Analyzing Hemp Plant Growth in Toxic Mine Land Soil With & Without Soil Amendments

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Abstract

Abandoned Mine Land (AML) soil contains dangerously high levels of heavy metals like cadmium, copper, and lead. These heavy metals change the soil pH and accumulate in native and agricultural plants [1]. Phytoremediation, using plants to remove heavy metals from soil, is an ecologically friendly way to restore AML sites. Industrial hemp (*Cannabis sativa*) is great at extracting heavy metals from soil and has the potential to be harvested for several commercial uses [2]. Soil amendment (SA) and Biochar, which mostly consists of charcoal, have been shown to improve soil conditions [3]. Also, mycorrhizae have been associated with increased plant heights in several plant species [4].

This investigation tracked the germination and growth of industrial hemp for 25 days in AML soil collected from Hazleton, PA. A total of 13 different soil treatments were designed, including garden soil; all AML soil; AML with a mixture, top dressing, or both of commercial soil amendment (SA); Biochar only; and a mixture of AML and Biochar. Additionally, all described soil conditions were designed in treatments with and without mycorrhizae microbe powder. Results suggest that SA and Biochar both increase shoot and root growth. The addition of microbe powder may also promote plant growth, but further investigations are needed to support that conclusion.

Materials & Methods

Industrial hemp seeds were planted in transparent containers – 2 per pot. Treatments were designed in pairs to test different soil mixtures with & without microbes. Seeds and planting depressions in +microbe treatments were coated in microbe powder before planting. For days 0-2, all -microbe treatments were sprayed with water only, and all +microbe treatments were sprayed with a mixture of water with microbe powder. From day 3 on, all pots received water only. Pots were kept in a uniform climate greenhouse for the duration of the experiment. *Garden Soil lacked a +microbe treatment because it already contains microbes.

Treatment	Microbes	Soil Description	Total Mass of Soil	Mass of Soil Ingredients	
Trt #1	-	AML Only	1,100g	1,100g AML	
Trt #2	+				
Trt #3	-	AML + 0.5" Top Dress SA	1,150g	1,050g AML	Top Dress: 100g SA
Trt #4	+				
Trt #5	-	AML + 1.5" Top Dress (1SA:2AML)	1,250g	890g AML	Top Dress: 120g SA + 240g AML
Trt #6	+				
Trt #7	- *	Garden Soil Only	140g	140g Normal Soil	
Trt #8	-	Biochar Only	285g	285g Biochar	
Trt #9	+				
Trt #10	-	75% AML + 25% SA	1,050g	787.5g AML	262.5g SA
Trt #11	+				
Trt #12	-	75% AML + 25% Biochar	620g	465g AML	155g Biochar
Trt #13	+				

Conclusions

The investigation found that adding soil amendment (SA) or Biochar to AML soil improved hemp growth, with increased shoot heights, root lengths, and biomass. The longest roots were observed in Trt 13 (75% AML + 25% Biochar and microbes). SA treatments led to taller shoots in the first 14 days, and Trt 10 & 6 had the second and third highest shoot weights, respectively (Trt 7 – Garden Soil was highest). While +microbe treatments showed some success, more replicates are needed to conclusively assess the effectiveness of mycorrhizae powder. Future studies should explore hemp growth in AML with soil amendment, Biochar, and microbes over longer periods in in larger pots and in the AML sites.

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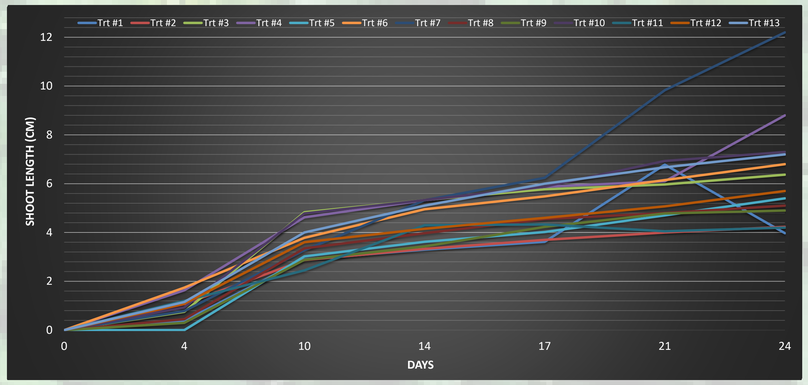
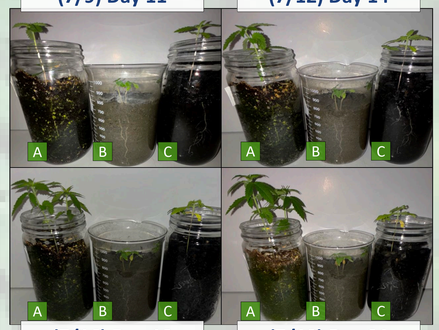
Results & Discussion

