ORIGINAL RESEARCH PAPER*

Examination of Manual Removal Strategies for Dog Strangling Vine

Short LF, Bearden S, McWatch B, Hafez L
Humber College Institute of Technology & Advanced Learning

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Abstract
In the summer of 2019, the Junior Naturalists posed a question regarding the control of Dog Strangling Vine (DSV), an invasive plant that is present in the Humber Arboretum. This group conducts stewardship activities in the Arboretum to help balance the environment by using non-chemical methods to control some of the invasive plant species there. They had been cutting off the flowers of the DSV to prevent seed production, but this did not affect the survival of the plants. This research project was created in response to the group's question. Four strategies were studied for their efficacy in controlling the growth of DSV. These strategies were digging out the plant, pulling out the stalk, cutting the crown beneath the soil surface, and cutting the stalk above the soil surface. While each approach has its benefits and drawbacks, digging the entire plant out of the ground was found to be the most effective in preventing the regrowth of the individual plant. The research is intended to guide student gardeners working in ornamental gardens at the Arboretum and stewardship volunteers working in public parks in non-chemical strategies to be used for controlling DSV. The most effective control efforts should be repeated from year to year, which can result in long-term control of DSV in cultivated gardens and natural areas.

This study has limitations since it was enacted on natural areas that had already been overtaken by DSV, which means that the numbers of plants, seeds, and other species in each plot were not consistently uniform. In a subsequent investigation, standardized, cultivated plots of DSV could be created and different competitive native species could be added to determine the effects of treatments on these combinations.

Introduction

***Cynanchum rossicum*, commonly referred to as Dog Strangling Vine (DSV)** is a perennial plant originally from a small area in eastern Europe that is a member of the Apocynaceae or milkweed family. This introduced species has infested a large portion of North America and is considered one of the main problem invasives in Ontario. It overtakes large areas and eradicates the native plants that were once present (Sandilands, 2013, pp. 104). It was most likely introduced as an ornamental plant in the 19th century. The earliest specimen was collected in Victoria, BC in 1885. It has not proliferated in that area, but was able to do so in southern Ontario, where it was cultivated as a source of rubber in a failed experiment during World War II. There are many theories as to why it has been so successful in specific regions, but these remain inconclusive (Miller and Kricsfalusy, 2008, pp.7).

The leaves of a DSV are oval with pointed tips, seven to twelve centimetres long, growing in an opposite leaf arrangement. They are initially green and turn yellow later in the summer. As a vine, it grows up to two metres and can wrap itself around trees, shrubs, and other herbaceous plants. Its small, star-shaped flowers are pink to dark purple with five petals. Eventually, these flowers develop into seed pods that form in July, turning from green to light brown as they grow. They produce and release large numbers of seeds in late summer that are easily carried by the wind, with each square metre of DSV being capable of producing up to 28,000 seeds.

In addition, DSV is an especially aggressive exotic as it is highly adaptable and easy to grow. It can grow in a variety of soil conditions, tolerating drought, shallow soils in addition to disturbed and undisturbed soils, as well as in shady and sunny areas, even though it does prefer the sun (DiTommaso, 2013, pp. 382). Notably, it forms symbiotic relationships with other plants' mycorrhizal networks that help Dog Strangling Vine to strengthen itself, eventually choking out surrounding plants (Sandilands, 2013, pp.104). It has also been suggested that DSV has allelopathic qualities, wherein it can alter the chemical composition of the soil to better suit its needs, thereby no longer suiting other species' needs (Sandilands, 2013, pp. 104). In addition to this, it reproduces quickly and aggressively by making huge numbers of seeds attached to feathery tufts of hair, called coma, that allow them to be carried over long distances by the wind, insects, and animals once they have been released from the plant's seed pods in the late summer and early fall.

As a lover of hydro corridors, DSV seeds have been dispersed through the Rouge, Don, and Duffins watersheds from the east, and it has most recently been estimated that DSV is now present in approximately 20% of the Toronto area (Sandilands, 2013, pp. 104). In the Greater Toronto Area, it has been present for at least a century but only began to cause alarm in the 1970s and 1980s, becoming a mainstream concern in the 2000s (Miller and Kricsfalusy, 2008, pp.8). This suggests that the plant's invasiveness began slowly and sped up after a certain threshold had been reached, as the plant's fitness is related to its population size and density. This phenomenon is otherwise known as the "allee effect," wherein it reaches a certain tipping point where it is able to thrive and colonize a large area. In other words, once any other vegetation has been suppressed and the soil chemistry has been sufficiently altered, the plant's population size begins to grow exponentially (Sandilands, 2013, pp.105). The more it can multiply, the stronger it gets, and the more it spreads.

DSV's effects on its surrounding area are extensive and severe, affecting the entire ecosystem around it. It has the capability of creating monocultures that outcompete any surrounding species, as well as modifying soil community composition, making the soil inhospitable to other plants. As it grows, the plant itself wraps itself around any adjacent plants, physically outcompeting them for necessary resources such as light, water, and nutrients. When allowed to grow profusely, they form a dense, tangled mat of vegetation that covers large areas and eliminates native and endangered plants, reducing wildlife habitats for birds and insects. In addition, monarch butterflies, an at-risk species, often mistake it for native milkweeds and lay eggs on DSV plants, whose roots are toxic for the caterpillars, subsequently killing them. Deer and other browsing animals avoid DSV, as its roots are toxic to mammals, which can increase grazing pressure on native plants and reduce existing native plant species' population size.

As a result of these numerous survival adaptations, DSV is notoriously difficult to eradicate. The use of herbicides is permitted for the control treatment of DSV; however, these chemicals are non-specific, killing all plants that are in the treated areas. If there are valuable plant species in the same area, chemical treatment is not recommended. In the past, when the DSV infestation was sparse, individual plants were treated by 'hand wicking' (using a chemically infused glove to apply the herbicide on an individual plant). This strategy is not an approved use of the chemical and it can no longer be used in this way (Pest Management Regulatory Agency, 2017).

It is easiest to manage before its population becomes established, focusing on smaller areas outside of a large infestation to control its spread (Anderson, 2012, pp. 12).

The only method that has been successfully proven to rid an area of DSV completely is by digging it out with its roots, although this is only feasible for small populations (Anderson, 2012, pp. 14). This method can be applied selectively to individual DSV plants, allowing other valuable plant species to thrive.

Once established, the main control methods focus on prevention of spread by reducing seed production, either by mowing, clipping, pulling, tarping, or physically removing seed pods (Anderson, 2012, pp. 18-19). However, none of these methods can be considered foolproof methods of complete eradication. They need to be repeated often, and sites need to be revisited for years after these control methods have been implemented, since seedlings can grow in the remaining disturbed soil (Anderson, 2012, pp. 19). It is even capable of remaining dormant in shaded forests, biding its time until a gap forms in the canopy for light to come through, and it is able to begin its growth process again (Milbrath, 2008, pp. 1287). Therefore, even if it appears to have been eradicated on a surface level, roots or seeds may still be present, waiting for an opportunity to thrive in any given environment. There has been some research indicating that interplanting competitive native species such as goldenrod or raspberry could help to reduce DSV's reproductive capacity by limiting resource availability (Maguire, Sforza and Smith, 2011, pp. 1238).

Method

DSV Controls Investigation

1. An area was located where there was a dominant culture of DSV in the Arboretum meadow (full sun); however, the area was not entirely uniform as regards the number of DSV stalks per square metre or the other species present.
2. An information sign was posted at the research site to inform passers-by regarding the work being done.
3. Using stakes and rope, twelve sections, measuring 2m x 3m, were created.
4. Within each section, there were two test plots marked using wooden stakes and string to define each plot measuring 1m x 1m each with a 0.5m buffer zone around the outside. The purpose of this perimeter zone was to allow researchers to walk around the test plots but not to interfere with growth within the test plot. Each entire section was treated according to the schedule, but data was only recorded from within the inner 1m x 1m sections.
5. The test plots were defined as follows:
   1A: DSV cut beneath the surface using knife once at the beginning of July.
   1B: DSV cut beneath the surface using knife once at the beginning of June and once at the end of August.
   1C: DSV cut beneath the surface using knife once at the beginning of June, once in the middle of July and once at the end of August.
   2A: DSV cut 5 cm above the surface using pruners once at the beginning of July.
   2B: DSV cut 5 cm above the surface using pruners once in the middle of June and once at the end of August.
   2C: DSV cut 5 cm above the surface using pruners once in the middle of May, once in the middle of June, once in the middle of July and once at the end of August.
   3A: DSV pulled out by the main stalk once in the middle of July.
   3B: DSV pulled out by the main stalk once at the beginning of June and once at the end of August.
   3C: DSV pulled out by the main stalk once at the beginning of June, once in the middle of July and once in the middle of August.
   4A: DSV stalks dug out using a spade to remove roots and new shoots once in the middle of June.
   4B: DSV stalks dug out using a spade to remove roots and new shoots once at the beginning of July and once at the end of August.
   5A: DSV Control—no removal during the growing season.
6. Measurement data (number of stalks, height of stalks, presence of flowers, presence of seeds and other plants present) was recorded once per week for each test plot, prior to scheduled removals—if any.
7. All plant material from DSV removals was placed into sealed garbage bags, placed in the direct sun for a week to allow the plant material to become non-viable and then disposed into the landfill to prevent further spread of the plant species.

Soil Samples

1. Soil samples were taken from two areas adjacent to the research site—one taken from an area where the DSV plants dominated and one taken from an area where there were only grasses evident.
2. The two samples were tested using soil sedimentation in a jar. The same weighed quantity of each dried soil sample (500g) was placed into each of two preserving jars.

3. Water was added to fill the jars and the soil/water mixture was shaken to completely mix the soil and water.
4. The soil was placed in a cool place for two days and allowed to settle completely.
5. The soil layers were examined, and the jars photographed.
6. The two soil samples were also sent to Agrifoods, University of Guelph Laboratory Services, for analysis of Total Salts (Electrical Conductivity), Organic Matter Content, Phosphorous, Magnesium, Potassium, pH, Sodium, and Calcium.

Auxiliary Experiment for DSV Plant Parts

This investigation originated from questions that arose from the main research.

The purpose was to test the growth potential of four different DSV plant parts. The plant parts were prepared as follows and five replicates of each were planted in separate pots:

Stem End—The DSV stalk was pulled out of the ground. The main stem was cut off, making sure not to cut the small buds at the base. There were a few short roots attached. A stem end was planted in each pot with soil.

Crown (roots trimmed)—The DSV crown was removed using a knife to cut around the base of the stalk below the soil surface. Long roots were trimmed with scissors. The DSV stalk was cut just above the crown. A trimmed root crown was planted in each pot with soil.

Root Mass—A spade was used to dig out the DSV making sure to include the roots. The stem was removed by pulling it off. The soil was removed to expose the roots. A Root Mass was planted in each pot with soil.

Roots Only—A spade was used to dig out an individual DSV plant, making sure to include roots. The stem was removed by pulling it off. The soil was removed to expose the roots. The roots were cut away from the crown. A bunch of root fragments was planted in each pot with soil.

1. All pots were watered once a week while observations were being done.
2. Pots were placed in a sheltered location and the soil was kept moist. They were observed for signs of growth each week.
3. Growth and changes were recorded.

Results

Summary Data for Humber DSV research

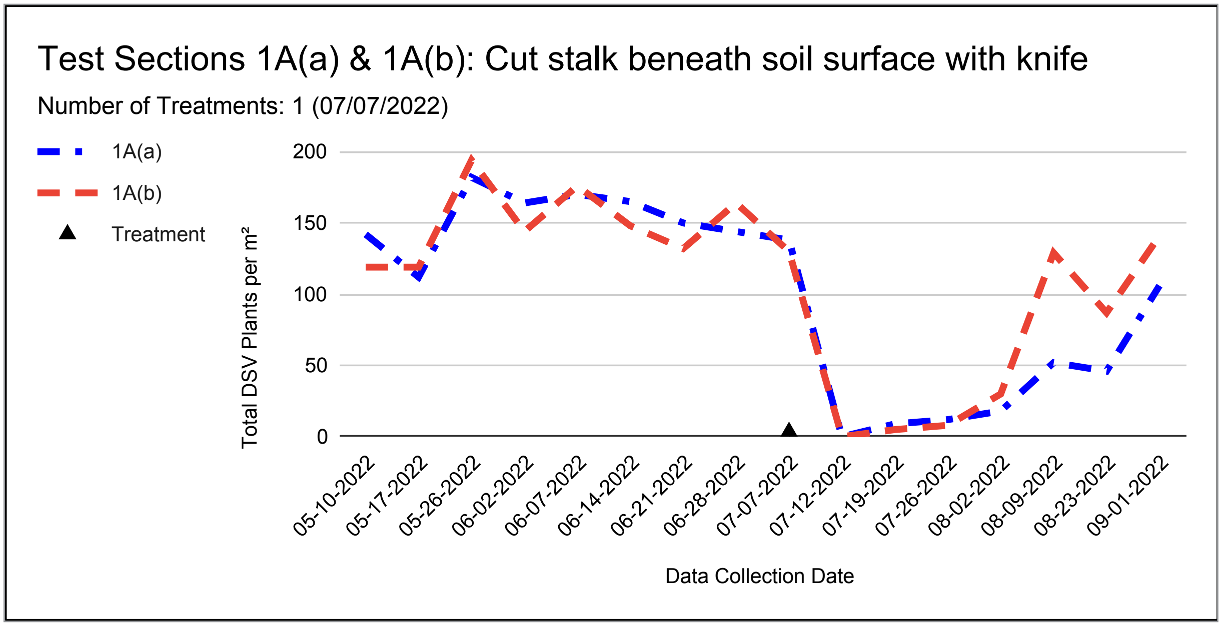
Number/m2 section

Date/ Section	May 10	May 17	May 26	May 31	Jun 07	Jun 14	Jun 21	Jun 28	Jul 07	Jul 12	Jul 19	Jul 26	Aug 02	Aug 09	Aug 23	Sep 01
1A (a)	142	112	182	164	170	165	150	144	138	0	9	12	18	52	46	106
1A (b)	119	119	194	144	206	148	132	164	130	0	5	8	30	129	87	141
1B (a)	150	186	265	185	37	28	117	153	142	138	142	129	176	228	226	32
1B (b)	65	119	178	130	11	18	61	108	91	91	84	86	97	137	201	39
1C (a)	106	126	190	165	30	34	74	121	95	108	122	8	13	24	20	14
1C (b)	112	132	203	174	10	14	83	105	108	108	111	7	15	28	32	24
2A (a)	33	129	195	153	171	166	155	155	171	39	15	51	132	199	292	241
2A (b)	35	132	234	169	200	165	159	179	196	26	19	38	121	216	268	229
2B (a)	92	131	202	168	165	152	41	61	81	98	106	129	125	177	191	21
2B (b)	81	121	184	164	157	167	16	43	40	76	85	106	99	210	154	35
2C (a)	88	131	91	128	135	154	22	87	123	50	98	2	16	123	163	63
2C (b)	99	119	100	151	164	175	36	192	227	100	154	0	20	200	223	61
3A (a)	59	114	177	145	128	92	126	129	117	126	126	19	44	64	83	138
3A (b)	80	115	174	139	102	103	91	105	105	109	110	21	37	123	124	133

