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POA ANNUA CONTROL TRIALS
WINTER AND SPRING-SUMMER 2018

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Contents

1. INTRODUCTION

Herbicide trials have been undertaken over the past 2 years to evaluate the efficacy of the available turf registered herbicides either by themselves or in combination with other herbicides to control herbicide resistant *Poa annua* in couch.

As a follow up to the trials undertaken in 2016 and 2017/18, trials were initiated to evaluate the use of glyphosate and glufosinate combinations as well as other herbicide actives that are not yet registered for use on turf.

2. METHODOLOGY

There were two trials undertaken in 2018;

Trial 1: The use of non-selective herbicides at low application rates to provide selective control of the *Poa annua* and not to damage the couch.

Trial 2: Evaluation of herbicide actives that have efficacy on *Poa annua* but are not yet registered for use on turf.

2.1 Trial 1: Glyphosate/Glufosinate

The trial was based on the use of non-selective herbicides at low application rates to provide selective control of the *Poa annua* and not to damage the couch.

In addition to assessing the individual herbicides, the "double knock" method was also assessed where a systemic herbicide of one mode of action (Glyphosate) is applied and then followed up with a contact herbicide (Glufosinate) of a different mode of action. The theory is to allow the systemic herbicide to be taken into the plant and then to further damage the plant by following up with an application of a contact herbicide.

Treatments: The treatments are detailed in table 1.

Table 1: Glyphosate and Glufosinate treatments

Treatment No.	Herbicides
1. (UTC)	Untreated control
2. (R0.5)	Glyphosate (a.i. 360g/L) at 0.5L product/ha
3. (R1)	Glyphosate (a.i. 360g/L) at 1.0L product /ha
4. (B0.5)	Glufosinate-ammonium (Basta™ a.i. 200g/L) at 0.5L product/ha
5. (B1)	Glufosinate-ammonium (Basta™ a.i. 200g/L) at 1L product/ha
6. (R0.5 x B0.5)	Glyphosate (a.i. 360g/L) at 0.5L product/ha + Glufosinate-ammonium (Basta™ a.i. 200g/L) at 0.5L product/ha
7. (R1.0 x B0.5)	Glyphosate (a.i. 360g/L) at 1.0L product/ha + Glufosinate-ammonium (Basta™ a.i. 200g/L) at 0.5L product/ha
8. (R1 x B0.5)	Glyphosate (a.i. 360g/L) at 1.0L product /ha + Glufosinate-ammonium (Basta™ a.i. 200g/L) at 0.5L product/ha
9. (R1 x B1)	Glyphosate (a.i. 360g/L) at 1.0L product /ha + Glufosinate-ammonium (Basta™ a.i. 200g/L) at 1.0L product/ha

There were 3 replicates of each treatment including an untreated control giving a total of 27 plots. Each plot was 2m x 2m ($4m^2$) with the herbicides applied using the B.A greenkeeper sprayer with yellow air inject nozzles from Teejet™ and a water volume of 450L/ha.

The trials were applied in the layout shown in figure 1.

The herbicides were applied as follows;

1. Glyphosate – 10/7/18
2. Glufosinate – 2/8/18 and 22/8/18 (Glufosinate applications were delayed due to weather conditions).

		2m	2m	2m	2m	2m	2m	2m	2m	2m
2m	**UTC**	P1	P2	P3	P4	P5	P6	P7	P8	P9
2m	**Basta (1.0L/ha)**	P10	P11	P12	P13	P14	P15	P16	P17	P18
2m	**Basta (0.5L/ha)**	P19	P20	P21	P22	P23	P24	P25	P26	P27
		Roundup (1.0L/ha)	**UTC**	**Roundup (0.5L/ha)**	**Roundup (1.0L/ha)**	**UTC**	**Roundup (0.5L/ha)**	**Roundup (1.0L/ha)**	**UTC**	**Roundup (0.5L/ha)**

Figure 1: Trial layout

2.2 Trial 2: Evaluation of new herbicide actives

Trial 2 evaluated several herbicide actives not yet registered for use on turf. The treatments are detailed in table 1. Note that the actives are not named to ensure confidentiality is maintained.

