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Enhancing Production of Warm-Season Crops in Nevada Using Rootstocks: A Grower Survey

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Demand for local organic produce is expanding in Nevada. But, our short growing season and harsh climate limit crop profitability. Rootstock technology used to improve crop stress tolerance is attracting interest among Nevada specialty crop growers.

Introduction

Nevada specialty crop growers are challenged by a short growing season and slow establishment of warm-season crops (Bristow, 2021a). At the same time, there is increased demand for local, organically produced vegetables in Nevada's urban areas (Gatzke, 2012; Curtis et al., 2010). Organic farming is one of the fastest growing segments of U.S. agriculture (Greene et al., 2009), and sales of locally produced organic products have more than doubled in Nevada from $7.5 million in 2012 to $18.9 million in 2017 (USDA National Agricultural Statistics Service, 2017). Further, food insecurity in Nevada is on the rise due to the recent pandemic and subsequent inflationary food prices (Solis, 2021; Stewart, 2022). Together, these factors represent an opportunity for Nevada growers to increase crop diversity and to adapt to climate uncertainty (Walia, 2020).

The total number of farms producing vegetables and cantaloupes in Nevada is 102. This represents close to 3% of the total market value of agricultural products sold in Nevada in (USDA National Agricultural Statistics Service, 2017). According to the Nevada Department of Agriculture (2014), vegetables and cantaloupes represent close to 15% of the total cash receipts from farm marketing in Nevada. Yet, farmers struggle to identify strategies to help them increase their market competitiveness in an arid climate with wide variance in day/night temperatures. After tomatoes, species in the Cucurbitaceae family are the most consistently cropped species in Nevada (USDA National Agricultural Statistics Service, 2017). Cantaloupes, in particular, perform well under arid conditions and are good candidates for more widespread production in the southwestern U.S. (Southwest Regional Climate Hub and California Sub Hub, 2016). Although cantaloupes are sensitive to freezing temperatures at all growth stages, they are relatively heat-resistant and may also tolerate the increasing water limitation predicted as a result of climate change.

In fact, there is a history of a cantaloupe industry in Nevada as early as the 1950s (NevadaGrown, n.d.). Nevada's high-altitude climate was said to produce cantaloupes with superior flavor. However, the market never took off because of shelf life and shipping issues with the cantaloupe variety used at that time. More recently, the local food movement has stimulated a resurgence in demand for Nevada cantaloupes, but strategies are needed to make production of cantaloupes cost effective and sustainable by overcoming biotic and abiotic stresses.

The use of rootstocks for vegetable and melon production in the U.S. is becoming more common for overcoming biotic and abiotic stresses (Kubota et al., 2008). We hypothesized that rootstocks could help with warm-season vegetable and cantaloupe production in Nevada. Use of rootstocks for vegetable production has increased mainly in the families Cucurbitaceae and Solanaceae (Kyriacou et al., 2017), both of which include major crops grown in Nevada. Rootstock technology involves grafting the scion of the desired plant variety onto the rootstock of a related species bred to confer some benefit to the crop. Rootstocks in vegetable production are mainly developed to overcome soil-borne pathogens and pests (King et al., 2010; Kubota et al., 2008), but they can also confer desirable root traits to facilitate nutrient and water uptake under abiotic stress (Bristow et al., 2021b; Schwarz et al., 2010), and they could help increase yields under organic production (Caradonia et al., 2020). However, we were unsure whether Nevada specialty crop growers were interested or ready to adopt rootstock technology; thus, we designed a grower survey with the following objectives:

1. To discover the challenges experienced by specialty crop growers that could affect potential crop yield and
2. To explore potential grower interest in using grafted (rootstock) crop plants to enhance crop biotic and abiotic stress tolerance.

Methods

In 2021, we emailed a survey to the 102 known growers of specialty crops in Nevada by using the Survey Monkey online survey platform. We used a mix of multiple choice, yes/no, Likert-type rating scale, open- and close-ended, and demographic questions. We used filtering and contingency questions and survey formatting strategies to verify our target audience and to reduce respondent burden by presenting respondents only with relevant questions. We used the same survey tool to survey a small sample of Arizona and California growers, not for statistical comparison, but only for the purpose of placing our results in context.

