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Survey of Pacific Northwest Grapegrowers on Their Use, Choice, and Understanding of Vineyard Canopy Sprayers

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Abstract

Background and goals

Agricultural sprayers are a part of most vineyard production systems. When developing Extension educational tools on sprayer use and optimization, and for pest management and drift mitigation, we often assume end users have a solid understanding of the machines they are operating. But is this a good assumption?

Methods and key findings

We conducted a survey of Pacific Northwest grapegrowers to better understand how they choose and use agricultural sprayers. We found that 39.4% of respondents calibrate their sprayers annually. Of those, 42.4% calibrate their sprayers at least twice a season in response to canopy development. Disc-core nozzles were the most common nozzle type used (41.7%), followed by one-piece nozzles (33.3%) and air induction nozzles (22.2%). Survey responses indicated a need for more information on a broader range of sprayer types, including multi-axial fan and pneumatic spray technologies. Respondents also indicated a desire for more information on application rate controllers.

Conclusions and significance

The survey revealed that: 1) new industry members are using diverse spray technologies; 2) all operations, regardless of size, could benefit from additional information on sprayer calibration and nozzle selection; and 3) there is interest in learning more about rate controllers and new technologies. This survey provided baseline information on agricultural sprayer use for consultants, extension and outreach specialists, and government agencies to identify spray application knowledge gaps that can be targeted for additional education efforts.

Key words: calibration, Extension, nozzles, outreach, sprayer, vineyards

Introduction

Winegrape production in the Pacific Northwest (PNW; comprised of Washington, Oregon, and Idaho) has seen rapid growth in the last 20 years. Washington has over 23,957 ha of winegrapes with an economic impact of $8.4 billion as of 2018 (Mefford et al. 2020), and 8754 ha of juice grapes in production (NASS 2017). Oregon has over 15,000 planted ha valued at over $5.7 billion (Eyler and Miller 2021). Idaho boasts 526 planted vineyard ha with an economic impact of $74.1 million as of 2017 (Mefford et al. 2019). Agricultural sprayers are a staple in the deployment of vineyard pest management strategies. However, sustainability issues related to worker exposure, off-target drift, and inappropriate application resulting in economic loss due to lack of pest control are commonly discussed challenges in the use of pesticides and their application in vineyards (Raisigl et al. 1991, Vercruysse et al. 1999, Brown et al. 2008, Landers 2010).

Optimizing the spray application process is fundamental to improving efficacy of pesticides and minimizing economic crop loss. Yet optimization extends beyond basic maintenance and calibration, to include matching air direction and volume to the canopy such that drift is minimized and coverage is maximized. The operation and best practices of a specific sprayer need to be understood by the entire farm crew, from owner to sprayer operator, and Extension and outreach services have a role in filling these knowledge gaps. Through reference material, targeted curriculum, or hands-on workshops, farming communities can benefit from current research and field-based data. Knowing baseline information about sprayer use in the PNW grapegrower community informs researchers, manufacturers, and Extension personnel on how to target and improve educational information.

Existing North American vineyard management materials related to sprayers or sprayer calibration predominantly focus on

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the traditional axial fan airblast sprayers (Ozkan 2017, Hoheisel et al. 2021, and as found on the website https://grapes.extension.org/airblast-sprayer-calibration-worksheet/), with only a few publications focusing on alternative sprayer designs and sensor-based sprayers (Warneke et al. 2019, Hansen and Hoheisel 2020, Deveau et al. 2021). With a changing landscape of sprayer designs and precision application technology, it is important to understand the current practices and issues in spraying vineyards. A 2009 survey of vine and tree fruit growers in the PNW, California, and New York (Hoheisel 2009) led to a "roadmap" identifying research and Extension needs related to spray application, and identified opportunities and challenges of different sprayer designs. In this survey, the short-term goal identified by growers was to better understand their existing sprayers. The medium- and long-term goals included adoption of precision application sensors, improved worker safety, increased biological control, and pest management that minimizes pesticide use. This survey builds on this past work to more specifically identify current sprayer technologies most used by PNW grapegrowers, and indirectly, to identify potential reasons for a delay in technology adoption. It also explores which aspects of sprayer calibration and optimization strategies are understood and deployed by growers. The intent was to learn where the informational needs and knowledge gaps are regarding agricultural sprayer use in PNW vineyards.

Materials and Methods

Survey design and implementation

Before releasing the survey to the PNW grapegrowing industry, it was reviewed by industry members and graduate research assistants, who provided feedback on its ease of use and the clarity of its questions. The complete survey consisted of three main topic sections with a total of 16 questions (Table 1). Not all questions were seen by all survey participants, as some questions were specific to a chosen sprayer. Participants completed the survey via Qualtrics XM online survey software (Qualtrics.com LLC).

The survey questions were reviewed by the Washington State University Office of Research Assurances and satisfied Institutional Review Board exemption criteria (IRB#17381, titled "Pacific Northwest Grape Production Canopy Sprayer Survey"). The survey was distributed through regional grower meetings, personal contact via direct email, and regional PNW viticulture-focused channels such as university newsletters and email listservs. No incentive to complete the survey was provided, and data were collected from August 2019 to July 2020.

Data analyses

There were 42 complete responses and six partial responses, of which five could be used for evaluation based on the questions that were completed. Responders were asked to identify the region where they grow grapes; some responders indicated production in multiple regions and were accounted for in all regions identified. Descriptive analyses of survey results were produced in Excel (Microsoft).

Results and Discussion

Respondent demographics

Most of the respondents (n = 45) identified production in either Washington (57.8%) or Oregon (40.0%) (Figure 1, left), with only 2.2% of the respondents from Idaho. These responses are fairly reflective of the total acreage distribution in the PNW, where Washington represents 68.7% of the total wine and juice grape acreage, followed by Oregon (30.2%) and Idaho (1.1%) (NASS 2017, Mefford 2019, 2020, Eyler and Miller 2021). A total of 3302 sprayed ha was represented (Figure 2), which accounts for 8.5% of the total planted winegrape hectares in the PNW.

