

## **Phytotoxicity and Efficacy Evaluations of Marengo SC Compared to Eight Other Market Contender Herbicides Applied to Dormant Nursery Fields**

**Principle investigator:** Dr. Hannah Mathers (Mathers Environmental Science Services, LLC, Gahanna, OH)

**Technical assistance:** James Beaver, MSc; and Emma Beaver (Mathers Environmental Science Services, LLC, Gahanna, OH)

**Abstract.** Phytotoxicity and efficacy were evaluated on three fields per each of three nursery locations in Ohio with over the top applications on dormant growth. The locations included Studebaker Nurseries, Inc., New Carlisle, OH, 45344; Wm A Natorp Co., Mason, OH, 45040 and Herman Losely and Son, Inc., Perry, OH, 44081. The species at Studebaker Nurseries included boxwood (*Buxus* 'Green Velvet' - 1yr and 5yr fields) and yew (*Taxus Xmedia* 'Runyan' - 3yr) with one application made April 1, 2015. The species at Natorp Co., included boxwood (*Buxus* 'Green Gem' - 3yr), (*Buxus* 'Green Velvet' - 1yr) and yew (*Taxus X media* 'Densiflora' - 1 yr.) with two applications made on similar adjacent beds (but not twice on the same beds), December 11, 2014 and March 12, 2015. The species at Losely's included yew (*Taxus Xmedia* 'Tauntonii' - 3yr and *Taxus cuspidata* 'Green Wave' - 1yr) and boxwood (*Buxus sempervirens* 'Green Mountain' - 3yr) with one application made April 8, 2015. The fields chosen had expected extreme weed pressures, except at Losely's where limited weed growth occurred. Thus, Losely efficacy is not presented in this report. The Losely, *Taxus Xmedia* 'Tauntonii' - 3yr, however, was the only species at the three nurseries to exhibit any long term phytotoxicity, weeks after treatment (WAT), with three treatments: Certainty, Echelon and Lontrel. Only Certainty provided non-acceptable phytotoxicity at 14 WAT. At Studebaker, where the predominant weed was Canada thistle, Lontrel was by far the most efficacious treatment providing commercially significant weed control to 12 WAT and 10 WAT, depending on crop. Lontrel was followed by Casoron 4G providing commercially significant weed control to 10 WAT and 7 WAT, again dependent on crop, at Studebaker's. At Natorp's, Casoron CS performed the best in the December 11, 2014 applications providing commercial control 28 and 26 WAT, depending on the crop. Casoron CS was followed by Marengo SC with commercial control at 26 and 21 WAT, depending on crop. With the March 12, 2015 applications at Natorp's, Marengo SC was the most efficacious treatment providing 15 and 13 WAT commercial control depending on crop and followed by V10233 with commercial weed control 13 WAT in two of three crops. The Gallery SC + Dimension 2EW treatments performed best at Natorp's in the December 11, 2014 applications providing commercial control 16 WAT.

**Introduction.** New nursery field preemergent herbicides such as Marengo SC (Indaziflam 7.4% by wt.) (OHP, Inc., Mainland, PA, 19451), V-10233 (Flumioxazin

33.5% + Pyroxasulfone 42.5%) (Nufarm Americas Inc., Alsip, IL, 60803) were developed in the “downturn” years of the green-industry or post 2008. Flumioxazin is currently labeled for the nursery and landscape markets as either BroadStar (the granular formulation) or SureGuard (liquid formulation). Pyroxasulfone is a new chemistry in the isoxazoline family that inhibits very long chain fatty acids and is currently labeled for use in corn and soybeans. Other herbicides such as Echelon (F6875 SC) (Sulfentrazone + prodiamine) (FMC, Philadelphia, PA 19103) and Certainty (Sulfosulfuron) (Monsanto Company, St. Louis, MO, 63167) were also researched in these “downturn years” in the IR-4 Project, Princeton, NJ 08540 as pre-and post, and post-emergent products, respectively. As the economy recovers, in 2014-15, the availability of superior herbicides is essential to control the weed propagule bank that remains after years of slashed herbicide budgets. These studies were initiated for this era of improved weed control budgets and to determine the optimum timing and product(s) to deliver the efficacy “power” required.

Other current herbicides in use in nursery such a Lontrel (Clopyralid monoethanolamine salt 40.9%) and a new Gallery SC formulation (Isoxaben 45.5%) combined with their Dimension 2EW (Dithiopyr 24%) advocated by Dow AgroSciences were also included in the research. Gallery SC + Dimension is becoming a favored ornamental landscape bed combination and a dormant application of this was of interest. The objectives of these studies were to evaluate phytotoxicity on three fields at each of three locations in Ohio with over the top applications on dormant growth and to evaluate efficacy in the surrounding bed.

#### **Materials and methods.**

*Studebaker Nurseries.* Three fields geographically separated were chosen at Studebaker Nurseries, Inc., New Carlisle, OH, 45344 including: field 445 planted spring 2014 with *Buxus* ‘Green Velvet’; field 67 planted spring 2012 with *Taxus Xmedia* ‘Runyan’; and, field 866, planted spring 2010 with *Buxus* ‘Green Velvet’. The herbicides were applied on April 1, 2015 over-the-top (OTT) to dormant material at the rates indicated (Table 1). Weed pressures were extremely high in all fields with field 866 being the worst and most diverse in terms of weedy species. However, the Canada thistle weed pressure in fields 445 and 67 was incredible (Fig. 1). For six of nine herbicides listed in Table 1, active ingredients and percent actives, manufacturers name, city and state have been provided above. The remaining three treatments at Studebaker were SureGuard (Flumioxazin 51%, Nufarm Americas Inc.), SureGuard + Dimension 2EW and Casoron 4G (Dichlobenil 4%) (OHP, Inc.). At Studebaker’s, evaluations were conducted at 3 WAT, 5 WAT, 7 WAT, 10 WAT and 12 WAT. After 12 weeks, the Studebaker fields were overgrown to the extent it was difficult to walk in the rows.



**Fig. 1.** (Above) Stuebaker Nurseries, Inc., New Carlisle, OH, 45344 field 67 planted spring 2012 with *Taxus Xmedia* 'Runyan.' Shown above are untreated rows heavily infested with Canada thistle (*Cirsium arvense*) taken April 23, 2015 (By: H. Mathers).

Wm A Natorp Co. Three fields owned by Wm A Natorp Co., Mason, OH, 45040 were chosen with two being geographically separated: field 6B planted fall 2013 with *Buxus* 'Green Velvet'; field 6B planted fall 2013 with *Taxus* 'Densiformis'; and, field 11A, planted fall 2011 with *Buxus* 'Green Gem'. All three fields were at Natorp's Settlemyre Rd. Farm, Lebanon, OH (N 39°24.939', W 084° 09.843') and were heavily infested with particularly heavy weed pressure from members of the Asteraceae in 6B fields (Fig. 2). The herbicides were applied on December 11, 2014 (Round 1) and March 12, 2015 (Round 2) over-the-top (OTT) to dormant material at the rates indicated (Table 2 and 3, respectfully). Stuebaker treatments were identical to the Natorp Round 2 treatments. The Natorp Round 1 treatments SedgeHammer Plus (5% Halosulfuron-methyl) (Gowan Co., Yuma, AZ, 85366) and Casoron CS (Dichlobenil 15%) (Chemtura Corporation, Middlebury, CT, 06749) were replaced with SureGuard + Dimension 2EW and Casoron 4G, respectively in Round 2. At Natorp's Round 1 evaluations were conducted at 2 WAT, 13 WAT, 16 WAT, 19 WAT, 21 WAT, 26 WAT and 28 WAT. For Round 2 evaluations were performed at 2 WAT, 6 WAT, 8 WAT, 13 WAT and 15 WAT. After 28 and 15 WAT, respectively, for round 1 and 2, Natorp beds were overgrown and walking in the rows to conduct evaluations was arduous.



**Fig. 2.** (Left) Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') showing heavy infestation of Asteraceae weeds in field 6B planted fall 2013 with *Buxus* 'Green Velvet'. Shown above is a control plot (untreated) taken June 8, 2015, 26 WAT. (By: H. Mathers).

*Studebaker, Natorp and Losely.* For each nursery and species, there were four replications with five subsamples/replication,

where the center three plants were evaluated for phytotoxicity and efficacy. A completely randomized design within each species was utilized. Plots were each 3 ft. wide x 8 ft. long and contained five plants per species or three experimental unit plants per plot at equal spacing. A total of 240 plots were utilized at the two nurseries and another 120 at Losely's. Liquid applications were applied via CO<sub>2</sub> backpack sprayer delivering 25 gal/ac (R&D Sprayers, Opelousas, LA 70570) equipped with 8002 vs nozzles (TeeJet, East North Avenue, Carol Stream, IL 60116 ) spaced 18" apart. Granular formulations were applied via handheld shaker jars after pre-weighing the amounts required for each plot area. Evaluations of phytotoxicity consisted of visual ratings on a scale of 0-10 with 0 being no phytotoxicity, 10 death, and  $\leq 3$  commercially acceptable. Efficacy was also visually rated at the same time as phytotoxicity and rated on a scale of 0-10 with 0 being no control, 10 perfect control, and  $\geq 7$  commercially acceptable. Treatment means of phytotoxicity were compared to untreated control using Dunnett's t-test ( $\alpha = 0.05$  and 0.10) in SAS® Proc Mixed. Treatment means for efficacy were separated using LSmeans ( $\alpha = 0.05$ ) also in SAS® Proc Mixed.

## Results and discussion.

*Efficacy* evaluations are presented for Studebaker Nurseries, Inc. (Table 1) and Wm. Natorp Co. Round 1 (Table 2) and Round 2 (Table 3). Weed pressure in Losely rows was very low, with the exception of some sporadic yellow nutsedge (*Cyperus esculentus* L.) (Fig. 3). These minimal weed populations prevented conclusive



treatment efficacy evaluation; therefore, efficacy results are not presented for Herman Losely and Son, Inc.

