Postemergence Weed Management in Fallow Using Weed Sensing Spray Technology: Tank Mixes and Organic Herbicides

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The objective of this study was to evaluate the efficacy of using weed sensing spray technology compared to broadcast application of multiple herbicides to combat troublesome weeds in fallow. This study had an emphasis on tank mixes involving saflufenacil as well as an organic herbicide, Suppress, comprised of capric and caprylic acids. The sprayer tested operates by detection of differential reflection of chlorophyll facilitated by infrared radiation and is considered a light-activated, sensor-controlled spray technology. By detecting chlorophyll in the field, weed sensing spray technologies [in this study, a WEED-IT (www.weed-it.com)] spray only when weeds are present and thus reduce the amount of herbicide used per application or per area. Utilizing this technology in fallow rotations can effectively reduce the cost associated with herbicide application and improve application accuracy when compared to broadcast systems.

The study was established at two sites, one at the Wilke Research and Extension Farm in Davenport, WA (Trial 1) and one in Ralston, WA (Trial 2). Postemergence treatments were applied to fallow ground with weed pressure, where most weeds ranged from roughly 6 to 24 inches for both trials, detailed in Table 1 and Table 2. Plots were 10' by 30' long. Herbicides were applied on June 24th (Trial 1) and July 9th (Trial 2), both by weed sensing and broadcast sprayers. Both sprayers pressurized by CO_2 and calibrated to deliver 29.4 gallons per acre. Following each weed sensing application, the milliliters dispensed was calculated and compared with the milliliters dispensed from broadcast applications. At site 1, prickly lettuce *(Lactuca serriola),* common lambsquarters *(Chenopodium album)* and tumble mustard *(Sysimbrium altissimum)* were the predominant weed species present at the time of application. At site 2 prickly lettuce *(Lactuca serriola),* Russian thistle *(Salsola tragus)* and tumble pigweed *(Amaranthus albus)* were the predominant weed species present at the time of application. Weed control was quantified visually as percent control 7 days after treatment (7 DAT) and weed counts were taken 34 DAT along with biomass for dry weight measurements for both trials.

Table 1. *Weed sensing and broadcast application details for Trial 1 and Trial 2.*

Study application	*Trial 1*		*Trial 2*	
Date	June 24th	June 24th	July 9th	July 9th
Application method	Weed sensing	Broadcast	Weed sensing	Broadcast
Weed size (in)	12	12	6 - 12	6 - 12
Air temperature (F)	70	70	63	63
Soil temperature (F)	50	50	68	68
Relative humidity (%)	59	59	50	50
Wind velocity (mph, direction)	7, SW	7, SW	7, N	7, N
Cloud cover	0%	0%	15%	15%

Results: Site 1

RT3 applied weed sensing effectively controlled prickly lettuce (0 g m^{-2}, 0 plants m^{-2}) and tumble mustard (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control being only 47.5% (prickly lettuce) and 83.8% (tumble mustard) 7 DAT. Though RT3 broadcast applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 2, Table 3, Table 4).

Gramoxone applied broadcast effectively controlled common lambsquarters (0 g m^{-2}, 0 plants m^{-2}) and tumble mustard (0 g m^{-2}, 0 plants m^{-2}) 34 DAT. Prickly lettuce biomass following Gramoxone broadcast application was 0.010 g m^{-2} and density was 0.009 plants m^{-2} 34 DAT despite having a 100% control rating 7 DAT. Though Gramoxone weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 2, Table 3, Table 4).

Sharpen and RT3 effectively controlled all 3 predominant species when applied both broadcast and weed sensing. All biomass and density values are 0, 34 DAT (Table 2, Table 3, Table 4).

Liberty and Sharpen effectively controlled all 3 predominant species when applied both broadcast and weed sensing, though common lambsquarter biomass was 0.053 g m^{-2} and density was 0.027 plants m^{-2} 34 days after broadcast application. Despite there being common lambsquarters present 34 DAT, such was not significant when comparing broadcast and weed sensing applications (Table 2, Table 3, Table 4).

