Assessing the impact of the COVID-19 pandemic on hazelnut production

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Highlights

- *The effects and extent of the COVID-19 pandemic vary geographically.*
- *The COVID-19 pandemic decreased the size of the family workforce in hazelnut farming.*
- *The COVID-19 pandemic increased the stockpiling of production inputs.*
- *Increased interest in digital resources due to COVID-19 may accelerate the digital transformation of agricultural extension and consultancy services.*

Abstract

This study examines the effects of the COVID-19 pandemic on hazelnut cultivation. Data were obtained from 196 hazelnut farmers in Turkey. Farmers' socioeconomic characteristics and satisfaction with COVID-19 precautions are compared by geographical region. Exploratory factor analysis is used to examine the impact of COVID-19, with comparisons made before and during the pandemic *via* a paired-sample *t*-test. The results indicate that, despite having similar socioeconomics and farm assets, farmers in Ordu and Sakarya were differently affected by the COVID-19 pandemic. Fertilization costs increased by 60.5%, pesticide costs by 64.4%, and labor wages by 19.1% during the COVID-19 pandemic, whereas hazelnut sales prices only increased by 5.2%. Overall, the impact of COVID-19 can be explained across 4 dimensions: timing issues, increase in input prices, inability to access financial resources and logistics issues. To generalize the results, it may be appropriate to select similar farmers in different regions and compare monetary values in real terms. In particular, farmers' increased interest in digital resources due to the pandemic should be considered an opportunity for digital transformation in agricultural extension.

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Introduction

The global COVID-19 pandemic brought an unexpected shock to the world's economies in 2020, raising concerns that adequate food security would not be achieved as the pandemic spread worldwide (Gu and Wang, 2020). The expectation of a deteriorated food supply chain was based on concerns about food security. In this context, the agricultural sector covers various activities, including producing, harvesting, processing, preparing, and distributing a range of food types for human and animal consumption. Therefore, a disrupted supply chain in the agricultural sector would profoundly affect the food supply. When the COVID-19 pandemic emerged, many were concerned about its potential impact on the agricultural sector and a number of pioneering simulation-based studies were conducted to address this (Dev, 2020; Glenn *et al*., 2020; Haqiqi and Horeh, 2021). With the progression of the pandemic, the number, diversity, and focus of studies examining the possible effects of the pandemic on agriculture increased rapidly. Some of these studies examined the effects of movement restrictions and social-distancing practices on agriculture (Siche, 2020; Cortignani *et al*., 2020), whereas others focused on the overall impact of the pandemic on the supply chain (Glenn *et al*., 2020; Adhikari *et al*., 2021; Alam and Khatun, 2021), food security (Uddin *et al*., 2020), farmer welfare (Middendorf *et al*., 2021; Wannaprasert and Choenkwan, 2021), global food supply

(Lin and Zhang, 2020; Adav *et al*., 2022), global food demand (Restrepo *et al*., 2021), input prices (Zankan *et al*., 2022), and macroeconomics (Zhang *et al*., 2020). Pu and Zhong (2020) stated that while challenges in global food supply chains had attracted public attention, little was known about the effects of COVID-19 on agricultural production, and most studies at the time had focused on logistics and distribution (Gray, 2020; Reardon and Swinnen, 2020). Similarly, Popescu and Popescu (2021) stated that many studies focused on the possible effects of the COVID-19 pandemic on the agricultural sector. However, very few studies examined the effects of the pandemic on agriculture by analyzing surveys, observations, and farmer expectations based on direct contact with local farmers (UNDP, 2020). Thus, studies considering the effects of the pandemic on agriculture at the farmer and product levels are limited, and those that have considered these aspects have mainly focused on cereals (Dev, 2020), vegetables, and fresh fruits (Gu and Wang, 2020; Alam and Khatun, 2021; Wannaprasert and Choenkwan, 2021; Adav *et al*., 2022). A common feature of these studies is the pandemic's effects on basic foodstuffs and perishable products; however, they have failed to consider agricultural products used as raw materials in various industrial sectors, which provide a livelihood for a significant number of farmers and their families. Agricultural products in this context include, for example, hard-shelled fruits such as hazelnuts and walnuts.

Hazelnuts are the main agricultural product of the Black Sea region and are the primary source of income for approximately 3 million farmers and their families (Aydoğan, 2022). On the one hand, Turkish hazelnuts form a significant portion of the global hazelnut supply: Turkey produces 66.4% of hazelnuts worldwide and is responsible for nearly 70% of the world's hazelnut exports. France, Germany, Italy, Poland, the Netherlands, and other developed countries are important markets for Turkey's hazelnut exports (Aydoğan *et al*., 2018). On the other hand, hazelnuts and their products are essential raw materials in the confectionery and oil industries, and their waste comprises essential input for animal feed and biofuel production (Kırca *et al*., 2018). Therefore, investigating the effects of the COVID-19 pandemic on hazelnut cultivation is vital to understand disruption across related supply chains and industries, and to develop appropriate measures to protect the living standards of rural hazelnut farmers.

