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THE PENETRATION RESISTANCE AS A SOIL DEGRADATION INDICATOR IN THE VITICULTURE

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Abstract

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This paper deals with monitoring of changes in soil compaction at two experimental sites (Lednice and Valtice) in the alleyway of vineyards. The experimental measurements were carried out during the period 2009–2011. Penetration resistance of the soil was measured using the penetrometer (type PN 10) to a depth up to 520 mm. The measurements were carried out alternatively in variants with grassed and cultivated alleyways of vineyards. The samples were performed in the wheeltracks and in the middle of an alleyway. The control samples were performed between the plants in the row. The results show that the penetration resistance reaches lower values on the grassed alleyway. At both variants is obvious increase of the penetration resistance above the critical value already in a depth of 0.2 m. From the annual comparison of the penetration resistance it is clear the higher increase in the third year.

viticulture, soil, penetration resistance, soil compaction

In connection with the intensification of crop production is a current topic of agricultural soils compaction. It should paid attention for the full implementation of all available ways to soil compaction elimination and removal (MARTINEC *et al.*, 2008). Soil compaction is significantly reflected in the reduction of their fertility and production capabilities of the soil. The consequences of the excessive compaction of soil from a social point of view are more serious, that soils are mainly potentially very fertile, for which of the yield reduction is reflected in many economical aspects of (JAVŮREK, VACH, 2008). The research results clearly showed that the soil compaction has resulted in an increase of the soils bulk density, reduction of the porosity (mainly lower volume of noncapillary pores) and at a higher level causes destruction of the soil aggregates. That leads to the degradation of other physical properties of soils, such as limited water permeability, changes in water content in the soil horizon and water flow in the soil. At the same time it affects the relationship between the content of the air (deficiency of oxygen in the root zone) and soil temperature (PROFFITT *et al.*, 1995). The issue of measuring the level of compaction of agricultural soils, was dealt by a number of authors such as ŠAŘEC (1997), MARTINEC *et al.* (2008), KROULÍK *et al.* (2009), FLORIÁN and KUBÍK (2010), problems of forestry soil compaction HERRICK, JONES (2001), LIPIEC *et al.* (2002), NERUDA (2008), and others. The accurate detection of the soils resistance is problematic and depends on many constant and variable factors (moisture, structure, chemical composition, texture, etc.). The issue of compaction of soils monitoring in the vineyards was solved by PAECOCK (1999), BAHAM (1999), in Czech Republic eg. by JANDÁK *et al.* (2010).

The aim of this contribution is to evaluate soils penetration resistance in grassed and cultivated alleyway of vineyards, at two experimental sites, during three year period.

MATERIAL AND METHODS

The experimental measurements were performed at the two experimental sites in the cadastral area of Lednice and Valtice during the period from 2009 to 2011.

Experimental site in Lednice: vineyard 19 years old, consisting of a variety Lemberger (Blauer Limberger), vine is grown at a high vine training with one cane, the spacing is 2.5 × 1.0 m, with a wooden posts supporting structure with the height of 1.8 m. Every second alleyway is grassed. Soil type, according to estimated pedological ecological unit, are these soils marked as 0.01.00. This type represents the modal black soils. It is therefore a medium – heavy soil with no skeleton, very deep, mostly with favorable water regime. Slope of the land was 0–3% (flat). Average water content in topsoil was in a range from 18.3 to 22.1% of the weight.

Experimental site in Valtice: vineyard 30 years old, consisting of a variety Irsay Oliver, is grown at a high vine training with two cane in spacing 2.8 × 1.0 m, with posts supporting structure with the height of 2.0 m. Every second alleyway is grassed. Soil type, according to estimated pedological ecological unit marked as 0.08.50, which represents the blacksoil pelic, carbonate. Soil is represented by loess, loess soils and slope soils, moderate and heavier, mostly without a skeleton and a higher sloping (5–10%). Average water content in topsoil was in a range from 17.3 to 19.3 by weight.

