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IMPACT OF TILLAGE METHODS ON DRY MATTER WEIGHT AND ROOT DISTRIBUTION IN PLANTS CULTIVATED

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ABSTRACT

The research investigated the effect of three tillage methods: A - ploughing, B – ploughless cultivation and C - direct drilling, on the distribution and dry weight of plant roots in sandy loam soil. More abundant roots were observed in winter wheat in direct-drilling objects and in spring barley exposed to ploughing. Dry matter of roots was higher in the 0-10 cm than in the 10-20 and 20-30 cm layers. The root distribution of cultivated plants was similar.

Key words: soil tillage methods, roots, winter wheat, faba bean, spring barley, sandy loam soil

INTRODUCTION

Post-harvest residues, including plant roots, play an important role enhancing and developing physical, chemical and biological soil properties helping the stability of agricultural ecosystems and environmental protection. The amount and quality of root system depend on habitat conditions, plant species as well as the tillage method [1,2,3,4,5,6,8,9,10].

The research aimed at defining the impact of three soil tillage methods, A - ploughing, B – ploughless cultivation, C - direct drilling, on the root dry weight and vertical distribution of faba bean, winter wheat and spring barley cultivated on light soil.

MATERIALS AND METHODS

A 1994-1996 field experiment was carried out on good-rye-soil-suitability-complex soil of light loamy sand with 13% of silt-and-clay content and 1.3% of humus in topsoil. The investigation included complete randomised blocks in four replications at the harvest plot size of 40 sq.m. The factors compared were, as follows:

I – three tillage methods: A - ploughing, B - ploughless cultivation, C-direct drilling,
II – three crops: faba bean -winter wheat - spring barley+ stubble intercrop (white mustard).

The traditional-soil-cultivation object – (A) was exposed to, depending on crop rotation (faba bean-winter wheat-spring barley + stubble intercrop) post-harvest skimming to the depth of 10-12 cm, pre-sowing ploughing to the depth of 18-20 cm and soil loosening and levelling prior to drilling with a tillage aggregate. In the non-ploughed object (B) skimming and pre-sowing ploughing were replaced with fixed-teeth cultivation (14 -16 cm). The direct-drilling object (C) was not exposed to tillage, while the drilling was done with a single-disc opener driller.

Faba bean 'Nadwislanski' cultivar was sown at the amount corresponding to 70 seeds, winter wheat 'Almari' cultivar to 700 grains, spring barley 'Klimek' cultivar to 420 grains per sq.m. Phosphorus and potassium fertilisation doses depended on the soil richness and the requirements of the plants cultivated. The nitrogen doses were as follows: for faba bean - 60, winter wheat - 100 and spring barley - 70 kg $N \cdot ha^{-1}$. Throughout the vegetation period the plants were protected against agrophages, as specified by the agronomic guidelines.

Post-harvest residue dry matter was defined after the harvest from two sites of each plot. Soil was sampled with a steel cylinder of 400 cm^2 down to 30 cm, dividing them into the following layers: 0-10, 10-20 and 20-30 cm. The roots were rinsed in the running water with about-1mm-in-diameter mesh sieve, then they were dried and weighed. The results were analysed statistically with a variance analysis; the significance of differences found between the mean values was evaluated with the Tukey test. Throughout the experiment, the most favourable climatic conditions for growth, development and plant yielding were observed in 1996, less favourable – in 1995, while least favourable in 1994.

RESULTS

The soil tillage methods compared applied in crop-rotation did not cause significant differences in the root dry matter weight of the plants cultivated (Table 1). Yet there was observed a tendency towards producing less root dry matter in faba bean and spring barley when exposed to ploughless cultivation and direct-drilling. Regardless of the soil tillage method employed, a similar root dry matter weight was obtained for all the plants from the 0-30 cm soil layer; however a slightly greater weight, although not statistically proved, was noted for cereals. However there was shown a significance of the interaction between soil tillage methods and plant species. Winter wheat in direct-drilling object, and spring barley cultivated in ploughed soil produced a significantly greater root dry matter, as compared with faba bean in direct-drilling object. The other objects did not show any such differences.

