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Progressing from Terra Preta de Índios to the Whole World

A comparison of variable economic costs associated with several proposed biochar application methods

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Introduction

Biochar is the carbon-rich product obtained when biomass is heated in a closed container with little or no available air through a process called pyrolysis [1]. Biochar can be used to improve agriculture in several ways, and its stability in soil and nutrient-retention properties make it an ideal soil amendment to increase crop yields [2]. In addition to the known agronomic benefits [3,4,5,6], biochar application to soil, in combination with sustainable biomass production, can be carbon-negative and therefore used to actively remove carbon dioxide from the atmosphere on a millennial timeframe [7].

The ability of biochar to store carbon and improve soil fertility will not only depend on its physical and chemical properties [8,9], but also on the technical and economic limitations of handling biochar at quantity in an agronomic setting. Despite building interest among scientists and policy-makers over the potential benefits of biochar, little is known about the physical act of applying biochar to soil [10]. We believe this is a critical area for investigation since a more complete understanding of various constraints of application will help enable an adequate assessment of the overall feasibility of biochar.

This article examines the problem of biochar application to soil. Specifically, we look at two methods of application—broadcast-and-disk and trench-and-fill—and provide cost estimates for each under varying rates of saturation. We draw on data from experimental work at Flux Farm and elsewhere [11], regional custom rates [12], implement specifications, and calculated estimates. Our calculations cover variable costs only—those costs that are dependent on the rates of application—and therefore ignore capital costs associated with the machinery needed for application. We also disregard the cost of biochar itself since projecting a market value at present remains speculative [13].

Results and Discussions

Our findings show that the broadcast process is generally cheaper, however we consider a trench-and-fill method to be more suitable for storing high quantities of biochar in soil. For broadcast application, we found that at saturation rates of 2.5, 5, 10, 25, and 50 tons per acre, a respective cost per acre is $29, $44, $72, $158, and $300 (Table 1). Our examination of the trench-and-fill process revealed that cost depended on several variables, including saturation rate, trench depth, and operator efficiency. We found that at saturation rates of 5, 10, 25, 50, and 75 tons per acre, with trenches 2 feet deep, and at trenching and application rates of 15 feet per minute, a respective cost per acre of applied biochar is $34, $85, $171, $341, and $512 (Table 2). In both methods, we found results that suggest biochar application could constitute a considerable cost, many times greater than typical agricultural processes.

Although our findings offer only a basic guide to calculating the cost of application, the intent of this paper is to serve as a launching pad for the much-needed additional research into the costs and other potential constraints of biochar application to agricultural soils.

Table 1. Broadcast-and-disk application results

Biochar saturation rate		Time	Application Costs			Subtotal	Disking	Total
Tons/acre *S*	ft^3/acre *28.3L/ft^3*	Total (hr) t_b	Labor L_b	Fuel f_b	Maint. m_b	Application A_b	Disking D	Cost C_b
2.5	228	0.4	$5	$7	$2	$14	$15	$29
5	456	0.9	$10	$15	$3	$29	$15	$44
10	912	1.7	$20	$30	$7	$57	$15	$72
25	2280	4.3	$51	$74	$17	$143	$15	$158
50	4559	8.5	$102	$149	$34	$285	$15	$300

