Yuzuncu Yil University
Journal of Agricultural Sciences
(Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi)
https://dergipark.org.tr/en/pub/yyutbd

ISSN: 1308-7576 e-ISSN: 1308-7584

Research Article

The Effects of Different Tillage Techniques on the Production Costs in Fallow-Wheat Rotation System

Derya SUREK[1], Celal CEVHER[*2], Ufuk TURKER[3]

[1]Soil, Fertilizer and Water Resources Central Research Institute, Ankara, Turkey
[2]Field Crops Central Research Institute, Ankara Turkey
[3]University of Ankara, Agricultural Machinery and Technology Engineering, Ankara

[1]https://orcid.org/0000-0001-5342-4382, [2]https://orcid.org/0000-0002-3631-0321, [3]https://orcid.org/0000-0002-7527-7376

*Corresponding author e-mail: celal.cevher@tarimorman.gov.tr

Article Info

Received: 29.06.2021
Accepted: 07.03.2022
Online published: 15.03.2022
DOI: 10.29133/yyutbd.959650

Keywords

Fallow-wheat,
Production cost,
Single product budget,
Wheat planting method

Abstract: The adoption and applicability of the technologies developed in agriculture by farmers are very important for agronomic studies. There are a limited number of economic studies comparing different tillage methods with each other. This study was conducted in the land of Polatlı Agricultural Enterprise between 2011 and 2017 to determine the amounts of physical production inputs and unit production costs of three different tillage operations in the fallow-wheat rotation system. The data consist of the production inputs in the Conventional Tillage, Minimum Tillage, and Direct Seeding practices. For the economic analysis, Single Product Budget Analysis was used. All the farmers' production costs in the fallow-wheat rotation system were considered in the analysis. Among the practices, Gross Production Value (GPV) was obtained the most from the (509.63$ ha^{-1}) practice. This practice was followed by Direct Seeding (486.13$ ha^{-1}) and Minimum Tillage (421.92$ ha^{-1}) practices, respectively. The profit threshold was exceeded in all practices, and production activities' variable and total costs were fulfilled. The highest relative profit rate was obtained in Direct Seeding (1.77) practice, and it was followed by Conventional Tillage (1.30) and Minimum Tillage (1.08) practices, respectively. In order to obtain an income of $1 in wheat production, the lowest production cost was obtained in the Direct Seeding practice. With the Direct Seeding application, it can be ensured that economic wheat production, preservation of soil structure, reduction of input costs, and less economic damage to the farmer in changing climate conditions can be achieved.

To Cite: Surek, D, Cevher, C, Turker, U, 2022. The Effects of Different Tillage Techniques on the Production Costs in Fallow-Wheat Rotation System. *Yuzuncu Yil University Journal of Agricultural Sciences*, 32(1): 143-151. DOI: https://doi.org/10.29133/yyutbd.959650

Nadas-Buğday Ekim Nöbetinde Uygulanan Farklı İşleme Tekniklerinin Üretim Maliyeti Üzerine Etkilerinin İncelenmesi

Makale Bilgileri

Geliş: 29.06.2021
Kabul: 07.03.2022
Online yayınlanma: 15.03.2022
DOI: 10.29133/yyutbd.959650

Öz: Tarımda geliştirilen teknolojilerin, çiftçiler tarafından benimsenmesi ve uygulanabilirliği, agronomik çalışmalar için oldukça önemlidir. Farklı toprak işleme metotlarının birbirleri ile kıyas edildiği ekonomik çalışmalar sınırlı sayıdadır. Bu araştırmada, 2011-2017 yılları arasında yürütülen nadas-buğday ekim nöbeti sistemindeki üç farklı toprak işleme uygulamasının fiziki üretim girdi