Date/ Section	May 10	May 17	May 26	May 31	Jun 07	Jun 14	Jun 21	Jun 28	Jul 07	Jul 12	Jul 19	Jul 26	Aug 02	Aug 09	Aug 23	Sep 01
3B (a)	83	106	259	230	24	87	147	166	176	162	142	170	179	264	309	11
3B (b)	48	115	237	213	18	67	140	146	170	153	149	163	168	253	262	14
3C (a)	69	125	174	176	22	39	69	84	93	91	100	7	11	26	2	6
3C (b)	101	176	222	192	30	42	111	104	113	113	127	10	24	50	8	27
4A (a)	56	116	228	193	182	186	0	0	1	2	2	4	5	6	8	11
4A (b)	64	131	235	162	167	197	0	0	0	0	2	9	9	16	14	24
4B (a)	74	129	188	191	146	172	188	139	136	0	0	0	0	0	2	13
4B (b)	70	137	182	187	153	162	158	134	125	0	0	0	0	0	0	7
Control (a)	58	69	175	113	95	134	113	92	107	74	93	75	79	111	114	122
Control (b)	94	125	210	154	150	176	129	110	128	115	111	96	105	159	185	134

Average Heights/m2 section

Date/ Section	May 17	May 26	May 31	Jun 07	Jun 14	Jun 21	Jun 28	Jul 07	Jul 12	Jul 19	Jul 26	Aug 02	Aug 09	Aug 23	Sep 01
1A (a)	20.8	35.1	55.7	71	74.4	77.3	79.6	81	0	12.5	12.5	10.2	10.9	12	12.4
1A (b)	20.4	36.1	51	72.4	81.2	82.9	85.3	87.5	0	12.8	12	9.6	9.4	12.4	12.3
1B (a)	25.8	40.3	60.4	21.2	20.1	19.2	22.9	23.7	25.8	28.4	27.2	26.8	24.8	26.5	11.4
1B (b)	22.4	34.7	50.2	13.5	14.1	18.3	20.4	22.7	23.2	23.4	25.2	23.7	21.9	24.5	8.1
1C (a)	19.2	31	55.9	15	15.5	16.2	25.5	22.3	21.4	22.4	10.4	9.4	10.2	10.3	6.3
1C (b)	21.8	37.1	56.3	15	17.3	17.4	19.7	22.1	22	22.8	10.9	9.3	9.5	8.9	6.8
2A (a)	21	31.9	47.9	49.7	53	55.4	54.4	53.4	12.4	13.5	13.9	14.6	17.6	15.7	14.9
2A (b)	20.1	28	38.4	41.2	47	45.1	45.8	44.9	18.6	19.5	18.3	16.1	11.3	16.3	16.4
2B (a)	22.9	37.2	54.6	67.7	80.8	16.9	13.8	16	16.7	15.9	16.3	15	18.7	18.3	6.9
2B (b)	25.2	38.9	50.3	71.7	79	14.3	13.7	14.8	14.7	14.5	14.3	12.2	15.3	16.2	7.6
2C (a)	23.1	18.2	31.9	45.1	54.3	16.3	21.2	24.5	27.5	28.2	10.9	9.8	13.2	12.5	7.7
2C (b)	22.6	16.5	31.2	44.3	52.8	16.7	16.7	20.7	20.8	24.3	10.6	10.3	11.2	12.5	8
3A (a)	21.6	28.9	42.6	59.2	61.9	66.2	71.4	65.4	68.9	61.3	10.9	9.9	11.6	11.5	8.7
3A (b)	26	36.4	54.7	62	65.8	66.2	70.8	84.6	77.5	76.4	12.8	14.8	11.3	11.5	10.6
3B (a)	20.8	34.6	53.8	11.3	19.6	24.2	29.2	32.1	32.9	35.6	34.2	33.2	30.2	31.5	7.9
3B (b)	20.4	39	52.5	7.1	20.3	24.6	28.9	32.9	34.3	42.8	34.6	33.9	28.4	32.1	8.4
3C (a)	24.4	36.2	55	13.5	18.7	22.6	27.1	29.3	32.2	27.4	9.1	8.8	9.2	8	7.1
3C (b)	25.4	37.8	53.6	9.5	20.4	27	30.4	37.6	36	37.1	9.8	11.1	10.3	9.4	7
4A (a)	21.8	36.2	50.3	61.5	65.6	0	0	4	4	4	4	5	6.5	8.5	5.5
4A (b)	23	34.8	47.1	62	67.4	0	0	0	0	4	4	4	6.4	7.6	5.6
4B (a)	25.4	41.7	53.5	72.2	80.2	79.7	89.5	91.2	0	0	0	0	0	5	2.3
4B (b)	24.9	34.4	52.3	75.9	82.4	84.6	83.6	94.3	0	0	0	0	0	0	1.7



Test Sections 1A(a) & 1A(b): Cut stalk beneath soil surface with knife
Number of Treatments: 1 (07/07/2022)
1A(a)
1A(b)
Treatment
Total DSV Plants per m²
200
150
100
50
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
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07-26-2022
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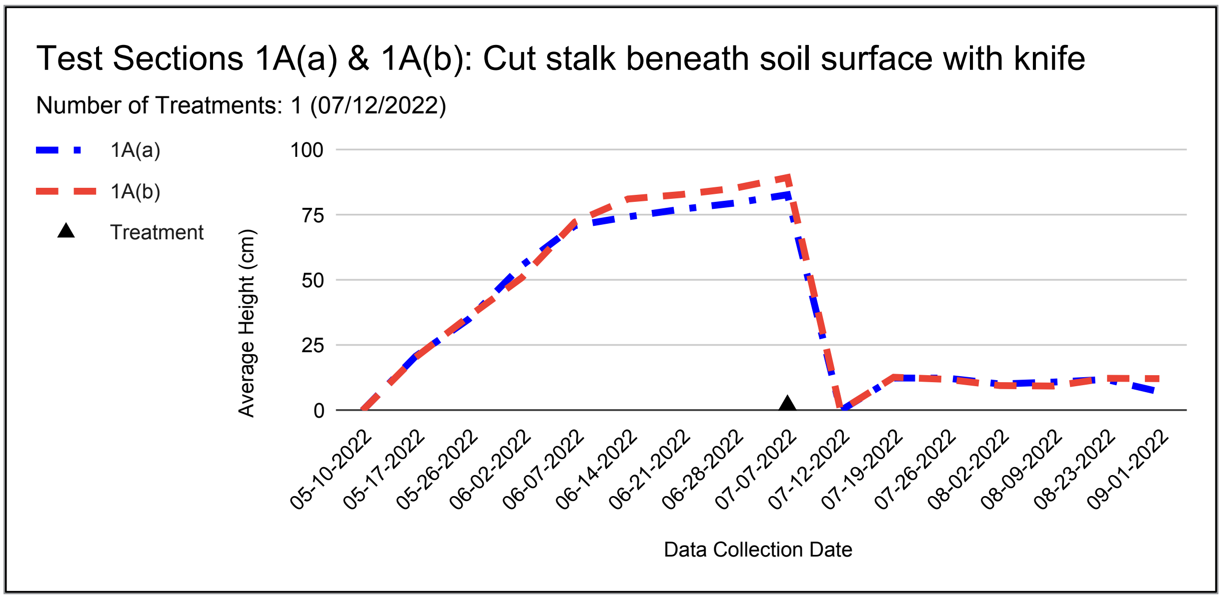
09-01-2022
Data Collection Date



Test Sections 1A(a) & 1A(b): Cut stalk beneath soil surface with knife
Number of Treatments: 1 (07/12/2022)
1A(a)
1A(b)
Treatment
Average Height (cm)
100
75
50
25
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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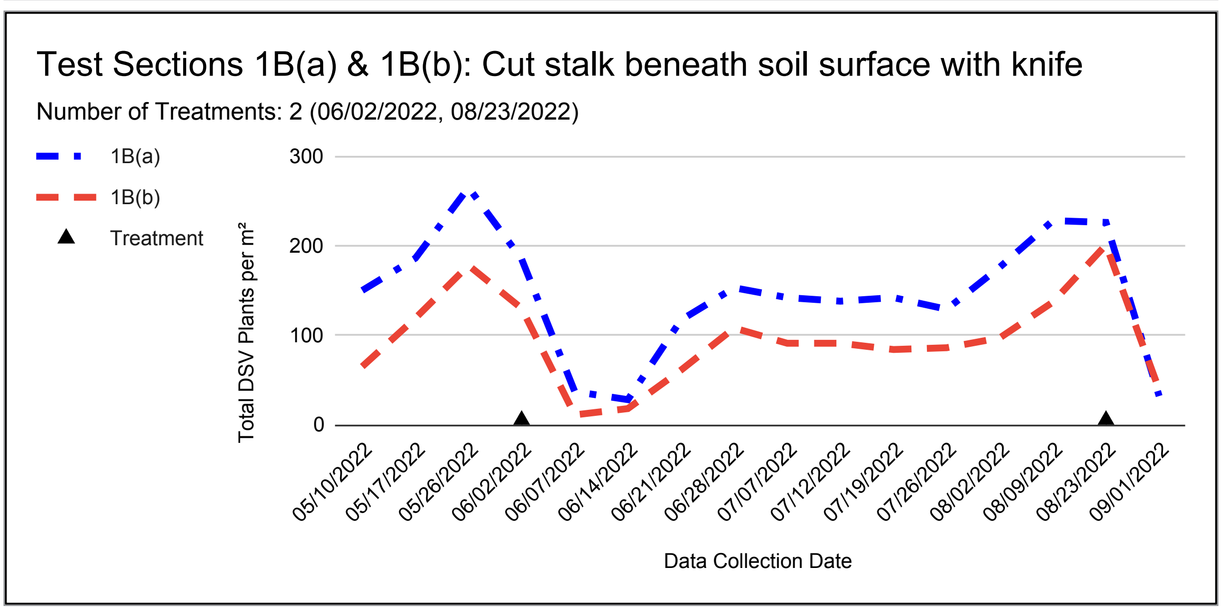
09-01-2022
Data Collection Date



Test Sections 1B(a) & 1B(b): Cut stalk beneath soil surface with knife
Number of Treatments: 2 (06/02/2022, 08/23/2022)
1B(a)
1B(b)
Treatment
Total DSV Plants per m²
300
200
100
0
05/10/2022
05/17/2022
05/26/2022
06/02/2022
06/07/2022
06/14/2022
06/21/2022
06/28/2022
07/07/2022
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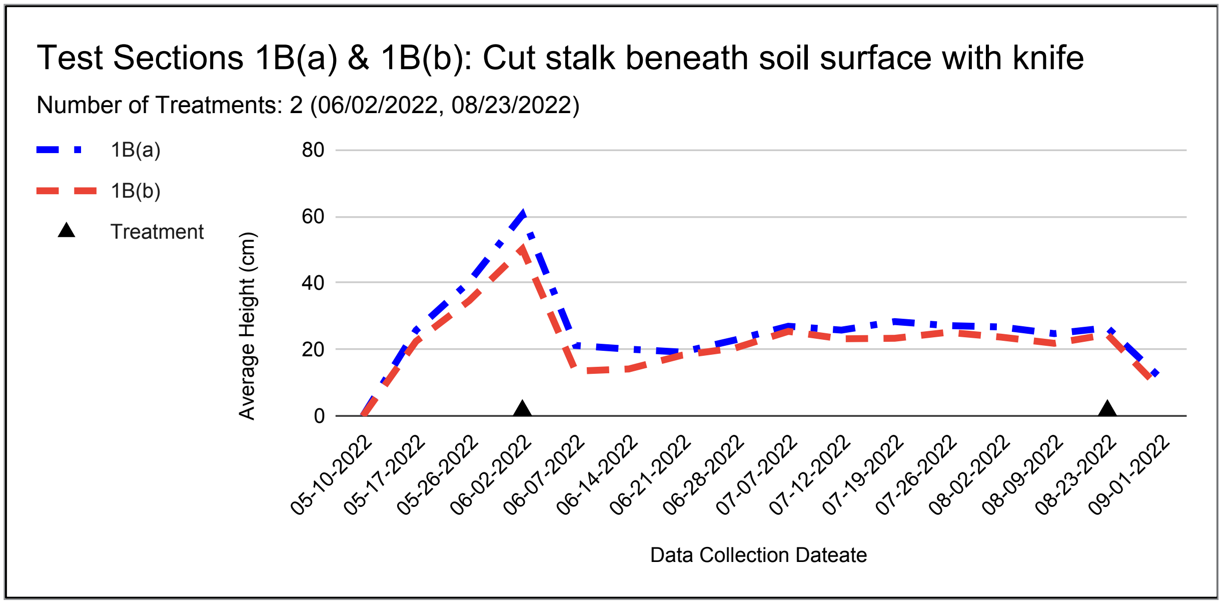
09/01/2022
Data Collection Date


