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EFFECT OF LAND USE ON SOIL AGGREGATE STABILITY AT BAKRAJOW SITE, SULAIMANI, KURDISTAN REGION, IRAQ

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Abstract

A field study was conducted to determine the effects of different plant coverage including broad bean (*Vicia faba*), wheat (*Triticum aestivum*), and natural grasses, and bare soil on aggregate stability and soil organic matter (SOM) content at two depths: 0 – 15 cm and 15 – 30 cm. Aggregate stability was measured on soils that contained aggregates smaller than 8 mm using a series of sieves (4, 2, 1, 0.5, 0.25 mm). Mean weight diameters (MWD) ranged from 0.413 to 0.748 mm for soils cultivated with broad bean after 3 and 6 months, respectively. Organic matter contents ranged from 9.7 to 23.0 g kg^{-1} after 6 months and the highest value was found in soils under natural grasses while the lowest value was found in soil cultivated with wheat. Statistical analyses showed that there were significant positive relationships ($P< 0.05$) between SOM content and MWD for each soil depth. The results indicated that the presence of legume and mixed grasses improved soil aggregation and increased organic carbon content in the soil studied.

Key words: Aggregate stability; mean weight diameter; organic matter content.

Introduction

Soil aggregates are groups of soil particles that bind to each other more strongly than to adjacent particles (Nimmo and Perkins, 2002). Aggregate stability refers to the ability of soil aggregates to resist disintegration when disruptive forces associated with tillage and water or wind erosion are applied (Rohoskova and Valla, 2004). Aggregates form as a product of complex interactions among biological, chemical, and physical processes in the soil (Kyung *et al.*, 2010).

The stability of these soil aggregates is an important soil property as it directly and indirectly influences other physical and chemical properties of the soil and can be an indicator of soil degradation (Cerda, 2000). Land use and management, can also impact the formation of soil aggregates and the storage of SOM (Carter, 2002). Aggregate stability occurs when the bonds holding the aggregates together are strong enough to resist stresses that would otherwise cause their disintegration (e.g., tillage, swelling and shrinking processes, kinetic energy of raindrops (Rohoskova and Valla, 2004). Williams and Petticrew (2009) reported that the aggregate stability was greater in the soils that had been fertilized using SOM compared to soils cultivated using inorganic fertilizers only.

Gros *et al*. (2004) showed that, plants can improve soil aggregate stability in undeveloped soil within a very short time, even only a few months. Han *et al*. (2007) reported that the content of water stable aggregates was higher in orchard than in annual upland crops. This is presumably in reverse order of cultivating intensity such as tillage. Catrin *et al*. (2009) found that revegetation measures increased soil aggregate stability by substantially accelerating vegetation development and by promoting soil formation processes such as accumulation of fine soil particles, organic matter and mycorrhizal gules. Cerda (1998) showed that another influence of vegetation is from the production of litter and organic matter. The greater the organic matter incorporated into the soil, the more stable the aggregates.

Plant composition and distribution control the distribution of OM in soil. The horizontal and depth distribution of roots, the distribution of plants across the landscape, and the susceptibility of roots to decay vary among species. Vegetation Management affects the plant community. Changes in the composition, distribution, and productivity of plant species affect aggregation-related soil properties, including aggregate stability, the amount and type of OM in the soil, and the composition and size of the soil biotic community. The amount of plant cover and size of bare patches also are important (USDA, 2013).

The aim of this investigation was to evaluate the role of vegetative cover or lack thereof on aggregate stability, mean weight diameter and organic matter content in a soils from Bakjrow area in Sulaimani city in the Kurdistan Region of Iraq.

Materials and Methods

This study was carried out in an experimental farm managed by the College of Agricultural Sciences, at the University of Sulaimani, Bakrajow campus located 8 km southeast of Sulaimani City. The texture of the soil was silty clay.

Soil samples were collected from the A horizon at two depths (0 – 15 and 15 – 30 cm) in plots cultivated with broad bean *Vicia faba*, wheat *Triticum aestivum*, and natural grasses and plot area was 16m^2 (listed in Table 1). In addition, bare soils (control) were sampled. The samples were collected in triplicate after 3 months and after 6 months of growth, air-dried, and passed through an 8-mm sieve. Soil organic matter content was determined on the fine-earth fraction ($\leq$ 2 mm) using the Walkley and Black method as described by Richards (1954). Wet aggregate stability was determined following Youker (1965) (Table 2).

