Controlling sweetpotato volunteers with herbicides

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Summary

A pot trial was conducted to test the ability of herbicides to control sweetpotato volunteers. Two pre-emergent (metolachlor and pendimethalin), four pre- and post-emergent (imazethapyr, oxyfluorfen, prometryn and terbuthylazine) and six post-emergent (2,4-DB, glyphosate, dicamba, fluroxypyr, glusosinate ammonium and MCPA) herbicides were tested. The six post-emergent herbicides killed or seriously set back plant vine growth. The pre and pre/post emergent herbicides were not as effective in controlling plant growth.

Introduction

Sweetpotato, a nutritious root crop, predominately grown in Queensland and northern New South Wales has an annual farm gate value of $90 M (ASPG pers. com.). Grading of sweetpotatoes is based on size and visual appearance. Merchants and retailers want roots that have smooth skins, are rich and vibrant in colour and fresh, firm and unblemished (Wolfenden et al. 2014). There is minimal tolerance for defects such as cracking, uneven shape, twisted or bumpy roots, insect damage holes, feeding marks, pimpling or skin lesions.

Sweetpotato being a root crop, is particularly sensitive to soil borne pests. Of these pests, nematodes are the most destructive causing an annual estimated $20 M loss to the industry (ASPG per. com.). Nematodes reduce root size, the efficiency with which roots forage for water and nutrients and can affect storage roots by causing cracking, internal and external lesions and galling (pimpling), (Overstreet 2013, Noling 2016). They can rapidly multiply with one female root knot nematode being able to lay up to 3,000 eggs.

Unfortunately for producers, nematodes are well suited to all Australia's main sweetpotato production soils. Surveys by DAF and Biological Crop Protection have indicated that Root-knot nematodes are present in virtually all sweetpotato fields. Although, in Australia, economic thresholds for nematode numbers in sweetpotato crops have not been established, it is assumed to be very low, possibly 0 or 1 nematodes per 200 mL soil (pers. comm. Project Reference Group, Hort Innovation project PW 17001 *Integrated management of nematodes in sweetpotatoes*).

There is no single 'silver bullet' for controlling nematodes. While nematicides are available, Integrated Pest Management programs, in which chemicals are a tool, are the recommended strategy for nematode management (Overstreet 2013, Adama 2015), Critical to this type of strategy is crop rotation with non-nematode host plants. To ensure the effectiveness of these rotations, all volunteer sweetpotato plants must be removed from the field to ensure there are not viable food sources remaining through the rotation period. Herbicides can play and important role in the management of these volunteers. This trial looked at the impact of several herbicides and in controlling sweetpotato storage root vines.

Materials and Methods

A pot trial was conducted in the Walkamin Research Facility (WRF) open roof screenhouse (17°08'09" S, 145°25'37" E, 600 masl). A randomized block design with 12 herbicide treatments and a nil herbicide control (Table 1) replicated four times was used. As there are no herbicides specifically registered to kill sweetpotato, the herbicides selected all have registration to kill an *Ipomoea* sp. weed species, the genus that sweetpotato (*Ipomoea batatas*) belongs to.

Table 1. List of herbicides trialled

Active ingredient	Application time	Mode of action group	Rate /ha
2,4-DB 500g/L	Post emergent	I	3.2 L/ha
glyphosate 570 g/L	Post emergent	M	3.7 L/ha
dicamba 500 g/L	Post emergent	I	560 mL/ha
fluroxypyr 333 g/L	Post emergent	I	1.8 L/ha
glufosinate ammonium 200 g/L	Post emergent	N	5 L/ha
imazethapyr 700 g/kg	Pre and post emergent	B	140 g/ha
MCPA 750 g/L	Post emergent	I	1.4 L/ha
metolachlor 720 g/L	Pre-emergent	K	4 L/ha
oxyfluorfen 240 g/L	Pre and post emergent	G	6 L/ha
pendimethalin 455 g/L	Pre-emergent	D	3.3 L/ha
prometryn	Pre and post emergent	C	2.2 kg/ha
terbuthylazine	Pre and post emergent	C	1.2 kg/ha
control (water)	nil	nil	-

Treatments

2,4-DB is a systemic herbicide that can be used to control annual and perennial broadleaf weeds. In the plant the 2,4-DB compound changes to 2,4-D and inhibits the growing points of stems and roots (Gupta P. 2018). It is absorbed through foliage and translocated around the plant via the plants vascular system. It induces abnormal growth in the plant such as twisting, bending of stems and petioles; leaf curling and cupping, and development of abnormal tissues and secondary roots resulting in eventual plant death. Plant death can take three to five weeks. (Cornell University undated)

