How to cite: Gassi, K. R. & H. Çelik Ateş, 2025. Perceptions of climate change and adaptation measures among wheat and barley producers. Ege Univ. Ziraat Fak. Derg., 62 (1): 63-75, https://doi.org/10.20289/zfdergi.1499619

Research Article
(Araştırma Makalesi)

Ege Üniv. Ziraat Fak. Derg., 2025, 62 (1):63-75
https://doi.org/10.20289/zfdergi.1499619

Perceptions of climate change and adaptation measures among wheat and barley producers*

Buğday ve arpa üreticilerinin iklim değişikliği algıları ve uyum önlemleri

* It has been summarized from the first author's master.

Koffi Romaric GASSI [1*]

Hacer ÇELİK ATEŞ [1]

[1] Isparta University of Applied Sciences, Faculty of Agriculture, Department of Agricultural Economics, 32260, Merkez, Isparta, Türkiye

***** Corresponding author (Sorumlu yazar):
romgassi@gmail.com

Received (Alınış): **22.06.2024** **Accepted** (Kabul Tarihi):**30.10.2024**

ABSTRACT

Objective: This study aims to assess producers' perceptions of climate change and identify the adaptation strategies adopted by them.

Material and Methods: Stratified sampling was used to determine sample size, with the Neyman method used to allocate participants by strata, resulting in a total of 116 respondents. Analytical techniques including proportional distributions, chi-square tests and multiple correspondence analysis were used.

Results: Results indicate an average producer age of 46 years, with 56.1% having attained high school or higher education, and an average farming experience of 22 years. The majority (90.5%) reported declining wheat/barley yields, attributing this trend predominantly to climate change effects, notably increased temperature (92.2%) and drought (95.7%), alongside decreased rainfall (100%) and water resources (95.7%). Forecasts suggest these trends will persist, with over 70% agreement. To address these challenges, most producers have adjusted autumn tilling dates (82.8%), fertilizer application (83.6%), sowing dates (88.8%), and wheat and barley harvesting schedules (69%).

Conclusion: Awareness campaigns are recommended to improve the perception of producers and strengthen their adaptation to climate change risks. The study's findings will provide policymakers with the insights needed to design and implement targeted training programs that address gaps in producers' perceptions and adaptation strategies.

Keywords: Adaptation measures, climate change, producer perception, Türkiye, Yalvaç

ÖZ

Amaç: Bu çalışmanın amacı üreticilerin iklim değişikliğine yönelik algılarını ölçmek ve üreticilerin uyguladıkları uyum önlemlerini ortaya koymaktır.

Materyal ve Yöntem: Örnek hacminin belirlenmesinde tabakalı örnekleme yöntemi kullanılmış, örnek hacminin tabakalara dağılımında ise Neyman yöntemi kullanılarak toplam 116 kişi ile anket yapılmıştır. Toplanan verilerin analizinde oransal dağılımlar, khi-kare ve çoklu uyum analizleri kullanılmıştır.

Araştırma Bulguları: Sonuçlar, ortalama üretici yaşının 46 olduğunu, %56.1'inin lise veya daha yüksek eğitime sahip olduğunu ve ortalama çiftçilik deneyiminin 22 yıl olduğunu göstermektedir. Çoğu üretici (%90.5) buğday/arpa verimlerinin azaldığını bildirmiş ve bu eğilimi ağırlıklı olarak iklim değişikliği etkilerine, özellikle artan sıcaklığa (%92.2) ve kuraklığa (%95.7) ve azalan yağışa (%100) ve su kaynaklarına (%95.7) bağlamıştır. Tahminler, bu eğilimlerin %70'in üzerinde bir mutabakatla devam edeceğini göstermektedir. İklim değişikliğinin sürekli etkileriyle başa çıkmak için, üreticilerin çoğunluğu sonbaharda toprağı sürüm tarihini (%82.8), gübre uygulamasını (%83.6), ekim tarihini (%88.8) ve buğday ve arpanın hasat tarihini (%69) değiştirmiştir.

Sonuç: Üreticilerin algısını geliştirmek ve iklim değişikliği risklerine uyumlarını güçlendirmek için farkındalık çalışmaları yapılması önerilmektedir. Çalışmanın bulguları, politika yapıcılara üreticilerin algıları ve uyum stratejilerindeki eksiklikleri ele alacak hedefli eğitim programlarını tasarlamak ve uygulamak için gerekli bilgileri sağlayacaktır.

Anahtar sözcükler: Uyum önlemleri, iklim değişikliği, üretici algısı, Türkiye, Yalvaç

INTRODUCTION

The concepts of climate and climate change have been frequently discussed in recent years, with various definitions found across different sources. Climate is defined as the average of meteorological events such as temperature, precipitation, and wind over a specific period (TOB, 2021). Climate change can be described based on numerous sources as the disruptions in the global atmospheric composition caused directly or indirectly by global warming resulting from human or natural greenhouse gas emissions (Fujisawa et al., 2015; Doğan & Karakaş, 2018; Tsujii & Gültekin, 2018). These changes manifest over the years as drought, altered precipitation patterns, and increased temperatures (Yang et al., 2022). Drought occurs following extended periods without rainfall, leading to significant crop losses in agriculture (Djellouli et al., 2019). Reduced precipitation increases the water demand of plants, thereby intensifying water stress (Assi, 2022). The rise in global temperatures deteriorates soil health, exacerbates adverse impacts on agricultural products, and results in large-scale crop losses (Krishnan et al., 2011; Korres et al., 2017). All these negative effects on agricultural production exert pressure on food security, particularly affecting food production and accessibility (IPCC, 2022).

