

Cowpeat as a Component of Potting Media for Foliage Plant Propagation and Production FDAC Contract # 011735

Progress report No. 4 to the Florida Department of Agriculture and Consumer Services
May 29, 2007

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Report No. 4: Deliverable 4-Characterization of Formulated Potting Media

Overall objective of the project

To determine if cowpeat can partially or completely substitute for peat as a component of potting media for foliage plant propagation and production

Procedures (deliverables) for the first-year's research (√ indicates reports have been submitted)

1. Preparation (√)
2. Media component characterization (√)
3. Formulation of potting media (√)
4. Characterization of the formulated media
5. Foliage plant propagation
6. Foliage plant production
7. Monitoring N-NO₃ and P in leachates

Report No. 4: Deliverable 4-Characterization of Formulated Potting Media

1. Materials and Methods

Materials. A total of 14 potting media were formulated (see the Report No. 3), and the formulated media were characterized physically and chemically as described below:

Physical properties. The 14 formulated media were air dried. Particle size distribution was determined by screening 350 cm³ of air dried samples of each medium using U.S. standard sieves 3.5, 7, 20, 35, and 60, which correspond to screen opening of 5.66, 2.83, 0.85, 0.5, and 0.25 mm, respectively (Gee and Bauder, 1986). Other physical properties including air space, bulk density, total porosity, and water holding capacity of the 14 media were individually characterized using the Australian Standards-Potting Mixes methods (Standards Australia, 1989).

Chemical properties. Electrical conductivity (EC) and pH of the 14 media were measured using the pour-through method (Yeager et al. 1983). The 14 media were ground to pass through a 40 mesh screen (0.42 mm), and the ground samples were analyzed for total N and C as well as P, K, Ca, Mg, S, B, Na, Fe, Mn, Cu, Zn, As, Cd, Cr, Pb, Hg, Mo, Ni, and Se. The samples were also extracted with 2.00 mM DTPA (Standards Australia, 1989), and extractable NO₃-N, NH₄-N, P, K, Ca, Mg, S, B, Na, Fe, Mn, Cu, Zn, As, Cd, Cr, Pb, Hg, Mo, Ni, and Se were analyzed. In addition, cation exchange capacities of the potting media were determined using the NH₄Cl extraction method described by Sumner and Miller (1996).

2. Results and Discussion

Physical properties. Particle size distribution affects physical properties of potting media (Bilderback et al., 2005). Gartner et al. (1974) reported that a favorable physical environment for plant growth resulted from potting media having 20 to 40% of particles less than 0.8 mm.

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Half of the 14 potting media had 40% of particle sizes less than 0.85 mm and the other half had 41% to 50% particles less than 0.85 mm. With increased percentages of cowpeat component from potting media 1 to 7, bulk density and air space generally increased but water holding capacity decreased (Figures 1-3 and Table 1). However, such physical property trends were not evident from potting media 8 to 13. Although there have been no universally accepted standards for the physical properties of potting media, media with bulk density ranging from 0.15 to 0.8 g/cm³, total porosity of 50 to 80%, water-holding capacity of 50 to 75%, and air space 10 to 30% are generally considered acceptable for producing potted plants (Bilderback et al., 2005; Chen et al., 2003). The physical properties of the 14 media were all within the suggested range (Table 2), indicating the formulated potting media should be physically appropriate for propagating and producing foliage plants.

Chemical properties. The electrical conductivity (EC) of the formulated media ranged from 0.41 to 4.16 dS/m and pH ranged from 5.9 to 6.4. Since the EC of cowpeat was initially high (2.96 dS/m), the increased substitution of Canadian peat or Florida peat by cowpeat resulted in the increase of EC from potting media 1 to 7 and 8 to 13 (Fig. 4). The cation exchange capacities of the media were generally close, varying from 23.4 to 29.4 cmol/kg (Table 2).

The C/N ratios decreased from 60.30 for potting medium 1 to 16.9 for potting medium 7 (Table 3), which is mainly due to the decrease of Canadian peat and increase of cowpeat. In general, with the increased percentage of cowpeat, total concentration of P, S, B, Cu, Fe, Mn, and Zn increased (Table 3 and 4). Concentrations of N also increased with the increased incorporation of cowpeat into potting media 1 to 7; but such an increase did not occur from potting media 8 to 13. Total concentrations of heavy metals were low except for Cr and Ni, which are largely attributed to the 20% of vermiculite where Cr and Ni were higher (Table 5).

