CLIMATE-SMART AGRICULTURE FOR THE REAL GREEN REVOLUTION

EDITOR: Assoc. Prof. Dr. Ahmet ÇELİK

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PREFACE

It has been revealed once again how important the agricultural sector is in the process of widespread epidemics. The agricultural sector plays a significant role in Turkey's GDP and employment, as well as in the rest of the world. If Turkey wants to achieve sustainable development goals and a redesigned green economy, the agriculture sector must be one of the top priorities. The rise in environmental issues, as well as the drop in farmers' product and revenue per unit area, has exposed the necessity for a climate-smart agriculture plan.

The challenges of transitioning to climate-smart agriculture on a large scale to enable the transformation and reorientation of agricultural systems to support food security under the new repercussions of climate change have been identified through researches on climate-friendly technologies and practices.

Climate-sensitive agricultural operations' measurability has the potential to transform and process food systems. In addition, it will enable farmers to adapt and be affected at a minimum level in a process where climatic problems are becoming increasingly unpredictable.

To summarize, one of the foundations of sustainable agricultural development is the use of natural resources with the most rational methods. It has demonstrated the importance of long-term agricultural planning and implementation during the transition to climate-smart agriculture.

Assoc. Prof. Dr. Ahmet ÇELİK

He completed his undergraduate (Harran University) education in 1995, his master's degree (Harran University) in 1997 and his doctorate (Çukurova University) in 2012. He worked in the private sector for 1 year in 1992. He started to work at the Ministry of National Education in 1997. Between 2000-2007, he worked as an Voluntary Instructor in the Directorate of Kahta Vocational School of Harran University. In 2007, he held various administrative positions at Adıyaman University. In 2013, he was appointed as Assistant Professor Doctor at Adıyaman University Kahta Vocational School, Department of Plant and Animal Production. He is still working as an Associate Professor at Adıyaman University, Faculty of Agriculture. He worked as an executive and assistant researcher in approximately 15 projects supported by the European Union, World Bank, GAP Administration, Çukurova, Adıyaman Universities and Non-Governmental Organizations. Assoc. Dr. Ahmet Çelik took part in 2 second thesis advisory and 22 graduate thesis juries. He is the Adıyaman Provincial Representative of TEMA Foundation and a member of the Turkish Soil Science Association. Assoc. Dr. Ahmet Çelik has been an assistant editor and member of the editorial board, columnist and section writer in various newspapers and scientific journals since 1994, as well as in DÜNYA Newspaper; He prepared research and informational supplements and supplements published alongside the newspaper. He has many national and international articles and papers published on soil quality, soil organic carbon, agriculture and waste management in environmentally friendly practices. He is married and has three children.

Assoc. Prof. Dr. Ahmet ÇELİK

CHAPTER 1

Tithonia diversifolia AS A PROMISING FORAGE CROP FOR TURKEY

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INTRODUCTION

Climate change is negatively effecting animal production and reducing food security. Therefore, alternative forages high in biomass, high in nutritional quality and well adapted to poor soils and climate conditions are incresingly necessary. High biodiversity in tropicals may provide alternatvie forages for pastures or fodder banks.

Tithonia diversifolia, is a shrub from Asteraceae family. It is distributed on borders of farms in humid and subhumid tropics in Africa. These plants have high biomass yield per land. The chemical composition of *T. diversifolia* shows its potential as source of biomass for ruminant nutrition especially when harvested at the booting stage. Also green biomass of it is a source of nutrients for rice and maize. Green leaf biomass is rich in nutrients, with 3.5% N, 0.4% P and 4.1% K in dry matter. Its biomass decomposes fast when incorporated in the soil for crops.

Here in this review, we presented some of the main parameters related to this species in focus with its feed value, forage value and alternative usages. A few comments for its cultivation in Turkey is also concluded as a result.

Introduction

Tithonia diversifolia, is a shrub from Asteraceae family. It is distributed on borders of farms in humid and subhumid tropics in Africa. Green biomass of Tithonia is a source of nutrients for rice (Oryza sativa) in

Asia and for maize (Zea mays) Africa. Green leaf biomass is rich in nutrients, with apprx. 3.5% N, 0.4% P and 4.1% K in dry matter. Its biomass decomposes fast when incorporated in the soil for crops. A few reports exist with higher maize yields with incorporation of tithonia biomass compared to synthetic mineral fertilizer at equivalent rates of N, P and K. Incorporating 5 t dry matter ha−1 of its biomass can reduce P sorption and increase soil microbial biomass. High labor need for cutting and carrying the biomass as a nutrient source is profitable with vegetables compared to low-valued field crops like maize (Jama et al., 2000).

West African Dwarf goats fed with a concentrate diet including wild sunflower leaf meal as a dry season feed supplement. Tithonia leaf meal inclusion at 0, 10, 20 and 30% levels applied for 16 weeks. As a result, no significant difference in the dry matter intake (DMI), weight gain and dry matter digestibility of the goats observed with different diets. However, the crude protein digestibility and nitrogen utilization of goats on 0% and 10% Tithonia inclusion were higher than those on 20% and 30% WSLM diet. It was concluded that wild sunflower leaf meal can serve as a forage supplement to the WAD goats up to 30% level of inclusion without any deleterious effect (Ja & Oloidi, 2014)

Climate change is negatively effecting animal production and reducing food security. Therefore, alternative forages high in biomass, high in nutritional quality well adapted to poor soils and climate conditions are incresingly necessary. High biodiversity in tropicals may provide altentavie forages for pastures or fodder banks. Use of Tithonia as feed for dairy and beef cattle in Brazil and Colombia are showing its potential to attend nutritional requirements for medium and high performance cows (Mauricio et al., 2017).

Effect of air drying on the antinutritive component of wild sunflower leaves was carried out. Composition of leaves were 18.1-21.1% for CP, 18.3-18.9% crude fibre, 3.5-4.0% ether extract, 14.1-14.1% total ash and 46.1-41.8% NFE. Tannin, phenol, phytin and oxalate contenct of fresh leaves were 0.20, 0.09, 16.8 and 1.56 (mg/100 g), respectively while content of dry leaves were 0.05, 0.02, 8.52 and 0.21 (mg/100 g), respectively. Alkaloid and flavonoid contents 0.24 and 0.22 (g/100 g), respectively in fresh leaves where 0.14 and 0.09 (g/100 g),respectively in the dried leaves. Tannin content (mg/100 g) of the leaves decreased from 0.20 to 0.05 after drying. Phenol content (mg/100 g) reduced from 0.09 to 0.02 after drying. Oxalate content (mg/100 g) decreased from 1.56 to 0.21 after drying. These results revealed a medium reduction anti-nutritive factors content of Tithonia leaves by a simple air-drying process (Odedire & Oloidi, 2011).

Tithonia has potential as a protein supplement and could be used as a an alternative to multipurpose tree legumes in growing goats fed with low quality basal diets (Celina, 2005).