Like many countries, Türkiye's agricultural sector is under threat from the impacts of climate change (Akyüz & Atiş, 2022). Wheat and barley, which are rain-fed cereals, are particularly vulnerable to changes in temperature and precipitation, affecting their area and yield (Tsujii & Gültekin, 2018). According to TÜİK (2023), the production areas for wheat and barley in several regions of Türkiye have declined in recent years. Consequently, despite the adverse effects of climate change, measures must be taken to ensure that producers can continue growing wheat and barley. Numerous scientific studies have analyzed the behaviors and adaptation measures of producers in Türkiye in response to climate change threats (Polat & Dellal, 2016; Akyüz & Atiş, 2022; Bolat & Bakırcı, 2022; Korkmaz & Şahin, 2023). For instance, Polat & Dellal (2016), analyzed the perceptions of producers who practice good agricultural practices regarding climate change and its impacts. Bolat & Bakırcı (2022), assessed the knowledge and perception levels of agricultural producers in the Erbaa plain concerning climate change. Korkmaz & Şahin (2023), determined the level of perception of climate change concerns by the respondents. Akyüz & Atiş (2022), explored the environmental attitudes of producers in the ‘‘Küçük Menderes’’ basin regarding climate change adaptation.

Considering that each region has its unique climate and soil structure, resulting in differences in the crops produced, these studies are understood to be conducted at a regional level. However, no previous study has been found regarding the perception of climate change in the Isparta region and Yalvaç district. This study aims to provide critical data for decision-makers to develop agriculture and address issues in the region by examining the perceptions of climate change and adaptation measures implemented by producers in Yalvaç district. Türkiye's Mediterranean region, including Yalvaç district, experiences a faster temperature rise compared to other regions. Projections for 2070 predict a 6°C increase in summer temperatures and almost a 20% decrease in winter precipitation. Over the past 100 years, the number of hot days and nights in the Mediterranean region has increased by more than 15 days, leading to reduced summer crop yields even with irrigation. In 2008, low rainfall in Isparta province (including Yalvaç district) resulted in poor grain yields and made harvesting with combine harvesters challenging, ultimately leading to insufficient hay supply for livestock farms. Additionally, rising temperatures due to climate change have decreased the water volume in the region's lakes (Çevre ve Şehircilik Bakanlığı, 2020). Under these conditions, wheat and barley producers must implement multiple measures to cope with the direct or indirect effects of climate change.

MATERIALS and METHODS

This research was approved by the ethics committee of Isparta University of Applied Sciences with document number E.62155, dated 10.24.2022.

This research utilized primary data collected through face-to-face surveys with wheat and barley producers in Yalvaç district.

The Yalvaç district in Isparta province was selected as the research area because it is the largest producer of wheat and barley, with the highest number of producers. This district is representative of the Isparta region both socially and economically in terms of wheat and barley production. The sample size was determined based on the area planted with wheat, considering that wheat producers also cultivate barley. Farms registered in the Farmer Registration System for the 2022 production season were taken as the main population (N=2247). The Stratified Sampling Method (Yamane, 2018) was used to determine the sample size, and the Neyman Method was applied for the distribution of the sample size across strata (Çiçek & Erkan, 1996).

$$n = \frac{\sum (N_h S_h)^2}{N^2 D^2 + \sum N_h S_h{}^2} \quad (1)$$

In the equation above: n: represents the sample size, N: denotes the total number of units, Nh: is the number of units in the h-th stratum, Sh: is the standard deviation of the h-th stratum, D: is defined as d/z, d: is the deviation from the mean, z: is the value from the z-distribution table corresponding to (N-1) degrees of freedom at a 95% confidence level and a 5% margin of error.

$$n = \frac{(19352)^2}{(2247)^2 \left(\frac{1.50}{1.96}\right)^2 + (256933.7)}$$

In the calculation, the sample size was determined to be 116 (Table 1). The following formula was used to determine the number of producers in each stratum (Çiçek & Erkan, 1996).

$$n_i = \frac{N_n S_n n}{\sum (N_n S_n)} \quad (2)$$

Table 1. Sample size

***Çizelge 1**. Örnekleme hacmi*

Stratum	Stratum margins (da)	Average	N_h	S_h	N_hS_h	Stratum Sample Number
I	1.00-20.00	10.39	1121	6.50	7281.51	44
II	20.01-50.00	32.03	793	6.73	5341.31	32
III	50.01-100.00	68.16	233	13.22	3082.54	18
IV	100.00 +	134.18	100	36.46	3646.59	22
Total		30.09	2247		19352	116

The Likert scale was used to measure the producers' perceptions of climate change. For data analysis, Multiple Correspondence Analysis (MCA), Chi-square tests, and proportional distributions were employed. Multiple Correspondence Analysis is a method for interpreting categorical data. This graphical approach highlights the similarities, differences, and relationships between row and column variables in cross-tabulations. It also allows for the observation of their simultaneous changes in a reduced-dimensional space (Süner & Çelikoğlu, 2010). The Chi-square test was used to analyze the relationship between two variables.

