Research article

Journal of Agricultural Biotechnology (JOINABT) 6(2), 67-80, 2025

Recieved: 28-Aug-2025 Accepted: 5-Nov-2025

https://doi.org/10.58728/joinabt.1773243

SAKARYA UNIVERSITY OF APPLIED SCIENCES

Assessment of Pesticide Preference and Applications Among Hazelnut Farmers in Türkiye

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ABSTRACT

Hazelnuts are one of Türkiye's most important agricultural export products. In the past decade, the negative impact of non-pest factors and organisms on hazelnut farming has led to the widespread use of chemical control. In Türkiye, there are legal regulations regarding the production, sale, use, and storage of pesticides, the calibration of equipment used in pest control, the use of personal protective equipment, and the protection of sensitive and wetland areas. However, especially in small enterprises, there is insufficient information on whether these regulations are being followed in chemical control practices. This study highlights the critical need for comprehensive farmer education programs focused on pesticide use, storage, and safety. Furthermore, strengthening regulatory oversight and increasing awareness about sustainable practices are essential to ensure environmental protection and product safety. This research utilized surveys conducted in the primary hazelnut-producing region of Ordu, Giresun, Trabzon, Samsun, Sakarya, and Düzce, which collectively account for about 90% of hazelnut production in Türkiye, examines the socio-demographic characteristics of farmers, their decision-making processes in plant protection activities, pesticide selection and prescription, pesticide purchasing and storage, preparation for application, and equipment usage. Based on the results, it is recommended that agricultural policies focus on developing region-specific educational programs for farmers. Additionally, stricter enforcement of pesticide regulations, including mandatory record-keeping for pesticide use, is necessary to ensure compliance. Collaboration with local agricultural cooperatives and government agencies could facilitate the dissemination of best practices. Future research should explore the potential of integrating precision agriculture tools to further optimize pesticide usage and reduce environmental impact.

Keywords: *Corylus avellana* L., Sustainable hazelnut farming, Agricultural practices, Farmer behavior

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Cite as: Taylan, E. & Bayat, A. (2025). Assessment of Pesticide Preference and Applications Among Hazelnut Farmers in Türkiye, *Journal of Agricultural Biotechnology,* 6(2), 67-80. https://doi.org/10.58728/joinabt.1773243

1. Introduction

Hazelnuts, which have a production area exceeding 1 million hectares in the world, are the most produced nuts after cashews, almonds, and walnuts. The production area of important hazelnut-producing countries has been increasing in recent years. Türkiye is the leader in both production area (71%) and production amount (63.5%). In production, Türkiye is followed by Italy, the United States, Azerbaijan, Georgia, Chile, China, Iran, and Spain, respectively [1]. Türkiye ranks first in the world in hazelnut production as well as in export. When 2024 world hazelnut export data is examined, Türkiye's share in world hazelnut exports is approximately 59%. According to the data of 9% of Türkiye's plant product export income, approximately 2.5 million dollars, was obtained from hazelnut exports [2]. Türkiye's place in the world hazelnut market is directly proportional to the abundance of production areas. Compared to hazelnut-producing countries, Türkiye's productivity per unit area remains quite low. Hazelnut yield per decare is 284 kg in the United States, 194 kg in China, 180 kg in Georgia, 144 kg in Chile, 138 kg in Azerbaijan, and 102 kg in Italy. Although Türkiye's average yield is 75 kg/da, this figure was 95 kg in 2023 [1]. Although there are many agricultural reasons for the low productivity in our country, one of the main reasons is the lack of adequate and technical control against diseases and pests [3]. Various organisms such as bacteria, fungi, viruses, insects, and mites can cause various diseases and damage in hazelnuts and negatively affect the yield. While some factors cause direct damage to the nut and cause serious losses in the product, others cause damage to different plant organs, the damage occurs over a long period, or even the plant dies completely. The spread and intensity of diseases and pests vary by region and year [4]. The most commonly used method to combat diseases and pests that cause damage in hazelnut orchards is chemical control. Although the least pesticide use in our country is in the Black Sea region, pesticide use in hazelnut farming is increasing every year due to changing conditions.