Tithonia plants have high biomass yield per land unit. It also improves soil fertility. Leaves of Tithonia is attracting for goats but needs supplementation for regulation of its nutritive potential (Nguyen et al., 2010).

Inclusion of *Tithonia* (tree marigold) forage for the control of gastrointestinal strongyles infestation in grazing young cattle was searched during rainy (RS) and dry season (DS). Two treatments (tree marigold and supplementation with concentrate feed) evaluated by comparing “parasite rate (FEC) of gastrointestinal strongyles”, protein percentage and phytochemical composition of the foliage. A significant effect was observed on the reduction of the parasite rate of the animals which consumed tree marigold forage (150 and 450 epg for the DS and RS, respectively), with regards to those of the control group, whose values exceeded 500 and 3 500 epg, respectively. It is concluded that the protein content and the presence of secondary metabolites contributed to the decrease of the parasite rate, for which tree marigold can be a forage plant with potential for ruminant production (Lezcano-Más et al., 2016).

A study was evaluated the biomass production and nutritional value of *Tithonia* harvested at booting and pre-flowering to observe its potential as a forage for ruminants. Plant samples were collected from eight locations, in two growing stages. Higher green matter production and dry matter production values were obtained (41.3 t/ha and 8.1 t/ha, respectively) at the booting stage, compared to pre-flowering stage (24.7 t/ha and 5.6 t/ha, respectively). Booting and pre-flowering stage dry matter (DM) values were 220 and 224 g/kg of DM; neutral detergent insoluble protein (NDIP) values were 86 and 98 g/kg of D; acid detergent insoluble protein (ADIP) values were 40 and 68 g/kg of DM; neutral detergent fiber (NDF) values were 476 and 520 g/kg of

DM; acid detergent fiber (ADF) values were 333 and 364 g/kg of DM; total carbohydrates (CHT) values were 706 and 743 g/kg of DM; crude protein (CP) values were 165 and 149 g/kg of DM; total digestible nutrients (TDN) values were 63,8 and 61,3; and cellulose (CEL)values were 268 and 187 g/kg de MS, respectively. As a result, as the growing stage advanced, a reduction was observed in the productivity and nutritional value of *T. diversifolia*. The chemical composition of *T. diversifolia* showed its potential as source of biomass for ruminant nutrition especially when harvested at the booting stage (Calsavara et al., 2016).

A study for separation of protein from fiber was conducted to produce Leaf Protein Concentrate (LPC). Methods of protein separation was acid precipitation of protein extract from *T. diversifolia*. Recovery rate of LPC from the leaves on dry matter were 31% for Titonia. Chemical analysis showed that protein content increased from 21.6% to 36.5% in the titonia LPC. Total amino acids increased from 18.8% to 35.2%. In vitro digestibility using pepsin-pancreatin showed that digestibility of LPC from titonia were 89.7% (Susana & Tangendjaja, 1988).

Height of cutting (20 and 50 cm) and frequency of cutting (30, 60 and 85 days) on dry matter production and crude protein were evaluated for Tithonia in Venezuela. The total dry matter (TDM), edible dry matter (MSC), the proportion of leaf and stem components and crude protein (CP) were evaluated. MSC was significantly different only for the frequency of cutting where it was highest at cutting at 85th day 0.53 kg/plant. The ratio of leaf:tender stems:thick stems was 18:3:78, both up to the frequency of cutting during evaluations. The crude protein was affected from the height and cutting, with average values of 24.16% for 20 cm and 26.35% at 30th day cuttings. In conclusion, the highest dry matter production and crude protein crude of 19.77% of *T. diversifolia* can be obtained by cutting at 85th day (Soto et al., 2012).

CONCLUSIONS

Climate change is negatively effecting animal production and reducing food security. As profile of primary metabolites, secondary metabolites and in vitro digestibility of DM correlates with climatic factors like temperatures, total precipitation and number of rainy days, changing climate is changing feed production habits worldwide. High biodiversity in tropicals may provide alternative forages high in biomass, high in nutritional quality and well adapted crops to poor soils and climates.

Tithonia diversifolia, as a shrub from Asteraceae family, produce high biomass yield per acreage when compared to many other forage crops. Also its good chemical composition suits well to ruminants when harvested at the booting stage. Nutrient-rich green biomass decomposes fast in the soils, too. Tithonia may be a promising ruminant feed crop not just in sunflower production zones of Turkey but also maybe in other areas with different temperatures, total precipitation and number of rainy days. To see its adaptation may also open a path to increase acreages of oil crop sunflower, too, to close the oil gap of Turkey.

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CHAPTER 2

THE USE OF UNMANNED AIR VEHICLES IN CEREAL CULTIVATION

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INTRODUCTION

Satellite-based remote sensing has been used efficiently for collecting information on various crops and agricultural applications (Atzberger, 2013; Sahoo et al., 2015; Shanmugapriya et al., 2019). However, high cost, insufficient spatial resolution, difficulties in obtaining high resolution data when the sky is cloudy, and limitations in temporal resolution to capture the necessary images at desired time are the major constrains of using satellite images to obtain spatial and temporal data (Tsouros et al., 2019). Alternatives based on unmanned air vehicle (UAV) platforms have capabilities for monitoring of crop growth conditions in large scale fields due to the high spatial and spectral resolutions of the sensors mounted (Schirrmann et al., 2016; Raeva et al., 2019). Operating at a low altitude provides quite high spatial resolution images of the fields and crops, and this significantly increases the reliability of the monitoring system. The temporal resolution of UAV based monitoring system is high, because of the flexibility in the image acquisition process, that is determined by the operator (Tsouros et al., 2019).

The UAVs equipped with different types of sensors are used to identify site specific management of fertilizers, pesticides, seeds, etc. This provides an opportunity to save costs and ability to overcome on time in any problem detected in field. In addition, the UAVS are used in weed (Torres-Sanchez et al., 2013; Huang et al., 2018) and disease (Kerkech et al., 2020; Bhandari et al., 2020) management, yield estimation (Duan et al., 2019; Maimaitijiang et al., 2020) and crop water stress (Zhang et al., 2019). The reflectance from leaf surface is used as an indicator for physiological status of plants, pigment composition (especially chlorophyl) of leaves is directly related to light reflected from leaf surface (Jones and Vaughan, 2010).

