Investigating the Practices and Challenges for Turfgrass Breeders and Distributors

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Abstract. An online survey was conducted to investigate the current practices of and challenges for turfgrass breeders and turfgrass seed distributors (or sales staff) in the United States. We found that turfgrass seed breeders rated producers/growers and consumers as more important parties compared with other interested parties. However, variations in ratings were found for breeders/distributors according to different program characteristics. The volume of seed sales of the species was the most highly rated technical consideration for both breeders and distributors. Compared with distributors, breeders considered the following technical factors more important than others: funding, labor, field trial performance, diversity in working priorities, availability of germplasms, scheduling, and staff training. Costs, followed by resource allocation and resource availability, were rated as the most challenging factors when breeders were implementing priorities. Our findings provide important insight regarding breeding and distribution practices and management in the turfgrass industry.

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niche market potential, and awareness of environmental changes) affecting the determination and implementation of turfgrass priorities for breeders and distributors. Other background information such as program size, program location, affiliation (university, government, or private company), years of working experience in the turfgrass industry, and the sex and education level of respondents were also collected.

We obtained a total of 54 responses, but several were incomplete; therefore, they were excluded from this study. Eleven complete responses from turfgrass breeders and 34 completes responses from turfgrass seed distributors were used for this study. Breeders and distributors rated the importance of factors affecting the selection of turfgrass priorities using a continuous scale of 0 to 10 (0 = very unimportant and 10 = very important). Factors such as the importance of the needs of interested parties and technical considerations were examined from the viewpoints of breeders and distributors. Breeders were also asked about the challenges they encountered when determining or implementing breeding trait priorities. We conducted $t$ tests to evaluate if the ratings of interested parties/technical considerations differed significantly between each of the analyzed factors.

The variables included the breeders’ and distributors’ ratings of the importance of interested parties, technical considerations, and challenges encountered when determining and implementing priorities. To identify the main factors that influence the ratings of breeders, we used double-bounded Tobit models (ratings range, 0 to 10; left-censored at 0 and right-censored at 10). An unobservable underlying latent variable ($Y'$) was used to express the observed dependent variable ($Y$) (Greene, 2007). The unobserved dependent variable $Y'$ is expressed as a function of a vector of the independent variable $X'$ by the following specification:

$$Y' = X'B + e; e \sim \text{Normal}(0, \sigma_e^2)$$

where $B$ is the vector of the unknown coefficient and $e$ is the error term assumed to follow a normal distribution with a mean of zero and standard deviation of $\sigma$. The observed dependent variables are represented by:

$$Y = \max(0, Y') \text{ and } Y = \min(Y', 10)$$

The dependent variables included measures of the importance of the needs of interested parties, technical considerations, and challenges that breeders encounter when setting priorities. The independent variable vector $X$ included information regarding program characteristics such as the targeted regions of turfgrasses, program size, years of working experience in the turf industry, and the education level and sex of respondents.

### Results

Summary statistics and pairwise $t$ test results of breeder and distributor ratings.

Summary statistics for demographics of surveyed breeders and distributors are listed in Table 1. More than 70% of the surveyed turfgrass breeders and more than 90% of the turfgrass seed distributors were male. On average, breeders and distributors had a similar number of years of working experience (between 19 and 20 years). The program size was approximately six full-time equivalent staff members for breeders and 23 for distributors. The average education level for breeders was a Master’s degree, whereas the average distributor had a Bachelor’s degree.

Table 2 shows the summary statistics for ratings on the importance of interested parties and technical considerations for both breeders and distributors. The most important parties influencing priority settings for breeders were producers/growers and consumers, followed by distributors or sales staff, turfgrass scientists, and wholesalers. Other parties such as public officials, marketing companies, professional peers, extension specialists, and university specialists were considered less important. Distributors, however, considered consumers as the most important party, followed by distributors or sales staff, producers/growers, and wholesalers. Similar to the turfgrass breeders, turfgrass seed distributors considered public officials, marketing companies, professional peers, as well as university and extension specialists as less important parties. We also conducted pairwise $t$ tests and found that the ratings for consumers, followed by those for producers/growers, were significantly higher than those for other parties. Technical considerations such as the volume of seed sales of the species, perceived market demand for specific traits, labor, availability of technologies, profit margins, field trial performance, and ease of production were the most important factors when breeders were setting program priorities.

