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The Effect of Biochar Obtained From Pruning Residue of Oil-Bearing Rose on Flower Yield and Essential Oil Content of Oil-Bearing Rose

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Abstract: Oil-bearing rose (*Rosa damascena* Mill.), which the most important rose species used in essential oil production in the world, is performed in Lake Region where 85% of production realized in Isparta, Turkey. Each year, oil-bearing rose pruned within February and March in the region, therefore, considerable amount of pruning residues burning in the field causing significant damage to the soil organic matter content. This research was carried out to determine the effect of biochar that is obtained from oil-bearing rose pruning residues on the flower yield and essential oil content of the oil-bearing rose. Collected residues were subject to 400 °C heat treatment in oxygen free environment, afterwards obtained biochar applied to oil-bearing rose plant at 500, 1000 and 2000 kg ha^{-1} doses. Biochar application increased daily flower yield quantity; however, no evidence was found if biochar is providing earliness. Based on the overall mean values, biochar application was improved total flower yield significantly compared to the control. The highest essential oil content was determined in the areas where the highest biochar dose applied as 2000 kg ha^{-1}.

Keywords: *Rosa damascena*, biochar, flower yield, essential oil content

Introduction

Rosa damascena Mill, which is called Pink Oily Rose, is the most intense specific aromatic rose variety among the cultivated roses. It has a high economic value for perfume, cosmetics, medicine and food industry. Lake Region of the Turkey and Kazanlak region of the Bulgaria are the world's most important oily rose production areas where Isparta alone realizes more than 80% of the oil-roses production of Turkey (Baydar, 2015). One of the most important factors affecting yield and quality in oil roses is pruning. Pruning allows for easier and faster collection of flowers, as well as easier cultural practices such as tilling, irrigation, fertilization, weed, disease, and pest management (Baydar, 2015). Common disposal method for pruning residues is burning in the field which cause organic matter loss and air pollution. Although this organic material can be incorporated to soil to improve soil organic matter contents, farmers are reluctant for considering possible fungal contamination. However, this material can be composted or charred to overcome this phenomenon. High temperature evolution in biochar production can certainly eliminate all pest or disease agents. Biochar have been using since 18th century for soil amelioration (Chan et al., 2010). Recently, utilization of char is shifted to carbon sequestration to mitigate the effects of global warming (Sohi et al., 2010; Prendergast-Miller et al., 2011; Zavollini et al., 2011). A number of advantages of biochar incorporation are reported such as preventing nutrient leaching (Laird et al., 2010) and enhancing soil biological activity (Luo et al., 2011). Although Luo et al. (2011) reported higher carbon dioxide (CO_2) formation in case of biochar application; the net CO_2 budget is favour of sequestration. Furthermore, Zavalloni et al. (2011) reported only 2.8% of the applied biochar returned back to atmosphere when biochar and wheat straw incorporated together. However, when straw applied alone this ratio increases up to 56%. Biochar reduces nitrate leaching (Ding et al., 2010) and N_2O formation (Yanai et al., 2007). N_2O is a by-product of denitrification process and it has 250 times higher destruction impact than CO_2 (Boyle and Ardill, 1989), thus biochar application is also environmentally friendly practice. However, Castaldi et al. (2011) reported that N_2O formation increased in the short-term (3 months) with biochar application, but that there was no difference in the long-term period (14 months) compared to the control. On the other hand, Prendergast-Miller et al. (2011) reported nitrate localization in the root zone by biochar application. This may lead to increase of denitrification or leaching. The rapid growth of the world population causes increases in the food requirement which lead farmers to produce more than earlier. As a result, considerable amount of harvest wastes/residues (straw, greenhouse plant wastes, hazelnut shells etc.) exist (Anonymous, 2004). Those substrates have a great potential to sustain soil organic matter. However, semi-arid climate regime stimulate mineralization, thus soil organic matter is not stable at the desired level. Unlike to raw organic material, the biochar remains in the soil for a very long time (Schmidt and Noack, 2000; Glaser et al., 2002). The aim of the study was to determine the effects of biochar obtained from pruning residues from oily rose production.

