Development of Tenacity 4FL as a Spring-Summer renovation program to eliminate Poa annua (post-emergence) in Kentucky bluegrass fairways

Syngenta protocol#: No number

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A trial was begun in the Spring 2013 and monitored through the Summer 2013 on a Kentucky bluegrass (KBG) fairway at the Washington State University Palouse Ridge Golf Club (PRGC) in Pullman, WA to determine the effect of Tenacity combined with other herbicides to control *Poa annua* . Individual treatment plots were 6' x 7' with four replications in a randomized complete-block design. Each treatment was applied 3 times on 3 week intervals: 2 May, 23 May, and 13 June, 2013 at 25 GPA with a bicycle-wheeled CO_2 pressurized (40 psi) sprayer with 11002 flat fan TeeJet nozzles. Weather data was recorded at each application date (Table 1). GPS coordinates for the location: N46° 44' 15.6", W117° 07' 56.2", Elev. 2564'. Soil characteristics: 28.8% sand, 52.5% silt, 18.8% clay, pH 6.4, and organic matter 4.9%. Percent *P. annua* was estimated initially, 6, 12, and 18 weeks after initial treatment (WAIT). Phytotoxicity to the KBG and *P. annua* was rated every 1 to 2 weeks up to 8 WAIT. Phytotoxicity was rated on a scale from 0 to 10, with 0 = no phytotoxicity and 10 = dead turf, rating >2 is considered unacceptable injury.

There was little effect on KBG phytotoxicity up through 8 WAIT (Table 2 and Fig. 1). The only treatment in which KBG phytotoxicity was unacceptable was Tenacity 5 fl oz/A + Xonerate 2 oz/A which occurred on 2 rating dates (6 Jun and 13 Jun) 5 and 6 WAIT. By 8 WAIT (27 Jun), All treatments resulted in acceptable phytotoxicity ratings on the KBG.

However, almost all treatments resulted in phytotoxicity >2 on the *P. annua* starting 2 WAIT up to the final rating taken 8 WAIT (Table 3 and Fig. 1). The Tenacity 5 fl oz/A + Xonerate 2 oz/A treatment resulted in the highest phytotoxicity on *P. annua* compared to the other treatments. The most common symptoms among all treatments were yellowing and browning of the *P. annua* leaves (Figs. 4 – 11). However, by 8 and 12 WAIT much of the *P. annua* in the Tenacity 5 fl oz/A + Xonerate 2 oz/A treatment was actually dying and fading away creating depressions in the fairway (Figs. 10, 11 and 15). Whereas, the other treatments, even though they also resulted in *P. annua* loss, the *P. annua* faded away without leaving open depressed areas. The KBG appeared to fill in as the *P. annua* controlled in the stand faded away. By 12 WAIT there was no observed phytotoxicity on the *P. annua* (no data) but Figures 12–15 are photos taken 12 WAIT.

All herbicide treatments except 19660A 1 fl oz/A + Turflon 16 fl oz/A resulted in a reduction of *P. annua* in the turfgrass stand 18 WAIT (Table 4 and Fig. 3). Tenacity 5 fl oz/A + Xonerate 2 oz/A resulted in the greatest reduction (>70%) of *P. annua*, by the end of the study, 18 WAIT (Figs. 16 and 18). Tenacity 4 fl oz/A + Xonerate 1 oz/A resulted in a 55% reduction of *P. annua* (Fig. 17). The

remaining treatments of Tenacity 5 fl oz/A + Turflon 16 fl oz/A and/or Trimmit 16 fl oz/A resulted in a slight reduction (<25%) of *P. annua* in the stand (Figs. 16-19).

There were broadleaf weeds (primarily dandelion) noted in several plots at the beginning of the study and when observed again at 8 WAIT no broadleaf weeds were noted in any of the treated plots (no data).

Overall, Tenacity 5 fl oz/A + Xonerate 2 oz/A resulted in the greatest reduction of *P. annua* in the stand >70% by 18 WAIT. However, associated with this treatment there was a high level of *P. annua* phytotoxicity beyond 8 WAIT. In addition, 8 and 12 WAIT there were open depressed areas in the fairway where the *P. annua* had died. Eventually KBG did grow into and fill these depressions by 18 WAIT. KBG fairways with such a high level of *P. annua* phytotoxicity for several weeks following the initial application coupled with areas that completely die out leaving pock marked fairways may result in undesirable playing conditions during the peak of the summer when play is highest. Eventhough Tenacity 4 fl oz/A + Xonerate 1 oz/A also resulted high levels of *P. annua* phytotoxicity for several weeks following initial application, this treatment did not cause *P. annua* to quickly disappear thus not creating open areas (depressions) in the fairway. This may be a more desirable *P. annua* control option to consider in terms of playability. In any event, complete *P. annua* control was not achieved with any of the treatment in this study, therefore, a multi-year program may need to be looked at to possibly achieve this goal.

Table 1. Climate data at each application date.

Application date	Air Temp (^{o}F)	2" Soil Temp (^{o}F)	Relative humidity (%)	Wind direction	Wind speed (mph)
5/2/13	54	46	41	E	3 - 5
5/23/13	63	53	32	N	0 - 2
6/13/13	52	55	57	SW	3 - 5

Table 2. The effect of various treatments to control *P. annua* on Kentucky bluegrass phytotoxicity. PRGC 17 fairway. Pullman, WA.

Treatment	Active ingredient amount	App. Interval (3 week)	Rate (fl oz or oz/A)	Kentucky bluegrass phytotoxicity* 2 WAIT 5/16/13	3 WAIT 5/23/13	5 WAIT 6/6/13	6 WAIT 6/13/13	8 WAIT 6/27/13
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	0.0 c**	0.0 c	2.0 ab	1.8 b	0.0 a
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16					
NIS (nonionic surfactant)		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	0.0 c	0.0 c	0.4 de	0.1 c	0.0 a
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	5/2/13	4	0.8 ab	0.8 ab	1.5 bc	1.3 b	0.0 a
Xonerate 70WG +	0.044 lbs AI/A	5/2/13	1 oz					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	5/23/13	4					
Xonerate 70WG +	0.044 lbs AI/A	5/23/13	1 oz					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	6/13/13	4					
Xonerate 70WG +	0.044 lbs AI/A	6/13/13	1 oz					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	0.5 b	0.5 b	1.0 cd	1.9 cd	1.0 a
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
19660A +	20 g AI/A	5/2/13	1	0.0 c	0.0 c	1.6 bc	1.5 b	0.0 a
Turflon Ester Ultra +	0.5 lbs AE/A	5/2/13	16					
COC (crop oil conc.)	0.5% v/v	5/2/13	0.5% v/v					
19660A +	20 g AI/A	5/23/13	1					
Turflon Ester Ultra +	0.5 lbs AE/A	5/23/13	16					
COC	0.5% v/v	5/23/13	0.5% v/v					
19660A +	20 g AI/A	6/13/13	1					
Turflon Ester Ultra +	0.5 lbs AE/A	6/13/13	16					
COC	0.5% v/v	6/13/13	0.5% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	1.0 c	1.0 a	2.5 a	2.8 a	0.0 a
Xonerate 70WG	0.088 lbs AI/A	5/2/13	2					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Xonerate 70WG	0.088 lbs AI/A	5/23/13	2					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Xonerate 70WG	0.088 lbs AI/A	6/13/13	2					
Control	0		0	0.0 c	0.0 c	0.0 c	0.0 c	0.0 a

*Kentucky bluegrass phytotoxicity was rated on a scale from 0 to 10; with 10 = dead.