Table 2: Herbicide actives and rate of application

	Treatments	Product	Active	Rate of application of product	No. applications
T1	Exp1	-	-	-	-
T2	Exp2	-	-	-	-
T3	Foramsulfuron	Tribute™ (SU)	22.5g/L Foramsulfuron	1.5L/ha	2
T4	Exp3				
T5	Methiozolin	PoaCure™	240g/L Methiozolin	8L/ha	1
T6	Exp4	-	-	-	-
T7	UTC	-	-	-	-

There were three trial sites as follows;

Location	Soil Type	Soil pH	Herbicide application dates
Sorrento GC (SGC)	Loamy sand	8.0	10 and 24/10/18
Devil Bend GC (DBGC)	Clay loam	6 – 6.5	15 and 29/10/18
The National GC (NGC)	Calcareous sand	8 – 8.5	12 and 26/10/18

There were 3 replicates of each treatment including an untreated control. At the SGC trial site the plot size was 2m x 3m ($6m^2$) and at DBGC the plot size was 2m x 2m ($4m^2$) with the herbicides applied using a B.A greenkeeper sprayer with yellow air inject nozzles from Teejet™ and a water volume of 450 - 500L/ha.

At the NGC site the trial area available was smaller and the plot size was 2m x 1.5m ($3m^2$) with 3 replicates. The herbicides were applied using a pressure pack sprayer with a yellow air inject nozzle from Teejet™ and a water volume of 400L/ha.

2.3 Trial Assessment Criteria

The plots were assessed as follows;

***Poa annua* counts:** *Poa annua* counts were undertaken using a 900mm x 600mm wire mesh grid placed in the centre of each plot. There were 216, 50mm x 50mm squares in the wire mesh and in each square it was noted if there were live *Poa annua* plants present or absent. A live plant was considered to have at least 25% green leaf.

The *Poa annua* counts were undertaken at pre-treatment and about 5, 8 and 10 weeks (WAT) depending on the trial site after the initial treatments.

Normalized Difference Vegetation Index (NDVI): The NDVI was used as a method of empirically measuring the effects of the treatments on the colour of the couch and the spring green up in the couch.

The Normalized Difference Vegetation Index was measured at about the same time periods as the *Poa annua* counts.

Visual Turfgrass Injury: Turfgrass injury was assessed based on loss of colour, loss of leaf and reduction in turf density and presentation as a golfing surface. Turfgrass injury was based on 5 being severe injury, no green colour and some loss of turf density and 0 being no visible discolouration or loss of turf density. A rating of 3 is considered to be the maximum acceptable turf injury.

The Visual Turfgrass Damage ratings were undertaken at each assessment or when there was obvious turf damage.

3. WEATHER

The weather data for each trial period is detailed in figures 2 and 3 and can be summarised as follows;

Trial 1: Glyphosate/Glufosinate

July

- Rainfall anomaly –28% less rainfall than the long-term average.
- Mean maximum temperature anomaly +1.19 °C (6th-highest on record).
- Mean minimum temperature anomaly +0.23 °C.

August

- Rainfall anomaly −21% less rainfall than the long-term average.
- Mean maximum temperature anomaly +0.39 °C.
- Mean minimum temperature anomaly −0.20 °C.
- Mean temperature anomaly +0.09 °C

September

- September rainfall for Victoria was 66% below average, making it the State's second-driest September on record and driest since 1914.
- September continued a run of nine consecutive months of below average rainfall for Victoria as a whole.
- Rainfall totals were below average throughout the State.
- Australia's driest September on record
- Victoria's mean minimum temperature was 0.96°C cooler than average, the lowest for September since 1994.

Source: http://www.bom.gov.au/climate/current/statement_archives.shtml

On the day the **Glyphosate** was applied the weather conditions were as follows;

- Maximum temperature 11.8^{o}C
- 7mm of rainfall on the previous day
- Cloudy and cool

On the days the **Glufosinate** was applied the weather conditions were as follows;
Application 1:

- Maximum temperature 14°C
- 2.6mm of rainfall after application

Application 2:

- Maximum temperature 13.5°C
- 3.4mm of rainfall on the previous day

Trial 2: Evaluation of new herbicide actives
October

- Rainfall anomaly –53% less rainfall than the long-term average.
- Mean maximum temperature anomaly +2.56°C (6th-highest on record).
- Mean minimum temperature anomaly +1.77°C (5th-highest on record).

