THE EFFECT OF CROP SPECIES AND N FERTILIZATION ON SOIL ORGANIC MATTER

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Abstract: Soil organic matter (SOM) is one of the most influential properties regarding soil fertility. Various crop species and varieties, as well as plant nutrition application may have an impact on the amount of soil organic matter. In a small plot field experiments the most characteristic agronomic impacts (biological bases, production sites, plant nutrition and crop year effects) influencing the efficiency of carbon sequestration of two major crop plants: - wheat Triticum aestivum and maize Zea mays have been studied. The aim of the research was to observe, identify and quantify agronomic impacts and their interactions that may have an influence on organic matter formation and so on carbon sequestration. Crop variety and plant nutrition proved to be the most important factors influencing organic matter production. Interactions have been found between crop plant genotypes and N levels applied.

Keywords: carbon sequestration, maize, winter wheat, plant nutrition, soil organic matter

Introduction

Climate change is one of the major issues of mankind. There is a continuous rise in temperature escorted by the increasing frequencies of weather anomalies. In case of: Hungary two facts can be observed; the ascending levels of temperature rise, with a magnitude of 1 °C and the annual precipitation decrease with increasing territorial and temporal variabilities Human activities are significantly altering the natural carbon cycle (Lal 2004). Long-term rise in atmospheric CO_2 highlights crop production regarding both adaptation and mitigation (Jolánkai et al 2005). The negative effects of climate change can be limited by changes in crops and crop varieties, improved water-management and irrigation systems, adapted plant nutrition, protection and tillage practices, and better watershed management and land-use planning (Berzsenyi and Lap 2005; Márton 2005; Sárvári 2005, Pepó 2010). The global potential of carbon sequestration through crop production, land use and soil management practices may offset one-fourth to one-third of the annual increase in atmospheric CO_2, a most endangering GHG (Lawlor 2005). Soil organic matter (SOM) is a result of carbon sequestration based on the photosynthetic activities of plants. Any organic matter manufactured by plants is originated from atmospheric CO_2. Plants (crop plants and natural vegetation) capture C and produce vegetative material, a biomass that comprises yield and by products. The prior one is regularly taken away from the crop site however the latter remains there providing a resource for SOM formation. Recent land use technologies aim the removal of plant residues in favour of using them as biofuels and so endangering soil remediation. The pool of organic C exists in dynamic equilibrium between gains and losses; soil may therefore serve as either a sink or source of C, through sequestration or greenhouse gas emissions respectively, depending on exogenous factors (Lal 2004). As biomass material undergoes decomposition, some microbial resistant compounds are formed. These include modified lignins, oils, fats and waxes. Also, some new compounds are synthesized, like polysaccharides and polyuronids. These materials form the basis for humus (Brady 1984).

When plant residues are returned to the soil, various organic compounds undergo decomposition. Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler

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organic and inorganic molecules (Juma, 1999). The continual addition of decaying plant residues to the soil surface contributes to the biological activity and the carbon cycling process in the soil. Breakdown of soil organic matter and root growth and decay also contribute to these processes. Carbon cycling is the continuous transformation of organic and inorganic carbon compounds by plants and micro- and macro-organisms between the soil, plants and the atmosphere. Decomposition of organic matter is largely a biological process that occurs naturally and determined by three factors: soil organisms, the physical environment and the quality of the organic matter (Brussaard, 2012). Soil organic carbon (SOM) contains approximately 58 % C, therefore a factor of 1.72 can be used to convert organic carbon (OC) to SOM. There is more inorganic C in calcareous soils in general (Edwards et al. 1999).

