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Influence of Bulk Density on Soil Resistance and Yield of Tobacco

Ivan Turšić[1,*], Milan Mesić[2], Ivica Kisić[2], Aleksandar Racz[3]

[1]Tobacco Institute Zagreb, Croatia
[2]Faculty of Agriculture, University of Zagreb, Croatia
[3]University of Applied Health Sciences, Zagreb, Croatia

Abstract Influence of soil compaction on the growth and development of flue-cured tobacco was investigated at the experimental station of the Tobacco institute Zagreb. Research was carried out in model trials, in Mitscherlich's pots. Three soil compaction levels (1.2, 1.4 and 1.6 gcm^{-3}) were randomized according to the block method with four replications. The soil used in the trials was the plough Iayer of Luvisol, the soil typical of the area in which flue-cured tobacco is grown in Croatia. Tobacco was picked in six harvests, and after the sixth harvest the tobacco root yield was determined by washing it out in a sieve. The soil resistance to penetration was measured during tobacco flowering, and a statistically significant increase of soil resistance (compaction) was recorded in the soil with medium and the highest bulk density compared to that with the Iowest density, increased soil compaction considerably reduced leaf yields and root development of tobacco. Tobacco leaf and root yields were significantly increased by intensified fertilization. The highest leaf and root yields were obtained in the lowest soil compaction.

Keywords Soil compaction, Soil resistance, Root development, Yield of tobacco

1. Introduction

In Croatia, flue-cured tobacco is grown on sandy and silty loam soils in the River Drava valley.

Frequent high contents of silt particles and fine sand in the soil mechanical composition, as well as shallow tillage, influenced an increase in soil compaction in the plough and sub-plough layers. High soil compaction caused reduced root development and lower tobacco leaf yields. Akehurst (1981), Hawks (1970), emphasize that flue-cured tobacco should be grown on loose soils, with a low content of organic matter, total and mineral nitrogen, slightly acid reaction (pH 5.5-6.0) and a rather light mechanical composition. The high content of fine sand and silt particles in the flue-cured tobacco production area in northern Croatia causes frequent crust formation and increased compaction of the plough layer (Butorac, Bašić, 1990). Also sub-plough horizons have increased compaction (bulk density) and reduced permeability due to the unfavourable ratio of macro and micro pores, as well as years-long shallow soil tillage (Turšić et al. 1994, Racz, Butorac et al. 1983, Soane and Ouwerkerk 1994). Lower tobacco yields are a result of soil compaction and increased bulk density, which often impedes the development of tobacco roots into deeper soil layers (Turšić, 1992).

Fertilization applied to soils of increased compaction had lower efficiency upon the yield and quality of flue-cured tobacco. Tobacco yield depends on the volume of soil in which its roots develop and from which it takes up the required nutrients. Soil compaction is often a limiting factor in tobacco production and it cannot be solved by intensified fertilization (Butorac et al., 1992, Turšić et al., 1994).

The research goal was to determine the influence of soil compaction on the root development and yield of flue-cured tobacco.

2. Materials and Methods

The investigation was carried out in the greenhouse of Faculty of Agriculture in Zagreb over the period of two years. Three levels of soil compaction were investigated (Table 1).

Table 1. Treatments of Trial

Bulk density gcm^{-3}	kg soil per pot
1.2	14.4
1.4	18.8
1.6	19.2

Soil compaction was measured in Mitscherlich vegetation pots of 12 dm^3. The field test was carried out according to block method in four repetitions. During tobacco flowering

* Corresponding author:
itursic@agr.hr (Ivan Turšić)
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period after topping, soil mechanical resistance was measured as well as soil moisture.

Tobacco was harvested six times. The yield was measured after drying of tobacco leaves. The root weight was measured at all three soil compaction levels. The results were analysed by analysis of variance.

3. Results

The trial soil was silty loam. It's bulk density in A_p horizon amounts 1.46 gcm-3 (Table 2, Picture 1).

Picture 1. Soil type (Luvisol)

The soil is subject to crust development, compaction because of 37% of silty particles and 30% of fine sand content in plough upper layers. The soil has low organic content, medium nitrogen level and good phosphorus and potassium level. The soil has acidic pH reaction (Turšić et al. 2005).

The results of field trials were confirmed by the trials in Mitscherlich vegetation pots in the greenhouse (Butorac et al. 1992, Turšić 1992). The increased soil compaction has significantly increased soil compaction (Table 4).

Picture 2. Influence of soil compaction on the growth of tobacco

The limiting values of soil mechanical resistance on tobacco root growth are between 2 and 5 MPa (Racz and Butorac, 1983, Butorac and Bašić, 1990, Soane and Ouwerkerk, 1994). In this investigation higher values of soil resistance were measured where bulk density was 1,4 and 1,6 gcm^{-3}. This lead to higher micropore content which has reduced aeration and soil water permeability. Reduced soil aeration and water infiltration has reduced the growth and development of tobacco root system and nutrients apsorption (Turšić et al. 2012).