Anahtar Kelimeler

Nadas-buğday,
Üretim maliyeti
Tek ürün analizi,
Buğday ekim yöntemi,

miktarları ve birim üretim maliyetlerinin tespiti amaçlanmıştır. Çalışma Polatlı Tarım İşletmesi arazisinde yürütülmüştür. Veriler, Geleneksel Toprak İşleme, Azaltılmış Toprak İşleme ve Doğrudan Ekim uygulamalarındaki üretim girdileridir. Ekonomik analizde, Tek Ürün Bütçe Analiz yöntemi kullanılmıştır. Analizde, çiftçinin nadas-buğday ekim nöbeti sistemindeki üretim maliyetlerinin tamamı dikkate alınmıştır. Uygulamalar arasında en fazla Gayri Safi Üretim Değeri Geleneksel Toprak İşleme ($509.63 ha^{-1}) uygulamasından elde edilmiştir. Sırasıyla bu uygulamayı Doğrudan Ekim ($486.13 ha^{-1}) ve Azaltılmış Toprak İşleme ($421.92 ha^{-1}) uygulamaları izlemiştir. Uygulamaların tamamında kâr eşiği aşılmış ve üretim faaliyetlerinin değişen ve toplam masrafları karşılanmıştır. En fazla nispi kar oranı Doğrudan Ekim (1.77) uygulamasında elde edilmiş, bunu sırasıyla Geleneksel Toprak İşleme (1.30) ve Azaltılmış Toprak İşleme (1.08) uygulamaları takip etmiştir. Buğday üretiminde 1 $'lık net gelirin elde edilmesi için, en düşük üretim masrafı Doğrudan Ekim uygulamasında elde edilmiştir. DS uygulaması ile ekonomik buğday üretiminin sağlanması, toprak yapısının korunması, girdi maliyetlerinin azaltılması ve değişen iklim koşullarında çiftçinin ekonomik bakımından daha az zarar görmesi sağlanabilir.

1. Introduction

Wheat, which can be cultivated in almost every region of Turkey, ranks first in terms of cereal production. According to the data of 2019, wheat cultivation areas constitute 6 846 327 ha (63.55%) of cereal cultivation in 10 772 160 ha in Turkey. Total wheat production in Turkey is 19 000 000 tons, and the average yield is 2 780 kg ha^{-1}. Central Anatolia Region (CAR) is Turkey's most important cereal cultivation area in terms of wheat cultivation area and production. In CAR, the wheat cultivation area is 2 708 600 ha, and it constitutes 39.5% of the total cultivation area, while wheat production, which is 6 971 613 tons, constitutes 36.7% of Turkey's wheat production. The fact that annual precipitation in CAR is insufficient and its distribution by seasons is irregular emerges as the most important ecological characteristic of the region. This situation causes the average wheat yield to be below the average of Turkey (2 670 kg ha^{-1}) (TurkStat, 2019). Therefore, the ecological characteristics of the region necessitate fallow-wheat rotation in many regions (Genc, 1976).

In CAR, where the fallow-wheat rotation system is applied, the income levels of small- and medium-sized farmers are low. Large-scale farmers experience losses in their agricultural incomes due to the high production costs (Cevher and Altunkaynak, 2020). This situation causes the farmers in CAR to fall behind compared to the farmers in other regions economically. For this reason, various studies should be conducted to increase the incomes of the farmers who practice the fallow-wheat rotation system. In this context, it is important to reduce studies the production costs. For example, draft force requirements for tillage have a significant share in total production costs. The previous studies conducted in the region determined that farmers could not use the agricultural production factors at the optimum level due to a lack of technical knowledge. It was determined that the most important cost component in wheat production is the diesel fuel expenditures (between 43.0% and 45.15 (Cetin and Vardar, 2009; Bayramoglu et al., 2010). Accordingly, the results obtained in agronomy research should be put forward with economic analysis methods in order to reduce the production cost in the fallow-wheat rotation system in CAR and Turkey and achieve successful results. Particularly in developing countries, the primary objectives of mechanizing crop production are to reduce human drudgery and raise the farm's output by either increasing the crop yield or increasing the area under cultivation (Ajmer, 2006; Jekayinfa, 2006).

In Turkey, many studies have been conducted to reduce the production costs and to increase incomes (Ozkan, 2001; Aydin and Unakitan, 2016; Ulu et al., 2016; Guler and Korkmaz, 2018; Bayramoglu et al., 2010; Basaran and Engindeniz, 2015; Cebi et al., 2017; Aytop and Akbay, 2018); however, there are few and limited numbers of studies analyze the input use efficiency in the fallow-wheat rotation system. For that reason, the present study aimed to contribute to the elimination of this deficiency with our study results. However, this is just the case in Turkey since there are worldwide conducted studies on the input use efficiency in different countries (Rosli et al., 2013; Adeoye et al., 2104; Malinga et al., 2015; Shahgholi and Moinfar, 2019). One of these studies, for example, revealed that fuel expenditures were 19 to EUR 54 less in the Direct Seeding (DS) tillage system compared to

the Conventional Tillage (CT) system in wheat production (Sarauskis et al., 2009). Similarly, Sqrensen and Nielsen (2005) reported that energy input decreased by 18-53% compared to CT, depending on the applied methods and techniques. According to Perrin et al. (1976) economic analysis of the agronomic studies would significantly contribute to the adoption of the results by farmers, and partial budgeting can successfully be used in this regard.

