Comparison of Diquat, Glufosinate, and Saflufenacil for Desiccation of 'Dark Red Norland' Potato

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SUMMARY. **Chemical desiccants are commonly used to regulate tuber size, strengthen skin, and facilitate harvest for potato (*Solanum tuberosum*) production. Glufosinate is labeled for potato vine desiccation; however, limited data are available. Saflufenacil, a protoporphyrinogen oxidase–inhibiting herbicide, is an effective desiccant in other crops. Field research was conducted to evaluate glufosinate and saflufenacil as desiccants applied to 'Dark Red Norland' potato. Desiccants consisted of diquat, glufosinate, saflufenacil, glufosinate plus carfentrazone, and glufosinate plus saflufenacil applied at three timings, DESIC-1, DESIC-2, and DESIC-3, when size B potatoes averaged 43%, 31%, and 17% of total potato weight. Potato vine desiccation was more difficult at DESIC-1 and DESIC-2 because of immature vines. Diquat was the most effective desiccant 7 days after treatment (DAT), desiccating potato vines 88% at DESIC-1 7 DAT. Glufosinate alone desiccated potato vines 65% at the same timing; however, carfentrazone and saflufenacil added to glufosinate increased vine desiccation 8% and 16% compared with glufosinate alone, respectively. Vine desiccation by all treatments ranged 99% to 100% at 14 DAT. Desiccant and timing effects on skin set were determined using a torque meter before harvest. Skin set resulting from all desiccants and timings ranged between 1.88 and 2 lb-inch, and no significant differences were observed. No significant differences in yield were noted among desiccants. This research indicates that glufosinate and saflufenacil are suitable alternatives to diquat for potato vine desiccation; however, safety of saflufenacil applied to potatoes before harvest has not been determined.**

Potato acreage in the United States during 2018 totaled 1,023,300 acres, producing 454,314,000 cwt of potatoes [U.S. Department of Agriculture (USDA), 2018]. Red potato production represented 7% of the total U.S. potato production (Richardson, 2017). Potato cultivar Red Norland is produced more than any other type of red skin potato on the Canadian prairies (Waterer et al., 2011). The cultivar is also popular in the mid-Atlantic U.S. region, where it is produced for fresh market use (Kuhar et al., 2018).

Vine desiccation before potato harvest is a common practice in the United States, giving producers the ability to regulate tuber growth and skin set, prevent spread of diseases, and facilitate more efficient harvest due to reduced vegetation. Vine desiccation may be executed via mechanical destruction or chemical desiccation (Boydston et al., 2018; Murphy, 1968). However, chemical desiccation is the preferred method to regulate tuber size and skin strength (Kuhar et al., 2018; Murphy, 1968). Vine desiccation timing is based on tuber size at desiccation and desired potato grade at harvest (Boydston et al., 2018). Furthermore, effective vine desiccation depends on vine maturity: mature vines are easier to desiccate than immature vines (Haderlie et al., 1989). Potato size, determined by diameter or weight, receives designations from smallest to largest of Creamer, B, A, and Chef potatoes (USDA, 2011). Producers of red-skinned potatoes rely on vine desiccation to regulate tuber size with the overall goal to maximize B potato yield, which has the greatest economic value of all potato grades (Richardson, 2017; Strange and Blackmore, 1990; USDA, 2011).

Skin set is the physiological process that occurs during the end of periderm maturation when tuber growth has ceased (Lulai and Orr, 1993; Nolte and Olsen, 2005). The periderm, or skin, prevents moisture loss and degradation by diseases and other pests (Nolte and Olsen, 2005). In comparison with the periderm of the 'Russet Burbank' potato, the periderm of many potato cultivars, including Red Norland, matures much slower (Lulai and Orr, 1993). Sabba and Bussan (2012) evaluated the skin set of the 'Red Norland' potato across multiple soil types and found no consistent relationship between skin set and soil type. However, relative humidity (RH) has been demonstrated to influence skin set. Postharvest skin set evaluations of the 'Norchip' and 'Norland' potato at 50% and 95% RH (and constant temperature) demonstrated that a phenotypic increase in skin set could only be achieved at 50% RH (Lulai and Orr, 1993). Time between vine desiccation and harvest also influences skin set. In a Washington study, 'Bintje' and 'Ciklamen' potatoes harvested 2 weeks after vine desiccation incurred 55% skinning injury compared with 5.1% when harvest was delayed 4 weeks (Boydston et al., 2018).