As mentioned above, existing studies examining the effects of the COVID-19 pandemic on the agricultural sector have focused on cereals, vegetables, and fresh fruits, which are generally perishable, non-storable, and seen as basic foodstuffs. However, it is critical to conduct studies in all areas of the agricultural sector to fully understand the pandemic's effects. Overall, there is a gap in the literature with respect to the effects of the pandemic on products such as hazelnuts, which are not basic foodstuffs but are widely used as raw materials in the food industry. Furthermore, existing studies have not clarified what proportion of increased monetary variables (input prices, sales prices, labor wages, *etc*.) can be attributed to COVID-19 and what proportion to inflation rates. Therefore, the primary purpose of the present study is to reveal the effects of the COVID-19 pandemic on hazelnut cultivation based on the following research questions: i) what is the net effect of the COVID-19 pandemic on production inputs, labor wages, worker numbers, yield, and hazelnut sales prices?; ii) can the effects of the COVID-19 pandemic on hazelnut cultivation be grouped according to specific factors?; iii) do the effects of the COVID-19 pandemic vary by geographic region?; iv) did the Turkish government's preventive actions during the COVID-19 pandemic meet farmers' expectations?

Materials and Methods

Research area

An average of 765,000 tons of hazelnuts are grown over 738,000 hectares in approximately 30 provinces in Turkey (Turkstat, 2022). Figure 1 shows the provinces responsible for the majority

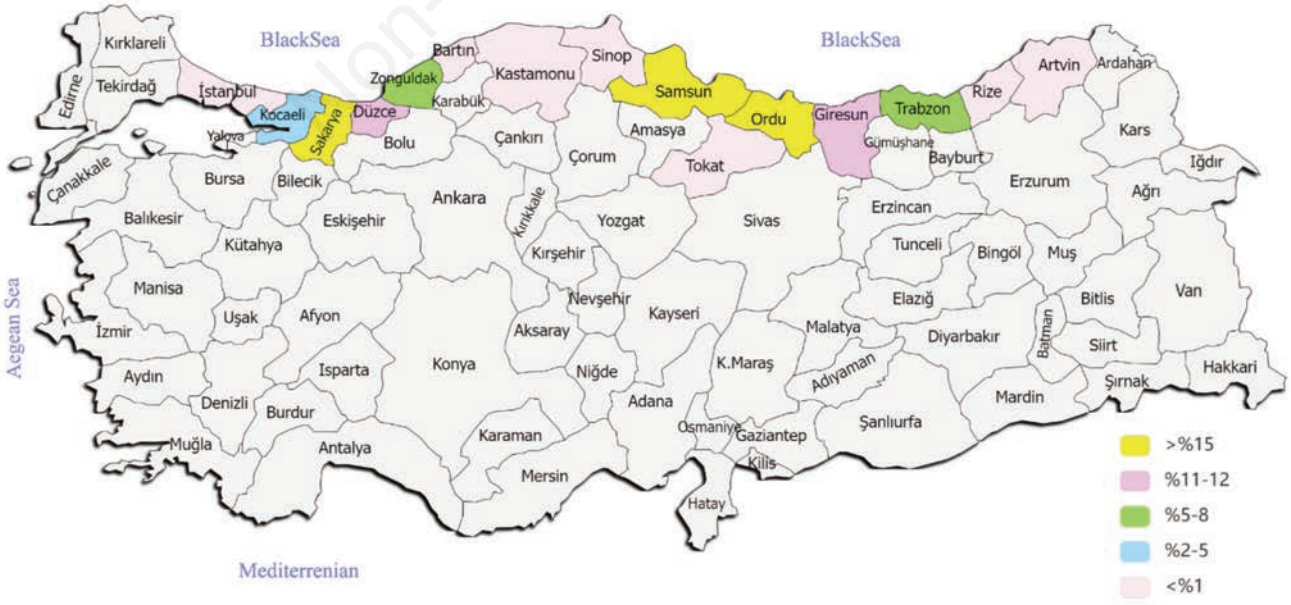

Figure 1. Hazelnut growing provinces in Turkey and research area.

(95%) of total hazelnut production in Turkey, including Ordu (31.4%), Samsun (14.6%), Sakarya (12.9%), Giresun (12.1%), Düzce (10.9%), Trabzon (6.9%), and Zonguldak (4.4%). Ordu and Samsun provinces, where nearly half of Turkey's hazelnuts are grown, are bordering neighbors; they differ from Sakarya province in terms of geographical structure, production techniques, and logistical infrastructure for hazelnut farming.