Vertical root distribution in the layers analysed, regardless of the soil tillage method, varied significantly yet it was similar in the plants tested and amounted to 49.0 - 52.3% obtained from the 0 -10 cm, 28.8 - 30.0% from the 10-20 cm and 18.9-30,0% from the 20-30 cm layers (Table 2). Root dry matter from the 0-10 cm layer was significantly greater than from the two other deeper layers yet the differences between them were not statistically proved. Regardless of the soil tillage method, cereals, spring barley, especially, produced more root dry matter in the 0-10 cm layer than faba bean did, while faba bean – in the 10-20 cm layer produced more than cereals. The percentage of roots of the plants tested in respective soil layers depending on the soil tillage method is presented in Fig. 1.

Greater differences in the root dry matter weight were noted for the 10-20 cm layer. Faba bean and spring barley gave lower root dry matter weight values from that layer in direct-drilling objects, while winter wheat - in ploughless cultivation objects, as compared with the other soil tillage methods.

Table 1. Root dry weight mean ($g \cdot m^{-2}$) for 1994-1996

Tillage method	Species			Mean
	Faba bean	Winter wheat	Spring barley	
A – Ploughing	374.4	357.5	418.2	383.4
B - Ploughless cultivation	327.9	381.2	375.5	361.5
C - Direct drilling	320.9	419.3	380.1	373.4
Mean	341.1	386.0	391.3	372.8
$LSD_{0.05}$	For tillage method - ns Species - ns For interaction of tillage systems x species = 92.0			

ns – non-significant differences

Table 2. Distribution of root dry weight, mean ($g \cdot m^{-2}$) for 1994-1996

Tillage method	Faba bean				Winter wheat				Spring barley			
	Soil layer (cm)											
	0-10	10-20	20-30	0-30	0-10	10-20	20-30	0-30	0-10	10-20	20-30	0-30
A	172.8	114.8	86.7	374.4	180.3	113.5	63.8	357.6	217.3	119.4	81.5	418.2
B	153.9	109.6	64.4	327.9	197.2	97.7	86.3	381.2	179.8	124.3	71.4	375.5
C	170.7	87.5	62.7	320.9	208.5	133.1	77.7	419.3	216.8	94.8	68.5	380.1
Mean	165.8	104.0	71.3	341.1	195.3	111.1	75.9	386.0	204.6	112.8	73.8	391.3
%	49.0	30.0	21.0	100	50.6	28.8	19.6	100	52.3	28.8	18.9	100
$LSD_{0.05}$ for	layers = 41.2				layers = 68.7				layers = 44.7			