The organic herbicide, Suppress, did not effectively control any of the 3 target species. There was a significant difference in % control 7 DAT when comparing broadcast and weed sensing applications for all 3 predominant weed species. Suppress applied weed sensing % control was consistently higher compared to that of broadcast for all 3 species (Table 4). Biomass g m^{-2} and density # m^{-2} for all 3 species was not significantly different when comparing broadcast and weed sensing applications (Table 2, Table 3, Table 4).

Effect of broadcast vs. weed sensing application was assessed with a focus on the predominant weed species present in the study area. According to the density # m^{-2} and biomass g m^{-2} harvested 34 DAT, applicator and herbicide treatment does not have an effect as all treatments were not significantly different (nontreated excluded) for trial 1.

Results: Site 2

RT3 applied broadcast effectively controlled prickly lettuce (0 g m^{-2}, 0 plants m^{-2}) and tumble pigweed (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control only being 30% (prickly lettuce), though tumble pigweed control was 92.5%. Russian thistle biomass 34 days after broadcast applications was 0.005 g m^{-2} and density was just 0.009 plants m^{-2}. Though RT3 weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 5, Table 6, Table 7).

Unlike at site 1, where Gramoxone effectively controlled 2 of the 3 species when applied broadcast (Table 2, Table 3), at site 2 only tumble pigweed was effectively controlled 34 DAT (Table 5, Table 6). Though Gramoxone weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications for prickly lettuce and Russian thistle (Table 5, Table 6, Table 7). There was a significant difference between Gramoxone applied weed sensing compared to broadcast for tumble pigweed % control (Table 7).

Unlike site 1, where Sharpen and RT3 effectively controlled all 3 predominant species, at site 2, only prickly lettuce was effectively controlled following weed sensing application (Table 5, Table 6). Though prickly lettuce was the only species effectively controlled for both application methods, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7).

Unlike site 1, where Liberty and Sharpen effectively controlled all 3 predominant species, at site 2, only prickly lettuce was effectively controlled following weed sensing application (Table 5, Table 6). Though prickly lettuce was the only species effectively controlled for both application methods, biomass g m^{-2}, density # m^{-2} and % control of prickly lettuce and Russian thistle was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7). There was a significant difference between Liberty and Sharpen applied weed sensing compared to broadcast for tumble pigweed % control (Table 7).

Suppress was effective at controlling prickly lettuce when applied weed sensing (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control being just 25% 7 DAT. Though prickly lettuce was the only species controlled, biomass g m^{-2}, density # m^{-2} and % control of all 3 predominant species was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7).

In this trial Gramoxone applied weed sensing was significantly different when compared to Gramoxone applied broadcast, where % control values were consistently higher following broadcast application 7 DAT for tumble pigweed. There was also a significant difference between Liberty and Sharpen weed sensing application compared to broadcast, where % control was consistently higher following broadcast applications 7 DAT (Table 7).

Weed sensing applications are as effective as broadcast applications at controlling prickly lettuce, Russian thistle, and tumble pigweed, with he exception of tumble pigweed control following weed sensing applications of both Gramoxone and Liberty and Sharpen. Future trials should investigate more tumble pigweed control utilizing weed sensing spray technology and Gramoxone and Liberty and Sharpen. Future trials should investigate additional herbicides and tank mixes to test their effectiveness at controlling problem weed species common to fallow. The threshold for weed sensing application effectiveness based on weed densities and herbicide applied should also be investigated.

The weed sensing sprayer was purchased through the support of the Camp Endowment and the Crop and Soil Science department.