Penetration resistance of soil in individual layers in the soil horizon was measured using a penetrometer (type PN10). The device consists of measuring needle tip, tensometric load cell sensor, optical sensor for measuring the depth, evaluation electronics with a microprocessor and battery. The measurement was carried out alternatively in a grassed and cultivated alleyway of vineyards. Individual samples were performed in the wheel tracks and in the middle of an alleyway. Control punctures were performed between the plants on the axis of the row. In each variant was performed randomly 20 punctures. To evaluate the results were used standard statistical parameters (arithmetical average, standard deviation).

RESULTS AND DISCUSSION

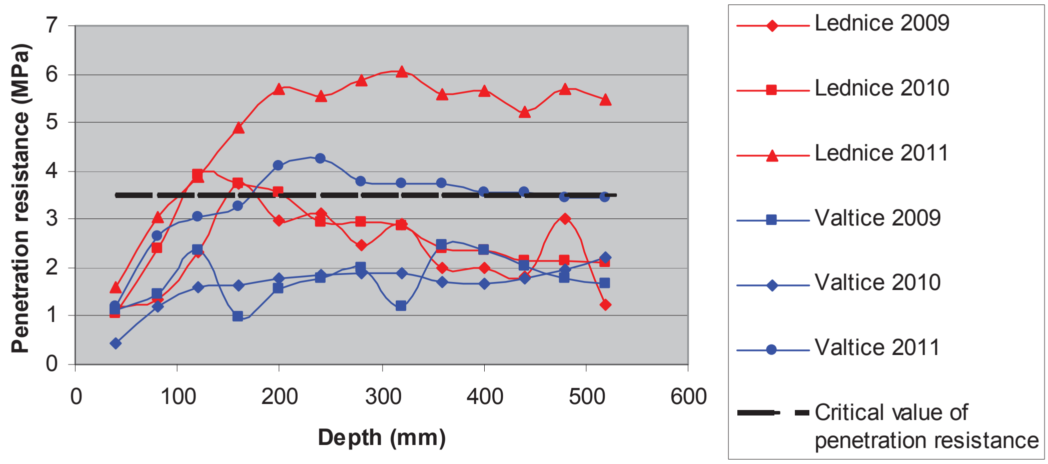
The measured values of soil penetration resistance from all localities and experimental variations are presented in a Tabs. I–V. Results of penetrometric curves are shown in Figs. 1–5. In these graphs are also plotted the limiting values of soil penetration resistance, which states LHOTSKÝ (2000).

From the comparison of values shown in Figs. 1–2 results that for variant with grassed alleyway is (except at the experimantal site Lednice 2011) very clear impact of passing of machinery in wheel tracks. The critical values (3.5 MPa) achieves penetration resistance at depths less than 0.20 m, while in the middle of the alleyway almost all measurements were not close to this value even at a depth 0.4–0.5 m. At the variants with black fallow is penetration resistances in a the wheel tracks generally higher and reach critical values at a depth of less than 0.2 m. With increasing depth are exceeding this critical value (Fig. 3). Fig. 4 shows shift of thecritical values in the middle of the alleyway to a depth 0.25–0.35 m.

The more favorable values in Valtice are caused probably by better quality of a soil environment and lower soil moisture.

I: *The values of the soil penetration resistance – grassed alleyway, wheel track*

