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Soil aggregate size distribution and stability of farmland as affected by dry and wet sieving methods

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Abstract

Soil aggregate has a vital role in improving soil structure and enhancing soil aeration. Dry-wet cycle is an important factor controlling potential changes in soil aggregate size distribution and stability. In order to investigate responses of soil aggregate size distribution and stability to dry-wet cycles, samples of undisturbed soil (in the depth range of 0–100 cm) at 20 cm layer intervals from long-term cultivated farmland in the Huanghuaihai Plain, China were collected and subjected to different levels of dry-wet cycles: 0, 1, 3 and 5 cycles, noted as DW0, DW1, DW3 and DW5, respectively. The soil is classified as fluvo-aquic with a silty texture, which has been cultivated with winter wheat and summer maize rotation for more than 50 years. The soil aggregate size distribution, mean weight diameter (MWD) and geometric mean diameter (GMD) were analysed using the dry sieving and wet sieving methods. The soil aggregates were dominated by aggregates >0.25 mm, and the proportion of soil aggregates >0.25 mm was more than 85% under dry sieving method, while the proportion of <0.25 mm soil aggregates was higher under wet sieving method. The percentage of aggregate destruction (PAD) was increased by DW1, but DW3 and DW5 had little effect on it. Treatments DW1 and DW5 significantly decreased the proportion of >5 mm soil aggregates under wet sieving method. The MWD values were generally higher in treatment DW3 under both sieving methods. GMD values in treatment DW1 significantly decreased under wet sieving method, but in treatments DW3 and DW5 they varied with soil layers. Differently, dry-wet cycles generally increased GMD values under dry sieving method across soil layers. The soil aggregate stability under dry sieving method was higher than that under wet sieving method, suggesting that water-stable aggregates dominated by a small proportion in this given soil.

Key words: dry and wet cycles, fluvo-aquic soil, water stability of soil aggregate.

Introduction

Soil structure has important influences on ensuring sustainable agriculture and moderating environmental quality. Soil aggregate formation is important for soil productivity because of its positive effects on soil properties and functions, such as soil water infiltration capacity and soil organic matter content (Christensen, 2001). In addition, soil aggregation has been widely recognized to have positive effects on soil water storage (Dungait et al., 2012; Lehmann, Kleber, 2015). The stability of soil aggregates is often used as an important predictor of soil structure, which plays a vital role in soil fertility and influencing soil erodibility.

The mean weight diameter (MWD) and geometric mean diameter (GMD) are usually used as parameters to express soil aggregate stability (Ye et al., 2017). Factors affecting stability of soil aggregates have been widely investigated. Previous studies have mainly focused on intrinsic soil properties, such as soil cation exchange capacity (Le Bissonnais et al., 2017), soil organic matter (Huang et al., 2017) and soil microbes (Zhang et al., 2016). However, little consideration has been taken into the influence of natural events on soil aggregation. It has been shown that soil moisture affected stability of soil aggregate in several ways. The extent of slaking would decrease with increasing the moisture content, especially in soil lacking organic matter. In addition, the soil moisture before sampling might also affect soil aggregate stability. Effects of drying on soil structure are not clear, since an increase or a decrease of water-stable aggregates were both observed (Denef et al., 2001).

The size distribution and stability of soil aggregates are under the control of various mechanisms. The processes would be intensive in *Vertisol* as the soil structure tended to be more dynamic during dry-wet cycles (Denef, Six, 2005; Bravo-Garza et al., 2009). Studies have shown that dry-wet cycles significantly affect soil aggregate stability (Ma et al., 2015; Hu et al., 2018), via influencing the matric water potential and soil aggregate size distribution (Utomo, Dexter, 1982; Huetal., 2018). It has been reported that dry-wet cycle has a significant effect on soil aggregation via affecting the formation and stabilization processes of soil aggregate (Rahman et al., 2018).