Pairwise comparisons using a $t$ test also suggested that the volume of seed sales of the species and perceived market demand for specific traits were rated significantly higher than other factors.

Table 3 presents the summary statistics for ratings of the challenges encountered by breeders when determining and implementing turfgrass trait priorities. The summary statistics of ratings together with the pairwise $t$ test results indicated that breeders rated resource availability such as financial and labor/personnel resources (technicians, breeders, etc.) as the most challenging when determining the program priorities. Additionally, when comparing the challenges encountered when implementing program priorities, breeders and distributors gave the highest ratings to costs, followed by resource allocation across different projects.

### Summary

The following independent variables for the last two sets of models were the same: program size, number of years of working experience as a turfgrass breeder, and breeder’s education level and sex. For all of the regressions, each effect discussed was ceteris paribus, meaning that the estimated coefficient describes the effect of the variable

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Table 1. Summary statistics of the background information of a national survey distributed to turfgrass breeders and distributors (n = 45).

| Variables                  | Breeders (n = 11) | Distributors (n = 34) |
|----------------------------|-------------------|-----------------------|
| Male                       | Mean (sd)         | Mean (sd)             |
| 1 if the respondent is male; 0 if the respondent is female | 0.73 (0.47)       | 0.94 (0.24)           |
| Work years                 | Number of years the breeder or distributor professional has been involved in the turfgrass industry | 19.20 (9.29) | 19.79 (11.35) |
| Program size               | Size of the program in terms of number of full-time equivalent staff | 5.91 (4.48) | 22.62 (45.21) |
| Education                  | Highest level of education | 4.73 (1.01) | 3.91 (0.67) |
| 1 = some high school; 2 = high school degree; 3 = some college; 4 = Bachelor’s degree; 5 = Master’s degree; 6 = PhD degree |

Table 2. Summary statistics of turfgrass breeders’ and distributors’ ratings of the importance of interested parties and technical considerations when selecting priorities based on a survey distributed to a national sample of turfgrass breeders and distributors (n = 45).

| Importance of interested parties that influence priorities (0 = very unimportant, 10 = very important) | Breeders | Distributors | Importance of technical considerations that influence priorities (0 = very unimportant, 10 = very important) | Breeders | Distributors |
|---------------------------------------------------------------------------------------------------|----------|--------------|---------------------------------------------------------------------------------------------------|----------|--------------|
| Mean (sd)                                                                                         | Mean (sd) | Mean (sd)    | Mean (sd)                                                                                         | Mean (sd) | Mean (sd)    |
| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
| Consumers                                                                                        | 8.55 (1.13) | 8.47 (1.83) | Perceived market demand for the specific trait                                                    | 7.90 (2.23) | 7.13 (2.05)  |
| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
| Consumers                                                                                        | 8.55 (1.13) | 8.47 (1.83) | Perceived market demand for the specific trait                                                    | 7.90 (2.23) | 7.13 (2.05)  |
| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
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| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
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| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
| Consumers                                                                                        | 8.55 (1.13) | 8.47 (1.83) | Perceived market demand for the specific trait                                                    | 7.90 (2.23) | 7.13 (2.05)  |
| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
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| Producers/growers                                                                                 | 8.91 (0.94) | 6.75 (2.74) | Volume of seed sales of the species                                                              | 8.64 (1.12) | 7.76 (1.99)  |
| Consumers                                                                                        | 8.55 (1.13) | 8.47 (1.83) | Perceived market demand for the specific trait                                                    | 7.90 (2.23) | 7.13 (2.05)  |

of interest with other conditions remaining the same.

Importance of the interested parties influencing the settings of priorities. Table 4 shows that turfgrass breeders and distributors targeting different geographical regions had different ratings for each interested party. For instance, breeders and distributors targeting the west regions rated the needs of consumers, sales staff, and professional peers as more important compared with the needs of those who did not target these regions. Extension specialists were rated as more important by those who were targeting the Midwest. Public officials/policymakers were considered more important, and professional peers were considered less important. Compared with their female counterparts, male respondents rated the importance of marketing companies higher. The differences in ratings between breeders and distributors were not significant for most parties. However, the significant coefficient of the breeder variable for the professional peers model suggested that breeders thought of professional peers as more important party compared with distributors.