The use of pesticides, one of the most important agricultural inputs, aims to increase product quantity and quality. Pesticides have high effectiveness in agricultural control and are an economical way to produce rapid results when used consciously and in a controlled manner. Intensive agricultural production is not possible without pesticides, which are indispensable for modern agriculture, and if production is carried out without the use of pesticides, there may be great losses in production amount [5]. Pesticides pass into the air, water, and soil, and from there to other living creatures living in these environments. The movements of a pesticide in the environment are affected by factors such as its chemical structure, physical properties, formulation type, application method, climate, and agricultural conditions [6]. The release of pesticides into the air may cause residue and toxicity in other non-target organisms and plants [7,8]. Pesticides remaining on the soil surface after soil and plant applications can reach groundwater and other water resources by being washed downwards in the soil or as surface runoff with rainwater [9]. The negative effects of unconscious use of pesticides on both the health of operators and the flora and fauna do not appear as quickly as the positive effects. The fact that hazelnut-producing enterprises in our country have small areas and those traditional methods are still used in the fight against diseases and pests increases the use of pesticides in hazelnut-production areas.

According to the results of the 2001 General Agricultural Census in Türkiye, there are a total of 3.075.516 agricultural enterprises in rural areas. In 67.43% of these enterprises, both crop production and animal breeding are carried out, in 30.21%, only crop production is carried out, and in 2.36%, only animal breeding is carried out [10]. Specialization is not common in agricultural enterprises throughout the country, and the mixed enterprise type, where plant and animal production is carried out together, is predominant, and the majority of these are family type enterprises [11]. For this reason, knowing the socio-demographic structure of the operators and their attitudes on this issue is extremely important in terms of determining the resources that are effective from pesticide selection to the purchasing process

and the existence of tools and equipment used in the fight, and determining and revealing the factors affecting the conscious use of pesticides.

This study aims to explore pesticide selection and application behaviors among hazelnut farmers in the Black Sea region, with a particular focus on how educational background, farming practices, and access to information influence decision-making. The research seeks to answer the following questions: (1) What are the key factors guiding farmers' pesticide selection? (2) How well do farmers adhere to recommended practices for pesticide use and storage? (3) What barriers exist to sustainable pest control methods?

2. Material and Method

2.1. Research area and data collection

This study, which reveals the experiences of hazelnut farmers on pesticide selection and applications in the fight against diseases and pests, was carried out with the resources available by the Hazelnut Research Institute Directorate in 2019 in a total of 25 districts in Giresun, Ordu, Samsun, Sakarya, Trabzon, and Düzce provinces, which account for approximately 90% of the hazelnut production in our country.

In this research, the collected data were analyzed using descriptive statistic in SPSS 23, including frequency distributions, percentages, and standard deviations. Additionally, chi-square tests were conducted to determine relationships between farmers educational background and their pesticide application practices. A reliability analysis was performed on the survey data to ensure internal consistency (Cronbach's alpha=0.85). This detailed approach enhances the robustness of the findings and ensures their validity.

In order to determine the number of surveys that could best represent the study area, the sample size was determined as 383 by "Proportional Random Sampling" [12]. The sample size was distributed proportionally according to provinces and districts; the confidence interval was taken as 95% and the margin of error was 0.05. The number of surveys to be held in the provinces of Ordu, Giresun, Trabzon, Sakarya, Samsun and Düzce has been determined as 112, 94, 59, 44, 41, and 33, respectively. Pre-prepared questions were applied to randomly selected operators through a face-to-face survey. The general outline of the survey was composed of questions regarding the age and education status of hazelnut farmers, as well as pesticide selection processes, storage of the supplied pesticide, preparation for application, acquisition, selection, and maintenance of application equipment.

2.2. Data analysis

The collected survey data were analyzed using the SPSS 23 software, incorporating descriptive statistic (e.g., frequency, percentages) and evaluated with the SPSS 23 package program. Tables were created using descriptive statistic consisting of frequency, percentage and standard deviation.

3. Results and Discussion

These findings align with previous research indicating that smallholder farmers in Türkiye often rely on their own experience and dealer recommendations rather than formal agricultural advice [13]. The continuous use of the same pesticide by 31.3% of farmers suggests a lack of awareness about resistance management, which is a growing concern in modern agriculture. Similar trends have been reported in other studies on pesticide use in the region [14].

Regulatory authorities should consider implementing periodic training programs to enhance farmers knowledge and promote sustainable pest management practices.