Results and Discussion

Effect of vegetative cover and depth on soil organic matter

The effect of vegetative cover on SOM after 3 and 6 months of growth are shown in Figs. 1and 2. The highest concentration of SOM was observed in the soil cultivated with a mixture of natural grasses. Values of organic matter were much higher after 6 months than after 3 months of plant growth. The values of SOM under natural grasses were 17.9 and 23.0 g $kg^{-1}$for 3 and 6 months, respectively. This may be due to the presence of various legumes, which can fix atmospheric nitrogen with higher root intensity (Vainds and Teuber, 1985). The lowest SOM content was found in soils that had been cultivated with wheat and the values were 9.0 and 9.7 g kg^{-1} for 3 and 6 months of plant growth, respectively. This may be due to the low input of organic residues from the wheat crops.

The results show that the concentration of SOM in the surface layer (0 -15 cm) was much higher than the subsurface layer (15-30 cm). This may because of the high input of organic residues in the surface layer than the subsurface layer due to higher root intensity in the surface.

Effect of vegetative cover and depth on soil aggregate stability

Cultivation of different plants had a considerable effect on aggregate stability. The results showed that mean weight diameter (MWD) was higher for the soil that had been cultivated with different plants compared to bare soil (Table 2). This may be due to the activity of the roots especially the root exudates, for example, different organic acids, and microorganism activity in the rhizosphere. This may lead to aggregation of the soil particles. In addition, the organic molecules those selves may coat the mineral particles which can lead to an increase in aggregate stability (Oades and Tisdell, 1982). Also, soil surfaces covered by vegetation may protect the aggregates from disintegration by the rain drops impact or irrigation. The dispersion of soil particles by these processes can lead to an increase in erosion. Catrin *et al*. (2009) reported that for a re-vegetated site, the soil aggregate stability was significantly higher than the control site used in that study.

The effect of vegetative cover on MWD is shown in Figs. 3 and 4. Generally, the results indicated that the MWD was higher after 6 months than 3 months for all treatments. The soil cultivated with legumes had a higher MWD value than the other treatments for both 3 and 6 months of plant growth. The values of the MWD for the soil cultivated with legumes were 0.413 and 0.748 after 3 and 6 months of plant growth, respectively, at 0–15 cm. The lowest MWD values were found in soils cultivated with a mixture of natural grasses and values were 0.301mm after 3 months of plant growth and 0.328 mm after 6 months of plant growth for bare soil, respectively, in the surface layer. Similarly, the highest value for the MWD was found in the surface layer and this may be due to the high root intensity with increasing SOM at the surface layer compared to the subsurface layer. Valerie et al. (2002) showed that plant species did not affect aggregate stability in the subsurface (15–45 cm) where soil biological activity is generally decreased.

Regression analyses showed that there were significant positive relationships ($P< 0.05$) between SOM content and MWD regards of the soil depth. The effect of SOM on MWD was more pronounced after 6 months than 3 months of plant growth. The correlation coefficient ($R = 0.677$) was higher for the 6 month plant growth period than the 3 month ($R = 0.454$). This may be due to the association of organic matter with minerals protecting it from decomposition by microorganisms.

Conclusion

The highest concentration of SOM was found in surface soil layers (0 – 15 cm) that were cultivated with a mixture of native grasses at 6 months of plant growth. Cultivation with different plants had a large effect on aggregate stability. The highest values of organic carbon were found in soil cultivated with broad bean, which, through a process of symbiosis with the rhizobium, encourage the fixing of atmospheric nitrogen. Soil physical properties such as soil aggregate stability, which affects soil productivity, were also improved. The improvement of soil aggregates by cultivation with crops lead to carbon sequestration in soils.

Table 1 : Grasses species present in the natural grasses plot.

Family scientific name	Plant scientific name
Poaceae	*Imparata cylindrica*
	Lolium rigidum
	Echinochlea crus–galli
	Lolium temulentum
	Avena fatua
	Phalaris minor
	Sorghum halepens
	Cynodon dactylon
Asteracea	*Carthamus oxyacanthus*
	Silybam marianum
	Xanthium strumarium
	Sonchus oleraceus
	Cichorim intybus
Fabacea	*Vicia angustifolia*
	Medicago hispia
	Glycyrrhiza glabra
	Lathyrus annus
Brassicacea	*Sinapis arvensis*
	Cardaria draba

Table 2 : Soil organic matter (SOM) content and aggregate mean weight diameter (MWD) after wet sieving the different treatments.