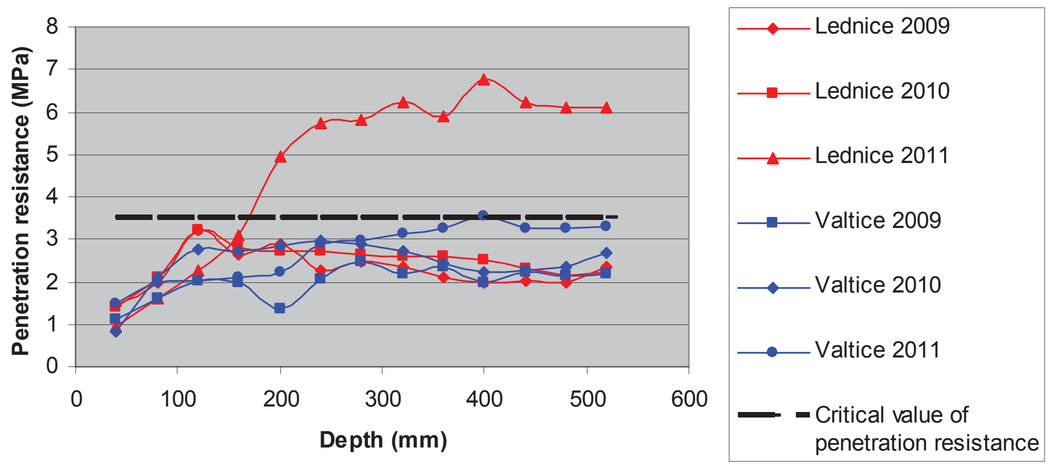
The depth (mm)	The experimantal site Lednice			The experimantal site Valtice		
	2009	2010	2011	2009	2010	2011
	Penetration resistance of soil (MPa)					
40	1.19	1.05	1.58	1.12	0.42	1.18
80	1.34	2.40	3.04	1.45	1.19	2.63
120	2.32	3.91	3.88	2.35	1.59	3.03
160	3.72	3.74	4.90	0.99	1.63	3.28
200	2.98	3.56	5.69	1.56	1.79	4.11
240	3.11	2.92	5.55	1.78	1.85	4.24
280	2.45	2.94	5.86	2.01	1.88	3.78
320	2.91	2.88	6.04	1.18	1.88	3.74
360	1.98	2.40	5.57	2.45	1.72	3.72
400	2.00	2.34	5.64	2.37	1.66	3.54
440	1.82	2.15	5.24	2.03	1.78	3.54
480	3.01	2.14	5.71	1.78	1.95	3.46
520	1.23	2.10	5.48	1.67	2.22	3.44
Average	2.31	2.66	4.94	1.75	1.65	3.36
Standard deviation	0.48	0.72	1.27	0.61	0.42	0.75



1: *The values of the soil penetration resistance – alleyway with grass, wheel track*

II: *The values of the soil penetration resistance – grassed alleyway, middle of the alleyway*

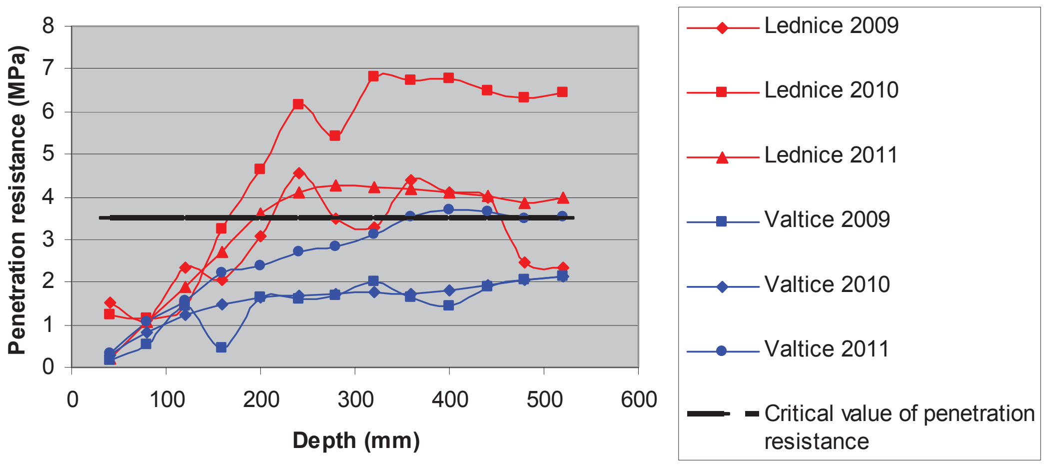
The depth (mm)	The experimantal site Lednice			The experimantal site Valtice		
	2009	2010	2011	2009	2010	2011
	Penetration resistance of soil (MPa)					
40	1.43	1.41	0.94	1.12	0.82	1.48
80	1.98	2.12	1.61	1.62	2.12	1.96
120	3.20	3.21	2.25	2.03	2.76	2.03
160	2.65	2.80	3.08	1.98	2.71	2.10
200	2.89	2.73	4.96	1.35	2.85	2.24
240	2.25	2.72	5.73	2.07	2.97	2.90
280	2.48	2.64	5.82	2.47	2.89	2.97
320	2.35	2.58	6.22	2.18	2.71	3.12
360	2.12	2.61	5.89	2.35	2.42	3.27
400	1.98	2.50	6.75	1.98	2.23	3.56
440	2.02	2.32	6.22	2.23	2.26	3.25
480	1.99	2.13	6.10	2.13	2.37	3.25
520	2.36	2.22	6.10	2.17	2.67	3.28
Average	2.28	2.46	4.74	1.98	2.44	2.72
Standard deviation	0.77	0.42	1.94	0.39	0.54	0.64