Most respondents, 54.8% (n = 23), identified as having smaller vineyards (0 to 10 ha/0 to 25 acres). "Large vineyards" (>101.6 ha/>251 acres) was the next most common vineyard size category (n = 13, 31.0%), followed by "intermediate-sized" vineyards (10.5 to 101.2 ha, combining the 26 to 100 acre and 101 to 250 acre selection options; n = 6, 14.3%). The respondents from the two middle categories of potential vineyard size were combined due to the small sample size represented in each. Most of the respondents indicated they grew winegrapes (*Vitis vinifera*; 95.2%); 4.8% of respondents grew both wine and juice grapes (*V. vinifera* and *Vitis labruscana* Concord; n = 2). None of the respondents grew only juice grapes. Winegrapes in the PNW typically require more chemical pest management inputs relative to juice grapes; thus, juice grapes would be less likely to need large, modernized equipment for repeated seasonal applications (Hoheisel and Moyer 2023).

Half of the respondents (50%) identified as vineyard owners (n = 21, Figure 1, right). Of those vineyard owners, 13 identified as only vineyard owners, while others also identified as owner/vineyard manager (n = 1), and owner/vineyard manager/sprayer operator (n = 1). Six selected all four job categories. Vineyard managers, farm equipment managers, and sprayer operators were also represented (Figure 1, right). Half of the respondents self-identified as midcareer (50%; 5 to 15 years). Those well-established in their careers (>15 years) represented 28.6% of the responses (n = 12), and early career (<5 years) represented 21.4% of the responses (n = 9).

Sprayer technology used

Respondents had the option of selecting from 23 different sprayers, including opportunities to identify a sprayer not listed. In total, 15 different sprayers were selected by respondents, for a total number of 64 individual machines identified (Figure 2). Some respondents (35.7%; n = 15) used more than one sprayer in their operation.

Unlike in other surveys or crops (Stover et al. 2002, Hoheisel 2009, Warneke et al. 2021), there was more diversity in sprayer designs (Table 2) used in PNW grapes (Figure 2). The two most common designs reported were airblast and pneumatic, each comprising 25% of the reported sprayers.

Table 1 Questions and associated response choices used for the survey.

DEMOGRAPHIC QUESTIONS

1. What is your primary role in the vineyard? (Select the option that best describes you)
1) Vineyard Owner
2) Vineyard Manager
3) Sprayer Operator
4) Farm Equipment Manager

2. Select the region(s) in which the grapes you work with are located (AVAs listed in each region)
1) Eastern Washington (AVAs included: Columbia Valley, Lake Chelan, Ancient Lakes, Naches Heights, Wahluke Slope, Yakima Valley, Rattlesnake Hills, Snipes Mountain, Red Mountain, Horse Heaven Hills, Walla Walla Valley, and Lewis-Clark Valley)
2) Western Washington (AVAs included: Columbia Gorge and Puget Sound)
3) Eastern Oregon (AVAs included: Columbia Gorge, Columbia Valley, Walla Walla Valley, The Rocks District of Milton-Freewater, and Snake River Valley)
4) Southern Oregon (AVAs included: Southern Oregon, Umpqua Valley, Red Hill Douglas County, Elkton Oregon, Rogue Valley, and Applegate Valley)
5) Western Oregon (AVAs included: Willamette Valley, Chehalem Mountains, Ribbon Ridge, Dundee Hills, Yamhill-Carlton, Eola-Amity Hills, and McMinnville)
6) Northern Idaho (AVA included: Lewis-Clark Valley)
7) Southern Idaho (AVAs included: Eagle Foothills and Snake River Valley)

3. How long have you been in the grape production industry?
1) Less than five years
2) 5 years to 15 years
3) More than 15 years

4. What types of grapes do you grow, work with, or manage?
1) Wine grapes only
2) Juice grapes only
3) Wine and Juice grapes

5. How many acres of grapes do you grow or directly manage?
1) 0 to 25 acres
2) 26 to 100 acres
3) 101 to 250 acres
4) over 251 acres

SPRAYER TYPES, NOZZLES, RATE CONTROLLERS, AND ACREAGE OF SPRAYER USE

6. What type of sprayers do you use to apply insecticides, fungicides, or fertilizers to the grape canopy? (Select all that apply)
1) ATV-Mounted Sprayer (any brand)
2) ATV-Mounted Fogger/Mist Blower (any brand)
3) Backpack sprayer (any brand)
4) Fogger/Mist Blower Backpack (any brand)
5) Blueline Accutech Sprayer
6) Blueline Gregoire
7) Clemen's GSG Fan Sprayer
8) Clemen's TSG Tunnel Sprayer
9) Gearmore airblast Sprayer
10) Gearmore Venturi Air Sprayer
11) Jacto Airblast Sprayer
12) Jacto Cannon Sprayer
13) Mist Blower Sprayer
14) OnTarget Electrostatic Sprayer
15) Progressive Ag LectroBlast Sprayer
16) Pellenc Eole Sprayer
17) Rears Duster Sprayer
18) Rears PAK Blast Sprayer
19) Rears PUL Blast Sprayer
20) Rears Tower Sprayer
21) Turbo-Mist
22) Vine Tech Quantum Mist
23) Other/custom sprayer

7. How many acres of grapes do you spray with each selected sprayer type?

8. Do you use a rate controller with your sprayer(s)?
Yes
Sometimes
No
I don't know

9. What brand(s) of rate controller do you use or own?

10. If you knew more about rate controller technology, would you be interested in using them during spray applications?
Yes
No
Potentially

NOZZLES AND CALIBRATION

11. What type of exchangeable nozzle tip do you use?
1) Air induction or venturi
2) Disc-core
3) Single piece (i.e., TeeJet TXVK series)
4) Other (please indicate)

12. What brand of exchangeable nozzles do you use?
1) Greenleaf
2) FIMCO
3) Hypro
4) Jacto
5) John Deere
6) Solo
7) TeeJet
8) Other (please indicate)

13. What type of stationary (non-exchangeable) nozzle does your sprayer have?
1) Air shear
2) Electrostatic
3) Venturi
4) Other (please indicate)