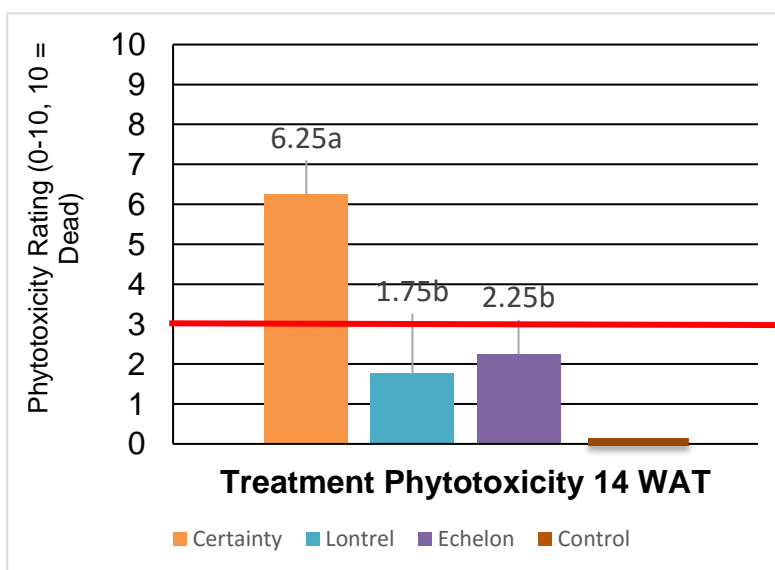
### *Phytotoxicity.*

At Studebaker Nurseries, Inc. and Wm. Natorp Co. Round 1 and 2, phytotoxicity was negligible in all species. Therefore, treatment phytotoxicity is not presented for these two sites. Herman Losely and Son, Inc., however, did have significant phytotoxicity lasting to 14 WAT for three treatments and one crop, *Taxus Xmedia* 'Tauntonii' – 3yr (Fig. 4). Only the Certainty treatment persisted with commercially unacceptable phytotoxicity  $\leq 3$  (6.25) at 14 WAT. Certainty caused a distinct yellowing in the *Taxus Xmedia* 'Tauntonii' (Fig. 5 and 6) even at 14 WAT (Fig. 6). Certainty is an ALS inhibitor and the damage was characteristic of this mode of action (MoA). ALS inhibitors are transported to the growing points and injury occurs first in the new growth (Fig. 5). Also typical of ALS inhibitors, damage is very species and cultivar specific.



**Fig. 3.** (Left) Herman Losely and Son, Inc., Perry, OH, 44081 showing *Taxus cuspidata* 'Green Wave' - 1yr and only sporadic and minimal infestations of yellow nutsedge (*Cyperus esculentus* L.). Picture taken July 24, 2015 (14 WAT) showing a single yellow nutsedge plant at the start of a SureGuard + Dimension 2EW plot (By: H. Mathers).

**Fig. 4.** (Right) Herman Losely and Son, Inc., Perry, OH, 44081 showing *Taxus Xmedia* 'Tauntonii' - 3yr phytotoxicity caused by three treatments. Only Certainty is causing injury that is not commercially acceptable  $\leq 3$  (6.25) at 14 WAT.





**Fig. 5.** (Left) Herman Losely and Son, Inc., Perry, OH, 44081 showing *Taxus Xmedia* 'Tauntonii' - 3yr injury from Certainty (Sulfosulfuron) (Monsanto Company, St. Louis, MO, 63167) applied at 7.5 fl. oz. /ac 14 WAT. Injury was characteristic of this ALS MoA showing first in the new growth as flashes of yellow in the whorls. Picture taken by H. Mathers, 07/24/2015.

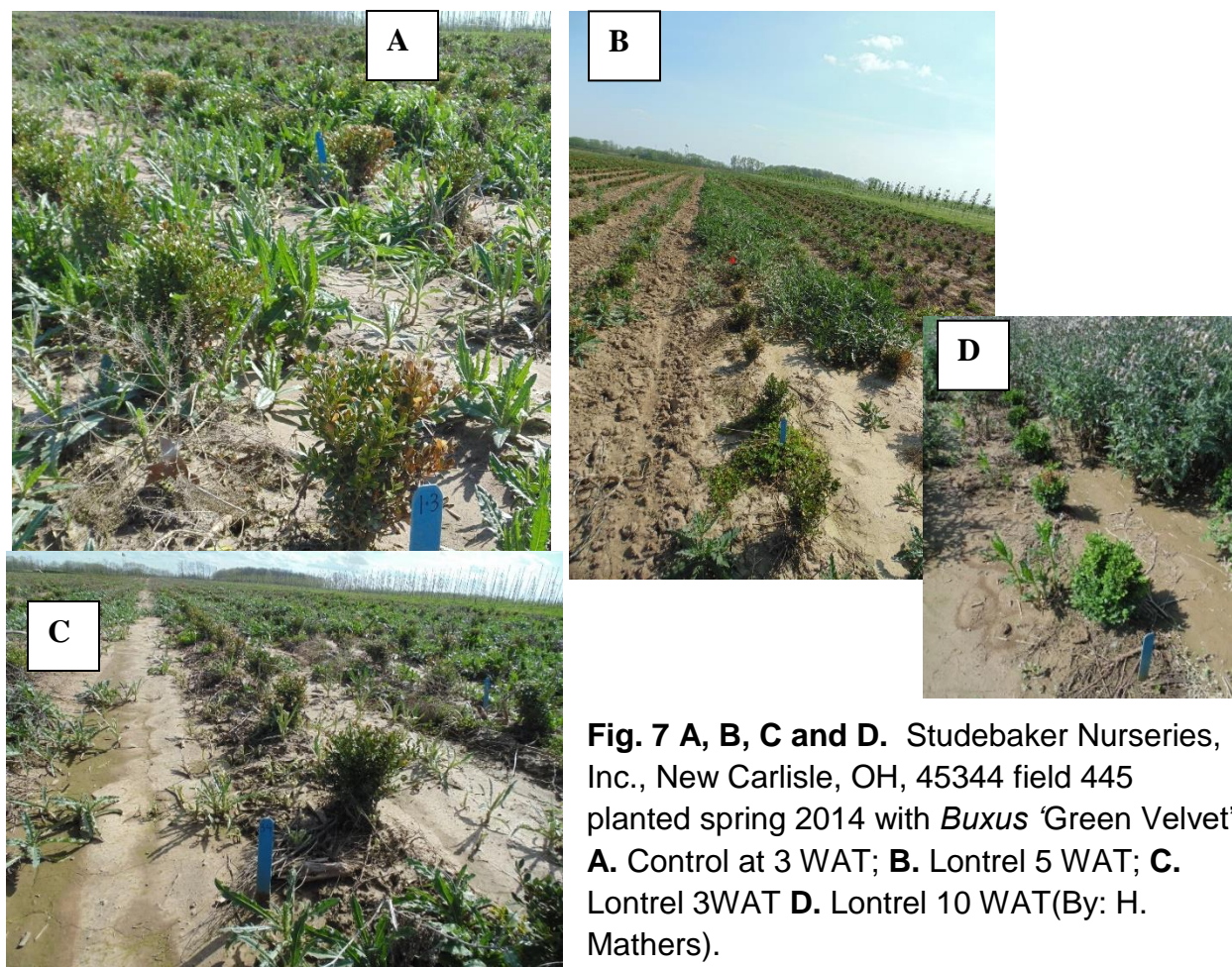


**Fig. 6.** (Above) Herman Losely and Son, Inc., Perry, OH, 44081 showing rows of *Taxus Xmedia* 'Tauntonii' - 3yr and the injured replicated plots caused by Certainty (Sulfosulfuron) (Monsanto Company, St. Louis, MO, 63167) applied at 7.5 fl. oz. /ac 14 WAT. Blue arrows indicate where the characteristic yellowing of this ALS MoA herbicide is visible in the new growth. Picture taken by H. Mathers, 07/24/2015. Note also the insignificant weed pressure in this Losely field.