Materials and methods

The Szent István University Crop Production Institute has recently started a new research programme on exploring the most characteristic agronomic impacts (biological bases, production sites, plant nutrition and crop year effects) influencing the efficiency of carbon sequestration of two major crop plants; wheat *Triticum aestivum* L. and maize *Zea mays* L.: The aim of the research is to observe, identify and quantify agronomic impacts and their interactions that may have an influence on organic matter formation and so on carbon sequestration. The trials were set up at the Nagygombos experimental site with a parallel version sown at Szárítópuszta in a three years consecutive series between 2007-2010. Six Martonvásár high starch maize hybrids were used in the trials representing different genotypes (Mv

Table 1. Carbon sequestration of maize (*Zea mays* L.) hybrids, Nagygombos

	Hybrid	Grain yield kg/m^2	Plant dry matter kg/m^2	AG biomass C content estimate, kg
0 N	Mv-251	0.48	0.34	0.33
	Maraton	0.86	0.61	0.59
	Norma	0.38	0.37	0.30
	Gazda	0.69	0.48	0.23
	Mv-454	0.70	0.46	0.45
	Mv-500	0.56	0.42	0.39
80 N	Mv-251	0.79	0.71	0.60
	Maraton	1.06	0.90	0.78
	Norma	0.79	0.67	0.55
	Gazda	0.76	0.77	0.61
	Mv-454	0.78	0.58	0.54
	Mv-500	1.36	1.04	0.96
120N	Mv-251	0.83	0.75	0.63
	Maraton	0.79	0.63	0.57
	Norma	0.80	0.78	0.63
	Gazda	1.14	1.17	0.92
	Mv-454	1.17	1.13	0.92
	Mv-500	1.43	0.62	0.82

C value $LSD_{0.05}$ – Hybrid:0.112; Nitrogen: 0.048

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250, Maraton, Norma, Gazda, Mv 454 and Mv 500) and a broad range of maturity groups (FAO 200-500). Also five wheat varieties (Mv Magdaléna, Alföld 90, Mv Suba, Mv Csárdás, Mv Toborzó) were exposed to ascending levels of nitrogen applications. Experimental double row 10 m^2 plots were designed in randomized blocks for maize, and full 10 m^2 plots in split-plot arrangement for wheat crop were sown both with four replications. The nitrogen applications were as follows: N 0, N 80 kg/ha, and N 120 kg/ha respectively. Basic plant nutrition and plant protection treatments were identical and appropriate regarding the agronomic requirements of the experimental field and providing ceteris paribus conditions to the trial.

Phenological, herbological, phytosanitary observations and yield characteristics have been evaluated. Yield samples were analysed at the Research Laboratory of the SIU Crop Production Institute, RET Regional Knowledge Centre and the NÉBIH National Food Chain Safety Office laboratories according to Hungarian standards for quality features (protein, carbohydrate, starch, cellulose, fat, ash etc). Carbon sequestration values were estimated on the basis of grain yield and total above ground biomass dry matter production. Statistical analyses were done by Microsoft Office 2003 programmes. The paper presents three years average data of the experiment

Results and discussion

The results obtained suggest that crop variety and plant nutrition proved to be the most important factors influencing organic matter production. Interactions have been found between crop plant genotypes and N levels applied.

Data of the maize trial are presented by Table 1. Grain yield, plant dry matter and carbon content values are presented by each hybrid in N application variants. Both hybrids and nitrogen applications proved to be significant concerning C values. Plant nutrition proved to be a strong factor in comparison with hybrid effects. However maize hybrids have shown differences as well. In general the

Table 2. Carbon sequestration of winter wheat (*Triticum aestivum* L.) varieties, Nagygombos

	Hybrid	Grain yield kg/m^2	Plant dry matter kg/m^2	AG biomass C content estimate, kg
0 N	Mv Magdaléna	0.54	0.59	0.45
	Alföld 90	0.68	0.75	0.55
	Mv Suba	0.76	0.83	0.62
	Mv Csárdás	0.69	0.76	0.58
	Mv Toborzó	0.70	0.75	0.58
80 N	Mv Magdaléna	0.74	0.85	0.64
	Alföld 90	0.71	0.77	0.59
	Mv Suba	0.80	0.89	0.68
	Mv Csárdás	0.81	0.88	0.65
	Mv Toborzó	0.84	0.91	0.69
120 N	Mv Magdaléna	0.78	0.85	0.65
	Alföld 90	0.84	0.84	0.67
	Mv Suba	0.75	0.82	0.63
	Mv Csárdás	0.79	0.75	0.62
	Mv Toborzó	0.80	0.86	0.66