Extractable concentrations of P, K, B, Cu, Fe, Mn, and Zn also increased with the increased incorporation of cowpeat (Tables 6 and 7). The increased concentrations of most nutrients were within the range of Australian Standard Potting Mixes recommendations (Standards Australia, 1989) (Tables 6-7). It is worthy to note that total concentrations of P and Fe in some media were high but extractable concentrations of P and Fe were much lower in the same media. This may suggest the formation of P-Fe complexes, which can reduce their solubility, particularly P. Extractable concentrations of heavy metals were largely negligible (Table 8). Compared to the total concentration of Na (Table 4), extractable Na concentrations in the potting media were less than 100 mg/L except for potting medium 7 which was 108 mg/L (Table 7). Additionally, heavy metal concentrations were largely negligible (Table 8).

Summary. The 14 formulated potting media appear to have physical and chemical properties suitable for propagation and production of foliage plants. The increased percentage of cowpeat resulted in increased concentrations of nutrients, indicating that less chemical fertilizer may be needed to produce foliage plants using cowpeat based media. Nitrogen in cowpeat based media may largely be in organic form as extractable NO₃-N and NH₄-N were lower. Mineralization of N may result in slow release of N for plant growth. Although total P was high in cowpeat (0.59%); concentrations of P in extractable form were moderate. In addition to its organic form, P may bind with Fe in cowpeat based media, thus reducing leaching. Extractable forms of heavy metals were either not detectable or extremely low, so there is little concern over heavy metal leaching when cowpeat is used as a component for foliage plant production.

References

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Table 1. Particle size distribution of the 14 formulated potting media.

Potting media	Particle size (mm)					
	>5.66	5.66-2.83	2.83-0.85	0.85-0.5	0.5-0.25	<0.25
1	1.83	10.83	50.83	23.67	9.54	3.30
2	2.64	10.40	42.41	20.79	14.52	9.24
3	4.32	11.73	49.38	19.44	8.64	6.48
4	3.54	11.65	42.92	18.88	11.80	11.21
5	6.42	10.96	46.12	16.58	10.03	9.89
6	3.51	9.56	42.13	18.04	11.86	14.89
7	5.32	10.52	40.27	15.36	10.76	17.78
8	4.40	9.92	40.88	17.28	17.44	10.00
9	5.04	10.43	40.17	16.24	16.50	11.20
10	4.41	14.26	44.10	15.18	12.00	10.05
11	3.08	11.06	37.31	15.00	14.90	19.04
12	4.71	9.83	35.41	14.84	13.61	21.60
13	5.53	12.87	36.68	12.87	10.68	21.36
14	7.58	15.42	42.09	12.29	9.80	12.81

Table 2. Physical properties, pH, electrical conductivity (EC), and cation exchange capacity (CEC) of the 14 formulated potting media.

Potting media	Bulk density (g/cm ³)	Total porosity (%)	Air space (%)	Water holding capacity (%)	EC (dS/m)	pH	CEC (cmol/kg)
1	0.175	69.4	8.9	60.5	0.41	6.1	29.43
2	0.198	71.3	10.1	61.3	1.12	5.9	27.57
3	0.218	70.7	10.6	60.1	1.65	5.9	27.25
4	0.215	72.6	12.0	60.6	2.71	5.9	26.20
5	0.243	68.3	11.1	57.2	3.73	5.9	25.11
6	0.258	70.8	13.5	57.2	3.16	6.0	25.44
7	0.265	68.8	16.7	52.1	4.16	6.2	24.79
8	0.350	65.6	9.5	57.1	0.83	6.1	23.44
9	0.340	63.5	11.5	53.7	0.90	6.4	24.21
10	0.330	64.6	9.7	56.7	1.54	6.1	24.21
11	0.350	66.2	9.2	54.4	1.66	6.2	24.49
12	0.270	64.3	8.8	53.5	2.32	6.4	23.45
13	0.250	67.5	10.4	59.2	2.65	6.0	25.44
14	0.280	65.7	10.5	55.2	1.53	6.2	24.21

Table 3. Total C and N, C/N ratio, and total concentrations of macronutrients of the 14 formulated potting media.