RESULTS and DISCUSSION

Socio-economic characteristics of producers

The majority of the producers surveyed are male (96.6%) with an average age of 46 years. The youngest participant is 26 and the oldest is 72 years old. According to Shahbaz (2018) and Tokgöz (2022), agricultural farms are predominantly managed by men. Yüzbaşıoğlu (2019), noted that women have less influence in agricultural operations and generally work as family labor, which explains the low representation of women in the sample. Similar results were found by Karakaş (2022), which revealed that most wheat producers in Çorum province are male (95%) with an average age of 47 years. Naseri (2015) found the average age of wheat producers in Uşak province to be 51 years. In terms of education, most producers have completed high school (39.7%), followed by elementary school (21.6%), middle school (20.7%), and university (16.4%). These results indicate that a majority of the producers have at least a high school education, suggesting a higher level of awareness about agricultural practices and a better ability to comprehend and express perceptions related to climate change. Producers with higher education levels are more likely to change their behavior in response to the impacts of climate change compared to those with lower education levels. Producers in Yalvaç have an average of 22 years of experience in wheat or barley production. A Chi-square analysis showed a statistically significant relationship ($p<0.000$) between the producers' age and years of experience, indicating that older producers have more experience. This relationship can be attributed to the fact that older producers have had more time to accumulate practical farming knowledge and experience. According to Arimi et al. (2020), producers with more agricultural experience tend to have better skills to cope with the effects of climate change. The survey revealed that 42.2% of the producers engage in activities other than agriculture. Among these, the highest proportions are government employees (38.8%) and self-employed individuals (34.7%), including drivers, shopkeepers, and traders. These findings indicate a diversity of income-generating activities among participants, which can have positive effects on the economic resilience of producers, particularly in the context of climate change challenges. Diversifying income sources can contribute to greater financial stability amidst climate and market fluctuations. Additionally, adopting effective measures in the face of climate change can enable producers to invest their surplus earnings into improving their agricultural operations. In Yalvaç district, the majority of producers (42.2%) produce wheat on owned land, followed by those who farm on rented land (34.5%) and those using a combination of owned and rented land (20.7%). Similar results were found in Uşak province, where the majority (59%) of land used for wheat production is owned (Naseri, 2015). In Isparta Yalvaç district, both barley and wheat are produced on owned, rented and shared lands. However, barley production is more commonly conducted on rented land (40.7%), followed by owned land (34.3%).

Producers' perception on the effects of climate change on wheat/barley production

Between 2012 and 2022, the majority of Yalvaç producers (90.5%) observed changes, such as yield reductions, in wheat and barley production. Furthermore, 52.4% of the producers stated that the decrease in wheat or barley yields between 2017 and 2022 was due to drought and lack of rainfall. More than 50% of the producers indicated that the decline in wheat or barley yields over the past decade was caused by drought, insufficient rainfall and frost (Table 2). These statements clearly demonstrate that producers are strongly affected by the impacts of climate on wheat and barley production.

Table 2. Reasons for the decline in wheat and barley yields according to producers

Çizelge 2. *Üreticilere göre buğday ve arpa verimindeki düşüşün nedenleri*

	Number	%
Reasons for yield decline between 2017 and 2022		
Insufficient rainfall, drought	55	52.4
Seasonal shifts, change of precipitation times	36	34.3
Not using fertilizer, insufficient use (price increase)	7	6.6
Frost, hail, excessive rainfall	7	6.6
Total	105	100
Reasons for yield decline between 2012 and 2022		
Insufficient rainfall, drought, frost	65	61.9
Temperature rise, global warming	34	32.4
High fertilizer prices, poor quality seed	6	5.7
Total	105	100

According to Kaya (2021), the decrease in wheat yields in Türkiye is primarily due to extreme temperatures (above 30°C) and insufficient rainfall (below 40 mm) occurring in May and June. The recurrence of these climatic events (extreme heat and low precipitation) over several years suggests that many winter wheat varieties will be unable to withstand the effects of climate change. Geren & Geren (2008), noted that inadequate rainfall between February and March, during the heading period, significantly reduces wheat yields in Türkiye. High temperatures and low rainfall in May are key climatic factors impacting wheat yields in the coastal regions of the Aegean in Türkiye. Similarly, a study conducted in Nigeria found that delayed rains and high temperatures are the most critical climate factors that significantly reduce crop yields in many farms (Chukwu et al., 2023).

All producers (100%) expressed concerns about the impacts of climate change. Their worries include reductions in wheat and barley yields, which they believe will lead to significant decreases in food supply in the coming years. Therefore, it is indicated that issues of food insecurity are fundamentally linked to climate change. Consequently, there is widespread awareness among producers about the potential risks of climate change to food security. Additionally, 20.7% of the producers are specifically worried that climate change will cause global warming and drought (Table 3). According to a study by the Ministry of Agriculture and Forestry, 76% of producers indicated that the effects of climate change would lead to severe famine (TOB, 2021).

Table 3. Producers' concerns about the impacts of climate change
Çizelge 3. *Üreticilerin iklim değişikliğinin etkileri hakkındaki endişeleri*

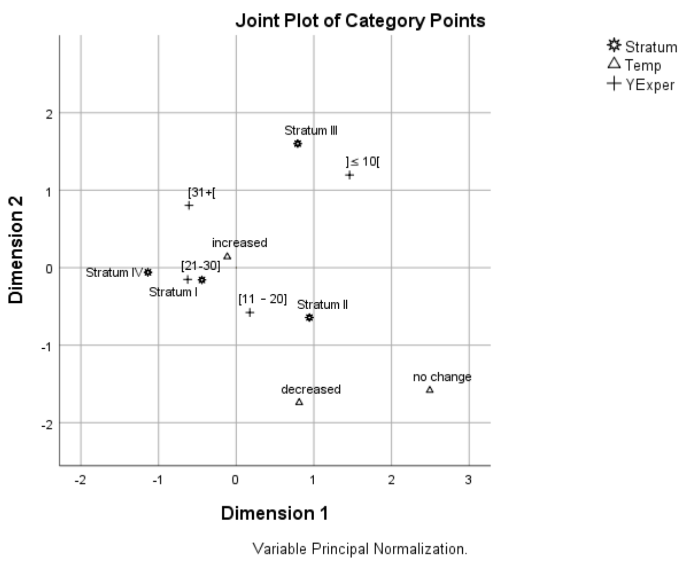
Producers' worries about the impacts of climate change	Number	%
Decreases in yield	38	32.8
Problems in food supply	27	23.3
Drought, decreasing rainfall and rising temperatures	24	20.7
Shift of precipitation to summer due to climate change	9	7.8
Lack of water (water shortage)	8	6.9
Reduced income	4	3.4
Degradation of ecology	3	2.6
Natural disasters, increase in diseases and pests, pollution problems	3	2.6
Total	116	100

