest and this was only 69% of the plants produced either on peat or on 1 cocopeat: 1 peat mixture. Increasing the sand content in the media resulted in taller plants but there was no marked difference between those grown on 2 cocopeat: 1 sand and 1 cocopeat: 1 sand.

Plants grown on 100% peat were the heaviest and this weight differed significantly from those grown on other media ($p < 0.0001$). As for plant height, adding sand to cocopeat increased plant fresh weight. The pattern of change in fresh weight was consistent with plant weight, but the extent was somewhat different. This can be seen clearly in quality index (fresh weight/plant height). Although plants grown on 1 cocopeat: 1 peat were as tall as those on pure peat, their quality index was lower because of smaller fresh weights.

Difference in growing media significantly affected the plant reproductive development ($p < 0.01$). The initiation of flower buds was delayed by 6 days in 1 cocopeat: 1 sand compared with other

Table 1. Growth and flowering of celosia plants grown on five media

Medium	Plant height (cm)	Plant fresh weight (g)	Days to plume bud appearance	Length of plumes (cm)
100% cocopeat	14.46b	7.21d	19.4b	7.24b
100% peat	21.18a	31.88a	16.7b	13.42a
2 cocopeat: 1 sand	15.38b	12.74c	20.9b	6.76b
1 cocopeat: 1 sand	16.24b	14.08c	26.1a	5.34b
1 cocopeat: 1 peat	21.10a	22.22b	20.0b	8.52b
Significant level	$p < 0.0001$	$p < 0.0001$	$p < 0.01$	$p < 0.01$

Mean values in each column with same letter are not significantly different at $p < 0.05$ according to DMRT

Table 2. Growth and flowering of marigold plants grown on five media

Medium	Plant height (cm)	Plant fresh weight (g)	Days to flower bud appearance	No. of flowers
100% cocopeat	30.1ab	40.2a	27.6a	12.3ab
100% peat	31.6a	41.1a	28.0a	7.9c
2 cocopeat: 1 sand	30.2ab	40.4a	28.3a	14.2a
1 cocopeat: 1 sand	29.2b	35.7a	27.9a	12.8ab
1 cocopeat: 1 peat	31.2a	39.1a	28.3a	11.3b
Significant level	$p < 0.05$	ns	ns	$p < 0.01$

Mean values in each column with same letter are not significantly different at $p < 0.05$ according to DMRT

treatments. Plants grown on 100% peat had significantly the biggest flowers ($p < 0.01$).

Marigold The responses of marigold plants to different media are shown in *Table 2*. The effects of growing media on vegetative development of marigold plants were less apparent compared with celosia. Plants grown on cocopeat containing 50% sand were the shortest and this differed significantly from other treatments ($p < 0.05$). Variation in medium composition did not affect the plant height and the number of days required for the appearance of flower buds. A similar result was also observed for plant fresh weight.

The number of flowers produced by marigold plants was markedly affected by the treatments ($p < 0.01$). Plants grown on 100% peat produced 36% less flowers than plants grown on 100% cocopeat. Adding sand to cocopeat had no effect on the flower number.

Discussion

Understanding both physical and chemical properties of growing media facilitates efficient use of the products to satisfy crop requirement. Changing medium composition alters their properties, and therefore crops grown on them must be managed somewhat differently.

In this study, high initial wettability of medium containing high proportion of cocopeat can be advantageous. Crop grown on cocopeat-based media can be efficiently irrigated using sub-irrigation methods such as flow and ebb system and capillary beds. These methods when employed can increase water use efficiency. Excessive water loss in the media during plant growth can be easily remedied and therefore irreversible drying can be avoided.

It is generally known that cocopeat has a very high moisture retention capacity (Meggelen-Laagland 1995). During the study, the moisture content of cocopeat was twice that retained in peat. Adding sand up to 50% (volume basis) reduced CMC, but the CMC did not fall lower than that in peat. The moisture content of the five media used in this study varied significantly, ranging from 18% (100% peat) to 43% (100% cocopeat) at 2 h after irrigation. Relatively low CMC in 100% peat was considered not critical for plant growth as no water stress symptom was observed even at 6 h after irrigation when its CMC was only about 14.0%. This is true since celosia plants on 100% peat had the most vigorous growth as shown by their fresh weight *(Table 1).*

Based on outline given by Johnson (1968), the aeration status (or AFP) can be considered ‘intermediate’ for media containing 100% cocopeat, 2 cocopeat: 1 sand and 1 cocopeat: 1 sand, and considered ‘high’ for 100% peat and 1 cocopeat: 1 peat. Low AFP in the first three media may have contributed to the poor growth in celosia. Mixing sand into cocopeat did not elevate AFP. In fact, AFP for 1 cocopeat: 1 sand was the lowest *(Figure 2)*. Similar effect of adding sand to a fine medium was also reported by Bunt (1988). The result could be different if sand or other materials with larger particle size were used. This assumption was based on the change in AFP for 1 cocopeat: 1 peat mixture, where its AFP was lower than that of 100% peat. Materials with small particles such as cocopeat tend to fill up pores, thus lowering the AFP. The importance of particle size in regulating AFP had been demonstrated by Handreck (1983) and such problem has been faced by commercial growers in the Netherlands (Meggelen-Laagland 1995).

Besides poor aeration, reduction in the growth of celosia in 100% cocopeat could also be related to other factors, especially electrical conductivity (EC). The initial EC of the cocopeat used in the study, measured using 1 substrate: 2 water (v/v) dilution method, was 1.97 mS/cm. The respective value for peat used in the study was 0.54 mS/cm. The initial EC value of cocopeat was considered high for most horticultural crops (Maas 1990; Yahya 1994). For a good growing medium, the acceptable initial EC level should be 0.4–1.0 mS/cm (Styre 1997). The better growth performance of celosia plants observed in 2 cocopeat: 1 sand mixture than those on 100% cocopeat with similar AFP supports this hypothesis.

Results in *Table 1* and *Table 2* showed that there were large differences between celosia and marigold in response to various compositions of media. This may represent great variations in crop growth requirement and its adaptation to different root environments related to growing media (Ortega et al. 1996), as well as differences in their tolerance level to high EC (Maas 1990).

Conclusion

Changes in the proportion of media altered the air-water relationship and thus significantly affected plant growth and development. Among the media tested, cocopeat has good horticultural properties because of its high initial wettability and high moisture retention capacity. However, inexperience growers may have problem with low aeration and high EC of cocopeat. Differences in sensitivity of the species tested indicate that there would be no single growing medium good for all types of crops. Since variation in the composition of cocopeat-based growing media markedly alters media characteristics, their horticultural significance therefore await further research.

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