Potting media	C/N ratio	C	N	P	K	Ca	Mg	S
		(%)						
1	60.30	22.90	0.38	0.11	1.12	1.64	3.15	0.24
2	36.80	23.20	0.63	0.15	0.96	1.63	2.56	0.33
3	28.70	22.10	0.77	0.22	1.09	1.80	2.87	0.41
4	24.50	21.30	0.87	0.25	1.14	1.39	2.69	0.38
5	20.50	19.90	0.97	0.32	1.12	1.60	2.58	0.47
6	18.00	18.40	1.02	0.34	1.20	1.21	2.55	0.44
7	16.90	20.60	1.22	0.39	1.19	0.92	2.19	0.48
8	17.90	16.50	0.92	0.04	0.79	0.89	1.99	0.19
9	17.30	19.60	1.13	0.09	0.72	0.78	1.63	0.20
10	17.10	19.50	1.14	0.15	0.82	0.80	1.82	0.25
11	17.70	22.30	1.26	0.21	0.78	0.83	1.62	0.30
12	17.30	22.70	1.31	0.26	0.79	0.89	1.52	0.34
13	16.10	19.20	1.19	0.32	1.17	0.87	2.30	0.40
14	20.50	20.90	1.02	0.18	0.88	0.68	1.87	0.27

Table 4. Total concentrations of micronutrients and sodium in the 14 formulated potting media.

Potting media	B	Cu	Fe	Mn	Mo	Zn	Na
	(mg/kg)						
1	5.97	21.00	23829.00	405.00	n.d. ^a	60.60	685.00
2	7.80	21.40	20296.00	294.00	n.d.	75.70	855.00
3	10.10	26.50	23605.00	326.00	n.d.	99.40	1079.00
4	10.40	28.60	24501.00	309.00	n.d.	112.00	1198.00
5	11.80	31.20	25453.00	293.00	n.d.	127.00	1310.00
6	13.20	34.30	26743.00	344.00	1.00	139.00	1424.00
7	14.50	37.30	26300.00	283.00	n.d.	160.00	1631.00
8	5.42	17.20	17518.00	214.00	n.d.	40.30	505.00
9	5.50	16.90	15924.00	191.00	n.d.	50.70	707.00
10	7.15	21.00	18655.00	225.00	n.d.	72.60	814.00
11	8.79	24.70	18107.00	222.00	n.d.	86.80	911.00
12	9.80	27.00	18301.00	240.00	n.d.	102.00	1041.00
13	12.20	32.80	25628.00	284.00	n.d.	138.00	1368.00
14	7.84	24.40	19702.00	253.00	n.d.	85.20	921.00

^aNot detectable using the EPA method 6010.

Table 5. Total concentrations of some heavy metals of the formulated 14 potting media.

Potting media	As	Cd	Cr	Hg	Pb	Se	Ni
	(mg/kg)						
1	n.d. ^a	0.18	253.00	n.d. ^b	5.83	n.d.	113.00
2	n.d.	0.13	189.00	n.d.	6.49	n.d.	91.00
3	n.d.	0.12	222.00	n.d.	4.63	n.d.	97.90
4	n.d.	0.11	224.00	n.d.	3.96	n.d.	100.00
5	n.d.	0.11	202.00	n.d.	3.53	n.d.	89.20
6	n.d.	0.12	225.00	n.d.	3.32	n.d.	100.00
7	n.d.	0.10	204.00	n.d.	2.71	n.d.	89.50
8	0.77	0.08	187.00	n.d.	3.80	1.15	83.90
9	n.d.	0.10	156.00	n.d.	11.00	0.91	70.10
10	0.50	0.09	177.00	n.d.	4.04	0.68	77.30
11	0.52	0.09	161.00	n.d.	4.90	0.80	72.90
12	n.d.	0.09	141.00	n.d.	3.57	0.57	63.70
13	n.d.	0.10	223.00	n.d.	2.85	n.d. ^a	96.10
14	n.d.	0.10	183.00	n.d.	4.38	0.65	84.00

^aNot detectable using the EPA method 6020; ^bNot detectable using the EPA method 7471.

