Impact of brown coal and biochar fertilizers on spring wheat productivity in the pot experiment

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Nowadays, there is clear evidence of a decline in the organic carbon contents in many soils as a consequence of the intensification of agriculture over past years (Sleutel et al., 2003; Jones et al. 2005). Organic carbon is a major component of soil organic matter that plays an important role in the formation of stable aggregates of the soil structure (Jones et al. 2005). Moreover, soil organic matter acts as a storehouse for nutrients, is a source of soil fertility, improves infiltration rates, increases the storage capacity for water, serves as a buffer against changes in soil reaction (pH), and acts as an energy source for soil microorganisms (Jones et al. 2005). Thus, improving nutrient use efficiency (NUE) and reversing the loss of soil organic matter are major global challenges. One possibility to improve the soil properties can be to use soil improvers, organic and organo-mineral fertilizers.

Brown coal that is characterized by very low heating value can be used as a component of organo-mineral fertilizers. It contains organic matter in a complex, porous, three-dimensional network, which varies depending on deposit location. Humic acids are very important components of brown coal and can account 10-80% of its organic matter (Allard et al., 2006). They contain many functional chemical groups that help to physically modify and improve the chemical properties of the soil and biologically stimulate plant growth (Ouni et al. 2014). Thus, humic acid products mainly as plant growth enhancers and as ingredients of fertilizer products are widely distributed throughout the world.

Biochar is the residue of pyrolysis and is often used to pre-dried biomass feedstock or is sold as charcoal briquettes. A novel approach is to explore the value of this by-product for coating purposes of the mineral fertilizers. According to Lehmann two aspects of biochar make it valuable for the purpose of adding this material to soil: (i) high stability against decay and (ii) its superior ability to retain nutrients as compared to other forms of soil organic matter. Thus, three environmental benefits arise from these properties: (i) mitigation of climate change, (ii) improvement of soils, and (iii) reduction of environmental pollution (Lehmann et al. 2007).

Biochar created from waste biomass (e.i., waste wood or plant material after extraction) by pyrolysis technique (Kwapinski et al., 2010; Azis et al., 2015) can contain certain amounts of extractable humic-like and fulvic-like substances (Lin et al., 2012). A number of studies (Rose et al., 2016; Manikandan et al., 2013; Saha et al. 2017) show that biochars can reduce nitrate and ammonium leaching from applied nitrogen fertilizers, but the effectiveness depends on the chemical characteristics of biochars and their rate of application. In agriculture, over-fertilization results in a decrease of fertilizer use efficiency and leads to environmental and ecological problems. Previous studies (Large, 1954; Lehmann et al., 2017) indicated that biochar can be used as the component of coating materials for fertilizers and its addition increases the degradability of polymer film, which is attributed to the fact that biochar could adsorb soil microorganisms.

The present work attempts to develop a method for the preparation of novel organo-mineral fertilizers with the use of brown coal and biochars as organic additives. Brown coal together with inorganic raw materials, which are used in urea superphosphate production, were granulated using two granulation methods: pan granulation and high shear granulation. Moreover, the coating process of urea superphosphate granules using three types of biochars was studied. The physico-chemical properties of the obtained organo-mineral fertilizers were investigated. The effect of brown coal based fertilizers and biochar coated fertilizers on spring wheat in pot experiments was evaluated.