14. How often do you change out nozzles in your canopy sprayer?
1) Annually
2) Every-other year
3) As the canopy size requires changes
4) When a nozzle breaks or gets clogged
5) Never
6) Other (please indicate)

15. Do you calibrate your sprayer?
Yes
No

16. How often do you calibrate your sprayer?
1) Annually
2) Every-other year
3) As the canopy size requires changes
4) When a nozzle breaks or gets clogged
5) Never
6) Other (please indicate)

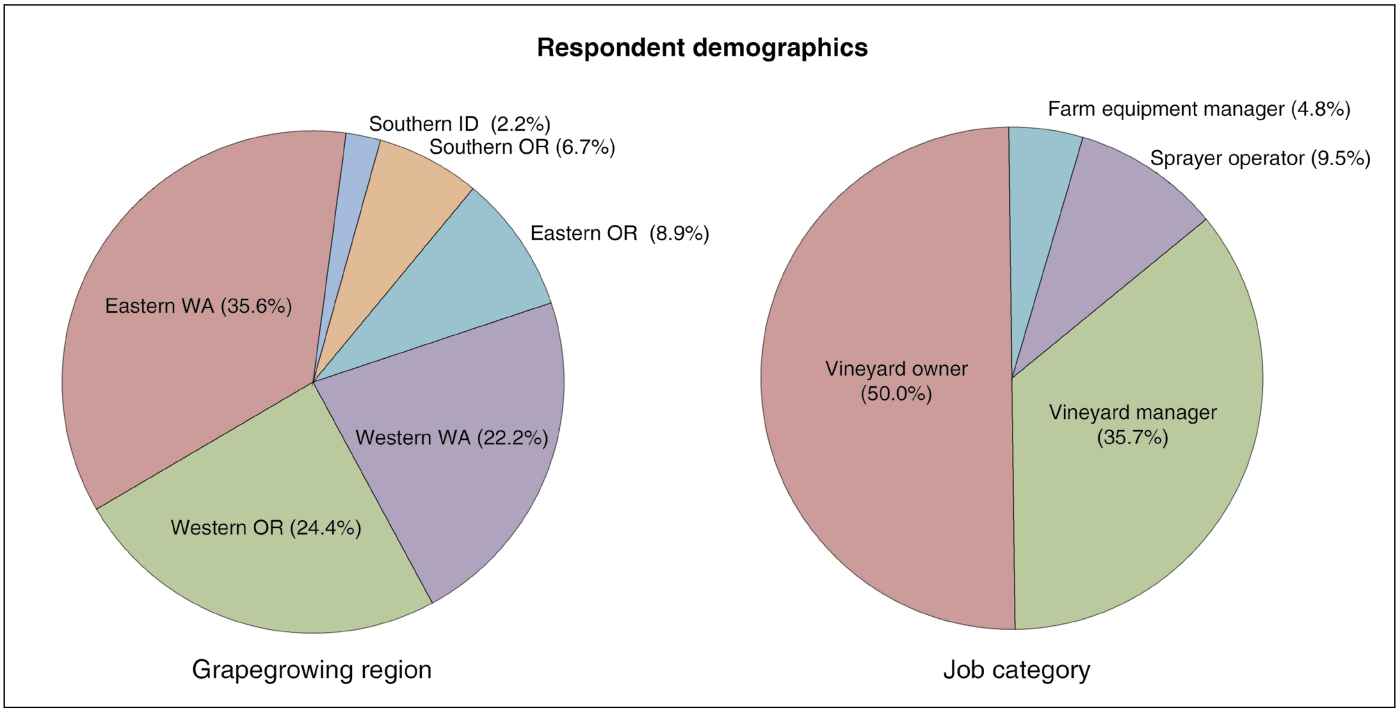

Figure 1 Survey respondents were asked to identify in which regions (left) they grew grapes (n = 45), and how they would self-classify their role in the vineyard (right) from a preset list of possibilities (n = 42). Regions across the three Pacific Northwest states (Washington, Oregon, and Idaho) were broadly defined and encompassed multiple American Viticultural Areas. Regions were grouped as they were based on environmental and production characteristic similarities of growers in those areas. Individuals were allowed to self-identify as having more than one role in the vineyard.