Sulfuric acid is the most effective potato vine desiccant when compared with dinoseb, diquat, endothall, glufosinate, and pyraflufen-ethyl; however,

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
45.3592	cwt	kg	0.0220
112.0851	cwt/acre	$kg \cdot ha^{-1}$	0.0089
0.3048	ft	m	3.2808
9.3540	gal/acre	$L \cdot ha^{-1}$	0.1069
2.54	inch(es)	cm	0.3937
25.4	inch(es)	mm	0.0394
11.2985	lb-inch(es)	$N \cdot cm^{1}$	0.0885
1.1983	lb/100 gal	$g \cdot L^{-1}$	0.8345
1.1209	lb/acre	$kg \cdot ha^{-1}$	0.8922
70.0532	oz/acre	$g \cdot ha^{-1}$	0.0143

sulfuric acid is a highly corrosive substance that requires specialized equipment and extreme precaution (Boydston et al., 2018; Haderlie et al., 1989). Before 1986, dinoseb, a dinitrophenol compound, accounted for 70% of the herbicides used for potato vine desiccation because of its effectiveness when applied in warm weather (Haderlie et al., 1989; Murphy, 1968; Mutch et al., 1984). After dinoseb was removed from the market for health concerns in 1986, diquat became the standard potato vine desiccant (Haderlie et al., 1989; Pavlista, 2001). Previous research reports diquat and dinoseb desiccated potato vines 80% and 85% at 2 weeks after treatment (WAT), respectively (Haderlie et al., 1989).

Diquat, a member of the bypyridylium herbicide family, is a Weed Science Society of America group 22 photosystem I electron diverter that is used as a desiccant in potato, oilseeds, and legumes [Fabaceae (Syngenta, 2015)]. Diquat can result in incomplete stem and leaf desiccation, generally a result of incomplete spray coverage, which can result in tuber regrowth (Boydston et al., 2018; Misener and Everett, 1981; Pavlista, 2001). Diquat should never be applied to drought stressed potatoes, and if a second application is required, a 5-d waiting period between applications is recommended for improved vine coverage (Kuhar et al., 2018; Syngenta, 2015). Paraquat, also a member of the bypyridylium family of herbicides, has been shown to effectively desiccate potato vines; however, paraquat facilitates potato deterioration during storage and, therefore, is rarely used (University of Maine, 2011).

Alternatives to diquat for vine desiccation include glufosinate, carfentrazone, and pyraflufen-ethyl (Kuhar et al., 2018). As a potato vine desiccant, harvest is legally required to be delayed at least 9 d following glufosinate application. Research comparing potato vine desiccation by glufosinate and diquat indicated glufosinate was not as effective as diquat at 3 and 7 d after treatment (Ivany and Sanderson, 2001). However, at 14 DAT, vine desiccation by glufosinate was similar to that by diquat (Boydston et al., 2018). In another study comparing potato vine desiccants, glufosinate, diquat, sulfuric acid, carfentrazone, and pyraflufen-ethyl were evaluated. Glufosinate plus pyraflufen-ethyl more effectively desiccated potato vines than glufosinate alone. Harvest two WAT resulted in similar tuber skinning injury among all treatments except glufosinate, which significantly reduced skinning injury. However, it is important to note that glufosinate treatments were applied several days before all other desiccants to account for slower vine death (Boydston et al., 2018). Glufosinate applied as a desiccant also resulted in a 6% increase in potatoes with a diameter of 35–70 mm, which is categorized as a B potato. Glufosinate consequently reduced the number of potatoes >70 mm, which are categorized as A potatoes and hold less economic value (Gonnella et al., 2009; USDA, 2011).