A considerable number of agronomic studies have been conducted on conventional wheat production in the fallow-wheat rotation system. However, the literature review showed that the number of studies making economic comparisons of CT, Minimum Tillage (MT), and DS tillage methods are limited in Turkey. For the environment friendly and sustainable agricultural production, traction power requirements should be minimized. Therefore, it is necessary to determine the most cost-effective tillage method in wheat production.

It is aimed to make an economic analysis of three different tillage applications (CT, MT and DS) in the fallow-wheat rotation system applied in CAR. In addition, it is within the scope of the study to determine which of the tillage practices the farmer will prefer according to the results of wheat production cost, gross profit, net profit, and relative profit ratio. This study is quite remarkable in terms of the lack of studies on this issue in Turkey, and thus the literature is expected to fill.

2. Material and Methods

2.1. Materials

Study data comprise the experimental data for the different tillage methods (CT, MT and DS) on wheat yield was investigated in the project titled "The Effect of Different Soil Tillage Technics on Carbon Sequestration and Soil Sustainability" carried out on the land of Polatlı Agricultural Enterprise between 2011-2017 under the guidance of Soil, Fertilizer and Water Resources Central Research Institute (Surek et al., 2018). Product and input prices were the purchase and sale prices obtained in the free market, Turkish Grain Board (TGB) wheat purchase prices, and fallow wheat production cost records for Ankara, 2018. In the analysis, costs and incomes were calculated at current prices for the year 2018, and then, were converted to US Dollar ($), considering the exchange rates issued at the midyear point by the Central Bank of Turkey. The studied tillage methods are given below.

Conventional Tillage (CT): It is the widely employed tillage method in the fallow-wheat rotation system. In this method, fallow land is tilled with moldboard plough at the first time, as secondary tilling is executed with wing type harrow. The tertiary and more tilling can also be considered if weeds develop in the spring.

Minimum Tillage (MT): Unlike the conventional system, the soil is tilled by ripping the soil instead of overturning the upper soil layer. That is, mouldboard plough is replaced with Gobble disc or wing type harrow in this tillage method.

Direct Seeding (Zero Tillage): No tillage is performed in this method. Instead, total herbicides are used to control the weeds.

2.2. Study Area

The experiment was conducted in the farmland of the Polatlı Agricultural Enterprise. The experimental area is shown in Figure 1. The study area is located in the CAR where the fallow-wheat rotation system is most commonly applied due to the insufficient and uneven rainfall regime. The study area has the characteristics of CAR. In this region, the total fallow land is 3 387 382 ha^{-1}, and about half of the farmers employ the fallow-wheat system. The area where tillage methods are applied and the areas where the methods can be applied are shown in figure 2.

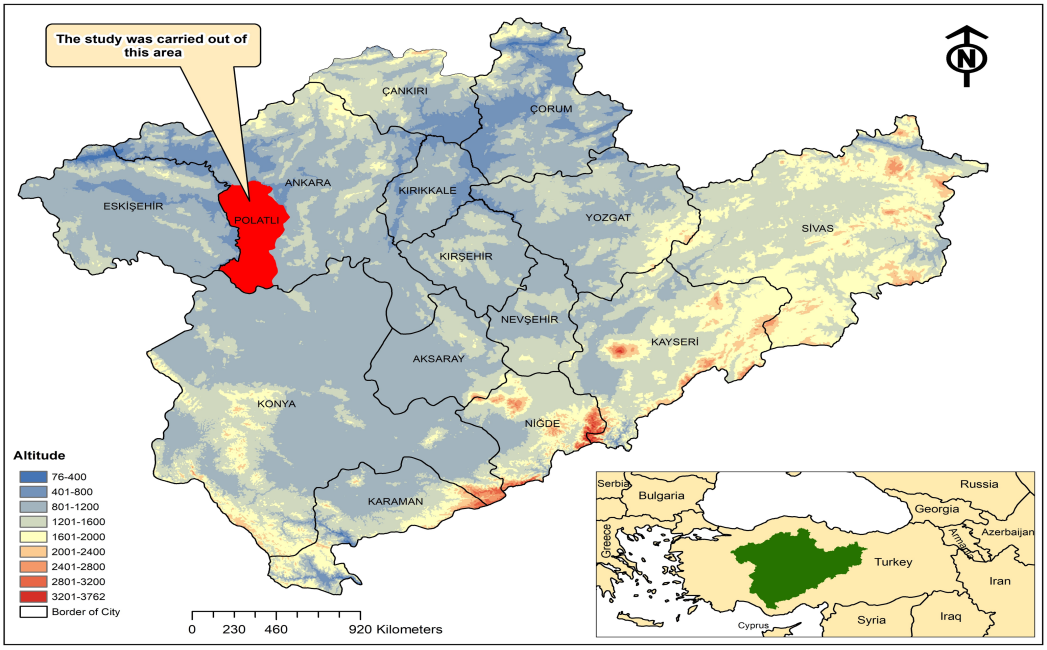

Figure 1. Area of study and areas to which study results can be applied.

