Application of Structural Equation Modeling to Scrutinize the Causes of Grape Losses in Production Chain

S. Rajabi¹, F. Lashgarara¹*, M. Omidi¹, and S. J. Farajallah Hosseini¹

ABSTRACT

Grape is the key product of Qazvin Province and a vast amount of it is annually lost during supply chain due to various causes. This study, therefore, aimed at examining the effective and significant causes of grape losses in supply chain in Qazvin. First, to identify the main causes of the grape losses and to develop the research framework, data was gathered through some qualitative methods. Twenty-three grape growers, researchers, and experts were interviewed by research team as the key informants. Meanwhile, grounded theory techniques were employed for data analysis simultaneous with data collection processes to develop the final theory and model. In second part, the study's hypotheses and research model were formed based upon the developed theory. Then, to examine the research model, Partial Least Square Structural Equation Modeling and Important-Performance Matrix Analysis techniques were used. The population involved/affected in this part was grape growers from five districts of Qazvin Province. The sample consisted of 380 grape growers who were selected through stratified random sampling. A questionnaire was utilized for data collection and data was analyzed with the Smart-PLS 3.0. Main findings show that “management practices and resource and equipment” had significant effect on the grape losses. In accordance with Important Performance Matrix Analysis (IPMA), “extension and advisory services and management practices” are of paramount prominence. Moreover, in indicators level, providing on-farm participatory training, intelligible educational programs in local media, and financial resources, had the utmost importance in mitigating grape losses.

Keywords: Extension and advisory services, Important-Performance Matrix Analysis (IPMA), Management practices, Partial Least Square Structural Equation Modeling (PLS-SEM).

INTRODUCTION

Losses of horticultural crops in general, and fresh fruits in particular, are quite crucial challenges within developing countries (Hailu and Derbew, 2015). Fruits sub-sector has the potential to contribute to improving smallholder’s nutrition, and food security (Van den Broeck et al., 2018) consumed in either fresh or processed forms. Yet, both forms are lost or wasted each year throughout the whole supply chain by dint of numerous causes (Gustavsson et al., 2011). As stated by most researchers, loss of fruit in developing countries transpires primarily during the initial and middle stages of the supply chain encompassing agricultural production and postharvest processing (Kereth et al., 2013; Hailu and Derbew, 2015), and average of losses is between 20-50% (Mashau et al., 2012; Kereth et al., 2013).

In Iran, analogous to other developing countries, fruits suffer the highest rate of losses compared to other agriculture crops (Alikarimi, 2017). Moghaddasi et al. (2005) accentuated that roughly 7.6 million tons of the 25 million tons of fruit and vegetables...
are lost annually in Iran. Nonetheless, the rate of losses varies among fruits and the problem of losses becomes a more serious challenge when it comes to fruits such as grapes (Rajabi et al., 2015). Among fruits, the most rates of the losses belong to grapes with 35-55 percent (Alikarimi, 2017). Losses during the supply chain may be aggravated due to grapes’ delicateness and extreme perishability compared to other fruits. According to Moghaddasi et al. (2005), approximately 3 million tons of grapes are annually produced and nearly 640000 tons are processed in Iran, of which 30-38% are lost and thrown away at various stages of the postharvest chain. Rajabi et al. (2015) examined the amount of grape losses and waste throughout supply chain among small-scale grape growers in Qazvin Province. They revealed that about 53% of the grapes produced were lost in various stages of supply chain, which, major part of it (about 46%) took place in processing stage (19%), agricultural production (17.6%), and postharvest (9%) while only about 7% of the grapes were wasted during distribution and consumption stages. It is clear that losses represent a waste of land, water, energy, inputs, and other resources, while these resources could be used to increase fruit production and affect smallholders’ food security (Tielens and Candel, 2014). Given all this, the ensuing questions were posed in this study:

**RQ1:** What are the main causes of grape losses in processing, agricultural production, and postharvest stages of grape supply chain in Qazvin Province?

**RQ2:** What are the most effective and the most important causes of the rising amount of grape losses in Qazvin Province?