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However, results of soil aggregation and its stability affected by dry-wet cycles varied differently. A study showed that soil aggregate stability in swelling soil was significantly decreased by dry-wet cycles, but no difference was observed in non-swelling soil treated with dry-wet cycles (Peng et al., 2011). Bravo-Garza et al. (2009) found that dry-wet cycles increased proportions of large soil aggregate in a smectite dominated *Vertisol*. Rahman et al. (2018) also showed that dry-wet cycles had positive effects on soil aggregate stability in a *Vertisol*, locally known as Shajiang Black soil. The variety of soil aggregate might be related to the difference of frequency of dry-wet cycles, methods of aggregate stability determination, organic matter content and the initial physical properties of soil aggregates (Kaiser et al., 2015; Pulido et al., 2016).

This study was conducted on a long-term agricultural field located at Zhoukou Normal University, Zhoukou city, Henan Province, central China. The soil in this area always undergoes intense dry-wet cycles, especially in the summer. Thus, the objectives of this study were: (1) to determine the effects of dry-wet cycles on soil aggregate stability and (2) to assess the difference between the dry and wet sieving methods. We hypothesized that dry-wet cycles would significantly affect soil aggregate stability, and the frequency of dry-wet cycles would also contribute to the difference.

Materials and methods

Site description and soil basic properties. The soil used in the experiment was collected in March 2019 during winter wheat growing season from a long-term agricultural field located at Zhoukou Normal University, Zhoukou city (114° 39′ E, 33°62′ N), in the Huanghuaihai Plain, Henan Province, China. The field site has a temperate monsoon climate where annual temperature is 15.1°C, and annual precipitation is 700 mm with more than 73% of the precipitation occurring from May to October. The soil is classified as *Endocalcari Endogleyic Cambisol* (WRB, 2014) and locally known as fluvo-aquic soil. This soil has a silty texture of 15% sand, 70% silt and 15% clay. The main properties of soil in top 20 cm layer were as follows: soil organic matter 12.1 g kg^{-1}, total nitrogen (N) 0.99 g kg^{-1} and available phosphorous (P_2O_5) 14.3 mg kg^{-1}. The cropping system is a winter wheat and summer maize rotation, and this field has been planted with winter wheat and summer maize for more than 50 years. The field was treated with conventional tillage, consisting of mouldboard ploughing to 30 cm depth, followed by secondary tillage with a soil grubber and a harrow for seedbed preparation.

Soil sample preparation. Three plots (20 × 20 m) were chosen in the farmland. Before sampling, residues and weeds were removed from the soil surface, and all soil samples were collected from the flat patches adjacent to the wheat rows. For each sampling plot, three soil profiles were randomly collected for undisturbed soil samples at the depths of 0–20, 20–40, 40–60, 60–80 and 80–100 cm, after removing the wheat plants and the litter aboveground. Undisturbed soil samples were collected in plastic boxes and transported to the laboratory. Three soil samples in the same soil layer in a plot were composited to obtain one sample. Big clods in the samples were gently crumbled along the natural fissures, and the plant debris was removed by hand.

Drying and wetting cycles. After collection, the soil samples were air dried, treated with dry-wet cycles. During the wetting process, the soil samples were slowly wetted with distilled water to get soil moisture of 60% field capacity for at least 120 min on filter paper 3 cm thick sponge with a tension of −0.3 kPa (Le Bissonnais, 1996). To minimize slaking action during the dry-wet cycles, undisturbed soil samples were first wetted with distilled water by saturation from the bottom of the sample holder. Then, soil samples were air dried for several days. Four treatments were included in this experiment; the samples were: 1) not treated with a dry-wet cycle (DW0), 2) submitted to one dry-wet cycle (DW1), 3) treated with three dry-wet cycles (DW3) and 4) treated with five dry-wet cycles (DW5). Each dry-wet cycle was replicated three times to obtain each size of soil aggregate.

