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Research Article

INVESTIGATION OF THE USABILITY OF WASTE SLUDGE AS AN ORNAMENTAL PLANT GROWING MEDIA

Güzella Yılmaz[1,*], Kenan Yıldız[1]

[1]*Department of Horticulture, Agriculture Faculty, Tokat Gaziosmanpasa University, Tokat, Turkey*

**Corresponding Author:*
E-mail: guzella.yilmaz@gop.edu.tr

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ABSTRACT. In this study, it was tested whether the waste sludge with added biochar can be used as a seedling growing medium in acacia, an ornamental plant. The waste sludge used in the study was taken from the municipal waste treatment plant of Tokat province. The biochar used in the study was produced from the biomass consisting of pruning wastes of the 'Populus alba' tree.
Apart from the control, two different media were used in the study. The first medium was prepared from 2% biochar and 98% waste sludge, the second medium was prepared by mixing 2% biochar, 49% peat and soil mixture (1:1 ratio), and 49% waste sludge. Compared to the control treatment (soil and peat; 1:1 ratio), both sludge media used in the study resulted in significant increases in height and diameter of acacia seedlings. The seedlings in the pots containing the waste sludge had more lateral branches and formed a better form. Root growth of seedlings was also better in both waste sludge treatments compared to control. As a result of the study, it was determined that the waste sludge with the addition of biochar can be used as a seedling growing medium for ornamental plants such as acacia.

Keywords: *Acacia (Robinia pseudoacacia), Waste Sludge, Biochar*

INTRODUCTION

As a result of the increase in population, rapid and uneven growth in living areas is observed throughout the world. The increase in population and accordingly the increase in needs and the growth of urban centers cause a serious increase in domestic and industrial wastewater sludge. Organic wastes with high nutrient content constitute the highest amount of substance in the waste sludge. However, waste sludge with high organic matter content also contains harmful pollutants. Waste sludge, which is not recycled and whose amount is increasing day by day, poses a great threat to human health and nature. The importance of conducting studies for the reuse of waste sludge without harming the nature is increasingly understood [1, 2]. For this purpose, one of the first applications that comes to mind is the use of waste sludge in agricultural production, accompanied by measures that can prevent its damage. The use of waste sludge, which is rich in macro and micro elements, in agricultural areas will provide an economical growing environment [3]. Waste landfill sludge, which contains approximately 50-70% organic matter and has a high nutrient source, is seen as a growing medium and fertilizer source. When sludge is compared with barnyard manure and organic compost in terms of nutrient content, it is stated that the nutritional values are similar [4, 5] and it contains all the elements necessary for the growth and development of plants [6]. Chaney [7] suggested in his study that N and P deficiency can be eliminated by adding waste sludge to the medium. It has been stated that the deficiency of elements such as Cu and Zn in long-processed agricultural lands can be eliminated by using waste sludge [8, 9]. Today, waste sludge has started to be used in many countries in areas such as agriculture, parks and gardens, forests, degraded areas, and nurseries [10]. The use of waste sludge as a growing medium, organic fertilizer and germination medium is also increasing in the production of ornamental plants in our country [11, 12, 13, 14]. It is thought that the use of waste sludge in the ornamental plants sector can replace the costly products used as a growing medium, reduce the amount of fertilizer to be given to the plant, and the waste sludge, which is a threat to the environment, will be made harmless to the environment and recycled [15]. Although sludge has advantages, it also has disadvantages such as pathogens and pollutants it contains, causing health problems for humans and environmental problems. In particular, the use of waste sludge without taking precautions against the high heavy metals that may be present in it poses an ecological risk [2]. Nickel, zinc, copper, cobalt, manganese and copper elements are essential for plant growth, but cadmium, selenium, arsenic, lead, mercury, aluminum and vanadium are toxic. Whether all these heavy metals are necessary for plant growth or not, if they accumulate excessively in tissues and organs, they adversely affect the plant [16]. Although the resistance of plants to heavy metal accumulation varies, heavy metal accumulation can negatively affect plant growth and development and even cause plant death [17]. The information obtained as a result of the studies shows that the waste sludge can be used successfully in ornamental plant cultivation by taking precautions against its negative effects and transforming it into a form that will not harm the environment and health [18].