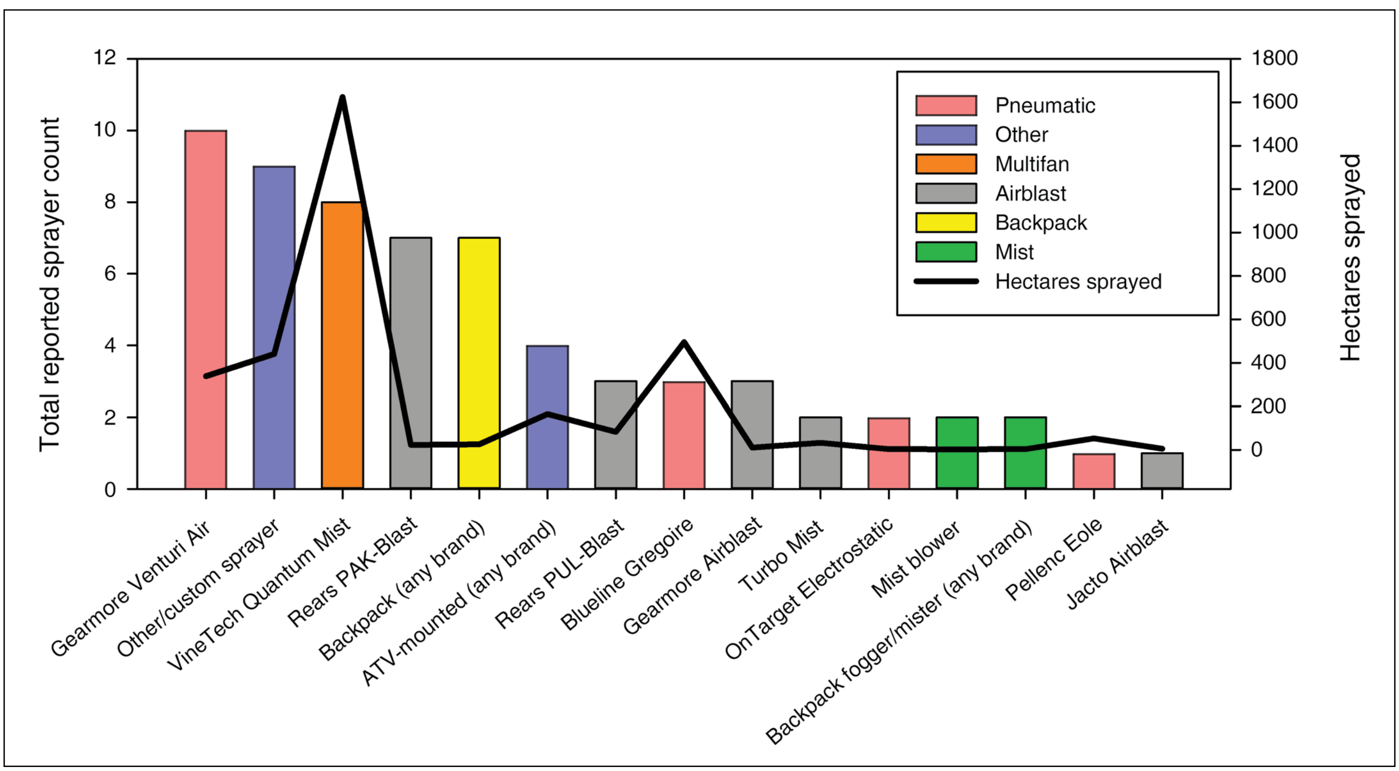

Figure 2 The total count of different sprayer brands reported by Pacific Northwest grapegrower survey respondents (bars), along with the total grape hectares sprayed with those sprayers (line). Sprayers are grouped by general spray approach/sprayer type as indicated by the bar color. Sprayer type includes pneumatic (pink), other sprayer types (blue), multifan sprayers (orange), airblast sprayers (gray), backpack sprayers (yellow), and mist sprayers (green). The VineTech Quantum Mist and Blueline Gregoire sprayers are multirow models. The 42 respondents used 15 different sprayer brands and many used multiple machine types in their production system.

Custom sprayers and ATV-mounted sprayers represented 20% of reported sprayers. Backpack sprayers (excluding mist-type) (11%), multifan sprayers (12.5%), and mist sprayers (including backpack mist) (6%) were also reported.

When considering size of farm, 31% of our respondents were from large farms where multirow sprayer use increases the work rate of the sprayer to apply pesticides in a reduced time (Warneke et al. 2021, Ozkan and Gil 2022). Consistently, the multirow Quantum Mist (VineTech) and Gregoire (Blueline) sprayers in the survey were used in >2000 ha (Figure 2). Smaller and intermediate producers, who were nearly 70% of the respondents, were using single-row machines. In the survey conducted by Hoheisel (2009), single-row airblast sprayers were the predominant sprayer used in the region. In this survey, conducted in the PNW, there has been a shift away from conventional airblast to using sprayers that produce lower air volume, often with the air better directed to the canopy. This is seen by the reported use of Quantum Mist, Gregoire, Venturi Air (Gearmore), PAK-Blast (Rears), Electrostatic (OnTarget), and Eole (Pellenc) sprayers in this survey. In comparison to conventional airblast, Quantum Mist uses multiple fans with lower air volume that can also be directed into the canopy. Pneumatic sprayers such as Gregoire, Venturi Air, Electrostatic, and Eole use high velocity but low volume air, and often have nozzles that are oriented perpendicular to the canopy. Even in the realm of airblast sprayers, the use of the PAK-Blast sprayer (Figure 2) shows an adoption of smaller fans as opposed to a standard Rears airblast. Smaller fans produce less air volume and have been shown to better match the grape canopy size for increased sprayer deposition (Balsari et al. 2002, Balsari and Marucco 2004, Ozkan and Gil 2022). Unfortunately, for many of these reported PNW sprayers, there is less available information and resources on calibration, use, and customization outside of the manufacturer-produced materials.

Early- and midcareer respondents had the greatest diversity in reported sprayer use; all 15 different sprayer types identified as being used in the PNW were selected by individuals in these two career categories. Those established in their career most commonly selected airblast technology, a specific brand of pneumatic sprayer (Venturi Air), or backpack sprayers. This may indicate that early-career industry members are either more willing to try different sprayer technologies in their operations or have been more exposed to different sprayer technologies.

While it is common for younger generations to adopt new technologies in farming (Kuehne et al. 2017, Vecchio et al. 2020), there may be other drivers in the change of spray technologies. Theories of technology adoption identify multiple influences on the adoption stage of technologies, such as relative advantage, usability or ability to trial, commonality of innovation, complexity, and compatibility with current system (Rogers 2003). As with most computers and chips, agricultural electronics have become more reliable, which has allowed for an improved user experience when operating new sprayer designs, thereby affecting adoption rate and commonality of use in a farming system (Warneke et al. 2019). However, this hasn't always been the case, and previous iterations of farming technology may have

Table 2 Sprayers have many different properties. Hydraulic sprayers can move liquid through a type of exchangeable nozzle, while pneumatic sprayers use air to shear the spray into fine droplets. Sprayers can be self-powered or powered through a power take-off (PTO). Air handling classification is how air is created and directed from the sprayer (as found on the website https://sprayers101.com/airblast-categories/). Sprayers can also spray a half row, single row, or multiple rows.