Test Sections 1B(a) & 1B(b): Cut stalk beneath soil surface with knife
Number of Treatments: 2 (06/02/2022, 08/23/2022)
1B(a)
1B(b)
Treatment
Average Height (cm)
80
60
40
20
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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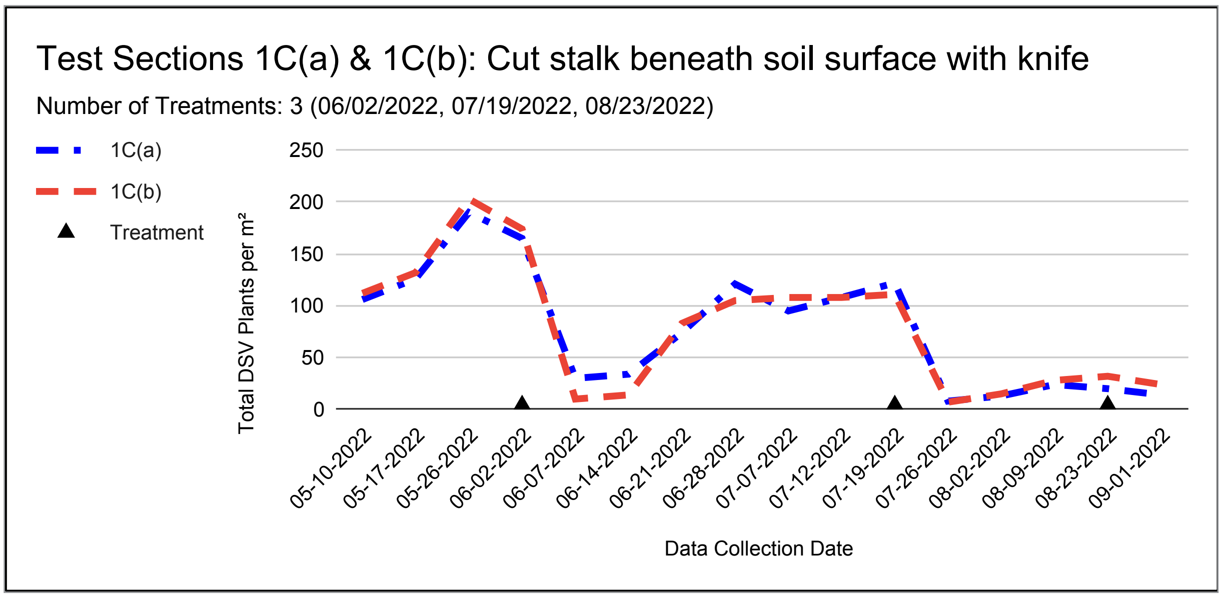
Test Sections 1C(a) & 1C(b): Cut stalk beneath soil surface with knife
Number of Treatments: 3 (06/02/2022, 07/19/2022, 08/23/2022)
1C(a)
1C(b)
Treatment
Total DSV Plants per m²
250
200
150
100
50
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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Data Collection Date

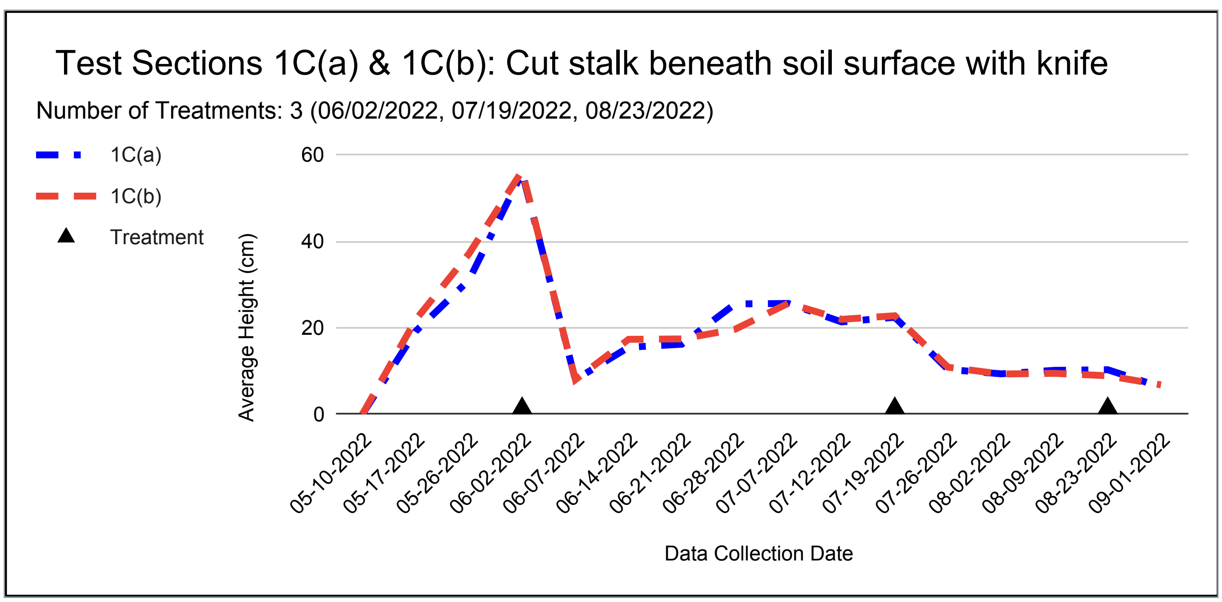

Test Sections 1C(a) & 1C(b): Cut stalk beneath soil surface with knife
Number of Treatments: 3 (06/02/2022, 07/19/2022, 08/23/2022)
1C(a)
1C(b)
Treatment
Average Height (cm)
60
40
20
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
07-19-2022
07-26-2022
08-02-2022
08-09-2022
08-23-2022
09-01-2022
Data Collection Date

Table 1. Observations for Plots 1A, 1B, 1C—Cut stalk beneath soil surface with knife

Date	1A Observations **Non-DSV plants present:** Grasses, Goldenrod	1B Observations **Non-DSV plants present:** Grasses, 3 Raspberry, Thistle, Wintercress, Vetch, 1 Hackberry sapling	1C Observations **Non-DSV plants present:** Grasses, Goldenrod
05/10/2022	DSV just emerging from soil	DSV just emerging from soil	DSV just emerging from soil
05/17/2022	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear
05/26/2022	More DSV flower buds	More DSV flower buds	More DSV flower buds
06/02/2022	DSV flowers opening, stem tips beginning to curl	DSV flowers opening, stem tips beginning to curl **Treatment done in 1B**	DSV flowers opening, stem tips beginning to curl **Treatment done in 1C**
06/07/2022	DSV in full bloom and stem tips curled and twisting together	DSV seedlings present	DSV seedlings present
06/14/2022	Some grasses but mostly DSV	No observations recorded	No observations recorded
06/21/2022	DSV seed pods visible	No observations recorded	No observations recorded
06/28/2022	More DSV seed pods, all still green	Only two DSV in flower	No observations recorded
07/07/2022	Soil very dry, difficult to cut stem beneath soil, more DSV seed pods, and stems are curled and tangled **Treatment done in 1A**	More DSV in flower	No observations recorded
07/12/2022	No observations recorded	Some DSV in flower, some seed pods	No observations recorded
07/19/2022	Grasses leaning over. DSV thin and yellow	No observations recorded	**Treatment done in 1C**
07/26/2022	Trampling in buffer zone suppressing grass and DVS, Grasses browning—evidence of drought and soil disturbance	Trampling in buffer zone suppressing grass and DVS, Grasses browning—evidence of drought and soil disturbance	Trampling in buffer zone suppressing grass and DVS, Grasses browning—evidence of drought and soil disturbance
08/02/2022	Ground very dry, grasses dry and yellow, DSV wilted with brown spots on leaves	Ground very dry, grasses dry and yellow, DSV wilted with brown spots on leaves	Ground very dry, grasses dry and yellow, DSV wilted with brown spots on leaves Lots of tiny DSV seedlings under the other plants
08/09/2022	Some DSV seedlings less than 10cm	DSV growth stunted but still producing flowers and seed pods	Carpet of DSV seedlings covering 15% of plot
08/23/2022	No observations recorded	Some DSV seed pods **Treatment done in 1B**	**Treatment done in 1C**
09/01/2022	DSV seedlings show minimal growth over past several weeks DSV thin stemmed, no seeds or flower	DSV seedlings show minimal growth over past several weeks, Some seedlings	DSV seedlings show minimal growth over past several weeks

For Plots 1A, 1B, and 1C, the stalk was cut beneath the soil surface with a special knife.

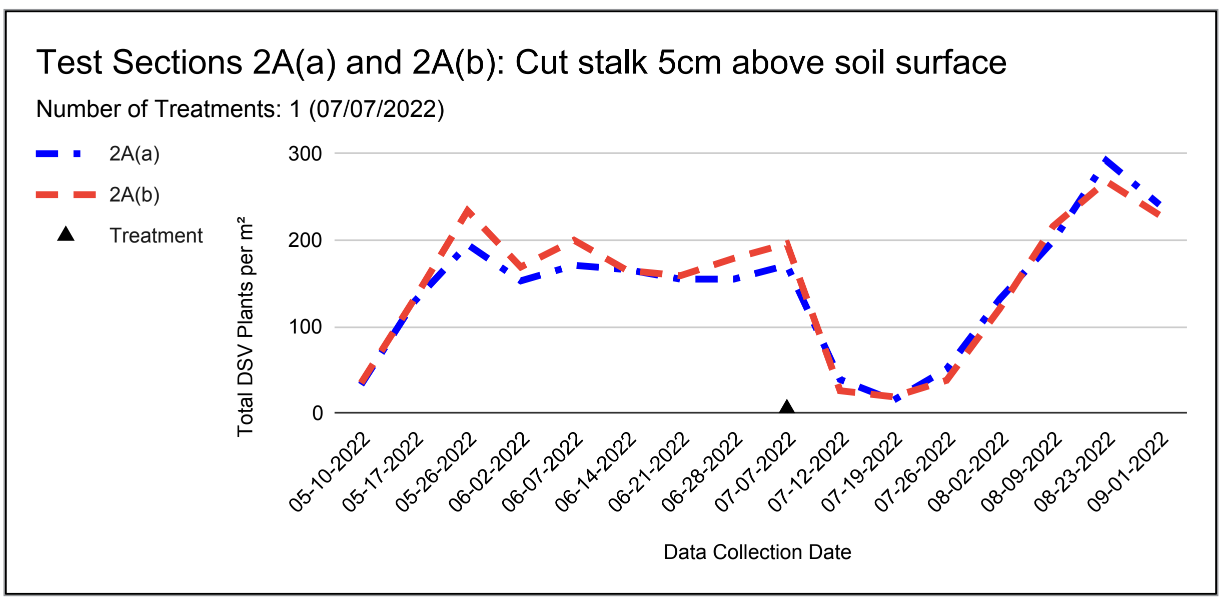
Attempts were made to include the growth crown at the end of the stalk but not all the roots. In 1A and 1C plots, grasses became dominant. 1B had some diversity present.

