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Araştırma Makalesi/Research Article

The Effects of Cardboard for Enhancing Water Holding Capacity of Soil

Gürkan Alp Kağan Gürdil[1] Ivo Balada[2] Bahadır Demirel[1] Fuat Lüle[3*]

[1]Ondokuz Mayıs University, Faculty of Agriculture, Department of Agricultural Machines and Technologies Engineering, Samsun, Turkey
[2]Czech University of Life Sciences, Faculty of Engineering, Department of Machine Utilization, Prague, Czech Republic
[3*]Adıyaman University, Faculty of Technology, Department of Energy Systems Engineering, Adıyaman, Türkiye
*Sorumlu Yazar: flule@adiyaman.edu.tr

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Abstract

In this study, the effects of layers formed by the mixture of grass, woodchips, leaves and cardboard on water holding capacity were investigated. Four different mixtures for layers were prepared. The layer was established in 12 weeks as specified in ČSN EN 14045 standards. The moisture content of the mixtures ranged from 47% to 48% and the C:N ratio ranged from 30: 1 to 31: 1. The first mixture contained no cardboard, while the others contained different amount of cardboard. This type of work is not only important in terms of waste utilization, but also in terms of studies on erosion control by increasing the soil water holding capacity.
Keywords: Substrate, Infiltration, Cardboard, Erosion.

Toprak Su Tutma Kapasitesini Arttırılmasında Atık Kağıt Tabakası Takviyesinin Etkisi

Öz

Bu çalışmada çimen, odun talaşı, yapraklar ve mukavva kağıt atıklarından oluşan bir karışım ile oluşturulan katmanların toprak içerisinde su tutma kapasitesine olan etkileri araştırılmıştır. Dört farklı karışım hazırlanmıştır. Mukavvadan oluşan kağıt atıkları tabakası ČSN EN 14045 standartlarında belirtildiği şekilde 12 haftada oluşturulmuştur. Karışımların nem içeriği % 47 ile 48 arasında ve C:N oranı ise 30:1 ile 31:1 arasında değişmiştir. İlk karışımda mukavva yer almazken diğer karışımlarda farklı oranlarda mukavva bulunmaktadır. Bu tip çalışmalar sadece atık değerlendirilmesi açısından değil aynı zamanda toprak su tutma kapasitesini arttırarak erozyon kontrolü ile ilgili çalışmalar açısından da çok önemlidir.
Anahtar Kelimeler: Katman, Sızma, Mukavva, Erozyon.

Introduction

Infiltration characteristics of a soil surface are one of the important factors determining the potential threats to soil erosion. The infiltration capability of soil has an important role in soil protection against water erosion. Lack of infiltration properties of a soil surface restricts water input into the soil, which in combination with high intensity of rainfall can cause formation of surface drainage and associated negative erosion phenomenon. Infiltration is influenced by many factors, which can be categorized into 4 groups - soil properties (structure, texture, morphological, chemical and soil-moisture parameters), properties of the soil surface (incidence of soil crust), the method of land management and natural conditions (Lukas et al., 2007). Walter (2006) compared the effect of conventional tillage and minimum tillage of basic cereal growth on infiltration capacity of the soil. From the resulting measurements it can be unambiguously concluded that there are preferable infiltration capacity of the variant with conventional tillage compared to minimum tillage. The soil after plowing can soak about once as much of water as the soil treated minimization technologies.

What is important for maintaining the basic physical parameters or improvement of soil physical /chemical properties and increasing the biological activity is the sufficient supply of organic matter into the soil. Soil structure is one of the factors influencing infiltration (Truman and Franzmeier, 2006). The condition of soil structure together with soil cultivation is related to water retention in soil (Gajic et al., 2004). Organic matter in the soil transforms into humus which condition the soil fertility. Humus content affects the water retention in the soil and is the source of nutrients for plants (Badalíková and Cervinka, 2007). By delivering compost into the soil, the supply of organic material increases, and consequently its physical properties improve especially its density. According to many research outcomes, it was discovered that the infiltration capacity of the soil in the saturated environment linearly increased when delivering a mixture of compost and sand opposite to compost in sand-clay soil or to loamy soil without supplied compost (Thompson et al., 2008). Quatteraa et al. (2007) indicated that by supplying compost into the soil, its hydraulic properties were improved including infiltration.