<table>
<tr><th>System</th><th>Nozzles</th><th>PTO</th><th>Air handling</th><th>Row</th><th>Sprayer name</th></tr>
<tr><td rowspan="8">Hydraulic</td><td rowspan="7">Exchangeable (one piece or disc-core)</td><td rowspan="2">No</td><td rowspan="2">No air</td><td rowspan="2">Half</td><td>Backpack (any brand)</td></tr>
<tr><td>ATV-mounted (any brand)</td></tr>
<tr><td rowspan="5">Yes</td><td rowspan="4">Low profile radial</td><td rowspan="4">Single</td><td>Rears PAK-Blast</td></tr>
<tr><td>Rears PUL-Blast</td></tr>
<tr><td>Gearmore Airblast</td></tr>
<tr><td>Jacto Airblast</td></tr>
<tr><td>Low profile radial or tower</td><td>Single</td><td>Turbo Mist</td></tr>
<tr><td>Exchangeable (one piece)</td><td>Yes</td><td>Wrap-around</td><td>Multi</td><td>VineTech Quantum Mist</td></tr>
<tr><td rowspan="6">Pneumatic</td><td rowspan="6">Air shear</td><td rowspan="2">No</td><td rowspan="2">Cannon</td><td rowspan="2">Half</td><td>Mist blower ATV-/tractor-mounted</td></tr>
<tr><td>Fogger/mist blower backpack (any brand)</td></tr>
<tr><td rowspan="4">Yes</td><td rowspan="4">Wrap-around</td><td rowspan="3">Multi</td><td>Gearmore Venturi Air</td></tr>
<tr><td>Blueline Gregoire</td></tr>
<tr><td>Pellenc Eole</td></tr>
<tr><td>Single or multi</td><td>OnTarget Electrostatic</td></tr>
<tr><td>Other</td><td>Variable</td><td>Yes</td><td>Variable</td><td>Variable</td><td>Other or custom</td></tr>
</table>

resulted in a negative user experience for those well established in their careers. Additionally, shortages of labor, social pressures of sustainability, and the incorporation to larger farm sizes increase the advantage of more efficient sprayer designs that incorporate multirow use or sensors for precision application to reduce chemical use.

Rate controller use

A rate controller is a computer that maintains the desired spray application volume on a per unit area (e.g., hectare), regardless of nominal changes in tractor speed. This is achieved by adjusting spray pressure, and thus, nozzle flow rate, as speed changes. For example, if a tractor speeds up, the rate controller would trigger an increase in spray pressure, thus increasing nozzle output. Where a rate controller was not used, increased tractor speed would result in a reduction in the total spray volume per hectare. Expanded capabilities of some rate controllers also include mapping sprayed areas.

While rate controllers can be useful, operator error may occur if they are not set up correctly or properly maintained. Given that rate controllers gather information on tractor speed from global positioning system (GPS) units or wheel sensors, incorrect mounting of sensors can result in inaccurate speed assessments, which then results in inaccurate spray volume compensation. Nearly all Quantum Mist, Gregoire, Eole, and OnTarget sprayers are sold with rate controllers; these were 22% of sprayers identified in this survey. However, 23.8% of the respondents (n = 10) indicated they used a rate controller most of the time, and 9.5% (n = 4) indicated they used one some of the time, suggesting that additional aftermarket rate controllers are being used. In fact, the models of rate controllers used that were identified in this survey include Arag, Raven, TeeJet, VineTech Fusion Controller, AgOtter, and Gearmore, with additional individuals indicating they had a rate controller, but were unsure of the model. Of these 14 respondents that indicated some level of rate controller use, 11 were associated with a large vineyard production system (>101.6 ha) and three with an intermediately sized vineyard production system.

The remaining 66% (n = 28) of respondents indicated they did not use a rate controller; these individuals indicated they use ATV-mounted, backpack, and airblast-type sprayers, which either cannot support or are rarely fitted with rate controllers. This suggests that as new sprayer designs are being adopted, so are other technologies that accompany those new sprayer designs, like rate controllers. When these respondents were asked if they would be more likely to use a rate controller if they knew more about them, 45.2% (n = 14) indicated they would, 25.8% (n = 8) indicated they might potentially adopt rate controller use, and 29.0% (n = 9) said they would not adopt the use of a rate controller but did not provide a reason as to why.

Sprayer calibration

Sprayer calibration includes aspects related to parts and equipment inspection, maintenance, and replacement; parts can include nozzles, hoses, pumps, and gauges. It also includes confirming and/or adjusting sprayer settings and water volume output to what is desired for the crop and the environment. In this survey, where only 36 of the 42 respondents answered the question on whether they calibrate their spray, 88.9% (n = 32) indicated they did, and 11.1% (n = 4) indicated they did not. Of the respondents who answered the question on sprayer calibration frequency (n = 33), the majority (81.8%) calibrated at least annually (annually, or as the canopy changes) (Figure 3). Just over 12% indicated "other" reasons for calibration frequency, which they specified as calibrating after every spray, calibrating when moving the sprayer between vineyard blocks, or recalibrating if something breaks. Annual calibration is a starting point in basic education, and the authors recognize the fortune in having an industry that does calibrate as often as they do. However, due to limitations of format and number of questions in this survey, it was challenging to determine the quality or accuracy of the calibration techniques used, and this serves as a potential point of additional educational efforts. While having 88.9% of survey respondents indicate they calibrate their sprayers, given the importance of sprayer calibration in pest management and drift mitigation, the real goal is 100%.

Nozzle choice

Nearly two-thirds of the respondents (n = 36) indicated they had sprayers with exchangeable nozzles (Figure 4, left), whereas 19 respondents indicated the use of machines with stationary nozzles (Figure 4, right). The predominant use of TeeJet nozzles is typical within the PNW region based on availability and manufacturers' or suppliers' stock. Outside

