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EFFECT OF PLOUGHING-DOWN OF GRAPEVINE CHIPS ON SOIL STRUCTURE WHEN USING SPECIAL AGRICULTURAL MACHINERY

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Abstract

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Within the period of 2008–2011, changes in soil structure were studied in two selected localities: one of them was situated in vineyards of the University Training Farm of Mendel University in Žabčice near Brno, the other was in vineyards situated in the cadastre of wine-growing municipality Velké Bílovice. Established were altogether three variants of experiments with application of crushed grapevine wood (chips): Variant 1 – control; Variant 2 – crushed grapevine wood ploughed down to the depth of 0.10 m; Variant 3 – crushed grapevine wood + grass spread on the soil surface as a mulch. Grapevine canes were crushed to chips using a special agricultural machinery while the soil in inter-rows was processed using conventional tilling machines. The obtained results showed that the best coefficient of structurality (expressing the degree of destruction of soil structure) was recorded in Variants 2 in both localities. Considering values of this coefficient it could be concluded that just this variant showed a positive effect on soil structure. This variant reduced the compaction of soil caused by the movement of agricultural machines in vineyard inter-rows Crushed grapevine waste wood can therefore compensate losses of organic matter in soil. Better values of structurality coefficient were recorded in the locality Žabčice.

soil texture, grapevine wood chips, soil tillage, vineyard machinery

After pruning, vineyards and orchard are a relatively stable source of waste wood. For several decades, this waste wood is available in individual localities in relatively stable amounts (ranging in vineyards usually from 1.8 to 2.8 $t.ha^{-1}$. Žufánek & Zemánek (1998) mentioned 2.5 $t.ha^{-1}$ as a normal average volume of fresh waste grapevine wood (canes). The shape of chips can be very different and depends on the concrete kind of waste wood and on the type of chipper. The maximum size of chips made by means of current machines ranges from 50 to 150 mm. Burg & Zemánek (2009) mentioned that drum, disk and worm chippers made chips of the size up to 20 mm, 40–50 mm and up to 80 mm, respectively.

In the past, waste grapevine wood was pushed up to inter-rows, transported to gathering places and burnt in piles. At present, the method of waste wood crushing is commonly used in many vineyards. An aggregation of tractor and chipper (mulching machine) crushes waste wood to small particles that are spread on the soil surface so that they can pass through the process of a slow decomposition. To enable a rational use of waste wood, technicians and designers are developing machines for gathering and pressing of pruned grapevine canes and also machines for waste wood gathering and chipping. Regarding soil and climatic conditions as well as methods of wood crushing and soil processing, various methods of tillage are evaluated and subsequently applied in vineyards. The most important objective of all methods of tillage is an effort to maintain an optimum soil humidity and to supply grapevine plants with nutrients (Zemánek & Burg, 2010). Soil cultivation is performed above all to kill weeds and to destroy the soil crust on the surface (i.e. to stop the soil capillarity).

Organic matter supplied into the soil in the form of chips improves stability of both macro and microaggregates of soil and influences infiltration of water into soil. The amount of supplied organic matter is very important not only for the maintenance of a good soil structure but also for a reduction of water erosion (Badalíková & Hrubý, 2006) and preservation of soil humidity for a longer period (Badalíková & Hrubý, 2009).

This paper deals with changes that take place in the soil environment in inter-rows of vineyards after the application (ploughing down) of chips made of waste grapevine wood.

MATERIALS AND METHODS

Experiments studying the replacement of organic dressing with chips made of waste grapevine wood were established in two localities with different soils, viz. in vineyards of the University Training Farm of Mendel University in Žabčice near Brno and in a vineyard site situated in the cadastre of the wine-growing municipality Velké Bílovice. The effect of application of grapevine chips and movement of tractors with mulching machines on the structure of soil was studied within the period of 2008–2011.

Characterisation of experimental localities

The wine-growing municipality of Velké Bílovice is situated in the maize-growing region and belongs to the region with a warm and dry climate. The maximum altitude is 200 m and soils are classified as chernozem on loess sediments, with mostly loamy particles and a high proportion of dust particles.

The wine-growing municipality of Žabčice is situated also in the maize-growing region and belongs to the warm and dry climatic region with maximum altitude of 200 m. In this locality, soils are mostly classified as alluvial fluvisols with loamy to sandy/loamy texture.