2.3. Data Collection

The primary data of the study were obtained from the experiment results established on the land of PAE as the previous relevant research findings, and the records of various organizations were used as the secondary data. The experiment results for the period of 2011-2017 were evaluated using the input and output prices for the year 2018. The calculations were made by considering the average data of the trial results. The current prices of the expenses incurred for each method (CT, MT, DS) were taken as a basis in calculating the wheat production cost. Input and product sales prices were obtained from the averages of prices traded in **Konya, Polatlı and Eskişehir** Commodity Exchange, Agricultural Credit Cooperatives of Turkey, Chambers of Agriculture, Ministry of Agriculture, and Forestry, Turkish Grain Board, and free market.

2.4. Data Analysis Methods and Techniques

Wheat production costs and revenues were calculated with the single product budget analysis method used by Kiral et al (1999). Accordingly, the costs and revenues were calculated for wheat production, considering each tillage method. In the Single Crop/product Budget method, cost and revenue components are taken into consideration only for the crops or product of interest, not all crops cultivated in an agricultural enterprise (Demircan et al., 2005; Aytop and Akbay, 2018). Descriptive statistics, gross income, net profit, and relative profit rates were calculated for the economic comparisons of the tillage methods. IBM SPSS 23 package program was used in the analysis of the data. The gross production value was calculated by multiplying the yields with the product prices. Afterward, gross profit and net profit were calculated according to the following formulas (Kiral et al., 1999).

$$\text{Gross Profit} = \text{Gross production value} - \text{Variable costs} \quad (1)$$

$$\text{Net (Absolute) Profit} = \text{Gross production value} - \text{Production costs} \quad (2)$$

$$\text{Relative (Proportional) Profit} = \text{Gross production value} \square \text{Production costs} \quad (3)$$

3. Results and Discussion

Production techniques in the fallow-wheat rotation system were compared and evaluated, taking into account the production costs and incomes in the CT, MT, and DS methods.

In the fallow-wheat rotation methods, the highest amount of fuel consumption was realized in the CT method. This method was followed by the MT and DS methods, respectively. It was determined that in the fuel consumption of the DS method, 51.61% savings were achieved compared to other methods. They reported that the DS method saves fuel consumption six times compared to other applications (Aase and Schaefer, 1996; Yalcin et al., 2005). It has been reported that MT and DS methods reduce the energy need between 15-50% compared to other methods (Anonymous, 2018). In our study, the highest average wheat yield was obtained in the CT method, followed by DS and MT methods, respectively. In a similar study on this subject, they reported that the highest wheat yield was in the MT method, followed by the CT and DS methods, respectively (Yalcin et al., 2005). The reason for this difference may be due to the fact that Yalcin et al. carried out in the Aegean Region, where the amount of precipitation is high, and our study was carried out in the Central Anatolian Region, where the rainfall amount is insufficient. Although the applied methods are similar, it is natural to have different results due to the differences in precipitation amount, soil structure, production costs, and other factors in the regions (Sümbül and Sönmez, 2021; Şatır and Berberoğlu, 2021).

In our study, the proportional distribution of draft power costs within the total production costs was determined. It was determined that the tensile strength ratio in the CT method was 45.89%, 44.21% in the MT method, and 17.81% in the DS method, respectively. In previous similar studies, it was determined that the ratio of the drawbar power costs used in the CT method to the total production cost in the Marmara Region ranged from 43.0% (Bayramoglu et al., 2010) to 45.15% (Cetin and Vardar, 2009). It can be said that the results of this research are in parallel with our research results. In another study, it was determined that the rate of draft force used in wheat production in Erzurum province was 28.16% (Birinci and Kucuk, 2004). These results show that the draft power ratios in wheat production differ according to the regions and have an important place in the production cost.