In the present study, we aimed to answer the aforementioned questions.

**MATERIALS AND METHODS**

In order to identify the main causes of the grape losses and then to determine the effective and crucial causes, this study was conducted in two parts. First, a qualitative process and a review of literature was performed to identify the main causes of the grape losses and to reach a research framework. Then, to determine effective causes and important causes pivoting on the results of the first section, Square Structural Equation Modeling (SEM) was employed.

**Research Framework and Hypothesis Development**

To identify the main causes of the grape losses and to develop the research framework, first, data was gathered through the utilization of some qualitative methods including in-depth interview, observation, field notes, and document review (for comparison and conformity with previous literature). Snowball sampling as a type of purposive sampling was used for respondents selecting sequentially based on theoretical sampling. We achieved theoretical saturation when the number of respondents reached 23 participants, including 12 smallholder farmers (grape growers) from various areas of Qazvin, five researchers from Qazvin Agricultural Research and Education Organization (QAREO), and Takestan Grape Research Institute (TGRI), and six experts from Qazvin Agriculture-Jahad Organization (QAJO). Meanwhile, grounded theory techniques were employed (open coding and selective coding) for data analysis simultaneous with data collection processes to develop the theory. The constant comparative process form concepts outlined as Figure 1.

“Model of Main Causes of Grape Losses” (MMCGL) consisted of five categories and several subcategories of causes of grape losses in stages of pre-harvest, postharvest, and primary processing by farmers, as described in the following sections.

According to the “MMCGL”, low level of knowledge, poor attitudes, and insufficient skills in all three stages of pre-harvest, postharvest, and primary processing could
The Causes of Grape Production Chain Losses

Poor infrastructures
Causes of grape losses
 Agricultural infrastructures
lack of appropriate trellis systems, irrigation systems, harvesting equipment, and local agro-meteorology center
 postharvest infrastructure
packing, storage (sorting, grading, pre-cooling, temperature and humidity settings), and transportation (roads and vehicles)
 processing infrastructure
lack of juicing, nectar making, drying (sun drying, shade drying, and solar drying), thermal processing

Figure 1. Model of the main causes of grape losses.

derive from the absence of innovative instructional approaches, providing educational programs for farmers without requiring assessment, lack of intelligible educational programs in local media, and lack of participatory trainings on-farm. Nevertheless, researchers emphasized that extension and advisory service providers are responsible to meet needs of each group and training is vital in the process of reducing losses (Abass et al., 2014; Hailu and Derbew, 2015; Midega et al., 2016; Epeju, 2016). In addition, increasing farmers’ technical know-how and training (Abass et al., 2014), fitting technical training (Hailu and Derbew, 2015), educational innovation (Epeju, 2016), understanding local farmers’ situations and needs (Midega et al., 2016), providing information through local media (McNamara and Tata, 2015) could be aggravating factors.

According to the model, weakness of agricultural management practices, technical management, farm health and safety management, environmental management, storage management, and processing management may raise grape losses in all three stages. In other words, good and timely agricultural practices, adaptive capacity to cope with climate changes, careful attention to the farm health, and good technical skills could be responsible for reducing grape losses. Some researchers revealed that improper practices (such as improper harvesting periods, mechanical injury, poor sanitation and improper packaging) result in crops losses (Hartikainen et al., 2018; Agarwal, 2017; Kereth et al., 2013); while improving post-harvest management systems (harvesting and handling techniques, packaging, storage and transportation facility, disease and pests, climate and weather condition) is apriority for farmers (Hartikainen et al., 2018; Kasso and Bekele, 2018; Arzani et al., 2009).
Based on the model, farmers are faced with limited financial resources; mechanization and equipment limitation; water resources restriction; limited skilled human resources during grape production process; and inappropriate handling and carrying tools. In other words, inadequate funds to provide input and equipment (Mandal, 2014); poor access to mechanization (Kasso and Bekele, 2018); water scarcity; inability to control pests and diseases (Abass et al., 2014; Mandal, 2014); lack of skilled manpower and labors (Kasso and Bekele, 2018); unsuitable packaging materials and transporting tools (Kasso and Bekele, 2018; Abass et al., 2014) may lead to higher grape losses.