COLLECTION OF SOIL SAMPLES

In both localities, soil samples were collected for the basic chemical analyses, humus content, soil humidity, and soil structure in two different layers (0–0.15 and 0.10–0.30 m). Samplings were performed always in three replications at the beginning and to the end of the growing season.

Soil structure was analysed on sieves with openings (mesh size) 0.25; 0.5; 1; 5; 10 and 20 mm. Each structural fraction was separately weighed and converted to percent values. Soil texture was evaluated using the coefficient of structurality, which expresses the ratio agronomically valuable and less valuable structural elements.

Experimental variant with different methods of grapevine waste wood application:

Variant 1 – control, without application of grapevine waste wood (chips);
Variant 2 – crushing and ploughing down of chips to the depth of 0.10 m;
Variant 3 – crushing of grapevine waste wood, mixing with cut grass and application on the soil surface (mulching).

The minimum length of experimental plots was 100 m and the width corresponded with the, inter-row spacings, i.e. 2.2 × 1 m.

For waste wood crushing and soil cultivation the following machinery was used on both localities:

Variant 2 – Vineyard tractor NEW HOLLAND TN 55V + mulching machine INO 160 (KUHN 170)
Variant 3 – Vineyard tractor NEW HOLLAND TN 55V + rotary cultivator AKR 152.

Size of wood chips was given of quantity vine in among – lines and speed of operation changes. Average length elements was 50–60 mm, at thickness 8–15 mm. Quantity defray wood chips was unlid from shackle among – lines, decree vine from hah and latitude catch mulch. At latitude catch mulch 1,6 m and decree vine 2,5 t.ha^{-1} was defray or leaved in to the eye soil 0,75 kg wood chips on m^2.

Size of wood chips was given of quantity vine in among – lines and speed of operation changes. Average length of elements was 50–60 mm, at thickness 8–15 mm. Quantity of wood chips defray was depended on row spacing, vine yield from hectare and mesh of mulching machine. At width of mesh 1.6 m and vine yield 2.5 t.ha^{-1} was defray or leaved in to the soil surface 0.75 kg wood chips on m^2.

Obtained results were statistically processed using the ANOVA method.

RESULTS AND DISCUSSION

The soil structure is an important stability feature of soil fertility. It is determined by the degree of clamping individual soil particles together into larger units by clay material, organic compounds etc.

To maintain the stability of soil structure, an adequate supply of organic matter is very important. Nowadays, the application of organic matter in the form of cane chips improves the coefficient of soil structure and, thus, also a reduction of undesirable soil compaction (Badalíková & Červinka, 2010).

In the locality Velké Bílovice (Tab. I), the highest and the lowest values of the coefficient of structurality were found out in Variants 2 (in the depth of 0.20) and 1 (on the surface), respectively, in the first experimental year (2008). In 2009, and increase in values of this coefficient was observed in all variants. The maximum increase was recorded again in Variant 2 (more than 2) so that it could be concluded that the ploughing horizon showed a high degree of structurality. In 2010, the lowest values of this coefficient were calculated were calculated in all variants, probably due to unfavourable soil humidity. In this year, values of the coefficient of structurality were lower than 1 in all variants, i.e. below the limit of structural stability. This could result in a deterioration of the quality of soil environment, above all as far as physical properties of soil were concerned, and subsequently also in negative effects on chemical properties of soil. In 2011, increased values of structurality coefficient were calculated above all in the upper soil layer. As shown in Fig. 1, an increasing trend of soil structure values was observed in Variant 2 (i.e. with crushed and ploughed-down chips). However, a statistically significant relationship (P = 0.05) was recorded only between individual years and localities (Tab. III).

In the locality Žabčice (Tab. II), the development of soil structure was more favourable in all years. The highest value of the coefficient of structurality was recorded in Variant 3 (viz. in the lower soil layer in 2009 and in the upper soil layer in 2011). In 2011, its value was even higher than 3. The trend line of the development of soil structure (Fig. 2) again indicates the existence of similar trends in Variants 2 and 3. In Variant 1, a deterioration of the soil structure resulted from a lower supply of organic matter so that the soil lost its structurality.

As mentioned by other authors, the development of soil structure was influenced also by activity of soil microorganisms and it is known that this is higher if soils with higher reserves of organic matter (Tebrügge *et al.*, 1994). Populations and activities of microorganisms improve with the increasing supply of plant residues and other organic matter.

When evaluating the whole soil profile, higher values of the coefficient of structurality were mostly found out in the upper soil layer (to the depth of 0.15 m) in both localities. A positive effect of grapevine chips was observed in Variant 2; in this variant the best average soil structure was found out in both localities.