Vegetation indices (VIs) retrieved from remote sensing based crop canopies are commonly used to evaluate vegetation cover, density, and monitor crop growth dynamics, etc. (Xue and Su, 2017). The VIs are calculated using specific reflectance bands based on red, green, blue (RGB) and infrared (IR) (Gago et al., 2015). The most commonly used VI index is the normalized difference vegetation index (NDVI), that is used to detect plants and "greenness" utilizing the elevated IR reflectance of leaf chlorophylls (Zarco-Tejada et al., 2012). The optimized index transformed chlorophyll absorption in reflectance index/optimized soil-adjusted vegetation index (TCARI/OSAVI) is a more sensitive VIs to chlorophyll content and minimizes soil, solar zenith angle and vigor of the plant background effects (Haboudane et al., 2002). The Ratio Vegetation Index (RVI) is the first defined VI shows that leaves absorb higher red light than infrared light, therefore, has been used to estimate green biomass and monitor high density vegetation coverage (Xue and Su, 2017). With development of remote sensing systems, plenty of VIs have been developed. Some of them are Difference Vegetation Index and Perpendicular Vegetation Index (Richardson and Weigand, 1977), Atmospherically Resistant Vegetation Index (Kaufman and Tanre, 1982), Soil-Adjusted Vegetation Index (Huete, 1988), Enhanced Vegetation Index (Liu and

Huete, 1995), Crop Water Stress Index (Idso et al., 1981) and Photochemical Reflectance Index (Gamon et al., 1992).

Nutrient Management in Cereal Cultivation using UAVs

The functional groups in soil organic matter response to the electromagnetic radiation, therefore special spectral characteristics in the visible and near-infrared reflections have been identified to quantify some of soil properties (Yang et al., 2021). However, the analysis of spectral characteristics in the laboratory on disturbed soil samples cannot provide a spatially distribution of soil properties in a specific field (Hong et al., 2020). The UAV technology using hyperspectral imaging spectrometry collects rich spectral and spatial information for the entire field (Vaudour et al., 2016). Zhang et al. (2020) studied the performance of UAV-based imaging system for to estimate corn yield and the effects of variable-rate nitrogen application on corn growth in a 27-ha field. The images were captured at three corn growth stages (R2, R3 and R6) using a UAV with a RGB camera flying at ~100 m above ground level. The prediction of corn yield using a low-cost UAV RGB imaging system indicated a potential use in practice. The accuracy of yield estimation was higher when images captured closer to maturity were used. In addition, the authors stated that the UAV RGB images can be used to evaluate the effect of variable-rate N application on corn growth. In another study, Fu et al. (2020) estimated the winter wheat N status using Gaussian processes regression analyses with the combination of RGB VIs, color parameters, and image textures. The leaf and plant N concentrations and the leaf and plant N densities were used to determine the most appropriate image features in estimating the crop N status. The image textures derived from high-resolution UAV-based RGB images were successful in estimating the N status of winter wheat. The researchers also stated that a low-cost digital camera mounted on a UAV could reliably used to monitor N status of winter wheat in a short period of time and a non-destructive way.

The nitrogen contents of crops is the most commonly used indicator in growth evaluation of crops; thus, accurate estimation of nitrogen content of crops during several growth stages is essential for management of fertilizers and estimation of yield. The nitrogen nutrition index, which was initially developed to quantify nitrogen deficiencies and excesses in winter wheat, is used as a reliable and quantitative indicator of the nitrogen distribution of crops (Liu et al., 2020). The efficiency of nitrogen nutrition index of corn and winter wheat using the optimal spectral indices of plant nitrogen concentration and above ground biomass has been evaluated by Chen and Zhu (2013). Liu et al. (2020) monitored the nitrogen nutrition index of winter wheat in field scale based on ground and UAV-based hyperspectral data. The results indicated that the red spectrum shifted with the changes in nitrogen nutrition index of winter wheat and the red edge position and the near-infrared waveband range of the hyperspectral data significantly varied. In addition, the green band, red edge, and near-infrared were sensitive to the changes in nitrogen nutrition index of winter wheat, therefore the aforementioned spectra can be used to estimate the nitrogen nutrition index of winter wheat.

Weed Management in Cereals using UAVs

Weeds grow in the same field with agricultural crops and compete for nutrient, water and sunlight with the main crops. The competition with the main crop may cause significant yield losses, and problems at harvesting. Herbicides are commonly used for weed management in conventional farming. Entire field is sprayed at the same rate of herbicides during weed management (Onen et al., 2018; Tsouros et al., 2019). However, weeds grown in patchy locations and the use of UAVs provides an opportunity to map the spatial distribution of weeds within the field and allow for site-specific weed control (Maes and Steppe, 2019). The weeds in a field can easily be detected and mapped using even a RGB mounted camera to a UAV when spectral signature of the weed is different from that of the crop (Alexsandridis et al., 2017). The sensors used in the cameras can discriminate the weed patches with high accuracy depending on altitude of UAV fly, resolution of camera mounted on the UAV resolution and the UAV used in detection (Esposito et al., 2021).

In row crops, weed detection on row crops is carried out in the early growing season, and if possible after germination (Figure 1) (Torres-Sanches et al., 2014). The grains (cereals) are the most commonly cultivated crops worldwide, and are vulnerable to weed infestation in early phenological stages. The UAVs have been used successfully to detect weeds in wheat (Torres-Sanchez et al., 2014), barley and corn (Huang et al., 2018). The location of all vegetation in the crop row structure is the most important process in UAV-based weed detection in row crops such as maize and wheat to accurately design of herbicide spraying (Peña et al., 2013).

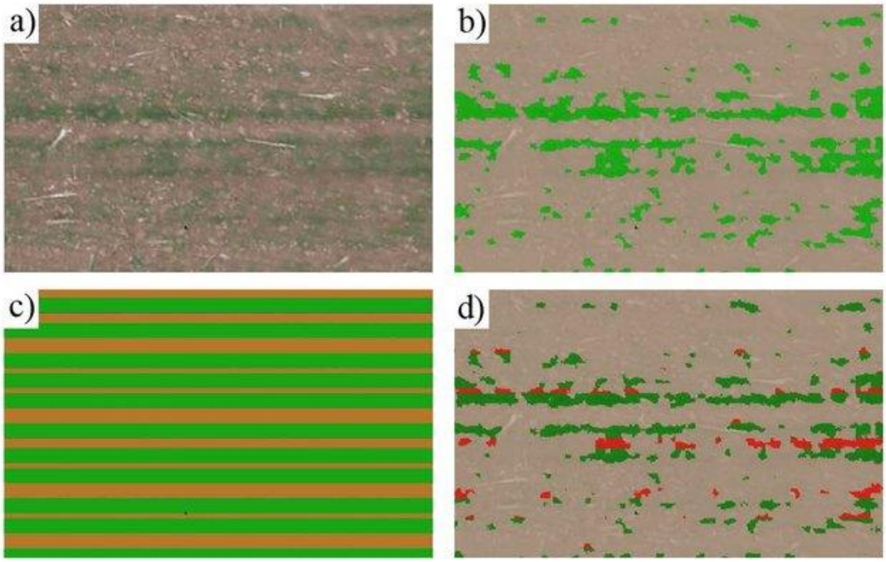

Figure 1. Four stages in weed mapping process: a) Wheat field without classification. b) Discrimination of all vegetation from soil surface and previous crop residue. c) Identification of crop row (in green) and soil surface (in brown). d) Distinguishing weeds located outside the rows (in red) from crops (Original image has been published by Torres-Sanchez et al. (2014).