While all producers are concerned about climate change, the level of concern varies among individuals. Specifically, 38.8% of producers are very worried about the effects of climate change. In contrast, 35.3% are neutral, neither worried nor unworried, and 25.9% are simply concerned about climate change. These findings indicate widespread concern among producers, though the degree of individual concern varies. Some producers may express higher levels of concern due to personal experiences or the direct impact of climate change on wheat and barley production. These data can be useful in developing differentiated awareness strategies and adaptation measures based on the producers' levels of concern. In the Wushen Banner region of China, a study by Zhang et al. (2020), found that 41% of producers were very worried about climate change, 51% were neutral, and 4% were not concerned about climate change. Similarly, a study by the TOB (2021), reported that the majority of producers believe the climate is constantly changing, with 92% expressing concerns about the impacts of climate change.

Perceptions of wheat and barley producers on climate change

To assess producers' perceptions on changes in specific weather indicators, a three-level Likert scale (1- decreased, 2- no change, 3- increased) was employed. According to the results, wheat and barley producers in Yalvaç district noted increases in average summer temperatures (95.7%), average winter temperatures (87.1%), drought intensity (85.3%), and soil degradation (68.1%). These findings align with Zhang et al. (2020), where the majority of producers in China's Wushen Banner region (95%) reported increases in annual temperature and drought. Producers in Punjab, India, have observed a rise in temperature in recent years (Kumar & Sidana, 2018), as have producers in Burundi (Batungwanayo et al., 2023). Similar observations have been made by producers in Pakistan, who reported temperature increases during both summer and winter months (Abid et al., 2015). All wheat and barley producers in Yalvaç district (100%) reported a decrease in average annual rainfall over the past decade. Producers also indicated declines in average spring rainfall (99.1%), average summer rainfall (85.3%), average autumn rainfall (98.3%), average winter rainfall (92.2%), the number of rainy days annually (94%), and available water resources (95.7%). These findings reflect growing concerns about climate change, particularly changes in rainfall patterns that significantly affect agriculture. Reduced rainfall can have a substantial impact on wheat and barley production, which heavily depend on climatic conditions. Furthermore, these results underscore the need to adapt agricultural practices and implement strategies to mitigate the potential effects of climate change. These results are consistent with other studies. In Wushen Banner, China, 95% of surveyed producers reported a decline in annual rainfall (Zhang et al., 2020). In Punjab, India, most producers have observed a decrease in seasonal rainfall in recent years (Kumar & Sidana, 2018). According to Kızmaz (2020), participants in various villages in Elazığ, Türkiye, noted a reduction in water resources. In Pakistan, producers reported decreases in rainfall during both summer and winter months (Abid et al., 2015).

According to multiple correspondence analysis, the relationship between farm size, agricultural experience, and producer opinions on annual temperature changes is presented in Figure 1. Producers with farms smaller than 20 decares and 21 to 30 years of agricultural experience believe there has been a greater increase in average annual temperature over the past decade. This finding suggests that producers with smaller farms may be more sensitive to climate change due to the more vulnerable nature of their operations. Additionally, extensive agricultural experience may heighten awareness of even small changes in climate conditions over the years.



Average annual temperature	Stratum	+ Years of experience
1. decreased	1. Stratum I (1.00-20.00) da	1.]≤ 10]
2. no change	2. Stratum II (20.01-50.00) da	2. [11 20]
3. increased	3. Stratum III, (50.01-100.00) da	3. [21-30]
	4. Stratum IV, (100.00 +) da	4. {31+[

***Figure 1**. Relationship between strata, years of experience and mean annual temperature.*

***Şekil 1**. Tabakalar, deneyim yılları ve ortalama yıllık sıcaklık arasındaki ilişki.*

The perceptions of producers regarding future climate variables (next ten years) were assessed using a three-level Likert scale (1. decrease, 2. no change, 3. increase). Producers believe that in the next decade, there will be an increase in annual average temperature (93.1%) and drought (86.2%). Similarly, they anticipate increases in irregular rainfall (76.7%), frost (64.9%), and hot winds (63.8%). However, producers also expect a decrease in annual average precipitation (94.8%) and in available water resources (87.1%) over the next decade. These findings highlight the importance of planning and adaptation to overcome potential challenges of climate change in the agricultural sector of Yalvaç district. According to Zhang et al. (2020), producers are in consensus about the future impact of climate change on their regions.

A five-level Likert scale (1. strongly disagree, 2. disagree, 3. neutral, 4. agree, 5. strongly agree) was used to measure producers' perceptions of climate change adaptation. According to the results, 97% of the surveyed producers agree that climate is changing; 98% agree that temperature and drought are increasing due to climate change; approximately 98% agree that rainfall is decreasing or becoming irregular because of climate change. Additionally, 97% of producers agree that climate change affects agricultural activities. For instance, 87% believe that declines in wheat and barley yields are linked to the effects of climate change, while those who remain neutral attribute yield declines to economic crises and high input costs. Therefore, 87% of producers associate high agricultural production costs with the effects of climate change, which in turn has led to increased food prices. Consequently, 83% of producers strongly agree that adjusting wheat or barley planting dates to later in the season is necessary to mitigate the impacts of climate change, which would consequently shift harvest dates. More than 40% of producers strongly agree that transitioning to dry farming, with lower water usage, is necessary due to water scarcity, although approximately 28% are undecided about transitioning to dry farming. Moreover, 80% of producers attribute plant diseases, pests, ecosystem degradation, and soil fertility decline to the effects of climate change. Producers also strongly agree (82%) that increased frost duration is due to climate change. About 65% of respondents remained neutral when asked if irrigation periods or amounts had changed, likely because a majority do not irrigate wheat or barley. Additionally, over 90% of producers agree that climate change affects agriculture, and 83% believe that adopting adaptation measures can reduce its effects. However, producers acknowledge the limitations of human capacity alone in coping with the impacts of climate change, given the high costs associated with managing these effects. Furthermore, 80% of producers agree that their knowledge about climate change is limited. According to Zhang et al. (2020), 97% of producers believe that climate change affects agricultural activities, and 79% attribute declines in crop and livestock yields to climate change. In China, 74% of producers believe that increases in production costs are due to climate change, and 87% believe that appropriate measures must be taken to combat the effects of climate change. In the Wushen Banner region of China, 79% of surveyed producers believe that the cost of adapting to climate change is high, and 65% believe that human capacity is limited in addressing the effects of climate change. Similarly, 80% of respondents in the survey by Zhang et al. (2020), believe that the costs of implementing adaptation measures are high. According to TOB (2021), 90% of respondents in a survey believe that climate change will be a significant issue for agricultural production. The majority (83%) believe that measures to prevent climate change will be effective.

