Developing reservoir sediment ceramsite as a novel growing medium: II pot experiments

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Introduction

Reservoir sediment can be recycled into ceramsite by sintering in high temperature (1050~1200℃). Ceramsite is widely used in soilless cultivation, however, it is also considered to have lower water retention and nutrient content. Consequently, we developed a novel method by low temperature (800℃) anaerobic sintering to produce biochar-containing ceramsite. The presence of biochar may improve its agronomic performance on soilless cultivation. In this study, we conducted a pot experiment in order to investigate the effects of the biochar ceramsite on plant growth with different water supply.

Material and Methods

Ceramsite production

The reservoir sediment was obtained from Shihmen Reservoir in Taoyuan, Taiwan. The sediment has 11% sand, 54% silt and 35% clay, contained 24‰ of total carbon. We added extra organic matter (peanut shell powder, 0%~10% w/w) in order to produce ceramsite with different amount of biochar. The mixture of sediment and peanut shell powder were pelletized and dried at 105 ℃, then sintered at 800℃, with a heating rate of 10℃/min and residence time of 2 hours. To investigate the influence of biochar, ceramsites were sintered in the air(SA) and N_2 atmosphere(SN), cause the presence or absence of biochar.

Pot experiment

The pot experiment was conducted at the greenhouse in National Taiwan University, Taipei, Taiwan. Substrates used for the experiment included six low-temperature ceramsites (SA+0, 5, 10%, SN+0, 5, 10%) and two commercial substrates, traditional high-temperature ceramsite (Com-1) and lava rock (Com-2). Two species *Tagetes erecta* and *Melissa officinalis* were selected. Each pot was filled with approximately 400 mL of one type of the substrate and planted with one species. Plants were grown under two frequencies of irrigation: watering once per day (100 mL/pot) for the full water supply and once per week for the limited water supply treatment, each with four replicates. The watering volume was base on the container capacity of the ceramsite substrates (20.7 to 26.8% v/v). The plant height and dry weight were measured after 10 weeks of cultivation.

Results and Discussion

The basic properties are measured and presented in Table 1. Compared to commercial substrates, low-temperature ceramsites have higher plant available water(PAW), and increased with the rate of organic matter addition. The oxidation or pyrolysis of the organic matter may provides extra porosity, leads to the raise of PAW. For the nutrient content, SN have higher NH_4^+ and NO_3^--N content, while the available P were lower than SA, probably due to the increased P availability after the oxidation of organic matter.

The results of the pot experiment are shown in Fig.1. There are no significant difference between SA ceremsites and two commercial substrates in all of the treatments. In contrast, SN ceremsites had significantly effect on the plant growth.

For species *Tagetes erecta*, the plant height and dry weight were respectively increased by 174% and 838% under the full water supply, and 75% and 655% under the limited water supply condition. However, the difference among the SN ceremsites were not observed. Under the limited water supply, the plant height in SN+0% was lower than SN+5% and SN+10%, but not significant.

For species *Melissa officinalis*, the plant height and dry weight were respectively increased by 97% and 975% under the full water supply, and 87% and 979% under the limited water supply condition. The significantly decrease of dry weight can be seen in the SN+10% ceramsite under full water supply, but not under the limited water supply condition. Due to the SN+0%, which has lower PAW, also cause little decrease on *Tagetes erecta* under the same condition, biochar may have positive effect on plant growth under water stress, but high rate of biochar may have negative effect on some species. The difference in PAW didn't affect the performance of SA and Com, which might be attributed to the lower water requirements of smaller individuals.

Table 1. The basic properties of ceramsites, row sediment(RS), and biochar(BC).