Glyphosate is a non-selective herbicide for control of both grasses and broadleaf weeds. In the plant glyphosate affects the manufacture of amino acids by affecting their production pathways. Production of anthocyanins, flavonoids lignin and chloroplasts are some compounds affected. Glyphosate is readily absorbed by leaves and translocated through the plant in the vascular system. Growth is affected soon after application. There is a general yellowing in the immature leaves and growing tips which then spreads. Plant death can occur within four to seven days with susceptible species and may take up to 20 days with less susceptible species (Cornell University undated).

Dicamba is a selective herbicide for control of broadleaf weeds. It disrupts the plants transport systems and interferes with the metabolism of nucleic acid. It is readily absorbed through roots, stems and the foliage and then translocated through the plant in the vascular system. It causes abnormal growth in the plant such as twisting, bending of stems and petioles; leaf curling and cupping, and development of abnormal tissues and secondary roots resulting in eventual plant death. Symptoms may occur within hours of the herbicide application, but plant death may take three to five weeks (Cornell University undated).

Fluroxypyr is a selective post-emergent herbicide for control of a wide range broadleaf weeds. Foliar absorption and translocation is the main route of the chemical into the plant, although there is minor root absorption. When absorbed in the plant it accumulates in the growing tissues and causes an auxin overdose which interferes with the plants ability to use nitrogen and produce enzymes. It causes abnormal growth eventually resulting in death. Fluroxypyr has some residual activity and growers need to be aware of plant back periods. Generally, there is little residual activity although, in soils containing less than 25% clay. susceptible crops may require up to a 12 month break before planting. Hard water should also be avoided, or if unavoidable a water conditioning agent added (EPA 1998, Guo et al. 2019, Corveta Agriscience undated, Herbiguide[1] undated)

Glufosinate ammonium is a non-selective herbicide for the control of broadleaf weeds and grasses. It has no residual activity. It is not actively translocated in the plant, so will only kill the foliage/stem areas it contacts. Due to rapid microbial breakdown, it has minimal if any root absorption. It causes a build-up of ammonium in the plant that destroys cells and stops photosynthesis. Glufosinate ammonium usually causes yellowing and wilting within three to five days and death within one to two weeks. Bright sunlight, high humidity and moist soil increase the rate of plant death. (Cornell University undated)

Imazethapyr is a pre- or post-emergence herbicide for control of broad leaf weeds and some grasses. It can have long term residual activity and plant back periods for some crops in dryland conditions can be up to 34 months. Some plant back periods may be reduced when greater than 2,000 mm of rainfall/irrigation has been applied (ADAMA 2019[1]). Imazethapyr is readily absorbed by foliage and slightly slower by roots. It is translocated around the plant in the vascular system. It works by inhibiting the production of a key enzyme required for the manufacture of certain amino acids. Susceptible plants growth may be inhibited within a few hours of application. The growing points may start dying within one to two weeks, followed by a slow yellowing and dying of the plant (Cornell University undated)

MCPA is a systemic post-emergence herbicide for control of broadleaf weeds. It is absorbed through foliage and translocated in the vascular system to growing points. It can also be absorbed through the soil (Kogan and Henandez, 1991). It acts as the plant growth hormone, auxin, causing uncontrollable growth and eventual plant death (Anon. 2017). Plant symptoms can include twisting and bending, leaf cupping and curling, thickening and elongation of leaves, dying of the growing point and wilting. Death may take up three or more weeks (Nufarm undated).

Metolachlor is a short residual, pre-emergent herbicide for control of broadleaf and annual grasses. It is primarily absorbed from the soil through the germination coleoptile (shoot) although there can be root absorption. Metolachlor stops or reduces seedling growth by inhibiting the formation of long chain fatty acids. It can be translocated through the xylem. Metolachlor needs to be irrigated after application to ensure the chemical is in the weed seed zone. (Butts et al. undated, Kenso 2004, Mann undated). Metolachlor breaks down faster in high organic matter soil, particularly when they are warm and moist as microbial action is increased under these conditions (Long et al. 2014). Metolachlor is registered for use in sweetpotato, to be applied immediately after transplanting sweetpotato vines, before weeds have germinated. This trial is looking at the effect on germinating/emerging sweetpotato roots. This is outside the registered label use for the product.