Measures and behaviors of producers against the effects of climate change

Table 4 presents the reasons why producers change their planting schedules. Subsequently, Table 5 illustrates different periods when planting activities were conducted between 2012 and 2022.

According to Tables 4 & 5, in response to the impacts of climate change, 83% of the surveyed producers reported changing the date of soil plowing in the fall. This adjustment is attributed to various reasons, such as the delayed onset of fall rains (41.7%) and changes in rainfall patterns (30.2%). In 2012, the majority of producers (85%) conducted soil plowing in October. However, due to the effects of climate change, 76% of producers carried out fall plowing in November in 2022, despite using the same cultivation techniques. Thus, over ten years, the date for fall soil plowing in most farms in Yalvaç shifted by one month, from October to November. This shift from October to November reflects a strategic adaptation by producers to account for changing rainfall patterns and the delayed arrival of fall rains. These adjustments in the timing of agricultural activities highlight the flexibility of producers in adapting to changing climate conditions, which is necessary to optimize yields and maintain the viability of their operations in the face of climate challenges. According to the chi-square test results, there is a significant relationship between the annual average fall rainfall and the producers' decision to change the date of soil plowing in the fall ($\chi 2=9.77$; $p=0.02$). This analysis indicates that annual average fall rainfall has a statistically significant effect on the producers' preference to change the soil plowing date.

Table 4. Various practices of producers in wheat and barley production in relation to climate change and their reasons

Çizelge 4. *Üreticilerin iklim değişimiyle ilgili olarak buğday ve arpa üretiminde çeşitli uygulamaları ve nedenleri*

	Number	%
Date of soil plowing in the fall		
Changed	96	82.8
Unchanged	20	17.2
Total	116	100
Why has it changed?		
Climatic shift and change in rainfall regime	29	30.2
Late arrival of fall rains	40	41.7
Drought	27	28.1
Total	96	100
Base Fertilization time		
Changed	97	83.6
Unchanged	19	16.4
Total	116	100
Why has it changed?		
Delaying sowing	7	7.2
Climatic shift and change in rainfall regime	27	27.8
Late arrival of rainfall	37	38.1
Drought	26	26.8
Total	97	100
Sowing date		
Changed	103	88.8
Unchanged	13	11.2
Total	116	100
Why has it changed?		
Climatic shift and change in rainfall regime	25	24.3
Late arrival of fall rains	47	45.6
Drought	31	30.1
Total	103	100
Surface fertilization		
Changed	85	73.3
Unchanged	31	26.7
Total	116	100
Why has it changed?		
Climatic shift and rainfall regime change	28	32.9
Irregular spring rainfall	11	12.9
Drought, no rainfall	46	54.1
Total	85	100
Changes in spraying		
Changed	68	58.6
Unchanged	45	38.8
No spraying	3	2.6
Total	116	100
Why has it changed?		
Climatic shift, rainfall regime change, irregularity in rainfall	28	41.2
Drought	40	58.8
Total	68	100
Harvest time		
Changed	80	69
Unchanged	36	31
Total	116	100
Why has it changed?		
Harvest time varies according to temperature	15	18.8
Climatic shift and rainfall regime change	41	51.2
Drought	24	30.0
Total	80	100

Table 5. Changes in producers' practices in wheat and barley production in 2012-2022

Çizelge 5. *Üreticilerin buğday ve arpa üretiminde 2012-2022 yıllarındaki uygulamalarındaki değişiklikler*

	Date of soil plowing in the fall							
	Date of soil plowing in the fall 2022				Date of soil plowing in the fall 2012			
	September		October	November	September		October	November
Number	1		26	89	16		99	1
%	0.9		22.4	76.7	13.8		85.3	0.9
	Base Fertilization time							
	Base Fertilization time 2022				Base Fertilization time 2012			
	October		November	December	September		October	November6
Number	20		95	1	9		100	7
%	17.2		81.9	0.9	7.8		86.2	6
	Sowing date							
	Sowing date 2022				Sowing date 2012			
	October		November	December	September		October	November
Number	18		93	5	10		100	6
%	15.5		80.2	4.3	8.6		86.2	5.2
	Surface fertilization							
	Surface fertilization 2022				Surface fertilization 2012			
	January	February	March	April	February		March	April
Number	1	4	21	90	2		23	91
%	0,9	3,4	18,1	77,6	1,7		19,8	78,4
	Changes in spraying							
	Change in spraying 2022				Change in spraying 2012			
	January	March	April	May	February	March	April	May
Number	2	4	100	7	2	6	100	5
%	1.8	3.5	88.5	6.2	1.8	5.3	88.5	4.4
	Harvest time							
	Harvest time 2022				Harvest time 2012			
	July		August		June		July	
Number	111		5		15		101	
%	95.7		4.3		12.9		87.1	