Carfentrazone-ethyl and saflufenacil are both group 14 protoporphyrinogen oxidase (PPO)–inhibiting herbicides (BASF, 2016; FMC Corp., 2015). Carfentrazone is labeled for potato vine desiccation and requires complete coverage of the targeted plant to ensure successful desiccation (FMC Corp., 2015). Limited data exist for carfentrazone used as a potato vine desiccant (Kuhar et al., 2018). Saflufenacil is used as a harvest aid in cotton (*Gossypium hirsutum*), oilseeds, and small grains and can be applied as a single application or sequential applications (BASF, 2016). Saflufenacil evaluated as a potential harvest aid in edible bean desiccated leaf, pod, and stem 87%, 80%, and 62%, respectively, and desiccation was similar to or greater than that by carfentrazone, diquat, and glufosinate 8 DAT (Soltani, 2013). Although saflufenacil is not currently labeled for potato vine desiccation and no published research exists, saflufencacil's history as a harvest aid has peaked interest in using the herbicide for potato vine desiccation.

Although alternatives to diquat exist for potato vine desiccation, research on these alternatives is limited. The primary objective of this research was to compare potato vine desiccation by diquat with that by glufosinate and saflufenacil. The secondary objective was to evaluate the relationship between desiccant and timing and their collective effects on yield, grade, and skin set of red-skinned potato.

Materials and methods

Experiments were conducted at the Eastern Shore Agricultural Research and Extension Center near Painter, VA (lat. 37.58939°N, long. 75.82375°W) during 2017 and 2018. The soil type for both years included a Bojac sandy loam (coarse loamy, mixed, semi-active, thermic Typic Hapludults) with 1% organic matter and pH 6.4.

In both years, potato cultivar Dark Red Norland was planted into fields prepared with one pass by a moldboard plow followed by a disc harrow followed by a field cultivator. Potatoes were planted on 13 Mar. 2017 and 30 Mar. 2018 on adjacent fields for a total of two site-years. The experimental design was a randomized complete block with treatments replicated three times. Plots consisted of two rows by 30 ft, with rows spaced 3 ft apart. Two border rows were used to separate plots and limit physical drift of desiccants from plot to plot.

Treatments consisted of a factorial arrangement of three vine desiccation timings by five herbicide treatments. Vine desiccation timings were initiated when percent B potatoes (pound B potatoes/pound total potatoes × 100) averaged 43% (DESIC-1), 31%

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(DESIC-2), or 17% (DESIC-3). Herbicide treatments consisted of diquat, glufosinate, saflufenacil, glufosinate plus carfentrazone, glufosinate plus saflufenacil, and no herbicide. Adjuvants co-applied with desiccants included nonionic surfactant (0.25% v/v), ammonium sulfate [AMS (15 lb/100 gal spray solution)], methylated seed oil [MSO (1% v/v)] plus AMS (8.5 lb/100 gal spray solution), AMS (15 lb/100 gal spray solution), and MSO (1% v/v) plus AMS (15 lb/100 gal spray solution) with diquat, glufosinate, saflufenacil, glufosinate plus carfentrazone, and glufosinate plus saflufenacil, respectively. All plots received paraquat (0.75 lb/acre) plus *S*-metolachlor (0.98 lb/acre) plus metribuzin (0.33 lb/acre) following drag-off on 5 and 23 Apr. during 2017 and 2018, respectively. Herbicide desiccation applications were made on 1, 8, and 15 June 2017 and 7, 14, and 21 June 2018. Herbicide application rates and sources for all herbicides are listed in Table 1. All herbicides were applied using a propane-pressurized backpack sprayer equipped with flat-fan nozzles (XR11003 extended-range flat spray nozzles; TeeJet Technologies, Wheaton, IL) delivering 20 gal/acre at 24 psi.