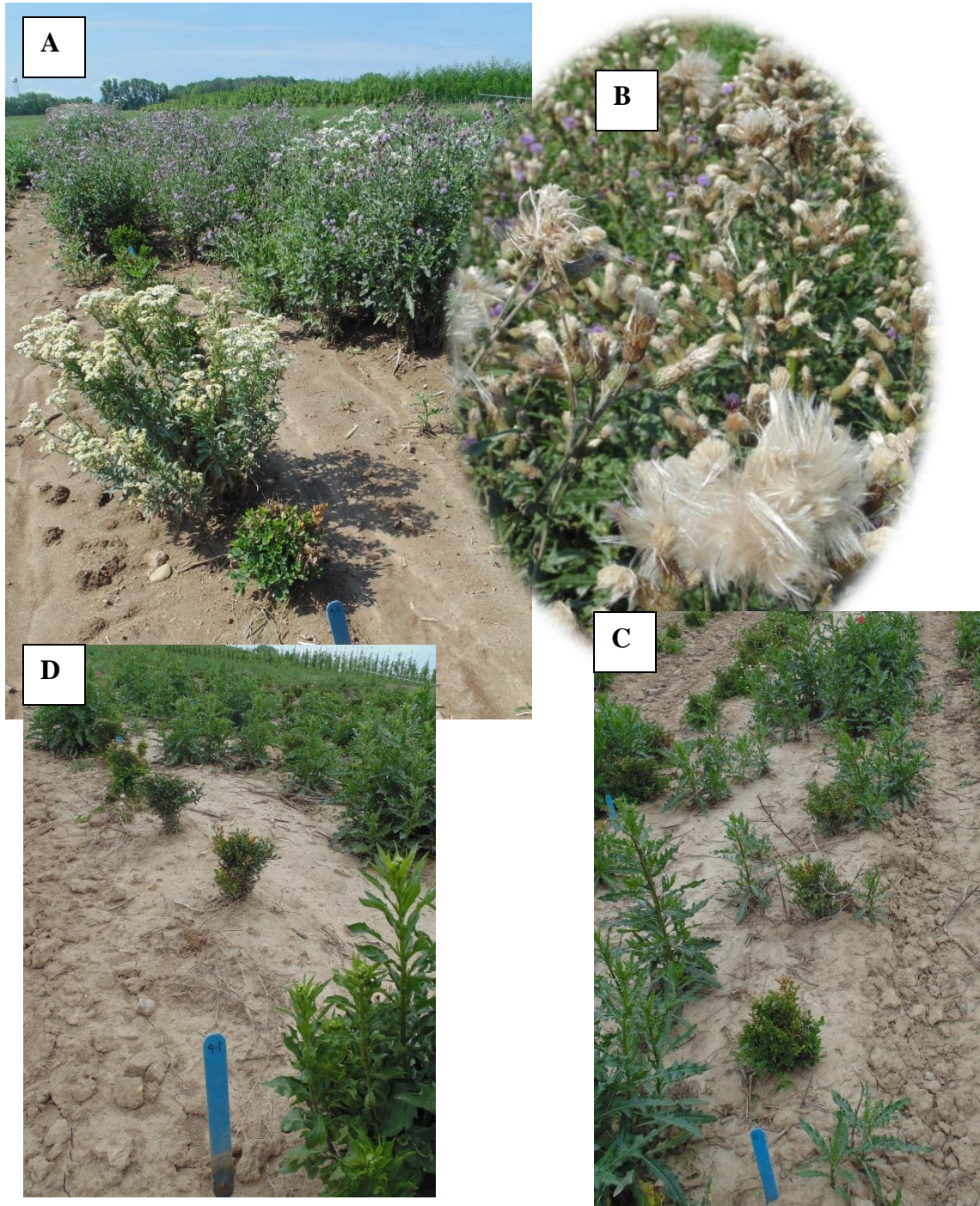
*Efficacy.**Studebaker Nurseries.*

*Buxus* 'Green Velvet' 1 yr. Field 445. The best treatment at Studebaker's in the *Buxus* 1yr planting was Lontrel at 16 oz. /ac. Lontrel provided exceptional control from 3 WAT (Fig. 7 C) to 12 WAT under severe infestations of Canada thistle (Fig. 7) (Table1). Casoron 4G provided statistically similar control at 3 WAT to 10 WAT compared to Lontrel; however, the Casoron efficacy dropped below commercially acceptable ( $\geq 7$ ) after 10 WAT (Table 1). Therefore based on duration of efficacy Lontrel was the best treatment (Table 1). Using the overall averages of treatments and Fisher Isd, Lontrel and Casoron are statistically similar in efficacy throughout the trial. However, using the  $\geq 7$  commercial rating system Casoron drops below commercially acceptable after 10 WAT making Lontrel the best treatment (Fig. 7D) (Table 1). The Gallery + Dimension 2EW, SureGuard + Dimension 2EW, SureGuard (Fig. 8 A, B and D) or V-10233 (Fig. 8C) were providing viable commercial control at any evaluation date in the 1 yr. *Buxus* (Table 1).



**Fig. 7 A, B, C and D.** Studebaker Nurseries, Inc., New Carlisle, OH, 45344 field 445 planted spring 2014 with *Buxus* 'Green Velvet' **A.** Control at 3 WAT; **B.** Lontrel 5 WAT; **C.** Lontrel 3WAT **D.** Lontrel 10 WAT(By: H. Mathers).

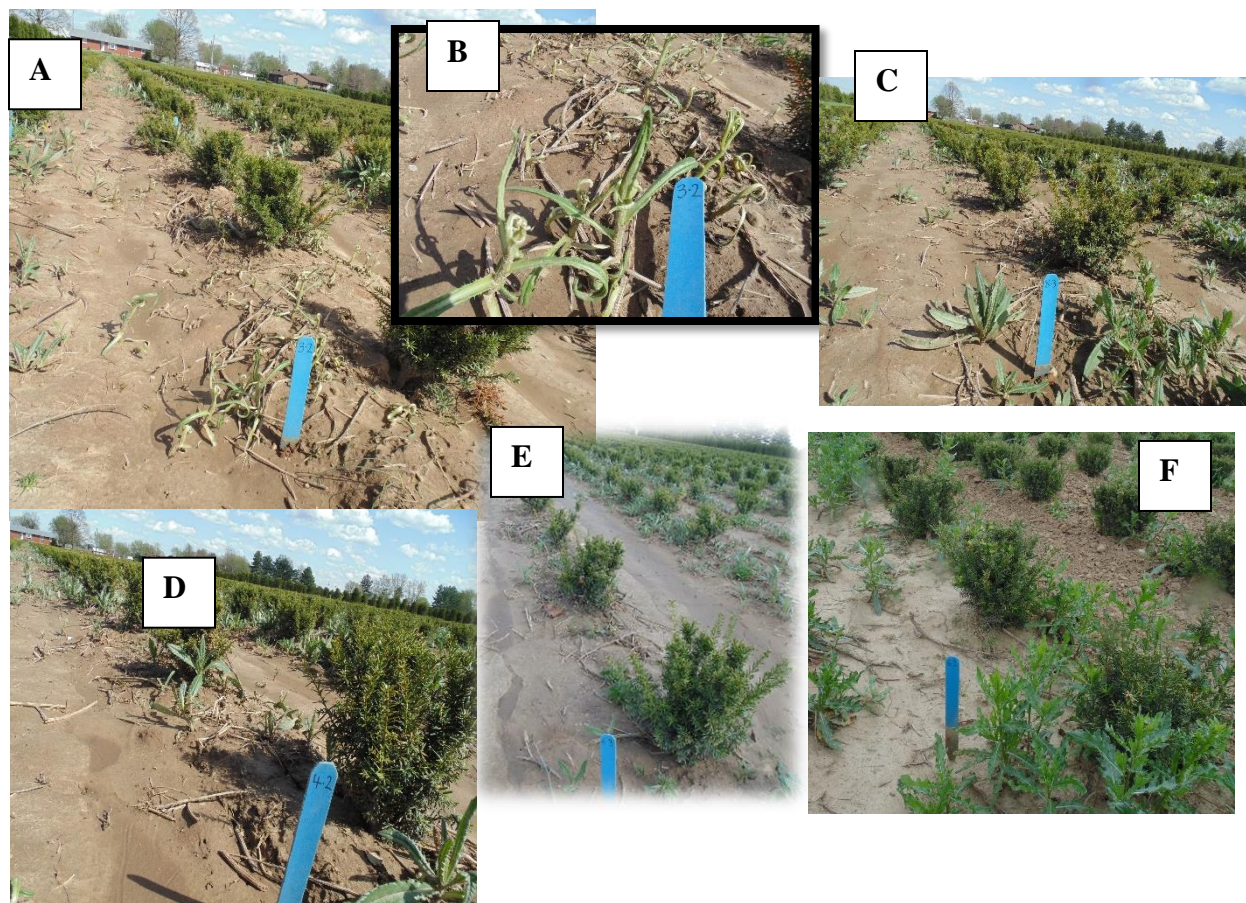




**Fig. 8 A, B, C and D.** Studebaker Nurseries, Inc., New Carlisle, OH, 45344 field 445 planted spring 2014 with *Buxus* 'Green Velvet' **A.** SureGuard 10 WAT; **B.** A blow-up of **A** showing abundance of Canada thistle going to seed in field 445. **C.** V10233 5 WAT; **D.** SureGuard 5 WAT (By: H. Mathers).



*Taxus Xmedia 'Runyan' 3 yr. Field 67.* Performance of all treatments was better in Studebaker field 67 versus field 445 with the one year *Buxus*. The best treatment at Studebaker's in the *Taxus* 3yr planting was Lontrel at 16 oz./ac (8.175) using the treatment averages and commercial ratings (Table 1). Lontrel provided exceptional control from 3 WAT to 12 WAT, again under severe infestations of Canada thistle. The next best treatment was Casoron 4G (Fig.9C) that provided statistically similar levels of control at 3 WAT to 10 WAT; however, again as in the 1yr *Buxus*, the Casoron efficacy dropped below commercially acceptable ( $\geq 7$ ) after 10 WAT (6.25 at 12 WAT) (Table 1). Gallery + Dimension 2EW (Fig.9D), or SureGuard + Dimension 2EW provided viable commercial control at 3 WAT and SureGuard + Dimension 2EW at 5 WAT (Table 1). The SureGuard + Dimension 2EW delivered just slightly better efficacy than SureGuard alone; however, the difference was never significant statistically at any evaluation date. The difference was commercially significant, however, at 5 WAT (Table 1). Marengo SC at 3 WAT (Fig. 9E) was commercially viable but not 5 WAT (Fig. 9F).



**Fig. 9 A,B,C,D, and F.** Studebaker Nurseries, Inc., New Carlisle, OH, 45344 field 67 planted spring 2012 with *Taxus 'Runyan'* **A.** Lontrel at 3 WAT; **B.** Blow up of picture A dying Canada thistle. **C.** Casoron at 3 WAT; **D.** Gallery + Dimension at 3 WAT and **E.** and **F.** Marengo 3 and 5 WAT, respectively.



*Buxus 'Green Velvet' 5 yr. Field 866.* The weed pressure in terms of species diversity and over all biomass was the worst in field 866 (Fig. 10 A and C), planted spring 2010 at Studebaker Nursery. Plants in this field had been neglected in terms of weed control for several years. This was reflected in the control which hit zero at 5 WAT (Table 1) (Fig. 10A). It is also indicated in a shorter duration of Lontrel and Casoron 4G (Fig. 10C) efficacy, ending at 10 and 7 WAT, respectively, versus 12 and 10 WAT in the other two Studebaker fields (Table 1). The SureGuard + Dimension 2EW delivered slightly better efficacy than SureGuard (Table 1). The addition of Dimension seemed to add some residual control to the SureGuard versus the SureGuard alone (Table 1). The best treatment for duration was the Lontrel (Fig. 10 B and 11C). V10223 lost commercial efficacy at 5 WAT as SureGuard and Marengo CS (Fig. 11B). The V10233 and SureGuard control worsened throughout the trial and was near negligible at 10 WAT for V10233 (Fig. 11A). The Marengo SC was more consistent than the V10233 holding more steady until 10 WAT (Fig. 11D).