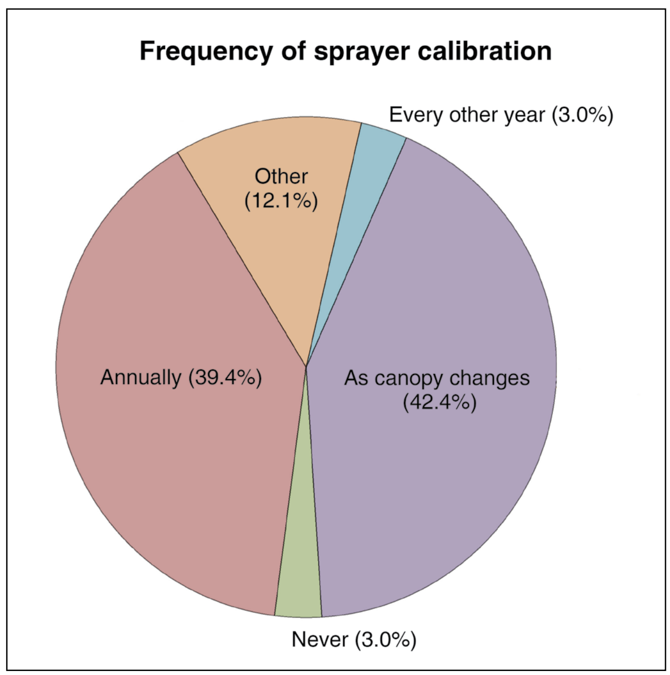

Figure 3 Survey respondents were asked about how frequently they calibrated their sprayer for optimized spray delivery (n = 33). When "Other" was selected for sprayer calibration frequency, respondents indicated they were calibrating after every spray, calibrating when moving the sprayer between vineyard blocks, or recalibrating if something broke.

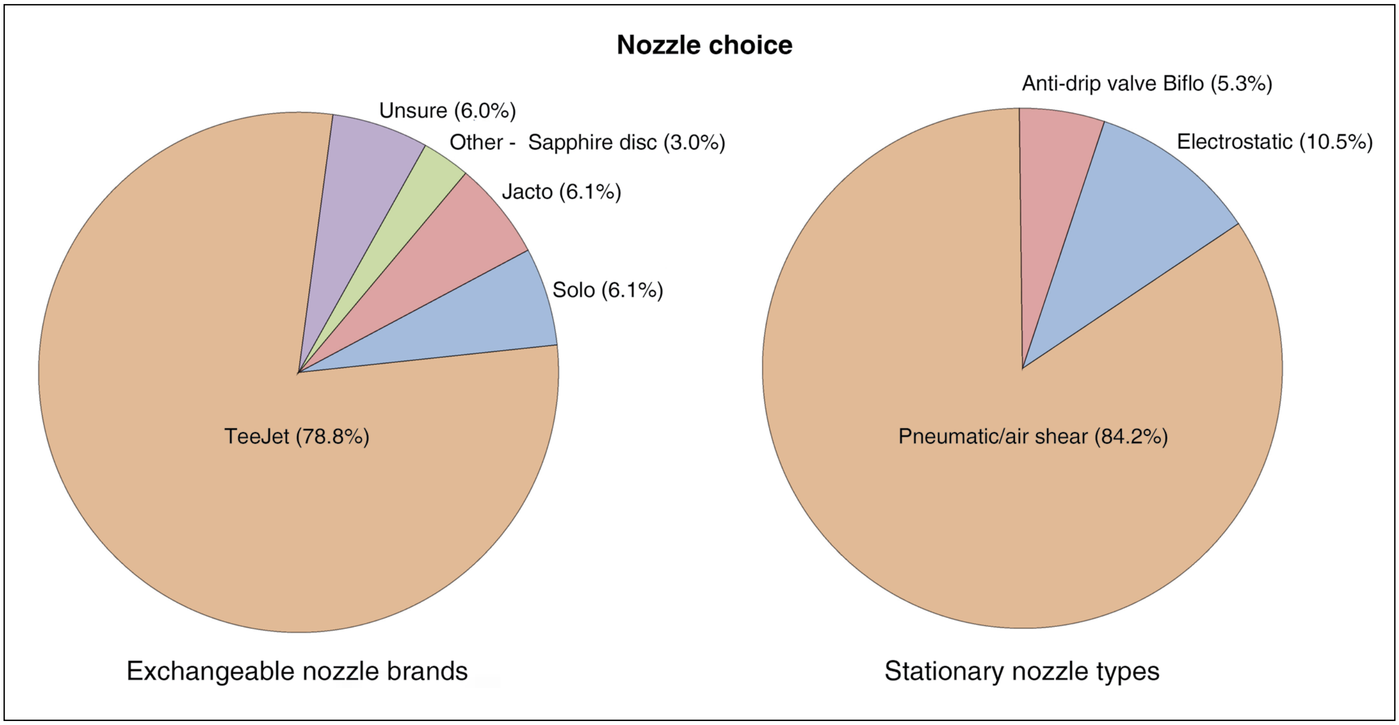

Figure 4 The types of nozzles respondents indicated they had on their sprayers. Different sprayer types can have different nozzles, broadly classified as exchangeable or stationary. Exchangeable nozzle styles (left) are relatively consistent, and as such, survey participants who indicated they used exchangeable nozzles (n = 36) were asked to identify them by brand name. Stationary nozzles (right) come in a range of designs, so survey participants (n = 19) were asked to identify those they used by a general category of stationary nozzle.

of the TeeJet brand nozzles, the respondents tended to use the nozzle produced by the manufacturer of their sprayer.

Of those using machines with exchangeable nozzles (i.e., airblast, multi-axial fan, ATV-mounted, backpack), the most common nozzle type was disc-core (41.7%), followed by single-piece/molded (33.3%), air induction (AI)/venturi (22.2%), and “other” (i.e., double cone; 2.8%). This indicates that sprayers with exchangeable nozzles are still being outfitted with disc-core nozzles that have a large and variable droplet size range (Yates et al. 1985, Bouse 1994), instead of the single-piece or AI nozzles (ASABE 2009). Traditional disc-core nozzles are two pieces that need to be replaced simultaneously. Unfortunately, given that the size of droplets that disc-core nozzles produce is generalized (i.e., larger orifices produce larger droplets), they are not compatible with ASABE S572.1 (2009) droplet size classification. This classification system can be helpful, as knowing the size of the droplets produced by a sprayer/nozzle combination gives the grower an additional tool in their toolkit for drift mitigation. For example, a grower in a windy location may choose nozzles that produce larger droplets to reduce off-target drift and improve target coverage, because smaller droplets are prone to drift in windy conditions (Semmes et al. 1990, Bonds and Leggett 2015). In vineyards, the sprayer is often within 1 m of the canopy, and nozzles producing “coarse” or “very coarse” droplets (341 to 502 µm, ASABE 2009), such as AI nozzles, have shown good deposition with reduced off-target drift (Grella et al. 2017, McCoy et al. 2022). While nozzles with “fine” or “very fine” (60 to 220 µm, ASABE 2009)