3.1. Gender, Age, and Educational Status of farmers

As is the case with most agricultural enterprises in our country, hazelnut farming enterprises are generally small family enterprises. In these enterprises, hazelnut farming is continued with traditional methods, and adjusting input costs, increasing productivity, and growing healthy products for the consumer depends on the sociodemographic structure of the farmer, economic situation, and desire to access information and information sources. All farmers included in the study are male, and their ages are grouped into two groups: 18-39 and 40 years and above. There were 63 farmers in the 18-39 age group and 320 farmers in the >40 age group (Table 1).

Table 1. Age distribution of farmers participating in the survey

Age	Frequency (Number)	Ratio (%)
18-39	63	16.4
>40	320	83.6
Total	**383**	**100.0**

A study found that the average age of hazelnut farmers is 50.41 years [15]. Similarly, revealed that 46 hazelnut farmers in Giresun Province fall within the 46-59 age range [16]. This demographic trend is also evident in regional studies; for instance, a master's thesis focusing on hazelnut production in Kocaeli revealed that the majority of producers, 52%, were aged 55 years and over [17]. Additionally, research on Sakarya apple farmers showed that 87.6% of these farmers are between the ages of 36 and 67 [18].

It was determined that 216 of the farmers whose educational status was evaluated were at primary level, 135 were at secondary level, and 32 were at higher education level (Table 2). In the study conducted with hazelnut farmers in Düzce province, it was stated that the rate of primary school graduates was 33% [14]. In the study involving hazelnut farmers, the low education level was determined as 78.5% [15]. In another study conducted in Ordu province, it was reported that 24.5% of hazelnut farmers were primary school graduates [19]. The low education level is seen in the study conducted with hazelnut farmers in Giresun province [20]. In the study conducted with apple farmers in Sakarya province, it is seen that the rate of farmers with low education levels is 73.2% [18]. Regarding the educational background in Kocaeli, the majority of producers (83%) are primary or high school graduates, with only 17% holding an undergraduate or postgraduate degree. This low educational profile is reflected in the high share (75%) of primary school graduates among farmers with a low level of pesticide awareness [17]. In a study conducted in Tokat province, it was concluded that a high percentage of farmers were primary school (48.42%) and secondary school (33.68%) graduates [21]. The low education profile is a widespread regional characteristic; research in Sakarya further showed that 95.1% of hazelnut producers had received only primary or high school level education. Crucially, the study also revealed that hazelnut producers involved in Good Agricultural Practices (GAP) had higher educational backgrounds compared to those not implementing GAP [22].

Table 2. Education levels of farmers participating in the survey

Education Level	Frequency (Number)	Ratio (%)
Illiterate	3	0.8
Literate	11	2.9
Primary school	201	52.5
Primary education	1	0.3
Middle school	62	16.2
High school	73	19.1
College	9	2.3
University	23	6.0
Total	**383**	**100.0**

3.2. Farmers Perspective on Hazelnut Diseases and Pests and the Number of Treatments Made in the Same Production Season

Although many diseases and pests that limit hazelnut cultivation have been identified to date (Anonymous, 2017), the diseases and pests that farmers effectively combat in the field vary according to years and damage rates; nut weevil (*Curculio nucum*), green shield bug (*Palomena prasina*) , fall webworm (*Hyphantria cunea*), cockchafer (*Melolontha melolontha)* and powdery mildew (Erysiphaceae). In addition, the Citrus long-antennae horned beetle (*Anoplophora chinensis*), which was seen in the Trabzon Macka location in 2016, spread to an area of 409 ha by 2021 [23]. It is also known that the damage caused by brown marmorated stink bug (*Halyomorpha halys*) has increased recently. When the answers given by the farmers s to the question of the pests that most affect hazelnut farming were examined, 86.4% (331) responded to the hazelnut borer, 5% (19) to the fall webworm, 2.6% (10) to the pest, and 34.7% (133) to the question about diseases and weeds, and powdery mildew and 32.9% (126) of weeds. It has been determined that farmers in the Western Black Sea region are more harmed by the fall webworm. A study on pesticide awareness in Kocaeli showed that chemical control is preferred over other methods, with herbicides being the most commonly used input, followed by insecticides. Critically, 51% of producers rely on recommendations from pesticide dealers for adjusting chemical doses, rather than reading product labels [17]. Especially in the Eastern Black Sea Region, where 50-55% of hazelnut production is met, increasing the awareness of farmers about the possible risks of pesticides without the need for intensive pesticide programs is important for sustainable hazelnut cultivation.