**Fig. 10. A, B and C.** Studebaker Nurseries, Inc., New Carlisle, OH, 45344 field 866 planted spring 2010 with *Buxus 'Green Velvet'* **A.** Control at 5 WAT **B.** Lontrel at 7 WAT and **C.** Casoron at 10 WAT with a few break through weeds (By: H. Mathers).







**Fig. 11. A, B, C and D.** Studebaker Nurseries, Inc., New Carlisle, OH, 45344 field 866 planted spring 2010 with *Buxus* 'Green Velvet' **A.** V10233 10 WAT **B.** Marengo at 5 WAT **C.** Lontrel at 10 WAT. **D.** Marengo SC at 10 WAT (By: H. Mathers).

**Table 1.** Visual ratings of efficacy for nine herbicides and an untreated control at 5 evaluation dates conducted at Studebaker Nurseries, Inc., New Carlisle, OH, 45344. Treatments were applied to dormant stock with 4 replications/ treatment and 5 subsamples/ replicate on April 1, 2015. Only the center three plants/ plot were sprayed and evaluated. *Buxus* 'Green Velvet' – 1 yr. was planted spring 2014; *Taxus Xmedia* 'Runyan' was planted spring 2012; *Buxus* 'Green Velvet' – 5yr. was planted spring 2010.

*Buxus* 'Green Velvet'- 1 yr. field 445

Treatment	Rate/ac	3 WAT <sup>2</sup>	5 WAT	7 WAT	10 WAT	12 WAT	Average
Control	--	2.25 <sup>yx</sup> a	2.5a	1.5a	0.35a	0a	1.32a
Echelon (F6875)	0.75 lb.	3.5a	3ab	2.75ab	2.3b	2.25b	2.76a
Lontrel	16 oz.	8.75cd	7.875cd	8d	7.625d	7.375d	7.925d
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	5.25b	3.75ab	3.25b	2.05b	0.5a	2.96b
Certainty	7.5 fl oz.	8cd	7c	5.75c	4.65	2.5b	5.58c
Marengo SC	15 oz.	7.875c	5.25b	4.75c	3bc	2b	4.575c
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	6.25b	4b	2a	0a	0a	2.45ab
Casoron 4G	150 lb.	9.5d	9d	9.25d	9.125d	6d	8.575d
SureGuard	12 oz.	6b	4.5b	4.75c	3.7c	4.375c	4.665c
V10223	15 oz.	6.75b	3.75ab	3.75b	1.875b	2.75b	3.775bc

*Taxus* 'Runyan' - 3 yr. field 67

Treatment	Rate/ac	3 WAT	5 WAT	7 WAT	10 WAT	12 WAT	Average
Control	--	0.75a	0.75a	1.75a	0a	0a	0.65a
Echelon (F6875)	0.75 lb.	5.5b	3.25b	3.25b	1.5b	1.25ab	2.95b
Lontrel	16 oz.	9d	8.25e	9.125e	7d	7.5d	8.175d
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	7.5c	6.5d	6.25c	3.25b	2.5b	5.2bc
Certainty	7.5 fl oz.	8.125cd	7.125de	7.375cd	5.75d	5.25cd	6.725cd
Marengo SC	15 oz.	8.25cd	6.75d	6.25c	4c	3.25b	5.7c
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	8.75cd	7d	6.5c	4.75c	4.5bc	6.3c
Casoron 4G	150 lb.	9d	7.75de	8.5de	7d	6.25d	7.7d
SureGuard	12 oz.	8.625cd	6.75d	6.25c	3.5bc	2.75b	5.575bc
V10223	15 oz.	8.25cd	4.75c	3ab	2.5b	1a	3.9b

*Buxus* 'Green Velvet' - 5 yr. field 866

Treatment	Rate/ac	3 WAT	5 WAT	7 WAT	10 WAT	12 WAT	Average
Control	--	0.75a	0a	0a	0a	0a	0.15a



Echelon (F6875)	0.75 lb.	5.75b	3.75b	1.75b	1a	0.75a	2.6b
Lontrel	16 oz.	7.5c	8d	8.875	7	6.25	7.525e
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	6b	4bc	4.25cd	1.75	1.25a	3.45b
Certainty	7.5 fl oz.	6.25b	5bc	5.25d	2.75	1a	4.05b
Marengo SC	15 oz.	7.75c	6.375c	6.75e	5	3.75	5.925d
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	7.75c	6.625c	6.5e	2.25	1.25a	4.875c
Casoron 4G	150 lb.	6.25b	8.5d	8.5f	6.375	5.5	7.025d
SureGuard	12 oz.	7.5c	5.5c	4.75d	3.25	0.75a	4.35bc
V10223	15 oz.	7.5c	5.25c	3.75c	2.5	1.25a	4.05b

z = weeks after treatment

y = Visual ratings based on a 0-10 scale with 10 being perfect efficacy, 0 no weed control and  $\geq 7$  commercially acceptable.

x = Treatment means followed by the same letter in the same column are not significantly different based on lsmeans ( $\alpha = 0.05$ ).

**Table 2.** Visual ratings of efficacy for nine herbicides and an untreated control at 7 evaluation dates conducted at Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843'). Treatments were applied to dormant stock with 4 replications / treatment and 5 subsamples / replicate on December 11, 2014 (**Round 1 Treatments**). Only the center three plants/ plot were sprayed or evaluated. *Buxus* 'Green Velvet' – 1 yr. was planted fall 2013; *Taxus Xmedia* 'Densifomis' – 1 yr. was planted fall 2013; and *Buxus* 'Green Gem' – 3yr was planted fall 2011.

*Buxus* 'Green Velvet,' 6B, 1 year old

Treatment	Rate/ac	2 WAT <sup>z</sup>	13 WAT	16 WAT	19 WAT	21 WAT	26 WAT	28 WAT	Average
Control	--	6.75 <sup>yx</sup> a	6.25a	5.25a	1.25a	0.75a	1.5a	0a	3.11a
Echelon (F6875)	0.75 lb.	9b	8.5bc	9cd	5b	4.5b	1.75ab	0.5a	5.46b
Lontrel	16 oz.	6.25a	7.75ab	8.25cd	8cd	7cd	7.5ef	6.5ef	7.32cde
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	8.25b	7.25a	7bc	5.75b	4.5b	3.25b	1ab	5.29b
Certainty	7.5 fl oz.	6.5a	7.25a	6.75b	5.75b	4.75b	4.75c	2.25bc	5.43b
Marengo SC	15 oz.	8.25b	7.5a	7.25bc	7.25c	7cd	6.25de	5.25de	6.96cd
SedgeHammer Plus 5% Halosulfuron	2 oz.	5.75a	7a	8bc	6.75c	6.25c	5.75cd	3.5c	6.14bc
Casoron CS	3 gal	5.75a	8.75bc	9.75d	9.75e	10e	9.25g	7.75f	8.71e
SureGuard	12 oz.	8.75b	8.5bc	10d	9.25de	8.75de	8.25efg	6.25e	8.54e
V10223	15 oz.	6.75a	9.5c	9.25d	9de	7.75d	7ef	4cd	7.61de

*Taxus Xmedia* 'Densifomis,' 6B, 1 year old

Treatment	Rate/ac	2 WAT	13 WAT	16 WAT	19 WAT	21 WAT	26 WAT	28 WAT	Average
Control	--	6a	6a	4.25a	0a	0a	0a	0a	2.32a
Echelon (F6875)	0.75 lb.	7.5b	7.75b	7b	6.5bc	6.25cd	2b	0.75a	5.39b
Lontrel	16 oz.	9c	7.25ab	7.75b	5.5b	6.75cd	5.75e	2.5b	6.36bc
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	7.5b	7.25ab	7.25b	5.25b	4.25b	3.75c	1a	5.18b
Certainty	7.5 fl oz.	9c	7.25ab	7.25b	7.25c	6.5cd	5cde	3.5b	6.54bcd
Marengo SC	15 oz.	8bc	8.25bc	9.5d	9d	8.75f	7.75f	6.25c	8.21de
SedgeHammer Plus %5 Halosulfuron	2 oz.	6.25ab	7.25ab	8bc	7c	7.25de	4.25cd	2.5b	6.07b
Casoron CS	3 gal	8.75bc	7.75b	8.75cd	9d	8.5ef	8.5f	6.25c	8.21de
SureGuard	12 oz.	8.5bc	8.25bc	8.75cd	8.5d	8.5ef	6e	5.25c	7.68cd
V10223	15 oz.	9c	9c	9.25cd	7.75cd	7.75def	5.25de	2.5b	7.21cd

*Buxus* 'Green Gem,' 11A - 3 year old

Treatment	Rate/ac	2 WAT	13 WAT	16 WAT	19 WAT	21 WAT	26 WAT	28 WAT	Average
Control	--	9.75a	6.5a	3.5	0	0	4.25	0a	3.43a
Echelon (F6875)	0.75 lb.	9.25a	8.25bcd	7.75	4.5	4	6	1.25ab	5.86b
Lontrel	16 oz.	10a	8.5bcd	6.5	4.25	1.25	5.75	1.75b	5.43bc
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	10a	9cd	8.25	6.25	3	5.5	2b	6.29bc
Certainty	7.5 fl oz.	9.5a	8.5bcd	9	6.75	7	7.5	0.5ab	6.96c
Marengo SC	15 oz.	10a	9.25c	9.25	8.5	8.25	6	5c	8.04c
SedgeHammer Plus %5 Halosulfuron	2 oz.	9.75a	8bc	7.5	7	6	5.75	0.75ab	6.39b
Casoron CS	3 gal	9.5a	9.5d	9.75	9	9.25	7.25	4c	8.32c
SureGuard	12 oz.	10a	9cd	7.75	7	7.5	7.25	2b	7.21c
V10223	15 oz.	9.5a	9.5d	9.75	9.25	9.125	7.75	1.25ab	8.02c

z = weeks after treatment

y = Visual ratings based on a 0-10 scale with 10 being perfect efficacy, 0 no weed control and  $\geq 7$  commercially acceptable.

x = Treatment means followed by the same letter in the same column are not significantly different based on lsmeans ( $\alpha = 0.05$ ).