Materials and Methods

Experiment was carried out for two consecutive years of 2016 and 2017. A three-years-old oily rose garden was selected from the Senir district of Isparta, Turkey. Soil pH, EC and CaCO3 contents were 7.82, 204 μS cm^{-1} and 16.3% respectively. Biochar was applied to the 1-meter sections with a 6-meter gap between. The space within the rows was 3.5 meter. Pruning residues collected from garden were air dried under the shelter and charred at 400 °C for 12 hour by self-constructed biochar production system. The doses of 500 (B500), 1000 (B1000) and 2000 (B2000) kg ha^{-1} biochar were incorporated to top 5-7 cm layer of the soil under canopy projection area with hand plugging. Control plot without biochar application was also included and labelled as B0. Experimental design was randomized block with three replicates. Doses were selected based on the amount and cost of biochar production. Regular cultivation including fertilization practices were followed. Biochar application was performed only once, at the year of 2016 whereas at the 2017, residual effects were evaluated. Harvest lasted for 22 days between April to May 2016 and 20 days between May to June 2017. The total precipitation on May 2016 was 27.4 kg m^{-2} whereas 42.4 kg m^{-2} in May 2017. The daily maximum temperature averages for harvest period at 2016 and 2017 were 20.9 and 20.8 respectively. Harvested petals were weighted by electronic balance on daily basis. The volatile oil content determined according to Erbas and Baydar (2016). Statistical analyses were realized by MSTATC software (Crop and Soil Sciences Department, Michigan State University, Version 1.2). Range test were performed at p=0.05 level.

Results and Discussions

Since *Rosa damascena* has asynchronous flowering, harvesting takes place as the gathering of the rose leaves after the flowers matured. Thus, the yields obtained from each day and averages are presented for each harvest day. The daily yield values and averages belonging to 2016 are presented in Figure 1 and Figure 2. The yield values obtained in the first year of the experiment (Figure 1) showed that biochar application led to increase in daily yield values. Although the fluctuation appeared within biochar doses in terms of yield values, all biochar doses yielded higher petal weights than control. The differences between the daily yield values are associated one day prior to climate conditions, which wormer and sunny days stimulated the flowering. There was no evidence that biochar was provided earliness. In general, major yield obtained between 10^{th} to 18^{th} days. Control treatment also represented slight increases, but it was well below the biochar applied plots. According to mean values (Figure 2), it is clearly seen that the biochar application increased significantly compared to control ($p < 0.05$).

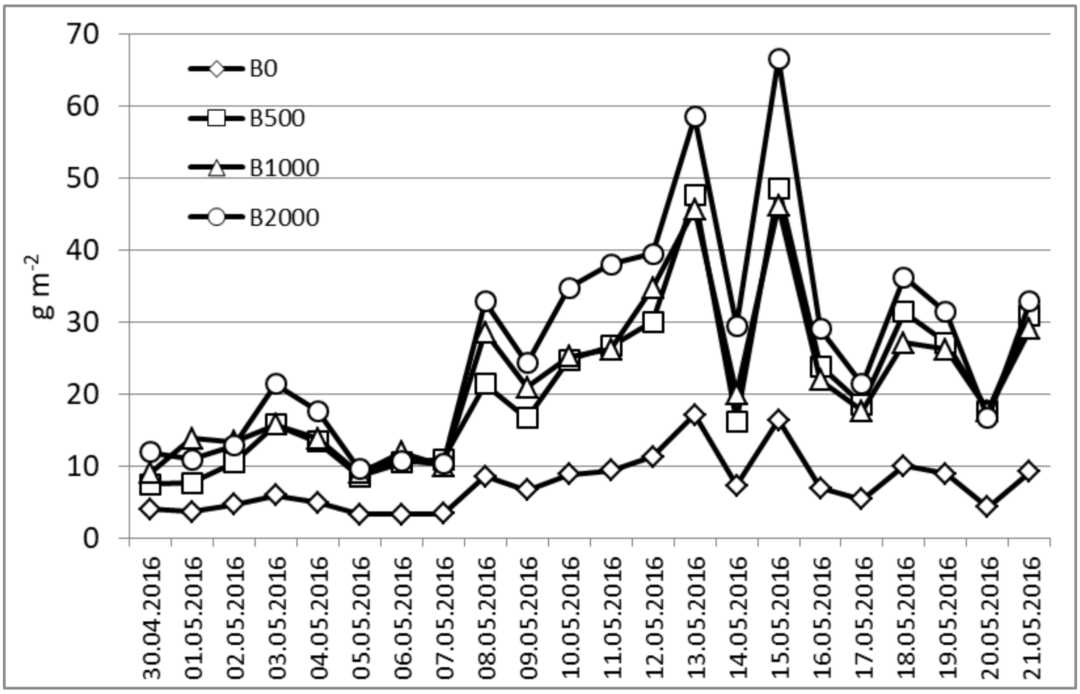

Figure 1. Daily petal yield at 2016

This experiment was carried out in relatively small parcels and considerable higher yield values were observed. This data needs to be proved by biochar applications to the larger scale. Because of the relatively small parcel sizes, the precise care to the plants can also be a factor to increase the efficiency. On the other hand, it is clear that biochar was effective on yield. Therefore, it was planned to carry out experiments on large scale, larger areas under farmers' conditions. In the second year of the experiment (Figure 3), daily temperature changes occurred due to excessive precipitation, so there was no tendency between daily harvest values. There was no significant difference in daily yield values between biochar application doses, but all biochar doses significantly increased the yield.

