

Table S1. The list of weed species in an experiment.

Annual weeds	Perennial weeds
<u>Spring/summer:</u>	<i>Artemisia vulgaris</i> L.
<i>Chenopodium album</i> L.	<i>Cerastium arvense</i> L.
<i>Echinochloa crus galli</i> (L.) P. Beauv.	<i>Cirsium arvense</i> (L.) Scop.
<i>Euphorbia helioscopia</i> L.	<i>Convolvulus arvensis</i> L.
<i>Fallopia convolvulus</i> (L.) A. Löve	<i>Rumex crispus</i> L.
<i>Galeopsis tetrahit</i> L.	<i>Elytrigia repens</i> L.
<i>Roripa palustris</i> Bess.	<i>Equisetum arvense</i> L.
<i>Persicaria lapathifolia</i> L.	<i>Juncus bufonius</i> L.
<i>Polygonum aviculare</i> L.	<i>Plantago lanceolata</i> L.
<i>Raphanus raphanistrum</i> L.	<i>Plantago major</i> L.
<i>Sinapis arvensis</i> L.	<i>Ranunculus repens</i> L.
<u>Fallow/winter:</u>	<i>Rumex acetosella</i> L.
<i>Galium aparine</i> L.	<i>Sonchus arvensis</i> L.
* <i>Poa annua</i> L.	<i>Stachys palustris</i> L.
* <i>Stellaria media</i> (L.) Vill.	<i>Taraxacum officinale</i> F. H. Wigg.
<i>Tripleurospermum perforatum</i> (Merat) M. Lainz	<i>Vicia cracca</i> L.
<i>Viola arvensis</i> Murray	
<i>Veronica arvensis</i> L.	

Note: *-belongs to this group for the last 10–15 years due to milder wintering conditions.

Table S2. Density (number m⁻²) of the most widespread weeds at different faba bean growth stages, as influenced by the tillage system in 2016–2018.

Most abundant weed species	Tillage systems				
	DP	SP	DC	SC	NT
2016					
BBCH 25–27					
Annual:					
<i>Chenopodium album</i> L.	1.6	2.0	6.6	2.5	5.4
<i>Echinochloa crus galli</i> (L.) P. Beauv.	30.8	37.9	16.2	18.3	8.3*
<i>Fallopia convolvulus</i> (L.) A. Löve	14.1	18.3	16.6	26.2	10.0
<i>Sinapis arvensis</i> L.	1.2	9.1**	7.0	4.1	3.3
Total annual	59.5ab	74.1a	71.2a	72.0a	50.8b
Perennial:					
<i>Cirsium arvense</i> L.	0.0	2.0	2.0	3.7	5.0*
<i>Elytrigia repens</i> L.	0.0	0.0	1.2	0.4	1.6
<i>Equisetum arvense</i> L.	0.0	0.0	0.0	0.0	9.5**
<i>Plantago major</i> L.	2.9	3.3	8.3	15.4	12.9
Total perennial	4.5b	6.6b	14.1b	19.5ab	34.5a**
Total weeds:	64.1a	80.7a	85.4a	91.6a	85.4a
BBCH 75–79					
Annual:					
<i>Chenopodium album</i> L.	0.0	1.6	0.0	1.6	1.2
<i>Echinochloa crus galli</i> (L.) P. Beauv.	28.7	25.8	14.5	22.4	6.6
<i>Fallopia convolvulus</i> (L.) A. Löve	5.4	7.1	4.1	9.5	3.3
<i>Persicaria lapathifolia</i> L.	0.0	0.4	1.6	2.0	11.2***
Total annual	35.8a	36.6a	24.1a	38.7a	25.4a
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.8	1.2	2.9	8.7**
<i>Elytrigia repens</i> L.	0.0	0.0	0.0	0.8	0.0
<i>Equisetum arvense</i> L.	0.0	0.0	0.0	0.0	5.4

<i>Plantago major</i> L.	0.8	2.4	6.2	12.4	15.8
Total perennial	0.8b	3.3b	12.5ab	16.2ab	30.4a*
Total weeds:	36.6a	39.9a	36.6a	54.9a	55.8a

2017

BBCH 25–27

Annual:					
<i>Chenopodium album</i> L.	3.3	2.9	4.1	3.3	2.9
<i>Echinochloa crus galli</i> (L.) P. Beauv.	19.9	22.9	39.1	62.9**	4.1
<i>Fallopia convolvulus</i> (L.) A. Löve	24.9	43.7	34.5	22.0	3.7
<i>Persicaria lapathifolia</i> L.	11.6	3.7	1.2	1.2	3.7
<i>Sinapis arvensis</i> L.	3.3	2.9*	4.1	3.3	2.9*
Total annual	104.6a	97.5a	103.7a	119.1a	20.9b**