**Table 3.** Visual ratings of efficacy for nine herbicides and an untreated control at 5 evaluation dates conducted at Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843'). Treatments were applied to dormant stock with 4 replications / treatment with 5 subsamples / replicate on March 12, 2015 (**Round 2 Treatments**). Only the center three plants / plot were sprayed and evaluated. *Buxus* 'Green Velvet' – 1 yr. was planted fall 2013; *Taxus Xmedia* 'Densiformis' – 1 yr. was planted fall 2013; and *Buxus* 'Green Gem' – 3yr was planted fall 2011.

*Buxus* 'Green Velvet,' 6B, 1 year old

Treatment	Rate/ac	3 WAT <sup>z</sup>	6 WAT	8 WAT	13 WAT	15 WAT	Average
Control	--	5 <sup>yx</sup> a	3.75ab	1.75a	2.75a	0a	2.65a
Echelon (F6875)	0.75 lb.	4.75ab	3a	2.75a	2.5a	0.75a	2.75a
Lontrel	16 oz.	6.5bc	7.75cd	4.75b	6.25c	5bc	6.05b
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	8de	6.75c	6.5c	4.5b	4b	5.95b
Certainty	7.5 fl oz.	8de	8.25d	7.5cd	6.5cde	5.75cd	7.2bcd
Marengo SC	15 oz.	8de	8d	8.75d	8.5f	6.75d	8d
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	8.25de	8.25d	6.75c	5bcd	4b	6.45bc
Casoron 4G	150 lb.	7.75cd	5b	7cd	6.25cde	5.25bc	6.25bc
SureGuard	12 oz.	9.25e	7.75cd	6.75c	4.75b	5bc	6.7bcd
V10223	15 oz.	9de	8.75d	7.75cd	7e	5.5cd	7.6cd

*Taxus Xmedia* 'Densiformis,' 6B, 1 year old

Treatment	Rate/ac	3 WAT	6 WAT	8 WAT	13 WAT	15 WAT	Average
Control	--	6.5a	0a	0a	0.75a	0a	1.45a
Echelon (F6875)	0.75 lb.	9b	6.75b	5.75cd	4.25c	2.25b	5.6bc
Lontrel	16 oz.	7a	6.25b	3.75b	6d	4.5cd	5.5bc
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	8.75b	6.5b	4.75bc	2.75b	2.5b	5.05b
Certainty	7.5 fl oz.	7.25a	6b	4.5bc	3.75bc	4.75cd	5.25b
Marengo SC	15 oz.	8.75b	9.375d	8.625f	8e	8e	8.55d
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	9b	7.75c	7.25ef	3.5bc	4.25c	6.35bc
Casoron 4G	150 lb.	7.25a	7.5c	6.5de	6.25d	5.75d	6.65c
SureGuard	12 oz.	9.25b	8.75cd	6.5de	5.25cd	4.5cd	6.85c
V10223	15 oz.	9.5b	8cd	6.75de	4.5cd	2.25b	6.2bc

*Buxus* 'Green Gem,' 11A - 3 year old

Treatment	Rate/ac	3 WAT	6 WAT	8 WAT	13 WAT	15 WAT	Average
Control	--	4.25a	1.75a	4.25a	5a	0a	3.05a

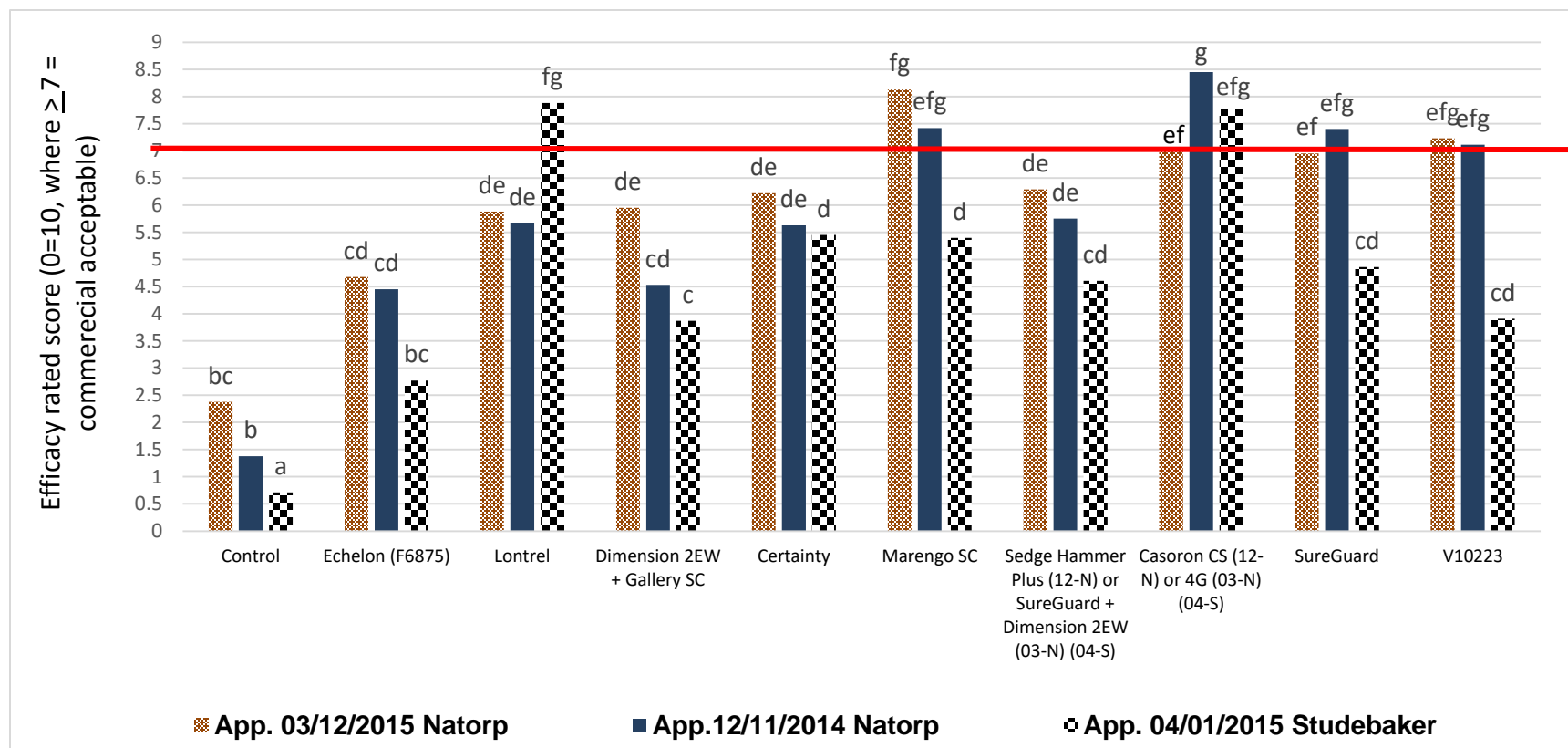
Echelon (F6875)	0.75 lb.	8.5	6bc	5.25ab	5.75ab	3bc	5.7b
Lontrel	16 oz.	7.75b	5.75b	5.25ab	8.25d	3.5c	6.1bc
Gallery SC + Dimension 2EW	0.5 lb. + 1.0 lb.	8b	7.25c	6.5b	8.25d	4.25c	6.85bcd
Certainty	7.5 fl oz.	8.5bc	7bc	6.25b	7.5cd	1.75b	6.2bc
Marengo SC	15 oz.	8.5bc	8.375cd	8.375c	7.75cd	6.25d	7.85cd
SureGuard + Dimension 2EW	12 oz. + 0.5 lb.	8.5bc	6.875bc	6b	5.75ab	3.25c	6.075bc
Casoron 4G	150 lb.	10cd	9d	9.125c	8.5d	4.5c	8.225d
SureGuard	12 oz.	9bc	8.75d	8c	6.75bc	4c	7.3cd
V10223	15 oz.	9.75cd	9d	8.125c	8cd	4.5c	7.875cd

z = weeks after treatment

y = Visual ratings based on a 0-10 scale with 10 being perfect efficacy, 0 no weed control and  $\geq 7$  commercially acceptable.

x = Treatment means followed by the same letter in the same column are not significantly different based on lsmeans ( $\alpha = 0.05$ ).





**Fig. 12.** Treatment by experiments interaction means 2014-2015 for dormant applications. The three experiments consist of two rounds of applications at Wm A. Natorp Co. and one set at Studebaker Nurseries, Inc. Values in columns are pooled over all evaluation dates and three species/ experiment. Columns with the same letters are not significantly different than one based on lsmeans ( $\alpha = 0.05$ ). Only evaluation dates that were common to all three applications are pooled to create this graph i.e., five dates are pooled for each experiment including the 12/11/2014 Natorp application.