2: *The values of the soil penetration resistance– grassed alleyway, middle of the alleyway*

III: *The values of the soil penetration resistance – black fallow, wheel track*

The depth (mm)	The experimantal site Lednice			The experimantal site Valtice		
	2009	2010	2011	2009	2010	2011
	Penetration resistance of soil (MPa)					
40	1.51	1.22	0.20	0.16	0.27	0.32
80	1.12	1.13	1.06	0.55	0.82	1.08
120	2.32	1.43	1.90	1.43	1.23	1.57
160	2.06	3.24	2.70	0.45	1.46	2.22
200	3.07	4.63	3.59	1.63	1.64	2.36
240	4.54	6.16	4.10	1.58	1.70	2.69
280	3.49	5.43	4.26	1.69	1.73	2.84
320	3.27	6.81	4.24	2.03	1.77	3.10
360	4.38	6.73	4.18	1.65	1.73	3.52
400	4.12	6.76	4.11	1.45	1.79	3.68
440	3.99	6.49	4.02	1.88	1.94	3.66
480	2.45	6.33	3.86	2.06	2.06	3.49
520	2.32	6.46	3.98	2.12	2.12	3.53
Average	2.97	4.83	3.24	1.44	1.55	2.62
Standard deviation	0.63	2.51	1.31	0.46	0.49	1.03



3: *The values of the soil penetration resistance – black fallow, wheel track*

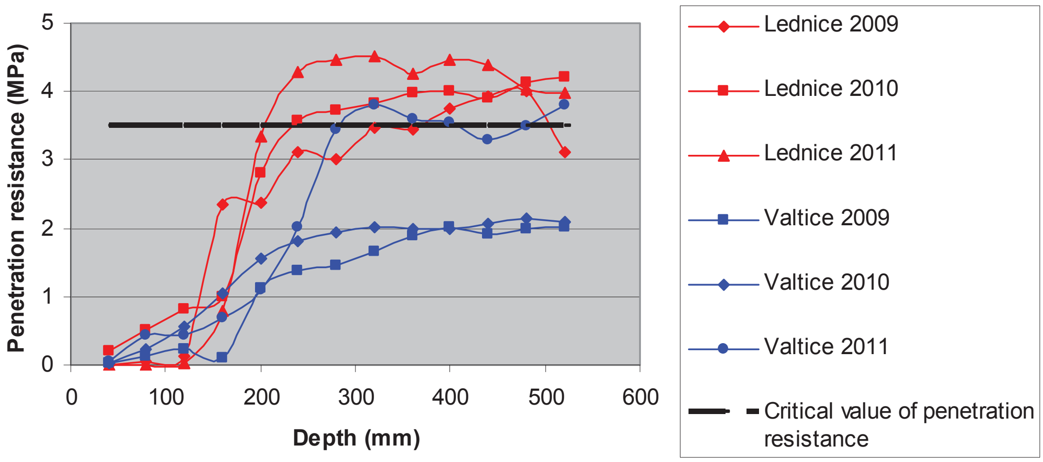
This fact is also confirmed by PEACOCK (1999), HUYSSTEEN (1983), who state that the soil compaction is the most pronounced in a wheel track, in a depth from 0.3 to 0.5 m, on soils adequately supplied with water.