November

- Rainfall anomaly –5% less rainfall than the long-term average.
- Mean maximum temperature anomaly +0.71°C.
- Mean minimum temperature anomaly +0.94°C.

December

- Rainfall anomaly +44% more rainfall than the long-term average.
- Mean maximum temperature anomaly +2.89°C (3rd highest on record).
- Mean minimum temperature anomaly +3.23°C (highest on record).

Source: http://www.bom.gov.au/climate/current/statement_archives.shtml

Table 2: Rainfall and temperatures for each trial site at the time of herbicide application

Location	Application date	Rainfall previous 5 days (mm)	Max. Temperature (°C)
Sorrento GC	10/10/18	3.0	18.0
	24/10/18	4.0	15.4
Devil Bend GC	15/10/18	0.6	27.2
	29/10/18	0.0	16.6
The National GC	12/10/18	7.4	20.6
	26/10/18	0.0	17.1

4. RESULTS

4.1 Trial 1: Glyphosate/Glufosinate

4.1.1 *Poa annua* counts

The *Poa annua* counts were undertaken pre-treatment and at 5, 8 and 10 weeks after treatment and the results are detailed in table 3 and figure 4.

In relation to the data the following observations are made;

i. On the 17/8/18 assessment, before the second application of Glufosinate, the following observations were made;
    a. Glyphosate at 1L product/ha provided greater control than either of the Glufosinate only treatments and the Glyphosate at 0.5L product/ha
    b. The Glufosinate at both application rates when combined with the Glyphosate at 0.5L product/ha provided better control than the individual treatments of Glyphosate at 0.5L product/ha and Glufosinate at both rates.

c. The Glyphosate at 0.5L product/ha and Glufosinate at 1L product/ha were significantly better than the untreated control.
d. The Glufosinate at 0.5L/ha was no different than the untreated control.

ii. On the 3/9/18 assessment the following observations were made;
a. Glyphosate at 1L product/ha and combined with both rates of Glufosinate provided significant reduction in the *Poa annua* population compared to the untreated control.
b. The application of Glufosinate appears to improve the efficacy of the glyphosate treatment.
c. The Glufosinate at both rates of application provided a significant reduction in *Poa annua* compared to the untreated control.
d. The Glyphosate at 0.5L product/ha showed a significant increase in the *Poa annua* population and was no different to the untreated control.

iii. On the 17/9/18 assessment the following observations were made;
a. Glyphosate at 1L product/ha and combined with both rates of Glufosinate provided significant reduction in the *Poa annua* population compared to the untreated control.
b. The application of Glufosinate appears to improve the efficacy of the glyphosate treatment.
c. The effects of the Glufosinate at both rates of application appeared to have worn off and there was no difference in the *Poa annua* population compared to the untreated control.
d. The Glyphosate at 0.5L product/ha showed a significant increase in the *Poa annua* population and was no different to the untreated control.

Table 3: Trial 1 % *Poa annua* control

Treatment	17/8/18	3/9/18	17/9/18
R1XB1	91[a]	76[a]	41[a]
R1XB0.5	84[ab]	72[a]	78[a]
R1	69[abc]	50[a]	53[a]
R0.5XB0.5	54[abcd]	56[a]	50[a]
R0.5XB1	42[bcd]	30[a]	-1[ab]
R0.5	16[de]	-87[b]	-83[b]
B1	-4[ef]	16[a]	-4[ab]
B0.5	-23[efg]	75[a]	-2[ab]
UTC	-59[g]	-119[b]	-81[b]
LSD (P<0.05)	48	73	101

Note: a negative figure indicates an increase in the *Poa annua* population

4.1.2 Turf quality and NDVI readings

The plots were assessed for turf quality and there was no visual difference in turf density or surface quality due to any of the treatments.

The results for the NDVI measurements are detailed in table 4. At the 3/8/18 and 17/8/18 assessments there was no significant difference in the NDVI between any of the treatments.