Oxyfluorfen is a pre- and post-emergent selective herbicide for control of annual broadleaf and grassy weeds. It is rapidly absorbed by shoots, less so by roots and is poorly translocated through the plant. Oxyfluorfen works by attacking the fats and proteins of the plant cell membranes. This causes breakdown in the cell membrane and cell desiccation It is persistent and relatively immobile in soils and the soil surface should not be disturbed after application. Plant symptoms can include leaves having a water-soaked appearance, then followed by necrotic spots., Depending on the crop, plant back intervals may be as long as 180 days (Vanstone and Stobbe 1978, Anon 2017, ADAMA 2019[2], Fenimore undated).

Pendimethalin is a pre-emergence selective herbicide for control of annual grasses and some broadleaf weeds. It inhibits pre-emergent seedling development, by affecting root and shoot growth. It is readily absorbed by young roots, but there is minimal translocation. Cell division in young roots, particularly root tips is inhibited, and they become thick and stubby. Pendimethalin works best when it is thoroughly mixed in the soil, either by mechanical incorporation or watered in. With some crops pendimethalin may have a 12 month plant back period (BASF 2013, Cornell University undated).

Prometryn is a selective pre- and post-emergence herbicide for control of broadleaf weeds and some grasses. It is mainly absorbed through the roots, although it is also absorbed through foliage, and translocated in the xylem where it accumulates in meristems and leaves. It inhibits electron transports affecting the photosynthetic system. Prometryn requires rain or irrigation soon after spraying for best activity. It works best on germinating seedlings or young and actively plantlets growing in moist soil. Young plants may stop growing then yellow and slowly die over 3-4 weeks. With some crops it may have a plant back period of up to eight months (EPA 1996, Nufarm 2009, Herbiguide[2] undated, OXON[1] undated)

Terbuthylazine is a selective pre- and post-emergence herbicide for control of annual broadleaf weed and some grasses. It is mainly absorbed through the roots or seedlings and to some extent by emerging cotyledons. It can also be absorbed through foliage. It is translocated in the xylem and accumulates in meristems and leaves. It inhibits electron transport which affect the photosynthetic system. Plants may yellow and die. There may be a plant back period in excess of six months for some crops (Kuechler et al. 2003, FAR 2007, Nufarm 2009, Herbiguide[3] undated, OXON[2] undated)

Trial process

Polystyrene boxes (internal measurement 44.5 cm L x 27.5 cm W x 12.0 cm H) were filled with a 2 cm layer of red basaltic Mapee soil, the soil common to the Walkamin cropping area. These soils are deep red uniform light to medium clay soils formed from basalt (Malcolm and Heiner 1996). The soil was taken from a newly cultivated fallow block on WRF. In the past 10 years, there was no recorded use of herbicide on this block.

Into each box seven sweetpotato storage roots (two large, two medium and three small) were placed on the layer of soil, positioned as shown in Image 1. More soil was then added to cover the roots to a depth of 2 cm. When planted, the boxes were watered to field capacity. The next day the boxes were inspected and boxes in which the soil had settled were topped to their original level and lightly watered.

Image 1. Placement of large, medium and small roots in box (In the trial these were sitting on 2cm of soil).

Due to rainy conditions, the pre-emergent herbicides were not applied till six days after planting the storage roots. Herbicides were applied using a 500 ml hand sprayer with 200 ml of solution in the sprayer. The spray was applied to provide target coverage (similar to that achieved from a field spray unit). After pre-emergent spray application, the boxes were watered to ensure the herbicide was incorporated in the soil profile. Plants were checked three times per week to gauge the effect of the pre-emergent herbicide.

Post-emergent herbicides were not applied until all boxes had emerged plants that were actively growing. Cool weather came through soon after emergence and plant growth stopped until warmer weather returned (100 days). The pre and pre/post-emergent herbicides did not stop vine emergence, so the pre/post emergent herbicides were applied again, this time as a post-emergent spray. All herbicides were applied using a 500 ml hand sprayer with 200 ml of spray solution in the sprayer. The spray was applied to provide coverage of the box and plants (similar to that achieved from a field spray unit).