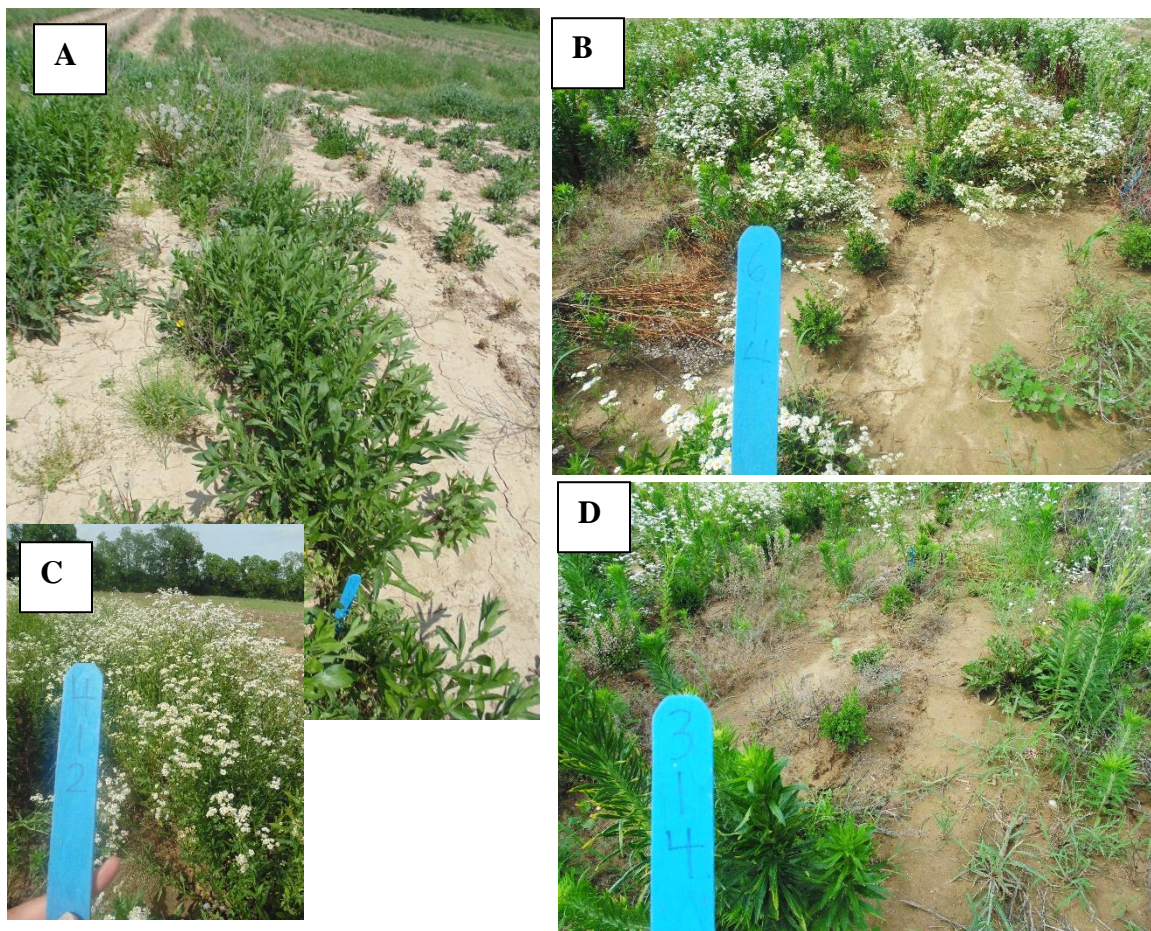
*Wm. A. Natorp Co.* At Natorp's, two dormant applications were conducted. In the industry, anecdotal information indicates that dormant applications performed early winter are better than late winter or spring. This study, however, contradicts this subjective thought as a blanket statement for all herbicides (Fig.12). There was little difference between applications made at Natorp's 12/11/2014 or 03/12/2014 with the exception of Casoron, with the 12/11/2014 application out-performing the 03/12/2014 application (Fig. 12). However, this could be due to the change of formulation from Casoron CS used in 12/11/2014 and Casoron 4G used in 03/12/2014. The 4G formulation is more commonly used in the industry, but the CS formulation is available in the Turf and Ornamental and Industrial Vegetation Management market through Chemtura. A further side by side comparison study of the two formulations would be required to determine if the increased efficacy with the 12/11/2014 application was attributed to timing or formulation. The number of significant differences in treatment efficacy between Natorp's and Studebakers, however, is very striking (Fig. 12). Individual treatments also differed in their efficacy by crop and application time as discussed below for Table 2 and 3.

With the exception of Certainty and Casoron, the efficacy was significantly lower at Studebaker than at Natorp's for all treatments (Fig. 12). Perhaps the variability between sites can be attributed to timing. Studebaker fields were applied 17 days later than Natorp fields. This would support the long-standing premise that application timing in the spring is very time sensitive. Following this assumption, the 12/11/2014 application would be more effective at ensuring the early spring window for optimal efficacy is not missed. We assume, however, the major difference between sites was due to weed species and weed pressure differences. This was supported with Lontrel being the only treatment that had superior efficacy at Studebaker's than Natorp where again Canada thistle predominated.

*Buxus 'Green Velvet,' 6B, 1 year old.* The most efficacious treatments averaged over dates in Round 1 in the 1yr. *Buxus* Natorp field were Casoron CS (8.71), SureGuard (8.54), V10233 (7.61) (Fig. 14A) and Lontrel (7.32) (Table 2). These four were not significantly different from each other statistically or commercially. The Marengo SC (6.96) (Fig. 14B) also was not statistically different than these four but was commercially lower (Table 2). In duration of efficacy only Casoron CS (7.75) remained commercially viable at 28 WAT. Lontrel (7.5) (Fig. 13D), Casoron CS (9.25), SureGuard (8.25) and V10233 (7) (Fig. 14A) were commercially acceptable at 26 WAT (Table 2). Although a strong product averaged over evaluations, Marengo SC lost commercial viability at 21 WAT (Table 2). Gallery + Dimension 2EW remained commercially viable in Round 1 until 16 WAT, but lost efficacy at 19 WAT (Fig. 13A). Gallery + Dimension seemed to lack efficacy on asters which were a predominant weed family at Natorp's (Fig. 13A and C).



In Round 2, on 1 yr. *Buxus*, using the averaged over evaluation date means, the most efficacious treatments were Marengo SC (8), V10233 (7.6) and Certainty (7.2) which were not statistically or commercially different than each other (Table 3). SureGuard (6.7) was not significantly different than Marengo, V10233 or Certainty; but was commercially different than these three (Table 3). In duration of efficacy, only Marengo and V10233 were commercially viable at 13 WAT (Table 3). No treatment was commercially acceptable at 15 WAT in the 1yr. *Buxus*. The best treatment in Round 2 in 6B *Buxus* was the Marengo SC (Fig.13 B). Gallery + Dimension 2EW was not commercially acceptable past 3 WAT in Round 2, indicating this herbicide combination is better applied in 12/11/2014 than later in 03/12/2015.



**Fig.13. A,B,C and D.** Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') showing heavy infestation of Asteraceae weeds in field 6B planted fall 2013 with *Buxus* 'Green Velvet'. **A.** Gallery + Dimension 2EW, Round 1 at 19 WAT. **B.** Marengo Round 2 13 WAT. **C.** Gallery + Dimension 2EW, Round 1 at 28 WAT. **D.** Lontrel 26 WAT Round 1. (By: H. Mathers).



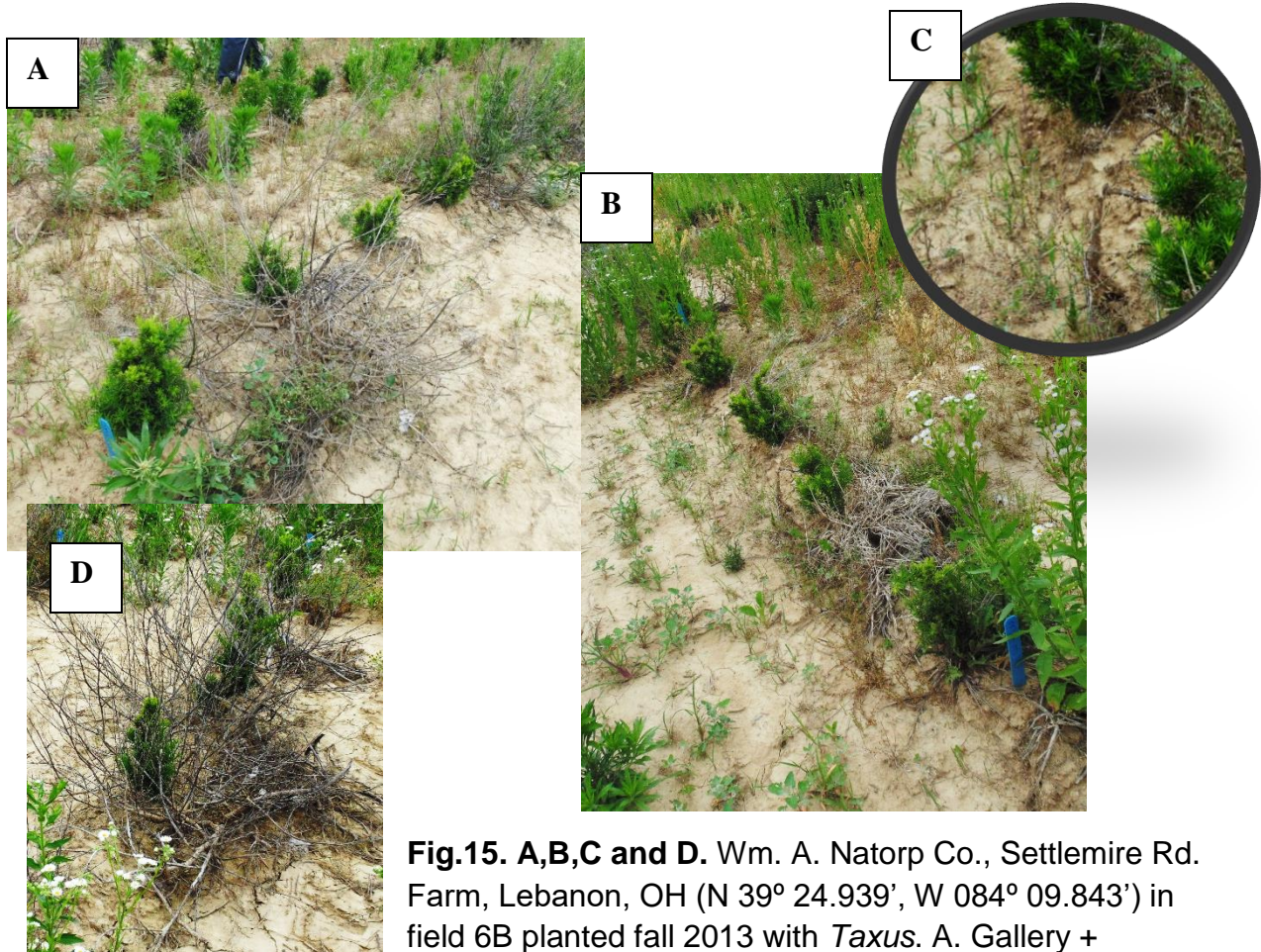


**Fig.14. A and B.** Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') showing heavy infestation of Asteraceae weeds in field 6B planted fall 2013 with *Buxus* 'Green Velvet'. **A.** V10233, Round 1 at 26 WAT. **B.** Marengo Round 1 26 WAT. (By: H. Mathers).



