*Bulgarian Journal of Agricultural Science, 31 (No 4) 2025, 823–828*

# Comparative evaluation between certified and non-certified food. The case of grapes

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## Abstract

Papadopoulos, S. & Markopoulos, Th. (2025). Comparative evaluation between certified and non-certified food. The case of grapes. *Bulg. J. Agric. Sci., 31*(4), 823–828

It is an international practice for the cultivation of grapes, intended for those of table consumption, to receive many applications of plant protection products. In particular, traditional seedless varieties of grapes are received many applications of hormones, pesticides and foliar fertilizers. The purpose of the study is to find that methodology, in which all these applications will be better managed. For this reason, a comparative evaluation was made between certified and non-certified grapes. The results showed that in the cultivation of certified grapes, there is a better management of the applications with a positive impact on the quality of the products, and also on the environment.

*Keywords:* Sustainable; integrated farming standards; pesticide residues; conventional products; certified products
*JEL classification codes:* Q10; Q15; Q18

## Introduction

The concept of integrated management in agriculture started as a market demand in the mid-1990s, with a view to implementing an alternative farming system that would not be as strict as the organic system, but would mitigate the negative consequences of various conventional farming measures (Lobstein, 1999; Morris and Winter, 1999). It was considered that the non-rational use of pesticides in conventional agriculture causes the accumulation of residues in products and this poses serious risks to human health, because pesticides are toxic substances even at low concentrations (Kaushik et al., 2009).

In order to respond to consumer concerns about food assurance issues, a strong activation of researchers and organizations has begun to define the principles of the integrated management in agriculture (IACPA, 1996; Jordan, 1993; Park et al., 1997; Proost and Matteson, 1997). So, the increased market interest in the risk to consumers' health from the pesticide management in fruit and vegetables (Codron et al., 2014) has prompted the major European retail chains to recognize substantially the integrated farming system as a golden intersection between producers and consumers (Morris and Winter, 1999), which can be applied at all stages of the productive supply chain, from the production field to the market shelf (Gellynch and Kuhne, 2007).

Although several factors influence the decrease of the pesticides' applications in fruits and vegetables (Lechenet et al., 2016), the adoption of the integrated farming systems (or farm management systems), not only contributed to the management of the pesticide residues, but also to the certification of the quality and the traceability of agricultural products (Canali, 2008; Gawron and Theuvsen, 2006). Moreover, the need for these systems supporting farmers is dealing with bureaucratic requirements (Knuth et al., 2018). The adoption of food safety and quality standards also has a positive effect on the quality performance and farmers' net income (Handschuch et al., 2013).

The integrated farming systems seem to have a positive impact on the environment, as evidenced by EU research, where 40% of the studied systems showed a quantitative reduction in pesticide infiltration in underground water, while the remaining 60% showed decreases in quantities of the applied pesticides. Also, in the 50% of the systems, there was a reduction in the nitrate filtration in water. Research has shown that this reduction in the use of fertilizers and pesticides is likely to have a positive impact on the flora and fauna of the area (European Commission DG Environment, 2003).

In Greece, the implementation of integrated management has reduced production costs. More specifically, the application of an integrated system for peach cultivation has led to a reduction in expenditure per acre to 25.1% in fertilizers and to 21.3% in pesticides. This result was due to the reduced use of pesticides and fertilizers, thus increasing the positive environmental and quality impacts (Theocharopoulos and Papanagiotou, 2005).

According to the literature, no broad research has been carried out, in order to determine the relationship between pesticide residues identified in grapes, with their integrated management. For this reason, this study compares the pesticide residues found in grapes of integrated management with those of conventional one, over a period of five years. It was based on primary data, collected through the certified reports of residue results.

The remainder of the paper includes the description of the material and methods employed.

## Materials and Method

***Sampling selection***

The survey was conducted in the prefecture of Kavala, in northern Greece, which has got the second largest production of Thompson seedless grapes in the country. A sample of 137 certified grape producers following an integrated farming system, and 86 producers following conventional viticulture were examined. All the producers submitted the pesticide residue analysis certificates of their grapes, for the last five years, from 2018, to 2022. All of these certificates issued by laboratories accredited under ISO 17025. In each certificate, the active ingredients and their quantities were determined, with a detection threshold of 0.01mg/kg.