According to the model, poor infrastructures could be divided into agricultural, postharvest, and processing infrastructures, every type of which has several subcategories (Figure 1). For example, lack of appropriate trellis systems, irrigation systems, harvesting equipment, and suitable local agro-meteorology center are some of the agricultural infrastructure limitations. In this way, Agarwal (2017) emphasized that losses are highest for the horticultural crops due to mechanical injury, improper packaging, inadequate storage, high temperature, transportation infrastructure, and processing units. Similarly, Beausang et al. (2017) referred to lack of processing facilities and Kasso and Bekele (2018) believed that harvesting and handling, storage, transportation and marketing facilities are major causes of post-harvest loss. Also, according to Gardas et al. (2019), high costs of marketing and limited marketing infrastructures could influence the efficiency of crops supply chain process.

Based on the model, numerous types of support services affect farmer’s practices regarding high rate of grape losses. In other words, lack of financial, agricultural, advisory and legal support services might increase losses. In this regard, Ghiasi et al. (2017) indicated that smallholders in developing countries have limited access to consulting and extension services. Also, Mandal (2014) referred to inadequate government support for applied research and extension. Government financial assistance is the other factor that has been emphasized by researchers (Briones, 2013 and Li et al., 2018) through which Briones (2013) and Ghazanfari et al. (2019) avowed input subsidies, credit, investment plans as the government assistance to the farmers. Meanwhile, Rahimi-Soureh (2001) referred to assured prices and subsidy; He referred to subsidy paid as a support policy in Iran.

According to the above, the study’s hypotheses and research model were formed (see Figure 2).

**Effective and Important Causes of Grape Losses in Supply Chain**

After a comprehensive literature review on theoretical bases of the causes of grape losses, based on the model, farmers are faced with limited financial resources; mechanization and equipment limitation; water resources restriction; limited skilled human resources during grape production process; and inappropriate handling and carrying tools. In other words, inadequate funds to provide input and equipment (Mandal, 2014); poor access to mechanization (Kasso and Bekele, 2018); water scarcity; inability to control pests and diseases (Abass et al., 2014; Mandal, 2014); lack of skilled manpower and labors (Kasso and Bekele, 2018); unsuitable packaging materials and transporting tools (Kasso and Bekele, 2018; Abass et al., 2014) may lead to higher grape losses.
losses and hypothesis development, the second main objective was to determine the effective and important causes of grape losses in supply chain including: agricultural production, postharvest, and primary processing by farmers in Qazvin Province.

Based upon the objectives, this paper has concentrated on determining effective causes and important causes of grape losses in Qazvin Province. As explained earlier, the research model includes six constructs: extension and advisory services, management practices, infrastructures, resources and equipment, and support services as independent constructs, and amount of grape losses as dependent construct.

The population of this study was smallholder farmers (grape growers) who were producing grapes at five regions (Khoramdasht, Ziaabad, Yahiaabad, Esfarvarin, and Takestan) in Qazvin Province (N=). The sample of the study consisted of farmers, based on Cochran, selected through stratified random sampling. From the total sample, 92% were male and 8% were female. As to age distribution, 12% of the respondents were below 25 years old, 39% aged 26-35 years, 38% were 36-45 years, and 11% were over 46 years. In terms of educational level, majority of the respondents (83%) had only high/elementary school level education, 9% were illiterate, and only 8% had academic degree.

In this research, a questionnaire was utilized for data collection. The questionnaire encompassed 26 questions pivoting on 7-point Likert scales. The questions derived from the MMCGL (Figure 1) (categories as constructs and subcategories as items) and were confirmed with previous studies and then modified to fit to the nature of this study. Validity and reliability were measured through pre-test, which was first distributed among 30 grape growers who were not in the sample of the study. The data was analyzed using Smart PLS 3.0 to ensure the measurement items were valid and reliable. To measure convergence validity of each constructs, factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR) were used. The results showed that the value of AVE of all constructs were greater than 0.50 (Barclay et al., 1995). In addition, CR for all construct was above the acceptable value of 0.70 in this study (Hair et al., 2010). Meanwhile, each square root of the value of AVE was more than correlation coefficient (Fornell and Larcker, 1981), thus discriminant validity was also supported. Additionally, Cronbach’s alpha coefficient was used to assess the inter item consistency and the results suggested that the Cronbach’s alpha of all the research variables had an acceptable reliability and it was more than 0.70. After verifying the validity and reliability, in total, 380 questionnaires were distributed among respondents, and 375 of them, that were fully and accurately completed, were used for data analysis purposes.