When the number of pesticide applications by farmers within the same production season was investigated, it was determined that 31.3% (120) sprayed once, 29.8% (114) sprayed twice, 23% (88) sprayed three times, and 11.7% (45) sprayed four times. In the same season, chemical control in hazelnut was concentrated between 3 (32%) - 4 (43%) in the Western Black Sea Region and 1 (39%) -2 (33%) in the Eastern Black Sea Region. It is seen that 61.1% of the farmers spray once or twice a year. Although this situation can be interpreted with the diversity in the pest population of the Western Black Sea Region, farmers may have to spray less in hazelnut production in the Eastern Black Sea Region, which is cultivated in rugged and difficult terrain conditions, due to reasons such as lack of suitable tools and

equipment and lack of labor force. However, manual control methods are still highly preferred by producers; a study indicated that mowing (89%) and animal grazing (43%) are the most frequently used methods for weed control. Consistent with this preference for traditional methods, chemical control (herbicide use) was reported as the least utilized method, applied by only 9% of farmers [24].

3.3. Prescribing of Pesticides

When examining the prescription status of the pesticides that farmers would use, it was found that 69.7% (267) responded "no", 26.4% (101) responded "always", and 3.9% (15) responded "sometimes" (Table 3). The prescription and sale of pesticides through a pharmaceutical system would reduce the influence of dealers in diagnosis and treatment. Although Türkiye has a plant protection products (PPP) database application, prescription, barcode, and QR code applications, the fact that these applications are not used in many parts of our country by agricultural chemical dealers and, consequently, by district agriculture and forestry directorates makes it difficult to record and control the amounts of pesticides used in terms of active ingredient types. This practice poses significant risk to food safety and sustainability within the country and also results in residue issues in exported food products [25].

Table 3. Pesticide prescribing approach

Prescribing Approach	Frequency (Number)	Ratio (%)
Sometimes	15	3.9
Always	101	26.4
No	267	69.7
Total	**383**	**100.0**

With the analysis of the data collected to determine the farmers sources of information in pesticide preference, it is seen that 88.3% of the farmers consider pesticide dealers when choosing pesticides (Table 4). The fact that dealers, who are likely to have commercial concerns, are so active in pesticide preference shows that the possibility of increasing the negative effects of risks arising from pesticides should not be ignored. In a study conducted with Sakarya apple farmers, the results regarding information on the drugs used showed that farmers took into account the recommendations of pesticides dealers at a rate of 33% and acted according to their knowledge and experience at a rate of 20.6% when deciding on the pesticides they would use for protection [18]. Although the source of information on pesticides consulted by the farmers was mostly pesticide dealers in both regions, more farmers in the Eastern Black Sea Region communicated with Agricultural Consultants (7%).

Table 4. Source of information in pesticide preference

Guide Resources in Pesticide Selection	Frequency (Number)	Ratio (%)
Chambers of Agriculture	1	0.3
TV, Internet	2	0.5
Own Experiences	3	0.8
Neighbor, Relative Suggestion	4	1.0
Agricultural Credit Cooperatives	4	1.0
Agriculture Forestry Organization	8	2.1
Agriculture Consultants	23	6.0
Pesticide Dealers	338	88.3
Total	**383**	**100.0**

3.4. Purchasing Pesticide

As a result of the analysis of the answers given by the farmers participating in the survey to the question of the most important factor they consider when purchasing pesticides, 34.5% (132) said the effect, 30% (115) the brand, 17.8% (68) the expiration date, it is seen that 6.8% (26) take into account the fact that it has been tried, and 6.3% (24) take the price into account (Table 5). The main reason why farmers focus on the effect and therefore the brand when purchasing agricultural pesticides, and the low rate of farmers taking factors such as expiration date and price into consideration is their concerns about the market value and product yield of their products. A the study it was determined that 81.5% of the farmers pay attention to whether pesticides are licensed or not when purchasing them, and in the study of [26]. it was determined that 93.75% of the farmers pay attention to the expiration date when purchasing pesticides. Considering that the brand of any pesticide stands out due to its effect, it can be said that 64.5% of the farmers in this study purchased pesticides by taking into account the effect level of the drug. In the data collected about the use of the same pesticide every year, it was seen that 31.3% (120) of the farmers had been using the same pesticide for 5-10 years, 29.8% (114) for 3-5 years, and 15.4% (59) for 1-3 years. 23.5% (90) of the farmers declared that they do not use the same pesticide (Table 5). When the results are examined, it is seen that hazelnut farmers do not have an awareness about the resistance of diseases, pests and weeds to pesticides. The decrease in the bio efficacy of the applied pesticides will cause farmers to experience economic losses, residue problems by applying higher doses, and more pollution to the environment.