Dry and wet sieving methods. Wet sieving was performed using the modified Yoder's method (Zhu et al., 2016). Briefly, 100 g of air dried soil was placed on filter paper in a mesh, and distilled water was added along with the edge of filter paper until the soil sample was saturated. Then, the soil sample was placed into the top sieve of each set and rapidly immersed in distilled water while being oscillated for 2 min at a displacement of approximately 3 cm at 30 rounds per minute. After sieving, each size of soil aggregate was collected, oven-dried at 40 °C and weighed.

The drying was performed by the standard dry sieving method (Gartzia-Bengoetxea et al., 2009). Briefly, 100 g air-dried soil placed on the top of a nest of five sieves (5, 2, 1, 0.5 and 0.25 mm) was agitated for 5 min with a sieve shaker Octagon 2000 (Endecotts Ltd., UK) at 200 oscillation min^{-1}. The soil aggregates retained on each sieve and in the bottom container under 0.25 mm sieve were collected and then weighed. To better appreciate the soil aggregate size distribution, 2–5, 1–2, 0.5–1 and 0.25–0.5 mm aggregates were merged into one group of meso-aggregate (0.25–5 mm).

The slaking ratio of soil aggregate size > 0.25 mm ($R_{0.25}$) was calculated by the equation:

$$R_{0.25} = M_{r>0.25} / M_T \times 100\%,$$

where $M_{r>0.25}$ is the weight of soil aggregate size >0.25 mm, M_T – the weight of total soil used during sieving.

The percentage of aggregate destruction (PAD) was calculated by the equation as follows:

$$PAD = (DSR_{0.25} - WSR_{0.25}) / DSR_{0.25} \times 100\%,$$

where $DSR_{0.25}$ is the proportion of macro-aggregate (size > 0.25 mm) using the dry sieving method, $WSR_{0.25}$ – the proportion of macro-aggregate using the wet sieving method.

The mean weight diameter (MWD) and geometric mean diameter (GMD) of soil aggregates were calculated according to Zhang et al. (2014):

$$MWD = \sum_{i=1}^{n} \bar{x}_i w_i \quad \text{and} \quad GMD = \exp\left(\sum_{i=1}^{n} w_i \ln \bar{x}_i\right),$$

where $\bar{x}_i$ is the mean diameter of each soil aggregate fraction (mm), w_i – the weight proportion of each size fraction remaining on each sieve.

Statistical analysis was performed using software package *SPSS*, version 19.0 (IBM Inc., USA). One-way analysis of variance (ANOVA) was used to analyse all data. Treatment means were compared using Duncan's multiple range post-hoc tests at the 5% level of probability. The figures were prepared using software *Sigma Plot*, version 12.0 (SyStat Ltd., UK). All experimentally determined data are expressed as means of three replicates.

Results and discussion

Soil aggregate size distribution. Distribution of soil aggregate size under wet sieving method in the four treatments is shown in Table 1. Compared with treatment DW0, DW1 significantly decreased the relative proportion of macro-aggregates (>0.25 mm) in each soil layer and increased the relative proportion of micro-aggregates (<0.25 mm). The highest proportion of >5 mm aggregates was recorded in the treatment DW3 except for in the 0–20 cm layer; the proportion of >5 mm aggregates was 31.3, 104.7, 230.8 and 6.1 % higher in 20–40, 40–60, 60–80 and 80–100 cm layers, respectively, than in treatment DW0. Treatments DW3 and DW5 significantly increased the proportion of <0.25 mm aggregates in 0–20 cm layer compared with DW0, but no significant effects of DW3 and DW5 were observed in 40–60 cm layer. Generally, dry-wet cycles significantly decreased the proportion of 0.25–5 mm aggregates in the 0–20 and 20–40 cm layers.