**Means within columns followed by the same letter are not significantly different. LSD *P* = 0.05.

Figure 1. The effect of various treatments to control *P. annua* on Kentucky bluegrass phytotoxicity. PRGC 17 fairway. Pullman, WA.

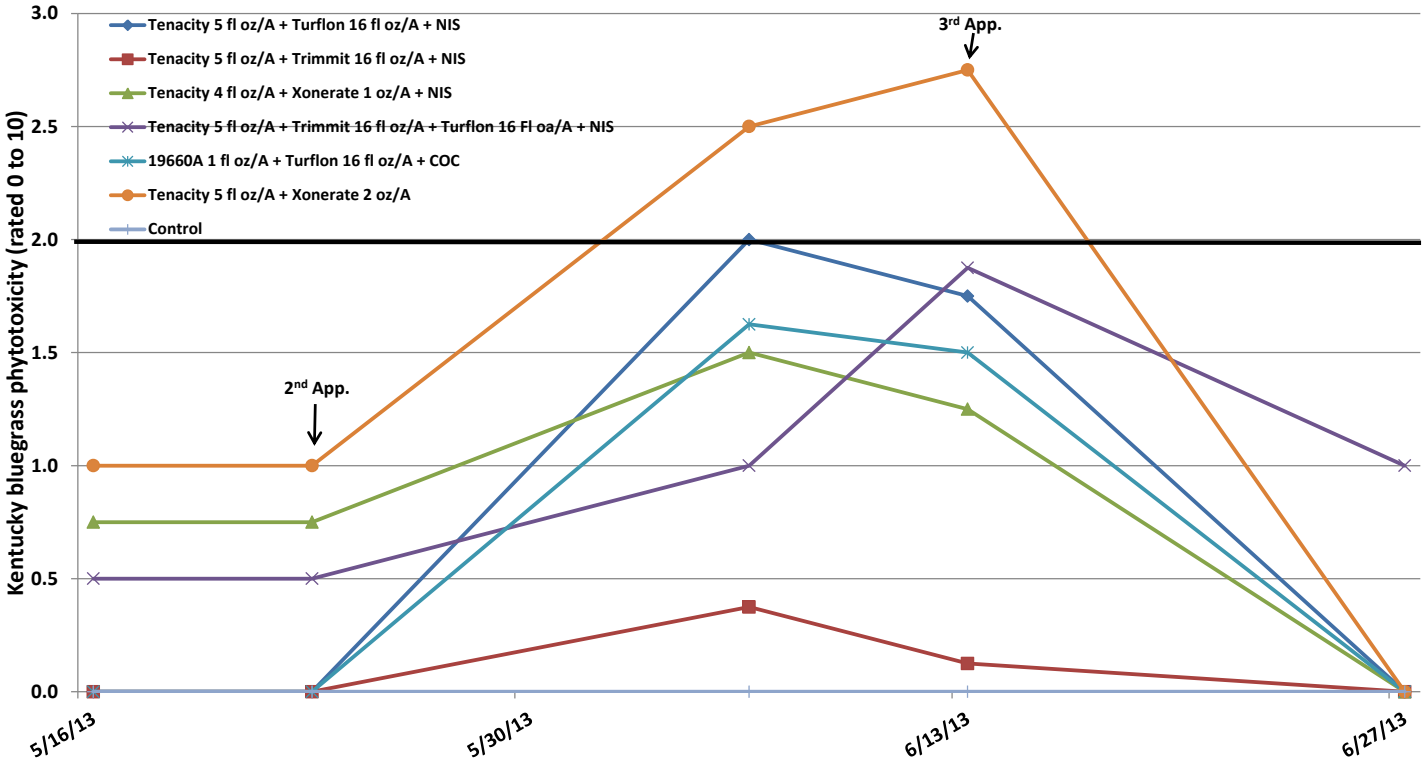

Table 3. The effect of various treatments to control *P. annua* on *P. annua* phytotoxicity. PRGC 17 fairway. Pullman, WA.

Treatment	Active ingredient amount	App. Interval (3 week)	Rate (fl oz or oz/A)	*Poa annua* phytotoxicity* 2 WAIT 5/16/13	3 WAIT 5/23/13	5 WAIT 6/6/13	6 WAIT 6/13/13	8 WAIT 6/27/13
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	1.3 c**	1.9 a	3.9 bc	4.4 c	3.4 bc
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16					
NIS (nonionic surfactant)		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	1.8 bc	1.9 a	2.9 c	3.8 c	3.3 bc
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	5/2/13	4	2.1 ab	2.0 a	4.3 b	6.3 b	4.1 ab
Xonerate 70WG +	0.044 lbs AI/A	5/2/13	1 oz					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	5/23/13	4					
Xonerate 70WG +	0.044 lbs AI/A	5/23/13	1 oz					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.125 lbs AI/A	6/13/13	4					
Xonerate 70WG +	0.044 lbs AI/A	6/13/13	1 oz					
NIS		6/13/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	2.3 ab	2.5 a	3.6 bc	4.5 c	5.8 ab
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16					
NIS		5/2/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16					
NIS		5/23/13	0.25% v/v					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16					
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16					
NIS		6/13/13	0.25% v/v					
19660A +	20 g AI/A	5/2/13	1	2.0 ab	2.4 a	3.4 bc	4.0 c	1.0 cd
Turflon Ester Ultra +	0.5 lbs AE/A	5/2/13	16					
COC (crop oil conc.)	0.5% v/v	5/2/13	0.5% v/v					
19660A +	20 g AI/A	5/23/13	1					
Turflon Ester Ultra +	0.5 lbs AE/A	5/23/13	16					
COC	0.5% v/v	5/23/13	0.5% v/v					
19660A +	20 g AI/A	6/13/13	1					
Turflon Ester Ultra +	0.5 lbs AE/A	6/13/13	16					
COC	0.5% v/v	6/13/13	0.5% v/v					
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	2.5 a	2.5 a	5.9 a	7.5 a	6.4 a
Xonerate 70WG	0.088 lbs AI/A	5/2/13	2					
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5					
Xonerate 70WG	0.088 lbs AI/A	5/23/13	2					
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5					
Xonerate 70WG	0.088 lbs AI/A	6/13/13	2					
Control	0		0	0.0 d	0.0 b	0.0 d	0.0 d	0.0 d

*Poa annua phytotoxicity was rated on a scale from 0 to 10; with 10 = dead.