In another study conducted with hazelnut farmers, regarding the reasons for farmers changing pesticides, 35% of the farmers stated that the pesticides were ineffective, 29% stated that they were price (other), 18% stated that new pesticides were released to the market, and 18% stated that pesticides were harmful to human and environmental health. It was determined that they changed according to their negative side effects [14].

Table 5. Habit of using the same pesticide

Using the Same Pesticide	Frequency (number)	Ratio (%)
1-3 Years	59	15.4
I change	90	23.5
3-5 Years	114	29.8
5-10 Years	120	31.3
Total	**383**	**100.0**

To the question "Do you get enough information about the product and its use before or after purchasing pesticides?", 53.3% (204) of the farmers answered "no" and 46.7% (179) answered "yes", and the farmers declared that they received sufficient information; 27.7% (106) from pesticide dealers, 7% (27) from labels, 6.3% (24) from Agriculture and Forestry organizations, 3.4% (13) from technical consultants, 2.1% (8) from internet, catalog etc. It is seen that they meet the information from the sources (Table 6).

Table 6. Source of information when purchasing pesticides

Information source	Frequency (number)	Ratio (%)
Neighbor	1	0.3
Internet	8	2.1
Advisor	13	3.4
Agriculture Forestry Organization	24	6.3
Ticket	27	7.0
Dealer	106	27.7
None	204	53.3
Total	**383**	**100.0**

It is seen that the majority of the farmers, 53% do not need sufficient information when purchasing pests and rely on their own experience, while 46% of the farmers who receive sufficient information get the information from the dealer. The possibility that farmers who act according to their own experiences and get information from dealers may ignore possible risks that may arise due to their commercial concerns may lead to an increase in the negative effects caused by pesticides.

3.5. Storage of pesticides

When examined where farmers store the pesticides they supply, 48% (184) are in cellars, etc. It is seen that they keep them in a structure outside the house, 20.4% (78) in the barn, 9.9% (15) in the house, and 3.9% (15) on the balcony. It was concluded that only 17.8% (68) of the farmers provide storage in a special cabinet and the awareness rate of this situation is quite low.

In a study conducted in the central district of Tokat province, it was concluded that the rate of farmers storing pesticides in a suitable warehouse was 32.35% [21].

3.6. Preparation of Pesticides for Application

As a result of the analysis of the answers given to the questions asked to the farmers in order to scale the process of preparing pesticides, the rate of the farmers who read the product labels is 42.8% (164). When asked which method they follow if there is a situation they cannot understand, 28.2% (108) of the farmers said they received technical information, 14.4% (55) said that they continue to use and 0.3% (1) stated that they do not use it. Operators must prepare and practice by being aware of the phrases "Highly Toxic", "Toxic", "Moderately Toxic", "Slightly Toxic" on the labels. It is seen that only 12% (46) of the farmers know what the abbreviations indicating the formulation types on the product labels mean. The aim of applying plant protection products is to deliver the effective substance to the plant surface at the specified dose and distribute it homogeneously, making the spraying economical and reducing environmental pollution to a minimum. The amount of active substance or preparation that must be applied to the unit area or unit volume to be effective on the target organism is called dose. In the process of preparing pesticides, farmers awareness of dose selection and label reading is important in terms of the economics of the application and its effects on the environment.

In a study where the tendency of operators to apply the recommended dose was determined, it was observed that 34.2% of the operators used more than the recommended dose. Although it is pleasing that 62.9% of the operators complied with the recommended dosage, it was concluded that 39.7% of the operators took into account the pesticide dealers' recommendation and 29.5% took their own experiences into consideration. The main reason behind the use of doses higher than the recommended dose is the idea that diseases, pests and weeds can be combated more effectively with the use of high doses. It is seen that distrust towards medicines and concerns about the market value of the product affect approximately 35% of hazelnut farmers. This situation; causes economic losses for farmers, durability problems, and acceleration of ecological degradation [13]. When asked about the importance of the phrases toxic and very toxic to them, operators responded that 79.4% (304) did not mean anything, 13.6% (52) said they prepared it more carefully, 6.5% (25) said they prepared it as they would other pesticides, 0.5% (304) said they prepared it according to the label. It is seen that the label information of the pesticides used in protection activities is not taken into account, and information such as formulation types and active substance information are not taken into consideration. Pesticide spraying aims to kill all insects in the orchard, and negative effects are not considered. Farmers need to know the label information for environmental balance.