The survey instrument was proof-tested by Nevada agricultural professionals. Our survey tool was considered exempt for the purposes of the University's Institutional Review Board. A survey informational and recruitment email was sent March 15, 2021, with email reminders sent April 5 and 13, 2021.

Statistical analysis of survey responses is not reported here. Statistical comparisons among Nevada growers was not possible due to wide variance in responses, so we are only reporting data trends. Arizona and California growers have a more mature specialty crop industry, so it was useful to observe general trends in their operations.

Demographic Data

The total number of survey respondents was 31, with 27 growers from Nevada, three from Arizona (Yuma County) and one from California (Monterey County). The response rate for Nevada growers was 26.5%. Nevada respondents represented the following counties: Clark, Churchill, Douglas, Elko, Humboldt, Lincoln, Lyon, Nye, Storey and Washoe.

Nevada respondents ranged in age from 30 years to 82 years, with an average age of 57.2 years (N=22). The average age of Arizona respondents was 59 years (N=2), and the one respondent from California was 60 years old. Nevada respondents were mostly small-scale growers, with 80.8% (n=21) having less than 5 acres planted in crops, and no growers with over 250 acres (**Fig. 1**). The one California respondent was also a small-scale grower at less than 5 acres. Two of the Arizona respondents had greater than 1,000 acres in crops, and one grower had 26-50 acres planted. We asked growers what system they used for growing their crops: conventional, organic, or both conventional and organic.

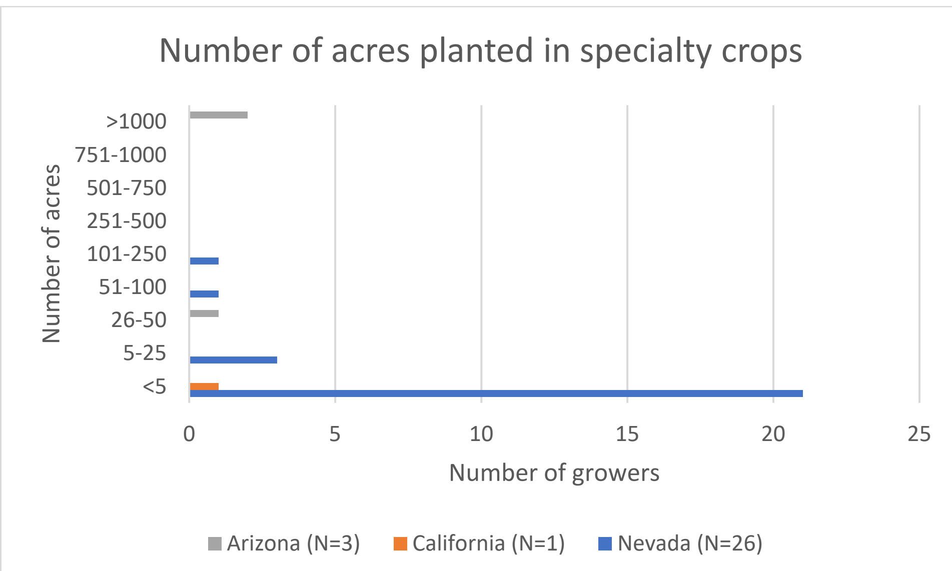

Fig. 1. Size of specialty crop operations of Nevada growers, compared to those of a small sample of growers from Arizona and California.

The system used by over half of Nevada growers was organic (51.9%; n=14), with 29.6% (n=8) growing conventional and 18.5% (n=5) growing both conventional and organic (**Fig. 2**). The Arizona grower respondents were split between conventional, and both conventional and organic. The California grower used both conventional and organic systems.