***Methodological approach***

**Two-Factor Analysis of Variance**

In order to investigate the main effects and interactions, a two-way ANOVA analysis was conducted. In particular, the main effects, which investigated were the "Management" and the "Year", on each one of the two dependent variables (factors) used in the survey (the amount and the number of active ingredients found in residue analysis). The first factor deals with the product and is the "Management" with two levels (grapes under conventional management and certified grapes under integrated management), while the second factor is the "Year" with five levels (2018, 2019, 2020, 2021 and 2022). Both factors consider that they have fixed main effects as the levels of each factor are under investigation (Montgomery, 2012). In addition, the interaction of these two factors (Management and Year) was also tested. The model adapted to each of the two cases has the form:

$$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ij} \qquad i = 1,2 \quad j = 1, \dots ,5$$

where,

$Y_{ij}$ is the value of the dependent variable, at the level, ($i$ = 1, 2) of the factor "Management" for the year $j$, ($j$ = 1, …, 5),

$\alpha_i$ is the main influence of the level of the factor "Management" $i$, ($i$ = 1,2) on the value of each dependent variable

$\beta_j$ is the main effect of the year $j$, ($j$ = 1, …, 5),

$(\alpha\beta)_{ij}$, ($i$ = 1, 2 $j$ = 1, … ,5) is the interaction between the level of "Management" $i$ and the year $j$,

$\mu$ is the true average of all observations

$\varepsilon_{ij}$ is the random error.

## Results

**Check for the quantity of the active ingredients**

In order to seek for differences in the quantity of active ingredients found in the residue analysis of certified and non-certified grapes, a two-factor analysis was performed. In this case, the dependent variable is the total amount of active ingredients, while the first factor is the "Management", with two levels (certified and conventional grapes), and the second factor is the "Year" (Table 1).

The results (Table 2), initially showed that there was no interaction ($F$ (4.237) = 2.147 with p-value = 0.076 > 0.05)) between the "Year" and the "Management", at a materiality level of 5%. This means that the effect of "Management" on the quantity of active ingredients found in the residue analysis does not appear to be different for the five different years. Therefore, if there is no interaction, the main effects of both "Management" and the "Year" can be researched. The con-

**Table 1. Dependent Variable: Quantity of Active Ingredients**

| Management | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Certified | 0.578 | 0.123 | 0.336 | 0.820 |
| Conventional | 1.213 | 0.149 | 0.920 | 1.506 |

trol of the main effect of the "Management" on the quantity of active substances detected in residue analysis appears to be significant at the 5% level of significance (Table 2, F (1, 7.777) = 6.705 with p-value = 0.033 < 0.05).

This means that there are differences between certified and conventional grapes in terms of the amount of active ingredients detected. The Bonferroni Multiple Comparison Test (Table 3) showed that certified grapes had an average of 0.636 mg/kg of less active ingredients than the conventional (uncertified) ones. The sample means and standard deviations for each management category are following:

The control of the main effect of the "Year" showed that there were significant differences between years relative to the total amount of active ingredients detected in the grapes (Table 2 F (4, 4) = 5.985 with p-value = 0.011 < 0.05).

As shown by the multiple comparisons and the corresponding averages of Table 4, these differences are mainly found in the years 2018, and 2019, where most of the active ingredients appear to be detected in conventional grapes. After 2020, there seems to be almost no difference in the amount of active ingredients detected in certified and conventional grapes (Figure 1).

Check for the number of the active ingredients

In order to investigate the differences in the number of active ingredients detected between certified and conventional (uncertified) grapes, a two-factor analysis was performed as mentioned. The dependent variable in this case is the total number of active ingredients, while the factors remain the "Management" and "Year". Moreover, in this case the interaction between the two factors was investigated, i.e. whether the categories of one factor differ for each category of the other factor (Table 5).