Zeytin and Baran (2003) carried out pot experiments in the clay-loam and sand-clay soil in dry regions of Turkey. They kept adding hazelnuts nut shells into the soil in an amount of 0-8% wt. During two cycles (extractions after 45 and then 90 days) they observed the effect of this organic matter on the physical and hydro physical properties of soils. They demonstrated positive effect on the stability of soil aggregates in water and in the category of pores, also the saturated hydraulic conductivity and porosity increased. Similar laboratory experiments took place in Jordan. Al-Widyan et al. (2005) examined the effect of organic waste from olive-pressing in the clay loam soil (waste formed 2%, 4% and 8% mixture weight). It was found that after such application, the physical properties of selected soil significantly were improved, especially retention and infiltration capabilities. Evanylo and Sharon (2002) did not note any water retention capacity increase even after two years of the compost application. Pliva (2017) stated that biodegradable waste (BDW) is currently being processed mainly by classical methods of biodegradation: composting, incineration and anaerobic digestion. Another, yet less common methods include alcohol fermentation and pyrolysis.

The objective of the study is to determine the effect of application of cardboard substrate on infiltration capacity of soil primarily water retention.

Materials and Methods

An experiment involving the mixture of grass, woodchips, leaves and cardboard was conducted to assess the effect of application of mixture on infiltration capacity of soil primarily water retention (Figure 1). The research was carried out in belt heaps for 12 weeks.

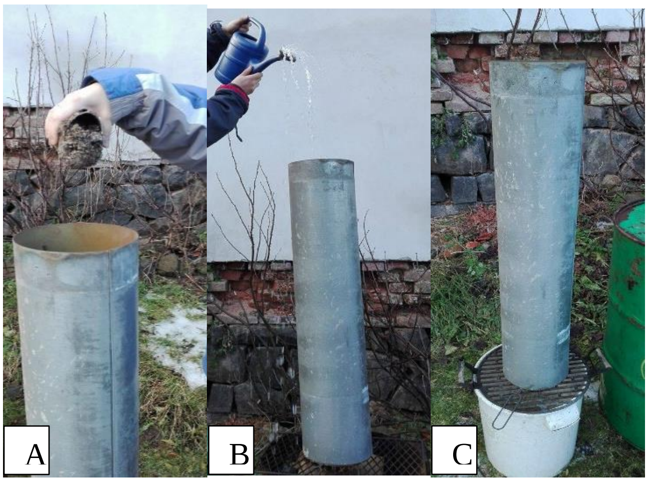

Figure 1. Research of infiltration of produced substrate containing cardboard and soil. A: Filling the tube by the substrate B:Rain simulation, C: Container for measuring outgoing water.

To determine the volumetric moisture content of the mixture, the following equation was used:

$$V_c = \frac{(m_1 * V_1) + (m_2 - V_2) + \cdots + (m_n * V_n)}{m_1 + m_2 + \cdots + m_n} \quad (1)$$

Where: V_c = volumetric moisture (%)

m_1, m_2, ... m_n: total mass of each raw material (kg)

V_1, V_2, ... V_n – the moisture content of each raw material (% wet basis, wb)

To determine the C:N ratio the following equation was used.

$$C:N = \frac{[C_1*m_1*(1-V_1)]+[C_2*m_2*(1-V_2)]+\cdots+[C_n*m_n*(1-V_n)]}{[N_1*m_1*(1-V_1]+[N_2*m_2*(1-V_2]+\cdots+[N_n*m_n*(1-V_n)]} \quad (2)$$

Where:

C_1, C_2…C_n: Carbon content of each raw material (%)
N_1, N…N_n: Nitrogen content of each raw material (%)

To investigate the substrate infiltration, the strainer tube was used (d = 200 mm) in which the substrate was inserted (V = 10 dm^3) and compacted (5 kg). Five liters of water was poured into the funnel for simulation of rainfall. The time to pass through the compacted mixture, the amount of water passed through the compacted mixture for hour, and the amount of water passed through the compacted mixture for 24 hours. The moisture content of the mixture was determined at 105 ^oC for 24 hours.