Production costs and production incomes of three different methods applied in the fallow-wheat rotation system are given in Table 1. When Table 1 is examined, the highest variable cost is in the CT method, followed by MT and DS, respectively. It is seen that this ranking continues in the same way in terms of total production costs. According to the production costs data, although the farmer is expected to choose the least production cost, it is an important indicator of how much profit the farmer will earn for one unit of cost. The main purpose of economic principles is to obtain the maximum profit for a certain cost (Erkus et al., 2005). In accordance with these principles, gross profit, net profit, and relative profit rates obtained from three different methods were determined. In the CT method, the cost of growing one kg of wheat was found to be \$0.256, \$0.306 in MT, and \$0.189 in DS, respectively. According to these results, it was determined that the wheat farmer lost \$0.030 per kilogram in the CT method and \$0.080 in the MT method but made a profit of \$0.037 in the DS method. It can be said that the DS method is superior to the other two methods to obtain 1 kg of wheat. Therefore, it is important for sustainable wheat production that CT and MT methods are not preferred by the farmers in the fallow-wheat rotation system. However, due to the low precipitation regime in the years of the study, wheat yield per hectare was low in all three methods. It has been determined that the wheat yield is 2780 kg ha^{-1} per hectare in Turkey, and this yield in the research region is lower than the country average, namely 2670 kg ha^{-1} (TurkStat, 2019). In the fallow-wheat rotation system, although there are differences between the tillage methods over the years, the amount of precipitation falling during the development period of the wheat has been a determining factor on the yield (Anonymous, 2018). Therefore, wheat product costs vary significantly at the level of province, region, and even enterprises (Birinci and Kucuk, 2004; Basaran and Engindeniz, 2015). Therefore, it is important to support different policies in different provinces for sustainable production and food security (Moradabadi et al., 2020).

In the fallow-wheat rotation, the Gross Production Value (GPV) consists of the wheat yield and the straw value as a by-product. When Table 1 is examined in terms of GPV, it is seen that the highest GPV was obtained in the CT method, followed by DS and MT, respectively. In a similar study conducted in CAR, it was determined that the GPV obtained in the CT method was higher than that obtained from the DS method (Kaya et al., 2010). In another study, it was reported that the DS method contributed to reducing the production cost and improving soil properties (Aryal et al., 2015). Our results are similar

to the results of the above-mentioned study. The farmer's preference for the CT method according to GPV may not be sufficient for sustainable wheat production. Therefore, the farmer should make a choice to decide on production by evaluating the net profit and relative profit rates (Erkus et al., 2005). In order to generate net income in a business, the total gross profit must be greater than any other expense element, excluding variable expenses. Therefore, in order to generate income in businesses, increasing the gross profit should be the ultimate goal. In our study, it was determined that the gross profit obtained in the CT method was \$214.00 ha^{-1}, 218.78 \$/ha in the MT method, and \$344.98 ha^{-1} in the DS method, respectively. According to these results, it was concluded that the highest gross profit per hectare was obtained from the DS method. Therefore, in terms of gross profit, it would be the right decision for farmers in the CAR to choose the DS method.

Considering the production inputs and unit costs of three different tillage methods in the fallow-wheat rotation system, the highest net profit was \$314.58 ha^{-1} in the DS method, followed by the CT method with 170.94 and the MT method with \$43.13 ha^{-1}, respectively (Table 1). These results were directly proportional to the production costs, but there were differences in terms of the yield obtained. Because it was concluded that the values obtained in terms of yield were high in the CT method; however, it was in second place in terms of net profit. The highest net profit in fallow-wheat production in CAR is achieved by choosing the DS method. Choosing this method in fallow-wheat rotation in CAR will be an important choice for farmers in terms of sustainable wheat production. In terms of sustainable production in agricultural enterprises, it is not sufficient to decide on the basis of GPV, gross profit, and net profit obtained as a result of production activities. The farmer should also consider the relative profit rate (Erkus et al., 2005). In our study, the relative profit ratio between applications was determined in the fallow-wheat rotation system and is shown in Table 1. It is seen that positive net profit is obtained in wheat production in CT, MT, and DS methods in fallow-wheat rotation. Accordingly, the production and profit threshold in the enterprises has been exceeded, and the variable and total costs of the production activity have been met. Under these conditions, the continuation of wheat production in agricultural enterprises from all three applications is economically acceptable. This result shows that the profit threshold is exceeded in wheat production in all three methods. However, it is seen that the highest relative profit ratio (1.77) was obtained in the DS method in fallow-wheat rotation. If this method is preferred by the farmer, it shows that \$1.77 income will be obtained for production costs of \$1. This ratio also shows that in wheat production in the DS method, an income of \$0.77 is obtained for \$1 expense. The relative profit rate was found to be \$1.30 ha^{-1} in the CT method and \$1.08 ha^{-1} in the MT method. In a similar study conducted on this subject, it was concluded that it would be more economical for farmers to switch from the CT method to the DS method in OAB conditions (Gültekin et al., 2011). According to Kan et al. (2018) It has been reported that the profit of nine plants in the CT method is more than 1.55 times the profit obtained from the same plants in the DS method. This difference may be due to the fact that we studied with a single product in our study. Although the wheat yield and gross production value obtained from the CT tillage method were the highest, the low production costs in the DS method and, therefore the increase in the relative profit brought the DS method to the fore. In the light of these results, we can say that it would be advantageous for the OAB farmer to choose the DS method in terms of sustainable wheat production. As a result of the evaluations, it was concluded that the DS method in the fallow-wheat rotation is more economical than the CT and MT methods. This result is consistent with Hernanz et al. (1986), Aase and Schaefer (1996), Cabrera et al. (1995), Arshad et al. (1991), Piggin et al., (2015), Khan et al. (2017) is similar to the results of the study. It has been determined that the DS method can be successfully applied in dry and hot climate conditions with insufficient moisture regime and wheat production is economically profitable (Turebayeva et al., 2022). However, it should not be forgotten that due to the technical, economic, and meteorological limits in plant breeding, these limits will affect the relative profit rate differently in different years. Global warming, the impact of which we have felt in recent years, and therefore the impact of climate change on practices should be taken into account.