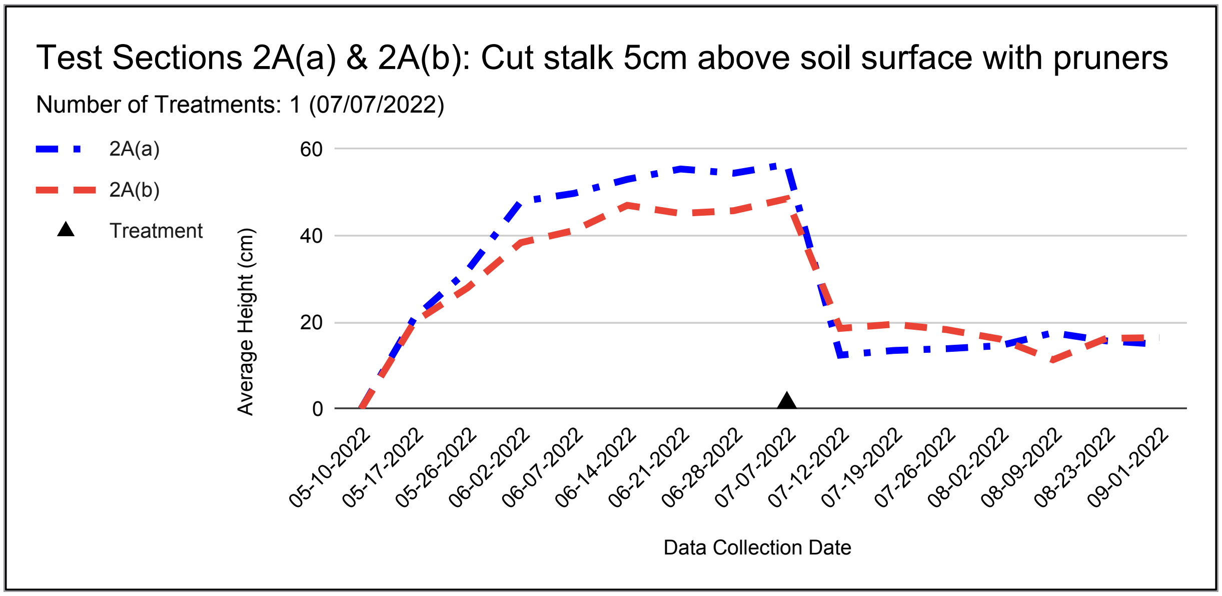
Photo 1: This shows the special knife and the cut-out root crown.

1A was cut only once which resulted in the numbers of stalks recovering but remaining small. There was no flower or seed production following.

1B was cut twice which resulted in the numbers of stalks recovering after both cuts but the plants remained small. There was some flower and seed production after the first cut but that was removed by the second treatment.

1C was cut three times. The numbers of stalks began to recover after the first cut, but the numbers remained low after subsequent cuts. The plants remained small.




Test Sections 2A(a) & 2A(b): Cut stalk 5cm above soil surface with pruners
Number of Treatments: 1 (07/07/2022)
2A(a)
2A(b)
Treatment
Average Height (cm)
60
40
20
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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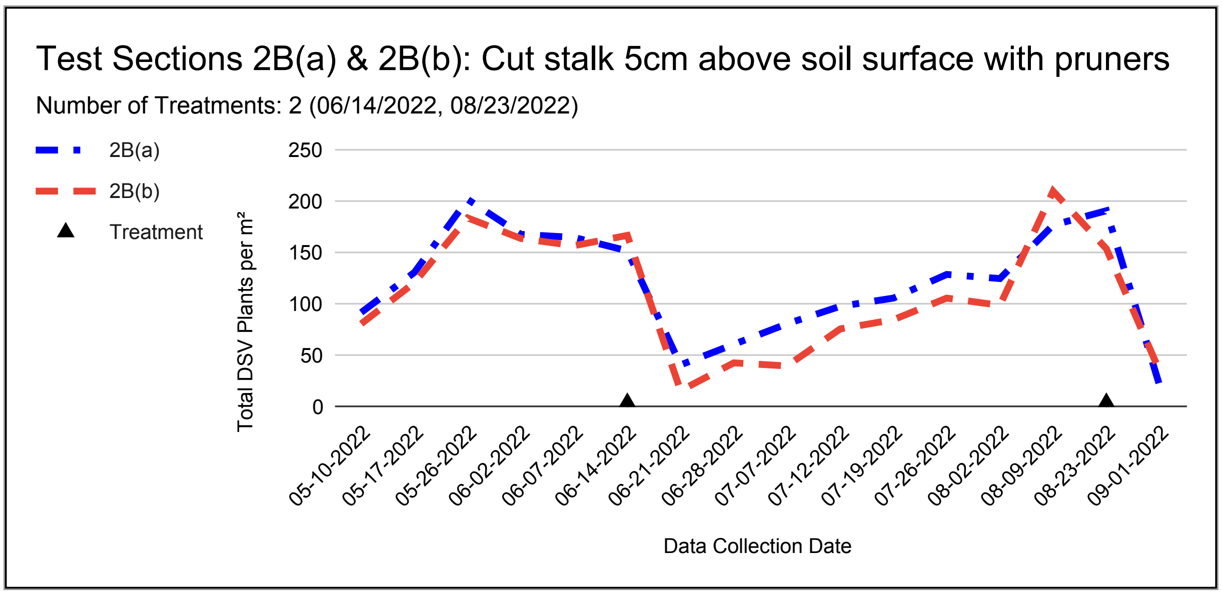
09-01-2022
Data Collection Date


Test Sections 2B(a) & 2B(b): Cut stalk 5cm above soil surface with pruners
Number of Treatments: 2 (06/14/2022, 08/23/2022)
2B(a)
2B(b)
Treatment
Total DSV Plants per m²
250
200
150
100
50
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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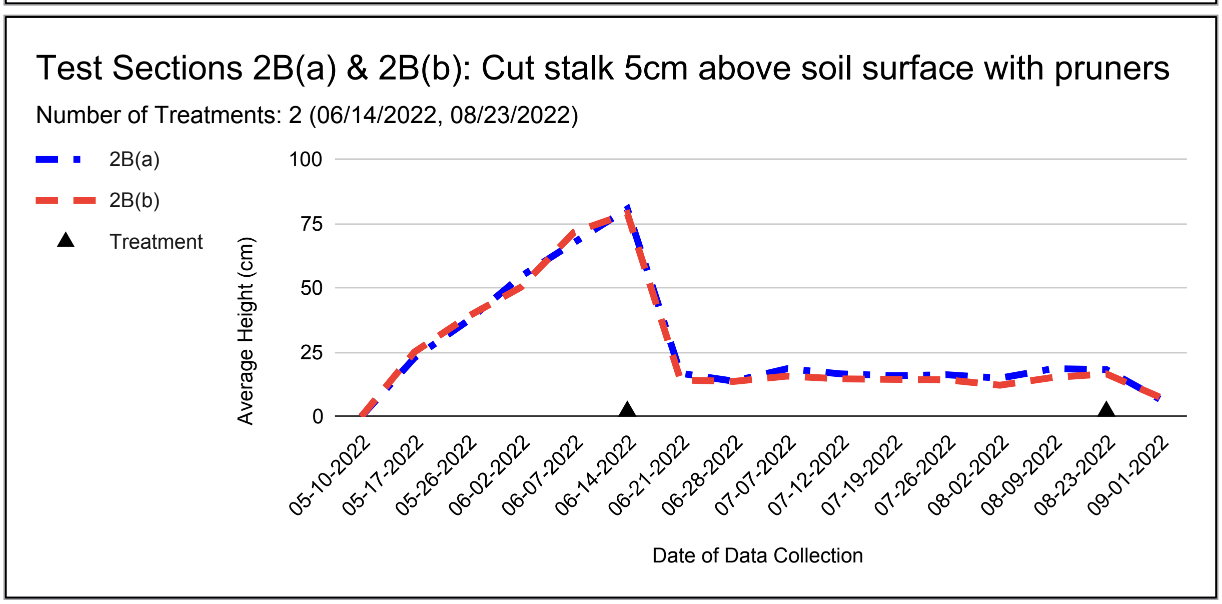
09-01-2022
Data Collection Date


Test Sections 2B(a) & 2B(b): Cut stalk 5cm above soil surface with pruners
Number of Treatments: 2 (06/14/2022, 08/23/2022)
2B(a)
2B(b)
Treatment
Average Height (cm)
100
75
50
25
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
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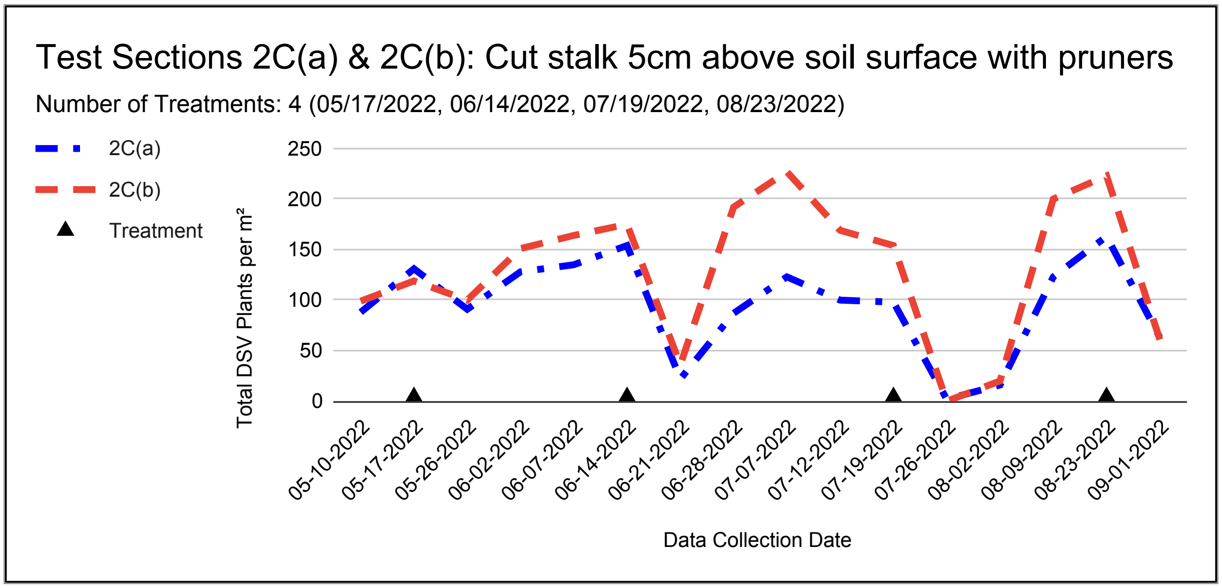
08-23-2022
09-01-2022
Date of Data Collection



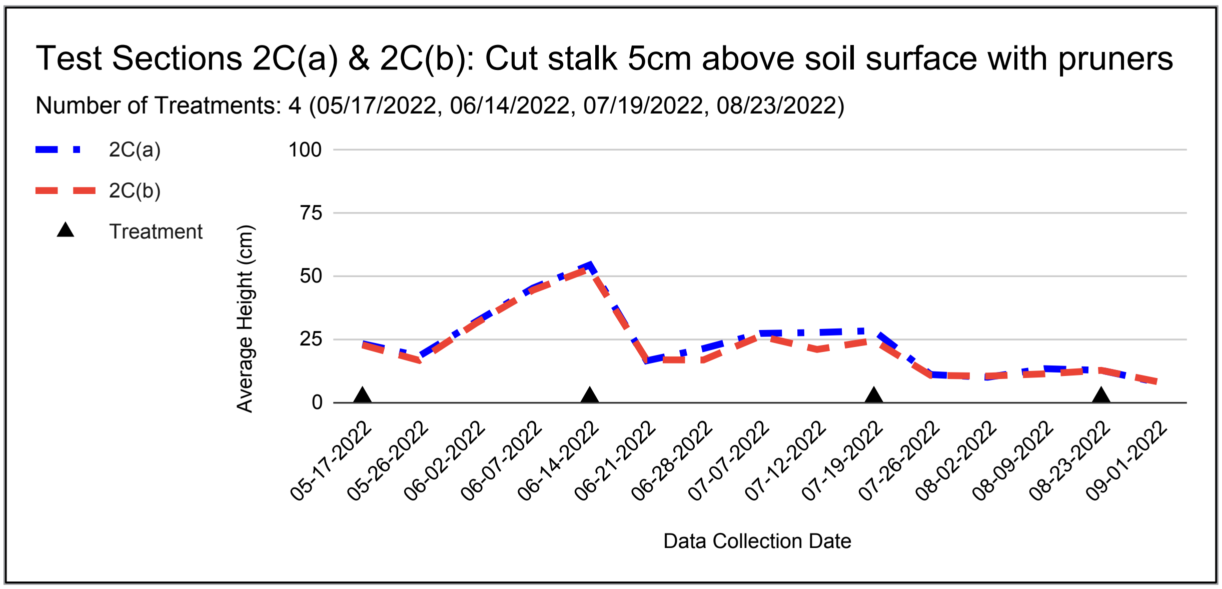


Table 2. Observations for Plots 2A, 2B, 2C—Cut stalk 5 cm above soil surface with pruners

Date	**2A Observations** **Non-DSV plants present:** Grasses, 1 Raspberry, Thistle, Wintercress, Vetch, St John's Wort	**2B Observations** **Non-DSV plants present:** Grasses	**2C Observations** **Non-DSV plants presesnt:** Grasses, 25 Raspberry, Thistle, Moss
05/10/2022	DSV just emerging from soil	DSV just emerging from soil	DSV just emerging from soil
05/17/2022	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear Treatment 2C
05/26/2022	More DSV flowers	More DSV flowers	No flowers after treatment
06/02/2022	DSV flowers opening, stem tips beginning to curl	DSV flowers opening, stem tips beginning to curl	No observations recorded