Perennial:					
<i>Cirsium arvense</i> L.	0.4	0.4	0.0	1.2	1.2
<i>Elytrigia repens</i> L.	0.0	0.4	1.2	1.2	0.0
<i>Equisetum arvense</i> L.	0.4	4.5	0.0	1.2	2.9
<i>Plantago major</i> L.	1.2	0.0	0.8	0.4	0.0
Total perennial	2.9a	5.4a	3.3a	4.5a	4.1a
Total weeds:	107.5a	102.9a	107.0a	123.6a	25.0b**

BBCH 75–79

Annual:					
<i>Chenopodium album</i> L.	3.3	0.0	0.0	0.0	0.4
<i>Echinochloa crus galli</i> (L.) P. Beauv.	9.2	10.0	8.8	11.6	9.2
<i>Fallopia convolvulus</i> (L.) A. Löve	2.5	5.0	8.8	5.0	1.7
<i>Persicaria lapathifolia</i> L.	3.8	0.0	0.0	0.0	0.0
<i>Sinapsis arvensis</i> L.	2.5	0.0	0.0	0.0	2.1
Total annual	27.9a	17.0a	18.7a	17.6a	17.9a

Perennial:					
<i>Elytrigia repens</i> L.	2.5	2.9	1.6	1.2	0.8
<i>Cirsium arvense</i> L.	0.4	0.4	0.0	1.2	1.2
<i>Equisetum arvense</i> L.	0.0	1.7	0.0	0.0	4.6
<i>Plantago major</i> L.	0.0	0.0	1.3***	0.0	0.0
Total perennial	2.5a	4.6a	2.9a	1.2a	5.4a
Total weeds:	30.4a	21.6a	21.6a	18.8a	23.3a

2018

BBCH 25–27

Annual:					
<i>Chenopodium album</i> L.	14.5	7.5	5.0	6.7	7.5
<i>Echinochloa crus galli</i> (L.) P. Beauv.	5.0	17.0	29.1	17.9	57.9
<i>Fallopia convolvulus</i> (L.) A. Löve	3.7	5.0	2.5	1.6	0.0
<i>Persicaria lapathifolia</i> L.	22.5	17.5	12.0	11.2	35.8
<i>Sinapis arvensis</i> L.	7.9	5.0	0.8*	0.4*	3.3
Total annual	103.7b	130.4b	132.9b	117.3b	226.6a*

Perennial:					
<i>Cirsium arvense</i> L.	0.8	5.4	2.0	17.0**	0.4
<i>Elytrigia repens</i> L.	0.0	1.2	0.4	1.6	1.2
<i>Equisetum arvense</i> L.	0.0	0.0	0.8	0.0	0.0
<i>Plantago major</i> L.	2.1	7.0	5.8	6.6	17.0
Total perennial	2.9b	14.2ab	9.5 ab	25.4a*	19.6 ab
Total weeds:	106.6b	144.6b	142.4b	142.7b	246.2a*

BBCH 75–79

Annual:					
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<i>Chenopodium album</i> L.	12.9	11.6	4.1	7.0	11.2
<i>Echinochloa crus galli</i> (L.) P. Beauv.	9.1	8.3	16.2	13.7	17.9
<i>Fallopia convolvulus</i> (L.) A. Löve	3.3	3.7	0.8	1.6	0.8
<i>Persicaria lapathifolia</i> L.	9.1	5.0	5.4	3.7	10.8
Total annual	45.8b	40.0b	42.5b	39.1b	62.3a*
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.0	0.0	1.9	0.4
<i>Elytrigia repens</i> L.	0.0	5.8	0.8	0.0	0.4
<i>Plantago major</i> L.	0.8	6.2	9.2	6.5	18.0
Total perennial	0.8b	12.9a*	10.0ab	8.4ab	19.5a*
Total weeds:	46.6b	52.9b	52.5b	47.5b	80.8a*

DP–deep ploughing (control treatment), SP–shallow ploughing, DC–deep cultivation, SC–shallow cultivation, NT–no-tillage (direct drilling). * significant difference at $p \leq 0.05 > 0.01$, ** at $p \leq 0.01 > 0.001$, *** at $p \leq 0.001$. $p > 0.05$ indicates no significant difference compared with DP. Different letters indicate significant differences between all treatments at $p \leq 0.05$.

Table S3. Air-dried biomass (g m^{-2}) of aerial part of the most widespread weeds at faba bean BBCH 75–79 growth stages as influenced by the tillage system in 2016–2018.