**Table 4. Dependent Variable: Quantity of Active Ingredients**

| Year | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| 2018 | 1.103 | 0.335 | 0.442 | 1.764 |
| 2019 | 1.809 | 0.268 | 1.280 | 2.337 |
| 2020 | 0.377 | 0.113 | 0.154 | 0.600 |
| 2021 | 0.355 | 0.150 | 0.059 | 0.650 |
| 2022 | 0.835 | 0.113 | 0.613 | 1.057 |

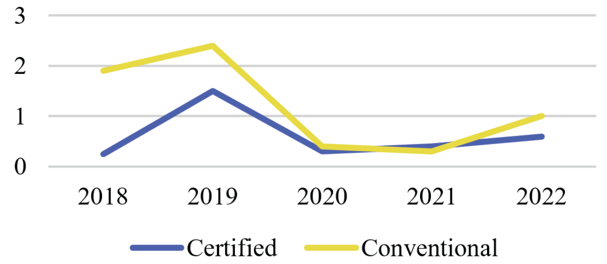


**Fig. 1. Estimated Marginal Means of Quantity of Active Ingredients**

**Table 2. Dependent Variable: Quantity of Active Ingredients**

| Type III Sum of Source | | Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Intercept | Hypothesis | 93.139 | 1 | 93.139 | 17.605 | 0.009 |
| | Error | 25.767 | 4.870 | 5.290 | | |
| Managment | Hypothesis | 11.728 | 1 | 11.728 | 6.705 | 0.033 |
| | Error | 13.604 | 7.777 | 1.749 | | |
| Year | Hypothesis | 35.489 | 4 | 8.872 | 5.985 | 0.111 |
| | Error | 9.275 | 4 | 2.319[c] | | |
| Managment *Year | Hypothesis | 9.275 | 4 | 2.319 | 2.147 | 0.076 |
| | Error | 255.953 | 237 | 1.080 | | |

**Table 3. Dependent Variable: Quantity of Active Ingredients**

| Mean Difference | | | Std. Error | Sig.[b] | 95% Confidence Interval forDifference[b] | |
|---|---|---|---|---|---|---|
| (I) Management | (J) Management | (I-J) | | | Lower Bound | Upper Bound |
| Certified | Conventional | -0.636* | 0.193 | 0.001 | -1.016 | -0.256 |
| Conventional | Certified | 0.636* | 0.193 | 0.001 | 0.256 | 1.016 |

Based on estimated marginal means*

The mean difference is significant at the 0.05 level.

[b] Adjustment for multiple comparisons: Bonferroni

**Table 5 Dependent Variable: Number of Active Ingredients**

| Management | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Certified | 4.398 | 0.267 | 3.872 | 4.924 |
| Conventional | 4.978 | 0.323 | 4.341 | 5.615 |

The results in Table 6 initially showed that there was no interaction (F (4.237) = 1.887 with p-value = 0.113 > 0.05) between “Year” and “Management” at materiality level 5%. Therefore, the main effects of both the “Year” and “Management” can be investigated on the number of active ingredients detected.

The control of the main effect of “Management” on the number of active ingredients appears to be not significant at the 5% level of significance (Table 6, F (1, 8.389) = 1.294 with p-value = 0.287 > 0.05). This means that there are no differences between certified and conventional (uncertified) grapes in terms of the number of active ingredients detected in the residues’ analysis. The sample means and standard deviations for each management category are following:

The control of the main effect of the year also showed, even marginally, that there were no significant differences between years over the total number of active ingredients detected in grapes (Table 6, F (4, 4) = 6.169 with p-value = 0.053> 0.05). The sample means and standard deviations for each year are presented on Table 7 and Figure 2.

## Discussion

The adoption and implementation of integrated management depends on many factors that deal with the characteristics of the producers, their behavior and the subsidies of the Common Agricultural Policy (Papadopoulos and Markopoulos, 2015; Papadopoulos et al., 2016). This means that a producer’s decision to adopt a system of integrated management is mainly led by the market, which only requires certified

**Table 7. Dependent Variable: Number of Active Ingredients**

| Year | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| 2018 | 3.792 | 0.729 | 2.355 | 5.228 |
| 2019 | 7.667 | 0.583 | 6.517 | 8.816 |
| 2020 | 3.523 | 0.246 | 3.039 | 4.008 |
| 2021 | 3.875 | 0.326 | 3.232 | 4.518 |
| 2022 | 4.583 | 0.245 | 4.101 | 5.066 |