4.1.3 Conclusions

Based on this trial the following conclusions are made;

i. Glyphosate is an effective selective post-emergent herbicide for the control of *Poa annua* in couch.

ii. The Glyphosate (360g/L) at 1L of product/ha is more effective than the Glyphosate (360g/L) at 0.5L of product/ha.

iii. The effectiveness of the Glyphosate (360g/L) at 0.5L of product/ha is enhanced by the addition of the Glufosinate at both application rates.

iv. The Glufosinate at both application rates appears to have a short-term effect on the *Poa annua*. In *Poa annua* control trials at the University of Tennessee where the couch is completely dormant with no green colour, the Glufosinate is used at 8 and 16L product/ha with the main restriction on the rate of application being the cost of the herbicide. From the UT trials it is presumed that Glufosinate at 0.5 and 1.0L product/ha is too low to be effective by itself.

v. None of the treatments had a significant effect on turf quality or the NDVI readings.

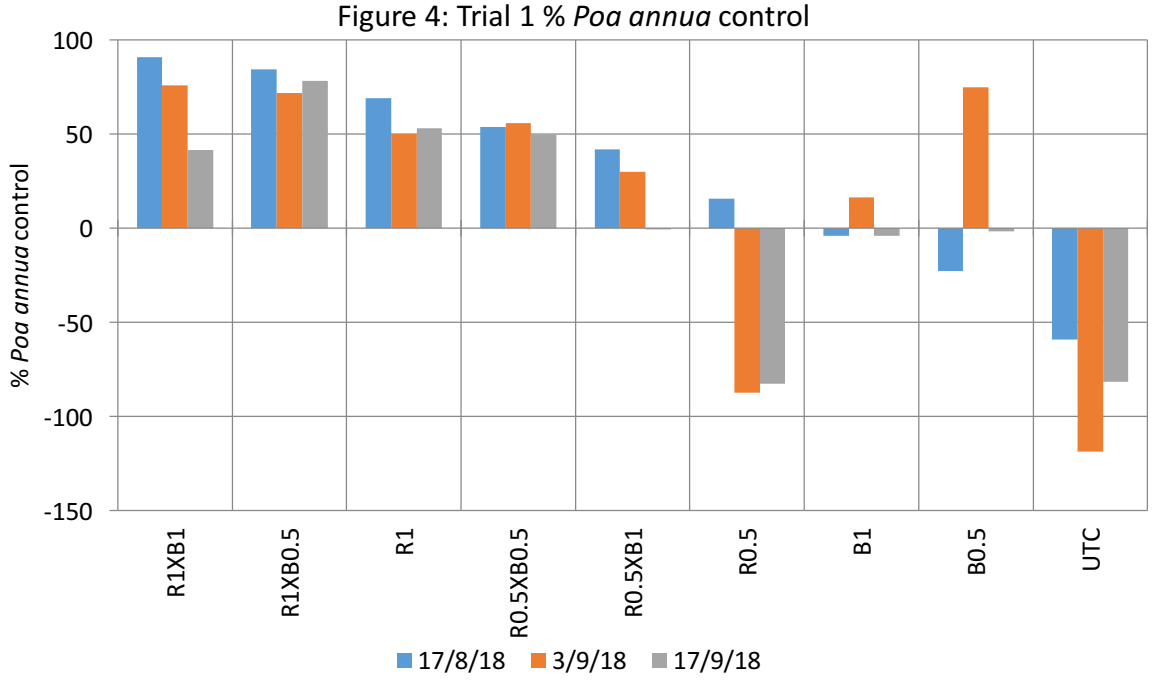
vi. Based on these trials and observations it is recommended for hard to kill *Poa annua* to make one application of Glyphosate (360g/L) at 1L of product/ha on dormant couch.