Most abundant weed species	Tillage systems				
	DP	SP	DC	SC	NT
2016					
Annual:					
<i>Chenopodium album</i> L.	0.0	5.9	0.0	2.0	1.3
<i>Echinochloa crus galli</i> (L.) P. Beauv.	92.6	65.2	61.8	54.5	13.5
<i>Fallopia convolvulus</i> (L.) A. Löve	3.8	5.6	3.2	5.4	1.5
<i>Persicaria lapathifolia</i> L.	0.0	0.1	2.0	0.8	27.9*
Total annual	104.5a	77.3ab	71.8ab	64.2ab	47.9b*
Perennial:					
<i>Cirsium arvense</i> L.	0.0	2.7	1.9	8.9	83.2*
<i>Elytrigia repens</i> L.	0.0	0.0	0.0	0.3	0.0
<i>Equisetum arvense</i> L.	0.0	0.0	0.0	0.0	5.2
<i>Plantago major</i> L.	1.0	1.6	4.9	10.5	4.9
Total perennial	1.0a	4.3a	28.1ab	19.9ab	93.6b*
Total weeds:	105.5a	81.6a	100.0a	84.1a	141.5a
2017					
Annual:					
<i>Chenopodium album</i> L.	0.4	0.0	0.0	0.0	0.0
<i>Echinochloa crus galli</i> (L.) P. Beauv.	27.0	27.7	25.4	30.1	19.4
<i>Fallopia convolvulus</i> (L.) A. Löve	1.0	5.5	8.3	6.2	0.1
<i>Persicaria lapathifolia</i> L.	1.6	0.0	0.0	0.0	0.0
<i>Sinapis arvensis</i> L.	1.9	0.0	0.0	0.0	0.9
Total annual	34.4a	34.0a	34.7a	36.7a	21.2a
Perennial:					
<i>Elytrigia repens</i> L.	1.3	5.0	5.8	2.5	0.9
<i>Equisetum arvense</i> L.	0.0	1.7	0.0	0.0	7.1
<i>Plantago major</i> L.	0.0	0.0	0.6***	0.0	0.0
Total perennial	1.3a	8.2a	6.4a	2.5a	9.6a
Total weeds:	35.7a	42.2a	41.1a	39.2a	30.8a
2018					
Annual:					
<i>Chenopodium album</i> L.	95.7	79.6	23.6	53.3	64.4
<i>Echinochloa crus galli</i> (L.) P. Beauv.	66.2	25.6	80.8	49.2	17.9
<i>Fallopia convolvulus</i> (L.) A. Löve	3.9	7.0	3.0	3.7	0.4

<i>Persicaria lapathifolia</i> L.	21.4	9.4	6.3	3.7	19.2
Total annual	203.2a	154.6a	155.5a	159.7a	185.9a
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.0	0.0	23.2	0.3
<i>Elytrigia repens</i> L.	0.0	26.8	2.4	0.0	0.6
<i>Plantago major</i> L.	0.6	12.4	61.2*	22.5	17.9
Total perennial	0.6b	39.4ab	63.7a*	45.8ab	18.9ab
Total weeds:	203.8a	194.0a	219.2a	205.5a	204.8a

DP–deep ploughing (control treatment), SP–shallow ploughing, DC–deep cultivation, SC–shallow cultivation, NT–no-tillage (direct drilling). * significant difference at $p \leq 0.05 > 0.01$, ** at $p \leq 0.01 > 0.001$. $p > 0.05$ indicates no significant difference compared with DP. Different letters indicate significant differences between all treatments at $p \leq 0.05$.

Table S4. The most widespread weed seed bank (thousand weed seeds m^{-2}) in different soil layers, as influenced by the tillage system in 2016–2018.