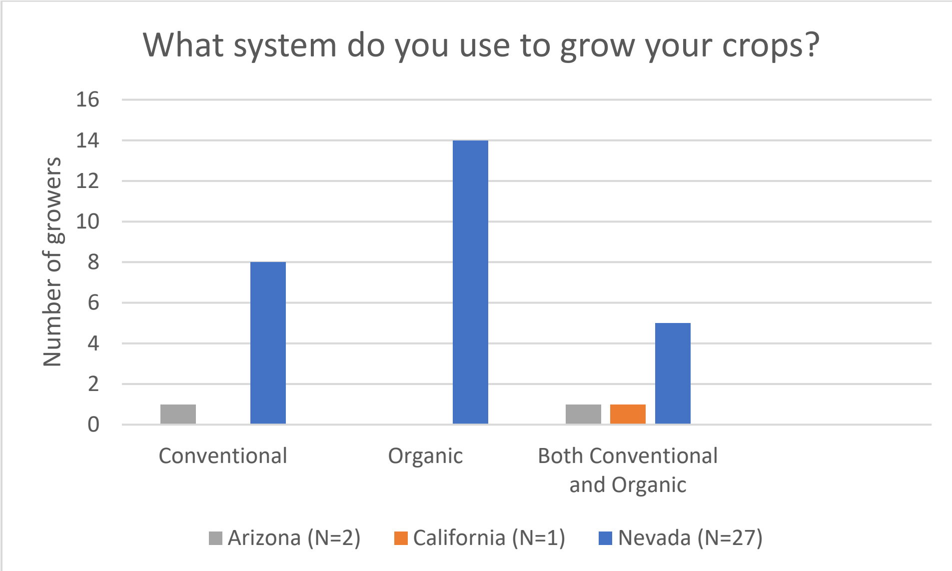

Fig. 2. Growing systems used by Nevada specialty crop growers, compared to those of a small sample of Arizona and California growers.

Nevada respondents were nearly equally divided between female (45.8%; n=11) and male (50.0%; n=12), with the rest preferring not to say (data not shown). The three Arizona growers were male, and the one California grower was female. The race of Nevada growers was mostly white (82.6%; n=19), one was black, and the rest preferred not to say. Sixteen out of 23 Nevada growers identified their ethnicity as not Hispanic, two were Hispanic, and the remaining five either identified as “other” or preferred not to say. The three Arizona growers identified as white, with one not Hispanic and two Hispanic. The one California grower identified as white/not Hispanic.

Results and Discussion

Nevada specialty crop growers are small scale, but diversified.

Crop diversity among Nevada grower respondents (N=27) was greater than it was among the respondents from Arizona (N=3) or California (N=1). Individual Nevada respondents grew as many as 17 of the 19 crops listed in the survey, whereas one Arizona respondent grew seven of those crops (broccoli, cabbage, cantaloupes, peppers, leafy greens, tomatoes and watermelons on 26-50 acres); another only grew four (broccoli, cabbage, leafy greens and watermelons on greater than 1,000 acres), and the third only grew cantaloupes on greater than 1,000 acres. The California respondent grew only one of the listed crops, tomatoes, but also grew culinary herbs (on less than 5 acres). The top vegetable crops grown among Nevada respondents included tomatoes (n=17), summer squash (n=16), cucumbers (n=15), leafy greens (n=15), cantaloupes (n=14), chile peppers (n=14) and garlic (n=14) (**Fig. 3**). “Other” crops listed by Nevada growers included berries, beans, culinary herbs, cut flowers, grapes, honey, mushrooms, sunflowers and sweet corn.