**Means within columns followed by the same letter are not significantly different. LSD *P* = 0.05.

Figure 2. The effect of various treatments to control *P. annua* on *P. annua* phytotoxicity. PRGC 17 fairway. Pullman, WA.

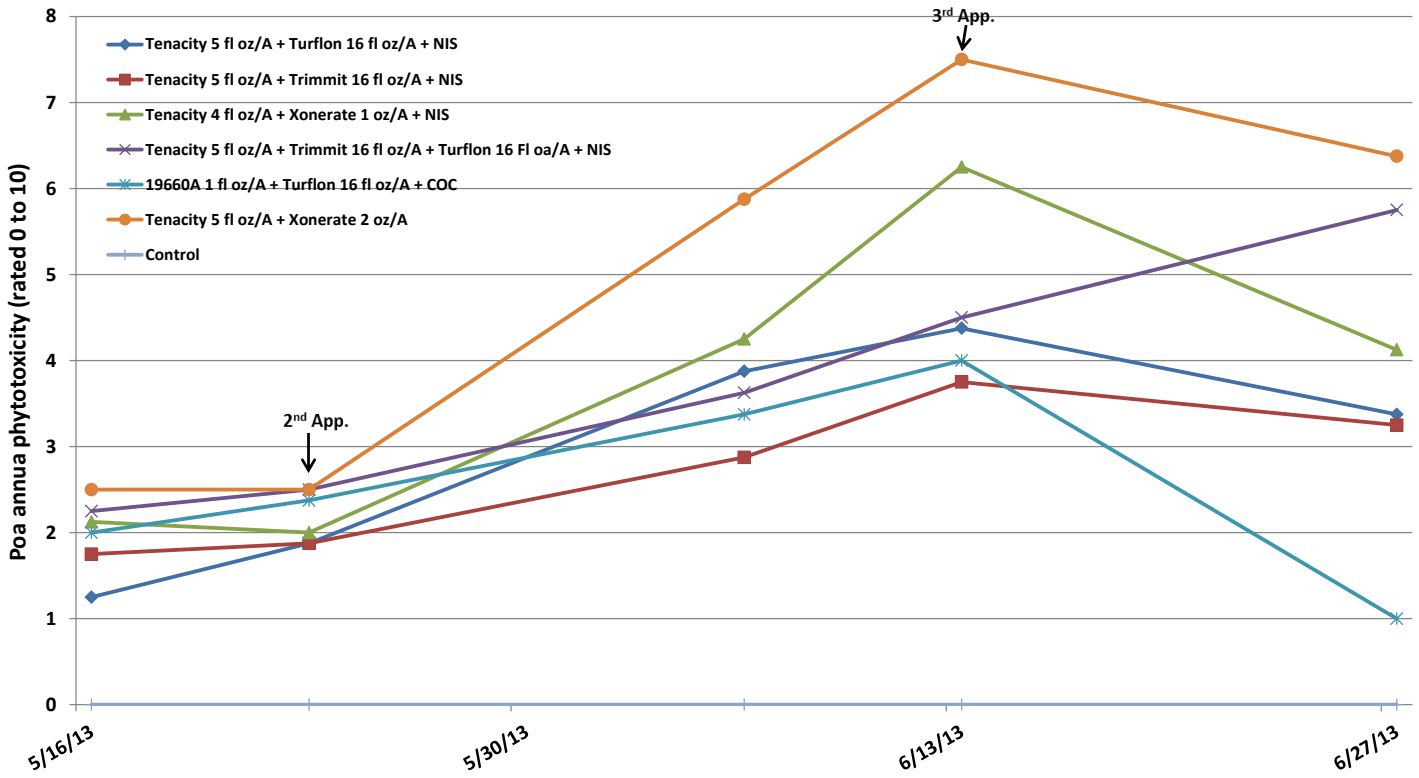

Table 4. The effect of various treatments to control *P. annua* on percent *P. annua* in the turfgrass stand. PRGC 17 fairway. Pullman, WA.

Treatment	Active ingredient amount	App. Interval (3 week)	Rate (fl oz or oz/A)	*Poa annua* (% of stand) Initial 5/2/13	(6 WAIT) 6/13/13	(12 WAIT) 7/24/13	(18 WAIT) 9/6/13
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	28.8 ab*	16.0 cd	13.0 cd	22.3 c
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16				
NIS (nonionic surfactant)		5/2/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5				
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16				
NIS		5/23/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5				
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16				
NIS		6/13/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	27.5 b	21.0 c	20.5 c	23.8 c
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16				
NIS		5/2/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5				
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16				
NIS		5/23/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5				
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16				
NIS		6/13/13	0.25% v/v				
Tenacity 4SC +	0.125 lbs AI/A	5/2/13	4	25.0 b	11.0 de	8.8 d	11.8 d
Xonerate 70WG +	0.044 lbs AI/A	5/2/13	1 oz				
NIS		5/2/13	0.25% v/v				
Tenacity 4SC +	0.125 lbs AI/A	5/23/13	4				
Xonerate 70WG +	0.044 lbs AI/A	5/23/13	1 oz				
NIS		5/23/13	0.25% v/v				
Tenacity 4SC +	0.125 lbs AI/A	6/13/13	4				
Xonerate 70WG +	0.044 lbs AI/A	6/13/13	1 oz				
NIS		6/13/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	32.5 ab	23.8 bc	20.5 c	28.8 c
Trimmit 2SC +	0.25 lbs AI/A	5/2/13	16				
Turflon Ester 2SC +	0.5 lbs AE/A	5/2/13	16				
NIS		5/2/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5				
Trimmit 2SC +	0.25 lbs AI/A	5/23/13	16				
Turflon Ester 2SC +	0.5 lbs AE/A	5/23/13	16				
NIS		5/23/13	0.25% v/v				
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5				
Trimmit 2SC +	0.25 lbs AI/A	6/13/13	16				
Turflon Ester 2SC +	0.5 lbs AE/A	6/13/13	16				
NIS		6/13/13	0.25% v/v				
19660A +	20 g AI/A	5/2/13	1	33.8 ab	31.3 b	31.3 b	45.0 b
Turflon Ester Ultra +	0.5 lbs AE/A	5/2/13	16				
COC (crop oil conc.)	0.5% v/v	5/2/13	0.5% v/v				
19660A +	20 g AI/A	5/23/13	1				
Turflon Ester Ultra +	0.5 lbs AE/A	5/23/13	16				
COC	0.5% v/v	5/23/13	0.5% v/v				
19660A +	20 g AI/A	6/13/13	1				
Turflon Ester Ultra +	0.5 lbs AE/A	6/13/13	16				
COC	0.5% v/v	6/13/13	0.5% v/v				
Tenacity 4SC +	0.156 lbs AI/A	5/2/13	5	28.8 ab	4.5 e	4.8 d	8.8 d
Xonerate 70WG	0.088 lbs AI/A	5/2/13	2				
Tenacity 4SC +	0.156 lbs AI/A	5/23/13	5				
Xonerate 70WG	0.088 lbs AI/A	5/23/13	2				
Tenacity 4SC +	0.156 lbs AI/A	6/13/13	5				
Xonerate 70WG	0.088 lbs AI/A	6/13/13	2				
Control	0		0	37.5 a	43.8 a	51.3 a	66.3 a

* Means within columns followed by the same letter are not significantly different. LSD *P* = 0.05.