Table 6. Extractable concentrations of macronutrients of the formulated 14 potting media.

Potting media	NO ₃ -N	NH ₄ -N	P	K	Ca	Mg	S
(mg/L)							
1	1.80	2.10	0.40	8.10	90.30	60.60	81.70
2	1.10	4.30	9.00	34.20	101.00	67.30	106.00
3	0.60	1.70	11.00	50.80	115.00	71.40	126.00
4	n.d. ^a	4.20	19.70	93.70	129.00	80.10	165.00
5	n.d.	3.50	20.10	116.00	152.00	88.30	199.00
6	0.70	1.30	36.30	108.00	104.00	46.00	84.30
7	n.d.	7.40	33.50	165.00	144.00	71.70	161.00
8	9.10	n.d.	0.30	7.10	87.10	27.70	32.90
9	4.30	0.30	5.30	26.40	90.40	32.30	48.90
10	0.60	0.20	11.70	53.20	93.50	36.60	70.10
11	1.00	0.30	21.70	57.70	73.40	25.10	30.00
12	0.70	0.40	31.40	92.10	96.30	34.30	52.10
13	n.d.	1.70	25.10	121.00	116.00	52.90	117.00
14	0.70	0.60	25.60	48.10	67.60	31.50	41.80
Au Standard ^b	N.A.	≤100	0.7-40	35-250	50-340	N.A.	>40

^aNot detectable using the EPA method 353.2

^bRecommendation by Australian Standard for physical and chemical requirements of non specialist potting mixes. N.A. = not available.

Table 7. Extractable concentrations of micronutrients of the formulated 14 potting media.

Potting media	B	Cu	Fe	Mn	Mo	Zn	Na
(mg/L)							
1	0.09	0.19	7.91	3.55	n.d. ^a	0.61	14.50
2	0.13	0.22	20.10	3.28	n.d.	1.59	32.10
3	0.15	0.26	25.80	3.12	n.d.	2.13	42.70
4	0.25	0.54	36.90	3.46	n.d.	3.37	68.60
5	0.29	0.41	37.90	3.32	n.d.	3.90	85.90
6	0.29	0.48	26.70	3.17	n.d.	5.40	75.90
7	0.37	0.57	30.20	3.14	n.d.	6.07	108.00
8	0.08	0.15	13.50	1.58	n.d.	0.34	15.90
9	0.14	0.20	19.60	1.48	n.d.	1.25	28.20
10	0.21	0.33	27.20	2.10	n.d.	2.46	45.10
11	0.20	0.34	24.00	1.94	n.d.	3.31	46.20
12	0.27	0.43	26.90	2.74	n.d.	5.21	70.00
13	0.30	0.43	27.80	2.77	n.d.	5.27	85.60
14	0.20	0.33	34.90	2.72	n.d.	2.89	38.60
Au Standard ^b	0.02-0.65	0.4-10	>35	1-15	N.A.	0.3-10	<100

^aNot detectable using the EPA method 6010; ^bSee footnote of Table 6.

Table 8. Extractable concentrations of some heavy metals of the formulated 14 potting media.

Potting media	As	Cd	Cr	Pb	Ni
	(mg/L)				
1	n.d. ^a	n.d. ^a	n.d. ^a	0.30	0.06
2	n.d.	n.d.	n.d.	0.21	0.06
3	n.d.	n.d.	n.d.	0.16	0.06
4	n.d.	n.d.	n.d.	0.13	0.07
5	n.d.	n.d.	n.d.	0.09	0.07
6	n.d.	n.d.	n.d.	0.10	0.05
7	n.d.	n.d.	n.d.	0.06	0.06
8	n.d.	n.d.	n.d.	0.34	0.04
9	n.d.	n.d.	n.d.	0.10	0.04
10	n.d.	n.d.	n.d.	0.06	0.05
11	n.d.	n.d.	n.d.	0.12	0.04
12	n.d.	n.d.	n.d.	0.08	0.05
13	n.d.	n.d.	n.d.	0.13	0.06
14	n.d.	n.d.	n.d.	0.11	0.05

^aNot detectable using the EPA method 200.7.