Table 1. The distribution of size of soil aggregates under wet sieving method

Layer cm	Treatment	Mass percent content of aggregates in each size range kg kg^{-1}		
		>5 mm	0.25–5 mm	<0.25 mm
0–20	DW0	0.1367 b	0.5140 a	0.3493 c
	DW1	0.0560 c	0.2003 c	0.7437 a
	DW3	0.1620 ab	0.3133 b	0.5247 b
	DW5	0.1720 a	0.2557 bc	0.5723 b
20–40	DW0	0.0957 b	0.4086 a	0.4957 b
	DW1	0.0357 c	0.3503 b	0.6140 a
	DW3	0.1257 a	0.3650 b	0.5093 b
	DW5	0.1120 ab	0.3083 c	0.5797 a
40–60	DW0	0.0233 b	0.2467 a	0.7300 b
	DW1	0.0060 c	0.1830 a	0.8110 a
	DW3	0.0477 a	0.2210 a	0.7313 b
	DW5	0.0430 a	0.1903 a	0.7667 b
60–80	DW0	0.0653 c	0.2057 a	0.7290 b
	DW1	0.0227 d	0.2186 a	0.7587 a
	DW3	0.2160 a	0.1737 b	0.6103 d
	DW5	0.1830 b	0.1507 b	0.6663 c
80–100	DW0	0.2423 a	0.1394 b	0.6183 b
	DW1	0.0597 c	0.1856 a	0.7547 a
	DW3	0.2570 a	0.1897 a	0.5533 c
	DW5	0.2137 b	0.1543 b	0.6320 b

Note. DW0, DW1, DW3 and DW5 indicate that samples were submitted to 0, 1, 3 and 5 dry-wet cycles, respectively; values followed by a different letter within a row indicate significant difference ($p < 0.05$).

Regarding the pore size class distribution, there were significant differences among different treatments under dry sieving method (Table 2). The dry-wet cycles resulted in a significant increase in proportions of >5 mm aggregates in each soil layer compared with treatment DW0, and the highest proportion of >5 mm aggregates was observed in DW3. The proportions of >5 mm aggregates were 83.8, 44.8, 33.4, 25.3 and 62.8 % higher in 0–20, 20–40, 40–60, 60–80 and 80–100 cm layers, respectively, compared with DW0 ($p < 0.05$). Treatment DW1 significantly decreased proportion of < 0.25 mm aggregates in each soil layer, but DW5 significantly increased it compared with DW0, while the effects of DW3 on < 0.25 mm aggregate varied with soil layers. Dry-wet cycles significantly decreased proportion of 0.25–5 mm aggregate across soil layers.

The formation of soil aggregate was generally affected by the drying and wetting process, and aggregate in different sizes would respond to the dry-wet cycles differently during its formation. In the early stage of micro-aggregate formation, the dry-wet cycle caused by rainfall and other factors would affect the suspension of soil particles as well as the polyvalent cation forms, such as iron ions, which played an important role in particle bonding (Tisdall, Oades, 1982). During the formation of large aggregates, rapid wetting on structurally unstable soil will lead to disintegration of soil aggregates, thereby affecting the stability of large aggregates.

Table 2. The distribution of size of soil aggregates under dry sieving method

Layer cm	Treatment	Mass percent content of aggregates in each size range kg kg^{-1}		
		>5 mm	0.25–0.5 mm	<0.25 mm
0–20	DW0	0.4123 c	0.5557 a	0.0320 b
	DW1	0.6803 b	0.3134 b	0.0063 c
	DW3	0.7580 a	0.2253 c	0.0167 bc
	DW5	0.7180 b	0.1763 d	0.1057 a
20–40	DW0	0.5417 c	0.4476 a	0.0107 b
	DW1	0.7010 b	0.2947 b	0.0043 c
	DW3	0.7843 a	0.2050 c	0.0107 b
	DW5	0.7510 a	0.1743 c	0.0747 a
40–60	DW0	0.5387 b	0.4003 a	0.0610 b
	DW1	0.7130 a	0.2713 b	0.0157 d
	DW3	0.7187 a	0.2420 bc	0.0393 c
	DW5	0.6720 a	0.2080 c	0.1200 a
60–80	DW0	0.7443 c	0.2370 a	0.0187 b
	DW1	0.8863 b	0.1110 b	0.0027 d
	DW3	0.9327 a	0.0590 c	0.0083 c
	DW5	0.8893 b	0.0464 c	0.0643 a
80–100	DW0	0.5787 c	0.3786 a	0.0427 b
	DW1	0.8937 b	0.1040 b	0.0023 c
	DW3	0.9420 a	0.0503 c	0.0077 c
	DW5	0.9020 b	0.0397 c	0.0583 a