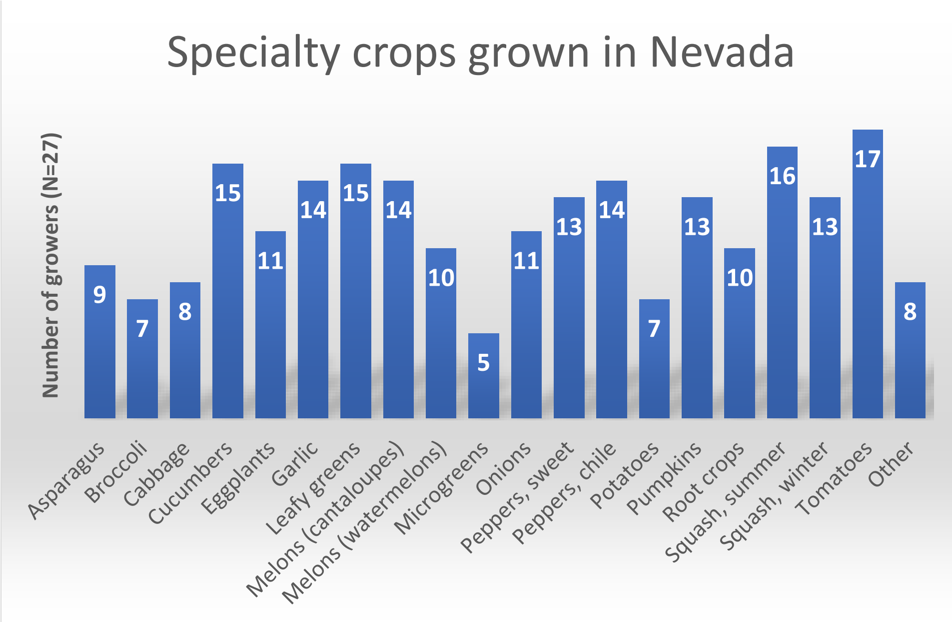

Fig. 3. Number of Nevada specialty crop grower respondents that produce the listed crops.

Respondents were asked to list up to three of their most profitable specialty crops in an open-ended question (**Fig. 4**). Specialty crops considered the most profitable by Nevada respondents included leafy greens (n=8 out of 15 who grow them), tomatoes (n=7 out of 17), peppers (chile and sweet; n=4 out of 15), squashes (summer and winter; n=4 out of 14), cantaloupes (n=3 out of 14), flowers (cut and edible, n=3 out of three), pumpkins (n=3 out of 13), berries (n=2 out of two), sweet corn (n=2 out of two), garlic (n=2 out of 14), mushrooms (n=2 out of two), onions (n=2 out of 11), carrots (n=1 out of 10 who grow root crops), eggplant (n=1 out of 11), honey (n=1 out of one), sunchokes (n=1 out of one) and vegetable transplants (n=1 out of one). The Arizona respondent to this question considered cantaloupes, lettuce and watermelons the most profitable. The California respondent considered culinary herbs their most profitable crops.

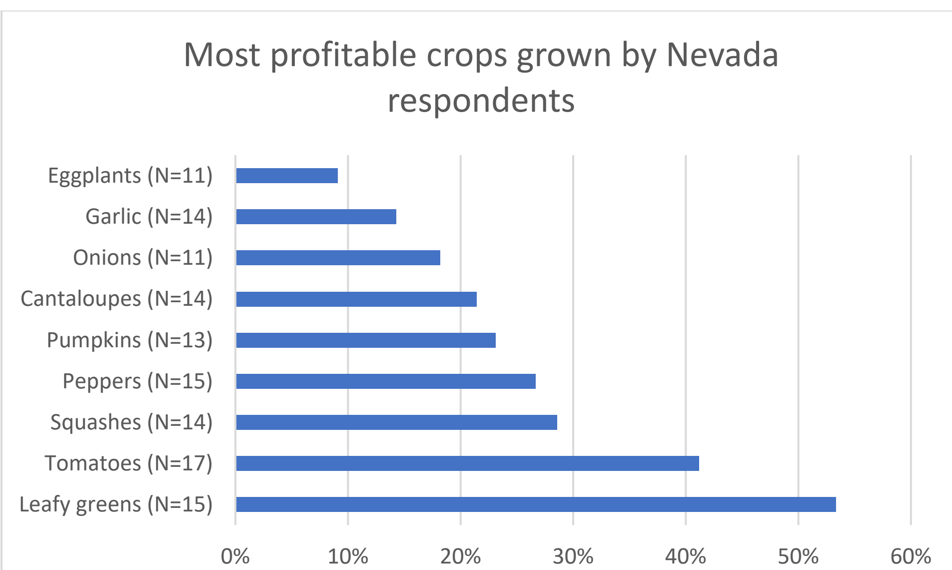

Fig. 4. In an open-ended question, we asked growers to list up to three of their most profitable crops (N=22). Percentages are based on the number of grower respondents who said they grow that crop.

Nevada growers consider weather, water availability, insect pests and soil fertility issues limiting factors to potential crop yields.

We asked survey respondents to rate the degree to which the listed factors limit or do not limit yield potential for their most profitable crops. We considered anything above a weighted average rating of 3 significant. In a follow-up open-ended question, we asked, “What information do you need to help you be more successful growing crops?”. Nevada growers’ responses showed trends similar to a small sample of growers in Arizona in that they believe crop yield potential is limited by weather, insect pests and soil fertility issues (**Fig. 5**). Only Nevada growers showed a weighted average rating above 3 for water availability.