Importance of the technical considerations influencing priorities. Table 5 presents the Tobit model results for different technical considerations. Respondents targeting the west regions considered information/feedback from consumers, consistency of the trait of the species, the need to withstand the test of seasonal changes (e.g., pollen and harvest windows), and maximization of economic returns/royalties as more important. Breeders and distributors targeting Canada tended to rate producers/growers and wholesalers as more important parties, but they rated extension specialists as less important. Program size also affected breeders’ and distributors’ ratings of the important parties. Programs with larger sizes rated consumers as less important parties, but they considered professional peers and turfgrass specialists as more important. Breeders and distributors with more working experience rated the producers/growers as less important parties. More educated respondents considered public officials/policymakers as more important and professional peers as less important.
Table 3. Summary statistics of breeders’ ratings of challenges encountered when determining and implementing priorities when selecting a trait for inclusion in a breeding program based on a survey distributed to a national sample of turfgrass breeders and distributors (n = 11).

| Challenges you face when determining priorities | Mean (sd) | Challenges you face when implementing priorities | Mean (sd) |
|------------------------------------------------|----------|-------------------------------------------------|----------|
| Resource availability: financial               | 8.91 (0.94) | Costs                                            | 8.40 (2.41) |
| Resource availability: labor/personnel (technicians, breeders, etc.) | 8.55 (1.13) | Resource allocation across different projects    | 7.10 (2.60) |
| Niche market potential                         | 6.78 (2.64) | Resource availability                            | 6.44 (2.51) |
| Knowing environmental changes                  | 6.57 (1.40) | Being the first/lack of technological ability to do something (e.g., not having the technology to perform genetic marker research) | 6.20 (2.62) |
| Availability in the marketplace                | 6.50 (3.02) | Consistency of the trait of the species          | 5.33 (3.50) |
| Resource availability: space/land              | 6.27 (2.80) | Collecting germplasm resources                   | 5.00 (3.07) |
| Identifying new sources of genes (germplasms) to reach breeding goals | 5.88 (3.00) | Evaluating new sources of germplasms             | 4.82 (2.36) |
| Not doing too much (future royalties/funding is unknown) | 5.80 (2.17) | Grower support                                   | 4.75 (3.58) |
| Practicality of targeting the trait of the species of interest | 4.29 (1.25) | Poor documentation of existing germplasm         | 4.33 (2.65) |

Table 4. Tobit model estimation results regarding the importance of interested parties influencing priorities for turfgrass breeders and distributors based on a survey distributed to a national sample of turfgrass breeders and distributors (n = 45).  