In another study, regarding the criteria for determining the pesticide dose of the farmers, most of them (47%) determined the pesticide doses according to the label on the pesticide, 18% according to the recommendations of pharmaceutical dealers, 18% according to the technical staff of the Provincial/District Directorate of Agriculture and Forestry, % It was determined that 12 of them made decisions based on their own knowledge and experience, and 6% based on other people [14].

It is seen that 89% (341) of the farmers use their own pesticide scale, 5.2% (20) use a tea glass, 5% (19) use their own scale, and 0.8% (3) use a water glass (Table 7). Similar results were obtained in the study showing that 69.74% of the farmers used their own pesticide measuring cup, 25% used a teacup, and 5.26% used a water glass as a measuring tool [27]. Any device that can be used other than the pesticide's own measuring cup may cause problems in adjusting the dose of the pesticide and will cause economic and ecological problems. It was concluded that the farmers in the study area are aware of this issue. For instance, a study conducted in Ordu highlighted a significant deficiency in environmental and ecosystem awareness regarding pesticide application: 52.50% of hazelnut producers did not consider bee colonies before application, and 69% failed to inform local beekeepers [20].

Table 7. Use of measuring cup

Scale Container	Frequency (Number)	Ratio (%)
Water glass	3	0.8
My own scale	19	5.0
Tea cup	20	5.2
Pesticide scale	341	89.0
Total	**383**	**100.0**

It was concluded that 59.8% (229) of the farmers prepared pesticides for use in the orchard, 26.9% (103) in the water source, 9.1% (35) at home, and 4.2% (16) in the village/neighborhood fountain (Table 8). Especially considering the land structure of the Eastern Black Sea region, small water resources pass through the farmers orchards and most of the farmers who declare that they prepare pesticides in the orchard do this preparation in places that interfere with large water resources. When we add to this ratio the farmers making preparations in water resources and village/neighborhood fountains, it is seen that more than 90% of the farmers act unconsciously when preparing pesticides for use.

Table 8. Preparing pesticides for use

Preparing for Use	Frequency (Number)	Ratio (%)
Fountain	16	4.2
House	35	9.1
Water supply	103	26.9
Orchard	229	59.8
Total	**383**	**100.0**

Of the farmers whose application situations by mixing pesticides were analyzed, 33.9% (130) never applied by mixing, 31.3% (120) applied by mixing 2 pesticides, 27.4% (105) received expert opinion, 4.4% (17) concluded that applied by mixing 3 or more pesticides (Table 9). Using pesticides by mixing them is a technical issue, and it is seen that 63.1% of the farmers use 2 or more pesticides by mixing them. As a result of these unconscious processes, the physical and chemical structures of the pesticides may deteriorate, and the resulting mixtures may cause toxic effects on trees [29].

Table 9. Farmers approach to application by mixing two different pesticides

Mixing Pesticides Together	Frequency (Number)	Ratio (%)
I gave up	28	7.9
I gave up, more	17	4.4
I get expert opinion	105	27.4
2 Medicine	120	31.3
Never	130	33.9
Total	**383**	**100.0**

When asked how they cleaned the sprayer after spraying, 40.5% (155) of the farmers said they rinsed it once with clean water, 22.7% (87) waited until the next spraying, and 19.1% (73) said they cleaned it with pressurized water. It was observed that 17.8% (68) of them answered that they cleaned it by filling it with one-third of water. Among the farmers who clean the sprayer, 33.2% (127) pour it on one side of the orchard, 18.8% (72) spray it on empty land, and 17.5% (67) use it in irrigation canals and streams, etc. It was concluded that 10.2% (39) of them disposed of medicated water by pouring it into water sources and sewers.

