

Supplementary Table S1. Number of bacterial colony forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in clay soil from the Vermont South trial site treated with different weed management strategies – winter treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	5.1 ± 2.3	11
Glyphosate	3.1 ± 2.1	6
Glufosinate	3.7 ± 2.3	8
Pine Oil	8.8 ± 2.3	12
Clove Oil	8.3 ± 2.8	13
Imazapyr	3.7 ± 2.1	4
Prodiamine	4.7 ± 2.6	5
MCPA + dicamba	6.3 ± 2.8	9
Acetic Acid + HCl	12 ± 5.8	18
Steam	9.6 ± 3.1	7
Nonanoic acid	5.7 ± 1.2	9

Supplementary Table S2. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in sandy loam soil from the Aspendale trial site treated with different weed management strategies– winter treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	4.1 ± 1.9	7
Glyphosate	2.1 ± 1.6	5
Glufosinate	2.3 ± 0.7	5
Pine Oil	2.1 ± 1.3	6
Clove Oil	2.9 ± 1.5	5
Imazapyr	1.7 ± 1.0	5
Prodiamine	3.1 ± 1.8	6
MCPA + dicamba	4.1 ± 1.8	7
Acetic acid + hydrochloric acid	3.6 ± 1.3	5
Steam	5.2 ± 2.1	7
Nonanoic acid	2.7 ± 1.9	5

Supplementary Table S3. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in clay soil from the Vermont South trial site treated with different weed management strategies – spring treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	8.7 ± 3.7	8
Glyphosate	7.2 ± 2.6	6
Glufosinate	8.4 ± 3.1	10
Pine Oil	7.9 ± 2.7	8
Clove Oil	7.9 ± 2.2	11
Imazapyr	7.6 ± 3.0	7
Prodiamine	8.4 ± 2.5	9
MCPA + dicamba	6.8 ± 2.7	12
Acetic Acid + HCl	7.9 ± 2.9	8
Steam	8.3 ± 2.6	8
Nonanoic acid	7.4 ± 3.1	10

Supplementary Table S4. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in sandy loam soil from the Aspendale trial site treated with different weed management strategies – spring treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	3.9 ± 2.7	6
Glyphosate	4.1 ± 2.3	6
Glufosinate	3.7 ± 1.4	6
Pine Oil	3.2 ± 1.8	7
Clove Oil	3.3 ± 1.6	6
Imazapyr	3.7 ± 2.1	5
Prodiamine	4.5 ± 2.7	6
MCPA + dicamba	3.9 ± 2.0	6
Acetic acid + hydrochloric acid	4.0 ± 1.5	6
Steam	4.2 ± 2.8	6
Nonanoic acid	3.9 ± 2.6	6

Supplementary Table S5. Number of bacterial colony forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in clay soil from the Vermont South trial site treated with different weed management strategies – summer treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^7)	Bacteria diversity
Control	8.2 ± 2.8	13
Glyphosate	8.8 ± 1.9	11
Glufosinate	7.6 ± 2.3	13
Pine Oil	7.2 ± 2.7	13
Clove Oil	6.9 ± 3.1	13
Imazapyr	7.6 ± 2.8	12
Prodiamine	7.0 ± 2.5	12
MCPA + dicamba	7.2 ± 2.9	12
Acetic Acid + HCl	6.8 ± 3.1	11
Steam	7.5 ± 2.8	9
Nonanoic acid	8.3 ± 2.8	12

Supplementary Table S6. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in sandy loam soil from the Aspendale trial site treated with different weed management strategies– summer treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	5.3 ± 2.0	7
Glyphosate	4.8 ± 1.9	8
Glufosinate	3.8 ± 1.6	7
Pine Oil	4.1 ± 2.9	8
Clove Oil	5.8 ± 3.1	8
Imazapyr	4.2 ± 2.1	8
Prodiamine	6.1 ± 3.0	8
MCPA + dicamba	6.0 ± 2.7	7
Acetic acid + hydrochloric acid	5.7 ± 2.3	8
Steam	5.8 ± 2.6	8
Nonanoic acid	6.2 ± 2.3	7

Supplementary Table S7. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in clay soil from the Vermont South trial site treated with different weed management strategies – autumn treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^7)	Bacteria diversity
Control	8.3 ± 3.2	12
Glyphosate	8.5 ± 3.0	13
Glufosinate	8.0 ± 2.9	11
Pine Oil	8.3 ± 2.8	11
Clove Oil	9.2 ± 2.8	13
Imazapyr	8.1 ± 3.1	13
Prodiamine	7.9 ± 2.9	12
MCPA + dicamba	8.3 ± 2.6	12
Acetic Acid + HCl	9.0 ± 3.2	13
Steam	8.7 ± 2.9	13
Nonanoic acid	8.7 ± 2.8	12

Supplementary Table S8. Number of bacterial colonies forming units (CFU) per gram of soil and diversity of bacteria based on different phenotypes observed in sandy loam soil from the Aspendale trial site treated with different weed management strategies – autumn treatment. Samples were collected 4 weeks after treatment with the different strategies.