It results in a slightly favorable effect on the values of the soil penetration resistance at the variant “grassed interrow”, as it is confirmed by many other authors. For example GRADWELL (1968) and PEACOCK (1999) write about the positive effect of vegetation cover on maintaining favorable soil structure, which helps to reduce the extent of compaction.

It is important to compare the values of penetration resistance at both versions in depths up to 0.15 m. While the values at the “grassed interrow” variant are higher (2.5 to 3.0 MPa), the values of the penetration resistance at the variant of black fallow, due to regular soil cultivation in these depths, varies from 1.0 to 2.0 MPa. From the grower’s perspective the black fallow created better conditions for water infiltration and also for water uptake of vines, which is particularly important in arid growing conditions. This situation is also confirmed by the results of BURG (2007), which express significantly lower values of penetration resistance at cultivated inter row in the depths of 40–80 mm.

All the graphs showed high penetration resistance values in Lednice in 2010 and 2011, which can be caused by the gradual deterioration of the soil quality at the loamy soil with the absence of organic fertilizer. That corresponds with the penetration resistance progress at this site in Fig. 1 and Fig. 2, IV: *The values of the soil penetration resistance – black fallow, middle of the alleyway*

The depth (mm)	The experimantal site Lednice			The experimantal site Valtice		
	2009	2010	2011	2009	2010	2011
	Penetration resistance of soil (MPa)					
40	0.00	0.21	0.00	0.02	0.02	0.06
80	0.05	0.50	0.00	0.14	0.22	0.43
120	0.12	0.82	0.03	0.23	0.56	0.44
160	2.34	1.00	0.78	0.09	1.04	0.69
200	2.37	2.81	3.35	1.12	1.55	1.09
240	3.11	3.56	4.28	1.37	1.80	2.02
280	3.01	3.72	4.46	1.45	1.94	3.45
320	3.46	3.83	4.52	1.67	2.02	3.80
360	3.45	3.97	4.27	1.89	1.98	3.60
400	3.74	4.00	4.46	2.01	1.98	3.55
440	3.94	3.91	4.38	1.92	2.07	3.29
480	4.00	4.12	4.02	1.99	2.15	3.50
520	3.12	4.22	3.99	2.01	2.09	3.81
Average	2.52	2.82	2.96	1.22	1.49	2.29
Standard deviation	0.82	1.49	1.87	0.53	0.74	1.46



4: *The values of the soil penetration resistance – black fallow, middle of the alleyway*

when the penetration resistance stagnated or even decreased with the depth.