Most abundant weed species	Tillage systems				
	DP	SP	DC	SC	NT
2016					
0–15 cm					
Annual:					
<i>Chenopodium album</i> L.	54.0	37.8	57.7	68.7	50.4
<i>Echinochloa crus galli</i> (L.) P. Beauv.	1.5	10.5	5.2	7.3	0.0
<i>Fallopia convolvulus</i> (L.) A. Löve	0.0	0.0	1.5	2.6	1.0
<i>Persicaria lapathifolia</i> L.	2.1	9.4	7.3	5.7	9.9
<i>Sinapis arvensis</i> L.	6.8	6.8	5.7	3.1	1.0
Total annual	64.5b	65.1b	77.7ab	88.4a**	63.0b
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.0	0.0	0.0	0.5
<i>Elytrigia repens</i> L.	6.3	6.3	9.9	3.6	5.2
<i>Sonchus arvensis</i> L.	0.0	0.0	0.0	0.0	0.5
Total perennial	6.3a	6.3a	12.0a	4.2a	6.8a
Total weeds:	70.8b	71.4b	89.7a*	92.6*a	69.8b
15–25 cm					
Annual:					
<i>Chenopodium album</i> L.	105.8	49.8**	28.0***	25.3***	21.8***
<i>Echinochloa crus galli</i> (L.) P. Beauv.	11.3	11.3	0.0*	0.8*	0.8*
<i>Fallopia convolvulus</i> (L.) A. Löve	0.8	0.8	0.8	0.8	0.0
<i>Persicaria lapathifolia</i> L.	5.2	5.2	5.2	0.0	3.5
<i>Sinapis arvensis</i> L.	10.5	5.2	3.5	0.8	15.7
Total annual	133.8a	85.7b*	37.6c***	28.0c***	42.0bc***
Perennial:					
<i>Juncus bufonius</i> L.	8.7	29.7	44.6	155.5***	112.8***
Total perennial	9.7b	31.5b	44.6b	115.5a***	112.8a***
Total weeds:	143.5a	117.2b*	82.2*c	143.5a	154.8a
2017					
0–15 cm					
Annual:					
<i>Chenopodium album</i> L.	36.7	27.3	32.0	44.1	23.6
<i>Echinochloa crus galli</i> (L.) P. Beauv.	1.0	1.0	0.5	1.5	1.0
<i>Fallopia convolvulus</i> (L.) A. Löve	1.5	1.5	1.5	2.1	0.0
<i>Persicaria lapathifolia</i> L.	13.6	12.6	9.4	16.2	5.2
<i>Sinapis arvensis</i> L.	0.5	1.0	0.5	0.5	0.5

Total annual	55.1a	44.6ab	45.6ab	64.5a	39.9b*
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.0	0.0	0.5	1.5*
<i>Juncus bufonius</i> L.	1.5	2.6	7.8	6.3	6.8
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					
Annual:					
<i>Chenopodium album</i> L.	33.2	56.8	36.7	40.2	25.3
<i>Echinochloa crus galli</i> (L.) P. Beauv.	3.5	0.0	0.8	0.0	1.7
<i>Fallopia convolvulus</i> (L.) A. Löve	0.8	2.6	1.7	0.0	0.0
<i>Persicaria lapathifolia</i> L.	14.0	33.1**	6.1	4.3	2.6
<i>Sinapis arvensis</i> L.	0.0	1.7	1.7	1.7	0.0
Total annual	55.2b	94.5a*	47.2b	48.1b	29.7b
Perennial:					
<i>Cirsium arvense</i> L.	0.0	0.8	0.0	0.0	0.0
<i>Juncus bufonius</i> (L.)	0.0	14.8	26.2	174.1**	114.6*
Total perennial	0.8b	17.5b	26.5b	174.1a**	114.6ab
Total weeds:	56.0d	112.0bc	73.7cd	222.1a*	144.3b*
2018					
0–15 cm					
Annual:					
<i>Chenopodium album</i> L.	54.0	70.3	63.5	74.0	46.7
<i>Echinochloa crus galli</i> (L.) P. Beauv.	9.9	9.9	20.4	8.4	8.9
<i>Fallopia convolvulus</i> (L.) A. Löve	0.0	1.0	1.0	1.0	0.5
<i>Persicaria lapathifolia</i> L.	4.7	9.9	27.8	22.0	35.1
<i>Sinapis arvensis</i> L.	4.2	1.0	0.0*	1.5	0.0*
Total annual	77.7a	92.4a	112.8a	107.6a	91.3a
Perennial:					
<i>Juncus bufonius</i> L.	1.5	0.0	4.2	0.0	0.0
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					
Annual:					
<i>Chenopodium album</i> L.	66.5	112.8	75.2	117.2	119.0*
<i>Echinochloa crus galli</i> (L.) P. Beauv.	6.1	14.8	7.8	12.2	32.2*
<i>Persicaria lapathifolia</i> L.	21.0	21.8	4.3	8.7	9.6
<i>Sinapis arvensis</i> L.	0.0	1.7	1.7	3.5	4.3
Total annual	96.2a	151.3a	89.2a	149.6a	167.1a
Perennial:					
<i>Juncus bufonius</i> (L.)	47.2	12.2	37.6	0.0	1.7
Total perennial weeds	47.2a	12.2a	37.6a	0.0a	1.7a
Total weeds:	143.4a	163.6a	126.8a	149.6a	168.8a

DP–deep ploughing (control treatment), SP–shallow ploughing, DC–deep cultivation, SC–shallow cultivation, NT–no-tillage (direct drilling). * significant difference at $p \leq 0.05 > 0.01$, ** at $p \leq 0.01 > 0.001$, *** at $p \leq 0.001$. $p > 0.05$ indicates no significant difference compared with DP. Different letters indicate significant differences between all treatments at $p \leq 0.05$.