To test the research model, we used the Partial Least Squares (PLS) technique of structural equation modeling with Smart-PLS 3.0 (Ringle et al., 2015). The reason to use the PLS technique was its suitability with the exploratory nature of this study. A two-step process was applied: assessment of measurement model, to evaluate reliability and validity of the variables; and assessment of structural model, to evaluate the relations among the constructs and significance of the path coefficients by bootstrapping technique (Henseler et al., 2009).

In the last step, the Importance-Performance Matrix Analysis (IPMA) of path modeling was carried out extending the findings of the basic PLS-SEM in order to determine the areas that needed to be considered and improved. However, IPMA is a different way of presenting path information by assessing the impact of latent variables with a high importance (structural model total effect) and low performance (average values of the latent variable scores) on the endogenous latent variable (Hock et al., 2010). In this case, IPMA is useful to
INTRODUCTION

In order to achieve the objectives, first, the developed model based on research model (Figure 2) in Smart-PLS 3.0 was assessed with a two-step process as follows: (a) Measurement model evaluation, and (b) Structural model evaluation. Second, in order to further investigate the constructs and to highlight the important constructs for improving the management activities, IPMA was carried out.

RESULTS

In order to achieve the objectives, first, the developed model based on research model (Figure 2) in Smart-PLS 3.0 was assessed with a two-step process as follows: (a) Measurement model evaluation, and (b) Structural model evaluation. Second, in order to further investigate the constructs and to highlight the important constructs for improving the management activities, IPMA was carried out.

Measurement Model

Initially, confirmatory factor analysis was executed to examine the reliability, convergent validity, and discriminant validity of the constructs for achieving the optimum values of parameters. As revealed in Figure 3 and Table 1, all factor loadings are higher than 0.5, and the AVE of all the reflective constructs are higher than the required value of 0.5. Besides, CR values of all the constructs are higher than the cut-off value of 0.7.

Meanwhile, to achieve adequate discriminant validity, each square root of the value of AVE was more than correlation coefficient. According to Table 2, the diagonal values of the correlation matrix were greater than the off diagonal values (Barclay et al., 1995; Hulland, 1999). Discriminant validity was also assessed using HeteroTrait-MonoTrait (HTMT) criterion (Henseler et al., 2015) and all the values were below the threshold of 0.85.

Structural Model

Structural model was assessed by evaluating the $R^2$ and path coefficient ($\beta$) values. The $R^2$ value of endogenous latent variable (amount of grape losses) was 0.703, which indicates that all the constructs significantly affect the endogenous latent variable. For the path coefficients, $\beta$ values of each path were found to be 0.419 for management practices, 0.353 for resources and equipment, 0.133 for extension and advisory services, 0.082 for infrastructures, and 0.010 for support services (Figure 3).

Figure 3. Measurement model: The main causes of grape losses.
The Causes of Grape Production Chain Losses