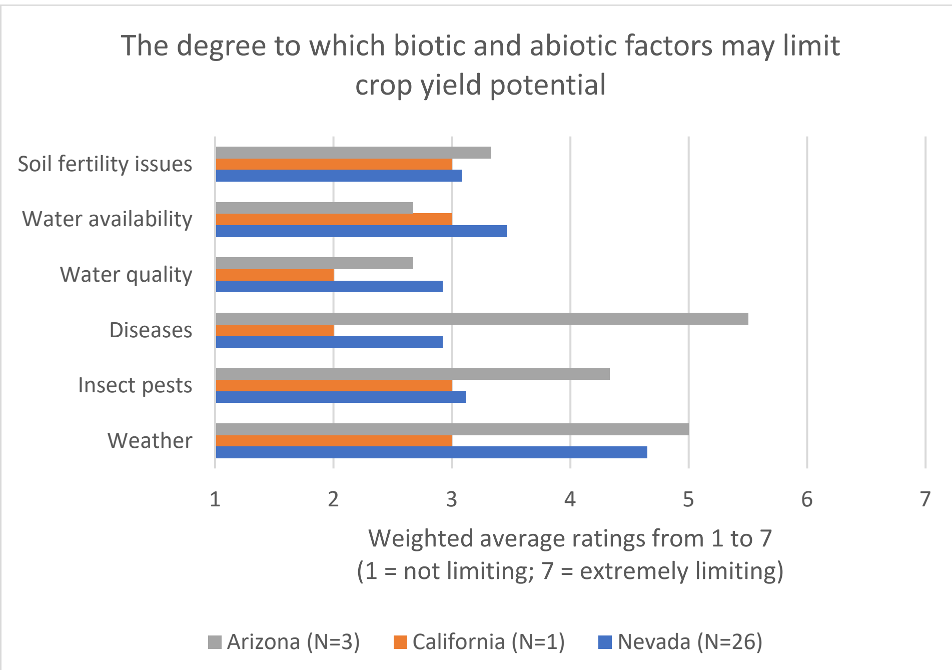

Fig. 5. Specialty crop growers rating of factors that may limit the yield potential of their crops (1 = not limiting; 7 = extremely limiting).

In fact, the greatest challenge for Nevada grower respondents was weather. As a Nevada grower in Elko put it, the problem is “growing in cold conditions that suddenly change to hot conditions.” A grower in Clark County cited a need for “research on crop varieties that do well in the desert,” and a grower in Humboldt County wants information on “proven varieties for northern Nevada.”

Insect pest issues and soil fertility issues are similarly a problem for both Nevada and Arizona grower respondents. Nevada growers in Churchill County stated a need for more information on “bugs and diseases” and “pests, viruses and soil.” Insects may not be the only biotic problem, though; a Storey County grower believes vertebrate pests to also affect crop yields. A grower from Nye County would like information on large-scale composting, presumably for soil-building. Diseases appear to be a serious issue for the three Arizona growers but did not rate above a weighted average of 3 for Nevada growers (**Fig. 5**).

Water availability appears to be more of a concern for Nevada grower respondents (**Fig. 5**), and may be related to which crops are grown and the county in which they are grown. Nevada growers *most likely* to believe that water availability (weighted rating of 6 or above, n=9) affects yield potential of their most profitable crops include those in Clark, Churchill, Elko, Lyon and Nye counties (data not shown). Further, Nevada cantaloupe grower respondents believe cantaloupe yield potential is less affected by water availability than do growers of other crops (**Fig. 6**), and Arizona cantaloupe grower respondents showed a similar trend (data not shown). These observations are borne out by studies that indicate cantaloupes are well adapted for arid climates and are not as sensitive to water limitations as other crops (Southwest Regional Climate Hub and California Sub Hub, 2016).