Figure 3. The effect of various treatments to control *P. annua* on percent change of *P. annua* in the turfgrass stand. PRGC 17 fairway. Pullman, WA.

Figure 4. The effect of various treatments to control *P. annua* 2 WAIT. PRGC 17 fairway. Pullman, WA.

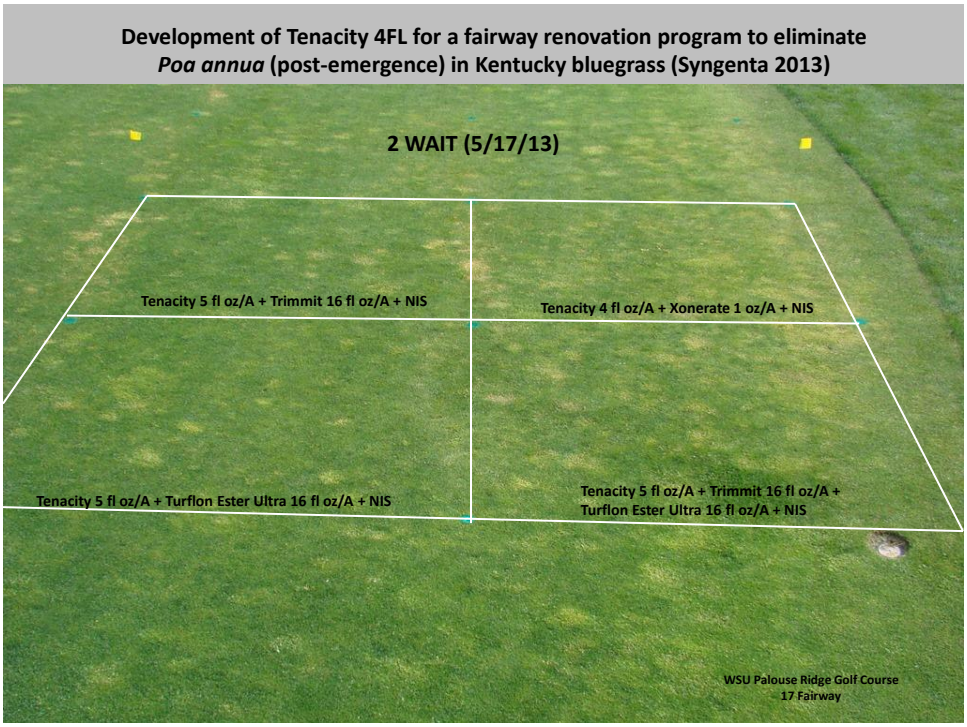

Figure 5. The effect of various treatments to control *P. annua* 2 WAIT. PRGC 17 fairway. Pullman, WA.

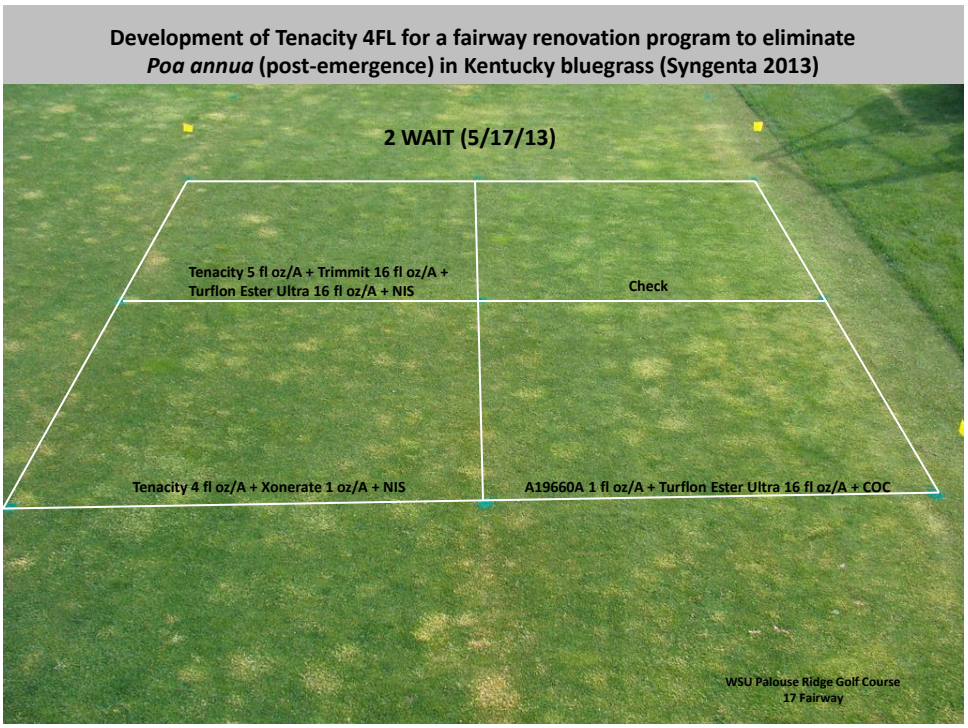

Figure 6. The effect of various treatments to control *P. annua* 2 WAIT. PRGC 17 fairway. Pullman, WA.

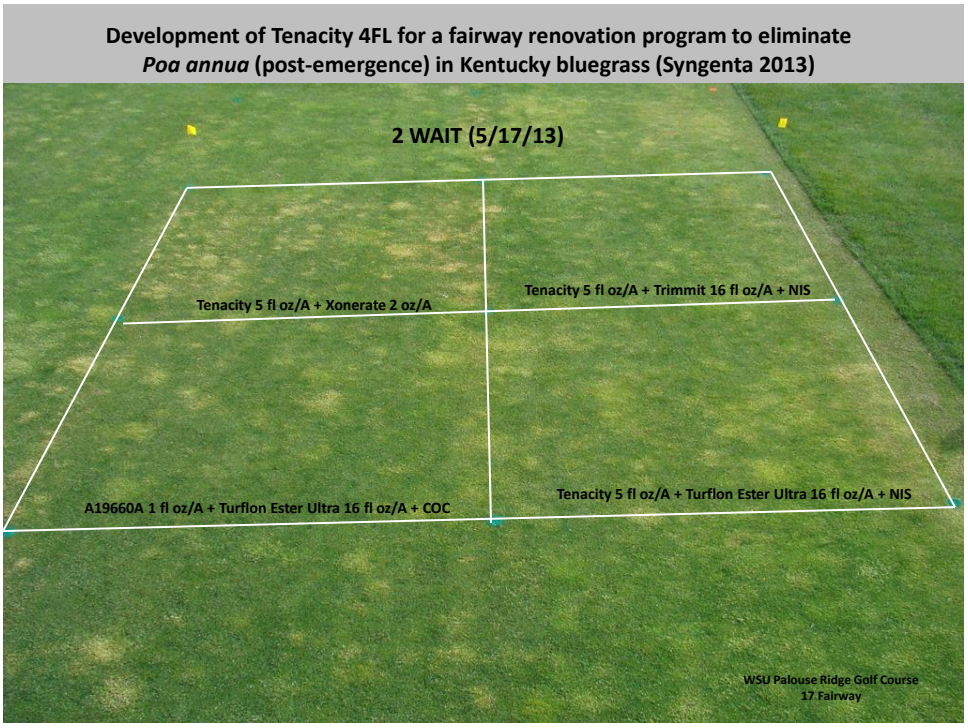

Figure 7. The effect of various treatments to control *P. annua* 2 WAIT. PRGC 17 fairway. Pullman, WA.