Treatments	Depth, cm	SOM after 3 months, g kg^{-1}	MWD after 3 months, mm	OM after 6 months, g kg^{-1}	MWD after 6 months, mm
Bare soil	0 – 15	16.6	0.375	17.9	0.328
	15 – 30	11.0	0.301	13.1	0.302
Wheat	0 – 15	9.0	0.397	9.7	0.348
	15 – 30	5.5	0.328	4.8	0.338
Broad bean	0 – 15	15.5	0.413	15.4	0.748
	15 – 30	14.5	0.277	15.2	0.464
Natural grasses	0 – 15	17.9	0.301	23.0	0.432
	15 - 30	11.4	0.227	11.7	0.422

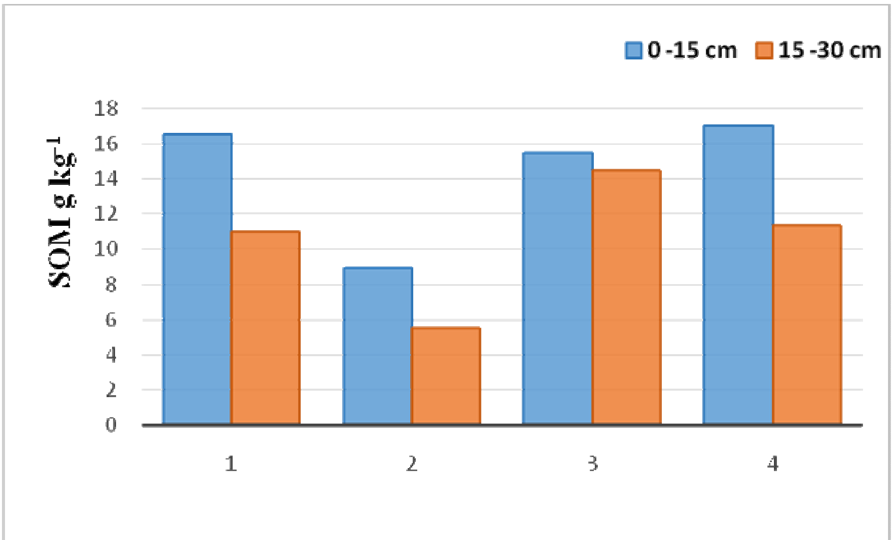

Fig. 1 : Effect of different vegetative cover (1 = bare soil, 2 = wheat, 3 = broad bean, and 4 = natural grasses) on soil organic matter (SOM) after 3 months.

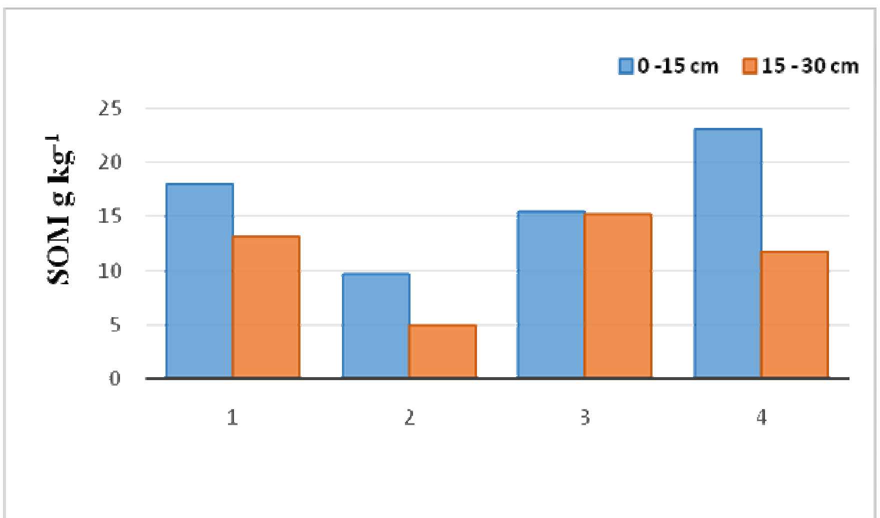

Fig. 2 : Effect of different vegetative cover (1 = bare soil, 2 = wheat, 3 = broad bean, and 4 = natural grasses) on SOM after 6 months.