In row crops weed detection, object-based image analysis provides more accurate results compared to the traditional pixel-based methods (Torres et al., 2014). Studies have shown that the use of weed spatial distribution maps prepared using object-based image analysis significantly reduces the amount of herbicide without any negative impact crop yield (de Castro et al., 2018). Lopez-Granados et al. (2018) investigated detected and mapped *sorghum halepense* (johnsongrass) patches and outlined the total surface area needed for a site-specific herbicide treatment based on the weed coverage. The researchers used object-based-image-analysis method applied on orthomosaicked images visible and multispectral cameras mounted on a UAV which collected data at altitudes of 30, 60 and 100 m on two maize fields. The most reliable with high accuracy weed maps in both maize fields were created using the multispectral camera at an altitude of 30 m. The use of weed spatial distribution maps of fields in site-specific weed control revealed 85 to 96% herbicide savings.

Estimation of Cereal Yields using UAVs

The information on accurate prediction of crop yield is useful for farmers as well as the entire agricultural sector to appropriately manage the market. Reliable yield predictions were recorded by the application of RGB-derived plant height and canopy cover data using UAVs (Maes and Steppe, 2019). Empirical regression models are used in yield prediction with UAV , because they are useful for scaling up yield to the entire field. However, regression coefficients may not be valid in next season on the same location, or to another location even in the same year (Rembold et al., 2013). Crop growth models were recommended as an alternative approach in prediction of crop yields (Maes and Steppe, 2019). Zhou et al (2021) investigated the potential of machine-learning algorithms and commercial multispectral cameras for within-field prediction of grain yield and protein content of winter wheat. The researchers compared the model performances for predicting wheat grain yield and protein content determined using the machine learning algorithms (e.g. random forest and artificial neural network) based on spectral reflectance and plant height and the traditional linear regression based on vegetation indices. The results revealed that machine learning approach did not improve the prediction accuracy of grain yield, while the linear regression model based on a vegetation index successfully predicted the wheat grain yield.

High-resolution UAV-based technology was used to estimate plant density of wheat (*Triticum aestivum* L.) (Jin et al., 2017), determine the canopy height and biomass of corn (*Zea mays* L.) (Li ve ark., 2016) and estimate rice (*Oryza sativa* L.) (Duan et al., 2019; Guan et al., 2019) and wheat yield (Guan et al., 2019). Guan et al. (2019) used two types of small UAVs (DJI Phantom 4 and DJI Phantom 4 Pro) to determining high-resolution NDVI values which were used to correlate with fertilizer application levels and the yields of rice and wheat crops. Significantly high correlations were obtained between NDVI values recorded during the middle reproductive to the early ripening stages and yield (R^2=0.601 - 0.809). The fertilizer application levels for rice and wheat were also successfully differentiated using the NDVI values. The results revealed that the small UAV-derived NDVI values can be used to predict yield and detect fertilizer application levels in rice and wheat production. In another study, canopy spectral data of wheat in multiple growth periods were collected using a multi-rotor UAV platform equipped with a multi-spectral camera (Fu et al., 2020). Data were subjected to a variety of parametric or non-parametric modeling methods to monitor leaf area index and leaf dry matter and to predict grain yield. The reliable yield estimation was obtained by NDVI at the jointing, booting, flowering and filling stage. The results indicated that multi-rotor UAV combined with the multi-spectral camera can be used to monitor wheat growth parameters and estimate yield.

Management of Irrigation and Water Stress in Cultivation of Cereals using UAVs

Irrigated agriculture is the largest water user of the world; therefore, the efficient use of water is important to increase the agricultural production (Navarro-Hellín et al., 2016). Total irrigated lands for field crops is estimated approximately 275 million hectares, which is expected to be increased by 1.3% per year (Hedley et al., 2014). The irrigation in Asia accounts for 80% of fresh water use, and almost 90% of water is used for rice production (Khepar et al., 2000). Although the need for food is dramatically increasing with the population increase throughout the world, the researchers are expecting severe shortages in water resources for agricultural use due to global warming and increase water consumption in industry and cities (Yang et al., 2020). Tuong and Bauman (2003) indicated that water shortage may have negative impacts on almost15 million hectares of rice fields in Asia by 2025. Therefore, water use efficiency in agricultural production has to be improved and water in agriculture should be more precisely applied to sustain food and fiber demands of future generations.

Soil water content in a field is traditionally determined by collecting multiple soil samples or measurements over the field, however, this method does not properly represent the actual field moisture content due to the spatial heterogeneity across the field (Barbedo, 2019). The development of sensors and UAVs allowed to obtain high resolution images and several indicators were derived from remotely sensed images to characterize soil moisture content of entire field (Gonzales-Dugo et al., 2014).

Lack of water or drought is the most studied stress indicator due to the potential relationship with irrigation efficiency (Zarco-Tejada et al., 2012). Therefore, the strategies for irrigation determined using UAVs uses one of the following four variables derived from aerial images (Barbedo et al., 2019). The variable are vegetation indices (Vis), photochemical reflectance index (PRI), difference between the canopy and air temperatures and crop water stress index. The vegetation indexes are used to highlight certain vegetation properties and the PRI is used to obtain information on a reflectance measurement sensitive to changes in carotenoid pigments present in leaves. The multispectral or hyperspectral images are used to obtain VIs and PIR, while thermal sensors are used to determine the difference between the canopy and air temperatures and crop water stress index (Espinoza et al., 2017). Zhou et al. (2021) used crop surface characteristics and image texture to determine water stress in winter wheat. The canopy image was obtained in blooming stage of winter wheat by an UAV equipped with multispectral sensor, and soil background effect was removed using VI threshold method. The researchers revealed that the use of UAV multispectral image texture and VIs allowed to successfully estimate stomatal conductance, thus water stress in winter wheat can accurately diagnosed.

The water status of wheat has been assessed by determining the equivalent water thickness in wheat using a UAV mounted multispectral sensor (Traore et al. (2021). The researchers indicated that the effective monitoring of effective water thickness in wheat under different nitrogen and water treatments may be used to manage irrigation and increase water use efficiency. The UAV-based thermal imaging system was used to quantify water stress for 18 contrasting wheat genotypes grown on moderately and highly sodic soils in Australia (Das et al., 2021). Crop water stress indices such as standardized canopy temperature index, crop water stress index, stomatal conductance index, vapor pressure deficit, and crop stress index computed from thermal imagery and data obtained from on-site agro-meteorological parameters close to flowering stage of wheat were used to evaluate soil water status and to investigate biomass and grain yield variability on under water-limited conditions. The researchers reported that UAV-thermal imaging and machine learning-based techniques are useful to quantify crop water stress to aid the prediction of biomass and grain yields of wheat genotypes in constrained sodic soil environments.

Variable rate irrigation (VRI) that is defined as "the ability to spatially vary water application depths across a field to address specific soil, crop, and/or other conditions" (Evans et al., 2013), may increase water use efficiency compared to the traditional precision irrigation and provides a solution to sustain agricultural production (Figure 2) (Shi et al., 2019).