| Consumers | Producers/growers | Wholesalers | Marketing companies | University colleagues | Sales staff members | Distributors | Professional peers | Turfgrass scientists | Extension specialists | Public officials/policymakers |
|-----------|------------------|-------------|---------------------|-----------------------|---------------------|--------------|-------------------|----------------------|-----------------------|------------------------|
| West      | 3.05**           | –0.63       | –0.26               | 0.45                  | –3.95**             | 1.69         | 4.01**            | 0.45                 | –1.86                 | 2.07                   |
| (2.30)    | (0.40)           | (0.13)      | (0.25)              | (0.43)                | (0.77)              | (0.77)       | (0.24)            | (0.92)               | (0.73)                |
| Midwest   | –0.16            | –1.77       | –0.25               | –2.02                 | –3.81              | 0.27         | 2.03              | 0.48                 | 7.34***               | 0.42                   |
| (0.14)    | (1.41)           | (0.15)      | (0.98)              | (0.85)                | (1.56)              | (1.67)       | (0.31)            | (3.25)               | (0.17)                |
| South     | –1.36            | –0.48       | 0.75                | –0.51                 | 0.40               | 0.05         | 4.33***           | –1.06                | 5.07**                | 5.61                   |
| (1.13)    | (0.33)           | (0.42)      | (0.34)              | (0.25)                | (0.02)              | (2.80)       | (0.59)            | (1.38)               | (1.77)                |
| Northeast | 0.32             | –0.14       | –1.53               | –0.02                 | 0.39               | 0.07         | 0.51              | –1.01                | 4.45**                | –1.63                  |
| (0.30)    | (0.99)           | (0.93)      | (0.01)              | (0.34)                | (0.04)              | (0.49)       | (0.76)            | (2.67)               | (0.85)                |
| Canada    | 0.07             | 4.68**      | 5.65**              | 3.16                  | –0.64              | 2.37         | 0.28              | 1.26                 | –7.69**               | 7.17                   |
| (0.05)    | (2.72)           | (2.41)      | (1.02)              | (0.33)                | (1.13)              | (0.17)       | (0.61)            | (2.31)               | (1.73)                |
| Program size | –0.02***         | 0.00        | 0.00                | 0.00                  | 0.00               | 0.00         | 0.02**            | 0.02**               | 0.00                  | 0.01                   |
| (2.35)    | (0.29)           | (0.42)      | (0.01)              | (1.43)                | (0.93)              | (0.34)       | (2.32)            | (2.16)               | (0.37)                | (1.04)                 |
| Work years | 0.00             | –0.10*      | 0.04                | 0.04                  | 0.00               | 0.04         | 0.00              | 0.00                 | 0.01                  | 0.01                   |
| (0.13)    | (2.03)           | (0.50)      | (1.30)              | (1.36)                | (0.79)              | (0.70)       | (0.27)            | (1.51)               | (0.12)                | (0.13)                 |
| Education | 0.22             | 0.17        | 0.57                | 0.67                  | 0.66               | –1.20        | 0.79              | –1.81**              | –0.38                 | –1.59                  |
| (0.40)    | (0.26)           | (0.68)      | (0.48)              | (1.86)                | (1.41)              | (0.90)       | (2.78)            | (0.46)               | (1.07)                | (1.84)                 |
| Male      | –0.21            | 1.44        | 2.54                | 2.89**                | –2.00              | 0.91         | 0.19              | 0.42                 | –0.06                 | 1.25                   |
| (0.19)    | (1.17)           | (1.61)      | (2.06)              | (2.50)                | (0.53)              | (0.09)       | (0.28)            | (0.03)               | (0.85)                | (0.29)                 |
| Breeder   | –0.67            | 0.94        | –1.90               | –0.08                 | 1.35               | –0.95        | 3.62**            | 1.58                 | –0.77                 | –4.06                  |
| (0.54)    | (0.70)           | (1.07)      | (0.04)              | (0.80)                | (0.47)              | (2.54)       | (0.92)            | (0.34)               | (1.44)                |
| Intercept | 9.19***          | 7.15**      | 1.95                | 0.27                  | 1.18               | 12.70**      | 11.30**           | 12.50**              | 5.79*                 | 11.60                  |
| (3.24)    | (2.19)           | (0.46)      | (0.04)              | (0.50)                | (3.09)              | (2.38)       | (3.85)            | (1.83)               | (1.75)                | (0.75)                 |

*aDependent variables for Tobit models in this table are the rated importance levels of interested parties as listed in each column, ranging from 0 to 10. The base group for these Tobit regressions comprised female distributors. Absolute t statistics are in parentheses. **Significant at the 1% level. ***Significant at the 5% level. ^Significant at the 10% level. Some climatic condition variables (for example, cool- or warm climate conditions) are also included in the model as control variables.

*bRegional variables (west, midwest, south, northeast, and Canada) represented the target region where grasses will be used.

*cMale was a dummy variable that equaled 1 if the respondent was a male (0 if a female).

*dBreeder was a dummy variable that equaled 1 if the respondent was a breeder (0 if not a breeder).

eThis regression was based on turfgrass breeder samples because only breeders rated the importance of university colleagues.

of time, and the availability of the germplasm as more important technical considerations; however, those who targeted the Midwest tended to rate collaboration opportunities as more important and volume of seed sales as less important. For those respondents targeting the regions, technical considerations such as the cost of development and collaboration opportunities were rated as more important, whereas funding, feedback from consumers, diversity in working priorities, availability of the germplasm, and scheduling and staffing ahead of seasonal changes were regarded as less important. In fact, many warm-season grasses in the south are vegetatively propagated; therefore, seed yield would not be an issue. It is possible that the cost of development is regarded as an important technical consideration because people are producing and selling more sod than seed. Respondents targeting the northeast United States rated collaboration opportunities such as unique germplasms with interesting traits, diversity in working priorities, and availability of the germplasm as more important. Respondents targeting Canada assigned lower ratings to more than half of the technical considerations in terms of their importance in setting trait priorities.