	SA+0%	SA+5%	SA+10%	SN+0%	SN+5%	SN+10%	Com-1	Com-2	RS	BC
PAW (%)	13	18	22	16	17	19	7	3	-	-
pH	8.5	9.4	9.2	8.8	9.4	9.8	6.5	8.6	7.6	10.1
Total C(‰)	ND	ND	ND	4	13	29	ND	ND	24	706
Total N(‰)	ND	ND	ND	ND	ND	ND	ND	ND	2	20
NH_4^+ (mg/kg)	ND	ND	ND	4.9	10.2	10.1	0.1	ND	82.1	10.9
NO_3^- (mg/kg)	18.0	17.9	16.5	85.0	105.6	114.9	14.5	29.7	20.1	5337.7
Available P (mg/kg)	12.3	10.0	25.7	2.6	5.0	5.3	3.6	24.3	0.8	141.3
CEC(cmol/kg)	3.0	2.1	2.6	3.4	1.5	1.5	ND	1.8	15.1	9.5
K^+ (cmol/kg)	0.9	0.9	0.9	0.9	0.8	1.0	0.2	0.6	0.4	11.1
Mg^{2+} (cmol/kg)	1.4	1.2	1.3	0.7	0.8	0.8	0.1	0.8	0.9	4.5
Ca^{2+} (cmol/kg)	5.4	5.2	4.6	5.2	5.9	5.8	0.6	5.7	4.8	16.9
Na^+ (cmol/kg)	1.2	0.9	1.0	1.1	1.2	1.2	0.1	0.8	0.2	2.0

ND means not detected or below the detection limit of the instrument.