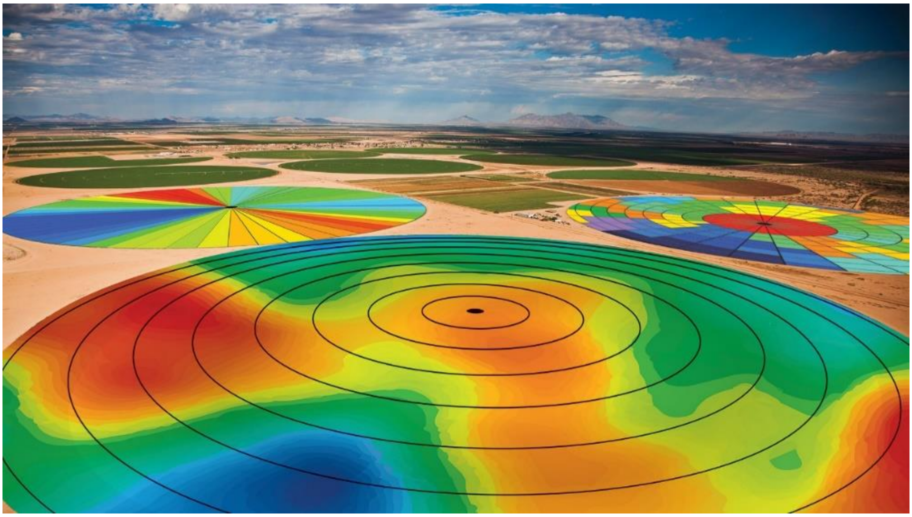

Figure 2. Prescription of variable rate irrigation in a center pivot (Anonymous, 2021)

CONCLUSIONS and RECOMMENDATIONS

The rapidly developing UAV-based remote sensing technology has provided significant benefits in many areas such as variable rate fertilizer application, weed and pest control, variable rate irrigation, variable rate seed planting, monitoring of crop production stages and estimation of yield. The advantages of UAV-based technology, such as being cheaper than traditional satellite-based remote sensing, providing more detailed images due to the high resolution and low altitude flying capacity, and obtaining data at any time, contributed to the adoption of this technology by farmers. The UAV-based remote sensing will help to ensure sustainability in agricultural production, increase productivity and conserve natural resources.

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CHAPTER 3

COMPARISON OF VEGETATION INDICES DERIVED FROM UNMANNED AERIAL VEHICLE DATA TO DISTINGUISH HARVESTED AND UNHARVESTED FIELDS

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INTRODUCTION

The platforms on satellites and piloted aircrafts have been used for a long time to obtain spectral data of Earth surface. Lack of adequate spatial and temporal resolutions of these platforms are the main disadvantages limiting their uses (Nebiker et al., 2008). Manned or unmanned aerial (UAV) platforms with visible and multispectral cameras offer a great opportunity to gather information from the sky, and to study the earth surface characteristics which are hardly visible and may not be distinguished from the ground by naked eye (Candiago et al., 2015). The number of bands in a remote sensing platform is increasing and the bandwidth is getting narrower with the development of high resolution spectral instruments (Honkavaara et al., 2013). The UAVs mounted with several sensors collect multispectral data at centimeter level resolution; thus offer great oppurtunity in agriculture and forestry management as well as in geosciences for quantitative observations at higher spatial and temporal resolution and lower costs compared to aircrafts or satellites (Tsouros et al., 2019). Farmers use the information derived from UAVs to manage their farms, improve productivity and optimize utilization of soil and water resources (Candiago et al., 2015).

The electromagnetic wave reflectance from canopies are recorded in sensors mounted on satellites or UAVs. The type of spectral reflectance from canopy changes with type of plant, water content and other genetic factors (Liu et al., 2016). Most of UAV-based method determining the characteristics of crops are related to the computation of the vegetation indices (Fuentes-Peñailillo et al., 2018). The VIs derived from the platforms mounted on satellites, aircrafts or UAVs are simple algorithms to quantitatively evaluate vegetation cover, plant growth stages, weed infestations, etc. Therefore, the VIs are reliable indicators in environmental monitoring, conservation of biodiversity, agricultural production, forest mangement, and other related fields (Xue and Su, 2017).

One of the first Vis was Ratio Vegetation Index (RVI) that was introduced by Jordan in 1969. The basic principle of the RVI is absorbtion of relatively more red lights by leaves compared to the infrared light (Jordan, 1969). Combining visible and near infrared bands in development of Vis significantly increased the sensitivity to the detection of green vegetation (Xue and Su, 2017). The most commonly used VI index calculated as normalized ratio between the red and near infrared bands is the Normalized DifferenceVegetation Index (NDVI) (Xue and Su, 2017). The higher NDVI values indicate vigorous plant growth and higher biomass accumulation during plant growth stages, which reveals a longer grain filling period and delaying leaf senescence during the maturation; thus increasing the yield (Babar et al., 2006). In 1977, Richardson and Weigand developed the Difference Vegetation Index (DVI) to distinguish vegetation from background soil. Later, Kaufman and Tanre (1982) developed Atmospherically Resistant Vegetation Index (ARVI) to reduce the dependence of vegetation index to the atmospheric effects, particularly ARVI is commonly used to eliminate the effects of atmospheric aerosols. In 1988, Huete introduced the Soil-Adjusted Vegetation Index (SAVI) to overcome the deficiencies in NDVI and PVI in describing the spectral behavior of vegetation and soil background. Condireing the effects of wet and dry soil conditions, three new versions of SAVI (SAVI2, SAVI3, and SAVI4) were developed by Major et al. (1990).

Accurate classification of land cover is extremely important for monitoring the environmental impacts of land use changes. In this study, In this study, the harvested and non-harvested parts of a silage corn field were determined by using vegetation indices computed using multispectral images taken with a low-flying UAV over a half harvested silage corn field. The effectiveness of plant indices in distinguishing unharvested and unharvested plots was compared and discussed.

Material and Methods

2. Study Area

The study area is located in Garip village of Bingol province, Turkey. Silage corn field is situated between 38°49´855´´-38°48´944´´N latitudes and 40°33´482´´-40°34´083´´E longitudes. Total coverage area of the area was 37.3 ha of which 14.25 ha has already been harvested, and 23.05 was about to be harvested at the time of UAV flying. Mean elevation above sea level of the field is 992 m.