The trial was lightly watered three times per week, except when conditions were wet. Records of the herbicide effects were also made at these times. Each plot (box) was observed and a five point rating scale given to the visuals symptoms the plants were showing;

1. Plants are healthy growing and showing no sign of herbicide application.
2. Plants are showing symptoms which may affect plant growth, such as wilting, of leaves or stem. This may have retarded growth to some degree but if symptoms remain at this level, the plants will continue to grow.
3. Plants showing moderate effects affecting their growth. The plants are wilting strongly or have bleaching, burnt or senesced leaves and stem. They still have a visual assessment of 50% green leaves, stems and growing tips and may or may not be able to grow out of this damage.
4. Plant showing considerable effect of the herbicide application. They still have some green leaves or stems, but it is unlikely they will be able to grow out of the damage.
5. Plants dead

In addition to the rating a description was made of the visual appearance of the plot, (e.g., stems wilting, leaves bleached or leaves bronzed, leaves senescing). The trial concluded 45 days after pre-emergent herbicide applications were made.

Results

Pre-emergent Herbicides

The two pre-emergent herbicides, metolachlor and pendimethalin, did not stop the emergence of sweetpotato vines. Neither did the pre- and post-emergent herbicides, imazethapyr, oxyfluorfen, prometryn and terbuthylazine. Pendimethalin while not stopping emergence or growth did cause the true leaves to be misshapen (Images 2 & 3).

Images 2 & 3. Leaf deformation seen in pendimethalin treatments.

Caution needs to be applied to the results for pre-emergent herbicide applications. This is due to the way the plants grew in the pots. The clay content of the Walkamin Mapee soils caused the soils to pull away from the pot edges creating a space (Image 4). A number of sprouts from sweetpotato roots did grow into these spaces and up the side of the pot. This may have resulted in these sprouts not growing through the herbicide layer and may in part be responsible for the lack of control evidenced by these treatments.

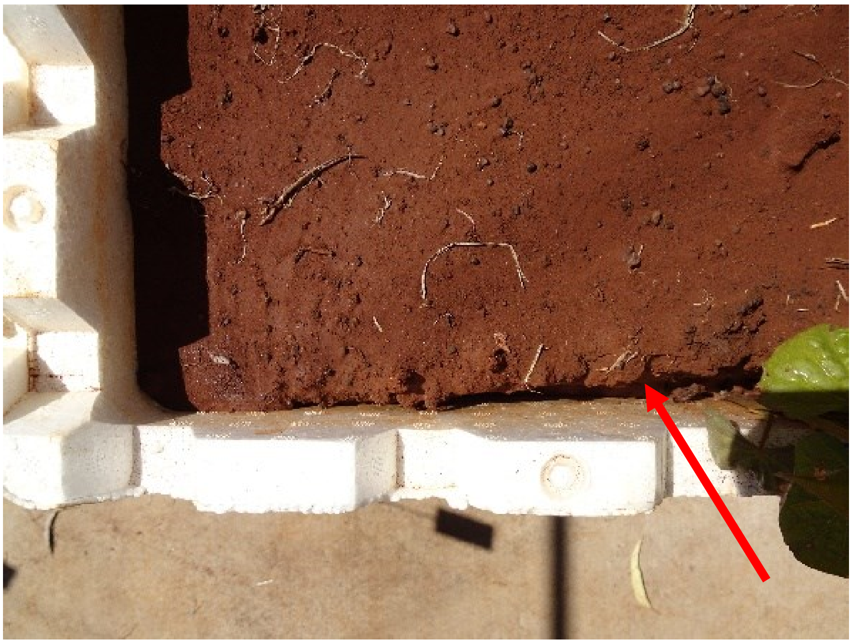


Image 4. Soil media pulled away from the side of the pot.

Herbicide application after sweetpotato emergence

Figure 1. graphs the various effects the post-emergent herbicide application had on the sweetpotato plants. Imazethapyr, oxyfluorfen, prometryn and terbuthylazine, the pre- and post-emergent herbicides had both pre and post applications made.