Table 1. Results of measurement model based on confirmatory factor analysis.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Items</th>
<th>Loadings</th>
<th>AVE</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension and advisory services</td>
<td>Edu.program. need.assess</td>
<td>0.723</td>
<td>0.648</td>
<td>0.879</td>
</tr>
<tr>
<td></td>
<td>Innovat.instruct</td>
<td>0.719</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intellig.edu.media</td>
<td>0.857</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Particip.training</td>
<td>0.905</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management practices</td>
<td>Agri.practic.manage</td>
<td>0.754</td>
<td>0.556</td>
<td>0.880</td>
</tr>
<tr>
<td></td>
<td>Environme.manage</td>
<td>0.591</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Farm.health.manage</td>
<td>0.829</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proces.manage</td>
<td>0.860</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage.manage</td>
<td>0.824</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technic.manage</td>
<td>0.560</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructures</td>
<td>Postharv.infrustruc</td>
<td>0.800</td>
<td>0.676</td>
<td>0.862</td>
</tr>
<tr>
<td></td>
<td>Process.infrustruc</td>
<td>0.902</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agri.infrustruc</td>
<td>0.758</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources and equipment</td>
<td>Financ.resource</td>
<td>0.718</td>
<td>0.637</td>
<td>0.897</td>
</tr>
<tr>
<td></td>
<td>Handl.tools</td>
<td>0.762</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechniza.equipment</td>
<td>0.842</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skilled.human.resource</td>
<td>0.873</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water.resource</td>
<td>0.787</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support services</td>
<td>Advisory.support</td>
<td>0.897</td>
<td>0.711</td>
<td>0.907</td>
</tr>
<tr>
<td></td>
<td>Agri.support</td>
<td>0.693</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Financ.support</td>
<td>0.860</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Legal.support</td>
<td>0.905</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Then, to assess the significance of all the paths, bootstrapping was performed. The path coefficient is significant if the t-value is larger than 1.96. The results showed that the relationships among extension and advisory services→grape losses, infrastructures→grape losses, and support services→grape losses, were not significant (Table 3). All other path coefficients were significant, specifically, management practices (t-value = 2.967; P = 0.000) and resource and equipment (t-value = 2.788; P = 0.005), each has significant and positive effects on the grape losses. Meanwhile, the extension and advisory services had a significant effect on management practices (t-value = 4.100; P = 0.000) and also support services had a significant effect on resource and equipment (t-value = 5.113; P = 0.000). Thus, “extension and advisory services” and “support services” had indirect effects on the grape losses. Therefore, H1a, H2, H3, and H4a are supported, whereas H1, H4, and H5 are not supported.

Importance-Performance Matrix Analysis

In the last step, IPMA was used in order to generate additional findings. We used IPMA for prioritizing both constructs and indicators separately and identifying the most important areas regarding the best grape-losses-management activities. The first step in using an IPMA is checking the requirements. Therefore, we reviewed the questionnaire and found that all the indicator data were on an interval scale from 1 to 7, a higher value represents a better outcome.

Next, we checked the signs of the outer weights, all of which were positive. Then, Smart-PLS computed the performance and important values of the constructs and indicators.

As shown in Table 4, in constructs level, “extension and advisory services”, and “management practices”, had high
Table 2. Discriminant validity and correlation between constructs.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Constructs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Extension and advisory</td>
<td>0.805</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Grape losses</td>
<td>0.545</td>
<td>0.740</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Infrastructures</td>
<td>0.238</td>
<td>0.591</td>
<td>0.822</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Management practices</td>
<td>0.581</td>
<td>0.767</td>
<td>0.593</td>
<td>0.746</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Resources and equipment</td>
<td>0.414</td>
<td>0.722</td>
<td>0.627</td>
<td>0.611</td>
<td>0.798</td>
<td></td>
</tr>
<tr>
<td>6. Support services</td>
<td>0.357</td>
<td>0.557</td>
<td>0.671</td>
<td>0.584</td>
<td>0.566</td>
<td>0.843</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Correlation is significant at the 0.05 level (2-tailed). Diagonal values are the square roots of the AVE, and below the diagonal values are the correlations between the construct values.