Ordu province is mountainous and located in the Central Black Sea region, where the mountains are adjacent to the coastline. As hazelnut cultivation is carried out on steep slopes, the possibilities for mechanized farming are minimal, and traditional production techniques based on human labor are dominant. Moreover, due to the prevailing rainy climate, possibilities for plant production are limited, excluding hazelnut and kiwi fruit cultivation. The economy of Sakarya, located in the West Black Sea region, is based on agriculture and industry. The plains in the Sakarya province are among Turkey's most productive agricultural areas, and its climate and geographical structure are suitable for a diverse range of products and modern agricultural techniques. Indeed, Sakarya is one of the most rapidly developing provinces in Turkey, as it is adjacent to provinces with the most developed industrial infrastructure, such as Istanbul, Bursa, and Kocaeli. To examine whether the effects of the COVID-19 pandemic change geographically, the Ordu and Sakarya provinces were selected as research areas due to their contrasting characteristics in cultivating hazelnuts.

Sample size and data

The sample consists of hazelnut farmers in the Ordu and Sakarya provinces. Contact details of the hazelnut farmers approached for this study were obtained from the Ordu and Sakarya provincial directorates of the Ministry of Agriculture and Forestry. The sample size was calculated with Equation 1, according to the proportional sampling method (Newbold *et al.*, 1995):

$$n = \frac{N \times p \times q}{(N-1) \times \sigma_{p_x} + p \times q} \quad (1)$$

where N refers to the number of hazelnut farmers in the Ordu and Sakarya provinces, n refers to the sample size when the finite correction factor is equal to 1; p and q, respectively, indicate the ratio of farmers who were affected and unaffected by the COVID-19 pandemic (p=0.5; q=0.5); and s_{px} denotes the variance. The sample size was calculated as 196 at the 95% confidence interval and was distributed between provinces according to the number of hazelnut farmers. Primary data were obtained through questionnaires from 148 hazelnut farmers from the Ordu province and 48 from the Sakarya province, whereas secondary data were sourced from previous studies, public institution databases, and related reports. All data pertain to the production period 2019-2021.

Analysis methods

As the main objective was to investigate differences in the possible effects of the pandemic according to geographical region, the farmers were examined in 2 groups: hazelnut farmers in Ordu and hazelnut farmers in Sakarya. Socioeconomic characteristics and farm assets were compared across both provinces *via* the *t*-test, and their reported satisfaction with governmental COVID-19 precautions was examined *via* the chi-square test.

Based on the results of previous studies (UNDP, 2020; Štreimikienė *et al*., 2022) and field experiments, 22 questions were prepared regarding the variables likely to be affected by the COVID-19 pandemic based on a 5-point Likert scale (strongly disagree=1 to strongly agree=5). The obtained data were examined *via* explanatory factor analysis, and the variables affecting hazelnut farming were grouped into 4 main categories: timing issues, increase in input prices, inability to access financial resources and logistics issues. To test the differences between these 4 categories according to the groups (provinces), factor scores were compared using the *t*-test. To examine the net change in fertilizer/pesticide costs, labor wages, and hazelnut sales prices before and during the pandemic, the 2019 monetary values of these variables were evaluated for 2021 using Equation 2:

$$P_{reel} = \frac{P_{2019} * CPI_{2021}}{100} \quad (2)$$

where P_{2019} denotes the 2019 price of the variables, CPI_{2021} denotes the difference between the September 2019 and September 2021 consumer price index in Turkey (which was 133.6; Turkstat, 2021), and P_{reel} denotes the 2019 equivalent of the nominal price of variables for 2021. The differences between the real values of these variables before and during the pandemic were compared using the paired-sample *t*-test.

The proportional net change of variables was calculated with Equation 3:

$$\Delta P_{net} = \frac{(P_{2021reel} - P_{2019reel})}{P_{2019reel}} \times 100 \quad (3)$$

where $P_{2019reel}$ denotes the value of variables in the pre-pandemic period, $P_{2021reel}$ denotes the value of variables during the pandemic, and ΔP_{net} denotes the net proportional change of variables between both periods. The student *t*-test was used to compare differences in the net proportional change of variables across geographical regions.

Results

Comparison of the socioeconomic characteristics of hazelnut farmers

Table 1 shows the distinctive socioeconomic characteristics of the sampled hazelnut farmers. The average farmer age is 55.5 years, and the average hazelnut farming experience is 36 years; there are no significant differences between the groups in terms of age and hazelnut experience (t=1.432; p>0.05). Moreover, the average farmer age is close to the average age for all farmers in Turkey (53 years). On average, farming families consist of 3 people, with an average of 2 from each family working in agricultural activities. Moreover, 49.1% of farmers are primary school graduates, 16.4% are secondary school graduates, and 21.1% are high school graduates. Among the farmers, the rate of university graduates is low, and the duration of formal education is 8 years, with no significant difference between provinces (t=1.587; p>0.05). The total monthly income of farmers in the Sakarya province is higher compared with the Ordu province (t=3.432; p<0.01). However, there are no significant differences between the Ordu and Sakarya provinces regarding the share of agricultural income in the total income of farming families.