Results and Discussion

The amount of materials (grass, woodchips, cardboard, and leaves) used, moisture content and C:N ratios of the resulting mixture are presented in Table 1. The mixtures were prepared in late October, stored in closed containers and the experiment was carried out in January. The recorded ambient temperature was 5 °C.

Table 1. The amount of materials and characteristics of the mixtures

Mixture	Grass (g)	Woodchips (g)	Cardboard (g)	Leaves (g)	Moisture (%)	C:N
1	5000	2000	0	500	48	30:1
2	5000	2000	50	500	47	30:1
3	5000	2000	100	500	47	31:1
4	5000	2000	150	500	47	31:1

To determine the time to pass through the compacted mixtures, twelve consecutive measurements were performed. The average time to pass through the compacted mixtures were 37.1, 37.4, 37.3, and 37.2 for Mixture 1, 2, 3, and 4, respectively. It was detected that the addition of cardborad slightly increased the time to pass through the compacted mixtures.

To determine the amount of water passed through the compacted mixture for hour (mL), twelve consecutive measurements were performed. The average time for the amount of water passed through the compacted mixtures for hour were 3337.5, 3279.2, 3186.7, and 3120.8 mL for Mixture 1, 2, 3, and 4, respectively. Results showed that the amount of water passed through the compacted mixture for hour decreased with the increase of the amount of cardboard in the mixture. In other words, the mixtures with cardboard increased ability to retain water.

To determine the amount of water passed through the compacted mixture for 24 hours (mL), twelve consecutive measurements were performed. The average time for the amount of water passed through the compacted mixtures for 24 hours were 4835.0, 4795.8, 4783.3, and 4786.7 mL for Mixture 1, 2, 3, and 4, respectively. Results showed that the amount of water passed through the compacted mixture for 24 hours decreased with the increase of the amount of cardboard in the mixture. In other words, the mixtures with cardboard increased ability to retain water. The mixtures with cardboard yielded higher water retention compared to the mixture without cardboard. The mixtures 2, 3 and 4 were almost identical but different from the Mixture 1, which demonstrated the lowest water retention ability among all.

Table 2. The time to pass through the compacted mixtures (second)

Measurement	Mixture 1	Mixture 2	Mixture 3	Mixture 4
1	37.4	36.8	38.1	37.9
2	37.3	38.0	36.4	37.5
3	36.5	36.2	36.9	37.0
4	36.3	37.5	38.3	36.9
5	37.6	37.3	38.0	36.2
6	37.7	37.1	37.0	36.1
7	37.2	37.3	37.7	37.3
8	36.2	36.2	37.3	37.1
9	38.4	36.8	36.6	39.0
10	38.7	38.4	36.9	36.4
11	36.2	38.4	37.6	36.9
12	36.2	38.5	37.3	38.5
Average	37.1	37.4	37.3	37.2

Table 3. The amount of water passed through the compacted mixture for hour (mL)

Measurement	Mixture 1	Mixture 2	Mixture 3	Mixture 4
1	3340	3290	3250	3150
2	3350	3280	3280	3140
3	3310	3270	3240	3120
4	3300	3320	3170	3170
5	3320	3260	3130	3090
6	3350	3210	3130	3080
7	3340	3230	3210	3180
8	3330	3280	3220	3160
9	3380	3350	3130	3090
10	3350	3280	3110	3080
11	3380	3300	3120	3080
12	3300	3280	3250	3110
Average	3337.5	3279.2	3186.7	3120.8

Table 4. The amount of water passed through the compacted mixture for 24 hour (mL)

Measurement	Mixture 1	Mixture 2	Mixture 3	Mixture 4
1	4850	4840	4760	4730
2	4830	4750	4780	4790
3	4790	4790	4810	4720
4	4860	4780	4790	4850
5	4820	4820	4720	4860
6	4850	4880	4830	4810
7	4760	4790	4760	4720
8	4950	4760	4720	4890
9	4890	4750	4780	4910
10	4790	4810	4850	4680
11	4820	4770	4910	4770
12	4810	4810	4690	4710
Average	4835.0	4795.8	4783.3	4786.7