Table 2. Trench-and-fill application results

SATURATION				TRENCHING						APPLICATION						
Saturation Rate		Trench Size		Time		Costs			Subtotal	Time		Costs			Subtotal	TOTAL
Tons/ac s_t	ft^3/acre $28.3L/ft^3$	Depth (ft) d	Rows/ac n	Rate (ft/m) r_t	Total (hr) t_{tr}	Labor l \$12	Fuel f \$18	Maint. m \$4	Cost c_t	Rate (ft/m) r_a	Total (hr) t_a	labor l \$12	Fuel f \$17.42	Maint. m \$3.97	Cost A_t	Cost C_t
5	456	1	4	12	1.3	$15	$23	$5	$43	12	1.3	$15	$22	$5	$42	$85
				15	1.0	$12	$18	$4	$34	15	1.0	$12	$18	$4	$34	$68
				20	0.8	$9	$14	$3	$26	20	0.8	$9	$13	$3	$25	$51
5	456	2	2	12	0.6	$8	$11	$3	$22	12	0.6	$8	$11	$3	$21	$43
				15	0.5	$6	$9	$2	$17	15	0.5	$6	$9	$2	$17	$34
				20	0.4	$5	$7	$2	$13	20	0.4	$5	$7	$2	$13	$26
12.5	1140	1	11	12	3.2	$38	$57	$13	$108	12	3.2	$38	$55	$13	$106	$213
				15	2.5	$30	$46	$10	$86	15	2.5	$30	$44	$10	$85	$171
				20	1.9	$23	$34	$8	$65	20	1.9	$23	$33	$8	$63	$128
12.5	1140	2	5	12	1.6	$19	$28	$6	$54	12	1.6	$19	$28	$6	$53	$107
				15	1.3	$15	$23	$5	$43	15	1.3	$15	$22	$5	$42	$85
				20	0.9	$11	$17	$4	$32	20	0.9	$11	$17	$4	$32	$64
25	2280	1	22	12	6.3	$76	$114	$25	$215	12	6.3	$76	$110	$25	$211	$343
				15	5.1	$61	$91	$20	$172	15	5.1	$61	$88	$20	$169	$274
				20	3.8	$46	$68	$15	$129	20	3.8	$46	$66	$15	$127	$206
25	2280	2	11	12	3.2	$38	$57	$13	$108	12	3.2	$38	$55	$13	$106	$213
				15	2.5	$30	$46	$10	$86	15	2.5	$30	$44	$10	$85	$171
				20	1.9	$23	$34	$8	$65	20	1.9	$23	$33	$8	$63	$128
50	4559	1	43	12	12.7	$152	$228	$51	$431	12	12.7	$152	$221	$50	$423	$853
				15	10.1	$122	$182	$41	$344	15	10.1	$122	$176	$40	$338	$683
				20	7.6	$91	$137	$30	$258	20	7.6	$91	$132	$30	$254	$512
50	4559	2	22	12	6.3	$76	$114	$25	$215	12	6.3	$76	$110	$25	$211	$427
				15	5.1	$61	$91	$20	$172	15	5.1	$61	$88	$20	$169	$341
				20	3.8	$46	$68	$15	$129	20	3.8	$46	$66	$15	$127	$256
75	6839	1	65	12	19.0	$228	$342	$76	$646	12	19.0	$228	$331	$75	$634	$1280
				15	15.2	$182	$274	$61	$517	15	15.2	$182	$265	$60	$507	$1024
				20	11.4	$137	$205	$46	$388	20	11.4	$137	$199	$45	$381	$768
75	6839	2	33	12	9.5	$114	$171	$38	$323	12	9.5	$114	$165	$38	$317	$640
				15	7.6	$91	$137	$30	$258	15	7.6	$91	$132	$30	$254	$512
				20	5.7	$68	$103	$23	$194	20	5.7	$68	$99	$23	$190	$384

Conclusions

We find it crucial that future research efforts focus more on application and associated costs of various application processes. The estimates provided in this analysis offer only a preliminary idea of expected costs of application for only two of many possible proposed and emerging methods. Confirmation of these results will only come through on-the-ground testing. In addition, more testing of the effects of various application rates on the soil needs to occur. There is still uncertainty regarding the benefits of various saturation rates, and it is also unknown what potential negative impacts various application methods can have on different types of soils for different types of crops. As part of this testing, special attention needs to be paid to the enduring effects of biochar in soil. Understanding how long the economic or agronomic benefits from biochar can continue to accrue may help justify the potentially high cost of application we observe in this paper.

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