Table 1. Partial budget analysis of conventional agronomic practices*

Cost and Income Elements	Conventional Tillage	Minimum Tillage	Direct Seeding
Yield (kg ha^{-1})	2255.0	1866.9	2151.0
Sale price ($)**	0.226	0.226	0.226
Gross production value (GPV) ($ ha^{-1})	509.63	421.92	486.13
By-product income (Straw)	237.73	192.45	235.47
Total Gross Income ($ ha^{-1})	747.36	614.37	721.60
Variable costs ($ ha^{-1})	533.36	528.58	376.62
Fixed costs ($ ha^{-1})	43.06	42.66	30.40
Total production costs ($ ha^{-1})	576.42	571.24	407.02
Unit cost ($ kg)	0.256	0.306	0.189
Gross profit ($ ha^{-1})	214.00	218.78	344.98
Net profit ($ ha^{-1})	170.94	43.13	314.58
Relative profit	1.30	1.08	1.77

* Own calculations.
** Turkish Grain Board, **Konya, Polatlı and Eskişehir** Commodity Exchange.

4. Conclusion

Performing economic analyses of the experiment results for agronomic practices before recommending to producers will increase the acceptance rate of the developed technologies by producers and contribute to the increase of the value of researchers in the eyes of producers. The highest wheat yield was obtained from CT in three different methods applied. This was followed by DS and MT applications, respectively. However, the cost of growing one kg of wheat in the DS application was found to be lower than in other applications. Due to the low rainfall, the wheat yield per hectare was below the average of Central Anatolia and Turkey in all three applications. In the applied methods, the production threshold has been exceeded (production threshold=total variable costs/product yield) and variable costs in production activities have been covered. Therefore, the fact that CT and MT methods are not preferred by the farmers in the fallow-wheat rotation system is considered important for sustainable wheat production.

By adopting the DS method, that is, in the chemical fallow application, when weed control is done on time and with appropriate pesticides, it can be an alternative to traditional fallow. In the light of the above information, research studies on DS implementation should be given priority in the region. In addition, providing the tools and equipment used in the DS application at a sufficient level will increase the success of this application. In this regard, district agriculture directorates and agricultural non-governmental organizations should act together and provide adequate support to farmers.

References

Aase, J. K., & Schaefer, G. M. (1996). Economics of tillage practices and spring wheat and barley crop sequence in the Northern great plains. *Journal Soil and Water Conservation*, 51 (2), 167-170.

Adeoye, I. B., Fashogbon, A.E. & Idris, B.A. (2014). Analysis of technical efficiency of pepper production among farmers under tropical conditions. *International Journal of Vegetable Science,* 20(2), 124-130.

Ajmer, S. (2006). Economic analysis of wheat production across cropping systems in North - West India. *Indian Journal of Agricultural Research*, 40(3), 171-177.

Anonymous. (2018). Conservation Agriculture: Economic Benefits. Retrieved January 20, 2019, from http://www.ecaf.org (Date of Access: 12.09.2020)

Arshad, M., Ahmad, S., & Kausar, A. G. (1991). Wheat productivity through zero tillage adaptation in rice-wheat system in FSR project area Shahkot. *Journal of Agricultural Research Lahore*. 29(2), 265-269.