Table 3. Hypothesis testing, relationships between constructs.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Sample mean</th>
<th>Standard deviation</th>
<th>t-value</th>
<th>P-value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 Extension and advisory services → Grape losses</td>
<td>0.151</td>
<td>0.161</td>
<td>0.826</td>
<td>0.409</td>
<td>Not supported</td>
</tr>
<tr>
<td>H1a Extension and advisory services → Management practices</td>
<td>0.583</td>
<td>0.142</td>
<td>4.100</td>
<td>0.000</td>
<td>Supported</td>
</tr>
<tr>
<td>H2 Management practices → Grape losses</td>
<td>0.400</td>
<td>0.141</td>
<td>2.967</td>
<td>0.000</td>
<td>Supported</td>
</tr>
<tr>
<td>H3 Resource and equipment → Grape losses</td>
<td>0.358</td>
<td>0.127</td>
<td>2.788</td>
<td>0.005</td>
<td>Supported</td>
</tr>
<tr>
<td>H4 Support services → Grape losses</td>
<td>0.016</td>
<td>0.198</td>
<td>0.049</td>
<td>0.961</td>
<td>Not supported</td>
</tr>
<tr>
<td>H4a Support services → Resource and equipment</td>
<td>0.589</td>
<td>0.111</td>
<td>5.113</td>
<td>0.000</td>
<td>Supported</td>
</tr>
<tr>
<td>H5 Infrastructures → Grape losses</td>
<td>0.108</td>
<td>0.189</td>
<td>0.436</td>
<td>0.663</td>
<td>Not supported</td>
</tr>
</tbody>
</table>

Table 4. IPMA results in construct level.

<table>
<thead>
<tr>
<th>Latent variables</th>
<th>Importance</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension and advisory services</td>
<td>0.442</td>
<td>58.779</td>
</tr>
<tr>
<td>Management practices</td>
<td>0.411</td>
<td>65.575</td>
</tr>
<tr>
<td>Resources and equipment</td>
<td>0.349</td>
<td>65.962</td>
</tr>
<tr>
<td>Support services</td>
<td>0.200</td>
<td>75.945</td>
</tr>
<tr>
<td>Infrastructures</td>
<td>0.079</td>
<td>69.589</td>
</tr>
</tbody>
</table>

importance values. As indicated, the direct effect of the extension and advisory services on grape losses is not significant; meanwhile, it leaves significant indirect effect on grape losses through management practices. Therefore, the total effect (importance) of extension and advisory services is of the highest importance. In this regard, managerial actions should prioritize improving the performance of extension and advisory services. In other words, the best management for grape losses can be achieved by enhancing the extension and advisory services.

In the same way, as shown in Table 5, in indicators level, “participatory trainings on-farm”, “intelligible educational programs in local media”, and “financial resources”, were the top three areas enjoying high importance that could be focused in grape losses management activities compared with other indicators.

Furthermore, when we focus on each of the significant constructs and low performance, in extension and advisory
services, indicators such as on-farm participatory trainings and intelligible educational programs in local media need more attention from experts, researchers, and extension agents. Concerning management practices, processing management and environmental management need to improve, and about resources and equipment, reinforcement of financial resources and mechanization and equipment should be considered.

**DISCUSSION**

In Iran, in line with other developing countries, substantial amount of losses of fruits occur in initial and sometimes middle stages of supply chain, particularly for grapes, which are the most vital product of Qazvin Province; yet, great amount of it is lost annually. Therefore, the main objective of this study was determining major causes of grape losses in grape supply chain, including agricultural production, postharvest, and primary processing by farmers in Qazvin Province by using PLS-SEM and IPMA.

**Key Findings**

According to the results, “management practices” had a strong and positive effect on the amount of grape losses. This finding was consistent with Kasso and Bekele (2018) and Abass et al. (2014) who suggested that good and timely agricultural practices, and good technical skills and postharvest handling competencies could be responsible for reducing losses. This result also validated the findings of Beausang et al. (2017) and Hartikainen et al. (2018) who revealed that adaptive practices to cope with environmental changes.

Second, “extension and advisory services” has indirect effect on the grape losses through management practices. The results
suggested that appropriate education and extension services and training programs reduce losses through raising farmers’ knowledge, attitudes, and skills, which was in accordance with previous studies (Kereth et al., 2013; McNamara and Tata, 2015; Hailu and Derbew, 2015; Midea et al., 2016; Epeju, 2016).