Table 4: Trial 1 NDVI readings

	3/8/18	17/8/18	17/9/18*
UTC	0.516	0.552	0.388
R1	0.486	0.507	0.409
R0.5	0.475	0.544	0.372
B1	0.549	0.560	0.556
B0.5	0.505	0.531	0.496
R1XB1	0.530	0.532	0.495
R1XB0.5	0.543	0.526	0.497
R0.5XB1	0.524	0.534	0.536
R0.5XB0.5	0.517	0.549	0.491
LSD (P<0.05)	**NS**	**NS**	**0.09**

*Note: Turf colour was affected by sand drift onto the plots

Figure 4: Trial 1 % *Poa annua* control



4.2 Trial 2: Evaluation of new herbicide actives

4.2.1 SGC Site

***Poa annua* counts:** The *Poa annua* counts were undertaken pre-treatment and at 28, 42 and 56 days after treatment 1 (DAT) and the results are detailed in table 5.

In relation to the data the following observations are made;

i. At 28 DAT all herbicide treatments had significantly greater *Poa annua* control than the untreated plots.
ii. At 42 DAT the Exp1, Exp2 and Foramsulfuron treatments had significantly greater *Poa annua* control compared to the untreated plots.
iii. At 56 DAT there was no significant difference between any of the treatments.

Turf quality and NDVI readings: The turf quality assessment and NDVI readings were undertaken at pre-treatment and at 28, 42 and 56 days after treatment 1 (DAT) and the results are detailed in table 6.

In relation to the data the following observations are made;

i. At 28 DAT the Exp1 treatment had significantly lower turfgrass quality compared to the other treatments. At 42 and 56 DAT there was difference in turf quality between the treatments.
ii. At 28 DAT the NDVI for the Exp1 plots was significantly less than the other treatments and reflected the phytotoxicity and colour loss due to the Exp1 treatment. At 42 and 56 DAT there was no significant difference between the treatments.

Table 5: Trial 2 SGC % *Poa annua* control

Herbicide	28 DAT	42 DAT	56 DAT
Exp1	92	95	62.5
Exp2	91	66	15
Foramsulfuron	99	83	-450
Exp3	74	28	-525
Methiozolin	96	23	-313
UTC	39	2	-85
LSD (P<0.05)	34	54	NS

Table 6: Trial 2 SGC Turf Quality and NDVI readings

	Turf Quality			NDVI	
	28 DAT	42 DAT	56 DAT	28 DAT	42 DAT
Exp1	5.0	6.0	7.8	0.577	0.596
Exp2	6.4	6.3	6.8	0.634	0.655
Foramsulfuron	6.4	6.3	6.8	0.655	0.625
Exp3	6.0	6.0	6.3	0.648	0.639
Methiozolin	6.4	6.3	6.8	0.650	0.643
UTC	6.4	6.3	6.8	0.626	0.633
LSD (P<0.05)	0.8	NS	NS	0.030	NS

Visual turfgrass damage: The Exp1 treatment had significantly greater visual turfgrass injury compared to all other treatments (table 7). At 42 DAT there was no significant difference in visual turfgrass injury between the treatments and the Exp1 treatment had recovered.

The Exp3 treatments exhibited strong phytotoxicity within 48 hours of treatment, however, the plots were almost completely recovered by 28 DAT.

Table 7: Trial 2 SGC Visual Turfgrass Injury

	28 DAT	42 DAT
Exp1	4	1
Exp2	0	0
Foramsulfuron	0	0
Exp3	1	0
Methiozolin	0	0
UTC	0	0
LSD (P<0.05)	1.1	NS

4.2.2 DBGC Site

***Poa annua* counts:** The *Poa annua* counts were undertaken pre-treatment and at 28, 42 and 64 days after treatment 1 (DAT) and the results are detailed in table 8. In relation to the data the following observations are made;

i. At 28 DAT the Exp1, Exp2 and Foramsulfuron had significantly better *Poa annua* control than the Exp3. There was considerable variation in the data.
ii. At 42 DAT the Exp1 and Exp2 treatments had significantly greater *Poa annua* control compared to the untreated plots and the Exp4 treatment.
iii. At 64 DAT there was no significant difference between any of the treatments.