*Taxus Xmedia 'Densiformis,' 6B, 1 year old.* In the Round 1 applications of *Taxus* at Natorp's, the two best treatments were Marengo SC (8.21) and Casoron CS (8.21) (Table 2) using the means averaged over evaluations. SureGuard (7.68) and V10233 (7.21) were not statistically or commercially different than Marengo and Casoron CS (Table 2). No treatment was commercially viable at 28 WAT and only Marengo (7.75) and Casoron CS (8.5) were commercially acceptable at 26 WAT. The Gallery + Dimension 2EW, as in the 1 yr. *Buxus*, providing commercially viable efficacy at 16 WAT (Fig. 15A) but not at 19 WAT (Table 2).

In Round 2, Marengo SC was significantly different statistically and commercially, than any other treatment using means over evaluations (Table 3) (Fig. 15A). In duration of efficacy, Marengo SC was also the only treatment holding commercially acceptable control at 13 and 15 WAT (Table 3). Lontrel (15B and C) and Gallery + Dimension lost commercial viability after 3 weeks in Round 2.

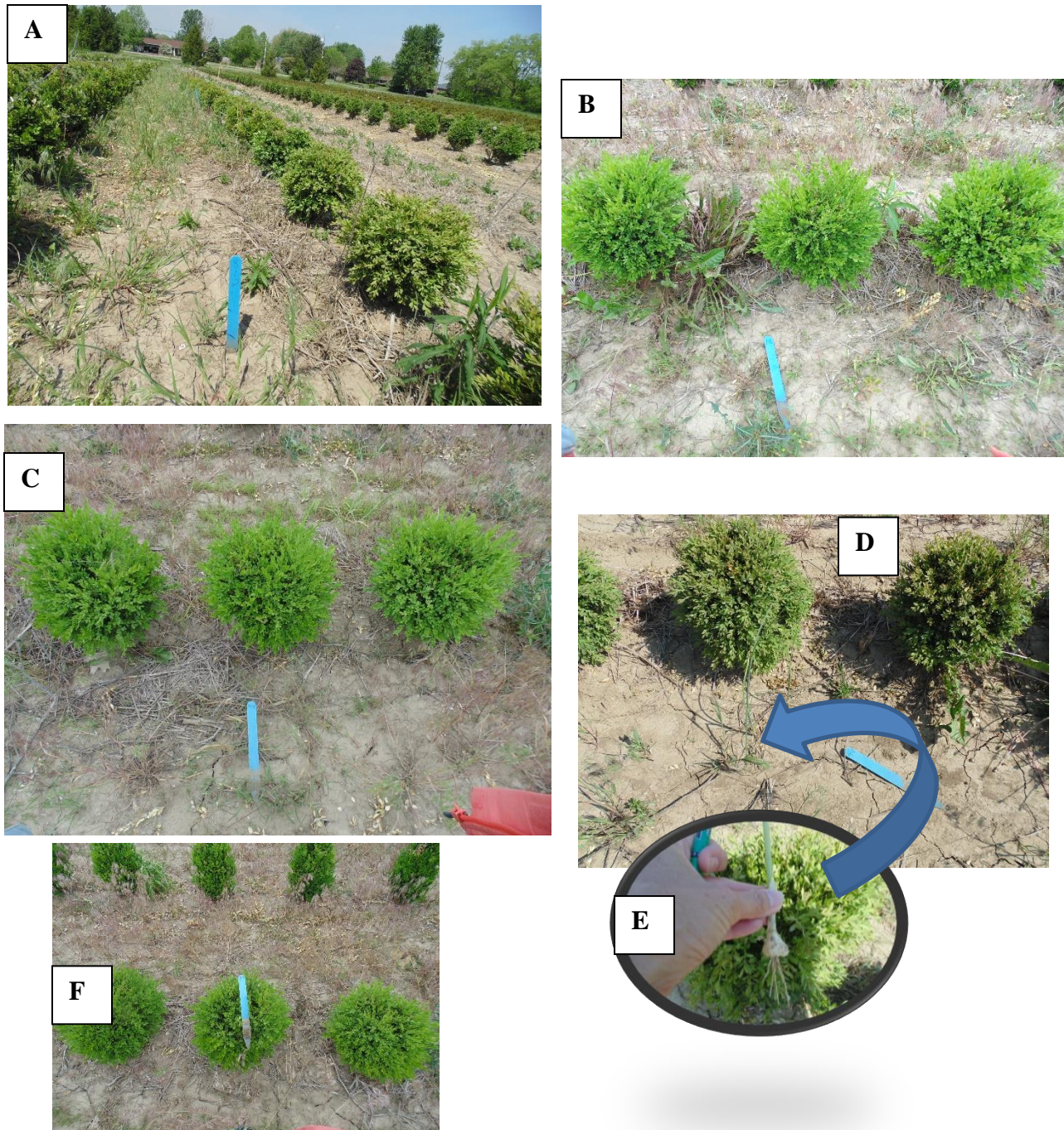


**Fig.15. A,B,C and D.** Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') in field 6B planted fall 2013 with *Taxus*. A. Gallery + Dimension 2EW, Round 1 at 16 WAT. B. Lontrel 13 WAT Round 2. C. A blow up of B showing abundant grass breaking through the Lontrel treatment at 8 WAT. D. Marengo Round 2 13 WAT (By: H. Mathers).

*Buxus 'Green Gem,' 11A - 3 year old.* The most efficacious treatments, averaged over evaluations in the Round 1 Natorp 3 yr. *Buxus*, were Casoron CS (8.32) (Fig. 16F), Marengo SC (8.04), V10223 (8.02) (Fig. 17 A) and SureGuard (7.21) (Table 2). These four were not statistically or commercially different from each other. No treatment was viable commercially at 28 WAT and only Casoron CS (7.25), V10223 (7.75) and SureGuard (7.25) were commercially acceptable at 26 WAT (Table 2). The Marengo SC had lost commercial viability at 21 WAT. Field 11A was inadvertently sprayed with Lontrel (at much lower rate than used in this study), between evaluations 21 and 26 WAT. The result of this Lontrel application conducted by Natorp field staff was a short term rally of certain treatments. Treatments that showed statistically significant recovery at 26 WAT as one could have anticipated were, of course, the control and the Lontrel 16 oz. / ac. Gallery + Dimension (Table 2) (Fig. 16 D and E) was also positively affected. We speculate that Lontrel was also applied to the 6B fields at the same time and again having the same recovery effects as in 11A; although, this was unconfirmed by the site manager. In 11A, certain treatments were not statistically improved by the supplemental Lontrel application including Certainty, Marengo SC, Casoron, SedgeHammer, SureGuard and V10233 (Table 2). Thus the ability of Casoron CS (7.25), V10223 (7.75) and SureGuard (7.25) to remain commercially acceptable to 26 WAT appears to not be due to the supplemental Lontrel application (Table 2).

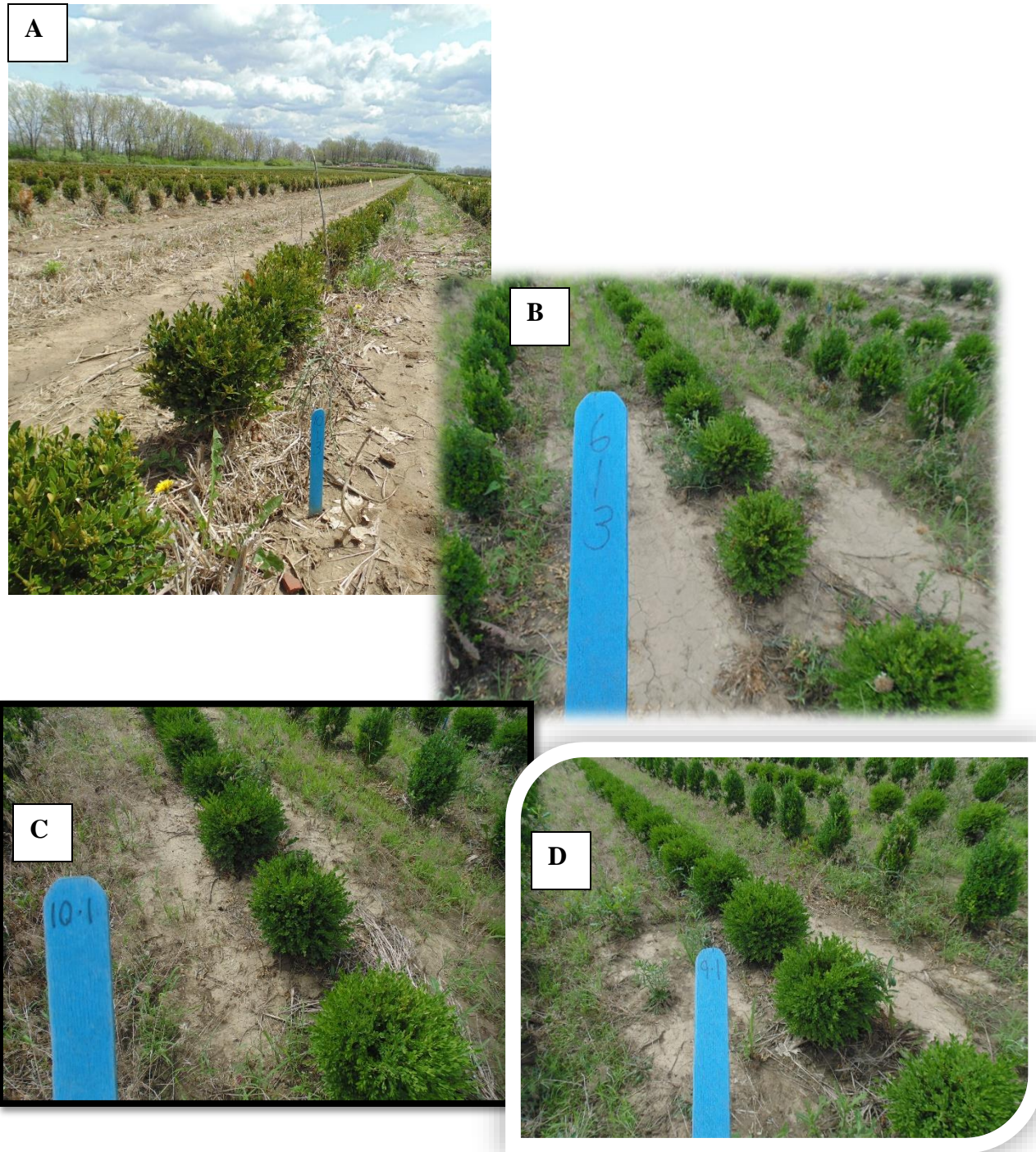
Round 2, 3 yr. *Buxus*, was also inadvertently sprayed with Lontrel by Natorp staff between 8 and 13 WAT. Again, there was a rally in the control (although not significantly), the Lontrel (significantly) and most notably in the Gallery + Dimension (Fig. 16C) (Table 3). With this recovery in the Gallery + Dimension plots, this treatment was commercially acceptable to 13 WAT (Table 13). This was the best showing of this treatment at any site or timing. Using the average treatment means over evaluation, the best treatment in the 3 yr. *Buxus*, in Round 2, were Casoron 4G (8.23), V10233 (7.88)(Fig. 17 C), Marengo SC (Fig. 17B) (7.85), and SureGuard (7.3) (Fig. 17D). These four were not statistically or commercially different than one another (Table 3). Gallery + Dimension was also not statistically different than these four but was commercially different (Table 3). Comparing the average means and the duration of control the best treatments were Marengo SC (Fig. 17B), Casoron 4G (Fig. 16A) and V10233 (Fig. 17C). All three provided 13 WAT control. Lontrel and Gallery + Dimension were also providing commercially acceptable control at 13 WAT in Round 2 (Table 3); however, this appeared to be due to the supplemental Lontrel that was applied between 8 and 13 WAT.