Date	2A Observations **Non-DSV plants present:** Grasses, 1 Raspberry, Thistle, Wintercress, Vetch, St John's Wort	2B Observations **Non-DSV plants present:** Grasses	2C Observations **Non-DSV plants presesnt:** Grasses, 25 Raspberry, Thistle, Moss
06/07/2022	DSV in full bloom and stem tips curled and twisting together	DSV in full bloom and stem tips curled and twisting together	No observations recorded
06/14/2022	No observations recorded	**Treatment done in 2B**	**Treatment done in 2C**
06/21/2022	DSV seed pods visible	Patches of soil appear to have been disturbed by an animal	No observations recorded
06/28/2022	More DSV seed pods, all still green	No observations recorded	Raspberry has grown very tall and covers most of the plot 2C(a) less in plot 2C(b)
07/07/2022	More DSV seed pods, stems are curled and tangled **Treatment done in 2A**	No observations recorded	No DSV in flower, all very small
07/12/2022	30% of plot covered in DSV seedlings	Lots of grasses, DSV is all thin stemmed and yellowish	Some DSV beginning to flower
07/19/2022	No observations recorded	No observations recorded	Treatment done in 2C
07/26/2022	60% of ground is covered in DSV seedlings less than 5 cm, goldenrod in buffer about to flower	1 DSV in flower	Raspberry plants have thrived with removal of DSV, DSV seedlings
08/02/2022	Trampling in buffer zone suppressing raspberries, grasses and DSV	Grasses dry and yellow, DSV wilted and yellowish, 2 DSV in flower Trampling in buffer zone suppressing raspberries, grasses and DSV	Carpet of DSV seedings less than 5 cm covering %70 of plot Trampling in buffer zone suppressing raspberries, grasses and DSV
08/09/2022	Many cut DSV stems have regrown with 2 or 3 new stems	No observations recorded	No observations recorded
08/23/2022	No observations recorded	DSV has chlorotic patches on leaves **Treatment done in 2B**	DSV has chlorotic patches on leaves **Treatment done in 2C**
09/01/2022	1 DSV with seed pod, regrowth is thin and stunted, 2 have produced seed pods, lots of DSV seedlings and regrowth shoots	All DSV has yellowish discoloured leaves, very little regrowth no seeds or flowers, lots of seedlings that show very little growth over past several weeks	All DSV has yellowish discoloured leaves, very little regrowth no seeds or flowers, lots of seedlings that show very little growth over past several weeks

For Plots 2A, 2B and 2C, the stalk was cut 5 cm above the soil surface with hand pruners. Some cut stalks grew back with multiple stems. Other plant species in the test plots were left uncut. Small DSV seedlings have appeared.

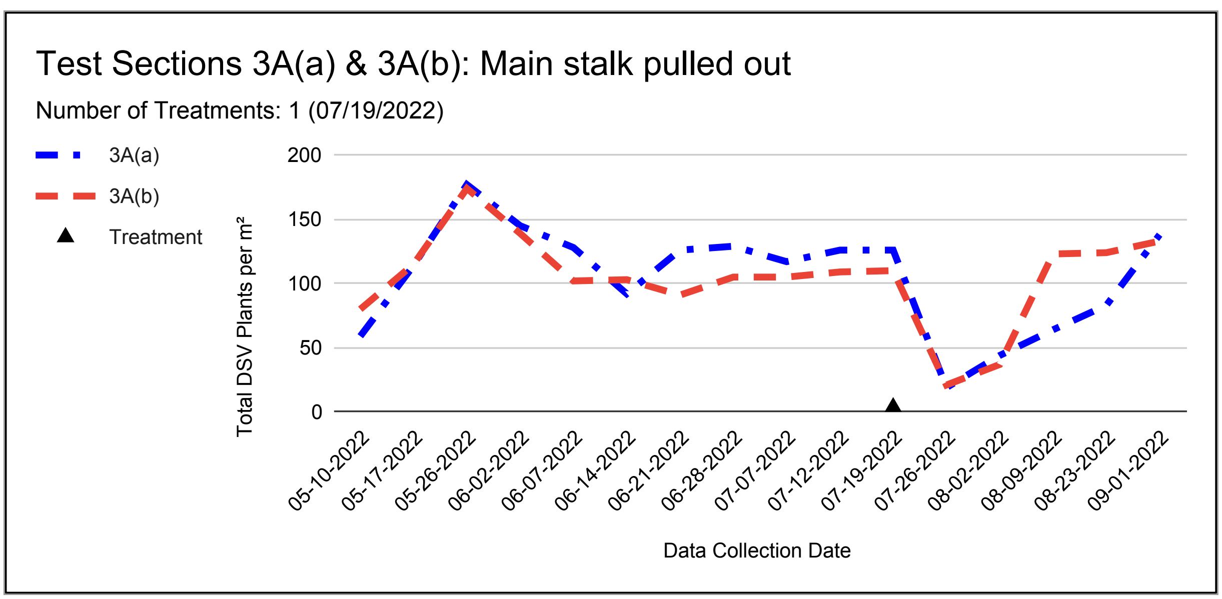
Photo 2: A cut stalk grew two branches. Small DSV seedlings are present.

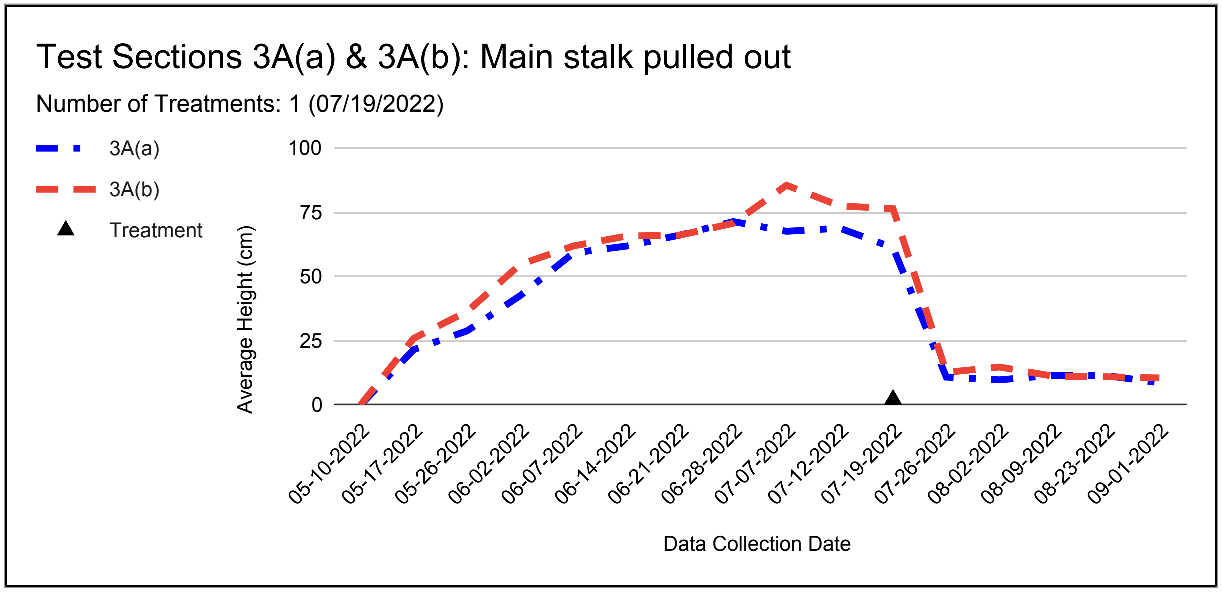
Plot 2A was cut once. The numbers of stalks recovered well but remained small. Many seedlings were observed under the grasses. Very few plants flowered.

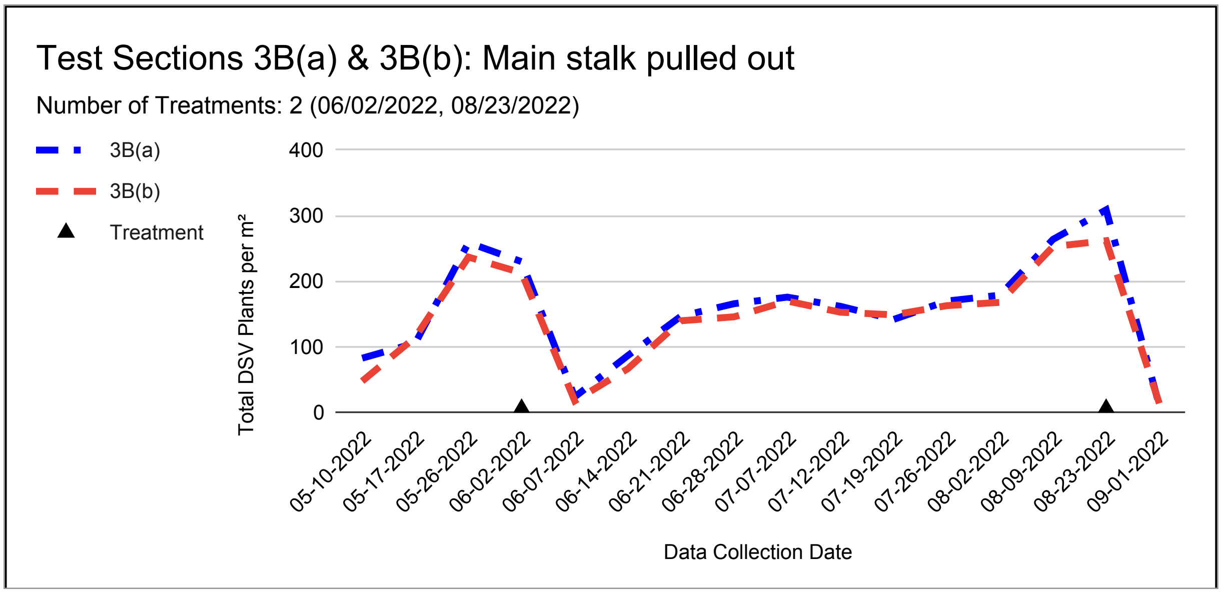
Plot 2B was cut twice. The numbers recover well by August, but the plants remain small and appear yellow and thin. Some DSV flowering was observed. Grasses dominate.

Plot 2C was cut four times. The numbers recover but the plants get smaller with each cut. There are many tiny seedlings throughout the plot. No seeds are produced. The raspberry plants that were originally present have thrived.

Photo 3: Raspberry plants dominate Test Plot 2C




Test Sections 3A(a) & 3A(b): Main stalk pulled out
Number of Treatments: 1 (07/19/2022)
3A(a)
3A(b)
Treatment
Average Height (cm)
100
75
50
25
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
07-19-2022
07-26-2022
08-02-2022
08-09-2022
08-23-2022
09-01-2022
Data Collection Date


Test Sections 3B(a) & 3B(b): Main stalk pulled out
Number of Treatments: 2 (06/02/2022, 08/23/2022)
3B(a)
3B(b)
Treatment
Total DSV Plants per m²
400
300
200
100
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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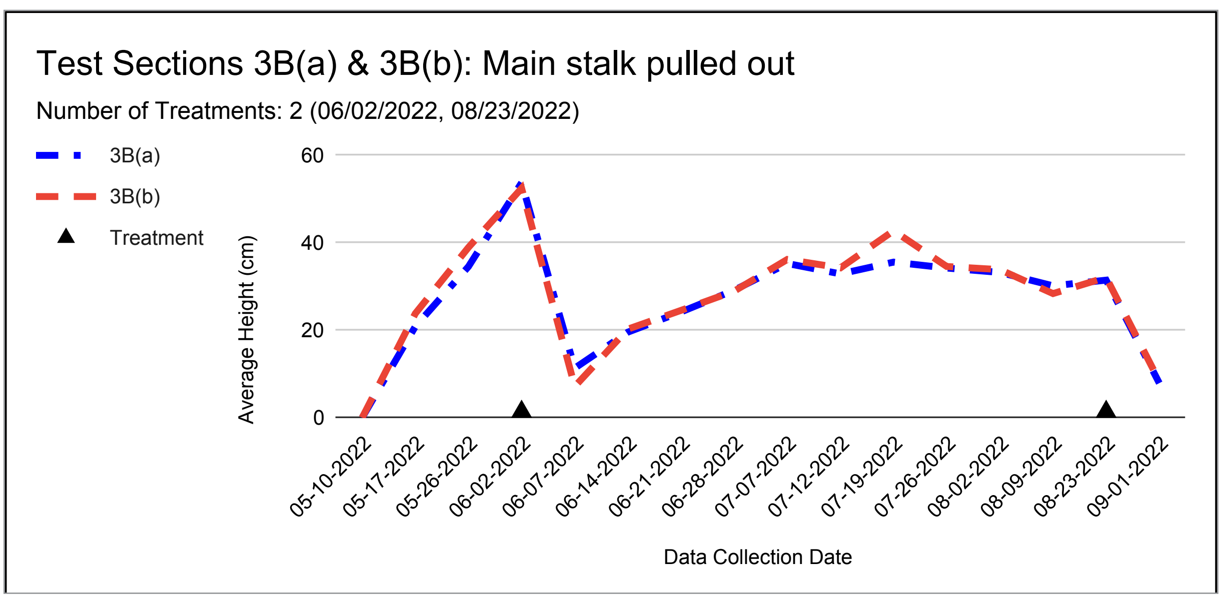
09-01-2022
Data Collection Date


