Conservation tillage in faba bean cultivation: weed seed bank

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The actuality of investigations. The current agricultural system aims to reduce tillage intensity through the use of innovative tillage technologies. Faba beans are particularly sensitive to weed competition, so detailed research is needed due to the lack of experimental data on the effects of different tillage technologies on weed seed bank content.

Materials and methods

Research was conducted in Vytautas Magnus University, Agriculture Academy (Lithuania), five contrasting tillage system were tested: deep and shallow mouldboard ploughing, deep cultivation-subsoiling, shallow cultivation-disking and no-tillage. The experimental data of 2016–2018 is discussed. Sampling was performed at the end of the growing season of faba bean (BBCH 75–79). The experimental site is located in Central Lithuania (54º52′ N, 23º49′ E) with an annual average air temperature of 6.7°C and an annual precipitation rate of 590–625 mm. The soil of the experimental site is silt loam Planosol (WRB 2014) neutral in reaction, high in phosphorus and medium in potassium.

The weed seed bank in the soil was determined at 0–15 and 15–25 cm depths shortly after the primary tillage in the autumn in at least 10 spots per each plot. Soil samples were taken with an agrochemical auger, mixed and a composite the average sample was formed. The soil sample (100 g) was dried and sieved through a 0.25 mm sieve, washed with a stream of running water until the soil particles were removed. Weed seeds and the remaining part of the mineral soil were separated from the organic part by a saturated saline solution (Stancevičius 1980).

Results

In our experiment, the weed seed bank was abundant, and in individual years and differently tilled plots amounted to 222 000 seeds m^{-2} or 2.22 million seeds per hectare . Wei et al. (2005) have found that the aboveground part of weeds has the greatest effect on the weed seed bank.

Table 1. Weed seed bank (thousand weeds m-2 at different soil layers, 2016

Weed species	Tillage systems				
	DP	SP	DC	SC	NT
0-15 cm					
Anual:					
Chenopodium album L.	**54.0**	**37.8**	**57.7**	**68.7**	**50.4**
Echinochloa crus galli (L.) P. Beauv.	**1.5**	**10.5**	**5.2**	**7.3**	**0.0**
Fallopia convolvulus (L.) A. Löve	**0.0**	**0.0**	**1.5**	**2.6**	**1.0**
Persicaria lapathifolia L.	**2.1**	**9.4**	**7.3**	**5.7**	**9.9**
Sinapis arvensis L.	**6.8**	**6.8**	**5.7**	**3.1**	**1.0**
Other annual	**0.1**	**0.6**	**0.3**	**1.0**	**0.7**
Total annual	**64.5b**	**65.1b**	**77.7ab**	**88.4**a**	**63.0b**
Perennial:					
Cirsium arvense L.	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**
Elytrigia repens L.	**6.3**	**6.3**	**9.9**	**3.6**	**5.2**
Sonchus arvensis L.	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**
Other perennial	**0.0**	**0.0**	**2.1**	**0.6**	**0.6**
Total perennial	**6.3a**	**6.3a**	**12.0a**	**4.2a**	**6.8**
Total weeds:	**70.8b**	**71.4b**	**89.7a**	**92.6*a**	**69.8b**
15–25 cm					
Annual					
Chenopodium album L.	**105.8**	**49.8****	**28.0*****	**25.3*****	**21.8*****
Echinochloa crus galli (L.) P. Beauv.	**11.3**	**11.3**	**0.0**	**0.8***	**0.8**
Fallopia convolvulus (L.) A. Löve	**0.8**	**0.8**	**0.8**	**0.8**	**0.0**
Persicaria lapathifolia L.	**5.2**	**5.2**	**5.2**	**0.0**	**3.5**
Sinapis arvensis L.	**10.5**	**5.2**	**3.5**	**0.8**	**15.7**
Other annual	**0.2**	**13.4***	**0.1**	**0.3**	**0.2**
Total annual	**133.8a**	**85.7*b**	**37.6***c**	**28.0***c**	**42.0***bc**
Perennial:					
Juncus bufonius (L.)	**8.7**	**29.7**	**44.6**	**155.5*****	**112.8*****
Other perennial	**1.0**	**1.8**	**0.0**	**0.0**	**0.0**
Total perennial	**9.7b**	**31.5b**	**44.6b**	**115.5***a**	**112.8***a**
Total weeds:	**143.5a**	**117.2b**	**82.2c**	**143.5a**	**154.8s**

Note: DP = deep ploughing; SP = shallow ploughing; DC = deep cultivation; SC = shallow cultivation; NT = no-tillage (direct drilling). * = significant difference at the 95% probability level ($p \leq 0.05 > 0.01$); ** = at the 99% probability level ($p \leq 0.01 > 0.001$); *** = at the 99.9% probability level ($p \leq 0.001$) and $p > 0.05$ = there is no significant difference at the 95% probability level. Different letters mean significant difference between all treatments at $p \leq 0.05$.