Comparison of farm assets and membership of agricultural organizations

The average land size of hazelnut farms in the research region is approximately 1.8 hectares, which is less than the average Turkish farm size of 6 hectares (Table 1). The average hazelnut-orchard size is roughly 1.4 hectares. The farmers' total land size and hazelnut-orchard size do not differ between provinces (t=0.083; p>0.05). The number of farmer land parcels in the Ordu province is higher compared with the Sakarya province (t=4.666; p<0.01). Besides hazelnut farming, 25.7% of farmers in Ordu and 27.1% in Sakarya also keep animals. There are no significant differences between the livestock numbers (3.3 LSU) of farmers in the Ordu and Sakarya provinces (3.3 and 5.0 LSU, respectively; t=1.360; p>0.05).

Overall, 84.1% of farmers in Ordu and 97.4% in Sakarya are members of at least one agricultural organization (χ^2=4.783; p<0.05). The number of farmers who are members of more than one agricultural organization in the Ordu province is higher compared with the Sakarya province (Table 2), and this difference is statistically significant (t=2.085; p<0.05).

Factors affected by the COVID-19 pandemic

Exploratory factor analysis was used to group the variables affected by the COVID-19 pandemic. Data reliability was checked using Cronbach's a; the obtained value of 0.839 indicates that the internal consistency of the data is good. Principal component analysis was used to determine the factors, and the Kaiser-Meyer-Olkin test was used to test the adequacy of the sample size, calculated as 0.705. The chi-square value in Bartlett's test of sphericity indicated that exploratory factor analysis was an appropriate method for the data in question (χ^2=1290.9; p<0.01).

The eigenvalues of each variable were used to group the factors. The eigenvalues of the following 4 factors are all significantly greater than 1 and explain 72.6% of the total variance (Table 3): timing issues, increase in input prices, inability to access financial resources, and logistics issues. The eigenvalues of 10 variables were less than 1 and thus were not considered for this study. Table 4 shows the differences in factors according to the groups.

Factor 1: timing issues

The COVID-19 pandemic affected the timing of hazelnut-orchard care. It was determined that hazelnut farmers could not perform fertilization, chemical pest control, and orchard maintenance at appropriate times. This problem stemmed from the inability to find workers on time as well as movement restrictions. Farmers in Ordu province were exposed to more negative effects than those in Sakarya in terms of access to fertilizer (t=2.859; p<0.01) and pesticides, as well as timely and adequate maintenance (t=2.766; p<0.01).

Table 1. Comparison of farmers' socioeconomic characteristics and farm assets.

Variables	Provinces	Count	Mean	SD	*t* value	p
Farmer age (year)	Ordu	148	55.9	11.8	1.432	0.154
	Sakarya	48	53.0	9.5		
Duration of formal education (year)	Ordu	148	8.6	4.0	1.587	0.114
	Sakarya	48	7.5	3.3		
Family size (person)	Ordu	148	3.6	1.5	1.156	0.249
	Sakarya	48	3.9	1.4		
Family workforce (person)	Ordu	148	2.5	1.2	0.875	0.383
	Sakarya	48	2.7	1.4		
Hazelnut experiences (year)	Ordu	148	36.4	14.1	0.627	0.531
	Sakarya	48	38.0	13.3		
Household monthly income ($)	Ordu	148	1025.3	445.5	3.432	0.01***
	Sakarya	48	1341.5	672.7		
Share of agricultural income in household total income (%)	Ordu	148	46.1	27.3	0.943	0.347
	Sakarya	48	50.8	26.6		
Total land size (ha)	Ordu	148	1.8	1.7	0.083	0.935
	Sakarya	48	1.8	1.9		
The number of land parcels	Ordu	148	3.7	2.8	4.666	0.01***
	Sakarya	48	2.2	1.4		
Animal assets (LSU)	Ordu	38	3.3	3.7	1.360	0.189
	Sakarya	13	5.0	3.9		
Hazelnut-orchard size (ha)	Ordu	148	1.5	1.4	1.048	0.296
	Sakarya	48	1.2	1.0		

SD, standard deviation; LSU, livestock unit; *** significant at 1%.

Table 2. Farmer participation in agricultural producer organizations.

Organizations	Provinces	Count	Mean	SD	*t* value	p
The number of memberships of agricultural organizations	Ordu	148	1.2	0.6	2.085	0.05**
	Sakarya	48	1.1	0.4		

SD, standard deviation; **significant at 5%.

Factor 2: increase in input prices

The most critical inputs in hazelnut cultivation were fertilizers, pesticides, and labor costs. Uncertainties created by the pandemic increased the unit costs of these primary inputs, and the increase in input prices varied according to the provinces. Although the costs of chemical fertilizers (t=6.154; p<0.01) and pesticides (t=4.39; p<0.01) in Sakarya increased more than they did in the Ordu province, the increase in labor wages was similar in both provinces.

Factor 3: inability to access financial resources

Hazelnut farmers obtain financing from legal financial institutions or their close relatives and neighbors. However, a climate of fear and uncertainty during the pandemic adversely affected the hazelnut farmers' access to financial resources. The problems experienced by hazelnut farmers in accessing financial resources were similar in both provinces.

