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Biochar Addition to the Loam Soil of Soybean Fields Can Reduce Trifluralin Usage in Velvetleaf Control †

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Abstract: Biochar, made by pyrolysis of various organic materials such as plants, can amend soil physicochemical properties and improve the efficiency of pre-planted incorporated (PPI) herbicides. The excessive consumption of PPI herbicides results in environmental predicaments that improving PPI herbicides' efficacy by changing soil biological properties might solve this problem. Trifluralin, a PPI, is recommended against annual broadleaf weeds such as velvetleaf in soybean fields. In the present study, treatments included normal soil (NS) (sand 30% + silt 35% + clay 35%) and manipulated soil (MS) (sand 27% + silt 32% + clay 32% + biochar 9%). Two blocks of NS received recommended dose (RD) (1.7 lit/ha) (NS+RD) and a reduced dose (1.2 lit/ha) (NS+ReD) of trifluralin. Meanwhile, the block of MS was exposed to the reduced dose (MS+ReD) of trifluralin. Two days after herbicide treatments, seeds of *Abutilon theophrasti* were sowed. Then, seven days after sowing, the growth of weeds was monitored and weed control percentage was calculated using the arcsine model based on observed data. Results showed that the NS+RD was the most effective treatment in velvet control (100%), followed by MS+ReD (93.5%) with no significant difference. The NS+ReD treatment resulted in 81% weed control showing significant differences with the NS+RD and MS+ReD. Thus, it seems that biochar acts as a neutral buffer and decreases the necessity of PPI herbicides application in soybean fields. The biochar application can potentially reduce soil contamination, weed resistance, environmental pollution, and the adverse effects of PPI herbicides on the soil microbial population.

Keywords: biochar; herbicide; loam soil; sustainable agriculture; weed control

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1. Introduction

Biochar, a carbon-rich material, is produced by pyrolysis of biomass under limited oxygen [1]. It is well-documented that biochar acts as a soil amendment through increasing cation exchange capacity, water retention, microbial activity, nutrient availability, and sequestering toxic heavy metals [2]. Nevertheless, the role of biochar in ameliorating physiochemical properties of soils [3] should be considered as a soil improver in agricultural ecosystems, especially in crop protection.

Soybean fields usually contain a complex of grass and broadleaf weeds such as velvetleaf (*Abutilon theophrasti*) from Malvaceae that can reduce the final yield of soybean [4]. For weed control in these agroecosystems, chemical herbicides are commonly used. Trifluralin, a pre-planted incorporated (PPI) herbicide, is recommended against annual grasses in soybean fields like *A. theophrasti* [5]. This herbicide belongs to dinitroanilines that act as an inhibitor of microtubule synthesis [6]. Excessive usage of PPI herbicides caused strongly adsorbed to soil particles with negligible leaching [7] and then make adverse effects on soil microbial population such as reduction in fauna diversity [8], soil contamination, environment, and especially groundwater pollution [9]. Thus, according to the PPI herbicides behavior in soils, it seems that the changes in soil physicochemical characteristics can solve the abovementioned problems by improving the efficiency of PPI herbicides and reducing their consumption.

The present study aimed to evaluate biochar potential to reduce the need for trifluralin in velvetleaf control through changing soil biological conditions in loam soil of soybean fields.

2. Materials and Methods

The effect of biochar application in soybean fields in order to control velvetleaf was assessed in three blocks and three independent biological replicates in the randomized complete block design. Two blocks were normal soil (NS) with loam soil containing sand (30%), silt (35%), and clay (35%) with pH = 7.55 and EC equal to 1.99 dS. M^{-1}. Another block had manipulated soil (MS) that contained sand (27%), silt (32%), clay (32%), and biochar (9%) with pH = 7.99 and EC equal to 1.46 dS. M^{-1}. All of the blocks were prepared in 3 m × 3 m terraces.

Two blocks of NS received recommended dose (NS+RD) (1.7 lit/ha) and reduced dose (NS+ReD) (1.2 lit/ha) of trifluralin (Trifluralin® 48% EC, Ariashimi Company, Iran), respectively. The sole block of MS received only a reduced dose of herbicide (MS+ReD). All herbicide treatments were accomplished in a pre-planted form combined with soil in 5 cm depth when soil humidity was 20%. Two days after herbicide treatments, the authenticated and uniform seeds of *A. theophrasti* were sown.

The growth of seedlings was monitored for six weeks after sowing for data collection. Then, observed data were changed to numerical percent with inverse trigonometric functions (ArcSin X). The Shapiro–Wilk's test and Levene's test were used for normalization and equality of variances, respectively. Finally, the one-way ANOVA followed by the Tukey test ($P<0.05$) was subjected to comparison means.

3. Results and Discussion

Results showed that velvetleaf control in NS+RD was 100% followed by MS+ReD with 93.5% control and no significant difference ($F=9.326$, $P=0.092$). Meanwhile, the velvetleaf control was measured to be 81% in NS+ReD having significant differences with NS+RD ($F=1.753$, $P=0.013$) and MS+ReD ($F=2.159$, $P=0.031$), respectively. According to the observed results, biochar addition to the loam soil of soybean fields can reduce herbicide consumption. Previous studies have reported the biochar ability on soil amendment and its impact on the fate and effects of herbicides in soil [10]. Due to its higher organic carbon content and specific surface area, biochar acts as the most efficient sorbent for herbicides in the soil [11]. Thus, it is suggested that the biochar addition to the loam soils of soybean fields can improve the trifluralin efficiency in velvetleaf control by magnifying herbicide persistence that leads to decreasing herbicide application.