Table 8: Trial 2 DBGC % *Poa annua* control

	28 DAT	42 DAT	64 DAT
Exp1	58	72	41
Exp2	72	66	21
Foramsulfuron	79	39	25
Exp3	-13	38	-25
Exp4	19	27	-46
UTC	29	19	-33
LSD (P<0.05)	52	35	NS

NDVI readings: The NDVI readings were undertaken at pre-treatment and at 28, 42 and 64 days after treatment 1 (DAT). There was no significant difference between the treatments at any of the assessment dates. The NDVI did not appear to have the capability of picking up the visual turfgrass injury which indicates that while the leaf appears damaged it is possibly still functioning.

Visual turfgrass damage: At 12 DAT the Exp3 treatment had severe turfgrass injury compared to all other treatments (table 9). The effect of the Exp3 was no longer visible at 42 DAT. At 42 DAT following the applications of Exp1 there was significantly greater visual turfgrass injury compared to all other treatments. There was also a significant, but slight effect from the Foramsulfuron when compared to the untreated control. There was no difference in turfgrass injury between the treatments at 56 DAT.

Table 9: Trial 2 DBGC Visual Turfgrass Injury

	12 DAT	42 DAT
Exp1	0.0	2.5
Exp2	0.0	0.0
Foramsulfuron	0.0	1.0
Exp3	5.0	0.0
Exp4	0.0	0.0
UTC	0.0	0.0
LSD (P<0.05)	0.4	0.8

4.2.3 NGC Site

***Poa annua* counts:** The *Poa annua* counts were undertaken pre-treatment and at 34, 49 and 67 days after treatment 1. At 34 DAT there was a significant difference between the treatments with the Methiozolin, Exp2 and Exp1 having significantly greater *Poa annua* control compared to the untreated control (table 10). At 49 and 67 DAT there was no significant difference between the treatments. At these later dates the data was highly variable and there was a natural decline in the *Poa annua* population.

Table 10: Trial 2 NGC % *Poa annua* control

	34 DAT	49 DAT	67 DAT
Exp1	97.6	100.0	100.0
Exp2	100.0	76.7	100.0
Foramsulfuron	51.5	-50.0	33.3
Methizolin	88.4	83.3	93.3
Exp4	75.1	64.4	66.7
UTC	43.2	0.0	83.3
LSD (P<0.05)	38	NS	NS

NDVI readings: The NDVI readings were undertaken at pre-treatment and at 34, 49 and 67 days after treatment 1 (DAT). There was a significant difference between the treatments at 49 DAT where the Exp1 had a significantly lower NDVI reading compared to all the other treatments (table 11). The NDVI readings were related to the visual turfgrass injury.

Visual turfgrass damage: At 34 DAT following the applications of Exp1 there was significantly greater visual turfgrass injury compared to all other treatments.

At 49 DAT the Exp1 had a significantly greater visual turfgrass injury compared to all other treatments (table 12). The Methiozolin had significantly greater turfgrass injury compared to the UTC.

Table 11: Trial 2 NGC NDVI readings

	NDVI 49 DAT
Exp1	0.383
Exp2	0.694
Foramsulfuron	0.678
Exp3	0.623
Exp4	0.647
UTC	0.678
LSD (P<0.05)	0.050

Table 12: Trial 2 NGC Turfgrass Injury

	19 DAT	34 DAT	49 DAT
Exp1	2.0	5.0	5.0
Exp2	1.3	0.0	0.0
Foramsulfuron	1.0	0.0	0.0
Methiozolin	0.3	1.3	2.0
Exp4	0.3	1.3	0.7
UTC	1.0	0.7	0.0
LSD (P<0.05)	NS	0.8	0.8

4.2.4 Conclusions

Based on these trials the following conclusions are made;

i. Exp1 provides effective *Poa annua* control, however, there is some medium term phytotoxicity. In observing other trials at different times of the year the phytotoxicity appears to be affected by the time of year and the weather conditions. The phytotoxicity relates to the activity/growth of the couch and therefore how much herbicide the couch takes up. When the couch is actively growing it takes up a greater amount of herbicide and therefore increased phytotoxicity. Exp1 is likely to be a better option when the couch is dormant rather than in full growth.

ii. Exp2 provides effective *Poa annua* control, however, there is some medium term phytotoxicity.

iii. Methiozolin has very good potential as an alternative herbicide for the control of *Poa annua* once it is registered for use in turf. With this trial the quantity of Methiozolin available was limited and a second application was required for an effective result.