This finding underscores the direct impact of rainfall conditions on producers' operational decisions. Facing increasingly unpredictable weather conditions, producers may need to adjust their plowing practices based on changes in fall rainfall. The timing of basal fertilization was changed by 84% of the surveyed producers. The reasons for this change include delayed rains (38.1%), changing rain seasons (27.8%), and drought (26.8%). In 2012, 86% of producers applied basal fertilizer in October. By contrast, in 2022, the same producers performed basal fertilization in November. This change in practice indicates that producers are attempting to minimize the negative impact of changing climate conditions on wheat/barley production and optimize the use of available resources. According to the chi-square test, there is a significant relationship between changes in the annual average spring rainfall and the timing of basal fertilizer application ($\chi 2$ =5.15; p=0.02). This finding shows that changes in the annual average spring rainfall have a statistically significant effect on the timing of basal fertilizer application. This illustrates that for sustainable agriculture, producers are making changes in their agricultural practices to adapt to climate changes. Producers (89%) changed their sowing dates between 2012 and 2022 due to the delayed onset of fall rains (45.6%), drought (30.1%), and changes in rainfall patterns (24.3%). Therefore, in 2012, most farms (86%) sowed wheat or barley in October. However, by 2022, due to the effects of climate change, the majority of producers (80%) sowed wheat or barley in November. Like the fall soil plowing date, the effects of climate change have caused a one-month shift in wheat or barley sowing activities. The shift of sowing activities from October to November represents a strategic adaptation aimed at optimizing crop growing conditions in light of new climatic realities. According to the chi-square test results, there is a significant relationship between changes in the annual average spring rainfall and the producers' decision to change the wheat/barley sowing date ($\chi 2$ =7.99; p=0.005). Adjusting the sowing date in response to changes in spring rainfall demonstrates the producers' sensitivity to specific weather conditions affecting the germination, growth, and development of wheat and barley. By adjusting the sowing time, producers aim to minimize risks associated with unpredictable weather conditions while maximizing the use of available resources. Surface fertilization is applied as early as possible during the tillering stage of wheat or barley. 73% of producers have changed their Surface fertilization dates. The primary reasons for this change between 2012 and 2022 are drought and reduced rainfall (54.1%), as well as climatic shifts and changes in rainfall patterns (33%). In both 2012 and 2022, the majority of producers (78%) applied Surface fertilization in April. However, in 2012, Surface fertilization was applied at the beginning of April, while in 2022, this application took place towards the end of April. This monthly shift demonstrates a strategic adaptation to optimize the efficiency of surface fertilization under changing weather conditions. Thus, producers exhibit the ability to take flexible measures and optimize agricultural practices to maintain productivity under variable weather conditions. According to the chi-square test results, there is a significant relationship between windy days and the application of Surface fertilization by wheat/barley producers ($\chi2 = 6.74$; $p = 0.03$). This significant relationship indicates that weather conditions, particularly wind, impact agricultural practices related to fertilization. Producers adjust their fertilization methods to windy conditions to minimize losses and maximize input efficiency. Strong winds can cause uneven distribution of fertilizers, affecting the uniform distribution of nutrients in the soil. Spraying dates were changed by 58% of the surveyed producers. About 2.6% of the surveyed producers indicated that they did not perform any spraying. The reasons given for changing spraying dates included drought, insufficient and irregular rainfall. In both 2012 and 2022, the majority of producers carried out spraying activities in April. Between 2012 and 2022, 69% of producers changed their wheat or barley harvest dates. The main reasons for this change in harvest dates were changes in rainfall patterns (51.2%) and drought (30%). In 2012, wheat or barley harvest began in June and ended in July. However, in 2022, the harvest began in late July and ended in August. This adaptation likely aims to optimize crop quality and yield despite the challenges posed by climate change. According to the chi-square test results, there is a significant relationship between annual average temperature changes and changes in wheat/barley harvest dates ($\chi2 = 6.60$; $p = 0.03$). This indicates that annual average temperature changes influence producers' decisions to change harvest dates. Overall, annual average temperature changes have a direct impact on producers' preferences regarding the timing of wheat or barley harvests. 20% of surveyed producers reported knowing measures to counteract the adverse effects of climate change but not implementing them. Irrigation, cover crops, mulching, and early warning systems are the main measures producers are aware of but do not practice. 61% of producers cited the high costs of purchasing and installing equipment as the reason for not taking measures to combat the effects of climate change. Thus, there is a need for financially accessible solutions to encourage the adoption of adaptation measures. Other barriers to implementing precautionary measures against the effects of climate change, as cited by producers, include insufficient water resources and lack of land ownership (Table 6).

Table 6. Adaptation measures known to producers

Çizelge 6. *Üreticiler tarafından bilinen uyum önlemleri*

	Number	%
Knowing but not practicing	23	19.8
Does not know	93	80.2
Total	116	100
If they are aware, what are they?		
	Number	%
Irrigation	10	43.5
Early warning systems	3	13.0
Cover crops and mulching	4	17.4
Insurance	1	4.3
Irrigation and other (roof, green manure etc.)	5	21.7
Total	23	100
(If you are aware, why haven't you implemented them?		
	Number	%
Water shortage	4	17.4
Cost, mistrust of insurance	16	69.6
Not his own land	3	13.0
Total	23	100.0