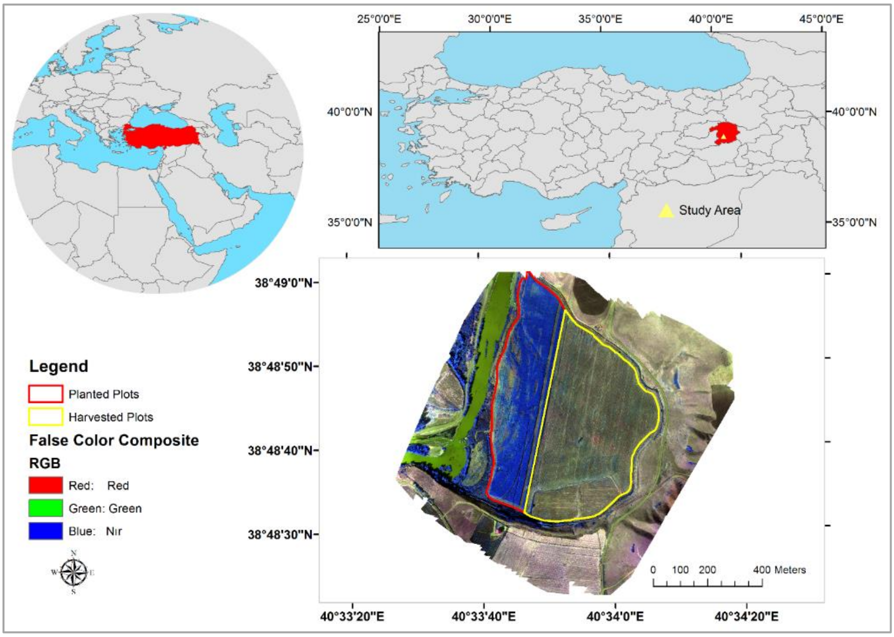


Figure 1. Study area and False Color Orthophoto of UAV images.

Image acquisition with UAV

The image of the field was acquired on 12 October 2021 with a single flight. Images were recorded using SenseFly eBeeX branded UAV and Parrot Sequioa 4.0 camera (Figure 2.) The eBeeX, which is a completely computerized autonomous system, is compatible with eMotion and Pix4D software with the RTK (Real Time Kinematic) and CORS Network Connecting features. Therefore, it is successfully used in precision agriculture applications. The wingspan of the UAV is 116 cm. The UAV used can obtain high-reliability data up to 3 cm resolution on an area of 500 hectares in a single flight with a flight time up to 90 minutes. The UAV used is a professional fixed-wing drone that can be used for all kinds of applications. Single-band resolution is 1.2 MP, and

RGB resolution is 16 MP. Multispectral images are green (550nm ± 40nm), red (660nm ± 40nm), red edge (735nm ± 10nm), and near infrared (790nm ± 40nm). Flight altitude was 150 m and front and side overlap were set to 80, 60%, respectively.

Figure 2. SenseFly eBeeX Drone and Parrot Sequioa Multispectral camera

Three thousand ninety six images obtained were processed in the Pix4D Mapper image processing software, which is a part of the system. The images were precisely coordinated due to the RTK GPS (Global Position Systems) on the UAV. Therefore, the images were converted into orthophotos in UTM Zone 37 coordinates without the need for ground control points. Radiometric corrections of multispectral images were carried out automatically by the software recognizing the camera. The Pix4D software also generates a digital surface model (DSM) to calculate the true reflection value of each object and to create a perspective image (Pix4D, 2017). The DSM and reflection maps are presented in Figure 3.

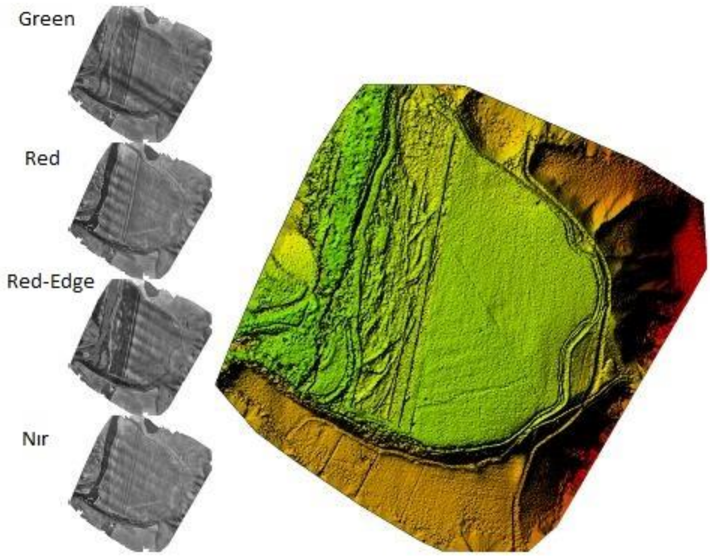


Figure 3. Multispectral Image Bands (tiff) and Digital Surface Model (DSM)

2.2. Calculation of Vegetation Indices

There were both corn plants and harvested soil surfaces in the study area, therefore, vegetation indices and indices such as SAVI (Huete et al. 1988), which provide correction of vegetation reflections by minimizing soil brightness effects, were also computed. In addition, some chlorophyll indices that were successful in predicting the chlorophyll pigment produced by photosynthesis by healthy plants were also included in the study. A total of 13 indexes were calculated as Geotiffs in ArcGIS 10.5 software for agricultural monitoring (Table 1). NDVI is a spectral index that relates the difference between reflected energy in the near-infrared side of the spectrum and reflected energy in the red side of the spectrum. The Red-Edge band provides information about the change in the amount of instantaneous reflection between the red and infrared wavelengths of the plants. Therefore, it is important in the monitoring of the biophysical plant characteristics. For this purpose, many vegetation indices were calculated using the Red-edge band. One of the vegetation indices used red-edge is the NDRE index that can precisely determine the leaf chlorophyll content of plants and changes in leaf area (Raeva et al., 2019). The RDVI index also uses near infrared and red wavelengths and takes high values especially in healthy vegetations. This index is insensitive to confusion caused by the effects of soil and sun geometry. The GNDVI index is similar to the NDVI index, except that the green band is used instead of the red band. Since this index is more sensitive to leaf area, it is more sensitive than NDVI, especially in determining the chlorophyll content (Hunt et al., 2008). Hunt et al. (2011) indicated that chlorophyll indices provides more accurate results in estimating leaf chlorophyll content compared to vegetation indices such as NDVI. Therefore, CI-RE and CL-Green chlorophyll indices were also calculated in the study. In addition, SAVI and similar indices, which give precise information about vegetation, are calculated to cover the areas where the ground is sparsely covered with vegetation and the soil layer can be seen, (Table 1). These indices are calculated similarly to the NDVI index, and the correction coefficients differ in the equations to adjust the canopy background (Vasudevan et al., 2016). The values of indices range from -1 to +1 and values close to +1 represent the full vegetation.