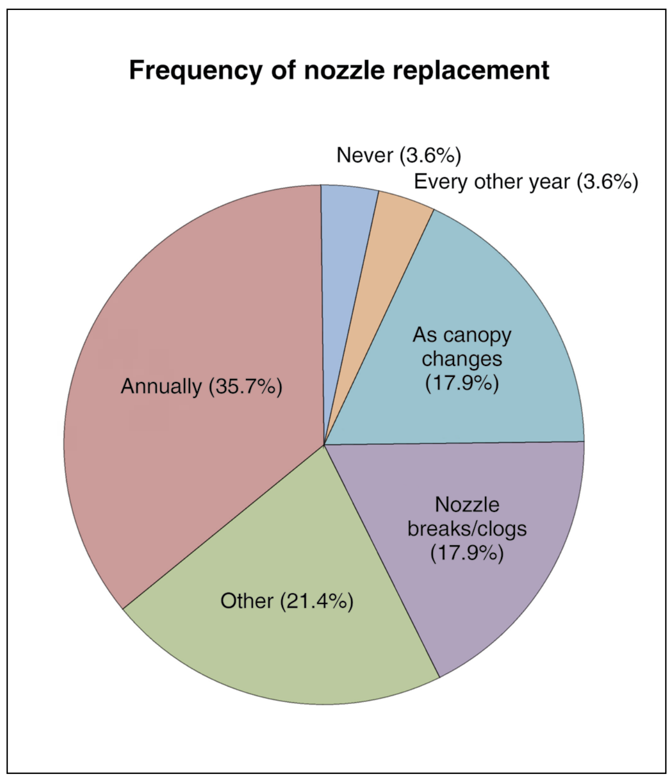

Figure 5 Survey respondents were asked how frequently they changed nozzles if they had a sprayer with exchangeable nozzles (n = 28). When “Other” was selected in regard to frequency of nozzle replacement, they indicated they were replacing nozzles when they felt the nozzles were showing signs of wear.

droplets, such as those with single-piece or some disc-core, have been shown to also have good coverage, air volume from the sprayer should be reduced or optimized to avoid off-target drift of small droplets (Grella et al. 2022, McCoy et al. 2022).

Only 35.7% of respondents with exchangeable nozzles changed them annually (Figure 5), but those that indicated an "other" frequency (21.4%) indicated that they changed nozzles when the nozzles wore with use. It is well known that nozzles either become clogged or wear and the issues vary with nozzle material (i.e., brass, stainless steel, plastic, or ceramic), chemistries used, and longevity of use (Menzies et al. 1976, Reichard et al. 1991, Baio et al. 2022). While having a high response rate for annual or need-based nozzle changing is positive, there is clearly a need for additional education and information as to why nozzle changes and use of ceramic nozzles are important for optimizing vineyard canopy spraying. Given the complex interaction between nozzle type, nozzle composition (e.g., ceramic, plastic, brass), sprayer air volume, and nozzle orientation, educational resources that simplify these interactions could be useful in improving adoption of more precise nozzles in exchangeable nozzle machines.

Conclusion

This survey of PNW grapegrowers provided a foundation of information of the region's canopy sprayer use, operation, and calibration frequency. Although the sample size was small, this information can be used as a starting point to build tailored information on types of sprayers, nozzles, and calibration options available to PNW grapegrowers. While there are resources on maintenance, calibration, and optimization of airblast sprayers, these are not the only sprayer types being used by grapegrowers. Understanding basic sprayer form and function is fundamental to helping reduce poor practices, increase sprayer efficiency, and reduce over- or under-application of pest control products. All of these factors affect the economics of spraying, as well as efficacy of a sprayed pest management program, and the likelihood of off-target spray drift. As regulations become more stringent and label laws more specific, it is important to give vineyard owners, managers, and spray operators pertinent information to make more informed decisions and update ineffective practices.

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References

American Society of Agricultural and Biological Engineers (ASABE). 2009. ASABE S572.1. Spray Nozzle Classification by Droplet Spectra. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Baio FHR, Zanin ARA, Teodoro LPR, Fontoura JVPF and Teodoro PE. 2022. Spray nozzle wear effects on droplet population. Eng Agríc 42:e20220070. DOI: 10.1590/1809-4430-Eng.Agric.v42n4e20220070/2022

Balsari P and Marucco P. 2004. Influence of canopy parameters on spray drift in vineyard. Asp Appl Biol 71:157-164.

Balsari P, Marucco P and Oggero G. 2002. Spray applications in Italian apple orchards: Target coverage, ground losses, and drift. Paper No. 021002. 2002 ASAE Annual Meeting. American Society of Agricultural and Biological Engineers, St. Joseph, MI. DOI: 10.13031/2013.9337

Bonds JAS and Leggett M. 2015. A literature review of downwind drift from airblast sprayers: Development of standard methodologies and a drift database. Trans ASABE 58:1471-1477. DOI: 10.13031/trans.58.11057

Bouse LF. 1994. Effect of nozzle type and operation on spray droplet size. Trans ASABE 37:1389-1400. DOI: 10.13031/2013.28219

Brown DL, Giles DK, Oliver MN and Klassen P. 2008. Targeted spray technology to reduce pesticide in runoff from dormant orchards. Crop Prot 27:545-552. DOI: 10.1016/j.cropro.2007.08.012

Deveau J, Ledebuhr M and Manketelow D. 2021. Airblast101: Your Guide to Effective and Efficient Spraying. 2d ed. Sprayers 101. Accessed 6 July 2023. https://sprayers101.com/airblast101/

Eyler R and Miller C. 2021. The Economic Impact of the Wine and Wine Grape Industries on the Oregon Economy 2019 and 2020 Estimated. Summary Report. Economic Forensics and Analytics, Inc., Petaluma, CA. Accessed 6 June 2023. https://industry.oregonwine.org/wp-content/uploads/sites/2/OR-Econ-Impact-2019-2020-FINAL.pdf

Grella M, Gallart M, Marucco P, Balsari P and Gil E. 2017. Ground deposition and airborne spray drift assessment in vineyard and orchard: The influence of environmental variables and sprayer settings. Sustainability 9:728. DOI: 10.3390/su9050728

Grella M, Marucco P, Zwertvaegher I, Gioelli F, Bozzer C, Biglia A et al. 2022. The effect of fan setting, air-conveyor orientation and nozzle configuration on airblast sprayer efficiency: Insights relevant to trellised vineyards. Crop Prot 155:105921. DOI: 10.1016/j.cropro.2022.105921

Hansen M and Hoheisel G-A. 2020. Sprayer technology: Every drop to the crop. Wine Bus Month 9:74-82.