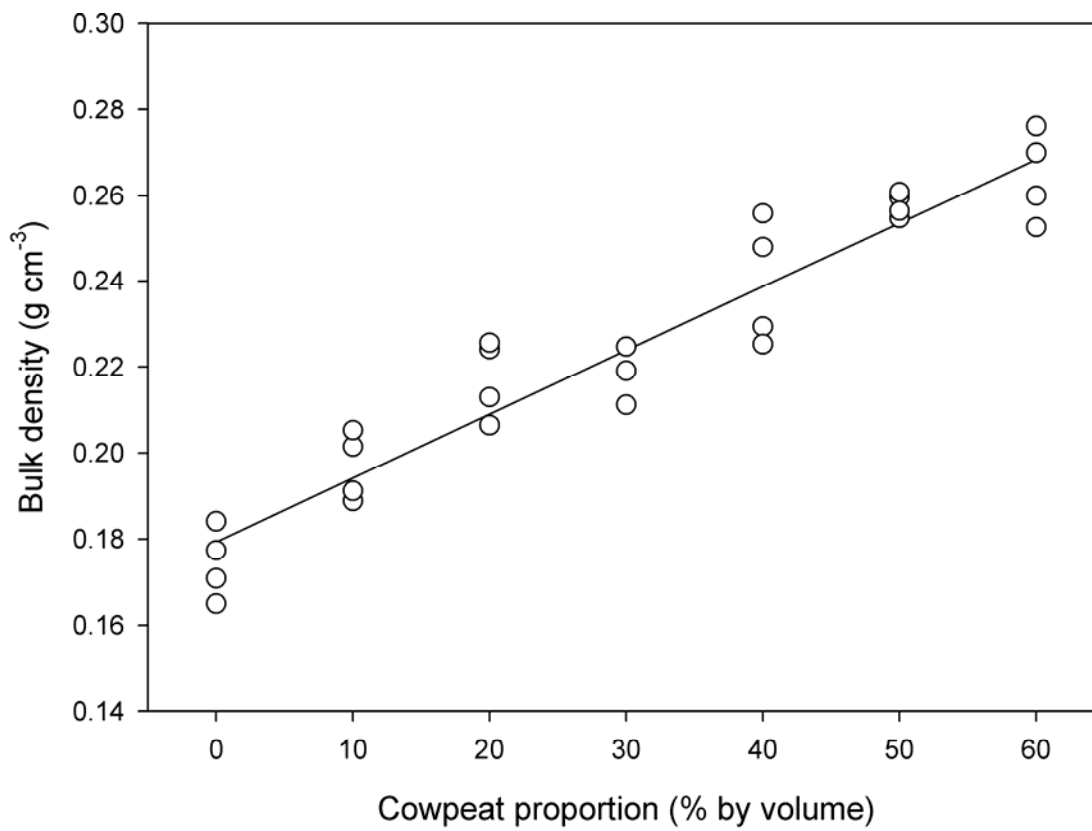


Figure 1. Relationship between the increased percentage of cowpeat and change in bulk density in potting media 1 to 7.