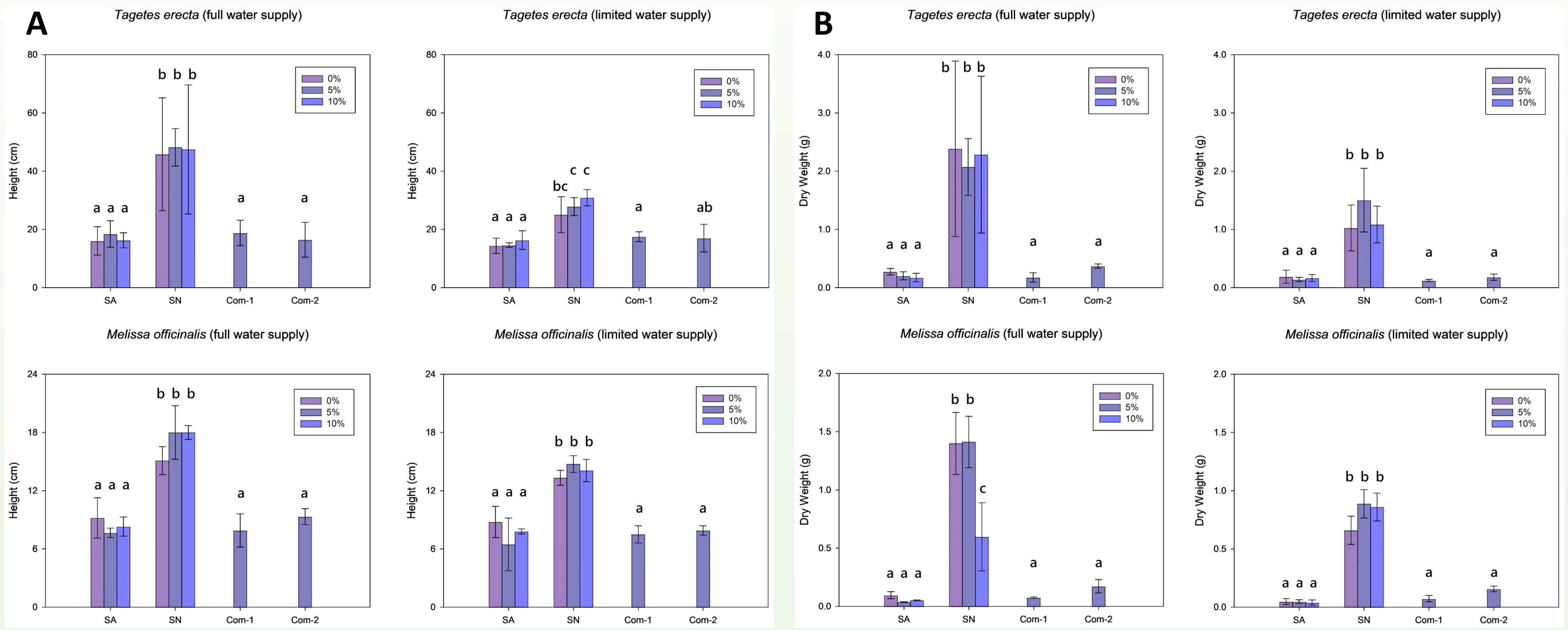

Fig 1. Plant Heights (A) and Dry weights (B) of *Tagetes erecta* and *Melissa officinalis* grown in different substrates under full or limited watter supply.

Different letters above the bar indicate significant difference (p<0.05, Tukey's test)

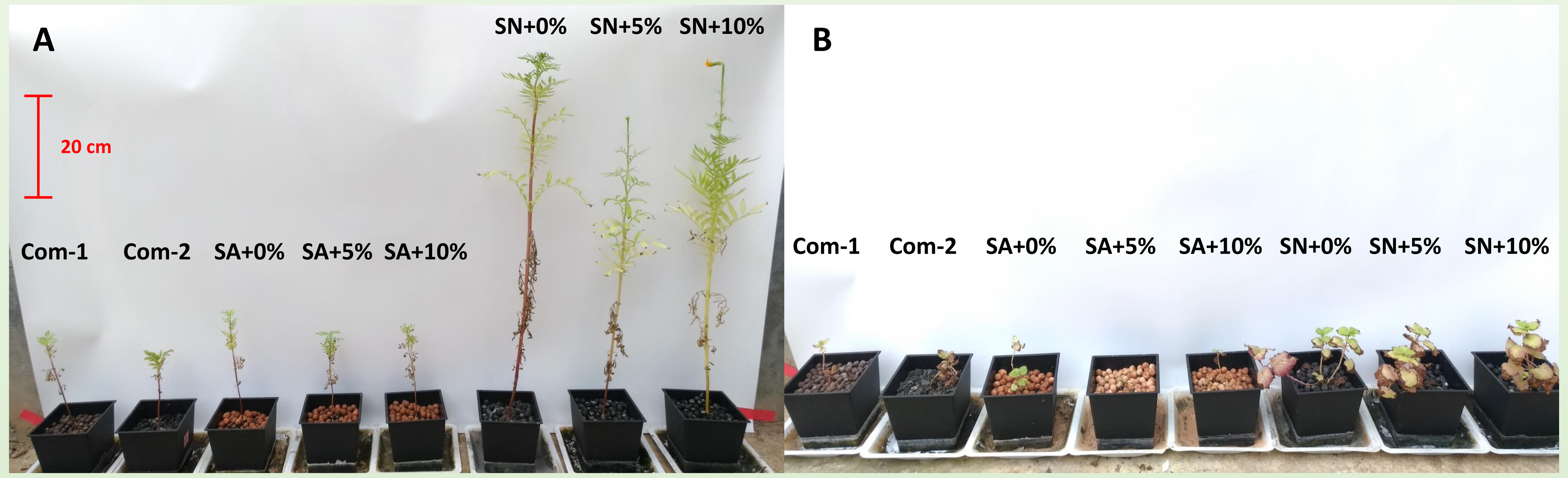

Photo 1. The performance of vegetation (A: *Tagetes erecta*, B: *Melissa officinalis*) planted in different in the end of the pot experiment.

Conclution

The addition of organic matter leads to the higer PAW, improves water supply of the plants. Further, biochar can be a source of nutrients, especially inorganic nitrogen, which may offer better growing environment for vegetation. The results suggest that the biochar ceremsite (SN) has the potential as a novel growing substrate.