Programs with larger sizes rated the need to withstand the test of time as a less important consideration. Respondents with more years of working experience rated the profit margins, species specifications, and staff training ahead of seasonal changes as more important considerations. However, the speed of production was rated as less important.

Education levels were found to have significant effects on some of the technical considerations. For example, respondents...
with higher education levels rated most technical considerations (such as funding, field trial performance, unique germplasms with interesting traits, consistency of the trait of the species, diversity in working priorities, staff training ahead of seasonal changes, information/feedback from consumers) as less important, whereas the information regarding new markets was rated as more important. Male respondents considered the maximization of economic returns and availability of the germplasm as more important, and they considered the consistency of traits of the species as less important. Being a breeder significantly affected the respondent’s ratings of many technical considerations. Compared with distributors, breeders gave higher ratings to the importance of funding, labor, field trial performance, working priority diversities, germplasm availability, scheduling, and staff training; however, their ratings for considerations such as the need to withstand the test of time and collaboration opportunities were lower.

Challenges breeders encountered when determining priorities and when selecting traits for inclusion in their breeding programs. The Tobit results for challenges that breeders encountered when determining priorities are listed in Table 6. The program size had a significant influence on the ratings of challenges. Keeping other variables constant, turfgrass breeders from larger programs considered challenges such as resource availability; these breeders considered the availability of labor/personal (technicians, breeders, etc.) as a more challenging factor. Breeders with higher education levels rated the availability of space/land and the availability in the marketplace as more challenging factors when determining priorities. Male breeders also thought of the availability of space/land as more challenging; however, they regarded the niche market potential as a less challenging factor.

Challenges breeders encountered when implementing priorities when selecting traits for inclusion in their breeding programs.

When implementing priorities, breeders with larger program sizes considered factors such as poor documentation of existing germplasms and evaluating new sources of germplasms as less challenging. Breeders with more working experience considered collecting germplasm resources, evaluating new sources of germplasm, consistency of the trait of the species, and coordination/timing in terms of training seasonal/part-time staff as more important challenges when implementing priorities. More educated breeders considered collecting germplasm resources, evaluating new sources of germplasm, consistency of the trait of the species, and that they recognize consumers’ needs and acceptance as the most important indicators for market success. Furthermore, breeders care about the benefits of the producers/growers; therefore, their breeding efforts should aim to provide producers/growers with more profits. This aspect may be unique to turfgrass because breeders need to develop products that will provide profits for the growers/producers (i.e., higher seed yield) and benefits for the consumers (turfgrass quality, drought tolerance, disease resistance, etc.). Breeding programs for agronomic crops (for example, maize and wheat), however, mainly focus on improving production efficiency to increase yield and grain quality (Carena, 2013); therefore, both producers and consumers obtain more surplus from yield increases (Nogueira et al., 2015).

Unlike breeders who regularly conduct field trials with growers and interact with producers to determine research progress and who care about the grower/producer benefits, turfgrass distributors might only consider market-related factors (consumers, distributors/sales staff, producers/growers, and wholesalers) as more important. In our survey, distributors cared most about the yield of turfgrass seeds, profit margins, and consumer acceptance. However, variations in ratings were found for breeders/distributors with different program characteristics. For example, programs with larger sizes were more likely to provide important implications and insight about breeding/distributing practices and management in the turfgrass industry. Overall, we found that turfgrass seed breeders rated the producers/growers and consumers as more important parties compared with other interested parties. This finding, similar to the results of a previous study of rosaceous fruit breeding programs (Yue et al., 2012), suggests that breeders are aware that the turfgrass industry is a market-driven industry and that they recognize consumers’ needs and acceptance as the most important indicators for market success. Furthermore, breeders care about the benefits of the producers/growers; therefore, their breeding efforts should aim to provide producers/growers with more profits. This aspect may be unique to turfgrass because breeders need to develop products that will provide profits for the growers/producers (i.e., higher seed yield) and benefits for the consumers (turfgrass quality, drought tolerance, disease resistance, etc.). Breeding programs for agronomic crops (for example, maize and wheat), however, mainly focus on improving production efficiency to increase yield and grain quality (Carena, 2013); therefore, both producers and consumers obtain more surplus from yield increases (Nogueira et al., 2015).