Treatment	Bacterial CFU (10^6)	Bacteria diversity
Control	6.3 ± 2.7	9
Glyphosate	5.3 ± 2.3	8
Glufosinate	5.7 ± 2.5	9
Pine Oil	6.0 ± 2.6	9
Clove Oil	5.8 ± 2.7	8
Imazapyr	4.9 ± 2.0	8
Prodiamine	6.3 ± 3.0	7
MCPA + dicamba	5.8 ± 2.8	8
Acetic acid + hydrochloric acid	5.9 ± 2.5	9
Steam	6.2 ± 2.8	9
Nonanoic acid	5.7 ± 2.4	9

Supplementary Table S9. Cumulative effects of the different weed management strategies on soil physical and chemical properties at Vermont South

Table11. Soil profiles for heavy clay soil at Vermont South											
	Control	Glyphosate	Pine oil	Glufosinate	Nonanoic acid	MCPA + dicamba	Acetic acid + Hydrochloric acid	Prodiamine	Clove oil	Imazapyr	Steam
pH (1:5 Water)	6.1	5.2	5.7	5.5	5.8	6	6.2	6.3	6.1	5.4	6.9
pH (1:5 0.01M CaCl ₂)	5.56	4.56	5.14	4.86	5.23	5.37	5.72	5.7	5.48	4.79	6.35
Electrical Conductivity (EC)	91.4 µS/cm	183.0 µS/cm	96.0 µS/cm	104 µS/cm	86.8 µS/cm	46.2 µS/cm	102 µS/cm	73.8 µS/cm	109 µS/cm	207 µS/cm	48 µS/cm
Total Soluble Salt (TSS)	301.62 ppm	603.9 ppm	316.8 ppm	343.2 ppm	286.44 ppm	152.46 ppm	336.6 ppm	243.5 ppm	359.7 ppm	683.1 ppm	158.4 ppm
Available Calcium (Ca)	2260 ppm	1560 ppm	1550 ppm	1336 ppm	1472 ppm	1142 ppm	1512 ppm	1452 ppm	1576 ppm	1474 ppm	2320 ppm
Available Magnesium (Mg)	525.6 ppm	460 ppm	488.4 ppm	373.2 ppm	415.2 ppm	336 ppm	450 ppm	457.2 ppm	452.7 ppm	404.4 ppm	424.8 ppm
Available Sodium (Na)	25.99 ppm	16.9 ppm	22.954 ppm	10.764 ppm	16.86 ppm	12.052 ppm	17.73 ppm	18.65 ppm	18.08 ppm	15.04 ppm	31.05 ppm
Available Nitrogen (N)	6.77 ppm	70.7 ppm	7.92 ppm	27.7 ppm	8.59 ppm	1.7 ppm	7.58 ppm	8.3 ppm	8.81 ppm	131 ppm	8.2 ppm
Available Phosphorus (P)	17.0 ppm	42.8 ppm	24.7 ppm	35 ppm	24.3 ppm	17.6 ppm	28.4 ppm	23.6 ppm	27.6 ppm	36.5 ppm	13.5 ppm
Available Potassium (K)	530.4 ppm	499.2 ppm	522.6 ppm	464.1 ppm	600.6 ppm	365.43 ppm	577.2 ppm	534.3 ppm	585 ppm	432.9 ppm	289.38 ppm
Available Sulphur (S)	11.8 ppm	17.6 ppm	15.0 ppm	8.86 ppm	12 ppm	5.85 ppm	13.5 ppm	11.9 ppm	18 ppm	20.4 ppm	4.11 ppm