Conclusion

Based on the first part of the measurement it can be concluded that the addition of cardboard slightly increased the time to pass through the compacted mixtures. Results showed that the amount of water passed through the compacted mixture for hour decreased with the increase of the amount of cardboard in the mixture. In other words, the mixtures with cardboard increased ability to retain water. In the same manner, the amount of water passed through the compacted mixture for 24 hours decreased with the increase of the amount of cardboard in the mixture. Thus, the mixtures with cardboard again increased ability to retain water. The mixtures with cardboard yielded higher water retention compared to the mixture without cardboard. The mixtures 2, 3 and 4 were almost identical but different from the Mixture 1, which demonstrated the lowest water retention ability among all. In conclusion, the results show us that the cardboard really has an impact on water retention in the soil. So, this waste material can be preferred to be used as soil additive material.

Turkey has a great potential of waste and residue especially those of organic from agricultural production. Unfortunately, we are not managing our wastes as used to be in developed countries. This idle potential can promote economic improvement and employee opportunities in the developing countries. Therefore, waste management either for energy or for soil improvement is very important for sustainable development. Besides, it's environmentally friendly and useful for erosion control, as well.

References

Al-Widyan, M.I., Al-Abed, N., Al-Jalil, H., 2005. Effect of composted olive cake on soil physical properties. Communications in Soil Science and Plant Analysis. 36 (9-10): 1199-1212.

Badalíková, B., Červinka, J., 2007. Humus content and its quality under different soil tillage systems in sugar beet and their influence on the yield of this crop. Humic Substances in Ecosystems 7, Torun, Poland. pp. 31-38.

Evanylo, G., Sherony, C., 2002. Agronomical and environmental effects of compost use for sustainable vegetable production. Composting and Compost Utilitation, Int. Symposium, 6-8, Columbus, Ohio, USA

Gajic, B., Durovic, N., Pocuca, V., 2004. Effect of irrigation on soil structure and water stability of aggregates. Zemljiste i biljka (Serbia and Montenegro). 53 (1): 45-54.

Lukas, V., Štibinger, J., Procházková, B., Neudert, L., 2007. Vliv rozdílného způsobu zpracování půdy na infiltrační vlastnosti půdního povrchu. In: Sborník odpobrných příspěvků a sdělení. MZLU pěstitelům 2007" Brno: AF MZLU v Brně, pp. 48-51. ISBN: 978-80-7375-058-9.

Plíva, P., 2017. Areas suitable for composting in the belt heaps. Biom.cz [online]. 2010-08-11. Dostupné z, URL: <http://biom.cz/cz/odborne-clanky/plochy-vhodne-pro-kompostovani-v-pasovych-hromadach>. ISSN: 1801-2655. (Erişim tarihi: 26 Mart 2017).

Quattaraa, K., Quttaraa, B., Nybergh, G., Sédogoa, M. P., Malmerb, A., 2007. Ploughing frequency and compost application effects on soil infiltrability in a cotton-maize (*Gossypium hirsutum-Zea mays* L.) rotation systém on a Feric Luvisol and a Ferric Lixisol in Burkina Faso. Soil & Tillage Research. 95 (1-2): 288-297.

Thompson, A.M., Paul, A.C., Balster, N.J., 2008. Physical and hydraulic properties of engineered soil media for bioretention basins. Transaction of the asable. 51 (2): 499-514.

Truman, C.C., Franzmeier, D.P., 2006. Structure, pedological concepts, and water flow. Rattan, L. (Eds). Encyclopedia of Soil Science, Soil Conservation Technology; Soil Science, Volume 2, Taylor&Francis Group is the Academic Division of Informa plc., New York. pp. 1698-1703

Walter, R., 2006. Infiltration Properties. Encyclopedia of Soil Science, Crop Science, Volume 1, Taylor&Francis Group is the Academic Division of Informa plc., New York. pp. 871-874.

Zeytin, S., Baran, A., 2003. Influence of Composted Hazelnut Husk on some Physical Properties of Soil. Bioresource Technology. 8 (3): 241-244.