It is worth mentioning that the biochar addition to the soil can also enhance the adsorption of herbicides by altering their mobility which leads to decreased herbicide leaching in soil [12]. Hence, to all appearances, low dose usage of trifluralin in loam soil of soybean fields can be related to biochar role in high adsorption of herbicide molecules to soil particles. Consequently, biochar application leads to promoting trifluralin performance in velvetleaf control. The issue seems to be even more serious taking groundwater pollution into account. On the other hand, decreasing the soil microbial communities' exposure to the PPI herbicides can be added to the benefits of biochar addition to the soil [13].

4. Conclusion

Biochar is a valuable soil amender that can help to reduce PPI herbicides in soil which profoundly contributes to gaining sustainable agriculture and improves environmental health. Finally, biochar application in long term supports soil microbial population and reduces soil contamination, environmental pollution, and weed resistance as well.

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References

1. Ali, S.; Rizwan, M.; Qayyum, M.F.; Ok, Y.S.; Ibrahim, M.; Riaz, M.; Arif, M.S.; Hafeez, F.; Al-Wabel, M.I.; Shahzad, A.N. Biochar soil amendment on alleviation of drought and salt stress in plants: a critical review. *Environ. Sci. Pollut. Res.* **2017**, *24*, 12700-12712. https://doi.org/10.1007/s11356-017-8904-x
2. Uchimiya, M.; Lima, I.M.; Klasson, K.T.; Wartelle, L.H. Contaminant immobilization and nutrient release by biochar soil amendment: roles of natural organic matter. *Chemosphere*. **2010**, *80*, 935-940. https://doi.org/10.1016/j.chemosphere.2010.05.020
3. Brassard, P.; Godbout, S.; Lévesque, V.; Palacios, J.H.; Raghavan, V.; Ahmed, A.; Hogue, R.; Jeanne, T.; Verma, M. Biochar for soil amendment. In *Char and Carbon Materials Derived from Biomass: Production, Characterization and Applications*; Jeguirim, M.; Limousy, L.; Eds.; Elsevier, **2019**; pp. 109-146. https://doi.org/10.1016/B978-0-12-814893-8.00004-3
4. Mitich, L.W. Velvetleaf. *Weed Technol*. **1991**, *5*, 253-255. https://doi.org/10.1017/S0890037X00033674
5. Reynolds, D.B.; Jordan, D.L.; Vidrine, P.R.; Griffin, J.L. Broadleaf weed control with trifluralin plus flumetsulam in soybean (*Glycine max*). *Weed Technol.* **1995**, *9*, 446-451. https://doi.org/10.1017/S0890037X00023666
6. Fernandes, T.C., Pizano, M.A. and Marin-Morales, M.A. Characterization, modes of action and effects of trifluralin: a review. In *Herbicides-Current Research and Case Studies in Use*; Price, A.J.; Kelton, J.A.; Eds.; IntechOpen, **2013**; pp. 489-516. https://doi.org/10.5772/55169
7. Bhardwaj, L.; Pandey, J.; Dubey, S.K. Effects of herbicides on soil enzymes and their regulatory factors in agroecosystem: A review. In *Plant, Soil and Microbes in Tropical Ecosystems*; Dubet, S.K.; Verma, S.K.; Eds.; Springer, **2021**; pp.71-100. https://doi.org/10.1007/978-981-16-3364-5_5
8. Singh, M.K.; Singh, N.K.; Singh, S.P. Impact of herbicide use on soil microorganisms. In *Plant Responses to Soil Pollution*; Singh, P.; Singh, S.K.; Prasad, S.M.; Eds.; Springer, **2020**; pp. 179-194. https://doi.org/10.1007/978-981-15-4964-9_11
9. Mendes, K.F.; Régo, A.P.J.; Takeshita, V.; Tornisielo, V.L. Water resource pollution by herbicide residues. In *Biochemical Toxicology-Heavy Metals and Nanomaterials*; Ince, Ince, O.K.; Ondrasek, G.; Eds.; IntechOpen, **2019**; pp. 49-64. https://doi.org/10.5772/85159
10. Khorram, M.S.; Zhang, Q.; Lin, D.; Zheng, Y.; Fang, H.; Yu, Y. Biochar: a review of its impact on pesticide behavior in soil environments and its potential applications. *J. Environ. Sci.* **2016**, *44*, 269-279. https://doi.org/10.1016/j.jes.2015.12.027
11. Spokas, K.A.; Koskinen, W.C.; Baker, J.M.; Reicosky, D.C. Impacts of woodchip biochar additions on greenhouse gas production and sorption/degradation of two herbicides in a Minnesota soil. *Chemosphere*. **2009**, *77*, 574-581. https://doi.org/10.1016/j.chemosphere.2009.06.053
12. Li, J.; Li, Y.; Wu, M.; Zhang, Z.; Lü, J. Effectiveness of low-temperature biochar in controlling the release and leaching of herbicides in soil. *Plant. Soil*. **2013**, *370*, 333-344. 2013 https://doi.org/10.1007/s11104-013-1639-7
13. Varjani, S.; Kumar, G.; Rene, E.R. Developments in biochar application for pesticide remediation: current knowledge and future research directions. *J. Environ. Manage.* **2019**, *232*, 505-513. https://doi.org/10.1016/j.jenvman.2018.11.043