Factor 4: logistics issues

Hazelnut farmers were exposed to high transportation costs during the pandemic and had problems reaching haulage companies. Issues related to logistics during the pandemic differed according to the provinces, where farmers in Sakarya had more logistical problems than farmers in Ordu (t=4.803; p<0.01). Logistic issues emerged due to increased transportation costs and an inability to reach transporters.

Changes in costs, yield, and sales prices before and during the pandemic

Table 5 compares the differences among input costs, labor wages, worker numbers, hazelnut sales prices, and yield variables before and during the pandemic. Fertilization costs (t=22.330; p<0.01), pesticide costs (t=24.386; p<0.01), labor wages (t=46.949; p<0.01), worker numbers (t=6.203; p<0.01), and hazelnut sales prices (t=3.351; p<0.01) increased during the pandemic compared with the pre-pandemic period.

The study revealed that fertilization costs increased by 60.5% on average, pesticide costs increased by 64.4% on average, and labor wages increased by 19.1% on average. Hazelnut sales prices increased by 5.2% on average during the pandemic (Table 6), which is to say that the costs increased more than the sales prices. Net proportional change amounts were compared to determine which group had the greatest differences in variables before and during the pandemic. The net proportional increase in fertilization costs (t=4.816; p<0.01), pesticide costs (t=4.133; p<0.01), labor costs (t=2.148; p<0.05), and hazelnut sales prices (t=2.163; p<0.05) were higher in Ordu compared with Sakarya.

Farmer satisfaction with COVID-19 precautions

With the onset of the COVID-19 pandemic, the Turkish government implemented a series of precautions to ensure the continuity of agricultural production (Table 7). These precautions were not directly related to hazelnut farming but covered all countrywide agricultural activities. Therefore, examining the satisfaction of hazelnut farmers with these precautions is important in terms of evaluating the effectiveness of the policies implemented.

The proportion of farmers who were satisfied with the government's implementations to delay loan repayments, exempt seasonal agricultural workers and the logistics sector from restrictions, ensure travel flexibility for hazelnut farmers, facilitate the sale of farm products and was higher than the proportion of

Table 3. Factors in hazelnut farming affected by the COVID-19 pandemic.

Factor name	Eigenvalue	Percentage of variance	Variables extracted	Factor loading
Timing issues	3.90	32.51	I could not buy pesticides as needed.	0.861
			I could not cultivate my hazelnuts as needed due to restrictions.	0.861
			I could not buy fertilizer as needed due to restrictions.	0.847
			I could not cultivate my hazelnuts adequately due to restrictions.	0.840
			I could not find enough workers.	0.646
Increases in input prices	2.45	20.45	I could not use enough pesticides due to the increased pesticide prices.	0.852
			I could not get enough fertilizer due to the increased fertilizer prices.	0.823
			I could not find enough workers due to increases in labor wages.	0.800
Inability to access financial resources	1.28	10.66	Financial institutions made it harder to borrow money.	0.881
			Neighbors and relatives refused to lend money.	0.805
Logistics issues	1.07	8.94	It was difficult to reach transporters.	0.894
			Transporting costs increased a lot.	0.665

Table 4. Comparison of factor scores by provinces.

Factors	Provinces	Count	Factors scores' mean	SD	*t* value	p
Timing issue	Ordu	148	0.18	1.07	7.740	0.01***
	Sakarya	48	-0.61	0.25		
Increase in input prices	Ordu	148	-0.18	0.99	5.248	0.01***
	Sakarya	48	0.61	0.77		
Inability to access financial resources	Ordu	148	0.01	0.97	0.257	0.797
	Sakarya	48	-0.04	1.10		
Logistics issues	Ordu	148	-0.18	1.02	5.885	0.01***
	Sakarya	48	0.61	0.63		

SD, standard deviation; ***significant at 1%.

farmers who were satisfied with the government's other anti-pandemic precautions. In particular, the farmers believed that the government's precautions on lowering loan interest rates, controlling price increases, preventing stockpiling, and improving agricultural extension services were ineffective.

Hazelnut farmers in Ordu were more satisfied with the government's precautions with respect to loan repayments compared to farmers in Sakarya (χ^2=4.969; p<0.10). Farmers in Sakarya province were more satisfied with the government's regulations exempting farmers from movement restrictions (χ^2=14.707; p<0.01), exempting the logistics sector from travel restrictions (χ^2=20.210; p<0.01), and facilitating the sale of farm products (χ^2=12.197; p<0.05) compared to farmers in Ordu. In addition, farmers in Sakarya were more dissatisfied with the precautions taken against price increases and stockpiling than were farmers in Ordu (χ^2=8.767; p<0.05). Farmers in Ordu perceived the government's regulations to continue agricultural extension and advisory services as more inadequate compared to farmers in Sakarya (χ^2=12.550; p<0.01).