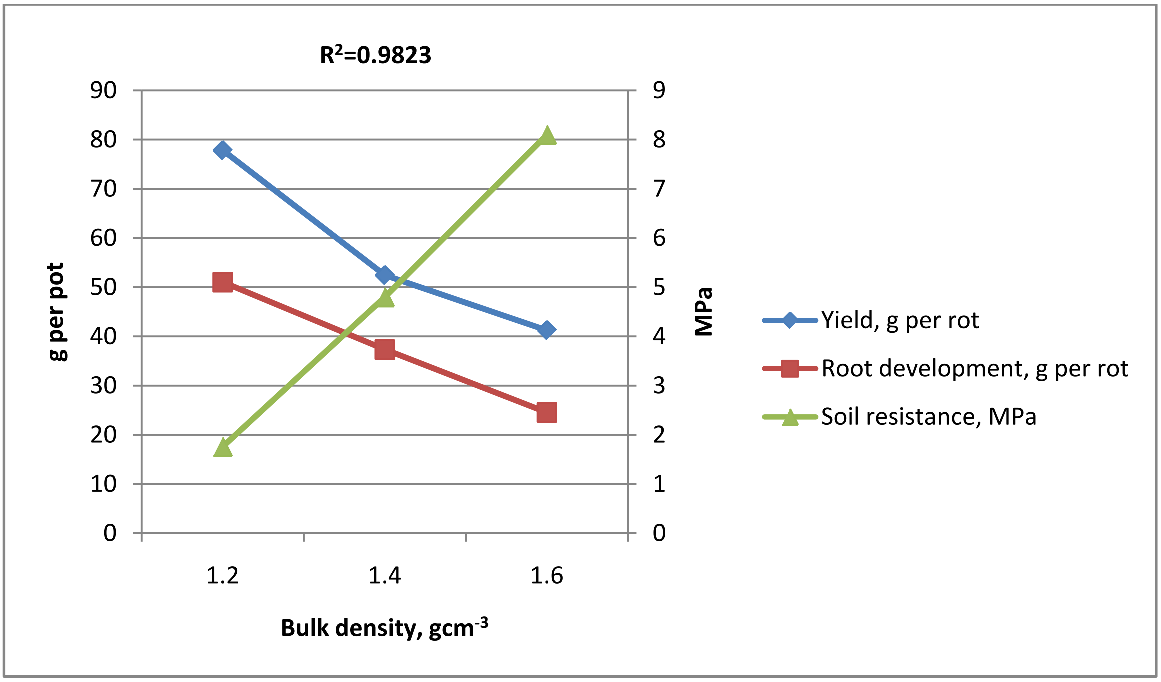
The increase of volume weight from 1,2 gcm^{-3} to 1,4 and 1,6 gcm^{-3} has decreased the root weight by 26,81% and 48,09% (Table 4).

Table 2. Main characteristics of the investigated soil

Depth cm	Texture	Bulk density gcm^{-3}	Humus %	pH in H_2O	Total nitrogen %	Available	
						P_2O_5	K_2O
						mg / 100 g	
0-28	Silty loam	1.46	1.10	5.1	0.09	14.3	21.4

Table 3. Effect of bulk density on specific resistance of soil, MPa

Specific bulk density of soil gcm^{-3}	2009		2010		Average	
	Soil resistance	Soil water content %	Soil resistance	Soil water content %	Soil resistance	Soil water content %
1.2	1.83	14.68	1.69	13.43	1.76	14.06
1.4	5.10	13.15	4.50	13.10	4.80	13.63
1.6	8.76	13.10	7.44	11.13	8.10	12.12
LSD, 5%	0.72	N.S.	0.84	1.81		



Graph 1. Influence of bulk density on soil resistance, root development and yield of tobacco

Table 4. Effect of bulk density of soil on root development

Specific bulk density of soil gcm^{-3}	Root, g per pot		Average
	2009	2010	
1.2	53.7	48.4	51.05
1.4	38.4	36.3	37.35
1.6	29.7	19.4	24.55
LSD, 5%	11.6	6.4	

This lead to lower leaf yield by 28,3% and 41,6% in first year as well as 25,4% and 43,6% in second year of investigation (Table 5, Picture 2 and Graph 1).

Table 5. Effect of bulk density on yield of tobacco, g per rot

Specific bulk density of soil gcm^{-3}	Yield, g per pot		Average
	2009	2010	
1.2	78.4	65.3	77.85
1.4	56.2	48.7	52.45
1.6	45.7	36.8	41.25
LSD, 5%	11.6	9.9	

This investigation has confirmed that higher soil compaction and unfavorable ratio of macro and micro pores have limiting impact on tobacco yield.

4. Conclusions

1. Increased soil bulk density led to increased soil resistance
2. Increased soil resistance decreased significantly the growth and development of flue-cured tobacco roots
3. Increase of soil bulk density from 1.2 to 1.4 and 1.6 gcm^{-3} led to significant decrease of tobacco leaf yield.

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