Explanation under Table 1

Results of our study showed that the content of aggregates > 0.25 mm was significantly decreased in the soil treated with dry-wet cycles, but the decreases in treatments DW3 and DW5 were less than in DW1. This is consistent with Degens and Sparling (1995), who reported that soil aggregates of > 2, 1–2 and 0.25–0.5 mm rapidly decreased by 48–65% in the first two dry-wet cycles and recovered to 78—100% of the initial aggregation after three dry-wet cycles, then reduced after 4–6 cycles. Generally, the soil aggregate size would reduce at the initial (1 to 4) stage of dry-wet cycles, but the distribution of each size soil aggregate tended to be stable and the soil aggregation effect reduced with increasing dry-wet cycles. No significant effect of dry-wet cycles on soil aggregate size distribution was observed in a silt loam soil (Cosentino et al., 2006). The difference might be due to variety in soil physic-chemical properties and the strength of dry-wet cycles.

With dry sieving method, the distribution of soil aggregates was skewed toward aggregates of > 5 and 0.25–5 mm. In contrast with the wet sieving method, micro-aggregate (< 0.25 mm) contributed to the highest fractions. The difference could be mainly due to the fact that the energy applied to the soil differs greatly between both methods. What is more, the proportions of soil aggregates > 0.25 mm obtained from wet sieving method were lower than those obtained from dry sieving method. This might suggest that proportions of water-stable aggregate were relative low in this given soil, the soil tended to suffer from erodibility. Previous studies indicated that the proportions of lager macro-aggregates generally decreased with wet sieving method due to the breakdown of the weak macro-aggregates into smaller aggregates by high disruptive forces of water, and soil aggregates only shocked by a rubbing effect under dry sieving method (Blaud et al., 2016; Nahidana, Nourbakhsh, 2018). In addition, soil aggregates obtained from dry sieving method concluded water-stable and non-water-stable aggregates, while the aggregates were only water-stable aggregate under wet sieving method. Results of our study indicated that the majority of aggregates in the agricultural soil were not water-stable. The water-stable aggregates obtained from wet sieving method can better reflect the size distribution of soil aggregates.

Soil aggregate stability measured by dry and wet sieving methods. The proportion of aggregate size > 0.25 mm ($R_{0.25}$) and percentage of aggregate destruction (PAD) under different treatments are presented in Table 3. The $R_{0.25}$ under wet sieving method ranged from 18.90% to 65.07% across the soil layers. Treatment DW1 significantly decreased $R_{0.25}$ in each soil layer under wet sieving method, and the decreases were 60.6, 23.5, 30.0, 11.0 and 35.7% in 0–20, 20–40, 40–60, 60–80 and 80–100 cm layers, respectively, compared with DW0. Treatment DW3 generally increased $R_{0.25}$ under wet sieving method except for in the 0–20 cm layer. Ranging from 0.8800 to 0.9977, the $R_{0.25}$ under dry sieving method was generally higher than that under wet sieving method. Treatment DW1 significantly increased $R_{0.25}$ in each soil layer compared with DW0, but DW5 significantly reduced the $R_{0.25}$ across the soil layers, while DW3 had no significant effect on the $R_{0.25}$ except for in the 80–100 cm layer.