Test Sections 3B(a) & 3B(b): Main stalk pulled out
Number of Treatments: 2 (06/02/2022, 08/23/2022)
3B(a)
3B(b)
Treatment
Average Height (cm)
60
40
20
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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07-26-2022
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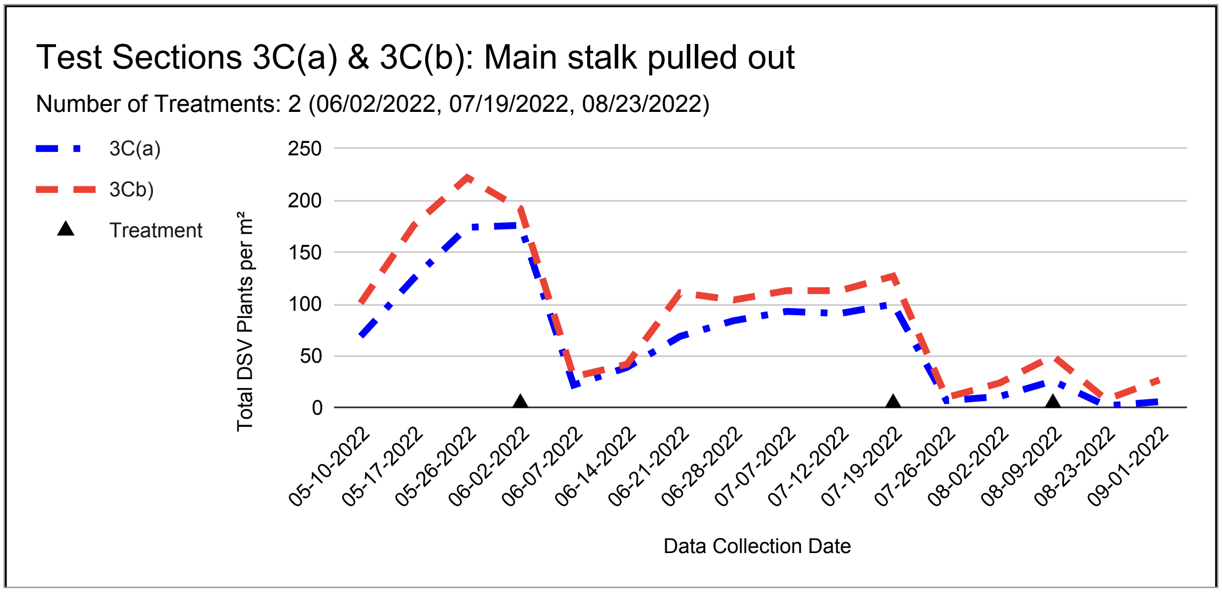
08-23-2022
09-01-2022
Data Collection Date



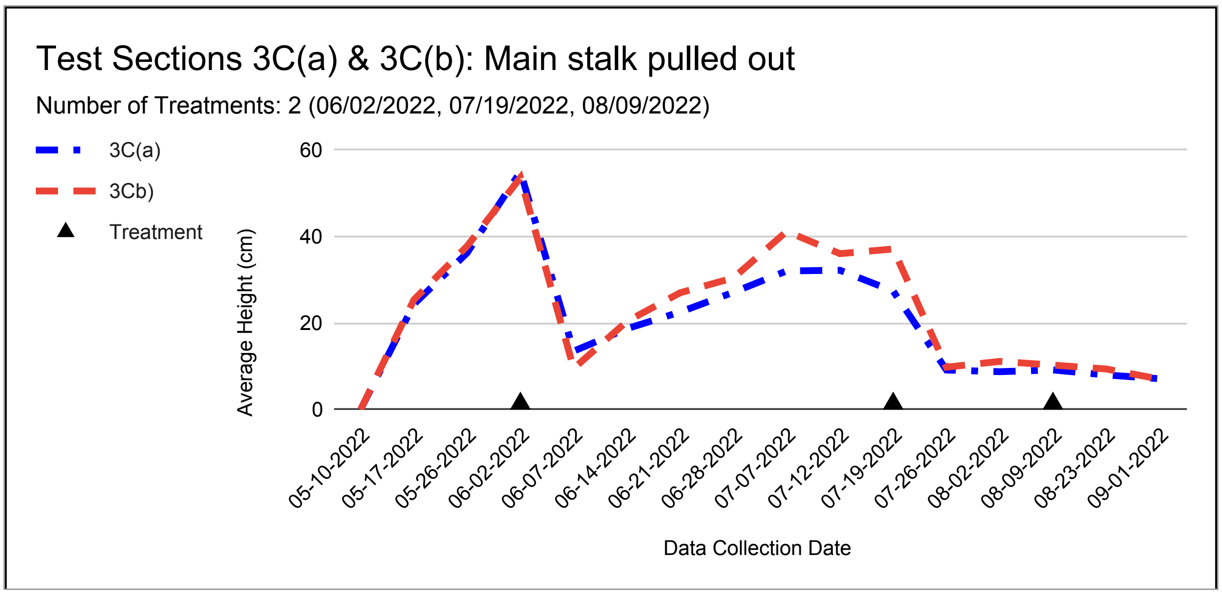


Table 3. Observations for Plots 3A, 3B, 3C—Main stalk pulled out

Date	**3A Observation** **Non-DSV plants present:** Grasses, Thistle	**3B Observations** **Non-DSV plants present:** Grasses, Thistle, Raspberry, Moss	**3C Observations** **Non-DSV plants present:** Grasses (Reed Canary Grass), Thistle, Vetch
05/10/2022	DSV just emerging from soil	DSV just emerging from soil	DSV just emerging from soil
05/17/2022	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear
05/26/2022	More DSV flowers throughout research site	More DSV flowers throughout research site	More DSV flowers throughout research site

Date	3A Observation **Non-DSV plants present:** Grasses, Thistle	3B Observations **Non-DSV plants present:** Grasses, Thistle, Raspberry, Moss	3C Observations **Non-DSV plants present:** Grasses (Reed Canary Grass), Thistle, Vetch
06/02/2022	DSV flowers opening, stem tips beginning to curl	DSV flowers opening, stem tips beginning to curl **Treatment done in 3B**	DSV flowers opening, stem tips beginning to curl **Treatment done in 3B**
06/07/2022	DSV in full bloom, stem tips curled and twisting together	DSV seedlings present	DSV seedlings present
06/14/2022	No observations recorded	No observations recorded	No observations recorded
06/21/2022	DSV seed pods visible	No observations recorded	No observations recorded
06/28/2022	More DSV seed pods, all still green	No observations recorded	No observations recorded
07/07/2022	More DSV seed pods, stems are curled and tangled	No observations recorded	No observations recorded
07/12/2022	Large DSV seed pods, stems leaning over and twisted, leaves curled and folded.	No observations recorded	Some DSV in flower, some small seed pods, stems leaning and twisted, leaves curled and folded
07/19/2022	**Treatment done in 3A**	No observations recorded	**Treatment done in 3C**
07/26/2022	20% of ground covered with DSV seedlings, grasses (species unknown) predominate, grasses suppressed in buffer by trampling	Some DSV has flowers and seeds, reduced DSV growth in buffer due to trampling	Some DSV seedlings, reduced DSV growth in buffer due to trampling
08/02/2022	Grasses still green, DSV wilted	No observations recorded	Reed canary grass tall and gone to seed, DSV small and yellowish
08/09/2022	No observations recorded	Most DSV has seed pods	DSV remains small
08/23/2022	Densely covered with grasses	**Treatment done in 3B**	Mostly reed canary grass **Treatment done in 3C**
09/01/2022	DSV is discolored, thin stemmed and has no flowers or seeds. Lots of seedlings less than 5cm that haven't grown noticeably over the past several weeks. Plot is predominantly filled with grasses.	A carpet of DSV seedings less than 5 cm tall covering 45% of plot, haven't grown noticeably over the past several weeks. DSV regrowth is small, thin and has no seed or flowers	DSV is small and thin and has no seeds or flowers. Lots of DSV seedlings haven't grown noticeably over the past several weeks. Lots of reed canary grass present

Plots 3A, 3B and 3C have had the main stalk pulled out. This removes the end of the stalk including the new growth buds.

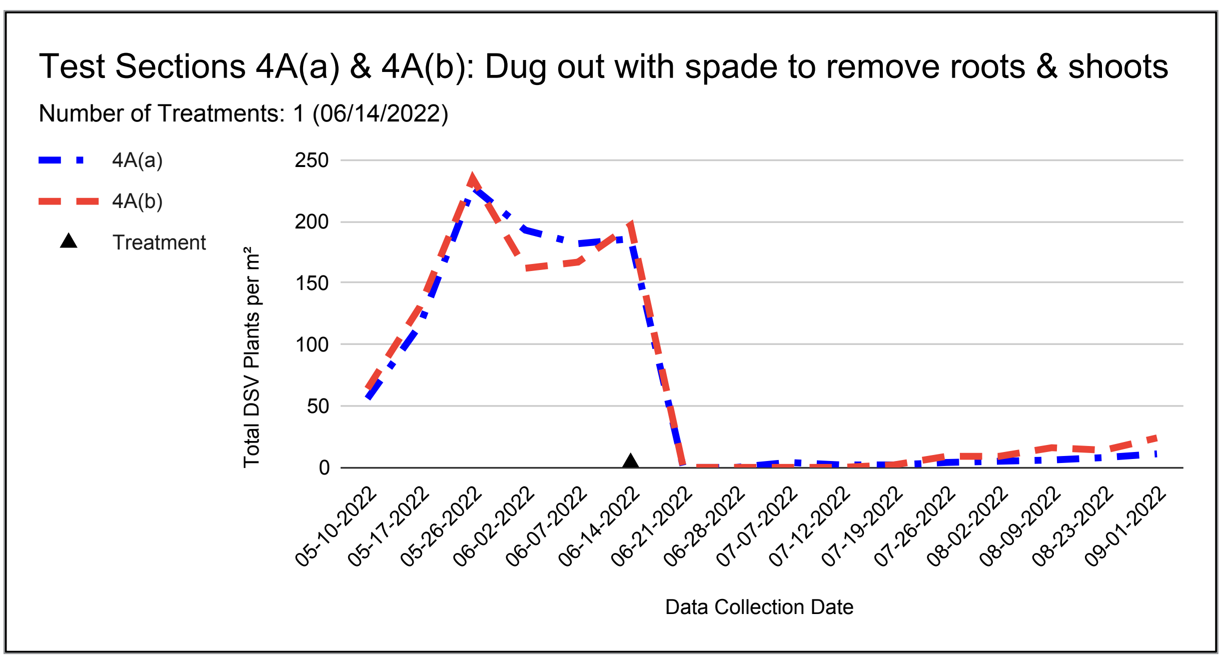
Photo 4: Stalk ends including growth buds.

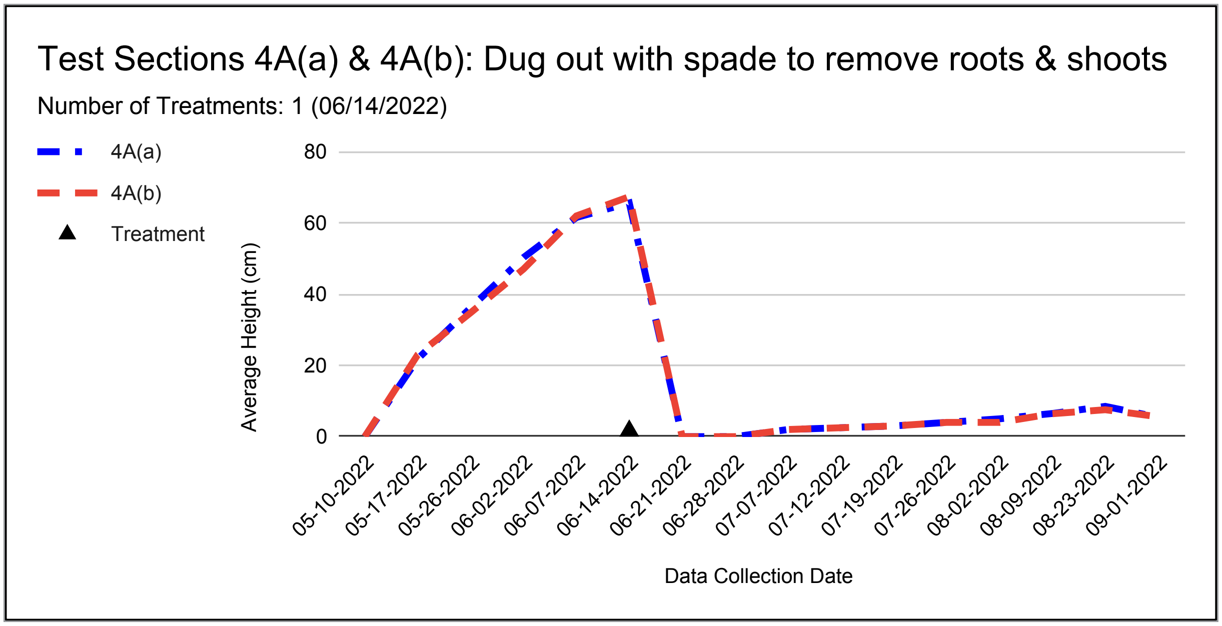
Plot 3A had stalks pulled out once. Although the numbers of stalks recover, the heights of the stalks do not. Pulling them out once seems to have stunted the growth and prevented seed production. There are tiny seedlings present.

Plot 3B had stalks pulled out twice. In this case, the numbers of stalks and heights recovered after the first treatment. Seed pods developed but were removed at the second treatment. The other plant species continued to grow undisturbed.

Plot 3C had stalks pulled out three times. After the first treatment, the numbers of stalks and the heights recover but, after the second treatment, they do not. This plot became dominated by Reed Canary Grass after the first treatment and remained that way throughout the season.

Photo 5: Plot 3C showing Reed Canary Grass dominating.