Aryal, J. P., Sapkota, T. B., Jat, M. L., & Bishnoi, D. K. (2015). On-farm economic and environmental impact of zero-tillage wheat: A case of North-West India. *Experimental Agriculture*, 51(1), 1-16.

Aydin, B., & Unakitan, G. (2016). Comparatively economical analysis of farms in Trakya Region. *Anadolu Journal of Agricultural Science*, 31(2), 223-232, (In Turkish).

Aytop, A., & Akbay, C. (2018). Economic analysis of spice red pepper (Maras Pepper) production. *Türk Tarım ve Doğa Bilimleri Dergisi,* 5(4), 455-464, (In Turkish)

Basaran, C., & Engindeniz, S. (2015). Analysis of input use efficiency in green pepper production: A case study for Izmir Province. ***Turkish Journal of Agricultural Economics*****,** 21(2), 77-84, (In Turkish).

Bayramoglu, Z., Akturk, D., & Tatlidil, F. (2010). The effect of rational source usage on production costs: A case study of Canola production. *Selcuk Journal of Agriculture and Food Sciences*, 24(3), 62-68, (In Turkish).

Birinci, A., & Kucuk, N. (2004). Calculating wheat production cost on the farms in Erzurum Province. *Ataturk University Journal of Agriculture Faculty* 35(3-4), 177-181. (In Turkish).

Cabrera, C. F., & Oleschko, L. K. (1995). The effect of tillage on the internal structure of soil. *Agricultura-Tecnica-en-Mexico*, 21(2), 139-158.

Cebi, U. K., Aydin, B., Cakır, R., & Altintas, S. (2017). Energy use efficiency and economic analysis in greenhouse head lettuce (Lactuca sativa cv Salinas) Farming. *Turkish Journal of Agricultural and Natural Sciences*, 4(4), 426-433, (In Turkish).

Cetin, B. & A. Vardar. (2009). An analysis of energy use and input costs for wheat production in Turkey. *Journal of Food, Agriculture & Environment,* 7(2), 352-356.

Cevher, C., & Altunkaynak, B. (2020). Investigation of socio-economic characteristics of wheat producers on certified seed use: The case of Ankara province. *Yuzuncu Yil University Journal of Agricultural Science*, 30(1), 115-123.

Demircan, V., Yilmaz, H., & Binici, T. (2005). Determination of cost and return of apple production in Isparta Province. **Turkish Journal of Agricultural Economics,** 11(2), 71-80, (In Turkish).

Erkus, A., Bulbul, M., Kiral, T., Acil, A. F., & Demirci, R. (2005). *Agricultural Economics.* No.5. Ankara: Ankara University Faculty of Agriculture Education Research and Development Foundation Publications, (In Turkish).

Genc, İ. (1976). *Field Crops Ecology*. Cukurova University Faculty of Agriculture. Adana. (In Turkish).

Guler, K. H., Korkmaz, M. (2018). Economic analysis of lavender production in forest villages of Isparta province. *Turkish Journal of Forestry*, 19(2), 156-162, (In Turkish).

Gultekin, I., Arısoy, R. S., Taner, A., Kaya, Y., Patigoc, F., & Aksoyak, S. (2011). Comparison of different soil tillage systems, under several crop rotations in wheat production at Central Anatolian Plateu in Turkey. *5th World Congress of Conservation Agriculture Incorporating 3rd Farming Systems Desing Conference*, 26-29 September, Brisbane-Avustralia.

Hernanz, J.L., Fernandez, Q.C., Sanchez, G.V., & Navarrete, L. (1986). Results obtained in experiments with direct drilling and minimum cultivation in the central zone. Conservar El Suelo.I.Simposium Sobre Minimo Laboreo En Cultivos Herbaceos. *Universidad Politecnica De Madrid*, 145-158.

Jekayinfa, S. O. (2006). Energy consumption pattern of selected mechanized farms in Southwestern Nigeria. *Agricultural Engineering International, The CIGR Ejournal, Manuscript*, EE 06 001.

Kan, M., Partigoc, F., Gultekin, I., Arisoy, R. Z., Kaya, Y., Gultekin, S., Sahin, M., Aydogan, S., Ozdemir, F., & Taner, A. (2018). Economical aspects of conservation agriculture (zero tillage-direct seeding) system in Turkey. *Fresenius Environmental Bulletin*, 27, 3332-3341.

Kaya, Y., Arisoy, R.Z., Taner, A., Aksoyak, S., Partigoc, F., & Gultekin, I. (2010). Comparison of conventional planting and direct seeding for wheat cheak pea rotations in Central Anatolian in rainfed conditions. *Journal of Agricultural Machinery*, 6(4), 267-272, (In Turkish).