Available Copper (Cu)	8.52 ppm	7.89 ppm	30 ppm	16.6 ppm	13.5 ppm	9.1 ppm	7.33 ppm	7.73 ppm	6.21 ppm	17.4 ppm	3.99 ppm
Available Zinc (Zn)	45.6 ppm	47.1 ppm	37.6 ppm	36.4 ppm	76.9 ppm	33.6 ppm	43.1 ppm	33.5 ppm	35.2 ppm	36.4 ppm	20.5 ppm
Available Iron (Fe)	12 ppm	56.0 ppm	81 ppm	109 ppm	69 ppm	58 ppm	30 ppm	39 ppm	26 ppm	34 ppm	8 ppm
Available Manganese (Mn)	8 ppm	13 ppm	9 ppm	6 ppm	8 ppm	4 ppm	5 ppm	5 ppm	6 ppm	6 ppm	8 ppm
Available Cobalt (Co)	0.73 ppm	0.69 ppm	0.62 ppm	0.44 ppm	0.52 ppm	0.42 ppm	0.51 ppm	0.39 ppm	0.51 ppm	0.46 ppm	3.02 ppm
Available Molybdenum (Mo)	0.20 ppm	0.26 ppm	0.36 ppm	0.45 ppm	0.28 ppm	0.29 ppm	0.26 ppm	0.28 ppm	0.29 ppm	0.29 ppm	0.17 ppm
Available Boron	0.52 ppm	0.40 ppm	0.35 ppm	0.31 ppm	0.31 ppm	0.28 ppm	0.29 ppm	0.37 ppm	0.35 ppm	0.44 ppm	0.24 ppm
Total Organic Matter (OM)	17%	17%	13%	10%	13%	8%	13%	13%	13%	12%	13%
Total Organic Carbon (OC)	8.45%	8.50%	6.35%	5.20%	6.50%	3.99%	6.40%	6.50%	6.25%	6.50%	6.45%
Exchangeable Calcium (meq/100g of soil)	10.9	7.18	7.39	6.31	7.05	5.54	7.14	6.97	7.45	6.59	11.3
Exchangeable Magnesium (meq/100g of soil)	4.22	3.5	3.88	2.94	3.31	2.72	3.54	3.66	3.74	3.01	3.45
Exchangeable Sodium (meq/100g of soil)	0.109	0.0675	0.0952	0.0442	0.0702	0.0508	0.0729	0.0779	0.0743	0.0585	0.132
Exchangeable Potassium (meq/100g of soil)	1.31	1.18	1.28	1.12	1.47	0.909	1.4	1.32	1.42	0.992	0.724
Exchangeable Hydrogen (meq/100g of soil)	9.88	12.3	9.43	9.64	10.1	7.28	7.51	8	8.47	9.53	5.6
Cation Exchange Capacity (CEC)	26.4	24.2	22.1	20.1	22	16.5	19.7	20	21.2	20.2	21.2
Adjusted CEC	18	20	15.7	17.5	15.5	12.5	13.3	13.5	14.9	17.1	15.6
Exchangeable Sodium Percentage (ESP)	0.41%	0.28%	0.43%	0.22%	0.32%	0.31%	0.37%	0.39%	0.35%	2.90%	0.62%
Calcium / Magnesium Ratio (Ca/Mg)	2.58	2.05	1.9	2.15	2.13	2.04	2.02	1.91	1.99	2.19	3.28
Base Saturation Percentage (BSP)	64%	51%	58%	53%	55%	57%	63%	61%	61%	56%	74%