Water availability is a complex issue, and explanations for differences in water availability for crop growth in various regions go beyond differences in annual precipitation rates. For example, Clark County, Nevada, and Yuma County, Arizona, have similar annual precipitation rates (5 inches for Clark County versus 3 inches for Yuma County), yet Clark County respondents believe water availability is more of a challenge to potential crop yield than do the respondents from Yuma County. Even considering the time of year precipitation is received (precipitation falling as snow versus rain, for example) doesn't fully explain the differences in perceived water availability for crop growth. Water availability in the western U.S. can be political and also involves issues such as water rights (appropriative versus federal), drought status, imposed water restrictions, water quality, population growth, urbanization, ground water versus surface water flows, and land ownership (public versus private) (Anderson and Woosley, 2005). The actual issues involved will vary by community.

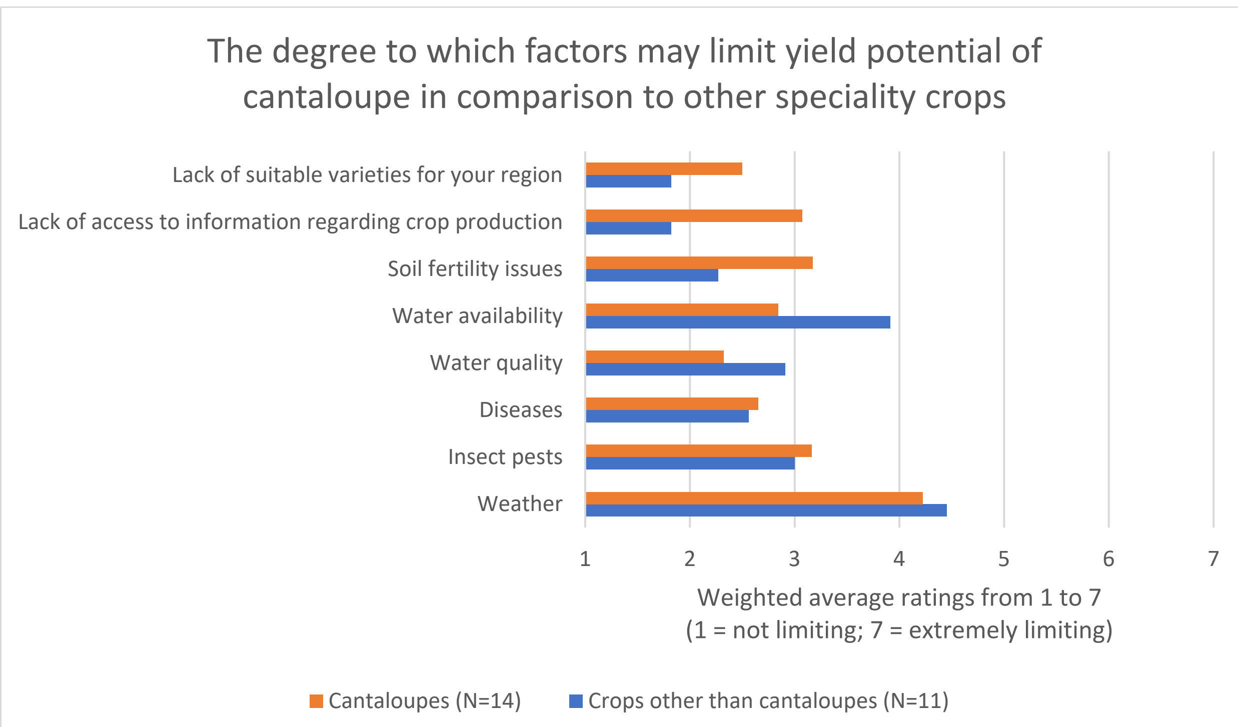

Fig. 6. Nevada cantaloupe growers were asked separately to rate the degree to which the listed factors may limit cantaloupe yield potential. Those ratings were compared to the ratings of growers of other specialty crops (1 = not limiting; 7 = extremely limiting).

Nevada growers are interested in trying rootstocks to improve crop stress tolerance.

We asked growers whether they are using grafting/rootstocks during production of any crops (**Fig. 7**). Although 23.1% (n= 6) of Nevada growers stated that they are currently using rootstocks/grafting during crop production, they are using them only for production of tree fruits, not for vegetable or cantaloupe production. Of those that are not using rootstocks for crop production, 45.0% (n=9) are interested in trying rootstocks, and another 15.0% (n=3) are unsure if they are interested. None of the

Arizona growers are currently using rootstocks, but one is interested in trying them. We asked respondents what information would help them decide whether using rootstocks made sense for their operation. Responses included: cost comparison of growing with and without rootstocks, information on effective methods/techniques for propagating, how rootstocks work, which work best in our area, and local experts to go to for troubleshooting. Two growers were also interested in information on tomato grafting.