Third, the result of IPMA in indicators level showed that “on-farm participatory trainings” have the highest importance in improving farmers’ performance and reducing grape losses. This result validated the finding of McNamara and Tata (2015) and Gadzirayi and Mafuse (2015). Gadzirayi and Mafuse (2015) indicated that farmer field schools were more effective in terms of improvement in farmers’ knowledge, skills empowerment, and change in crop practices. The IPMA results further revealed that “intelligible educational programs in local media” play a crucial role in improving farmers’ performance, which was consistent with the result of the study of McNamara and Tata (2015), who believed that an education program could utilize demonstrations through radio messages, print media, and local newspaper articles. This finding was in accordance with previous studies (Rezaei et al., 2017; Nazari and Hassan, 2011). The findings of Rezaei et al. (2017) revealed a significant relationship identified among networks and media on farmers’ perception and their activities toward better management. Nazari and Hassan (2011) indicated that mass media is an effective channel for communicating agricultural messages, which increases knowledge and influences behavior. In this regards, Kassem et al. (2019) revealed that the print media such as pamphlets are highly qualified for disseminating information. In addition, the IPMA results confirmed that “financial resources” was one of the areas enjoying great importance. This was consistent with the result of the study of Kiaya (2014) that indicated the investment was required to reduce losses. This result also validated the finding of Briones (2013) pointed out input subsidies, credit, and investment plans as the government assistance to the farmers. Meanwhile, Rahimi-Soure (2001) referred to assured prices and subsidy and indicated that the total subsidy is paid for agriculture in line with support policies in Iran.

Implications for Research

This study has several implications to the existing literature. Firstly, it should be noted that we developed and introduced the “Model of Main Causes of Grape Losses” (MMCGL) as the new theory in this area. Secondly, we used this model as the conceptual framework to identify important causes of grape losses and the results revealed that good and adaptive management practices would reduce amount of grape losses, while these practices are strongly affected by appropriate extension and advisory services. However, researchers emphasized that extension and advisory service providers are responsible to meet the needs of different actors who are involved in supply chain (McNamara and Tata, 2015), while prior studies often neglected the indirect effects of extension and advisory services through managerial skills. Thirdly, we used IPMA for prioritizing and identifying the most important areas regarding the best grape losses management activities and found that “on-farm participatory trainings” and “intelligible educational programs in local media” were two effective educational approaches that extension and advisory service providers could adopt in Qazvin Province to reduce amount of grape losses. Generally, effective extension cannot be achieved without the active participation of the farmers themselves. In participatory approaches, farmers involve in decision-making processes, development of the programs, implementing programs, and evaluating programs (Cohen and Uphoff, 1980). Therefore, on-farm participatory trainings have the highest importance in improving farmers’ performance. In addition, it seems
that mass media is an effective channel for communicating agricultural messages that increase knowledge and influences behavior of audience (Nazari and Hassan, 2011; McNamara and Tata, 2015). This is the most important contribution in our research.

Implication for Practice

From a practical perspective, this study might help extension and advisory service providers to target their training strategies facing grape growers, especially the smallholders. According to the results, “on-farm participatory trainings” and “intelligible educational programs in local media” were two effective educational tools to improve knowledge, practices, and skills of grape growers. In this regard, educational programs for farmers could be offered in proper time and appropriate manner in local media such as radio, TV, newspaper, and pamphlet. In addition, considering the expansion of mobile applications and ICT even in the rural and among illiterate farmers, training and educational programs can be presented through popular communication apps. Therefore, communication apps have become common tools for transmitting voice, video, documents, and other services in the form of groups and channels. Therefore, researchers, extension agents, and specialists can use this capacity to improve their training and extension services for grape growers and their families and receive their comments and feedbacks.

Limitation and Future Research

All studies have limitations that affect the findings. We also had some major limitations in this study that should be interpreted. First, we developed and introduced the “Model of Main Causes of Grape Losses” as the new theory in this area and, then, we examined it as the conceptual framework in this study. To confirm the validity of this model, future study should examine this model as a conceptual framework in other Provinces and even other similar crops. Second, the size of the sample in this study is relatively small, which may affect the generalizability of the findings to all grape growers. Third, in this study we concentrated on smallholder grape growers in Qazvin Province. Therefore, we can’t generalize the findings to other types of farmers in different areas. Finally, we suggest future studies investigate the role of “extension and advisory services” and “management practices”, in general, and “on-farm participatory trainings”, and “intelligible educational programs in local media”, in more details, since they were found as the highly important areas in grape losses management in Qazvin Province.