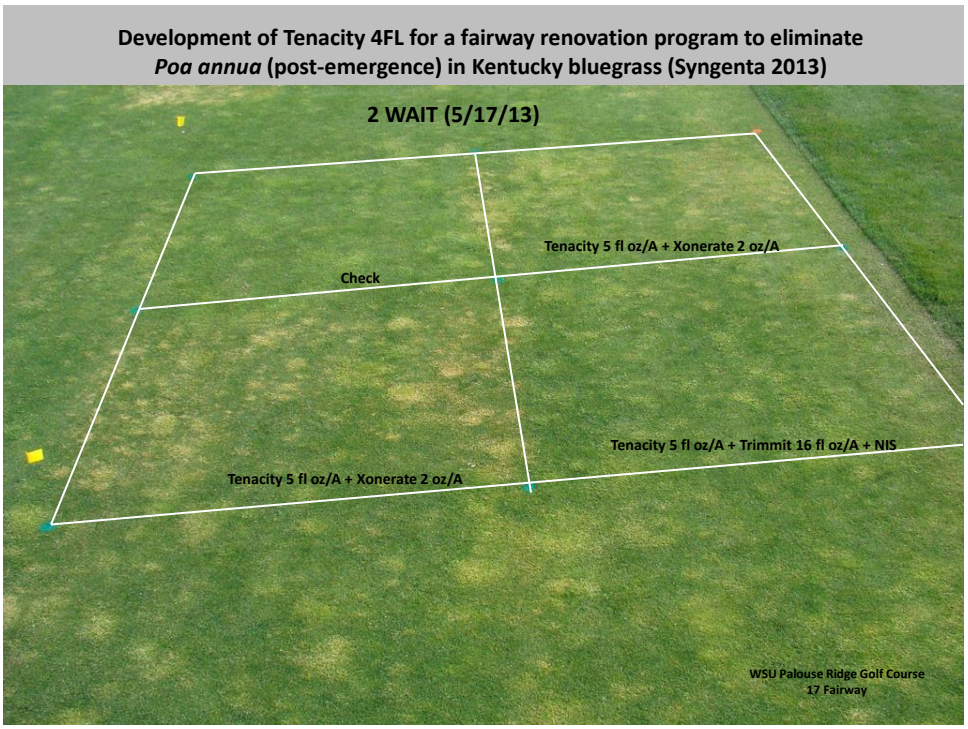

Figure 8. The effect of various treatments to control *P. annua* 8 WAIT. PRGC 17 fairway. Pullman, WA.

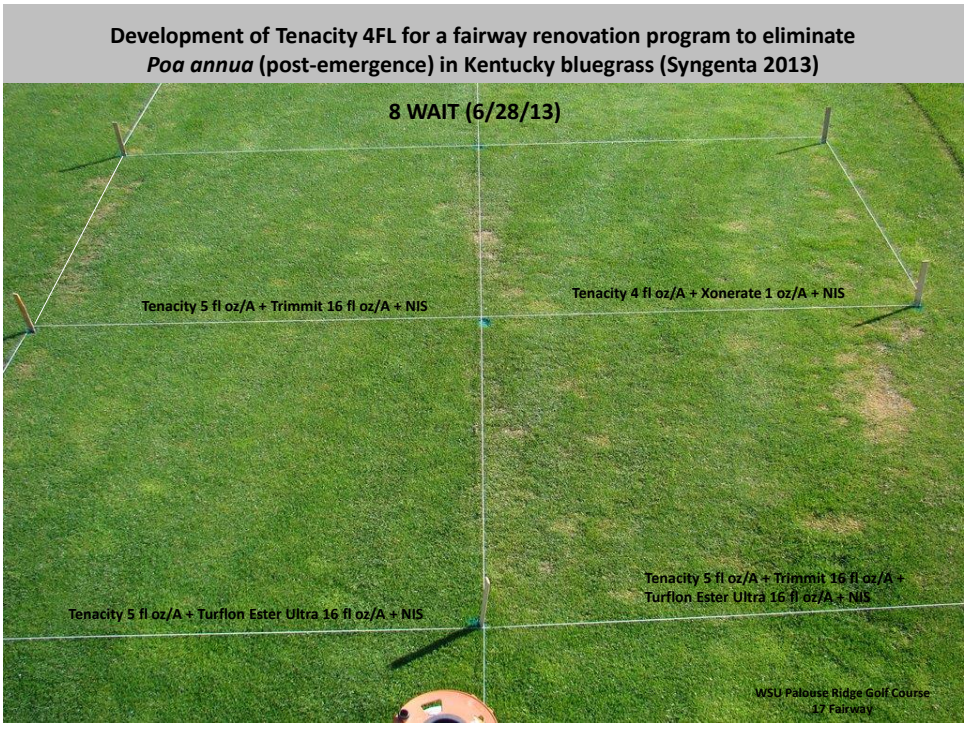

Figure 9. The effect of various treatments to control *P. annua* 8 WAIT. PRGC 17 fairway. Pullman, WA.