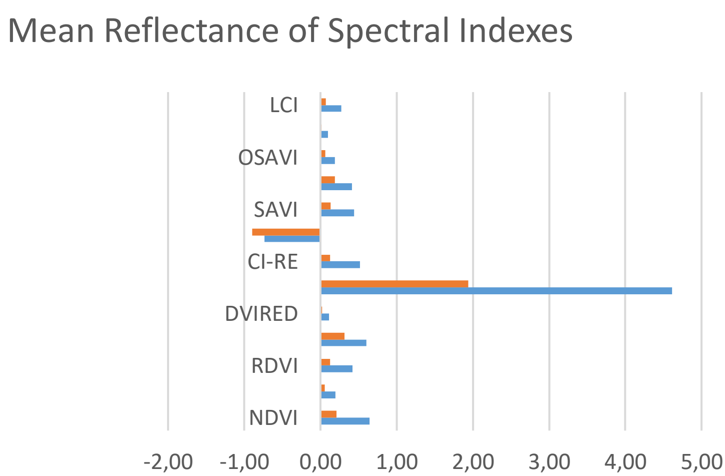
Table 1. Indexes calculated from multispectral bands.

Vegetation Index	Equation	Reference
Normalized difference vegetation index (NDVI)	NDVI = (NIR − R)/(NIR + R)	Tucker, 1976
Normalized difference red edge (NDRE)	NDRE = (NIR − REG)/(NIR + REG)	Barnes et al. (2000)
Red difference vegetation index (RDVI)	RDVI = (NIR − R)/(NIR + R)^0.5	Qiao et al. (2020)
Green normalized difference vegetation index (GNDVI)	GNDVI = (NIR − G)/(NIR + G)	Kataoka et al. (2003)
Red edge difference vegetation index (DVIRED)	DVIRED = NIR − REG	Jordan et al. (1969)
Chlorophyll index with red edge (CI-RE)	CI-RE = (NIR/REG) − 1	Gitelson et al. (2005)
Chlorophyll index with green (CIgreen)	CI-green = (NIR/G) − 1	Dash et al. (2010)
Leaf chlorophyll index (LCI)	(NIR − REDEDGE) / (NIR + RED)	Pix4D, (2017)
Soil-adjusted vegetation index (SAVI)	SAVI = 1.5(NIR − R)/(NIR + R + 0.5)	Huete et al. (1988)
Soil-adjusted vegetation index with green (SAVIGRE)	SAVIGRE = 1.5(NIR − G)/(NIR + G + 0.5)	Verrelst et al., (2008)
Optimized soil-adjusted vegetation index (OSAVI)	OSAVI = (1 + 0.16)(NIR − R)(NIR + R + 0.16)	Rondeaux et al. (1996)
Optimized soil-adjusted vegetation index with green (OSAVIGRE)	OSAVIGRE = (1 + 0.16)(NIR − G)(NIR + G + 0.16)	Rondeaux et al. (1996)

Results and Discussion

More than half of the corn planted field was harvested at the time of image acquisition. In this study, the possibility of using spectral indexes in vegetation monitoring on cultivated and harvested plots were investigated. The maps for a total of 12 vegetation indices calculated from the UAV image are shown in Figures 4, 5 and 6. In addition, the average index values of two separate plots are presented in Table 2.

Table 2. Mean spectral index values of harvested plot and non-harvested (with corn plants) plots



	NDVI	NDRE	RDVI	GNDVI	DVIRED	RVIGRE	CI-RE	CIgreen	SAVI	SAVIGRE	OSAVI	OSAVIREG	LCI
Index Averages of Harvested Plots	0,21	0,06	0,13	0,31	0,02	1,94	0,12	-0,90	0,13	0,19	0,06	0,02	0,07
Index Averages of Planted Plots	0,65	0,20	0,42	0,60	0,11	4,61	0,52	-0,74	0,44	0,42	0,19	0,10	0,27

Index Averages of Harvested Plots

Vegetation indices (VI) are calculated using the spectral characteristics of healthy plants, which give light absorption by chlorophyll pigments in the red wavelength and higher light reflection in the infrared wavelength (Qiao et al., 2020). The VI of a healthy vegetation will be high, while the bare soil surfaces, water surfaces, and rocky areas will have low or negative values (Raeva et al., 2019). The land surface on study area was covered with bare soil and vegetation at the time of image acquisition, therefore, the VI values in the maps obtained varied between negative and positive values. The average VI values in the cultivated plot were higher compared to the the average VI values obtained in the harvested part of the field. The averages of the reflections for all indices, except CL-Green, were positive. Chlorophyll indices reveal the photosynthetic potential in agricultural products, and the Cl-Green index usually ranges from -1.0 and above. Values greater than 4.0 generally indicate vegetation with high chlorophyll content (Kurbonav and Zakharova, 2020). The mean VI values in the unharvested land were higher than the VIs computed for the harvested land. Candiago et al. (2015) reported that the common range of the NDVI index values for foliage plants is between 0.2 and 0.9, values between 0.2 and 0.3 represent shrubs and pastures, and values between 0.4 and 0.9 represent agricultural crops and forest lands. The averages NDVI indices obtained in both harvested and unharvested part of the field were also within the expected limits for the cultivated (NDVIavg.:0.65) and harvested (NDVIavg.:0.21) plots. This confirms that vegetation indices can be reliably used in separating soils covered with photosynthetic vegetation from other land surfaces.

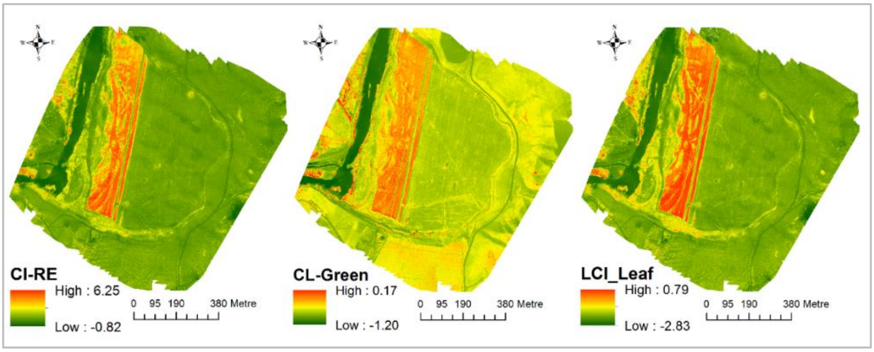


Figure 4. Spatial distribution of chlorophyll indices (CI-RE, CL-Green and LCI-Leaf) within harvested and unharvested corn field

Some of the indice maps created for the corn field defined the details of the field condition more clearly, while the distinctions of the field details cannot be seen sufficiently with the use of some indices. In particular, the NDVI, which is the most commonly used VI indices, does not distinguish the sparsely vegetated areas in the corn field as clearly as the NDRE. This distinction can be attributed to the red edge band used in the NDRE index. The reflections from plants is higher in the rededge spectrum, thus enables to distinguish the details of the crop field more clearly (Raeva et al., 2019). In addition, a disadvantage of the NDVI index is that the vegetation on the side of the harvested land and the planted land show similar reflection. The red edge wavelength in high-resolution UAVs enables to clearly distinguish the locations with problems such as nutrient deficiency, disease, pest hazard or weed infestation. The maps produced with chlorophyll indices were more successful than NDVI in separating harvested agricultural land and unharvested vegetation. Since the leaf details and the amount of chlorophyll were calculated in more detail with the CI-RE index calculated using the red border band, the harvested land and vegetation could be easily separated from each other (Figure 4).