Visible estimates of potato stem and leaf desiccation were evaluated on a 0% to 100% scale (Haderlie et al., 1989) and collected at 4, 7, and 14 DAT. Before harvest, potatoes from each plot were collected for a skin set evaluation. Evaluations were conducted via a torque meter equipped with 100-grit aluminum oxide sandpaper measuring tuber skin set in pound per inch. Plots were mechanically harvested at the conclusion of the season to determine potato yield. Following harvest, potatoes were graded into size categories: Chef, A, and B (USDA, 2011). To determine total yield, Chef, A, and B potatoes from each plot were combined.

Data for vine desiccation, tuber skin set, and potato yield were subjected to analysis of variance using the Fit Model procedure in JMP Pro 13 software (SAS Institute, Cary, NC). Desiccation timing, desiccant treatment, and site-year were considered fixed effects, whereas replications were treated as random. Treatment means were separated using Fisher's protected least significant difference [LSD (P = 0.05)], when appropriate.

Results and discussion

All data satisfied the normality assumption and did not require transformation. The three-way interactions of year by desiccant by desiccation timing were not significant for any parameter recorded. Likewise, the two-way interactions of year by desiccant and year by desiccation timing were not significant for any parameter recorded. However, the two-way interaction of desiccant by desiccation timing was significant for potato stem desiccation. Therefore, data for potato stem desiccation are presented by timing, whereas potato leaf desiccation, skin set, and yield were pooled across year and desiccation timing and presented by desiccant. Means for desiccation timing were included for potato leaf desiccation, skin set, and yield.

Potato stem desiccation. Potato stem desiccation was more difficult earlier in the season at DESIC-1 and DESIC-2 when Size B potatoes averaged 43% and 31%, respectively, compared with DESIC-3 when Size B potatoes averaged 17% (Table 2). At the first two desiccation timings, 4 DAT, diquat was generally more effective than glufosinate alone and saflufenacil alone. Diquat works much faster than glufosinate; therefore, observation soon after application often favors diquat (Ivany and Sanderson, 2001; Soltani, 2013), as was the case for this experiment. Diquat applied at DESIC-1 and DESIC-2 desiccated potato stems 80% and 81% at 4 DAT, respectively; potato stem desiccation by glufosinate alone and saflufenacil alone was <71%. A similar trend was observed 7 DAT at which diquat remained more effective than glufosinate or saflufenacil. Potato stem desiccation by diquat applied at DESIC-1 and DESIC-2 desiccated potato stems 88% to 93% at 7 DAT. Activity of glufosinate alone and saflufenacil alone 7 DAT was no better than 80%. However, by 14 d after DESIC-1 and DESIC-2 potato stem desiccation by all treatments ranged 99% to 100%. Later in the season, diquat applied at DESIC-3 continued to be more effective than glufosinate 4 DAT. However, potato stem desiccation by diquat and saflufenacil at this time was similar. Moreover, 7 and 14 d

Table 1. Herbicides and adjuvants used for potato vine desiccation experiments in Painter, VA, in 2017 and 2018.

Herbicides and adjuvants[z]	Trade names	Application time[y]	Application rate[x]	Manufacturer
Diquat	Reglone®	POST	0.5 lb/acre	Syngenta Crop Protection, Greensboro, NC
Nonionic surfactant	Scanner®	POST	0.25% v/v	Loveland Products, Inc., Greeley, CO
Glufosinate ammonium	Rely® 280	POST	0.38 lb/acre	Bayer CropScience, Research Triangle Park, NC
Ammonium sulfate	Actamaster® Soluble Crystal Spray Adjuvant	POST	8.5, 15 lb/100 gal	Loveland Products, Inc.
Saflufenacil	Sharpen®	POST	0.71, 0.36 oz/acre	BASF Chemical Co., Research Triangle Park, NC
Methylated seed oil	MSO® concentrate with Leci-Tech®	POST	1% v/v	Loveland Products, Inc.
Carfentrazone	Aim® EC	POST	0.8 oz/acre	FMC Corp., Philadelphia, PA

[z]Crop Data Management Systems, Inc. (2019) reports specimen labels for each product, and mailing addresses and website addresses of each manufacturer.
[y]POST = postemergence.
[x]Ammonium sulfate applied at 8.5 lb/100 gal when applied with saflufenacil alone and 15 lb/100 gal when applied with glufosinate; 1 lb/100 gal = 1.1983 $g \cdot L^{-1}$, 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$, and 1 oz/acre = 70.0532 $g \cdot ha^{-1}$.