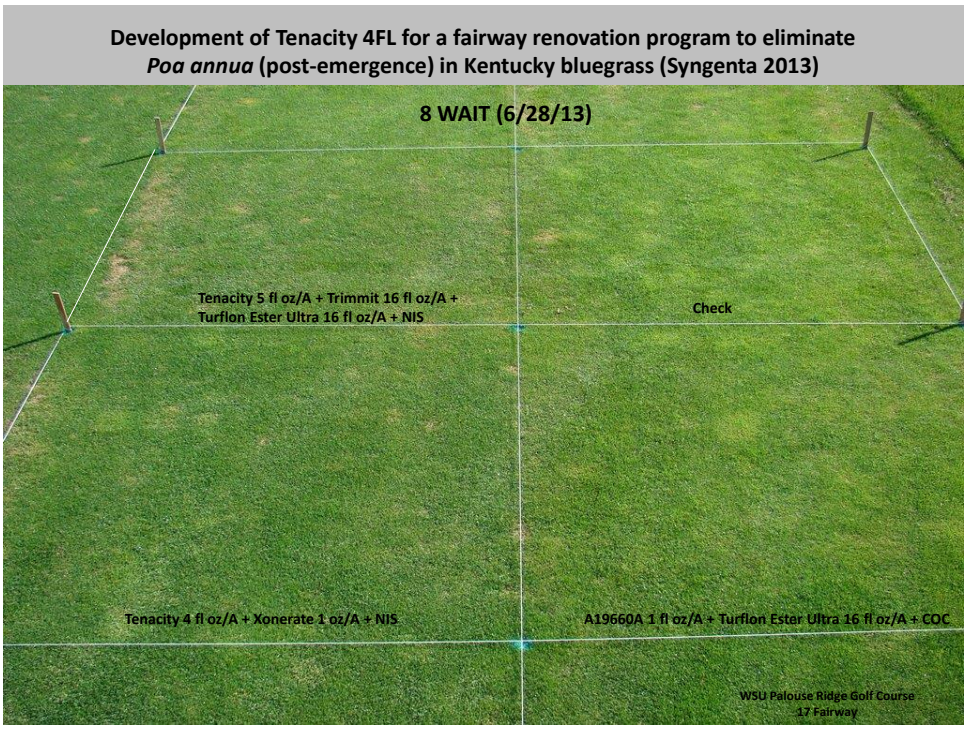

Figure 10. The effect of various treatments to control *P. annua* 8 WAIT. PRGC 17 fairway. Pullman, WA.

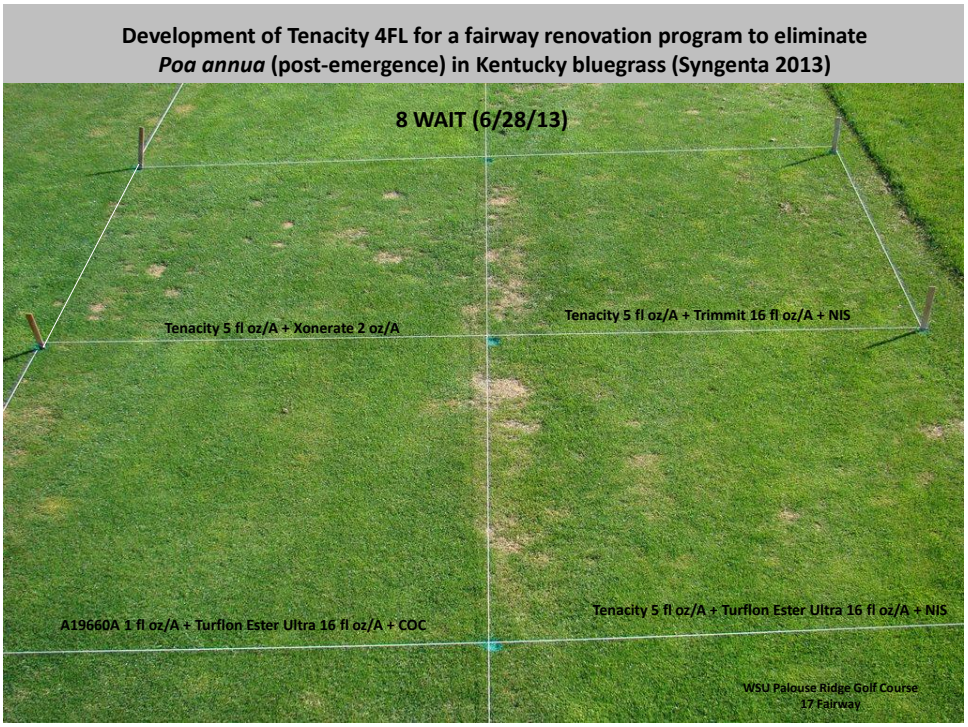

Figure 11. The effect of various treatments to control *P. annua* 8 WAIT. PRGC 17 fairway. Pullman, WA.

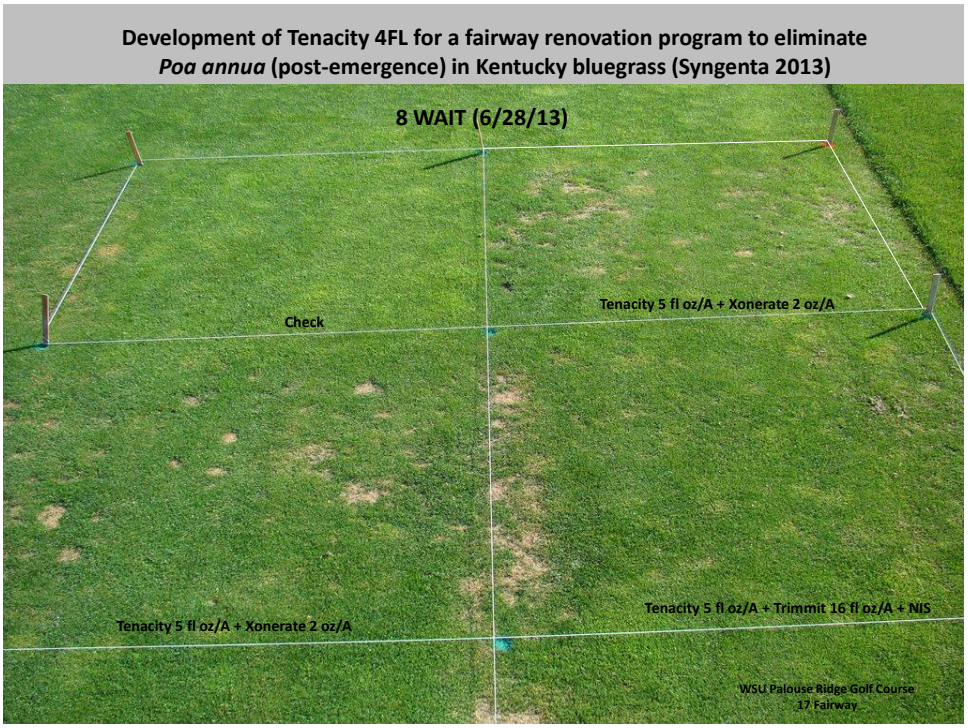

Figure 12. The effect of various treatments to control *P. annua* 12 WAIT. PRGC 17 fairway. Pullman, WA.

Figure 13. The effect of various treatments to control *P. annua* 12 WAIT. PRGC 17 fairway. Pullman, WA.