C value $LSD_{0.05}$ – Variety: 0.092; Nitrogen: 0.067

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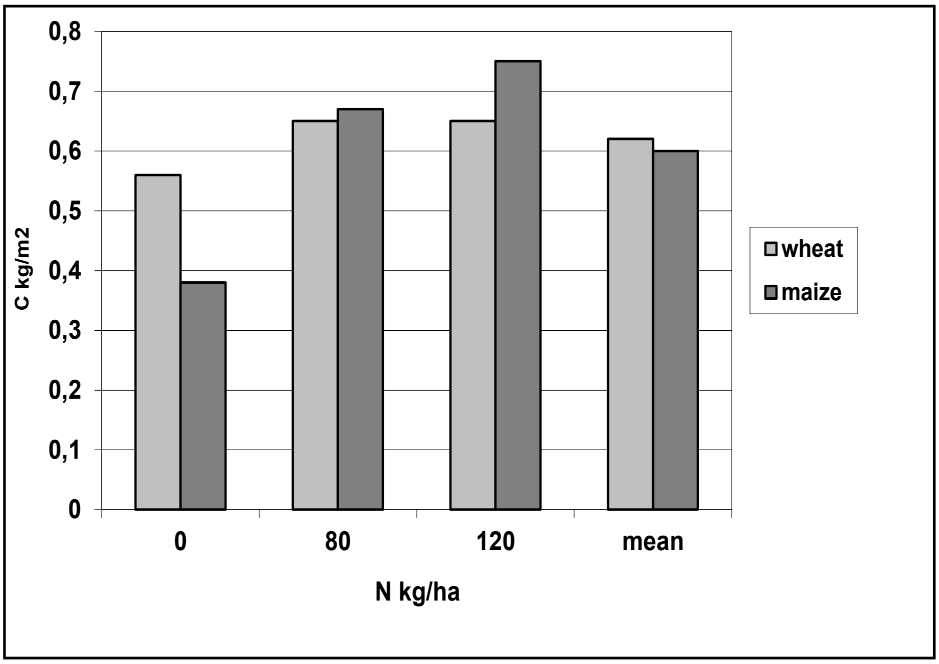
Figure 1. Nitrogen impact on carbon sequestration of grain crops, Nagygombos



results suggest, that late maturity hybrids had higher carbon sequestration abilities, but this difference was influenced by the nutritional levels, too.

Experimental results of winter wheat trials are summarised in Table 2. Identical to the other experiment, grain yield, plant dry matter and carbon content values are presented by each wheat variety in respective N applications. Compared to the maize trial data, wheat varieties were found to have less consequent specificity regarding C content, however N applications had really strong interactions with varieties. The difference between untreated control and N applications proved to be significant in all varieties, however 80 versus 120 kg/ha treatments had less impact on that.

Figure 1. presents a graphical evidence of carbon sequestration performance differences of the two crops examined.

Figure 2. Carbon content of above ground biomass, straw/stem residues, and the possibly derived soil organic matter, kg/m^2

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The photosynthetic activities of plants determine soil organic matter (SOM). The organic matter manufactured by plants is originated from atmospheric CO_2. All plants, like maize and wheat in this study capture C and produce vegetative material, a biomass that comprises yield and by products. Figure 2 provides information on the magnitude of carbon sequestration in relation with the crop species studied. Wheat and maize, regardless to the yield differences of the crops produced almost identical amount of C within the above ground biomass. Wheat straw had a higher and maize stalks had less C content, and as a result of that expected SOM has shown differences suggesting a better performance of wheat by products.

Conclusions

Wheat in general was more stable regarding C values, however maize crop was proved to be more efficient concerning ascending N doses. All together in mean values there was no measurable difference between the two crop species. Crop variety and plant nutrition proved to be the most important factors influencing organic matter production. Interactions have been found between crop plant genotypes and N levels applied. Atmospheric C budget can be balanced by photosynthetic dry matter production of natural vegetation and agricultural crops. The latter can be influenced by agronomic applications. Soil organic matter is based on the sequestration of C derived from plant residues. Wheat represents a better source for organic carbon in comparison with maize crop.

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