Table 2. Potato stem desiccation as influenced by desiccant and timing in Painter, VA. Data for 2017 and 2018 are pooled.

	Desiccation timing[y]																	
	DESIC-1[x]						DESIC-2						DESIC-3					
	4 DAT		7 DAT		14 DAT		4 DAT		7 DAT		14 DAT		4 DAT		7 DAT		14 DAT	
Desiccant[z]	%																	
Diquat	80	a[w]	88	a	99	NS[w]	81	a	93	a	100	NS	94	a	100	NS	100	NS
Glufosinate	37	c	65	cd	100		67	b	80	cd	100		76	b	98		100	
Saflufenacil	62	b	63	d	99		71	b	76	d	100		93	a	99		100	
Glufosinate + carfentrazone	63	b	73	bc	100		73	ab	85	bc	100		89	a	99		100	
Glufosinate + saflufenacil	72	ab	81	ab	99		75	ab	88	ab	100		93	a	100		100	

[z]Diquat, glufosinate, and carfentrazone were applied at 0.5 lb/acre, 0.38 lb/acre, and 0.8 oz/acre, respectively. Saflufenacil was applied at 0.71 oz/acre alone and 0.36 oz/acre when mixed with glufosinate; 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$ and 1 oz/acre = 70.0532 $g \cdot ha^{-1}$.
[y]Size B potatoes averaged 43%, 31%, and 17% at DESIC-1, DESIC-2, and DESIC-3, respectively (USDA, 2011).
[x]DESIC-1 = first vine desiccation timing, DESIC-2 = second vine desiccation timing, DESIC-3 = third vine desiccation timing, DAT = days after treatment.
[w]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at $P = 0.05$; NS = not significant.

Table 3. Potato leaf desiccation averaged over desiccation timing as influenced by desiccant in Painter, VA. Data for 2017 and 2018 are pooled.

	4 DAT[y]		7 DAT		14 DAT	
Desiccant[z]	%					
Diquat	96	NS[w]	99	NS	100	NS
Glufosinate	94		99		100	
Saflufenacil	93		96		100	
Glufosinate + carfentrazone	95		99		100	
Glufosinate + saflufenacil	96		99		100	
Dessicant timing[x]						
DESIC-1	93	b[w]	95	b	100	NS
DESIC-2	91	b	99	a	100	
DESIC-3	100	a	100	a	100	

Table 4. Potato skin set averaged over desiccation timing as influenced by desiccant in Painter, VA. Data for 2017 and 2018 are pooled.

Desiccant[z]	Skin set lb-inch[y]	
Diquat	1.98	NS [x]
Glufosinate	1.91	
Saflufenacil	2	
Glufosinate + carfentrazone	1.88	
Glufosinate + saflufenacil	1.98	
No desiccant	1.92	
Dessicant timing[w]		
DESIC-1	1.96	NS
DESIC-2	1.99	
DESIC-3	1.9	

[z]Diquat, glufosinate, and carfentrazone were applied at 0.5 lb/acre, 0.38 lb/acre, and 0.8 oz/acre, respectively. Saflufenacil was applied at 0.71 oz/acre alone and 0.36 oz/acre when mixed with glufosinate; 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$ and 1 oz/acre = 70.0532 $g \cdot ha^{-1}$.
[y]1 lb-inch = 11.2985 $N \cdot cm^{-1}$.
[x]NS = not significant.
[w]Size B potatoes averaged 43%, 31%, and 17% at DESIC-1, DESIC-2, and DESIC-3, respectively (USDA, 2011); DESIC-1 = first vine desiccation timing, DESIC-2 = second vine desiccation timing, DESIC-3 = third vine desiccation timing.

after DESIC-3, all treatments similarly desiccated potato stems 98% to 100%. Immature vines result in slower desiccation than mature vines that have begun to naturally deteriorate (Haderlie et al., 1989), which may explain treatment similarities later in the season when potato vines were more mature.