Table 3. The slaking ratio of soil aggregate size >0.25 mm ($R_{0.25}$) and percentage of aggregate destruction (PAD) under wet and dry sieving methods

Layer cm	Treat-ment	$R_{0.25}$ kg kg^{-1}		PAD %
		wet sieving	dry sieving	
0–20	DW0	0.6507 a	0.9680 b	32.78 c
	DW1	0.2563 c	0.9937 a	74.12 a
	DW3	0.4753 b	0.9833 ab	51.66 b
	DW5	0.4277 b	0.8943 c	52.17 b
20–40	DW0	0.5043 a	0.9893 b	49.02 b
	DW1	0.3860 b	0.9956 a	61.23 a
	DW3	0.4907 a	0.9893 b	50.40 b
	DW5	0.4103 b	0.9253 c	55.65 b
40–60	DW0	0.2700 a	0.9390 b	71.23 b
	DW1	0.1890 c	0.9843 a	80.78 a
	DW3	0.26.87 a	0.9607 ab	72.01 b
	DW5	0.2333 b	0.8800 c	73.46 b
60–80	DW0	0.2710 c	0.9813 b	72.39 a
	DW1	0.2413 c	0.9973 a	75.80 a
	DW3	0.3897 a	0.9917 ab	60.71 b
	DW5	0.3337 b	0.9357 c	64.33 b
80–100	DW0	0.3817 b	0.9573 b	60.12 b
	DW1	0.2453 c	0.9977 a	75.41 a
	DW3	0.4467 a	0.9923 a	54.98 b
	DW5	0.3680 b	0.9417 c	60.92 b

Explanation under Table 1

A significant difference of PAD was observed among treatments. Ranging from 32.78% to 75.80%, the PAD was significantly increased in treatment DW1 compared with DW0 except for in the 60–80 cm layer. Treatments DW3 and DW5 significantly increased the PAD in 0–20 cm layer but decreased it in the 60–80 cm layer, while no significant effects of DW3 and DW5 on the PAD were observed in the residual layers.

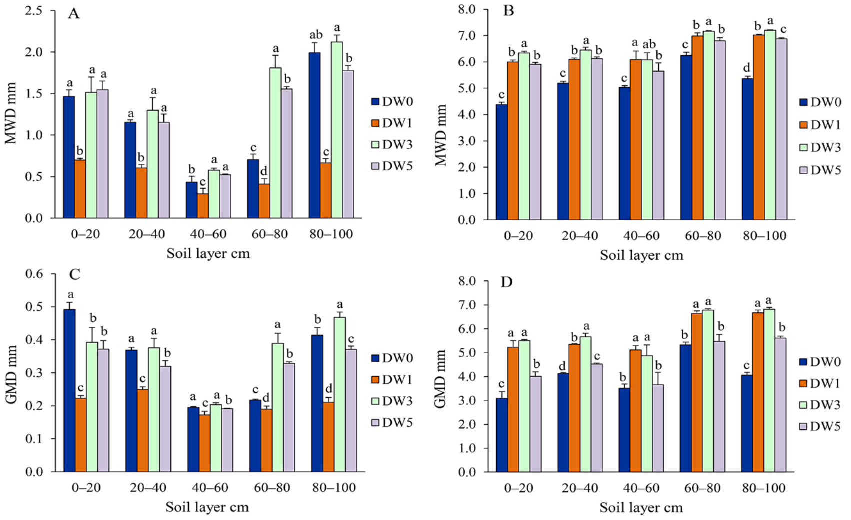
It is believed that dry-wet cycles would affect soil aggregate stability. The soil aggregate stability results (expressed as MWD and GMD) from this study are presented in Figure. The MWD values were significantly decreased in treatment DW1 in each soil layer compared with DW0 under wet sieving method; treatments DW3 and DW5 generally increased MWD values in each soil layer relative to DW0 (Fig. A). Ranging from 4.38 to 7.20 mm, the MWD values under dry sieving method were higher than those under wet sieving method. Results of our study showed that the MWD values followed the order of DW3 > DW1 > DW5 > DW0 under dry sieving method (Fig. B). The values of GMD showed a similar trend with MWD under corresponding sieving method. Compared with DW0, DW1 significantly decreased GMD values in each soil layer, the decreases were 54.7, 32.2, 12.1, 12.7 and 49.1 % in 0–20, 20–40, 40–60, 60–80 and 80–100 cm layers, respectively (Fig. C). Treatment DW3 significantly decreased the GMD value in 0–20 cm layer, but significantly increased it in 60–80 and 80–100 cm layers; no significant differences were observed between DW3 and DW0 in 20–40 and 60–80 cm layers. Treatment DW5 significantly decreased the GMD values compared with DW0 except for in the 60–80 cm layer. Different from the GMD under dry sieving method, the GMD values were generally increased by dry-wet cycles and followed the trend of DW3 > DW1 > DW5 > DW0 except for in the 40–60 cm layer (Fig. D). The GMD values in the treatments DW1 and DW3 varied slightly across the soil layers.