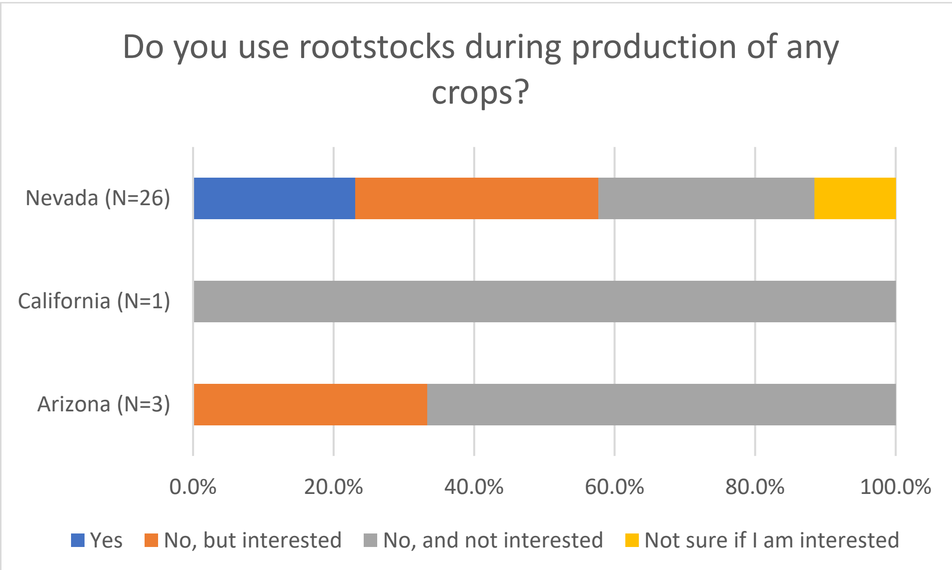

Fig. 7. Use of rootstocks by Nevada specialty crop growers, compared to that of growers in Arizona and California.

Growers in Nevada and Arizona may be interested in trying cantaloupe production.

Fourteen out of 26 Nevada grower respondents currently grow cantaloupes, with five growers having produced them in the past, but not anymore due to production issues with the available varieties at the time (data not shown). Of those who do not currently grow cantaloupes (n=12), at least six might consider trying them (**Fig. 7**). Two of the Arizona growers already produce cantaloupes, and the third has never grown them but is interested in trying them. Our survey shows that although cantaloupes are among the top crops grown by Nevada specialty crop grower respondents (**Fig. 3**), only three of the 14 respondents who grow them consider them among their most profitable crops (**Fig. 4**). According to Nevada cantaloupe grower respondents, weather, insect pests and soil fertility are among the top abiotic and biotic stressors during cantaloupe production (**Fig. 6**), and rootstock technology has been used to overcome many of the stressors that plague Nevada's major specialty crops (Djidonou et al., 2017; Gisbert-Mullor, 2021; Kyriacou et al., 2017). Rootstock technology could be useful in bringing cantaloupes to a higher level of profitability and in enhancing grower interest. Our research group is currently evaluating the performance of grafted versus ungrafted plants.

Using rootstocks for production of cantaloupes is not common, although the technique has been used for production of watermelon (Daley et al., 2014) and also tested on cantaloupe (Guan and Zhao, 2015). Use of rootstocks may be an effective strategy for overcoming some of the problems that growers have experienced with cantaloupe production in the past. They are susceptible to a variety of stresses (**Fig. 6**), such as soil-borne diseases, and those stresses may affect the impact of water stress on cantaloupes (Villalba-Bermell et al., 2021).

Effective information delivery is critical to grower education and success.

When we asked Nevada grower respondents about other challenges to crop yield potential, "lack of access to information regarding crop production" and "lack of suitable varieties for the region" were selected (**Fig. 6**). Although neither factor rated as high as other yield-limiting factors, Nevada growers cited both as greater issues for cantaloupe yield potential than for yield potential of their other crops.