Khan, H.Z., Shabir, M.A., Akbar, N., Iqbal, A., Shahid, M., Shakoor, A., & Sohail, M. (2017). Effect of Different Tillage Techniques on Productivity of Wheat *(Triticum aestivum L.)*. *Journal of Agriculture and Basic Sciences,* 2(1), 44-49.

Kiral, T., Kasnakoglu, H., Tatlidil, F., Fidan, H., & Gundogmus, E. (1999). Cost calculation methodology and database guide for agricultural products. *Agricultural Economics Research Institute Project Report* -13, Ankara, (In Turkish).

Malinga, N. G., Masuku, M. B., & Raufu, M. O. (2015). Comparative analysis of technical efficiencies of smallholder vegetable farmers with and without credit access in swazil and the case of the Hhohho Region. *International Journal of Sustainable Agricultural Research,* 2(4), 133-145.

Moradabadi, S. A., Ziaee, S., Boshrabadi, H. M., & Keikha, A. (2020). Effect of agricultural sustainability on food security of rural households in Iran. *Journal of Agricultural Science and Technology*, 22(2), 289-304.

Ozkan, B. (2001). Agricultural product costs in Antalya province, input use and production costs for important products in some regions in Turkey. *Agricultural Economics Research Institute*, publication number: 64, Ankara, (In Turkish).

Perrin, R., Winkelman, D., Moscardi, R., & Anderson, J. (1976). From agronomic data to farmer recommendations an economics training manual. Mexico.

Piggin, C., Haddad, A., Khalil, Y., Loss, S., & Pala, M. (2015). Effects of tillage and time of sowing on bread wheat, chickpea, barley and lentil grown in rotation in rainfed systems in Syria. *Field Crops Research*, 173: 57-67.

Rosli, A., Radam, A., & Rahim, K. A. (2013). Technical efficiency of pepper farms in Sarawak, Malaysia: An application of data envelopment analysis. *International Journal of Business and Social Science,* 4(7), 227-234.

Sarauskis, E., Vaiciukevicius, E., Romaneckas, K., Sakalauskas, A., & Baranauskaite, R. (2009). Economic and energetic evaluation of sustainable tillage and cereal sowing technologies in Lithuania. *The Fourth International Scientific Conference, Rural Development*, 15-17 October, Akademija-Lithuania.

Shahgholi, G., & Moinfar, A. (2019). Investigation tine type effect on soil fragmentation for conservation tillage. *Yuzuncu Yil University Journal of Agricultural Sciences*, 29(3), 548-558.

Sqrensen, C. G., & Nielsen, V. (2005). Operational analyses and model comparison of machinery systems for reduced tillage. *Biosystems Engineering*, 92(2), 143-155.

Surek, D., Ozcan, H., Yeter, T., Kosger, Y., Namli, A., Turker, U., Kilinc, E., & Koc, A. (2018). The effects of soil tillage techniques on carbon retention and sustainability of soils, project final report. *TAGEM/TSKAD/11/A13/P01,* (In Turkish).

Sümbül, A., & Sönmez, B. (2021). Relationships of wheat, dry bean and chickpea yields with global climate change in Suşehri District, Turkey. *Yuzuncu Yil University Journal of Agricultural Sciences*, 31(4), 813-824.

Şatır, O., & Berberoğu, S. (2021). Evaluation of land use suitability for wheat cultivation considering geo-environmental factors by data dependent approaches. *Yuzuncu Yil University Journal of Agricultural Sciences*, 31(3), 528-542.

Turebayeva, S., Zhapparova, A., Yerkin, A., Aisakulova, K., Yesseyeva, G., Bissembayev, A., & Saljnikov, E. (2022). Productivity of Rainfed Winter Wheat with Direct Sowing and Economic Efficiency of Diversified Fertilization in Arid Region of South Kazakhstan. *Agronomy,* 12 (1), 111. https://doi.org/10.3390/agronomy12010111.

TurkStat. (2019). Turkish Statistical Institute: Agricultural Statistics Data. Retrieved on March 15, 2020, from http://www.tuik.gov.tr (Date of Access: 25.10.2020) (In Turkish).

Ulu, O., Engindeniz, S., & Altug, O. (2016). Analysis of input use efficiency in okra production in Izmir Province. *Turkish Journal Agricultural Economics*, 22(2), 69-76, (In Turkish).

Yalcin, H., Cakir, E., & Aykas, E. (2005). Minimum and conventional tillage in wheat. *Journal of Agronomy*, 4(4), 329-332.