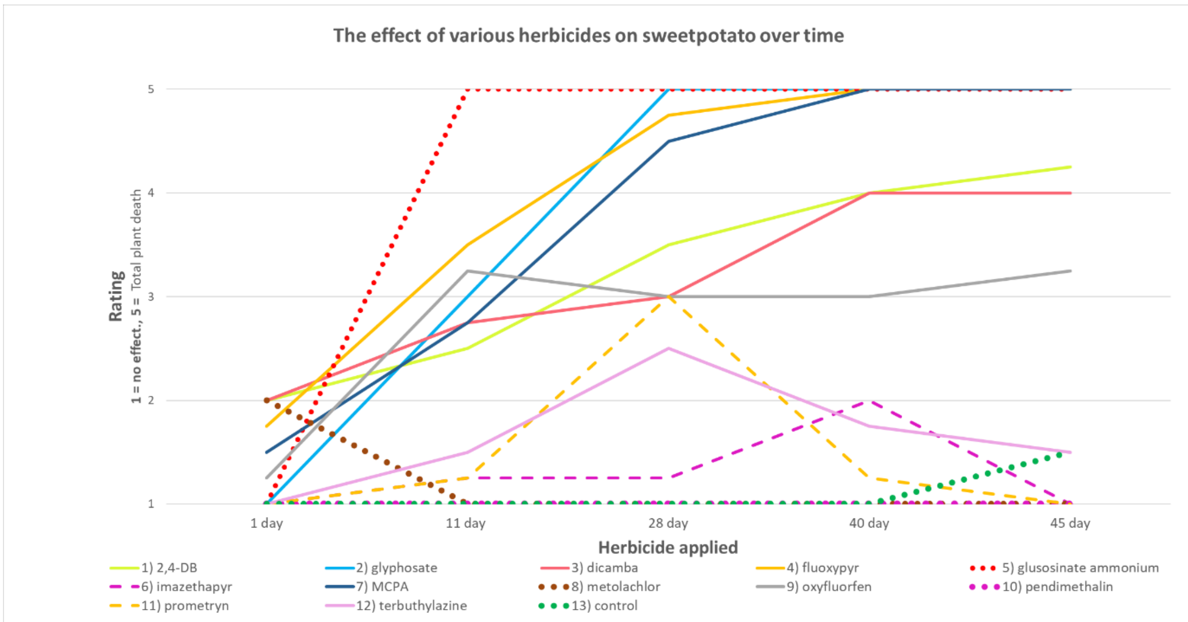


Figure 1. The effect of pre and post-emergent herbicide applied to sweetpotatoes.

Post-emergent herbicides

2,4-DB showed slight wilting of plants within 24 hours of application. By day four, a few plants were showing slight yellowing. This then progressed to some vein clearing, curling and bronzing of leaves. By day 15 the plants were at a seriously damaged and continued to slowly progress towards complete death.

Glyphosate did not start showing any obvious signs of plant damage until day 8. By day 8 there was sign of leaf yellowing, bronzing and some older leaf senescence. By day 11 plants were seriously damaged and by day 28 all plants were dead.

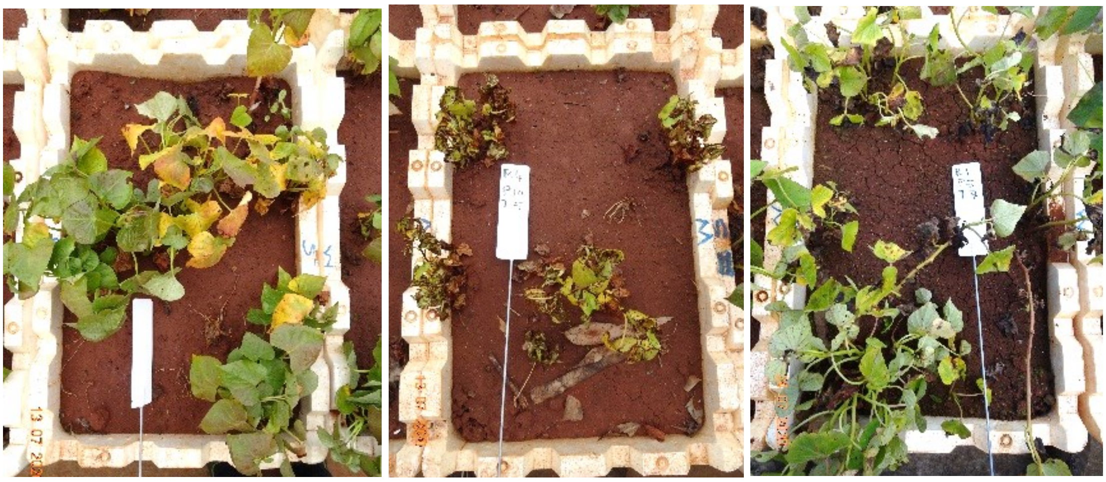
Dicamba sprayed plants were exhibiting signs of wilting within 24 hours of herbicide application. By day 4, plants were exhibiting wilting, leaf yellowing, bronzing and leaf burn symptoms. These continued to worsen and by day 17 had reached a level 3 rating and day 40 a level 4 rating. By the end of the trial, the plants remained at a rating 4.