Discussion

Global viruses are not a new phenomenon, with HIV/AIDS, influenza, ebola, severe acute respiratory syndrome, Middle East respiratory syndrome, and COVID-19 being severe examples. Although pandemics do not occur very often, they may have devastating effects on human life and, in particular, the livelihoods of those living in rural areas (Cabore *et al*., 2020; Phillipson et al., 2020). Due to the possible spread of zoonotic diseases (Morens and Fauci, 2012), the world should be prepared for future pandemics. In this regard, analyzing the effects of the COVID-19 pandemic and the precautions taken to mitigate it will significantly contribute to coping with pandemics in the future. Accordingly, the present study focused on the effects of the COVID-19 pandemic on hazelnut farming.

One of the most important outputs of the current study is its categorization of the impact of COVID-19 on hazelnut farming into 4 dimensions: timing issues, increase in input prices, inability to access financial resources and logistics issues. Of these, timing issues refer to the inability to reach the inputs and workforce required for production on time. Previous studies have argued that the social isolation and intercity travel bans implemented by governments affected worker transfers and decreased labor supply (Cortignani *et al*., 2020; Pulubuhu *et al*., 2020; Okolie and Ogundeji, 2022), explaining the disruptions in access to production factors in the context of labor shortages. However, the current study identified problems in the timely acquisition of pesticides and fertilizers, which are primary production inputs in hazelnut cultivation. Findings related to the increase in input costs (Nchanji *et al*., 2021; Obese *et al*., 2021), problems of access to financial resources (Habanyati *et al*., 2022), and logistics (Fang *et al*., 2021) are consistent with previous studies.

Extant work has indicated that the COVID-19 pandemic increased input prices (Ogada *et al*., 2021; Habanyati *et al*., 2022; Menon and Schmidt-Vogt, 2022). However, each of these studies revealed the effects of the pandemic *via* qualitative approaches. Thus, the literature would benefit from quantitative studies examining the effects of COVID-19. Moreover, existing studies

Table 5. Comparing changes in costs, wages, and yield variables before and during the pandemic.

Paired samples statistics	Periods	Count	Mean	SD	*t* value	p
Fertilizer cost difference ($/ha)	Pandemic	196	153.2	4.2	22.330	0.01***
	Pre-pandemic	196	75.9	2.3		
Pesticide cost difference ($/ha)	Pandemic	196	155.6	4.4	24.386	0.01***
	Pre-pandemic	196	73.1	2.1		
Labor wages difference ($/ha)	Pandemic	196	177.2	1.7	46.949	0.01***
	Pre-pandemic	196	112.6	1.2		
Hazelnut yield difference (kg/ha)	Pandemic	196	1445.3	4.9	1.078	0.283
	Pre-pandemic	196	1409.0	4.7		
The difference in the number of workers (person/ha)	Pandemic	196	65.2	4.7	6.203	0.01***
	Pre-pandemic	196	54.1	3.7		
Hazelnut sales price difference ($/kg)	Pandemic	196	0.14	0.03	3.351	0.01***
	Pre-pandemic	196	0.08	0.06		

SD, standard deviation; ***significant at 1%.

Table 6. Comparison of the proportional change in some variables by provinces.

Proportional changes	Provinces	Count	% Change	SD	*t* value	p
Fertilizer cost change (%)	Ordu	148	69.0	4.83	4.816	0.01***
	Sakarya	48	31.8	6.02		
Pesticide cost change (%)	Ordu	148	70.9	3.04	4.133	0.01***
	Sakarya	48	43.5	6.54		
Labor wages change (%)	Ordu	148	20.4	1.33	2.148	0.05**
	Sakarya	48	14.5	2.38		
Hazelnut sales price change (%)	Ordu	148	6.8	1.27	2.163	0.05**
	Sakarya	48	0.1	3.96		

SD, standard deviation; **, ***significant at 10%, 5% and 1%.

(Alam and Khatun, 2021; Nchanji *et al*., 2021; Adav *et al*., 2022) have primarily focused on fresh fruit and vegetable cultivation. As a point of departure, the current quantitative study contributes to the qualitative findings of previous studies by revealing that, for hazelnut cultivation, the COVID-19 pandemic increased fertilizer costs by 60.5%, pesticide costs by 64.4%, and labor wages by 19.1%, whereas hazelnut sale prices increased by only 5.2%. There is consensus in the literature about the increase in input prices, but many studies have also documented the problem of input scarcity (Tran *et al*., 2020; Alam and Khatun, 2021). Therefore, it is appropriate to examine the effects of the pandemic on agricultural production in 2 categories: price increase of production inputs and availability of production inputs. The current study confirmed a price increase in production inputs and a shortage of workers. Unlike other studies, the results show that the problem of acquiring fertilizers and pesticides used in hazelnut farming is due to the desire of input sellers to store production inputs. This is because input wholesalers expected that fertilizer and pesticide prices would rise. In this way, the present study makes an essential contribution to the body of literature by finding that the COVID-19 pandemic increased the stockpiling of production inputs.