Results of both dry and wet sieving methods showed that the soil aggregate stability varied significantly among the treatments subjected to dry-wet cycles. Soil mechanical stability was improved by dry-wet cycles in the studied soil. This might be due to the fact that the soil used in this experiment was relatively sticky and heavy, the soil tended to agglomerate when treated with dry-wet cycles, which resulted in an increase in soil mechanical stability.

Macro-aggregate yields for the treatment DW1 were significantly smaller than for the DW0 under wet sieving method. However, macro-aggregates were susceptible to slaking when dried and rewetted (Kaiser et al., 2015). Dry-wet cycle would weaken the binding forces between soil particles inside the soil aggregates. During the dry-wet cycles, micro-fissures inside the aggregates were created by differential swelling and shrinking, which rendered the aggregates easier to breakdown (Hu et al., 2018). Dry-wet cycles would reorganize the microstructures of soil aggregates, and new equilibrium states of microstructures were gradually formed with an increase in times of dry-wet cycles (Ma et al., 2015).

Previous studies have shown that dry-wet cycles would improve the water stability of soil aggregates in *Vertisols* and facilitate the formation of water-stable aggregates, while aggregates in clay soil and silt loam soil would be reduced, especially when soil received one to four dry-wet cycles (Denef et al., 2001; Bravo-Garza et al., 2010). The effects of dry-wet cycles on soil aggregate were also related to the tillage. Utomo and Dexter (1982) showed that water stability of soil aggregates first increased with dry-wet cycles up to 4 to 6 cycles and then decreased with further cycles in tilled soil, while increased amplitude of dry-wet cycles decreased the soil aggregate stability in no-till soil. This might be due to the fact that water stability of soil aggregates disturbed by tillage in the first few cycles of dry-wet cycles is a manifestation of the reformation of the inter-particle bonds, which had been destroyed by tillage. However, the reformation of organic bonds is transient, and the soil aggregate stability in tilled soil would then decrease.

Further studies of the underlying mechanism of soil aggregate stability under different soil types are required.



Note. Error bars depict the standard deviation (± SD); the lowercase letter within each soil layer indicated significant difference at $p < 0.05$.

Figure. The mean weight (MWD) and geometric mean (GMD) diameters values in different treatments under wet (A, C) and dry (B, D) sieving methods

Conclusions

1. The proportion of macro-aggregates was decreased in treatment DW1, in DW1 the proportion of micro-aggregates significantly increased, but the effects of treatments DW3 and DW5 on micro-aggregates varied with soil layers under wet sieving method. Dry-wet cycles caused significant increases of >5 mm aggregates and decreases of 0.25–5 mm aggregates, while <0.25 mm aggregates were decreased by DW1 and increased by DW5 under the dry sieving method.

2. The proportion of aggregate size >0.25 mm ($R_{0,25}$) decreased markedly under the wet sieving method, while it generally first increased then decreased with increasing dry-wet cycles under the dry sieving method. This suggested that the soil aggregate stability was significantly affected by dry-wet cycles. The proportion of aggregate size >0.25 mm obtained from wet sieving method was markedly lower than that obtained from dry sieving method, indicating that proportions of water-stable aggregate were relatively low, which was not conducive to the maintenance of soil structure.