When using waste sludge in plant cultivation, it is predicted that adding biochar to the waste sludge is the right choice to protect the plants from the damage of the waste sludge. Biochar is the product obtained by burning organic wastes at 2500C and higher temperatures, in an airless or low air environment [19]. Biochar is called black gold because it reduces atmospheric carbon in agricultural areas, increases plant yield and functions [20]. It has been determined that the transfer of cadmium in the soil to the plant can be significantly reduced by the application of biochar [21]. There are many studies that reveal the properties of biochar such as carbon stability, high water holding capacity, soil regulation, contribution to nutrient cycle, and porosity [22, 23, 24]. It has been reported that the biochar, with its negative charge, ensures the retention of water and nutrients [25]. It has been reported that the biochar, which supports plant growth and development, also absorbs phytotoxic organic molecules in the soil [26] and suppresses soil-borne pathogens [27].

With this aspect, waste sludge has the quality to make important contributions to the faster and healthier production of outdoor ornamental plants, which are used in large quantities. Considering this situation, in this study, the effect of waste sludge with added biochar on the development of black locust [28], which is one of the plants frequently used in landscape designs and afforestation studies, was investigated.

MATERIAL AND METHOD

The study was carried out in an unheated greenhouse in Gaziosmanpaşa University Agricultural Application and Research Center. Seedlings of black locust (Robinia pseudoacacia) were used in the study. Acacia seeds were sown in peat on April 22, 2021. After approximately 45 days (June 4), the seedlings reaching 5-6 cm in size were surprised in 1 liter plastic pots. Three different mediums were used in the pots, which constituted the trial subjects. One of them, the control group, was composed of half soil and peat mixture (Control). The second medium was prepared by mixing 49% control medium, 49% waste sludge and 2% biochar (AC98). The third medium was prepared to be 98% sludge and 2% biochar (AC49).

The waste sludge used in the experiment was obtained from the domestic waste storage sludge of Tokat province. The heavy metal and some nutrient contents of the waste sludge used in the study are given in Table 1. The biochar used in the study was produced from biomass consisting of the waste of the bean plant. After the supplied raw materials were dried and milled, they were turned into biochar by slow pyrolysis at 500 oC in the biochar unit. The pyrolysis process was carried out in specially prepared chrome steel containers in the muffle furnace.

Table 1. *Heavy metal and nutrient content of the waste sludge used in the study (mg/kg)*

Nutritional Elements	Total concentration (mg/kg)	Concentration suitable for the plant and adequacy status for the plant (mg/kg)*
N	%0.88 (Sufficient)	
P	5732	73,4 (More)
K	4792	275 (Sufficient)
Mg	18375	1874 (More)
S	4529	2120 (Much)
Ca	58308	7845 (More)
Fe	38676	150 (Much)
Zn	189	86 (Much)
Mn	790	54,7 (Much)
Cu	161	32,2 (Much)
B	53	18,3 (More)
pH	6,70 (Nötr)	
Tuz (%)	0,306 (Medium Salty)	
Kireç (%)	6,1 (medium chalky)	
organic matter (%)	6,45 (Yüksek)	
Heavy metals		
Heavy metal	Total concentration (mg/kg)	Receivable concentration by the plant and the risk status for the plant (mg/kg)
Ni	83,5	7,12 (Risky)
Al	18545	9,86 (No risk)
Cd	1,0	0,12 (No risk)
Co	9,85	0,62 (Medium Risk)
Cr	104	0,08 (No risk)
Pb	47,7	0,64 (Medium risk)

** Sparks ve ark., 2020. Methods of soil analysis, part 3: Evaluated according to chemical methods [28]*

***86/278/EEC — It has been evaluated according to the criteria specified for soil and sludge in the Sewage Sludge Directive.*

The experiment was established with 4 replications according to the randomized plots design, with 5 plants (pot) in each replication. At the end of the growing season (November 8), plant height, stem diameter, number of lateral bough, root number and fresh root weight were measured. The stem diameter was measured 1 or 2 cm above the soil surface, where the stem part was considered to be the thickest. The number of roots was determined by counting the primary roots emerging from the pile root. The number of lateral bough was determined by counting the lateral shoots from the buds on the main stem. In order to determine the wet root weight, the plants were removed from the soil without damaging their roots, and the remaining soil particles were cleaned, washed and dried after they were weighed.