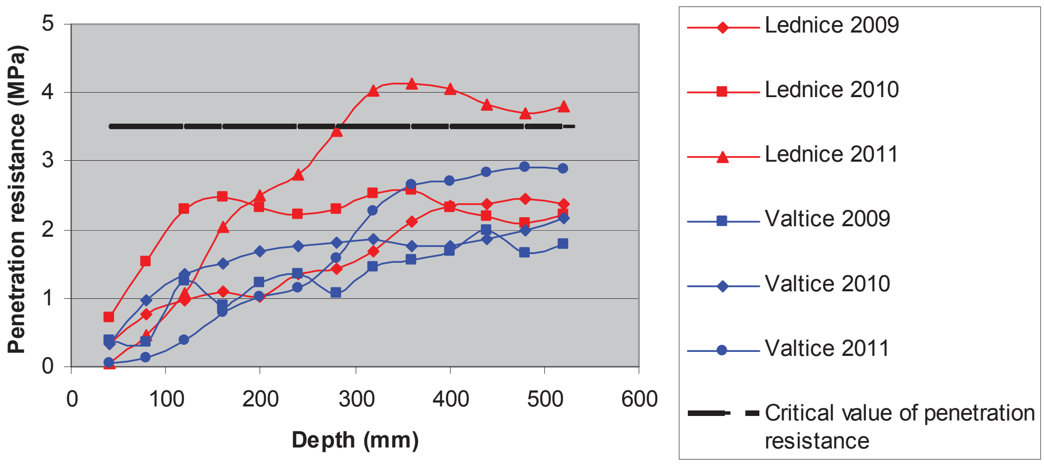
In terms of the changes in dynamics of penetration resistance, the measurements confirmed the gradual increase over three years. The values slightly increased in the first and the second year, but in the third year the values increased significantly. These facts suggest that the recommended three years long interval for deep tillage does not have to be generally applicable. When selecting the frequency of this intervention it is necessary to consider soil and growing conditions, for example soil type, inter row treating method, number of passes, type of mechanization, etc. In exact cases it can be better to use deep tillage in shorter intervals, for example two years. According to BAHAM (1999), soil cultivation helps to reduce the compaction at black-fallowed inter row in the postharvest period or before flowering at the depths of 0.10 to 0.15 m. HAMZA and ANDERSON (2005) also described the possibilities of alleviation of soil compaction using appropriate cultivation and tillage tools and treating the soil at the suitable moisture level.

CONCLUSION

The paper deals with the evaluation of soil penetration resistance at grassed inter row and cultivated vineyards in the years 2009–2011. The aim of the monitoring was to describe differences in soil penetration resistance between the observed variations at both sites. The results show that the grassed inter row reached lower penetration resistance values, but in the wheel tracks at both

V: *The values of the soil penetration resistance – the axis of the row, control*

The depth (mm)	The experimantal site Lednice			The experimantal site Valtice		
	2009	2010	2011	2009	2010	2011
	Penetration resistance of soil (MPa)					
40	0.34	0.71	0.04	0.37	0.32	0.04
80	0.76	1.52	0.47	0.35	0.96	0.13
120	0.97	2.30	1.08	1.24	1.35	0.38
160	1.10	2.47	2.04	0.89	1.51	0.78
200	1.02	2.31	2.49	1.23	1.69	1.03
240	1.34	2.21	2.81	1.34	1.76	1.14
280	1.44	2.30	3.45	1.06	1.82	1.57
320	1.68	2.52	4.02	1.45	1.85	2.28
360	2.12	2.57	4.13	1.56	1.76	2.66
400	2.35	2.31	4.05	1.68	1.76	2.71
440	2.37	2.20	3.82	2.00	1.85	2.83
480	2.45	2.10	3.70	1.65	1.99	2.92
520	2.37	2.22	3.81	1.78	2.17	2.87
Average	1.56	2.13	2.76	1.28	1.60	1.64
Standard deviation	0.74	0.47	1.38	0.70	0.46	1.07



5: *The values of the soil penetration resistance – control, axis of row*

variants showed the penetration resistance increase above the critical value of 3.5 MPa even in a depth of 0.2 m. There is a significant increase of penetration resistance in the third year. This means that when choosing the frequency of deep tillage it is necessary to consider the soil and growing conditions. Sometimes it is better to use the deep tillage in shorter intervals, for example two years.

SUMMARY

This paper deals with the monitoring of changes in the soil compaction at two sites (Lednice and Valtice) in the inter rows of vineyards during the period 2009–2011. The penetration resistance of soil was measured using a cone penetrometer (type PN 10) to a depth of 520 mm. The measurements were carried out alternatively in grassed inter row and in cultivated vineyards. Individual punctures were performed in the wheel lines and in the middle of the inter row. Control punctures were performed between the individual vines and in the axis of the rows. The results show that at both sites the penetration resistance in grassed inter rows in wheel tracks ranged from 1.65 to 3.36 MPa, in the middle of inter row from 1.98 to 4.74 MPa, in cultivated inter row in wheel tracks from 1.44 to 4.83 MPa and in the middle of inter row from 1.22 to 2.96 MPa. Inter-annual comparison of the penetration resistance showed an increase in the third year.