Fig. 1: Comparison of Shoot & Root Lengths Among All Treatments Tested

Soil Description	Garden Soil	AML Only		AML + 0.5" SA Top		AML + 1.5" Mix Top		Biochar Only		75% AML + 25% SA		75% AML + 25% Biochar	
Treatment #	Trt 7	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6	Trt 8	Trt 9	Trt 10	Trt 11	Trt 12	Trt 13
Microbes	-	-	+	-	+	-	+	-	+	-	+	-	+
Day 25 Picture													
Avg Final Shoot Length	12.2 cm	4.0 cm	4.2 cm	6.4 cm	6.4 cm	5.4 cm	6.8 cm	5.1 cm	4.9 cm	7.3 cm	4.2 cm	5.7 cm	7.2 cm
Avg Final Root Length	19.6 cm	9.8 cm	11.7 cm	11.4 cm	8.8 cm	7.5 cm	15.6 cm	16.8 cm	16.1 cm	15.4 cm	6.8 cm	18.5 cm	23.9 cm

Fig. 3: Shoot Lengths (cm) of All Treatments Over Time





Pictured from Left to Right: **[A]** Trt 7 – Garden Soil **[B]** Trt 1 – AML Only **[C]** Trt 8 – Biochar Only

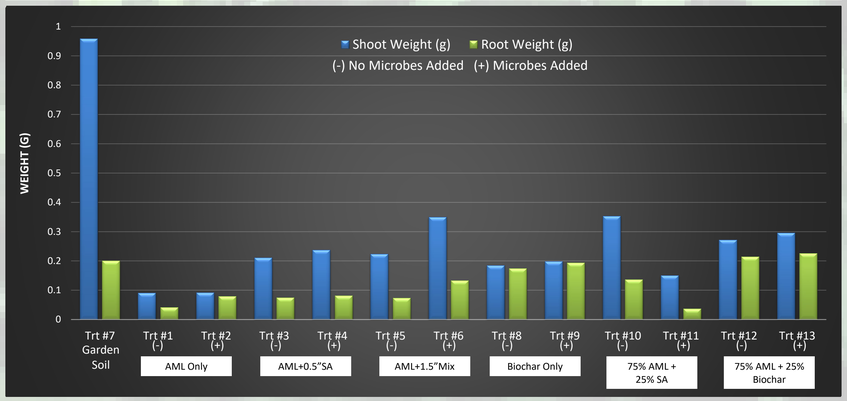
Biochar appears to promote root growth, especially when mixed with AML vs alone.

- Trt 13 had the longest roots - 4.3cm longer than Trt 7. (Fig. 1)
- Trts 12, 8, & 9 roots outcompeted all treatments minus Trt 7 by ≥0.5cm. (Fig. 1)
- Trts 12-13 had the greatest root weights, both outcompeting Trt 7. (Fig. 2)

Adding SA, top dressed or mixed, resulted in more shoot & root growth on average.

- Trt 10 had tallest shoots minus Trt 7. (Fig. 1)
- Trt 10 & Trt 6 had the greatest shoot weights, minus Trt 7. (Fig 2)
- Trts containing SA & -microbes (Trt 3, 5, 10) had greater shoot & root weights than Trt 1. (Fig 2)

Fig. 2: Avg. Fresh Weight (g) of Shoots & Roots per Treatment



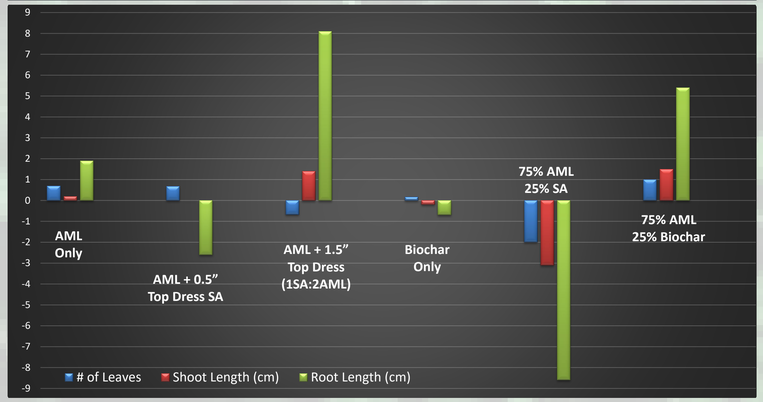
Trts containing SA on Avg Showed More Initial Growth, Even Compared to Trt 7.

- Days 0-14, Trts 3, 4, & 10 had taller shoots than Trt 7 & all Biochar-containing Trts (Fig. 3)
- Day 4, avg Trt 6 plants were 0.11-1.74cm taller than all other treatments. (Fig. 3)

Adding Microbes May Help Plant Growth

- Garden Soil (Trt 7) has microbes and had significantly more shoot growth. (Fig. 1-2)
- Half the +microbe trts had more growth. (Fig. 4)
- Growth in -/+microbe Biochar trts may be minimally different due to Biochar's own growth-promoting properties. (Fig. 4)
- Results may be skewed for 75%AML + 25%SA trts due to ending with 2-3 plants only. (Fig. 4)

Fig. 4: Comparison Between +Microbe & -Microbe Treatments



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