In locality Žabčice, values of the structurality coefficient were higher than in Velké Bílovice. This resulted, among others, from differences in soil texture and soil types. As mentioned also by Sedláčková (2006), these differences might be the reason of the occurrence of differences in soil structurality. Application of all kinds of organic mater into the soil enables to preserve not only the crumb structure of soil with a number of agronomically valuable aggregates but also

I: *Average annual values of the structurality coefficient (V. Bílovice, 2008–2011)*

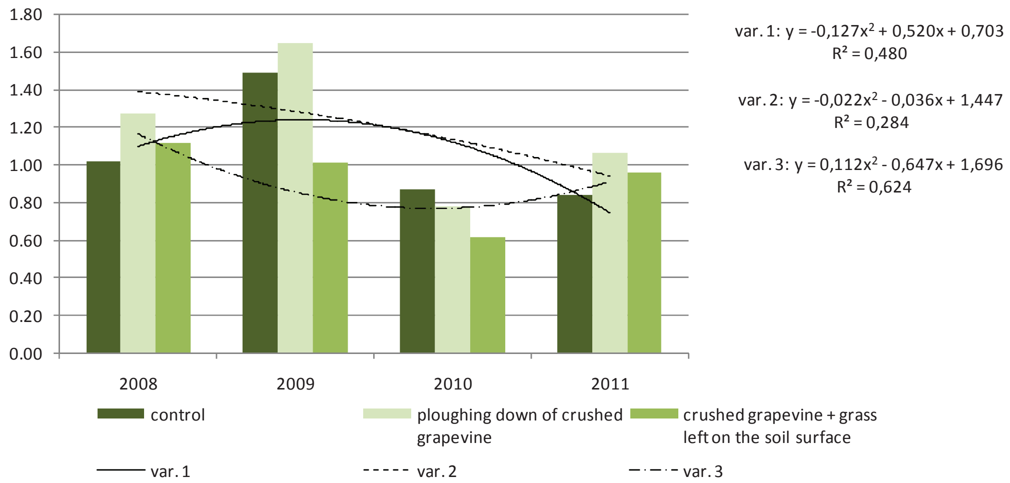
Variant	Depth (m)	2008	2009	2010	2011
1	0.0-0.10	0,98	1,22	0,86	1,34
	0.10-0.20	1,05	1,90	0,88	0,59
2	0.0-0.10	1,13	1,21	0,84	1,45
	0.10-0.20	1,42	2,29	0,70	0,80
3	0.0-0.10	1,22	1,23	0,50	1,15
	0.10-0.20	1,02	0,83	0,75	0,82

II: *Average annual values of the structurality coefficient (Žabčice, 2008–2011)*

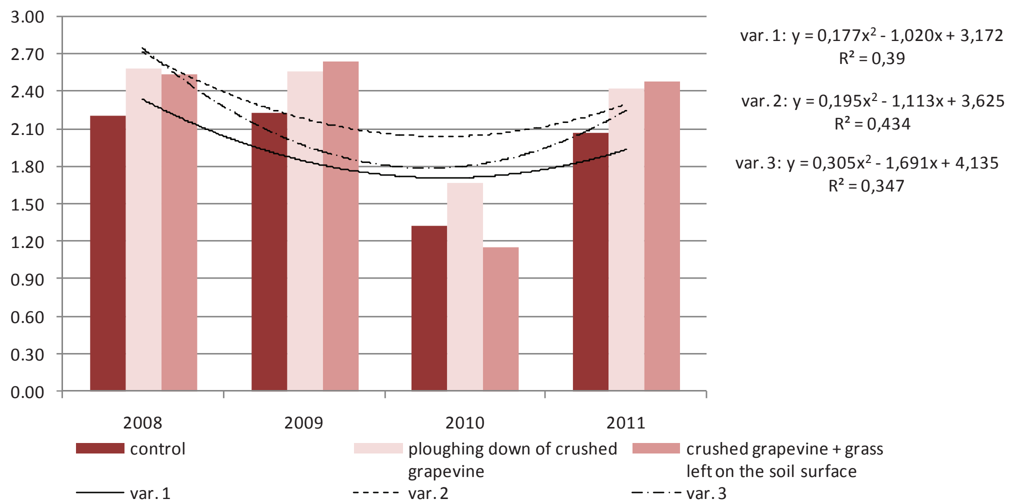
Variant	Depth (m)	2008	2009	2010	2011
1	0.0-0.10	2,38	2,00	1,17	2,09
	0.10-0.20	2,02	2,47	1,47	2,04
2	0.0-0.10	2,57	3,11	1,63	2,24
	0.10-0.20	2,59	2,01	1,69	2,60
3	0.0-0.10	2,74	2,09	0,95	3,15
	0.10-0.20	2,32	3,18	1,35	1,79