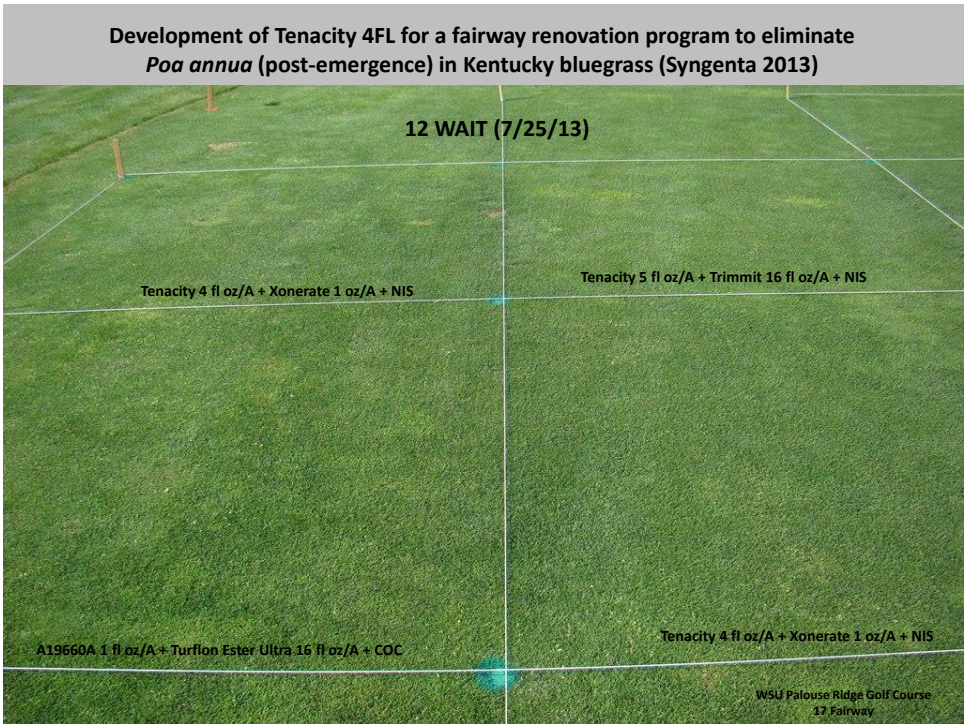

Figure 14. The effect of various treatments to control *P. annua* 12 WAIT. PRGC 17 fairway. Pullman, WA.

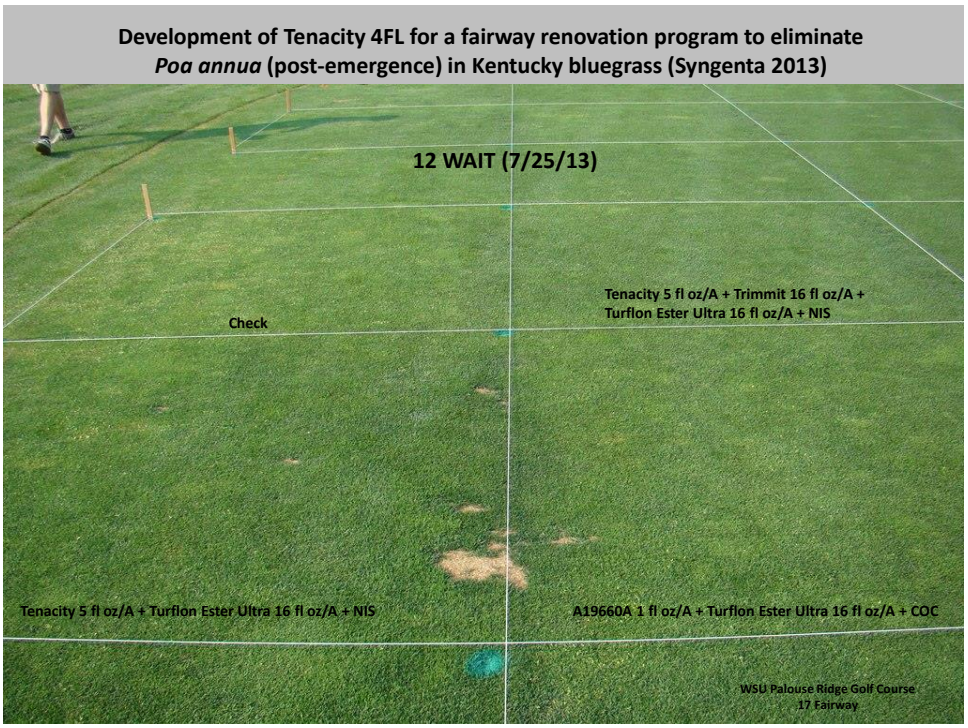

Figure 15. The effect of various treatments to control *P. annua* 12 WAIT. PRGC 17 fairway. Pullman, WA.

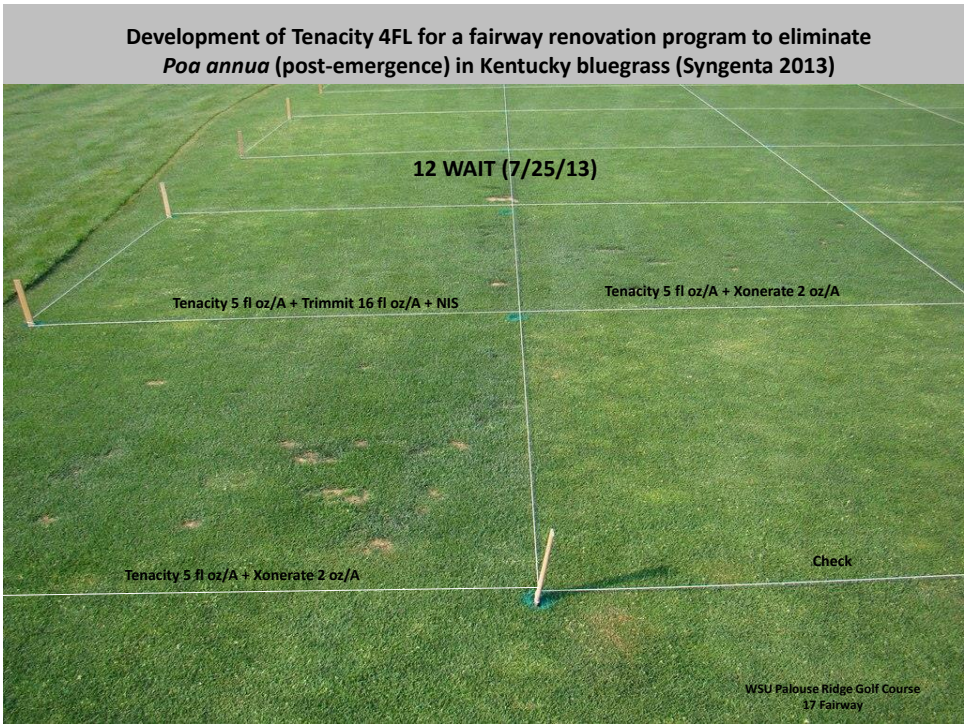

Figure 16. The effect of various treatments to control *P. annua* 18 WAIT. PRGC 17 fairway. Pullman, WA.