A, B, C – see, Table 1

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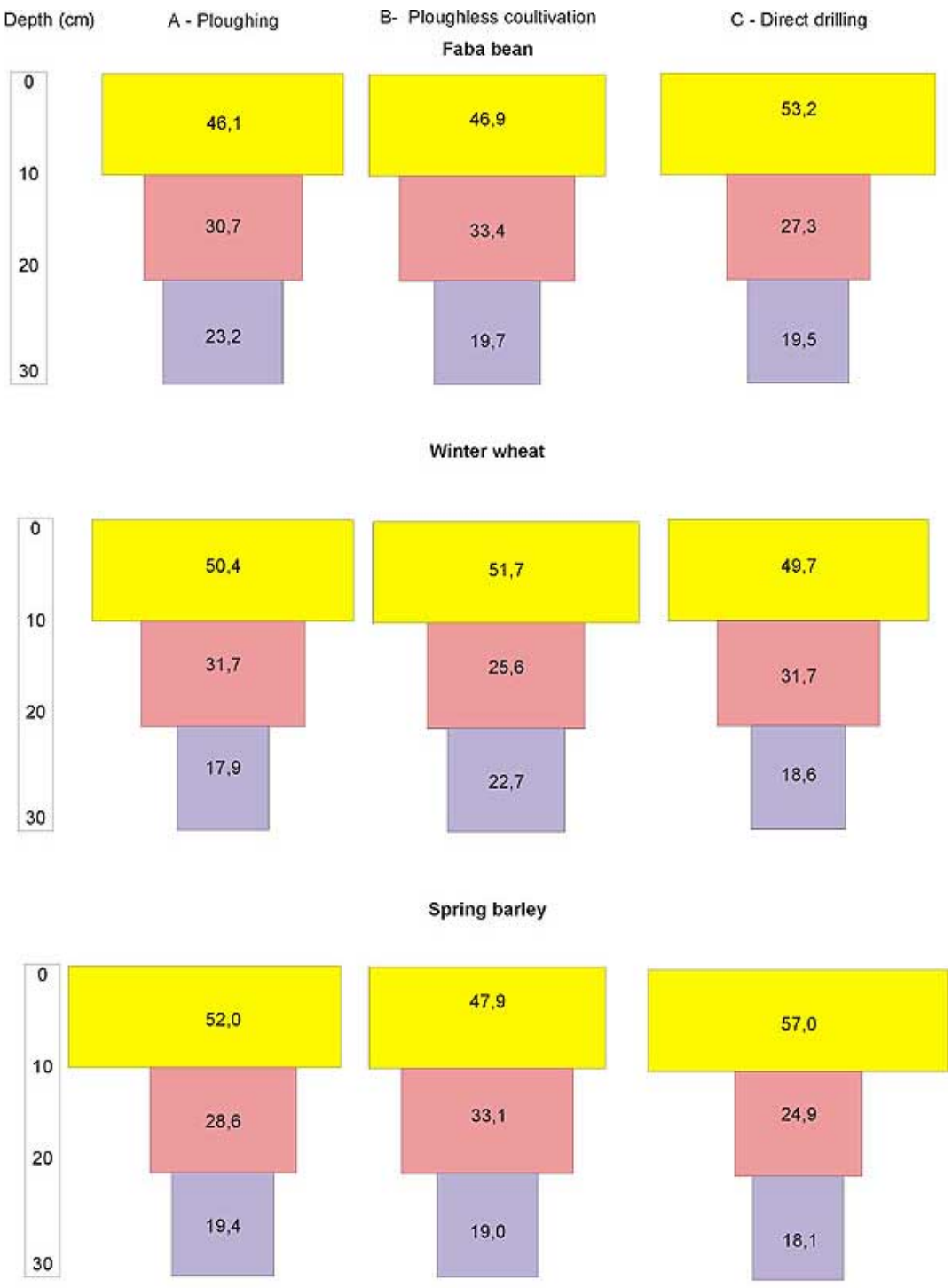
Figure 1. Effect of tillage method on root distribution within the soil profile, % of total root weight (1994-1996)



DISCUSSION

The plants tested gave, regardless of the soil tillage method, a similar root dry matter weight from the 0-30 cm layer. In a similar experiment conducted on limestone soil [10], a significantly greater weight value was obtained for faba bean as compared with those determined for winter wheat and spring barley, while the dry matter weight of cereal roots was lower than those reported in the present experiment. The soil tillage methods compared did not cause significant differences in the root dry matter weight in the layer investigated. However Palys and

Kuraszkiewicz [10] found a greater root dry matter weight of the plants cultivated in the direct-drilling objects. Out of all the plants researched, winter wheat gave the greatest root dry matter weight in the direct-drilling objects, while spring barley in ploughed object. Similarly a vertical root distribution on light soil differs from that of the plants cultivated on the limestone soil [9]. Ehlers et al. [4] and Goss et al. [7] relate a greater root mass produced by winter wheat when exposed to direct-drilling as well as when exposed to shallow tillage to a more abundant development of the root system, increased number of bio-ducts and bio-pores produced by the forecrop. Besides Drew [3] and Goss [6] claim that a greater phosphorus concentration in the upper parts of soil profile on no-tillage objects can stimulate a development of lateral roots. Braim et al. [1], Ellis et al. [5] claim that the spring barley root system on sandy loam soil was less developed when exposed to direct drilling as well to a shallow cultivation depth, which Braim et al. [1] relate to a slower rate of nitrogen uptake.

CONCLUSIONS

1. Of all the plants investigated, winter wheat produced a greater root mass in direct-drilling objects, while spring barley when exposed to ploughing.
2. A greater root weight was noted in the 0-10 cm layer, as compared with the 10-20 and 20-30 cm layers.
3. Faba bean and spring barley produced less root mass in the 10-20-cm layer on the direct-drilling objects, while winter wheat when exposed to ploughless cultivation.

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