In addition, the percentage of aggregate destruction (PAD) was generally increased by treatment DW1, while DW3 and DW5 had little effect on the percentage of soil aggregate destruction. Thus, the soil aggregate slaking extent is reduced with repeated dry-wet cycles, showing that most soil aggregates become more slaking resistant. However, the >0.25 mm soil aggregates would generally disrupt into small aggregates when dry-wet cycles increased.

3. Treatment DW1 significantly decreased mean weight (MWD) and geometric mean (GMD) diameters; DW3 generally increased them, while DW5 showed variable effects across soil layers under wet sieving method. Differently, dry-wet cycles generally increased the MWD and GMD across soil layers under dry sieving method. However, soil aggregate stability would decrease when soil subjected to dry-wet cycles. Notably, the MWD and GMD were relative lower in 40–60 cm layer under wet sieving method, where the proportion of aggregate size >0.25 mm was lower and the percentage of soil aggregate destruction was generally high. This suggested that soil aggregates >0.25 mm were important to maintain soil aggregate stability.

Generally, dry-wet cycle played a vital role in soil aggregation in *Endocalcari Endogleyic Cambisol* in this studied area.

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Dirvožemio trupinėlių pasiskirstymas pagal dydį ir stabilumas taikant sauso ir šlapio sijojimo metodus

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Santrauka

Siekiant pagerinti dirvožemio struktūrą ir padidinti aeraciją, didelę reikšmę turi trupinėlių būklė. Sausas ir šlapias ciklas yra svarbus veiksnys, lemiantis galimus trupinėlių pasiskirstymo pagal dydį ir stabilumą pokyčius. Siekiant įvertinti trupinėlių pasiskirstymo pagal dydį ir stabilumą reakciją į sausus ir šlapius ciklus, nesuardyti dirvožemio mėginiai surinkti iš 0–100 cm gylio, 20 cm sluoksnio intervalais iš dirbamos žemės Huanghuaihai lygumoje, Kinijoje, ir veikti įvairiais sausais bei šlapiais 0, 1, 3 ir 5 ciklais, pažymėtais DW0, DW1, DW3 ir DW5. Tirtas dirvožemis – rudžemis su dumblo tekstūra, kuriame per ilgesnę nei 50 metų rotaciją buvo auginti žieminiai kviečiai ir vasariniai kukurūzai. Trupinėlių pasiskirstymas pagal dydį, skersmens vidutinis svoris ir vidutinis geometrinis skersmuo analizuoti taikant sauso ir šlapio sijojimo metodus. Taikant sauso sijojimo metodą dirvožemyje dominavo (sudarė daugiau nei 85 %) >0,25 mm dydžio trupinėliai; <0,25 mm dydžio trupinėlių dalis buvo didesnė taikant šlapio sijojimo metodą. Trupinėlių suirimo procentas padidėjo DW1 variante, o DW3 ir DW5 variantuose turėjo nedidelę įtaką. Taikant šlapio sijojimo metodą DW1 ir DW5 variantuose >5 mm dydžio trupinėlių dalis reikšmingai sumažėjo. Taikant abu metodus trupinėlių skersmens vidutinio svorio vertės buvo didesnės DW3 variante. Trupinėlių vidutinio geometrinio skersmens vertės DW1 variante reikšmingai sumažėjo taikant šlapio sijojimo metodą, tačiau DW3 ir DW5 variantuose jos kito priklausomai nuo dirvožemio sluoksnio. Ir atvirkščiai, sausi ir šlapi ciklai padidino trupinėlių vidutinio geometrinio skersmens vertes taikant sauso sijojimo metodą visuose dirvožemio sluoksniuose. Trupinėlių stabilumas buvo didesnis taikant sauso sijojimo metodą nei šlapio; tai rodo, kad tirtame dirvožemyje vandenyje patvarūs trupinėliai sudarė mažą dalį.

Reikšminiai žodžiai: dirvožemio trupinėlių stabilumas vandenyje, rudžemis, sausas ir šlapias ciklai.