Discussion and Conclusions

The results presented in this study are useful for turfgrass research, breeders, distributors, and policymakers. Our findings provide important implications and insight about breeding/distributing practices and management in the turfgrass industry. Overall, we found that turfgrass seed breeders rated the producers/growers and consumers as more important parties compared with other interested parties. This finding, similar to the results of a previous study of rosaceous fruit breeding programs (Yue et al., 2012), suggests that breeders are aware that the turfgrass industry is a market-driven industry and that they recognize consumers’ needs and acceptance as the most important indicators for market success. Furthermore, breeders care about the benefits of the producers/growers; therefore, their breeding efforts should aim to provide producers/growers with more profits. This aspect may be unique to turfgrass because breeders need to develop products that will provide profits for the growers/producers (i.e., higher seed yield) and benefits for the consumers (turfgrass quality, drought tolerance, disease resistance, etc.). Breeding programs for agronomic crops (for example, maize and wheat), however, mainly focus on improving production efficiency to increase yield and grain quality (Carena, 2013); therefore, both producers and consumers obtain more surplus from yield increases (Nogueira et al., 2015).

Unlike breeders who regularly conduct field trials with growers and interact with producers to determine research progress and who care about the grower/producer benefits, turfgrass distributors might only consider market-related factors (consumers, distributors/sales staff, producers/growers, and wholesalers) as more important. In our survey, distributors cared most about the yield of turfgrass seeds, profit margins, and consumer acceptance. However, variations in ratings were found for breeders/distributors with different program characteristics. For example, programs with larger sizes were more likely to
rate professional peers and turfgrass scientists as important parties because of their existing or potential collaborations. Additionally, breeders were more likely to rate professional peers higher than distributors, indicating that breeders may have more interactions with other professional peers. The volume of seed sales was the most highly rated technical consideration for both breeders and distributors. Compared with distributors, breeders considered technical factors (such as funding, labor, field trial performance, diversity in working priorities, availability of the germplasm, scheduling, and staff training) as more important because they had to bear a higher proportion of production costs.

The influence of program characteristics varied for different technical and societal challenges when breeders were determining or implementing priorities. In general, resource availabilities were rated as the most challenging when determining the program priorities; costs, followed by resource allocation and resource availability, were rated as the most challenging factors when breeders were implementing priorities. Although turfgrass breeders encounter a variety of challenges different from those of breeding programs for rosaceous crops (Yue et al., 2012), resource-related challenges were still among the most influential factors when making decisions about selecting traits. Breeding programs with larger sizes were less concerned with the technical challenges (such as identifying new sources of genes, documentation of existing germplasms, and evaluating new sources of germplasms) and societal challenges (for example, finding niche market potential); however, resource-related challenges were considered more important. Moreover, breeders with more experience found technical challenges (such as funding, labor, field trial performance, diversity in working priorities, availability of the germplasm, scheduling, and staff training) as more important because they had to bear a higher proportion of production costs.

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as collecting germplasm resources, evaluating new sources of germplasms, and consistency of the traits in the species) and societal challenges (such as coordination of staff training) to be more important factors and resource availabilities to be less challenging. These results are in line with those of Yue et al. (2012), because some technical and societal challenges may be considered especially important for breeding programs with certain characteristics and resource availability. We suggest that these societal challenges could be addressed by strengthening the coordination and work of similar breeding programs and evaluating supply chain stakeholder perceptions of successful cultivars.

In conclusion, this study provided insight for the turfgrass industry by investigating the technical and socioeconomic challenges encountered by breeders and distributors when prioritizing traits. The findings suggested that market-driven programs were actually in need of both turfgrass breeders and distributors. With the information from this study, breeders, distributors, funding agencies, and policymakers can gain a better understanding of how market-based evaluations can benefit breeding programs and how breeding systems are constrained by technical and societal challenges. Future studies are needed to examine the reasons for the differences across programs and to explore effective ways of overcoming different challenges encountered by breeders.

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