CONCLUSION

In recent years, climate changes have negatively impacted the agricultural sector in various regions of Türkiye, particularly in the Yalvaç district. Wheat and barley producers in this district are acutely aware of the climate shifts and are experiencing the effects intensely. The most notable perceptions are the decrease in precipitation and the increase in temperatures in recent years. Producers have attributed the decline in wheat and barley yields to drought, lack of rainfall, frost, and rising temperatures. To continue producing wheat and barley and to ensure sustainable agriculture, producers have adopted a series of measures to adapt to the impacts of climate change. These measures include changes in sowing dates, fertilization, and harvesting. There is a need for the support of Provincial/District Agriculture Directorates to address the producers' knowledge gaps and assist them in adapting to climate change. These directorates should plan and implement new training and extension programs aimed at enhancing the capacity and resilience of producers to adapt to climate change, in collaboration with local stakeholders. Efforts should focus on disseminating best practices and successful applications, addressing emerging issues during adaptation, and providing education and extension activities in these areas. Organize participatory training workshops where producers can share their experiences and learn from one another about the impacts of climate change. These workshops should include testimonies from producers who have successfully implemented adaptation measures. Establish demonstration plots where producers can observe the positive effects of climate-adapted agricultural practices, such as the use of resistant crop varieties or water management techniques, in real-time. Collaborate with local radio stations, newspapers, and other community media to regularly disseminate information about climate change and its impact on agriculture. Working with research institutes and climate change experts to plan and implement region-specific and locally tailored special training programs will also provide significant benefits. Research and development efforts on climate-resilient varieties should be accelerated. These programs can be tailored to the specific needs of producers and cover topics such as best sustainable agricultural practices, water management, energy-efficient irrigation techniques, and other climate adaptation strategies. Such extension activities will enable producers to continue producing wheat and barley amid climatic changes and ensure the sustainability of agriculture. The government should take the necessary measures and accelerate new incentive and support policies regarding financial assistance.

Data Availability

Data will be made available upon reasonable request.

Author Contributions

Conception and design of the study: KRG, HÇA; sample collection: KRG; analysis and interpretation of data: KRG; statistical analysis: KRG; visualization: KRG, HÇA; writing manuscript: KRG, HÇA.

Conflict of Interest

There is no conflict of interest between the authors in this study.

Ethical Statement

This research was approved by the ethics committee of Isparta University of Applied Sciences with document number E.62155, dated 10.24.2022.

Financial Support

The authors declared that they received no financial support.

Article Description

This article was edited by Section Editor Dr. H. Ece SALALI.

REFERENCES

Abid, M., J. Scheffran, U.A. Schneider & M. Ashfaq, 2015. Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth System Dynamics Discussions, 6: 225-243. https://doi.org/10.5194/esd-6-225-2015.

Akyüz, Y. & E. Atiş, 2022. Üreticilerin iklim değişikliğine uyum çerçevesinde çevresel tutumlarının belirlenmesi: Küçük Menderes havzası örneği. Ege Üniversitesi Ziraat Fakültesi Dergisi, 59 (3): 557-566. https://doi.org/10.20289/zfdergi.1063327.

Arimi, K., M.F. Kolayemi, O. Fatufe & A.T. Joshua, 2020. Cowpea farmers' vulnerability and adaptation to climate change in Iddo local government area of Oyo State, Nigeria. Yuzuncu Yıl University Journal of Agricultural Science, 30 (3): 601-610.

Assi, Y.F., 2022. Impact du changement climatique sur la production du riz dans les différentes régions de Côte d'Ivoire : cas du Haut Sassandra, de Gôh, de Poro, de Tonkpi, de Gbêkê et de N'zi. European Scientific Journal, 10: 697-708. https://doi.org/10.19044/esipreprint.10.2022.p697.

Batungwanayo, P., V. Habarugira, M. Vanclooster, J. Ndimubandi, A.F. Koropitan & J-D. Nkurunziza, 2023. Confronting climate change and livelihood: smallholder farmers' perceptions and adaptation strategies in northeastern Burundi. Regional Environmental Change, 23 (47): 1-20. https://doi.org/10.1007/s10113-022-02018-7.

Bolat, Y. & M. Bakirci, 2022. Erbaa Ovasında (Tokat) Tarımsal üreticilerin iklim değişikliğine yönelik bilgi ve algı düzeylerinin belirlenmesi. Doğu Coğrafya Dergisi, 27 (48): 37-48.

Çevre ve Şehircilik Bakanlığı, 2020. Bölgesel İklim Değişikliği Eylem Planları. T.C. Çevre ve Şehircilik Bakanlığı Yayınları. Ankara, Türkiye.

Chukwu, V.A., O.O., Osuafor, I. Ukwuaba, J. Enyigwe & P. Chinenye Chinaza, 2023. Farmers' adaptation strategies to the effect of climate variation on yam production in Ebonyi State, Nigeria. Journal of Agriculture and Crops, 9 (2): 240-249. https://doi.org/10.32861/jac.92.240.249.

Çiçek, A. & O. Erkan, 1996. Tarım Ekonomisinden Araştırma ve Örnekleme Yöntemleri. Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi Yayınları No: 12: 118 s.

Djellouli, F., A. Bouanani & K. Baba-Hamed, 2019. Caractérisation de la sécheresse et du comportement hydrologique au niveau du bassin versant de l'oued Louza (Algérie occidentale). Techniques Sciences Méthodes, (6): 23-30. https://doi.org/10.1051/tsm/201906023.

Doğan, H.G. & G. Karakaş, 2018. The effect of climatic factors on wheat yield in Turkey: a Panel Dols Approach. Fresenius Environmental Bulletin, 27 (6): 41624168. https://hdl.handle.net/20.500.12513/4067.

Fujisawa, M., K. Kobayashi, P. Johnston & M.G. New, 2015. What drives farmers to make top-down or bottom-up adaptation to climate change and fluctuations? A comparative study on 3 cases of apple farming in Japan and South Africa. PLoS ONE, 10 (3): e0120563. https://doi.org/10.1371/journal.pone.0120563.