Supplementary Table S10. Cumulative effects of the different weed management strategies on soil physical and chemical properties at Aspendale

Table 12. Soil profiles for sandy loam soil at Aspendale											
	Control	Glyphosate	Pine oil	Glufosinate	Nonanoic acid	MCPA + dicamba	Acetic acid + Hydrochloric acid	Prodiamine	Clove oil	Imazapyr	Steam
pH (1:5 Water)	6.9	6.8	6.7	7.1	7	6.8	7	6.9	6.8	6.7	6.7
pH (1:5 0.01M CaCl ₂)	6.36	6.33	6.23	6.64	6.5	6.32	6.45	6.36	6.3	6.23	6.21
Electrical Conductivity (EC)	43.7 µS/cm	48.3 µS/cm	44.9 µS/cm	49 µS/cm	51 µS/cm	40.8 µS/cm	43 ppm	38.6 µS/cm	35.2 µS/cm	74.7 µS/cm	51.3 µS/cm
Total Soluble Salt (TSS)	144.21 ppm	159.39 ppm	148.17 ppm	161.7 ppm	168 ppm	134.64 ppm	141.9 µS/cm	127.38 ppm	116.16 ppm	246.51 ppm	169.29 ppm
Available Calcium (Ca)	1194 ppm	848 ppm	970 ppm	1080 ppm	816 ppm	802 ppm	1144 ppm	1252 ppm	850 ppm	1496 ppm	1404 ppm
Available Magnesium (Mg)	303.6 ppm	228 ppm	246 ppm	265.2 ppm	283.2 ppm	220.8 ppm	265.2 ppm	266.4 ppm	235.2 ppm	318 ppm	349.2 ppm
Available Sodium (Na)	61.41 ppm	53.59 ppm	58.42 ppm	51.29 ppm	62.56 ppm	38.18 ppm	40.25 ppm	39.56 ppm	56.81 ppm	46.46 ppm	48.53 ppm
Available Nitrogen (N)	2.1 ppm	8.6 ppm	5.51 ppm	7.32 ppm	5.4 ppm	5.24 ppm	5.7 ppm	5.06 ppm	4 ppm	31 ppm	3.76 ppm
Available Phosphorus (P)	5.97 ppm	5.97 ppm	3.55 ppm	3.39 ppm	2.47 ppm	5.11 ppm	5.43 ppm	4.83 ppm	4.47 ppm	10.1 ppm	8.26 ppm
Available Potassium (K)	85.8 ppm	62.01 ppm	60.84 ppm	56.94 ppm	75.27 ppm	48.75 ppm	53.04 ppm	51.48 ppm	70.98 ppm	93.6 ppm	104.13 ppm
Available Sulphur (S)	6.66 ppm	3.94 ppm	4.92 ppm	5.56 ppm	6.1 ppm	5.11 ppm	4.9 ppm	5.29 ppm	5.15 ppm	5.71 ppm	7.68 ppm
Available Copper (Cu)	12 ppm	11.3 ppm	20 ppm	15.5 ppm	13.2 ppm	12.5 ppm	10.1 ppm	11.2 ppm	8.27 ppm	11.1 ppm	11.9 ppm
Available Zinc (Zn)	39 ppm	48.6 ppm	62.1 ppm	52.4 ppm	45.2 ppm	58.7 ppm	63.2 ppm	81.8 ppm	48.3 ppm	54.7 ppm	41 ppm
Available Iron (Fe)	12 ppm	9 ppm	11 ppm	7 ppm	6 ppm	7 ppm	14 ppm	9 ppm	10 ppm	10 ppm	15 ppm
Available Manganese (Mn)	3 ppm	7 ppm	6 ppm	7 ppm	4 ppm	5 ppm	4 ppm	3 ppm	3 ppm	7 ppm	7 ppm
Available Cobalt (Co)	0.49 ppm	0.44 ppm	0.66 ppm	0.44 ppm	0.44 ppm	0.48 ppm	0.41 ppm	0.42 ppm	0.37 ppm	0.51 ppm	0.47 ppm
Available Molybdenum (Mo)	0.09 ppm	0.16 ppm	0.17 ppm	0.17 ppm	0.12 ppm	0.18 ppm	0.12 ppm	0.10 ppm	0.08 ppm	0.11 ppm	0.15 ppm
Available Boron	0.25 ppm	0.29 ppm	0.27 ppm	0.26 ppm	0.28 ppm	0.23 ppm	0.29 ppm	0.24 ppm	0.23 ppm	0.34 ppm	0.43 ppm
Total Organic Matter (OM)	6%	5%	5%	4%	5%	4%	4%	6%	4%	5%	4%
Total Organic Carbon (OC)	2.77%	2.26%	2.43%	2.18%	2.25%	1.95%	2.25%	2.87%	2.13%	2.49%	2.23%
Exchangeable Calcium (meq/100g of soil)	5.73	3.97	4.6	5.09	3.82	3.78	5.45	6.02	4.06	6.99	6.71
Exchangeable Magnesium (meq/100g of soil)	2.43	1.78	1.94	2.08	2.21	1.74	2.1	2.14	1.87	2.48	2.78
Exchangeable Sodium (meq/100g of soil)	0.256	0.218	0.241	0.21	0.254	0.157	0.167	0.165	0.236	0.189	0.202
Exchangeable Potassium (meq/100g of soil)	0.211	0.149	0.148	0.138	0.181	0.118	0.13	0.127	0.174	0.224	0.255
Exchangeable Hydrogen (meq/100g of soil)	2.76	1.85	2.11	1.49	1.8	1.82	1.7	2.33	1.88	2.08	2.29
Cation Exchange Capacity (CEC)	11.4	7.97	9.04	9.01	8.26	7.62	9.55	10.8	8.22	12	12.2
Adjusted CEC	8.63	6.12	6.93	7.52	6.46	5.8	7.85	8.45	6.34	9.88	10
Exchangeable Sodium Percentage (ESP)	2.25%	2.74%	2.67%	2.33%	3.07%	2.06%	1.75%	1.53%	2.87%	1.58%	1.65%
Calcium / Magnesium Ratio (Ca/Mg)	2.36	2.23	2.37	2.44	1.73	2.18	2.59	2.82	2.17	2.82	2.41
Base Saturation Percentage (BSP)	77%	78%	78%	84%	79%	77%	83%	79%	78%	84%	82%