Growers need reliable, research-based information to make informed decisions about, and to successfully use, rootstock technology for cantaloupe and other specialty crop production. We asked respondents to select from a list the most effective methods for delivery of educational information (**Fig. 8**). Although all options were relevant for many growers, the most popular selection was "workshops/conferences" (60%; n=15). "Newsletters" and "Extension publications" were close behind at 48% (n=12) and 44% (n=11), respectively. It is not surprising that "workshops/conferences" was a popular option, as the Nevada Farms Conference has been a successful venue for grower education for the past 16 years. Held mostly in Reno or Fallon, Nevada, the event is planned by a board of growers and other agriculture professionals and brings researchers and Extension workers from across the state to present the findings of their latest work. It also offers an opportunity for growers to interact with presenters to delve more deeply into questions that are most relevant for them. However, given the size of the state, the long distances some growers may need to travel and the diversity of crops grown, we recommend Extension and outreach be provided in multiple formats and tailored to specific audiences as needed (Ruhf et al., 2017).

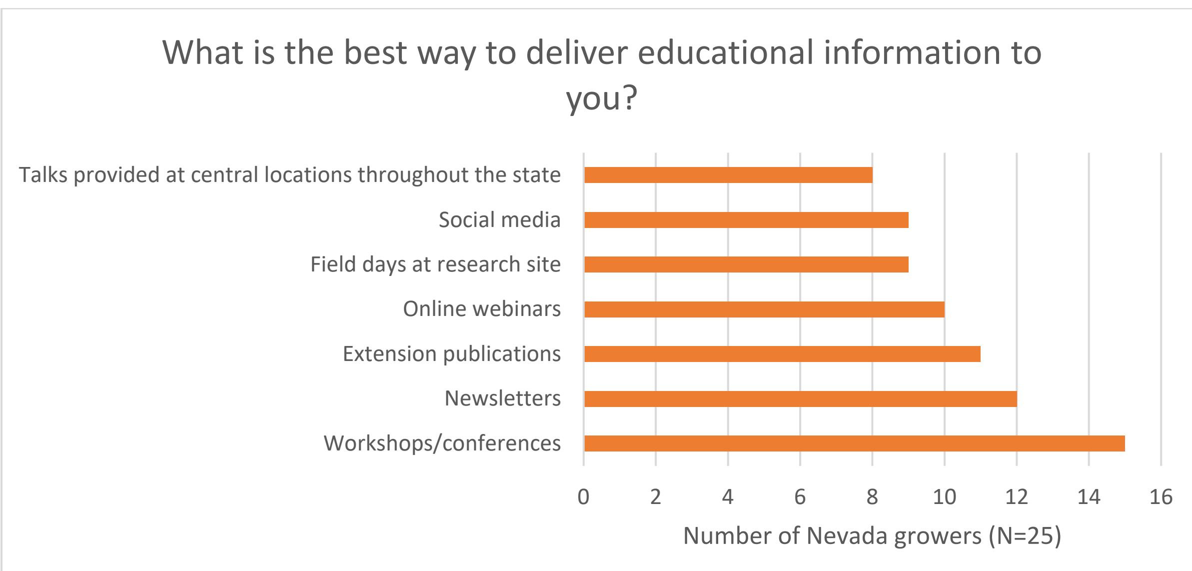

Fig. 8. Respondents were asked which methods of educational delivery were most effective for them. They could select multiple options.

Conclusions

Nevada specialty crop growers are small scale, but they manage highly diversified farms. The major crops grown include many in the Cucurbitaceae and Solanacae families, including cantaloupes and tomatoes. Rootstocks have been developed for overcoming both biotic and abiotic stresses in these crops. Cantaloupes, in particular, are well-adapted to arid climates, and there is interest among growers in expanding the cantaloupe market. Rootstock technology may prove useful in overcoming the barriers to cantaloupe production in Nevada, such as crop establishment and disease tolerance, and growers are cautiously optimistic about their use. Adoption of rootstock technology will require research on the most effective rootstocks for production of cantaloupes and other specialty crops in Nevada's climate, and education and training will be needed to assure effective use of the technology.

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