CONCLUSIONS

In this study, the “Model of Main Causes of Grape Losses” was added to previous literature about crops losses and wastes, as a new theory in this area. In addition, this study showed how the “on-farm participatory trainings” and “intelligible educational programs in local media” could be two effective educational approaches that extension and advisory service providers could adopt in Qazvin Province to reduce amount of grape losses. However, this study suggested that amount of grape losses would be reduced significantly by offering educational programs to farmers. These trainings should include issues on modern cutting, grafting, soil and grapevine nutrition, irrigation, pruning, drying, juicing, and packaging methods of the grapes or about pest and diseases management, use of hormones and micronutrients, protection of seedlings and fruits against climate change and unforeseen rain, harvesting in proper time and in appropriate manner, and pre-cooling ways. Education can be done through local media such as radio, TV, newspaper and pamphlet and through mobile applications and channels. It is necessary for future research to examine other effective factors that could decrease the grape losses in Qazvin Province.
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کاربرد مدلسازی معادلات خاک‌پوشی جهت بررسی علل ایجاد ضایعات زنجیره تولید انگور

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چکیده

انگور یکی از محصولات کلیدی استان قزوین محسوب می‌گردد و سالانه مقدار زیادی از آن در طول زنجیره تولید به جمع ضایعات می‌پیوندد. لذا، هدف اصلی این مطالعه، بررسی و ارزیابی دلایل موثر و مهم ضایعات زنجیره تولید انگور در استان قزوین است. در این راستا، ابتدا جهت تعیین دلایل اصلی ایجاد ضایعات انگور و دستیابی به چارچوب مفهومی مطالعه بر اساس آن، داده‌های مورد نیاز با استفاده از روش‌های کیفی مانند مصاحبه عميق، یادداشت در عرصه، و مورع مابع، گردآوری شد. تعداد 25 انگورکار، محترم و کارشناس یافته‌ها، توسط نمی‌تحقیق مورد مصاحبه قرار گرفتند. در همین حین، تکنیک گزارش‌های جهت تجزیه و تحلیل داده‌های جمع آوری شده و در طول فرآیند گردآوری داده‌ها، جهت دستیابی به توری و مدل، به کار گرفته شد. در دوم، فرضیه‌های تحقیق و مدل تحقیق بر اساس توری ایجاد شده از بخش اول، شکل گرفتند. سپس، برای ارزیابی و سنجش مدل تحقیق، مدل‌سازی معادلات خاک‌پوشی با راه‌حل حداکثر مربعات جزئی، و ماتریس تحلیل اهمیت-عملکرد، مورد استفاده قرار گرفت. جامعه آماری این بخش از مطالعه انگورکاران پنج ناحیه از استان قزوین بودند. پرسشنامه ای محترم ساخته برای گردآوری داده‌ها در این بخش استفاده شد و داده‌های حاصل با استفاده از نرم افزار Smart-PLS 3.0 و نرم‌افزار بهترین تحلیل‌های اهمیت-عملکرد، دو جو مورد تحقیق جزئی و تحلیل قرار گرفت. یافته‌های مهم حاصل از این بخش نشان داد تفاوت اقادات مدیریتی، و موانع و تجهیزات تأثیر مثبت و معنی داری بر ایجاد ضایعات انگور دارد. بر اساس یافته‌های حاصل از مارتریس تحلیل اهمیت-عملکرد، دو جو مورد تحقیق جزئی و تحلیل قرار گرفت. یافته‌های مهم حاصل از این بخش نشان داد تفاوت اقادات مدیریتی، و موانع و تجهیزات تأثیر مثبت و معنی داری بر ایجاد ضایعات انگور دارد. بر اساس یافته‌های حاصل از مارتریس تحلیل اهمیت-عملکرد، دو جو