On the last four days of harvest, the tendency to decline in yield started, and the harvest was terminated at the point where the crop was provided enough income to meet the labour cost.

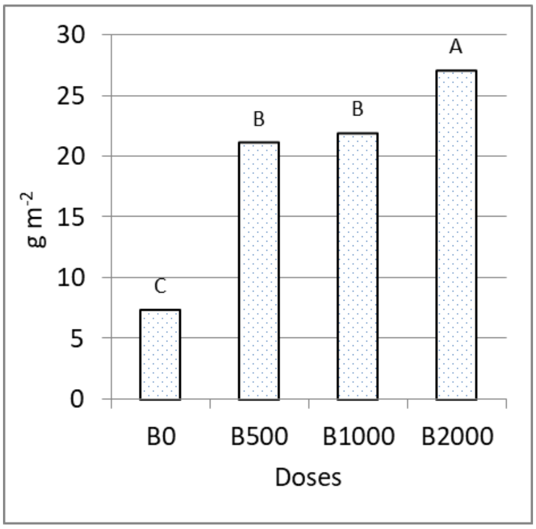

Figure 2. Mean petal yield of 2016

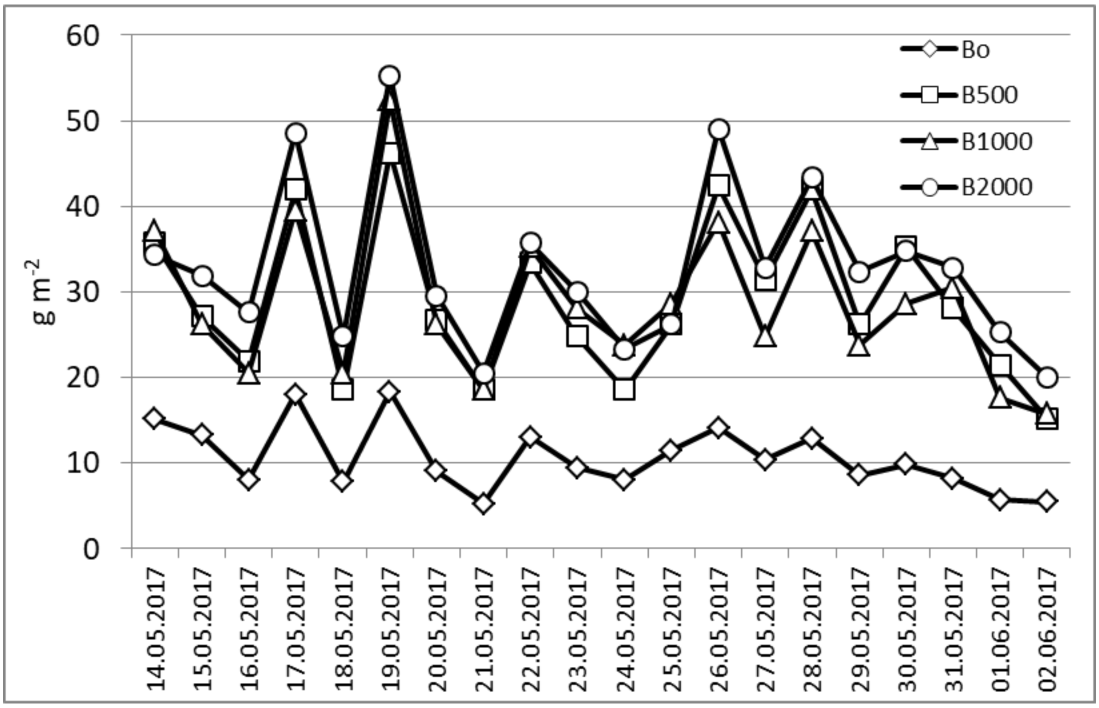

Figure 3. Daily petal yield at 2017

The harvest period in the second year was 2 days shorter than the first year in this case. This was thought to be due to the fact that the yield values were higher at the beginning of the harvest than the first year. As a result, major proportion of yield was realized at the beginning stage of the harvest. There was no difference between B500 and B1000 doses in terms of average yield values (Figure 4). B1000 showed statistically higher ($p<0.05$) results than the others, and all applications increased the yield compared to the control.