3.7. Sprayer Usage

It is seen that only 10.2% (39) of the examined enterprises spray with rented machines, 24.8% have orchard sprayers, 19.8% have mechanical knapsack sprayers, 51.4% have motorized backpack sprayers, and 3.4% have wheelbarrow orchard sprayers (Table 10). The difference in land structure between the two regions directly affects farmers in use of spraying usages. While big sprayers that can be connected to the tractor are used in the Western Black Sea region, mechanical or motorized back spray pumps are mostly used in the Eastern Black Sea region.

Table 10. Sprayer use of farmers participating in the survey

Used Sprayer	Frequency (Number)	Ratio (%)
Motorized backpack atomizer	2	0.5
Wheelbarrow orchard sprayer	13	3.4
Mechanical knapsack sprayers	76	19.8
Orchard sprayer	95	24.8
Motorized backpack sprayer	197	51.4
Total	**383**	**100.0**

It was determined that 81.5% of the farmers did not pay attention to whether the machine was licensed when purchasing it, and 91.4% did not know what the CE marking meant. The answers given by 33 farmers who declared that they knew the meaning of the CE mark were safe with 4.4% (17), licensed

with 4.2% (16), high quality with 1.6% (6), and imported with 0.5% (2). It seems that there is no awareness of the CE marking among farmers.

3.8. Decision Making Process in Purchasing a Sprayer

As a result of analyzing the answers given by the farmers who were surveyed to the question of the most important factor they consider / will consider when purchasing a sprayer, 36.8% (141) of them met my purpose, 24.3% (93) were the same as their neighbors/tried. It is seen that 17.2% (66) of them will take into consideration the dealer's recommendation, 11.5% (44) of them will take the brand, and 9.1% (35) of them will consider the price (Table 11). It is observed that only 66 of the farmers act according to the dealer's recommendations when choosing a sprayer, and they pay less attention to the pesticide dealers they use as a source of information when choosing a sprayer. This can be explained by the fact that since tools and equipment are long-term investments, farmers generally turn to proven products.

Table 11. Sprayer purchasing process

Sprayer Purchasing Process	Frequency (Number)	Ratio (%)
None	2	0.5
Local	2	0.5
Price	35	9.1
Brand	44	11.5
Dealer	66	17.2
Same as neighbor	93	24.3
Meeting my purpose	141	36.8
Total	**383**	**100.0**

4. Conclusions

When the research results were evaluated, it was seen that the average age of hazelnut farmers was high and outsourcing of labor or incomplete practices were common, especially in the Eastern Black Sea Region. This situation leads to a decrease in profitability rates. Additionally, nearly 60% of farmers have low levels of education. It is expected that innovative smart agricultural technologies will be adopted more easily as profitability increases and educated people participate in production. The use of new technologies suitable for the land conditions of the Eastern Black Sea region is important for the future of hazelnuts.

The Black Sea region is the region where pesticides are used the least in Türkiye, and especially in the Eastern Black Sea region, spraying is done at most once or twice a year. The proportion of farmers who use chemical control 3 and 4 times in the same season is 23% and 11.7%, respectively, and these farmers are in the Western Black Sea region. More pesticides are being used in this region due to the damage caused by the fall webworm.

The majority of farmers use pesticides without a prescription and have been using the same pesticide for 5-10 years. Continuous reliance on the same pesticide without rotation contributes to resistance development, diminishing efficacy overtime without a prescription and practices based on the recommendations of dealers with commercial concern are risky in terms of product, operator,

environment and consumer health. It was determined that 82% of pesticides were stored in inappropriate places (outdoor structures, barns, houses, balconies) and 18% were stored in special cabinets. Educated farmers store pesticides more safely.

While brand and effect are prioritized in pesticide preference, the rate of farmers reading label information is 42.8%, and only 28.2% receive technical support. For safer use of pesticides, these rates need to be lowered to higher levels.

Due to the rugged terrain conditions of the Eastern Black Sea Region, farmers generally use mechanical/motorized backpack sprayers instead of high-tech sprayers. In this case, success in spraying depends largely on the knowledge and performance of the operator.

5. Declaration

5.1. Competing Interests

The authors declare that they have no competing interests.

5.2. Author Contributions

Emin TAYLAN: Data collection, evaluation, and article writing.

Ali BAYAT: Data evaluation, article writing.

5.3. Ethics Committee Approval

This study does not require ethics committee approval.

5.4. Acknowledgements

The authors would like to express their gratitude to the General Directorate of Agricultural Research and Policies (TAGEM) for their support.

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