**Fig.16. A,B,C,D, E and F.** Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') in field 11A with 3 yr. *Buxus*. **A.** Casoron 13 WAT Round 2; **B.** Recovery in the control field 11A Round 2 13 WAT; **C.** Gallery + Dimension recovery 13 WAT Round 2; **D.** Gallery + Dimension Round 1, 16 WAT; **E.** A blow-up of wild garlic pictured in D, infesting Round 1 plots; **F.** Casoron 21 WAT Round 1 (By. H. Mathers).





**Fig.17. A,B,C and D.** Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') in field 11A with 3 yr. *Buxus*. **A.** V10233 16 WAT Round 1 with wild garlic actively growing; **B.** Marengo SC 13 WAT, Round 2; **C.** V10233 13 WAT, Round 2; **D.** SureGuard, 16 WAT, Round 1 (By. H. Mathers).

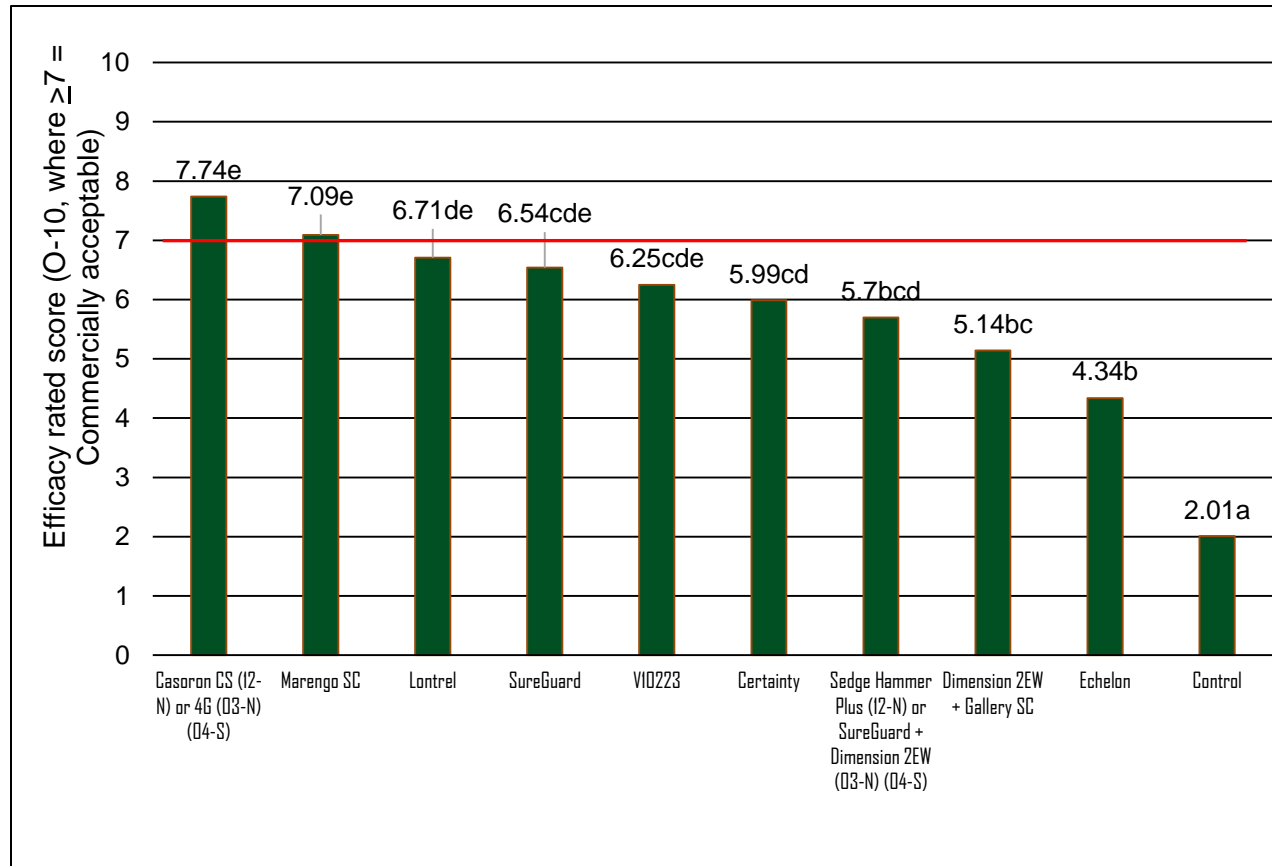
## Conclusions.

As a main effect of treatments, pooled over all variables, only two treatments Casoron (CS or 4G) and Marengo SC provided above commercially acceptable control (Fig. 18). The interaction of treatment means by site or timing showed little difference between Natorp application on 12/11/2014 or 03/12/2015 (Fig. 12). If individual treatments are compared between crops and evaluation dates; however, date of application becomes more important (Table 1, 2 and 3). Specifically, Marengo SC, Lontrel, SureGuard and Casoron seem to perform better when applied in 12/11/2014 versus 03/12/2015 with certain crops and although difficult to compare conclusively across nurseries, 04/01/2015. Another trial with these three timings and four products, at one site, would be warranted to investigate this interaction further.

Three benefits of dormant applications are noted: 1) Utilization of nursery staff in winter which is traditionally a “down-time” labor-wise versus spring; 2) Insurance that applications will be completed before germination, versus waiting for spring when conflicting operations take precedence; and, 3) Optimized control of weeds that are active in cold weather including wild garlic, nutsedge, Canada thistle and other problematic perennial and biennial weeds. To develop these benefits further, more studies with dormant applications are required. These dormant applications also seem to be key in providing the “power” and “duration” of efficacy necessary to clean up nursery fields recovering after “downturned” economic years in the industry, without increased phytotoxicity. The evidence that Casoron, Lontrel, V10233 and SureGuard were all performing better with December applications is an interesting new finding that could change how these products are advocated for nursery and even landscape use in the future. Marengo SC was the only treatment that was better in the March applications. At Natorp’s within the three crops, Casoron appeared three times in the most efficacious treatments applied 12/11/2014 versus only once in the 03/12/2015 applications. Casoron, therefore, was 3:1 in favor of December applications. Marengo SC appeared two times in the most efficacious 12/11/2014 treatments versus three times in the 03/12/2015 applications. Marengo SC was therefore 2:3 in favor of March applications. Lontrel appeared only once in the most efficacious treatments in the two rounds of three crops at Natorp’s. Thus Lontrel was 1:0 in favor of the 12/11/2014 application in field 6B *Buxus*. V10233 appeared three times in the most efficacious treatments applied 12/11/2014 versus two times in the 03/12/2015 applications or 3:2 in favor of December applications. SureGuard appeared three times in the most efficacious 12/11/2014 treatments versus only once in the 03/12/2015 applications or 3:1 in favor of December applications.

Only Certainty caused non-acceptable phytotoxicity at 14 WAT. At Studebaker’s, where the predominant weed was Canada thistle, Lontrel was the best treatment (Fig. 12) providing commercially significant weed control to 12 WAT and 10 WAT, depending

on crop. Lontrel was followed by Casoron 4G (Fig. 12), providing commercially significant weed control to 10 WAT and 7 WAT, again dependent on crop, at Studebaker's. At Natorp's, Casoron CS performed the best in the December 11, 2014 applications providing commercial control 28 and 26 WAT, depending on the crop. Casoron CS was followed by Marengo SC (Fig. 12) with commercial control at 26 and 21 WAT, depending on crop. With the March 12, 2015 applications at Natorp's, Marengo SC was the most efficacious treatment providing 15 and 13 WAT commercial control depending on crop and followed by V10233 with commercial weed control 13 WAT in two of three crops. The Gallery SC + Dimension 2EW treatments performed best at Natorp's in the December 11, 2014 applications providing commercial control 16 WAT dependent on crop.



**Fig. 18.** Main effects of means pooled over Studebaker Nurseries, Inc., New Carlisle, OH, 45344 (04/01/2015 application) and Wm. A. Natorp Co., Settlemire Rd. Farm, Lebanon, OH (N 39° 24.939', W 084° 09.843') (applied 12/11/2014 and 03/12/ 2015); three crops at each application time and eight or five evaluation dates. Each column represents up to 576 observations. This graph serves as a summary only and would not be acceptable for scientific publication due to pooling over different crops.