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REFERENCES

BAHAM, J., 1999: Soil Compaction in Western Oregon Vineyards. Results. Crop & Soil Science. Oregon State University.

BURG, P., 2007: Hodnocení penetračního odporu půdy v alleyway vinic s ohledem na používaný technologický postup. Acta universitatis agriculturae et silviculturae Mendelianae Brunensis, Roč. LV, číslo 5, s. 29–36, ISSN 1211-5816.

FLORIÁN, L., KUBÍK, M., 2010: Sledování vývoje zhutňování půdy pomocí penetrometru na vybraných plochách bazálního monitoringu půd. ÚKZUZ v Brně, Odbor bezpečnosti krmiv a půdy. Závěrečná zpráva.

GRADWELL, M.W., 1968: Compaction of pasture topsoils under winter grazing. In: Proc. 9th Int. Soil Science Conf. University of Adelaide, SA, pp. 429–435.

HAMZA, M. A., ANDERSON, W. K., 2005: Soil compaction in cropping systems: A review of the nature, causes and possible solutions. Soil and Tillage Research, Vol. 82, Issue 2, p. 121–145.

HERRICK, J. E., JONES, T. L., 2001: A Dynamic Cone Penetrometer for Measuring Soil Penetration Resistance. Dep. of Agronomy and Horticulture Univ. New Mexico. Jordana.

HUYSSTEEN, L., 1983: Interpretation and Use of Penetrometer Data to Describe Soil Compaction in Vineyards. Viticultural and Oenological Institute. Republic of South Africa.

JANDÁK, J., POKORNÝ, E., PRAX, A., 2010: Půdoznalství. Skriptum. Brno: Mendelova univerzita v Brně, 2010. 143 s. 2470. ISBN 978-80-7375-445-7.

JAVŮREK, M., VACH, M., 2008: Negativní vlivy zhutnění půd a soustava opatření k jejich odstranění. Metodika pro praxi. Praha: VÚRV, v.v.i., 26 s. ISBN 978-80-87011-57-7

KROULÍK, M., HŮLA, J., LOCH, T., 2009: Pracovní postupy pro omezení zhutnění půdy a erozního ohrožení. Mechanizace zemědělství, 2009, roč. 59, č. 4, s. 52–55. ISSN 0373-6776.

LIPIEC, J., FERRERO, A., GIOVANETTI, V., NOSALEWICZ, A., TURSKI, M., 2002: Response of structure to simulated trampling of woodland soil. Adv. Geoecol., 35 (2002), pp. 133–140.

LHOTSKÝ, J., 2000: Zhutňování půd a opatření proti němu. Praha: Ústav zemědělských a potravinářských informací, Praha, 2000. 61 s. ISBN 80-7271-067-2.

MARTINEC, J., PETRÁŠOVÁ, V., FOUKALOVÁ, J., POKORNÝ, E. a kol., 2008: Vliv vybraných fyzikálních a chemických vlastností ornice a podorničí na výnos a kvalitu cukrové řepy. In: sborník příspěvků ze semináře s mezinárodní účastí "Hodnocení zemědělského půdního fondu v podmínkách ochrany životního prostředí". 1. vyd. Praha: Ústav zemědělské ekonomiky a informací, s. 108–114. ISBN 978-80-86671-56-7.

NERUDA, J., 2008: Harvestorové technologie lesní těžby. MZLU v Brně, 150 s. ISBN 978-80-7375-146-3.

PEACOCK, B., 1999: Managing Compacted Soils in Vineyards. 26 January 1999, Symposium on University of California Cooperative Extension – Tulare County.

PROFFITT, A. P. et al., 1995: A comparison between continuous and controlled grazing on a red duplex soil. I. Effects on soil physical characteristics. Soil Tillage Res., 35 (1995), pp. 199–210.

ŠAREC, O., 1997: Vliv mechanizace na zhutňování půd a měření zhutnění půd. 4. Mezinárodní veletrh zemědělské techniky TECHAGRO Brno, s. 138–140.

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