RESULTS AND DISCUSSION

Both media with the addition of sludge and biochar caused a significant increase in plant height compared to the media used as control. While the average height of acacia seedlings in the control medium consisting of soil and peat mixture was measured as 12.4 cm, the plants in AC98 medium reached 31.1 cm and the plants in AC49 medium reached 42.0 cm (Table 2). Hernandez-Apaolaza et al. [30], in their study with different ornamental plants, stated that when 30% waste sludge was added to the environment, there was a significant increase in plant growth. Dede [31] examined the effect of the media prepared by mixing hazelnut husk and waste sludge in different proportions on the development of acacia, thuja, ligusturum and lilac plants. reported that it can be used successfully. Demirkan et al. [32] determined in their study with ground azalea (Clarkia amoena) that waste sludge added to potting soil at the rate of 50% or 70% increased shoot growth.

Sapling diameter is one of the important quality criteria considered in the classification of seedlings. Both AC98 and AC49 media used in the study provided a significant increase in the diameter of acacia seedlings compared to the control. While the plants grown in the control medium had a diameter of 1.9 mm, the diameters of the plants in AC98 and AC49 media were 4.1 and 4.9 mm, respectively. The number of side branches, which is an important feature in terms of suitability for different uses, was also found to be higher in environments containing waste sludge and biochar mixture than in the control. While the plants formed an average of 3.9 side branches in the control environment, they formed 9.3 in the AC98 environment and 11.6 in the AC49 environment. It was determined that root growth was better in media containing sludge and biochar compared to control media. Root development was determined by measuring the number of lateral roots and wet root weights. The lateral root is one of the factors that will significantly affect the chance of a seedling after planting and its further development. In the study, both AC98 and AC49 media caused a significant increase in the number of lateral roots. Likewise, plants grown in a mixture of sludge and biochar had a significantly higher wet root weight than plants in the control treatment (Table 2). Oleszczuk et al. [26] reported in their experiments with Lepidium sativum that sludge from two different sources inhibited root growth, but when used together with biochar, the harmful effect of sludge decreased.

Table 2. *The effect of media containing different amounts of sludge on the development of acacia seedlings.*

Application	Plant Height	Stem Diameter	Number of side bough	Number of Lateral Roots	Fresh root weight
Control	12.4 c	1.9 b	3.9 c	5.1 b	3.8 b
W.Sludge (%49)	31.1 b	4.1 a	9.3 b	10.9 a	12.9 a
W.Sludge (%98)	42.0 a	4.9 a	11.6 a	10.9 a	12.0 a

Differences between means with different letters in the same column are significant according to the Duncan multiple comparison test($p<0.05$).

Consistent with the results obtained from this study, Mendez et al. [33] reported that the waste sludge and biochar added to the pot significantly increased plant growth in their study with lettuce. In many studies reporting that environments containing waste sludge increase plant growth, it has been stated that this is due to the fact that waste sludge is rich in nutrients, especially nitrogen [30]. On the other hand, in some studies, it has been reported that waste sludge has a phytotoxic effect and adversely affects plant growth, especially when used in high doses [17]. In this study, no inhibitory effect of sludge was observed even at high doses. This result may be due to the application of waste sludge together with biochar. As a matter of fact, there are research results stating that the inhibitory effect of sludge on plant growth can be reduced or eliminated by the application of biochar [26].

CONCLUSION

As a result, the findings show that the waste sludge has the potential to be used as potting soil in ornamental plant sapling cultivation. The use of waste sludge instead of the increased peat, which eliminates the cost, will make an important economic contribution to the growers. In addition, the damage to the environment caused by excavations made to obtain peat and waste sludge deposits will be reduced. Although positive results are obtained for acacia in this study, different results can be obtained depending on the source of the sludge, the plant species and the biochar ratio. Considering this situation, it is necessary to carry out studies to determine the appropriate waste sludge and biochar combination for plant species.

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