Geren, R.Ü.H. & H. Geren, 2008. Ege Bölgesi sahil kuşağında buğday verimini etkileyen iklim faktörleri ve çeşitlerin adaptasyonları. Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 18 (2): 1-10. https://dergipark.org.tr/tr/pub/anadolu/issue/1765/21757.

IPCC (Intergovernmental Panel on Climate Change), 2022. "Annex II: Glossary, 2897-2930". In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Eds. H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem & B. Rama). Cambridge, 3068 pp.

Karakaş, G., 2022. Determination of climate change adaptation behavior of wheat producing farmers; the case of Çorum Province in Turkiye. Turkish Journal of Agriculture-Food Science and Technology, 10 (8): 1459-1467. doi: https://doi.org/10.24925/turjaf.v10i8.1459-1467.5337.

Kaya, Y., 2021. Winter wheat adaptation to climate change in Turkey. Agronomy, 11 (4): 689. https://doi.org/10.3390/agronomy11040689.

Kızmaz, Z., 2020. İklim değişikliğinin kırsal alandaki etkisi ve alternatif arayışlar: sosyolojik bir yaklaşım. Fırat Üniversitesi Sosyal Bilimler Dergisi, 31 (1): 431-453. https://doi.org/10.18069/firatsbed.827702.

Korkmaz, M. & H. Şahin, 2023. İklim değişikliği endişesini etkileyen faktörler: Mersin iline yönelik bir araştırma. Turkish Journal of Forest Science, 7 (2): 210-222. https://doi.org/10.32328/turkjforsci.1333268.

Korres, N.E., J.K. Norsworthy, N.R. Burgos, & D.M. Oosterhuis, 2017. Temperature and drought impacts on rice production: An agronomic perspective regarding short- and long-term adaptation measures. Water Resources and Rural Development, 9: 1227. https://doi.org/10.1016/j.wrr.2016.10.001.

Krishnan, P., B. Ramakrishnan, K.R. Reddy & V.R. Reddy, 2011. High-temperature effects on rice growth, yield, and grain quality. Advances in Agronomy, 111: 87-206. https://doi.org/10.1016/B978-0-12-387689-8.00004-7.

Kumar, S. & B.K. Sidana, 2018. Farmers' perceptions and adaptation strategies to climate change in Punjab agriculture. Indian Journal of Agricultural Sciences, 88 (10): 1573-1581.

Naseri, Z., 2015. Uşak Ilinde Kuru Koşullarda Buğday Üretimi Yapan Üreticilerin Olası Kuraklık Sigortasını Benimsemesinde Etkili Olan Faktörlerin Analizi. Fen Bilimleri Enstitüsü, Ege Üniversitesi, (Unpublished) MSc Thesis, Uşak, 189 s.

Polat, K. & İ. Dellal, 2016. Ramsar alanlarda iyi tarım uygulamaları yapan üreticilerin iklim değişikliği algısı: Göksu Deltası örneği. Tarım Ekonomisi Araştırmaları Dergisi, 2 (1): 51-62.

Shahbaz, P., 2018. Factors Affecting Farmers' Adaptation Strategies to Climate Change in Central Punjab, Pakistan. Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü, (Unpublished) MSc Thesis, Samsun, 92 pp.

Süner, A. & C.C. Çelikoğlu, 2010. Toplum tabanlı bir çalışmada çoklu uygunluk analizi ve kümeleme analizi ile sağlik kurumu seçimi. Dokuz Eylül Üniversitesi İktisadi İdari Bilimler Fakültesi Dergisi, 25 (2): 43-55.

TOB (Tarım ve Orman Bakanlığı), 2021. İklim Değişikliği ve Tarım Değerlendirme Raporu. T.C. Tarım ve Orman Bakanlığı Yayınları, Çankaya, Ankara-Türkiye, 114 s.

Tokgöz, M., 2022. Sakarya İli Adapazari İlçesi Merkez ve Köylerindeki Siğircilik İşletmelerinde Buzaği Yetiştiriciliği, Beslenmesi ve Sorunlarinin İşletme Büyüklüğü Açisindan İncelenmesi. Atatürk Üniversitesi Fen Bilimleri Enstitüsü, (Unpublished) MSc Thesis, Sakarya, 120 pp.

Tsujii, H. & U. Gültekin, 2018. "An Econometric and Agro-meteorological Study on Rain-fed Wheat and Barley in Turkey Under Climate Change, 343-374". In: Climate Change Impacts on Basin Agro-ecosystems. The Anthropocene: Politik Economics Society Science (Eds. T. Watanabe, S. Kapur, M. Aydın, R. Kanber & E. Akça). Springer, Cham, Gewerbestrasse, Switzerland, 433 pp.

TÜİK, 2023. Tarımsal İstatistik Verileri. (Web page: https://data.tuik.gov.tr/Kategori/GetKategori?p=Tarım-111) (Date accessed: March 2023).

Yamane, T., 2018. Temel Örnekleme Yöntemleri. (III. Basım) Literatür Yayıncılık. Istanbul. Türkiye, 509 s.

Yang, Y., J. Yu, Q. Qian & L. Shang, 2022. Enhancement of heat and drought stress tolerance in rice by genetic manipulation: A systematic review. Rice, 15. https://doi.org/10.1186/s12284-022-00614-z.

Yüzbaşıoğlu, R., 2019. Tokat İli merkez ilçe kırsalında üreticilerin toprak analizi yaptırma eğilimleri. Bahri Dağdaş Bitkisel Araştırma Dergisi, 8 (1): 163-169.

Zhang, C., J. Jin, F. Kuang, J. Ning, X. Wan & T. Guan, 2020. Farmers' perceptions of climate change and adaptation behavior in Wushen Banner, China. Environmental Science and Pollution Research, 27: 26484-26494. https://doi.org/10.1007/s11356-020-09048-w.