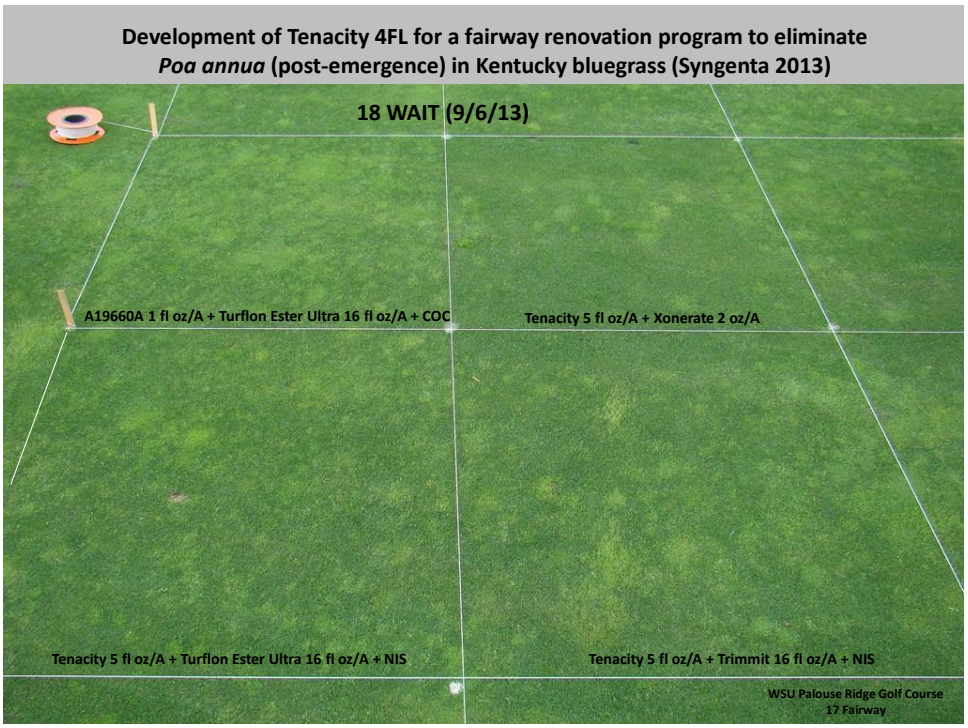

Figure 17. The effect of various treatments to control *P. annua* 18 WAIT. PRGC 17 fairway. Pullman, WA.

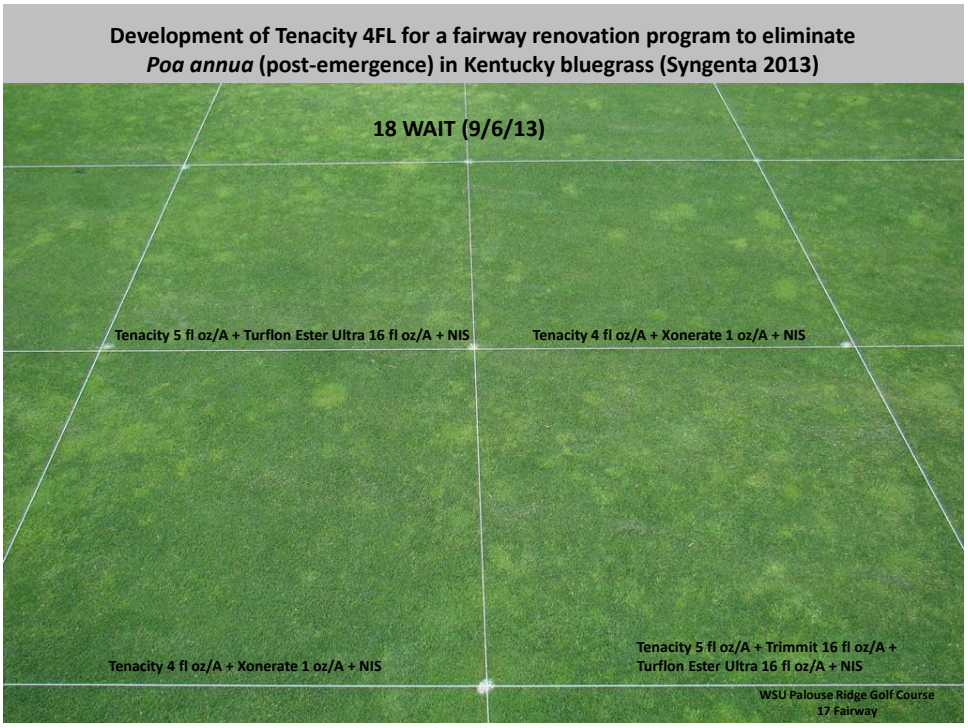

Figure 18. The effect of various treatments to control *P. annua* 18 WAIT. PRGC 17 fairway. Pullman, WA.

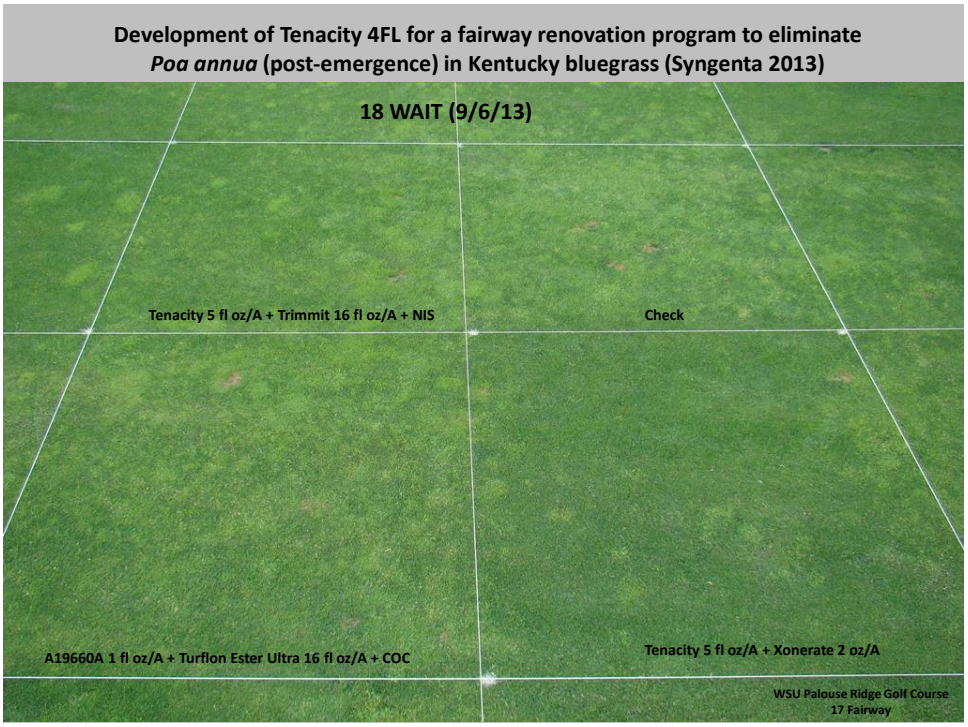

Figure 19. The effect of various treatments to control *P. annua* 18 WAIT. PRGC 17 fairway. Pullman, WA.