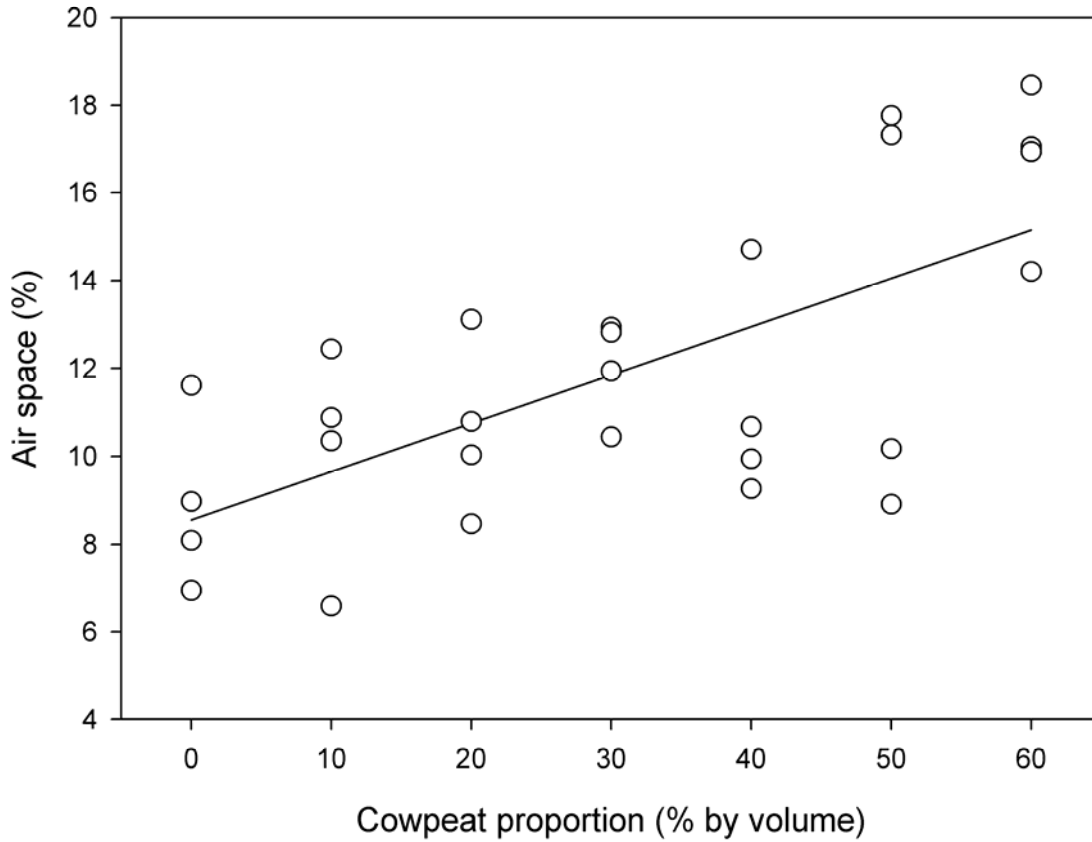


Figure 2. Relationship of increased percentage of cowpeat and corresponding change in air space in potting media 1 to 7.