The maintenance and harvesting required for hazelnut farming in Turkey are based mainly on manual labor, and the need for workers increases significantly at harvest time. Many studies have proven that the COVID-19 pandemic adversely affected the labor market worldwide (Cortignani *et al*., 2020; Pulubuhu *et al*., 2020; Uğur and Buruklar, 2021). However, the labor shortage issues differed from country to country. The labor trouble experienced in many countries was explained by factors such as travel restrictions for cross-border migrant workers (Singh *et al*., 2020), the risk of workers getting sick, the concern of being unable to access adequate treatment opportunities when they were sick (Larue, 2020), and the risk of being quarantined when they returned to their home country (Štreimikienė *et al*., 2022). The number of cross-border migrant workers in Turkey is negligible, with hazelnut work often depending on immigrant workers, whereas, in other countries, it often depends on cross-border immigrant workers. Thus, the reasons for labor shortages in other countries *versus* in Turkey differ. Regulations facilitating travel were introduced for agriculture workers during the pandemic in Turkey. However, as a general practice, people aged below 20 or over 65 were subject to social isolation. On the one hand, considering that the average age of all farmers in Turkey (Uysal and Gürer, 2022) and hazelnut farmers in the study area is around 55, it can be said that the shortage of workers in hazelnut farming resulted from the social isolation regulations. On the other hand, child labor in hazelnut cultivation is a fundamental problem

Table 7. Farmer satisfaction with COVID-19 precautions.

COVID-19 precautions	Province	Count	Satisfaction status (%)				χ^2	p
			Insufficient	Undecided	Sufficient	Total		
Lowering loan interest rates	Ordu	148	37.9	26.5	35.6	100	4.252	0.119
	Sakarya	48	56.4	17.9	25.6	100		
	Total	196	42.1	24.6	33.3	100		
Providing flexibility in loan repayments	Ordu	148	27.3	27.3	45.5	100	4.969	0.10*
	Sakarya	48	46.2	20.5	33.3	100		
	Total	196	31.6	25.7	42.7	100		
Postponement of debt payments to institutions	Ordu	148	13.6	62.9	23.5	100	4.087	0.130
	Sakarya	48	10.3	79.5	10.3	100		
	Total	196	12.9	66.7	20.5	100		
Postponement of institutional rent payments	Ordu	148	6.8	88.6	4.5	100	0.655	0.721
	Sakarya	48	7.7	84.6	7.7	100		
	Total	196	7.0	87.7	5.3	100		
Travel flexibility provided to seasonal workers	Ordu	148	18.2	18.9	62.9	100	1.780	0.411
	Sakarya	48	23.1	10.3	66.7	100		
	Total	196	19.3	17.0	63.7	100		
Travel flexibility provided to farmers	Ordu	148	15.9	40.2	43.9	100	14.707	0.01***
	Sakarya	48	20.5	7.7	71.8	100		
	Total	196	17.0	32.7	50.3	100		
Restriction exemptions provided to the logistics sector	Ordu	148	9.1	56.1	34.8	100	20.210	0.01***
	Sakarya	48	20.5	15.4	64.1	100		
	Total	196	11.7	46.8	41.5	100		
Facilitated sale of farm products	Ordu	148	18.9	49.2	31.8	100	12.197	0.05***
	Sakarya	48	5.1	33.3	61.5	100		
	Total	196	15.8	45.6	38.6	100		
Strict follow-up on unreasonable price increases and stockpiling	Ordu	148	62.1	26.5	11.4	100	8.767	0.05**
	Sakarya	48	87.2	10.3	2.6	100		
	Total	196	67.8	22.8	9.4	100		
Precautions taken for the continuity of agricultural extension and consultancy services	Ordu	148	87.9	5.3	6.8	100	12.550	0.01***
	Sakarya	48	64.1	20.5	15.4	100		
	Total	196	82.4	8.8	8.8	100		
Digital content in agricultural extension and consultancy services checked for adequacy	Ordu	148	82.6	7.6	9.8	100	6.061	0.05**
	Sakarya	48	64.1	15.4	20.5	100		
	Total	196	78.4	9.4	12.3	100		

*, **, *** significant at 10%, 5% and 1%, respectively.

in Turkey. Karadeniz *et al*. (2021) reported that 79.7% of children working in hazelnut orchards are between the ages of 15 and 17, whereas Yılmaz (2017) reported an average age of 15. In light of this, another reason for the labor shortage in hazelnut farming was the social isolation of individuals under the age of 20. Moreover, the social isolation of individuals aged under 20 or over 65 working in hazelnut farming decreased the size of the family labor force. This decrease is one of the main reasons for the shortage of the total labor force in the study region. As a result, the government's COVID-19 social isolation policy ultimately decreased the size of the family labor force but increased both labor wages and the demand for hired workers.