Test Sections 4A(a) & 4A(b): Dug out with spade to remove roots & shoots
Number of Treatments: 1 (06/14/2022)
4A(a)
4A(b)
Treatment
Average Height (cm)
80
60
40
20
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
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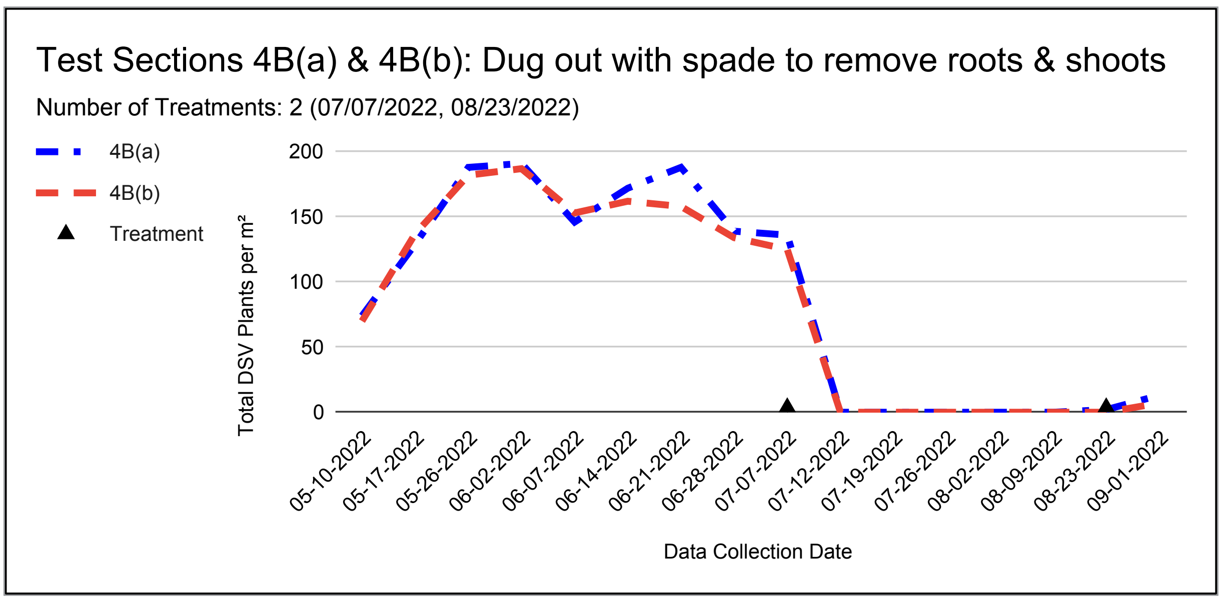
09-01-2022
Data Collection Date


Test Sections 4B(a) & 4B(b): Dug out with spade to remove roots & shoots
Number of Treatments: 2 (07/07/2022, 08/23/2022)
4B(a)
4B(b)
Treatment
Total DSV Plants per m²
200
150
100
50
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
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09-01-2022
Data Collection Date

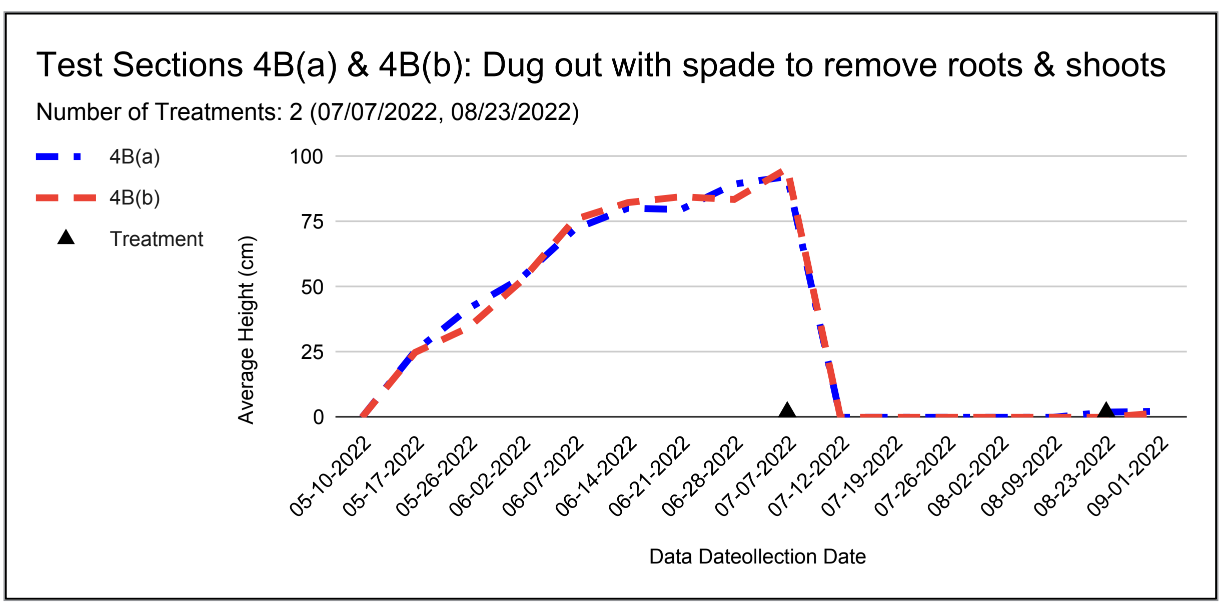

Test Sections 4B(a) & 4B(b): Dug out with spade to remove roots & shoots
Number of Treatments: 2 (07/07/2022, 08/23/2022)
4B(a)
4B(b)
Treatment
Average Height (cm)
100
75
50
25
0
05-10-2022
05-17-2022
05-26-2022
06-02-2022
06-07-2022
06-14-2022
06-21-2022
06-28-2022
07-07-2022
07-12-2022
07-19-2022
07-26-2022
08-02-2022
08-09-2022
08-23-2022
09-01-2022
Data Dateollection Date

Table 4. Observations for Plots 4A, 4B—Dug out with spade to remove roots & shoots

Date	4A Observations **Non-DSV plants present:** Grasses, Goldenrod	4B Observations **Non-DSV plants present:** Grasses, Thistle
05/10/2022	DSV just emerging from soil	DSV just emerging from soil
05/17/2022	Some DSV flower buds starting to appear	Some DSV flower buds starting to appear
05/26/2022	More DSV flowers	More DSV flowers
06/02/2022	DSV flowers opening, stem tips beginning to curl	DSV flowers opening, stem tips beginning to curl
06/07/2022	DSV in full bloom and stem tips curled and twisting together	DSV in full bloom and stem tips curled and twisting together
06/14/2022	**Treatment done in 4A**	DSV beginning to develop seed pods
06/21/2022	No DSV or any vegetation	DSV seed pods visible
06/28/2022	No growth	More DSV seed pods, all still green
07/07/2022	No growth	More DSV seed pods, stems are curled and tangled **Treatment done in 4B** (very difficult to dig, soil dry and clay-like, roots dense and tangled)
07/12/2022	No growth	No DSV or any vegetation
07/19/2022	No growth	No growth
07/26/2022	Some thistle and bindweed growing back	No DSV, appearance of a few small thistles
08/02/2022	DSV growth in buffer zone of plot, some thistle and bindweed	4-thistles
08/09/2022	Bindweed slowly spreading	Thistles still tiny
08/23/2022	Clover and many Wintercress seedlings growing	**Treatment done in 4B**
09/01/2022	30% of ground covered in wintercress seedling, some thistle, mostly bare soil, some patches of DSV regrowth, some very small seedlings. Two DSV shoots have produced seed pods.	8 thistles, 3 wintercress seedlings, mostly bare soil, some very small DSV seedlings

For Test Plots 4A and 4B, the DSV plants were completely dug out with a spade to remove all roots & shoots. This treatment also removed the other plant species present because the roots were tangled together.

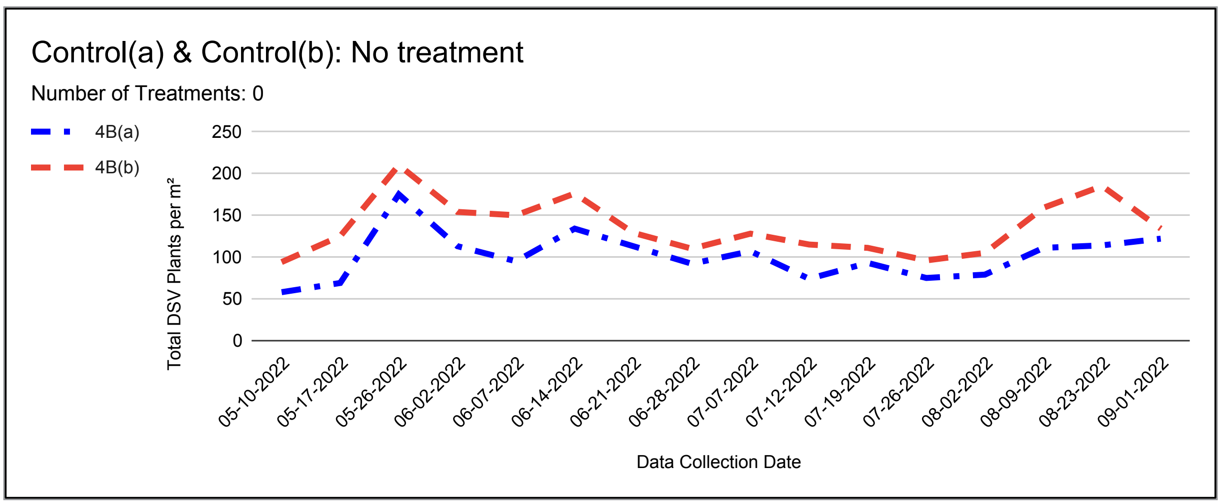
Photo 6: Plant roots from dug-up plants are tangled together.

Photo 7: Plant roots from dug-up plants are tangled together.

After removal, the DSV stalks did not recover in numbers of stalks or heights. A few other species returned in both Test Plots.

Test Plot 4A: Many Wintercress seedlings appeared in late August after rain.

Test Plot 4B was treated twice in July and August resulting in complete removal of DSV stalks. There was a slight recovery of a few DSV seedlings.



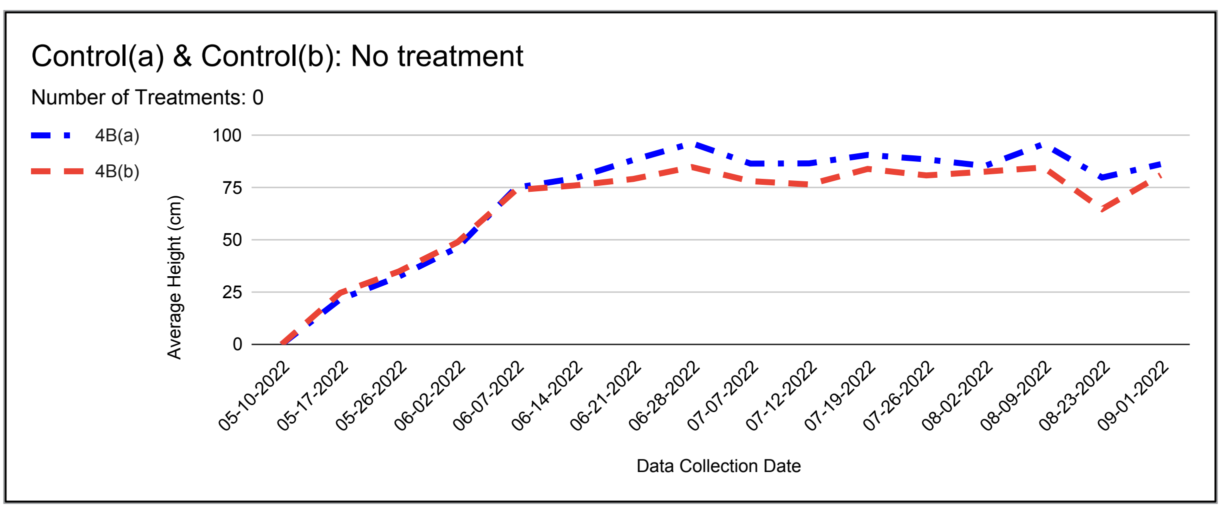


Table 5. Observations for Control Plot—No treatment

Non-DSV plants: Grasses, Thistle, Vetch, Bindweed, Milkweed

Date	Control
05/10/2022	DSV just emerging from soil
05/17/2022	Some DSV flower buds starting to appear
05/26/2022	More DSV flowers
06/02/2022	DSV flowers opening, stem tips beginning to curl
06/07/2022	DSV in full bloom and stem tips curled and twisting together
06/14/2022	DSV seed pods beginning to form
06/21/2022	DSV seed pods visible
06/28/2022	DSV stems curled and tangled, more DSV seed pods, all still green
07/07/2022	Plot appears to have been trampled by animal, difficult to measure DSV, more DSV seed pods, and stems are curled and tangled
07/12/2022	Vetch gone to seed
07/19/2022	DSV very tangled and difficult to measure and count
07/26/2022	DSV dominates, tangled and difficult to count and measure, some DSV seedlings appearing
08/02/2022	DSV seed pods maturing, DSV wilted and very tangled
08/09/2022	Mature seed pods split and beginning to disperse seeds
08/23/2022	Appears to be some newer shoots that are smaller, still all green and have not produced seeds or flowers among the mature plants
09/01/2022	DSV is beginning to dry out turning yellow and brown, stems lying down and tangled, seed pods exploding lots of fluffy seeds everywhere! DSV seeds dispersing

The Control Plot acted as a reference to determine the growth cycle of DSV at this location. The DSV plants were allowed to grow undisturbed. Collecting data became increasingly difficult as the summer progressed because the vines became tangled. There were a few different plant species within the plot, but those individual plants did not thrive in this environment.