In general, saflufenacil plus MSO improved initial potato stem desiccation by glufosinate. Glufosinate applied at DESIC-1 desiccated potato stems 37% and 65% at 4 and 7 DAT, respectively. At this same timing, saflufenacil added to glufosinate increased stem desiccation 35% at 4 DAT and 16% at 7 DAT. Similarly, glufosinate plus saflufenacil was more effective than glufosinate 7 d after DESIC-2 and 4 d after DESIC-3. It should be noted that glufosinate plus saflufenacil was equally effective as diquat at all rating intervals when applied at DESIC-1, DESIC-2, or DESIC-3. Similar to saflufenacil, carfentrazone added to glufosinate improved initial potato stem desiccation by glufosinate alone, especially 4 d after DESIC-1 and DESIC-3.

POTATO LEAF DESICCATION. Potato leaf desiccation was more uniform and complete than stem desiccation across timings and desiccants, similar to findings by Pavlista (2001). Furthermore, leaf desiccation efficacy was not as dependent on vine maturity. Leaf desiccation by all treatments ranged 93% to 96% at 4 DAT (Table 3). Similarly, at 7 and 14 DAT, all desiccants desiccated potato leaves 96% or greater. Averaged across treatments 4 DAT, desiccation was significantly greater when desiccants were applied: DESIC-3 compared with DESIC-1 and DESIC-2. Furthermore, 7 DAT, desiccants applied DESIC-2 and DESIC-3 were slightly more effective than desiccants applied DESIC-1. All treatments and timings resulted in 100% potato leaf desiccation 14 DAT.

SKIN SET. Similar to results for leaf desiccation, no differences in skin set were noted among desiccant treatments (Table 4). Skin set for all desiccants ranged 1.88 to 2 lb-inch. In addition, averaged over desiccant treatments, values for skin set were similar across all desiccation timings. Adequate rainfall resulted in appropriate soil moisture before and after vine desiccation to allow for effective skin set. About 60% soil moisture at vine desiccation is required for adequate skin set (Nolte and Olsen, 2005). At least 18 d separated vine desiccation and harvest, which is sufficient time for effective skin set. At shorter harvest intervals, differences in skin set may be observed (Boydston et al., 2018; Nolte and Olsen, 2005). The extended harvest delay may also

Table 5. Potato yield and grade in response to desiccant averaged across desiccation timing in Painter, VA. Data for 2017 and 2018 are pooled.

Desiccant[z]	Chef[y]		Size A		Size B		Total	
	cwt/acre[x]							
Diquat	1.1	NS[w]	159.53	NS	68.94	NS	221.13	NS
Glufosinate	1.5		154.01		62.48		211.45	
Saflufenacil	2.37		165.44		62.07		221.85	
Glufosinate + carfentrazone	1		163.01		62.34		217.55	
Glufosinate + saflufenacil	1.69		161.03		60.65		215.38	
No desiccant	2.69		175.31		65.2		243.21	
Dessicant timing[v]								
DESIC-1	0.38	b	122.75	b	60.23	NS	188.51	b
DESIC-2	1.67	a	162.64	a	63.76		228.07	a
DESIC-3	2.49	a	171.03	a	65.38		233.76	a

[z]Diquat, glufosinate, and carfentrazone were applied at 0.5 lb/acre, 0.38 lb/acre, and 0.8 oz/acre, respectively. Saflufenacil was applied at 0.71 oz/acre alone and 0.36 oz/acre when mixed with glufosinate; 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$ and 1 oz/acre = 70.0532 $g \cdot ha^{-1}$.
[y]Potatoes were graded according to USDA standards for potato grades (USDA, 2011).
[x]1 cwt/acre = 112.0851 $kg \cdot ha^{-1}$.
[w]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at $P = 0.05$; NS = not significant.
[v]Size B potatoes averaged 43%, 31%, and 17% at DESIC-1, DESIC-2, and DESIC-3, respectively (USDA, 2011); DESIC-1 = first vine desiccation timing, DESIC-2 = second vine desiccation timing, DESIC-3 = third vine desiccation timing.