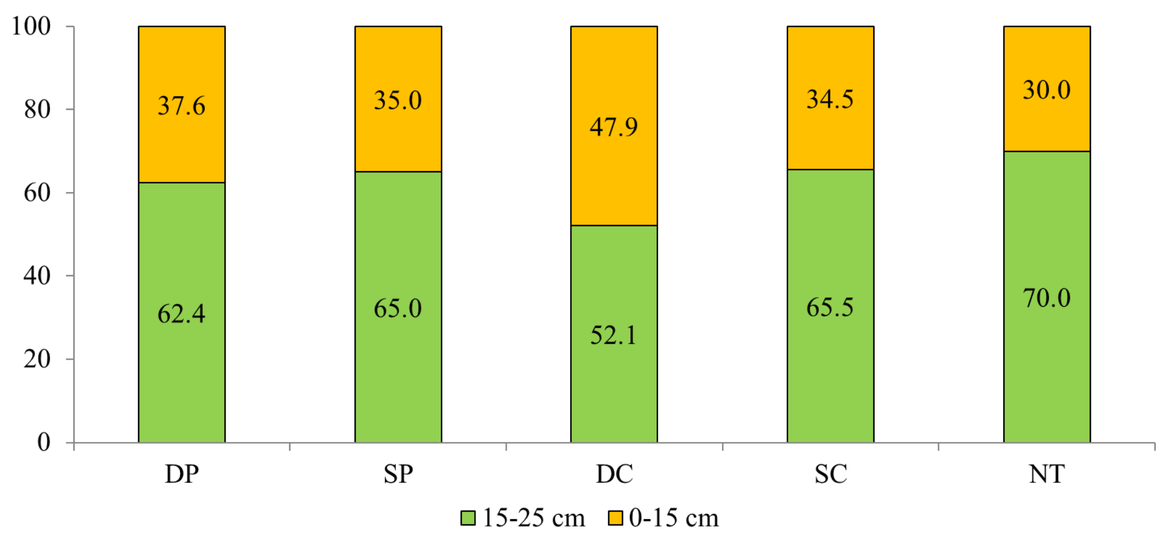
In experiment, in contrast to the upper layer, greater differences in weed seeds were found in the deeper (15–25 cm) soil layer. With decreasing tillage intensity, the number of incorporated weed seeds decreased, it was significantly the highest in the DP plots. *Chenopodium album* L. weeds had the greatest effect on these findings.

The correlation analysis of our experimental results showed a moderately strong relationship (r = 0.583) between the number of annual weeds at the beginning of vegetative period (BBCH 25–27) and the seed bank of annual weeds at the 0–15 cm soil layer, although this relationship for *Echinochloa crus galli* L. species was stronger and more significant (r = 0.919*). Similar relationships were found between the number of weeds of all species and seed bank at the beginning of vegetative period (r = 0.62) and at the end (BBCH 75–79) (r = 0.660).

Table 2. Weed seed bank (thousand weeds m-2 at different soil layers, 2017-2018

Weed species	Tillage systems				
	DP	SP	DC	SC	NT
	2017				
0-15 cm					
Total annual	**55.1ab**	**44.6ab**	**45.6ab**	**64.5a**	**30.9*b**
Total perennial	**1.5a**	**3.1a**	**7.8a**	**6.8a**	**8.4a**
Total weeds:	**56.6b**	**47.7bc**	**53.4b**	**71.3a**	**39.3c**
15–25 cm					
Total annual	**55.2b**	**94.5*a**	**47.2b**	**48.1b**	**29.7b**
Total perennial:	**0.8b**	**17.5b**	**26.5b**	**174.1**a**	**114.6ab**
Total weeds	**56.0d**	**112.0bc**	**73.7cd**	**222.1*a**	**144.3b**
	2018				
0-15 cm					
Total annual	**77.7a**	**92.4a**	**112.8a**	**107.6a**	**9.3a**
Total perennial	**1.5a**	**0.0a**	**4.2a**	**0.0a**	**0.0a**
Total weeds:	**79.2c**	**92.4bc**	**117.0a**	**107.6ab**	**91.3bc**
15–25 cm					
Total annual	**96.2a**	**151.3a**	**89.2a**	**149.6a**	**167.1a**
Total perennial:	**47.2a**	**12.2a**	**37.6a**	**0.0a**	**1.7a**
Total weeds	**143.4b**	**163.6a**	**126.8b**	**149.6a**	**168.8a**

Note: DP = deep ploughing; SP = shallow ploughing; DC = deep cultivation; SC = shallow cultivation; NT = no-tillage (direct drilling). * = significant difference at the 95% probability level ($p \leq 0.05 > 0.01$); ** = at the 99% probability level ($p \leq 0.01 > 0.001$); *** = at the 99.9% probability level ($p \leq 0.001$) and $p > 0.05$ = there is no significant difference at the 95% probability level. Different letters mean significant difference between all treatments at $p \leq 0.05$.



Notes: DP = deep ploughing (control treatment), SP = shallow ploughing, DC = deep cultivation, SC = shallow cultivation, NT = no-tillage (direct drilling). $p > 0.05$

Fig 1. The distribution of weed seed bank (%) between the two soil layers, averaged data of 2016–2018

Conclusions

On average, the highest number of seeds of the total weed species in the ploughlayer was found in the SC and NT plots, but the differences were insignificant compared with the other treatments. Moderately strong correlations were found between the abundance of weeds in the faba bean crop and weed seed bank. The weed seed bank in the ploughlayer was almost evenly distributed between the layers (0–15 cm and 15–25 cm) and did not differ significantly between the tillage systems.