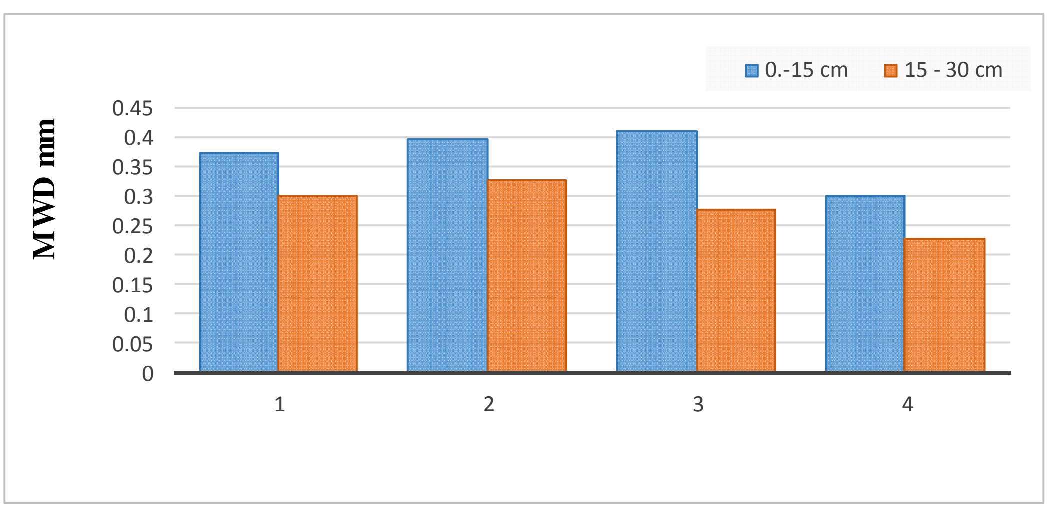

Fig. 3 : Effect of vegetative cover (1 = bare soil, 2 = wheat, 3 = broad bean, and 4 = natural grasses) on mean weight diameter (MWD) after 3 months.

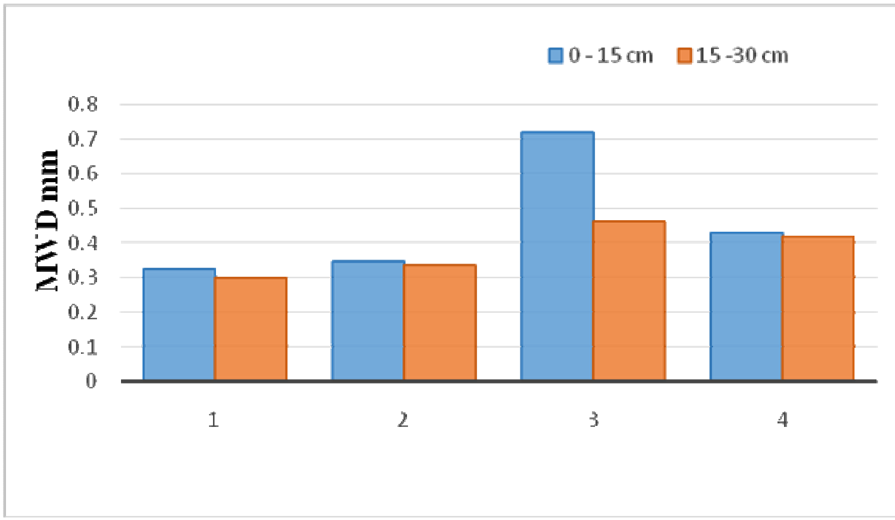

Fig. 4: Effect of vegetative cover (1 = bare soil, 2 = wheat, 3 = broad bean, and 4 = natural grasses) on MWD after 6 months.

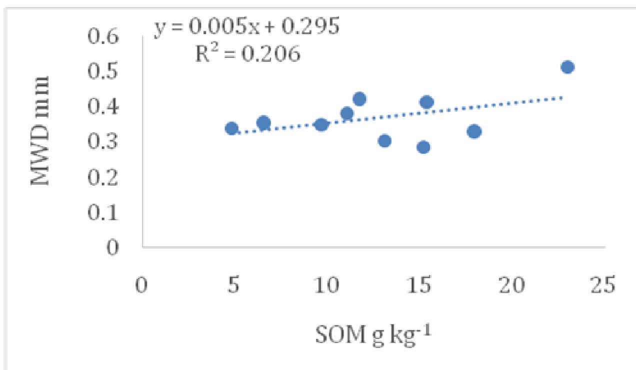

Fig. 5 : Relationship between SOM content and aggregate MWD after 3 months of plant growth.

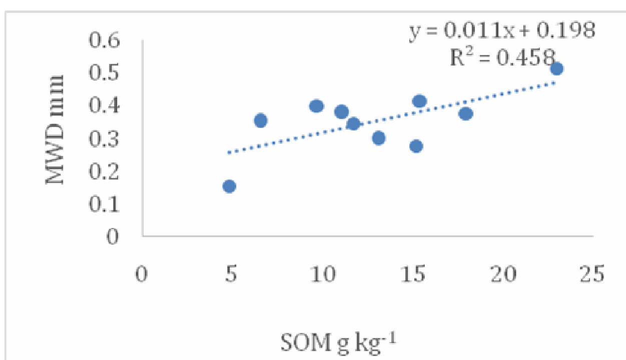

Fig. 6 : Relationship between SOM content and aggregate MWD after 6 months of plant growth.

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