Many studies on the effects of the COVID-19 pandemic on agricultural production have focused on the negative effects on input prices and labor supply; however, relatively few studies have analyzed differences between these effects according to geographical regions (Bloem and Farris, 2021). On the one hand, some studies have examined the effects of the pandemic on agricultural systems in different countries (Tripathi *et al*., 2021; Menon and Schmidt-Vogt, 2022), whereas others have compared the effects of the pandemic on the same crop in different countries (Andrieu *et al*., 2021; Nchanji *et al*., 2021). On the other hand, some studies have examined the effects of the pandemic on different areas of agricultural production in the same country (Fang *et al*., 2021; Habanyati *et al*., 2022). In summary, to determine the geographical impact of the pandemic, the agricultural system, agricultural products, and government regulations should be consistent factors, and only the geographical region should change. In this regard, the current study demonstrated that the impact of the COVID-19 pandemic (in terms of timely access to inputs and financial resources, increase in input prices, and logistics issues) differed according to region. Similarly, the increases in fertilizer costs, pesticide costs, and labor wages that exceeded any rise in hazelnut sales prices were felt more strongly in rural areas far from metropolitan cities. With the onset of the pandemic, government officials in Turkey developed and implemented a series of precautions (Table 7) to ensure that agricultural production was not interrupted and to minimize disruption to rural residents. The effectiveness of the pandemic regulations was dependent on individuals being aware of the regulations and trusting that they would mitigate the spread of COVID-19. In the literature review, it was determined that studies investigating the interest of farmers in pandemic prevention policies generally focused on farmers' knowledge levels and attitudes about pandemic precautions (Ahmed *et al*., 2021; Akaninyene *et al*., 2022). Unlike these studies, Rohit *et al*. (2022) found that farmers trusted the government's pandemic-control precautions. In the current study, the government's lack of restrictions on travel for agricultural workers and farmers, exemption of the logistics sector from restrictions, and policies for marketing were found to be sufficient, with a high level of satisfaction. However, there was a prevailing opinion that the precautions and market controls taken to constrain access to financing resources and prevent excessive price increases and opportunism were insufficient.

Conclusions

This study focused on the effects of the COVID-19 pandemic on hazelnut cultivation and the way these effects varied geographically. The study concluded that to measure the net effect of the pandemic between geographical regions, it is appropriate to select similar farmers in different regions that produce the same product and to compare monetary values in real terms by eliminating the effect of inflation. The results indicate that the effects of the COVID-19 pandemic were geographically different, and the satisfaction levels of farmers with government precautions differed according to province. Therefore, in the future, differentiating pandemic regulations across agricultural regions and sub-regions would ensure robust results.

A significant finding was that, during pandemics, an implemented regulatory government policy should not negatively affect the outcome of another policy. In this context, a critical impact of the COVID-19 pandemic is the reduction of the family workforce. Pandemic precautions applied without considering the effects on labor and family-work-intensive sectors, such as hazelnut cultivation, will increase the demand for temporary workers by reducing family labor, resulting in higher wages. It would be helpful for governments to prepare alternative scenarios for future pandemics and simulate their consequences.

In response to the research questions raised in this study, it was concluded that the effects of the COVID-19 pandemic can be examined in 4 groups: timing issues, increase in input prices, inability to access financial resources, and logistics issues. The results reveal that the COVID-19 pandemic increased the prices of production inputs, wages, the number of workers needed, and hazelnut sales prices but did not affect hazelnut yield. This situation can be explained by the fact that hazelnut farmers bought production inputs at higher prices, employed workers at higher wages, and maintained their hazelnut orchards. Another finding shows that COVID-19 caused stockpiling. Input sellers stored the inputs in their warehouses instead of marketing them, expecting the prices to increase further by taking advantage of loopholes in the laws. This situation was the main reason for the increase in input prices in Turkey during the COVID-19 pandemic.

Government regulations during the pandemic focused on ensuring a continuous food supply chain and research studies have examined the effects of the pandemic on the scarcity of production input, increases in input prices/labor wages, and worker shortages. However, government regulations on agricultural education and advisory services for farmers have been limited, as have studies examining the impact of the pandemic on farmers' socioeconomic and social relations. In other words, the need for information about the COVID-19 pandemic, agricultural activities, and possible changes in the social relations of rural farmers has been ignored. Due to the government's failure to prioritize adequate regulations for agricultural education and advisory services and a lack of adequate research on this subject, the effects of the pandemic on the socioeconomic status of farmers are unclear. Therefore, it may be beneficial for scholars and governments to focus on digital-extension studies that can be applied during pandemics to produce rich-content materials and methods.

In conclusion, though this study was conducted using data from a 3-year period before and during the pandemic, the long-term effects of COVID-19 still need to be determined. Future studies should focus on the long-term dynamics of the COVID-19 pandemic, such as the impact on hazelnut farmers' decision-making processes, rural communications, social relations, production methods, and operating profitability. Although this study was conducted in Turkey, the results will also benefit decision-makers in countries such as Azerbaijan, Chile, China, Georgia, Iran, Italy, Russia, Spain, and the US, where hazelnut cultivation is extensive.

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