The DSV plants began to grow in early May. By late May/early June, flowers appeared.

The flowers developed into green seed pods by late June and by early July the stalks were twisting upon each other. The plants reached their maximum heights in late June/early July. The seed pods turned brown, became dry and split to reveal the fluffy seeds by August. By early September, the plants' leaves yellowed, and the seeds dispersed in the wind.

Soil Sample Analyses

Table 6. Soil Analysis Summary (Agrifoods)

Soil Sample	pH	Organic Matter % dry soil	Phosphorus mg/L P	Potassium mg/L K	Magnesium g/L Mg	Sodium mg/L Na	Calcium mg/L Ca
DSV present	6.8	6.9	9.8	97	240	15	3400
No DSV present	6.6	6.8	9.9	72	260	21	3300

Soil Sedimentation Jars (July 2022)

Photo 8: Soil Sedimentation tests in mason jars

The soil analysis data and sedimentation layers in the jars appear to be very similar between the soils collected from areas where there was an abundance of DSV and areas where there were only grasses.

Table 7. Auxiliary Experiment for DSV Roots and Crowns Observations

Date	Stem Ends	Root Crown	Root Mass	Root Fragments
Aug 2	Set up planting	Set up planting	Set up planting	Set up planting
Aug 9	Growth evident in all pots (A,B,C,D,E)	Growth evident in pots A,B,C.D	Growth evident in D & E	No growth evident in any pots
Aug 17	Growth evident in all pots (A,B,C,D,E)	Growth evident in all pots (A,B,C,D,E)	Growth evident in all pots (A,B,C,D,E)	No growth evident in any pots
Sept 6	Growth evident in all pots (A,B,C,D,E) but the shoots are not gaining any height	Growth evident in all pots (A,B,C,D,E) but the shoots are not gaining any height	Growth evident in all pots (A,B,C,D,E) but the shoots are not gaining any height	No growth evident in any pots

Photo 9: Left to right: stem end, root crown, root mass, root fragments

Photo 10: Root fragments

Discussion

Plots 1A, 1B, 1C—Cutting Beneath the Soil Surface

Cutting the DSV stalks below the surface using a special knife was very challenging when done for large numbers of stalks for prolonged periods of time in dry clay soil that was very hard. The researchers often acquired sore points or blisters on the hands. In the two Test Plots where this treatment was used in July, the plants remained small and did not produce flowers. For the Test Plot that was treated in June, the recovering plants did produce flowers. This indicates that, if this technique is used, it should be done in July or later. It could be used in a garden setting where the soil is more easily worked and the plants surrounding the DSV stalk are valuable and cannot be disturbed by extensive digging.

It does not seem to be practical as a method to be used in a park/meadow setting by Stewardship Volunteers.

Plots 2A, 2B, 2C—Cutting Above the Soil Surface

Repeatedly cutting the DSV stalks above the soil surface suppressed their growth. In the research setting, where the stalks were selectively cut, this allowed the other plant species that were already present to thrive. Grasses were able to dominate in some Test Plots and, in one plot, Raspberry Canes became the dominant plant present. Because the area had been mown prior to setting up the test site, all raspberry canes from the previous season were cut down. Fruit is produced only on second-year canes. It will be interesting to see whether the Raspberry Canes produce any fruit next summer or whether their growth is suppressed by the DSV.

Cutting above the surface is not very practical to carry out by hand for large areas. However, if there are very few valuable other species present, this would be useful if mechanized, i.e., using a mowing device. It must be noted that when an area is mowed, the DSV is suppressed, but no other plant species can attain heights greater than the mowing height (Biazzo and Milbrath, pp. 174). This would be most useful to create a grass path through a meadow but not to enhance the growth of a wildflower meadow. Repeated mowing would be required.

Plots 3A, 3B, 3C—Pulling out the Stalk

An easy and quick method for controlling DSV is to pull the stalk out without disturbing the soil. Care must be taken to hold the stalk close to the soil surface when pulling to ensure the stalk does not break above the surface. It seemed that this was most effective when the soil was moist, allowing the lower part of the stem along with the new growth buds to be removed. When the stalks were pulled in June, the plants recovered quickly. It appears that it is better to pull plants in July or later to stunt the growth. Once the plants were removed, the grasses that were already present became dominant. In particular, the Test Plot with the Reed Canary Grass seemed to have a dramatic effect on the growth of the DSV. After removal, there seemed to be only a few small DSV plants and tiny seedlings.

Upon observation of patches of Reed Canary Grass in the surrounding fields adjacent to the Research Site, a similar phenomenon was observed. The DSV does not grow where the Reed Canary Grass is dominant. The area does not experience any disturbance, i.e., no mowing and no foot traffic.

Non-Native Reed Canary Grass is known for being very aggressive, as well as for remaining dormant as part of a region's seed bank until a gap forms and it is able to germinate (Lavergne and Molofsky, 2004, pp. 422). Disturbed areas can enhance Reed Canary Grass' ability to proliferate, so the pulling out of DSV could have created the perfect opportunity for the grass to thrive. In addition, Reed Canary Grass shares DSV's strong ability to compete for nutrients, its symbiotic relationship with mycorrhizal fungi in the soil, and its tolerance of a wide range of growing conditions (Lavergne and Molofsky, 2004, pp. 423). Both species can limit their underground or above-ground growth to conserve resources. DSV generally focuses on above-ground growth, while reed canary grass has stronger roots and forms rhizomes, which likely makes it a strong competitor for DSV (Lavergne and Molofsky, 2004, pp. 417).

Plots 4A & 4B—Digging out the Plant

Of the four strategies used to control the growth of Dog Strangling Vine (DSV), the most effective approach was to dig the entire plant out of the ground. This approach was also the most difficult to accomplish due to the effort required to remove the tangled roots in dry clay soil. In a garden setting, where the plants are not growing so densely, this would be the recommended method of choice since the soil is likely to be more easily worked and the plants can be isolated for removal. The DSV plants could be selectively dug out. Care should be taken to dig the root mass out to a depth of 8 to 10 cm to ensure removal of the growth crown and most of the roots. Sometimes, there appears to be a series of growth crowns at different depths so deep digging is recommended if feasible to ensure complete removal of the individual plant.

Photo 11: Note the multiple growth crowns below the main stalk.

In a park meadow setting, digging the plant out may not be as practical. If there were isolated plants in particular areas of concern, they could be dug out without disturbing their surroundings, particularly if there are valuable plants present.

After all the plants were dug out in the research setting, thistle and bindweed returned in small numbers. Their rhizomes must have been below the area that was dug. In Test Plot 4A, there must also have been a large seed bank of the biennial, Wintercress, present in the soil. After the rain, the seeds germinated. These small plants will overwinter and bloom the following spring. It will be interesting to see if it dominates in that location or if the DSV returns.

Photo 12: Wintercress seedlings sprouting after a rain.

Soil Analyses

The soil analyses conducted did not show any remarkable differences between soil taken from an area that had a dense cover of mature DSV plants and soil that was taken from an area that had only grasses growing in it. It appears as that there must be other factors that we were not able to analyse using the methods available to us at this time. This is an area that could benefit from further investigation.

DSV Roots and Crowns

From our findings examining the plant parts that could potentially propagate new DSV plants, it appears that many parts of the DSV plant are able to propagate new plants. There is also some research to indicate that the plant can grow from root fragments, although this was not our observation (Miller and Kricsvalusy, 2008, pp. 34). However, to err on the side of caution, after any removal strategy, it seems important that care must be taken to ensure that no parts of the plant are left behind. They should be sealed in a plastic bag, solarized for 1 to 2 weeks (left in the sun until the plant material is not viable) and then discarded into landfill to prevent spread of the plant.

Limitations of the Study

There were limitations in conducting this experiment. To begin, this experiment was conducted in natural areas that had already been overtaken by DSV. The numbers of plants, seeds, and other species in each plot were not consistently uniform. Therefore, some plots may have had more or fewer DSV plants and seeds than others, and/or more competitive plant species present. Therefore, each plot was a unique experiment.

Trends within each plot were analysed independently from others. Perhaps in a subsequent investigation, standardized, cultivated plots of DSV could be created and different competitive native species could be added to determine the effects of treatments on such combinations. This would require multiple seasons because time would be required to establish the standardised plots prior to treatments.

As previously mentioned, DSV is known for engaging in a "sit and wait" strategy, wherein it can lay dormant for extended periods of time until it has the advantage over any surrounding species. This experiment lasted only from May until September, so we cannot be sure whether or not the DSV that did not reappear after removal was simply dormant beneath the surface of the soil and would regrow in time. Similarly, considering the numerous seeds that each DSV plant produces, it is possible that there are seeds from the surrounding areas now be part of the soil's seed bank that could grow at the first opportunity. Small seedlings that remained small throughout the summer were observed to be present in many of the test plots. They may be the plants that will prevail and grow next season. Again, to answer these questions, further study in subsequent years would be required. It would be interesting to observe the recovery of the DSV at this test site in the following spring/summer season to determine the long-term effectiveness of the different treatments.

Research indicates that repeated mowing or defoliation attempts are necessary to have long-term, significant effects on the growth habit of DSV (Milbrath, 2008, pp. 1287). To assess the eradication of DSV in the plots that appeared to be under control by the end of the experiment, the sites would need to be revisited regularly over the course of several years, with the potential for repeating the appropriate control method for each individual plot.

Conclusion

This study is intended to guide student gardeners working in ornamental gardens at the Arboretum and stewardship volunteers working in public parks in non-chemical strategies to be used for controlling DSV. The indications are that the most effective control method is digging out the plant including the roots. Because this is not always practical, an alternative recommended approach would be to pull out the plants as often as possible, starting in late July before the seed pods mature. These control efforts should be repeated from year to year, to affect long-term control of DSV in the cultivated gardens and natural areas.

Conflict of Interest

The authors declare that no conflict of interest or monetary interest exists.

Note on Contributors

Short LF, Bachelor of Science (Honours Biology & Chemistry), Environmental Stewardship Specialist, Humber Arboretum, Humber College Institute of Technology & Advanced Learning, Toronto, Ontario, Canada, lynn.short@humber.ca. Lynn is currently working in the Humber Arboretum using manual methods to control various invasive species on the property.

Bearden S, Bachelor of Arts (Gender and Women's Studies), student in the Landscape Technician Diploma Program, Humber College Institute of Technology & Advanced Learning, Toronto, Ontario, Canada, sophiabearden@gmail.com. Sophia is the recipient of the 2022 Horst Dickert Scholarship from the Ontario Horticulture Trades Foundation.

McWatch B, Pre-Health Sciences Pathway Certificate, student in the Paramedics Diploma Program, Humber College Institute of Technology & Advanced Learning, Toronto, Ontario, Canada, bella.mcwatch@hotmail.com. Bella is currently working towards a Diploma in the Paramedics program.

Hafez L, Bachelor of Arts (Global Development Studies), student in the Landscape Technician Diploma Program, Humber College Institute of Technology & Advanced Learning, Toronto, Ontario, Canada, lanahafez@hotmail.com. Lana is the recipient of the 2022 Cullen Family Scholarship Program from the Ontario Horticulture Trades Foundation.

References

Anderson, H. (2012). Invasive Dog-strangling Vine (Vincetoxicum rossicum): Best Management Practices in Ontario. *Ontario Invasive Plant Council*.

Biazzo, J. and Milbrath, L. (2019). Response of pale swallowwort (Vincetoxicum rossicum) to multiple years of mowing. *Invasive Plant Science and Management*, 12, 169-175.

DiTommaso, A., Milbrath, L., Bittner, T., & Robert Wesley, F. (2013). Pale Swallowwort (Vincetoxicum rossicum) Response to Cutting and Herbicides. *Invasive Plant Science and Management*, 6, 381-390.

Lavergne, S. and Molofsky, J. (2004). Reed Canary Grass (Phalaris arundinacea) as a Biological Model in the Study of Plant Invasions. *Critical Reviews in Plant Sciences, 23*(5), 415-429.

Maguire, D., Sforza, R., & Smith, S. (2011). Impact of herbivory on performance of *Vincetoxicum* spp., invasive weeds in North America. *Biol Invasions*, 13, 1229-1240.

Milbrath, L. (2008). Growth and reproduction of invasive Vincetoxicum rossicum and V.nigrum under artificial defoliation and different light environments. *Botany*, 88, 1279-1290.

Miller, G., and Kricsfalusy, V. (2008). *Dog-strangling Vine:* Cynanchum rossicum. (Kleopow) Borhidi: A Review of Distribution, Ecology and Control of This Invasive Exotic Plant. Downsview, ON: Toronto and Region Conservation/ Rouge Park.

Pest Management Regulatory Agency. (2017). Re-evaluation Decision RVD2017-01, *Glyphosate*. Retrieved from Government of Canada website: https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates/registration-decision/2017/glyphosate-rvd-2017-01.html

Sandilands, C. (2013). Dog Stranglers in the Park?: National and Vegetal Politics in Ontario's Rouge Valley. *Journal of Canadian Studies, 47*(3), 93-122.