III: *Analysis of Variance*

Source of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. level
SITE	26.945204	1	26.945204	89.486	0.0000 ***
YEAR	10.853250	3	3.617750	12.015	0.0000 ***
TREATMENT	1.061069	2	0.530534	1.762	0.1779 NS
REPLICATION	1.571158	3	0.523719	1.739	0.1650 NS
RESIDUAL	25.895569	86	0.301111		
TOTAL	66.326250	95			



1: *Developmental trends of soil structure within the study period of (Velké Bílovice, 2008–2011)*



2: *Developmental trends of soil structure within the study period of (Žabčice, 2008–2011)*

improves its retention capacity due to the formation of pores and micropores (Burg & Zemánek, 2009). Also Horn *et al.* (2006) and Lhotský (2000) mentioned that good reserves of organic matter in soils exposed to compaction caused by movement of agricultural machinery shows a positive effect on its structure. Clinton *et al.* (2005), similarly, reported that a good soil structure can be preserved in situations with a balanced ratio of soil particles and their mutual forces. Also tillage and application of organic matter residues into the soil represent important factors that influence the structural condition of soil (Martens, 2000). Retention of water in soil is also dependent on tillage. GAJIC *et al.* (2004) found out that soil irrigatio influenced the stability of soil macro and microaggregates. If we want to preserve a good soil structure, it is necessary to assure adequate reserves of organic matter in soil; this observation was corroborated also by Pulleman (2002).

CONCLUSIONS

After a period of four years, the application (and ploughing down) of crushed grapevine waste wood showed a positive effect on soil and improved the stability of soil structure in both experimental localities. Basing on calculated values of the structurality coefficient it can be concluded that this treatment shows a positive effect on soil structure and reduces the compaction of soil in vineyard inter-rows caused by the movement of agricultural machinery even under less favourable conditions.

More favourable values of the structurality coefficient were calculated for the locality Žabčice, where the application of grapevine chips appeared to be important also with regard to the resistance of structural aggregates and their capability to resist more to various negative effects.

SUMMARY

The aim of this study was to evaluate changes in the pedosphere of vineyard interrows after the application of crushed grapevine waste wood (chips).

Methods of processing of grapevine waste wood (chips) and its application into the soil as an ersatz of organic matter were studied in two localities with different soils, viz. University Training Farm in Žabčice near Brno and in a vineyard situated in the cadastre of wine-growing municipality Velké Bílovice. The effect of ploughed-down chips and movement of tractor aggregates and mulching machines on soil structure was studied within the period of 2008–2011.

The locality Velké Bílovice is situated in the maize-growing region and belongs to the region with a warm and dry climate. The maximum altitude is 200 m and soils are classified as chernozem on loess sediments, with mostly loamy particles and a high proportion of dust particles.

The locality Žabčice is situated also in the maize-growing region and belongs also to the warm and dry climatic region with the maximum altitude of 200 m. In this locality, however, soils are mostly classified as alluvial fluvisols with loamy to sandy/loamy texture.

In both localities, the stability of soil structure was estimated using samples collected in two different depths in two different depths (0,0–0.15 and 0.10–0.30 m). Samplings were performed at the beginning and to the end of the growing season. Soil structure was analysed on sieves with openings (mesh size) 0.25; 0.5; 1; 5; 10 and 20 mm. Each structural fraction was separately weighed and converted to percent values. The soil structure was determined using the coefficient of structurability, which expressed the ratio of agronomically valuable to less valuable structural elements.

Results of four-year experiments indicated that the application of crushed grapevine waste wood showed a positive effect on the stability of soil structure in both localities (in spite of the movement of mulching machinery). Calculated values of the coefficient of structurabily indicated that this method of waste wood liquidation showed a positive effect on soil structure; this resulted in a reduced compaction of soil due to the application of agricultural machinery even under less favourable conditions.

Better values of the structurability coefficient were calculated in the locality Žabčice, where the application of grapevine chips appeared to be important also with regard to the resistance of structural aggregates and their capability to resist more to various negative effects.

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