Images 5, 6 & 7 (left to right) Plants affected by 2,4-DB, glyphosate and dicamba

Fluroxypyr was showing yellowing leaves, leaf bronzing and senescence and slight wilting by day 4. These symptoms continued to develop reaching a rating of 3 by day 8. By day 17, many of the plants were showing a high portion of senesced leaves, and plants virtually dead by day 26.

Glufosinate ammonium plants were showing some slight yellowing within 24 hours, but otherwise were looking healthy. Within four days, this had developed considerably. There was obvious leaf burn, and some leaves were senescing. Plants were totally dead by day 11. Glufosinate ammonium was the fastest acting herbicide in this trial.

MCPA was showing some leaf burn after 24 hours. By day 4 plants older leaves were yellowing and leaf edges senescing. Other leaves were pale in colour and plants tips were showing slight wilting. By day 24 plants were severely damaged (rating 4) and plants completely died by day 40.



Images 8, 9 & 10 (left to right) Plants affected by fluroxypyr, glufosinate-ammonium and MCPA

Post -emergent applied pre- and post-emergent herbicides

Imazethapyr treated plants did show a few reddened leaves and some yellow edges by day 15, but this receded until days 28 to 35 when symptoms appeared again. These stayed until day 42 and again disappeared.

Oxyfluorfen was showing reddened and bronzed leaves and some wilting after 24 hours of herbicide application. In one plot leaves were senescing. By day 6 plants were severely damaged and given a 3 rating. Most leaves were yellow, bronzed or red and the plants were wilting slightly. From this point until the end of the trial symptoms remained stable. The plants were not growing nor were they not showing signs of dying.

Prometryn showed some slight reddening and bronzing of the leaf in the first 8 days, but not enough to move it from a rating 1. Over the next 20 days symptoms slowly developed on the plants. By day 26, plants had whitened leaves with brown patches and leaf senescence and drop was occurring. From day 28 till 42 plants recovered from these effects and by the trial conclusion appeared to be growing well again.

Terbuthylazine plants grew well until day 11, when plants showed some reddening of leaves and a few older leaves yellowing with senescing leaf margins. These progressed to day 33 when older leaves had dropped, and many remaining leaves had yellowed or whitened. Leaves were also starting to curl upwards. From day 33 to the trials end the plants recovered.

Images 11, 12 & 13 (left to right) Plants affected by imazethapyr, oxyfluorfen, prometryn and terbuthylazine

Discussion

Four herbicides, glyphosate, fluroxypyr, glusosinate ammonium and MCPA successfully killed the sweetpotato vine within the timeframe of the trial. A censored analysis of variance (ANOVA), only looking at treatments that showed plant death indicated that glusosinate ammonium sprayed plants died significantly faster than the other treatments and predicted that 2.4-DB sprayed plants would have died soon after the completion of the trial (Table 2). Two other herbicides dicamba and oxyfluorfen severely limited the plants growth. Given the extent of damage to the plants it could be expected that dicamba sprayed plants and possibly the oxyfluorfen sprayed plants may have also succumbed. With the exception of oxyfluorfen, all of these chemicals were post-emergent herbicides. It should be noted that the oxyfluorfen plots were actually treated twice with the herbicide, once as a pre-emergent spray and again as a post-emergent. Although the pre-emergent spray did not show an effect on plant growth, it is not known if the post-emergent spray or the combination of the spray applications caused the toxic effect on the plants.

Table 2. Sweetpotato time to death after herbicide application

Treatment	Mean days to death
2,4-DB	46.5 c
glyphosate	23.6 b
fluoxypyr	29.0 b
glusosinate ammonium	8.7 a
MCPA	32.2 b

lsd= 13.04

Over time the pre-emergents imazethapyr, prometryn and terbuthylazine showed an effect on sweetpotato plant growth. However, in each of these cases the plants were able to overcome the herbicide effect. Again, it is not known if the effect on plants was caused by the post-emergent application of the herbicide or if it was a combination effect caused by the two herbicides.

Pendimethalin a pre-emergent herbicide while not seeming to affect the plants growth rate or leaf colour, did cause leaf deformation and this continued for the life of the experiment, indicating there may have been a continual effect from this residual herbicide.

Of the herbicides trialled in this experiment, the post-emergent herbicides best controlled sweetpotato vine growth. It would be interesting in future work to look at the post-emergent effect of oxyfluorfen and see if it does have a capacity to kill sweetpotato. Due to the onset of cold weather, this trial did not look at possible storage root regrowth. This is an issue that may need to be considered in field applications. Also, the trial did not consider any plant back intervals for follow on crops post herbicide application. These are stated on herbicide labels and must be adhered to.

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