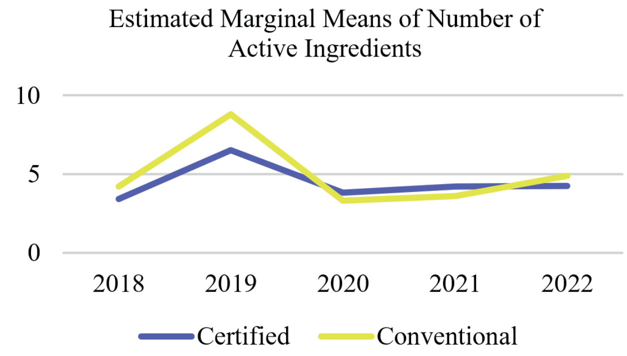


**Fig. 2. Estimated Marginal Means of Number of Active Ingredients**

products and less by the need for pesticide and residue management in the fruit and vegetables produced.

At the same time, there are many factors that affect the reduced use of pesticides, and thus the reduced pesticide residues in fruits and vegetables. In many cases however, the number of active ingredients and the total amount of residues detected in fruits and vegetables is imposed by the market and, above all, by European supermarket chains purchasing these products. They have adopted stricter rules than the European legislation.

One of the main reasons for the certification of the integrated management systems is the pesticide management. Among the main procedures of this system is the recording of all applications of pesticides and fertilizers accepted by

**Table 6. Dependent Variable: Number of Active Ingredients**

| Type III Sum of Source | | Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Intercept | Hypothesis | 2552.390 | 1 | 2552.390 | 74.038 | 0.001 |
| | Error | 158.768 | 4.605 | 34.474 | | |
| Management | Hypothesis | 9.780 | 1 | 9.780 | 1.294 | 0.287 |
| | Error | 63.385 | 8.389 | 7.555 | | |
| Year | Hypothesis | 237.825 | 4 | 59.456 | 6.169 | 0.053 |
| | Error | 38.554 | 4 | 9.638 | | |
| Management * Year | Hypothesis | 38.554 | 4 | 9.638 | 1.887 | 0.113 |
| | Error | 1210.261 | 237 | 5.107 | | |

the crop. The pesticide residues will be tested on the harvested product to confirm the compliance of the final product with the legislation. But, does plant protection program differ in a certified vineyard from a conventional one?

Since 2001, when the certification of integrated management was timidly started, perhaps the difference was great, but there is no evidence to confirm it. Concerning this survey data, in 2018 and 2019, a difference between grapes of integrated and conventional agriculture was shown as regards the total amount of pesticide residues, detected in the laboratory analysis. This was an expected outcome if we take into account the reasons behind the development of these integrated systems.

However, in the last three years there does not appear to be a statistically significant difference between certified and conventional grapes. This is a result that needs further investigation, as this means that conventional producers either reduced the pesticide applications or changed the application protocol. Perhaps, the reduction of applications is due to weather conditions.

Finally, it is noteworthy that there is no statistically significant difference between certified and conventional grapes as regards the number of active ingredients detected in the residue analysis.

## Conclusion

The current research sheds light on a rather unexplored field of how the Integrated Farming Systems respond to the management about the pesticide residues on fruits and vegetables. Though geographical limitation, the findings shows that the total amount of active ingredients detected was higher in grapes of following the conventional farming than those of integrated farming. Although the result was expected as IFS has a process that manages pesticide applications, this difference in the total amount between the two systems is not significant in the recent years. Also, important is the fact that no banned active ingredient was found in both systems. Although the conventional producers are obliged to follow good agricultural practices and cross- compliance, no exceedance of the pesticide residue levels (MRLs) in their grapes was observed.

The most interesting result of the research is that all the grapes, certified and conventional, are safe for consumption, as all the analyzes shows that all the active ingredients that have been detected are authorized for vine cultivation, and are below the maximum residue level (MRLs). Despite the fact that consumer preferences are influenced by a number of factors (Brankov et al., 2019), the importance of this research lies in the fact that, in general, consumer demands for food are constantly increasing, and therefore the need to apply contemporary food production systems, such as the aforementioned.

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*Received:* **January, 04, 2024**; *Approved*: **July, 07, 2024;** *Published:* **August, 2025**