Table 2. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard biomass. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		July 28th, 2020 34 DAT		
				Prickly lettuce	Common lambsquarters	Tumble mustard
				Biomass	*Biomass*	*Biomass*
		lb ai A^{-1}	*Field rate*	*g m^2*	*g m^2*	*g m^2*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.09 b	0.05 b	1.67 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00 b	0.53 b	0.00 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.01 b	0.00 b	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.33 b	1.32 b	2.03 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.05 b	0.00 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.00 b	0.00 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.44 b	1.21 b	6.72 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.52 b	1.29 b	1.24 a
Nontreated				2.42 a	5.28 a	10.84 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 3. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard density. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		July 28th, 2020 34 DAT		
				Prickly lettuce	Common lambsquarters	Tumble mustard
				Density	Density	Density
		lb ai A^{-1}	*Field rate*	*plants m^2*	*plants m^2*	*plants m^2*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.01 b	0.01 b	0.02 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00 b	0.19 b	0.00 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.01 b	0.00 b	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.04 b	0.11 b	0.11 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.03 b	0.00 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.00 b	0.00 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.03 b	0.05 b	0.09 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.07 b	0.08 b	0.05 a
Nontreated				0.22 a	0.43 a	0.20 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 4. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard % control. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		*July 1st, 2020 7 DAT*		
				Prickly lettuce	**Common lambsquarters**	**Tumble mustard**
				Control	***Control***	***Control***
		lb ai A^{-1}	*Field rate*	*%*	*%*	*%*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	53 b	79 bc	98 b
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	48 b	75 bc	84 bc
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	100 a	100 ab	99 ab
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	93 a	84 abc	85 ab
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	99 ab	99 ab
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	100 ab	100 ab
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	100 a	100 a	100 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	100 a	100 ab	100 ab
Suppress	Broadcast	6% v/v	115 fl oz/A	43 b	50 c	56 c
Suppress	Weed-It	6% v/v	115 fl oz/A	84 a	75 bc	89 ab
Nontreated				0 c	0 d	0 d

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 5. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed biomass. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		August 12th, 2020 34 DAT		
				Prickly lettuce	Russian thistle	Tumble pigweed
				Biomass	Biomass	Biomass
		lb ai A^{-1}	Field rate	g m^2	g m^2	g m^2
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00 a	0.01 a	0.00 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.23 a	1.75 a	0.19 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.38 a	1.44 a	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.08 a	2.11 a	0.30 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.02 a	0.49 a	0.03 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 a	0.85 a	0.85 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.09 a	1.99 a	1.82 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 a	7.11 a	0.70 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.55 a	7.16 a	3.09 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.00 a	7.35 a	1.85 a
Nontreated				0.30 a	8.56 a	3.00 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 6. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed density. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		August 12th, 2020 34 DAT		
				Prickly lettuce	Russian thistle	Tumble pigweed
				Biomass	*Biomass*	*Biomass*
		lb ai A^{-1}	*Field rate*	*plants m^2*	*plants m^2*	*plants m^2*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0 a	0.01 a	0.00 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.04 a	0.20 a	0.02 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.04 a	0.06 a	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.03 a	0.11 a	0.06 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.01 a	0.06 a	0.01 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 a	0.24 a	0.10 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.01 a	0.14 a	0.19 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 a	0.23 a	0.05 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.01 a	0.26 a	0.28 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.00 a	0.34 a	0.40 a
Nontreated				0.02 a	0.25 a	0.07 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 7. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed % control. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		*July 16th , 2020 7 DAT*		
				Prickly lettuce	**Russian thistle**	**Tumble pigweed**
				Control	***Control***	***Control***
		lb ai A-1	*Field rate*	*%*	*%*	*%*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	30 a	33 ab	93 b
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	16 a	8 b	- b
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	98 a	87 a	98 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	25 a	49 ab	70 b
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	89 a	100 ab
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	49 ab	38 ab	45 b
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	93 a	89 a	100 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	33 a	69 ab	80 b
Suppress	Broadcast	6% v/v	115 fl oz/A	30 a	21 b	8 b
Suppress	Weed-It	6% v/v	115 fl oz/A	25 a	18 b	15 b
Nontreated				19 a	18 b	0 b

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Disclaimer

Some of the pesticides discussed in this presentation were tested under an experimental use permit granted by WSDA. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties up to $7,500. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.