Table 6. Percent Chef, Size A, and Size B potato grades of total yield in response to desiccant averaged across desiccation timing in Painter, VA. Data for 2017 and 2018 are pooled.

Desiccant[z]	Chef[y]		Size A		Size B	
	%					
Diquat	0.4	NS[x]	66.6	NS	33.1	NS
Glufosinate	0.5		67.9		31.6	
Saflufenacil	0.9		69.7		29.4	
Glufosinate + carfentrazone	0.3		69.1		30.5	
Glufosinate + saflufenacil	0.7		69.3		30.1	
No desiccant	0.9		70.7		28.4	

[z]Diquat, glufosinate, and carfentrazone were applied at 0.5 lb/acre, 0.38 lb/acre, and 0.8 oz/acre, respectively. Saflufenacil was applied at 0.71 oz/acre alone and 0.36 oz/acre when mixed with glufosinate; 1 lb/acre = 1.1209 $kg \cdot ha^{-1}$ and 1 oz/acre = 70.0532 $g \cdot ha^{-1}$.
[y]Potatoes were graded according to USDA standards for potato grades (USDA, 2011).
[x]NS = not significant.

explain why the nontreated control yielded similar skin set to treated plots, as the vines were able to naturally senesce (Haderlie et al., 1989).

Yield. Although potato yield and grade for all desiccant treatments were statistically similar (Table 5), numerical trends were evident, especially between plots receiving a desiccant and plots not receiving a desiccant. In the absence of a desiccant, potatoes tended to be larger. Chef and Size A potato in nontreated plots were 2.69 and 175.31 cwt/acre, respectively, compared with 1 to 2.37 cwt/acre for Chef and 154.01 to 165.44 cwt/acre for Size A in treated plots. Across treatments, Chef and Size A potato were significantly reduced when desiccants were applied DESIC-1 compared with DESIC-2 and DESIC-3. Although not statistically significant, percentage of Chef potatoes in nontreated plots was greater than that in all desiccant treatments, except saflufenacil (Table 6). Similarly, percent Size A potatoes in nontreated plots was ≈71% compared with 67% to 69% in treated plots. Despite treatment differences between Chef and Size A potatoes, little differences were observed when comparing desiccants for Size B yield. Size B potatoes hold the greatest value among potato grades (Richardson, 2017). Gonnella et al. (2009) found that environmental conditions have a much greater impact on potato yield than desiccants. Rainfall for April, May, and June totaled 6, 22, and 6 cm, respectively, in 2017 and 5, 13, and 12 cm, respectively, in 2018. Overall, rainfall was adequate for the growing season, and neither year experienced absence of rainfall >10 d. This may explain why differences in potato yield and grade were minimal. However, it should be noted that despite differences in yield and grade, desiccants can facilitate harvest and skin set when the harvest interval is short (Murphy, 1968).

Diquat is the primary potato vine desiccant in the United States, and research on alternatives is limited (Kuhar et al., 2018; Pavlista, 2001). This research indicates that glufosinate and saflufenacil are suitable alternatives to diquat for potato vine desiccation. Although these products had slower desiccation activity, ultimately, vine and leaf desiccation and subsequent effects on skin set, potato yield, and grade were similar to those on diquat. It should also be noted that carfentrazone and saflufenacil improved initial potato vine desiccation by glufosinate. Carfentrazone is more expensive than saflufenacil, and when applied alone, carfentrazone is less effective than diquat and glufosinate. Therefore, potato producers are less interested in carfentrazone than saflufenacil as a desiccant. However, carfentrazone was co-applied with glufosinate in this study to serve as a comparison treatment to glufosinate plus saflufenacil. Saflufenacil, like other PPO-inhibiting herbicides, is a good candidate for co-application with glufosinate used for potato vine desiccation (Boydston et al., 2018; Soltani, 2013). However, more information on saflufenacil as a potato vine desiccant is needed, especially residue studies to determine mammalian safety of the herbicide applied before potato harvest.

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