Pot experiments

In 2018 and 2019, a greenhouse experiment was conducted to determine the effects of brown coal based fertilizers and biochar coated fertilisers compared to control, commercial fertilizer, and urea superphosphate (USP) on grain yield per plant, spike number per plant, and plant height of spring wheat cv. Varius. Wheat was grown in pots containing 7 kg of soil. Fertilizers were applied at a sowing by mixing fertilizer granules with soil. Fertilizer treatments were as follows: T_0 – control: 2.36 g MAP (NP 10-55), 3.7 g K_2SO_4, 10.4 g $(NH_4)_2SO_4$; T_1 – 11.48 g urea superphosphate (NP 21 – 9), 0.54 g KH_2PO_4, 3.35 g K_2SO_4; T_2 – 5.88 g commercial fertilizer (NPK(S) 6-12-34-(10), 1.09 g MAP, 9.33 g $(NH_4)SO_4$; T_3 – 25.06 g brown coal based fertilizer with ammonia (BC+USP+NH_3), 0.65 g KH_2PO_4, 3.29 g K_2SO_4; T_4 – 29.06 g brown coal based fertilizer with magnesite (BC+USP+M), 0.49 g KH_2PO_4, 3.39 g K_2SO_4; T_5 – 13.50 g medicinal plant biomass biochar coated urea superphosphate, 0.54 g KH_2PO_4, 3.35 g K_2SO_4; T_6 – 13.50 g energy-crop willow biochar coated urea superphosphate, 0.54 g KH_2PO_4, 3.35 g K_2SO_4; and T_7 – 13.50 g wood chips biochar coated urea superphosphate, 0.54 g KH_2PO_4, 3.35 g K_2SO_4. Each treatment has received the same dose of NPK (2.4 g N, 1.3 g P_2O_5, 2 g K_2O per a pot). Plants were watered to 60% field capacity. After harvest time determined the yield and yield components of spring wheat.

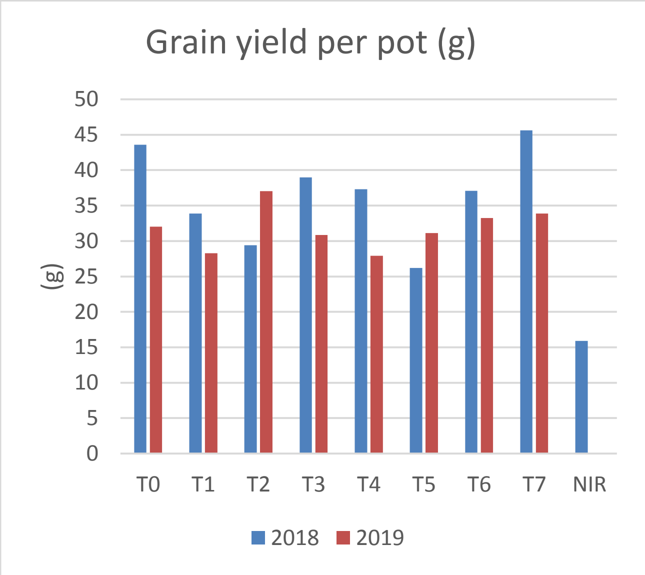

Figure 1. Grain yield of spring wheat in 2018 and 2019

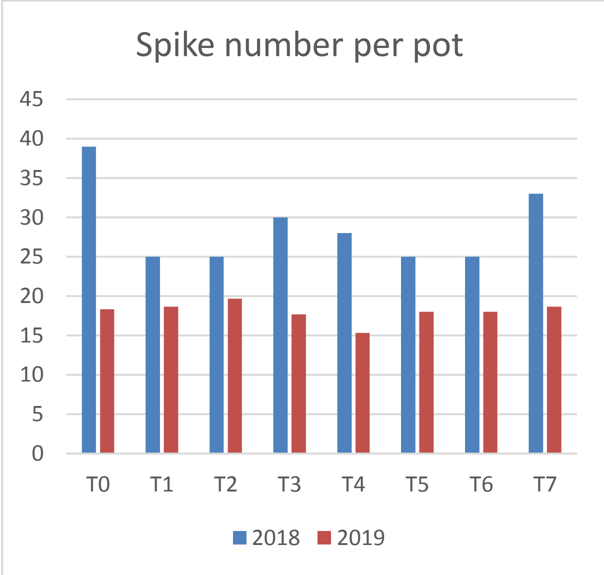

Figure 2. Number per spike of spring wheat in 2018 and 2019

Conclusions

Results from pot experiments in greenhouse showed that spring wheat responded positively to soil application of the brown coal based fertilizers and biochar coated fertilizers. The yielding results were statistically significant only in the first year of research, however, there was a tendency to positively influence both the addition of biochar and brown coal on yielding and the number per spike.

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