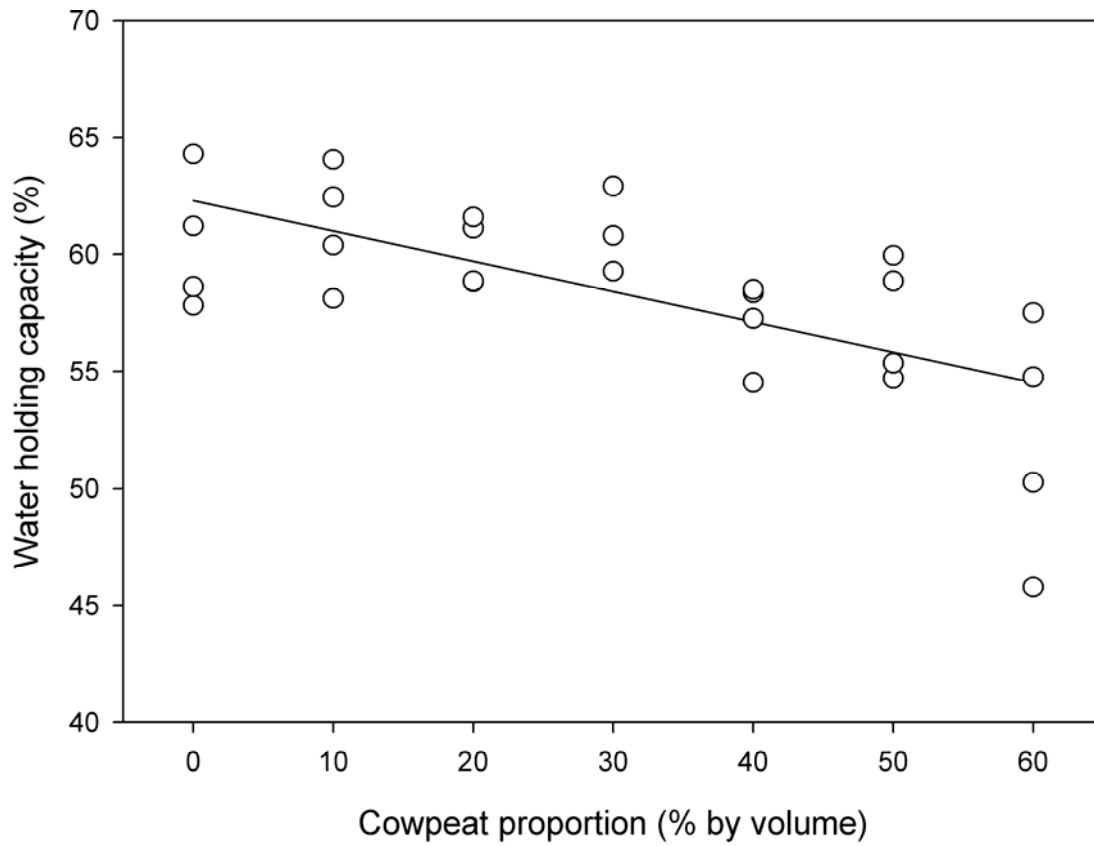


Figure 3. Relationship of increased percentage of cowpeat and corresponding change in water holding capacity of potting media 1 to 7.

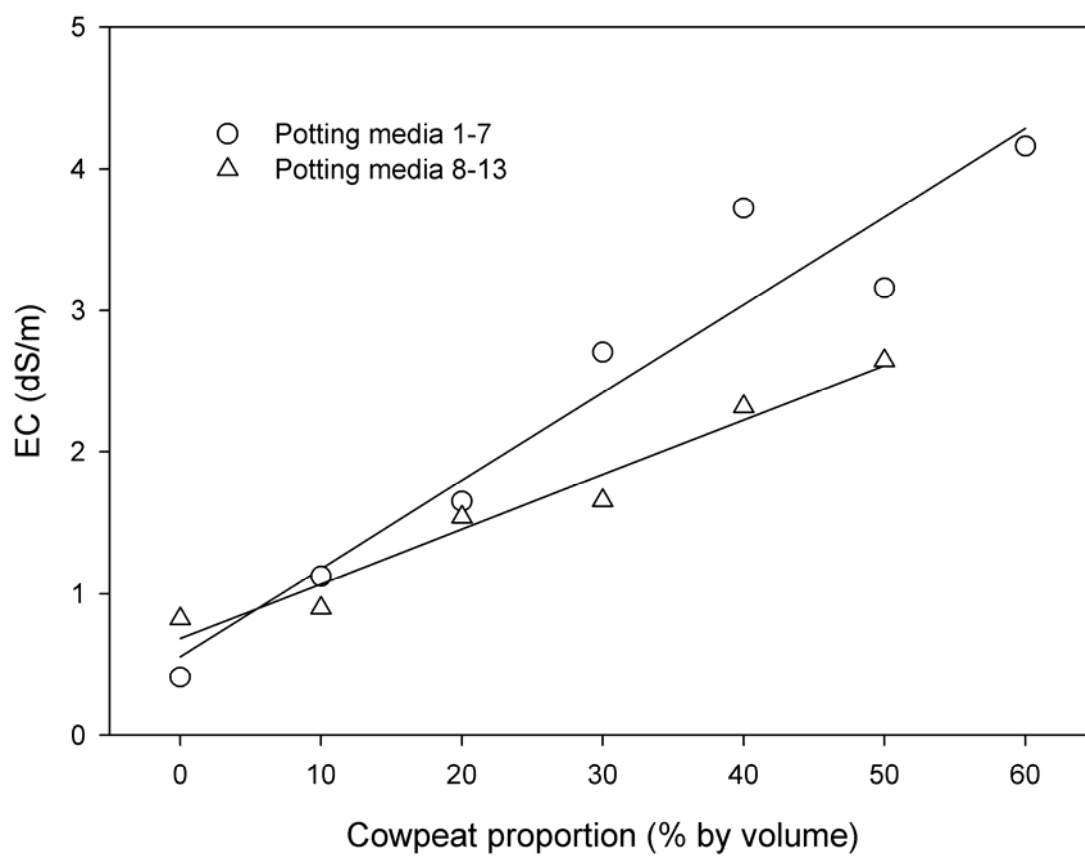


Figure 4. Relationship of increased percentage of cowpeat and corresponding change in EC value of potting media 1 to 7 and potting media 8-13.