The volatile oil values were only could determine for the second year of the experiment and the gathered results are given in Figure 5. Biochar applications increased the amount of essential oil compared to the control, but the application at higher doses (B2000) caused a decrease in essential oil compared to B500 and B1000. Those differences were not significantly significant ($p>0.05$).

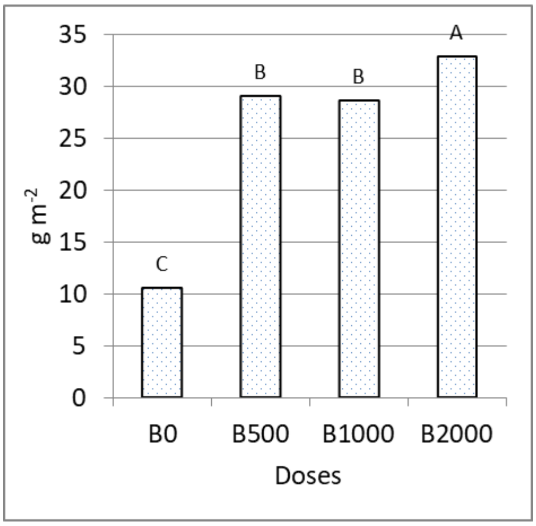

Figure 4. Mean petal yield of 2017

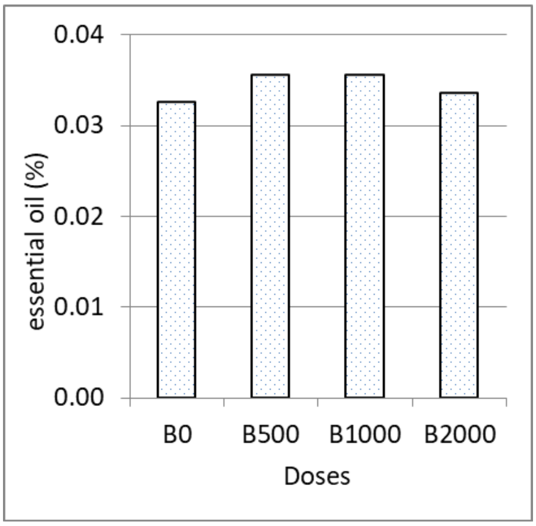

Figure 6. Essential oil contents of the petals in 2017

Conclusions

The most obvious result obtained from this study was that the biochar application influenced yield of oily rose plant in a relatively short time. Biochar application was performed on the beginning of April 2016 and harvest started at the end of this month. Surprisingly, the beneficial effects of biochar become visible contrary to Demirbas et al. (2017) report, which they found that the incubation after biochar incorporation increased the effectiveness. The other promising result was long-lasting effects of biochar on yield.

In the 2017 harvest season, the yield values of each biochar dose (B500, B1000 and B1000) were found to be higher than those of the control fields without biochar. When comparing the years, biochar was more effective on 2017 comparing to 2016, which is in accordance with results of Demirbas et al. (2017).

Long-lasting effects was reported earlier (Schmidt and Noack, 2000; Glaser et al., 2002).When the yields obtained from biochar incorporated plots were evaluated statistically, there was no difference between the two doses of B500 and B1000, but they provided a visible increase in yield compared to the control, thus, B100 dose was recommended to the farmers. However, in future studies, it would be beneficial to try further higher doses.

Essential oil content of the leaves is not the critical value for the farmers, because it is not a factor for pricing. However, for the buyers, these small changes lead to gain the huge amount of extra income considering the price of crude oil that distilled from rose petals. In case of effective agricultural extension activities, buyers can encourage the producers to use biochar.

The other observed benefit of the biochar incorporation was weed control. We observed less weeds in the biochar applied areas. This findings yet unproven, it should be tested by controlled experiments. The mechanism of beneficial effects of the mentioned biochar was not the purpose of the this experiment; however, its stimulating effects on the soil microorganisms, such as increasing of both microbial biomass and enzyme activity (Lehmann et al., 2011) can increase soil nutrient bioavailability. Although, Lehmann et al. (2011) did not point out the mechanism of stimulating effect of biochar on soil microorganisms; Lehmann et al. (2011) and Liang et al. (2006) emphasized that the biochar have a great surface area which protect nutrients in the soil. Further research should be conducted to understand the relationship between biochar and microorganisms or biochar and soil nutrient.

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