Hoheisel G-A (ed.). 2009. A Roadmap to Improve Chemical Delivery Technologies in Specialty Crops. Accessed 6 July 2023. https://s3-us-west-2.amazonaws.com/sites.cahnrs.wsu.edu/wp-content/uploads/sites/66/2012/01/Road-Map_MASTER_V3.pdf

Hoheisel G-A and Moyer MM (eds.). 2023. 2023 Pest management guide for grapes in Washington. Washington State University Extension Publication EB0762. Pullman, WA. https://pubs.extension.wsu.edu/2019-pest-management-guide-for-grapes-in-washington

Hoheisel G-A, Khot LR, Moyer MM and Castagnoli S. 2021. Six steps to calibrate and optimize airblast sprayers for orchards and vineyards. Pacific Northwest Extension Publishing PNW749. Pullman, WA. https://pubs.extension.wsu.edu/six-steps-to-calibrate-and-optimize-airblast-sprayers-for-orchards-and-vineyards

Kuehne G, Llewellyn R, Pannell DJ, Wilkinson R, Dolling P, Ouzman J et al. 2017. Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. Agr Sys 156: 115-125. DOI: 10.1016/j.agsy.2017.06.007

Landers AJ. 2010. Effective Vineyard Spraying: A Practical Guide for Growers. Effective Spraying. Ithaca, NY.

McCoy ML, Hoheisel G-A, Khot LR and Moyer MM. 2022. Adjusting air-assistance and nozzle style for optimized airblast sprayer use in eastern Washington vineyards. Catalyst 6:9-19. DOI: 10.5344/catalyst.2021.21001

Mefford C, Cohen S, Lobel B and Tarhouni Z. 2019. Idaho Wine Commission Economic Impact Study. Community Attributes Inc. Accessed 7 March 2021. https://idahowines.org/content/uploads/2023/06/CAI.ID-Wine-Commission.Econ-Impacts.Final-Report.-2019-0916.pdf

Mefford C, Cohen S, Lobel B and Tarhouni Z. 2020. Economic & Fiscal Impacts of Wine & Wine Grapes in Washington State. Community Attributes Inc. Accessed 7 March 2021. https://www.washingtonwine.org/wp-content/uploads/2020/04/CAI.Washington-Wine-Impacts-2020-Update.FINAL-REPORT.2020-04161.pdf

Menzies DR, Fisher RW and Neff AE. 1976. Wear of hollow cone nozzles by suspensions of wettable powders. Can Ag Eng 18:14-15.

National Agricultural Statistics Service (NASS). 2017. Washington Vineyard Acreage Report 2017. Accessed 7 March 2021. https://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Fruit/2017/Vineyard2017.pdf

Ozkan E. 2017. Calibrate Your Sprayer to Determine Your True Application Rate. Ohio State University Extension. Accessed 21 March 2021. https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/b/28945/files/2017/04/Airblast-Sprayer-calibration-orchards_Vinyards-28b2hjg.pdf

Ozkan E and Gil E. 2022. Sprayers for effective pesticide application in orchards and vineyards. FABE 533. Ohioline: The Ohio State University Extension. Accessed 10 October 2023. https://ohioline.osu.edu/factsheet/fabe-533

Raisigl U, Felber H, Siegfried W and Krebs C. 1991. Comparison of different mist blowers and volume rates for orchard spraying. BCPC Monograph 46:185–196. British Crop Protection Council, Farnham, Surrey, U.K.

Reichard DL, Ozkan HE and Fox RD. 1991. Nozzle wear rates and test procedure. Trans ASAE 34:2309-2316. DOI: 10.13031/2013.31873

Rogers EM. 2003. Diffusion of Innovations. 5th ed. Free Press, United Kingdom.

Semmes RH, Cromwell RP and Shoup WD. 1990. Downwind transport of aerially applied sprays under high temperature, high humidity conditions. Appl Eng Agric 6:257-261. DOI: 10.13031/2013.26378

Stover E, Scotto D and Salvatore J. 2002. Pesticide spraying in Indian River grapefruit: I. Survey of current practices. HortTech 12:454-460. DOI: 10.21273/HORTTECH.12.3.454

Vecchio Y, De Rosa M, Adinolfi F, Bartoli L and Masi M. 2020. Adoption of precision farming tools: A context-related analysis. Land Use Policy 94:104481. DOI: 10.1016/j.landusepol.2020.104481

Vercruysse F, Steurbaut W, Drieghe S and Dejonckheere W. 1999. Off target ground deposits from spraying a semi-dwarf orchard. Crop Prot 18:565–570. DOI: 10.1016/S0261-2194(99)00060-5

Warneke B, Pscheidt JW, Rosetta R and Nackley L. 2019. Sensor sprayers for specialty crop production. PNW727. Pacific Northwest Extension Publishing. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw727.pdf

Warneke BW, Zhu H, Pscheidt JW and Nackley LL. 2021. Canopy spray application technology in specialty crops: A slowly evolving landscape. Pest Manag Sci 77:2157-2164. DOI: 10.1002/ps.6167

Yates WE, Cowden RE and Akesson NB. 1985. Drop size spectra from nozzles in high-speed airstreams. Trans ASAE 30:0405-0410. DOI: 10.13031/2013.32268