5. RECOMMENDATIONS

Based on these results it is recommended to;

i. Trial the Exp1 during the winter months to determine efficacy and phytotoxicity.

ii. Trial the Exp2 during the winter months to determine efficacy and phytotoxicity.

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Thanks to Leigh Yanner (Course Manager) and Tony Gordon (Course Superintendent Moonah and Ocean Courses) at The National GC, Trevor Uren (Course Superintendent) at Devil Bend GC and Shane Greenhill (Course Superintendent) at Sorrento GC for making the trial sites available and their assistance in setting up the trials.

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The *Poa annua* control strategies stated in this report are specific to the particular circumstances of the trial and are not meant to be implemented without careful thought and planning and taking into account local conditions. Any reference to chemicals not registered in Australia, or not registered for use on turf, is mentioned for education purposes only.

APPENDIX 1: PHOTOGRAPHS

Figure 5: 24 DAT Roundup™ at 1L/ha (3-8-18)

Figure 6: 24 DAT Roundup™ at 0.5L/ha (3-8-18)

Figure 7: 24 DAT (3-8-18)

Figure 8: 24 DAT Control and Roundup™ at 0.5L/ha (3-8-18)

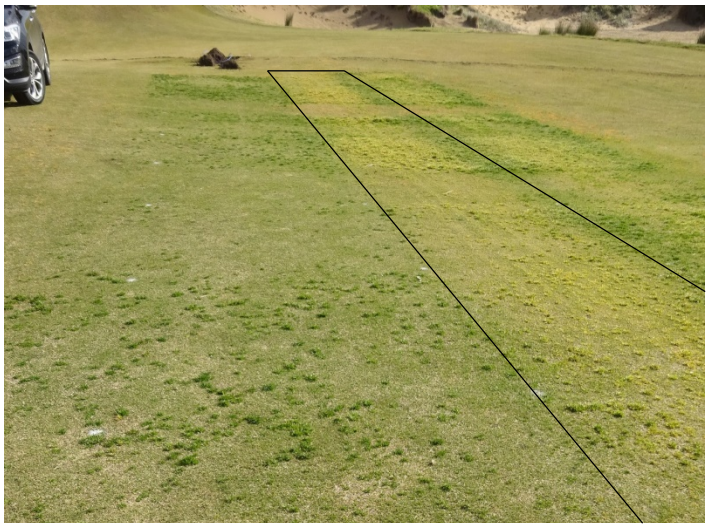

Figure 9: 55 DAT Basta™ at 1L/ha (3-9-18)

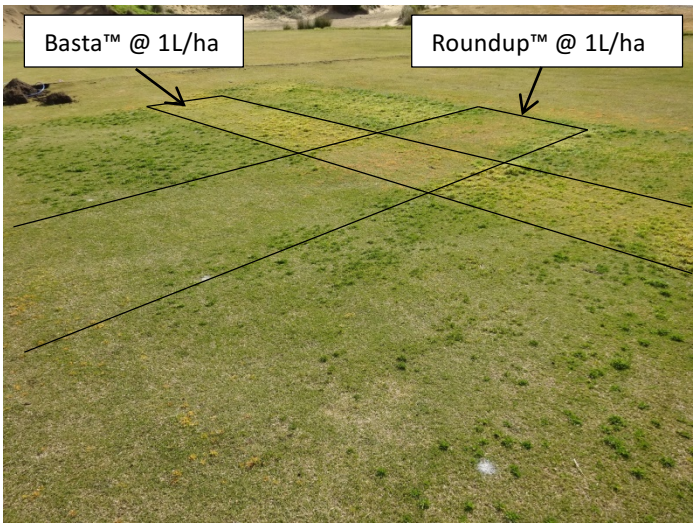

Figure 10: 55 DAT Basta™ and Roundup™ interactions (3-9-18)

Figure 11: 55 DAT Basta™ and Roundup™ interactions (3-9-18)

Figure 12: 55 DAT Untreated control and Basta™ (3-9-18)

Figure 13: Phytotoxicity from Exp3

Figure 14: Phytotoxicity from Exp1

Figure 2: Weather data during glyphosate/glufosinate herbicide trial
Observations drawn from Cerberus (BOM station 0863610)

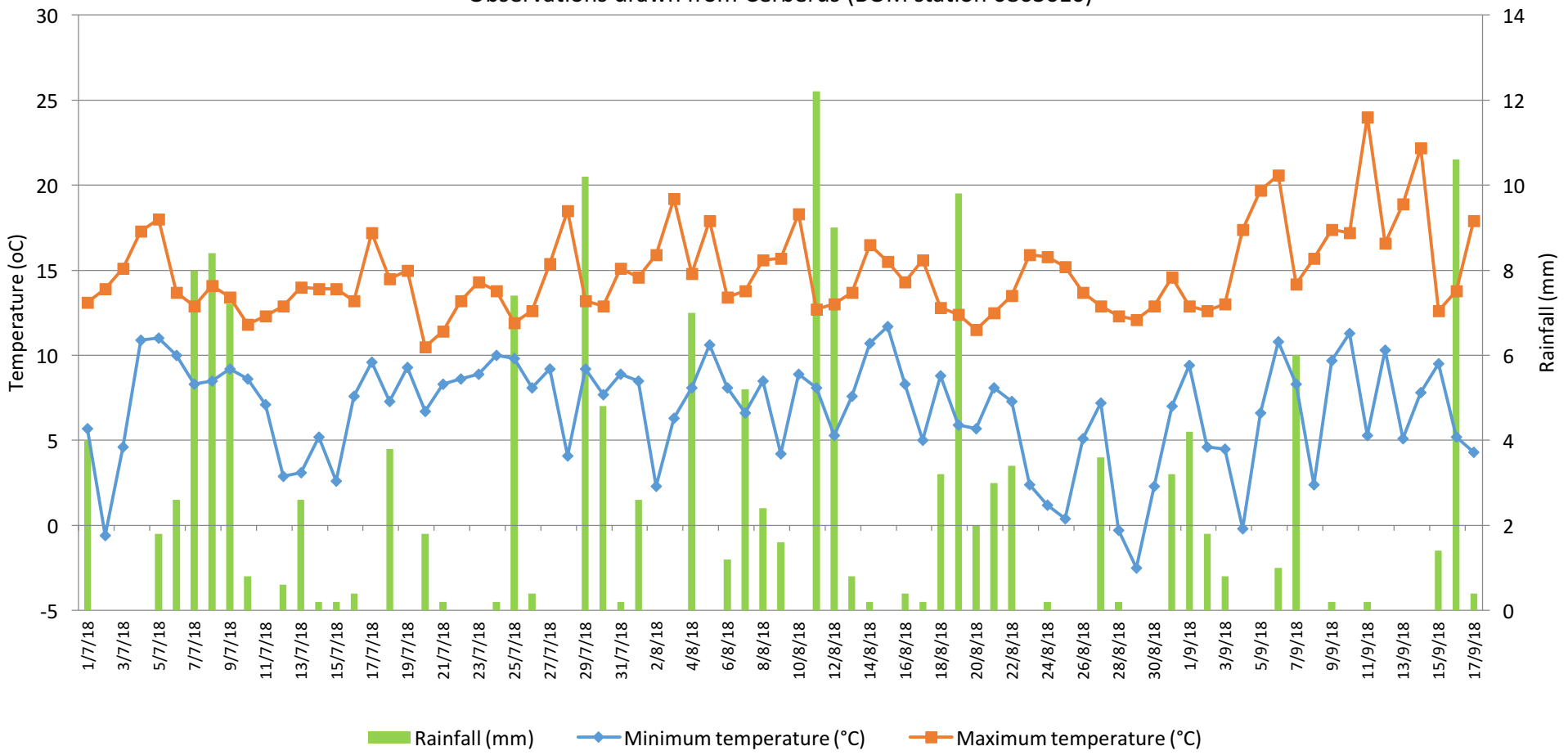

Figure 3: Weather data during spring-summer herbicide trial period
Observations drawn from Cerberus (BOM station 0863610)