The main difference between NDVI and Green Normalized Difference Vegetation Index (GNDVI) is the use of green band in GNDVI instead of the red band in the NDVI. Therefore, if leaf area index is moderately high, then GNDVI is preferred to assess variability in leaf chlorophyll content (Gitelson et al., 1996). The mean GNDVI value for harvested and unharvested fields was 0.31 and 0.60, respectively. Cicek et al. (2010) compared the GNDVI values of corn and soybean plants grown in tile drained and not drained and manure applied and not applied fields. The researchers stated that the GNDVI values in tile drained and manure applied fields were higher compared to the GNDVI values computed for the fields with no tile drainage.

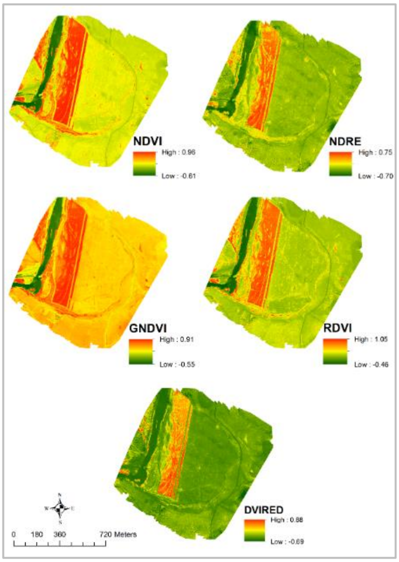


Figure 5. Spatial distribution of vegetation indices (NDVI, NDRE, GNDVI, RDVI and DVIRED) within harvested and unharvested corn field

The SAVI and RDVI indices produced similar results (Figure 4 and 5). The SAVI values in the whole field ranged between 1.01 and -0.47, and the RDVI values were between 1.05 and -0.46. The mean SAVI for unharvested and harvested fields was calculated as 0.44 and 0.13, respectively, and the RDVI was calculated as 0.13 and 0.42, respectively. The similarity of SAVI and RDVI indices can be attributed to the use of NIR and Red bands used in the equations both indices.

The Optimized Soil Adjusted Vegetation Index (OSAVI) has been developed as an alternative to accommodate variability due to high soil background values (Fern et al., 2018). The OSAVI successfully distinguish the harvested and unharvested parts of the field. The mean OSAVI values for harvested and unharvested parts of the corn field was 0.06 and 0.019, respectively. Similarly, Fern et al. (2018) reported that the OSAVI is the most appropriate vegetation index for green biomass and vegetative coverage in the semi-arid regions. In another study, Dong et al. (2015) found significantly high correlation between OSAVI values and fraction of absorbed photosynthetically active radiation from corn and wheat fields.

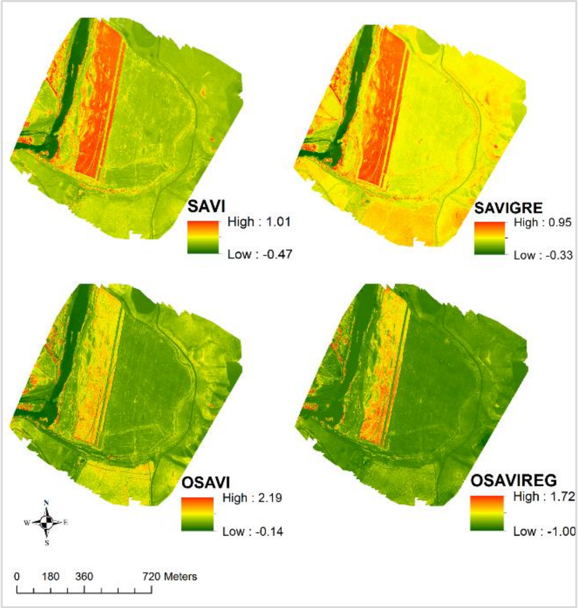


Figure 6. Spatial distribution of vegetation indices (SAVI, SAVIGRE, OSAVI and OSAVIREG) within harvested and unharvested corn field

CONCLUSION

In this study, the potential of vegetation indices in distinguishing the harvested and unharvested parts of a small corn field was investigated. The results of the study revealed that each of the vegetation indices calculated using the reflections in different regions of the electromagnetic spectrum has advantages or disadvantages compared to each other. The results showed that using more than one vegetation index to distinguish different land uses or objects in the field can provide more reliable results, compared to single vegetation index.

The importance and use of UAVs in agricultural monitoring have significantly increased. However, an expert staff is needed in the detailed and intensive data processing stages. This can be easily overcome by training the farmers engaged in agricultural production. In addition, high cost of UAV systems is another important limiting factor (Tsouros et al., 2019). In addition, the images with a UAV can only be taken in very restricted areas with limited flight times and flights can only be carried out when the weather conditions are favorable.

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CHAPTER 4

DETERMINATION OF FERTILITY AND ECONOMIC LEVEL OF SOILS WHERE ORGANIC AND TRANSITION PRODUCTS GROWN IN KOCAELI

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INTRODUCTION

Kocaeli province (40^0 31'- 41^0 13' N 29^0 22'-32^0 21' E) is located in the Marmara Region and bordered by the provinces of Istanbul, Yalova, Bursa and Sakarya, the Marmara Sea and the Black Sea. In the distribution of Kocaeli's land size by soil groups, the top three are non-calcareous brown forest soils (70.56%), rendzina soils (15.89%) and alluvial soils (4.65%) (Anonymous, 2002).

Kocaeli is known as an industrial city, with limited organic agricultural production. The organic farmers' market established in 2016 promotes organic agricultural production. According to 2017 data, there are 9 growers who engage in organic crop production in Kocaeli; 2 of them grow only organic crops, 2 of them both organic and transitional crops, and 5 of them only transitional crops (Ünal and Çavuşoğlu, 2018).
Pursuant to the Regulation on the Principles and Implementation of Organic Farming, a crop is required to go through the transition period to be certified organic. For a crop to be considered as organic, transition period is minimum two years from the date of planting for annual crops and three years prior to the harvest of the first organic crop for perennial crops (Anonymous, 2010). Transition period, which is the first stage of organic farming, is hard to overcome for growers. It is possible to encounter yield losses because, during this period, the use of chemicals and fertilizers is prohibited and the production system has just changed (İlbaş, 2009; Akgün, 2011). In their studies, researchers found that organic tomato growers faced some problems throughout the transition period due to nitrogen deficiency, that yield losses were encountered

during the period due to nutritional deficiency and fight against plant diseases, and that wheat yield decreased by 23-65% in the transition period (Scow et al., 1994; Bruggen and Termorshuizen, 2003; Gopinath et al., 2008). Ünal et al. (2016) reported that, in Kocaeli in 2014, 4 of 12 growers in transition period ceased their activities and did not go into organic agricultural production.

There are limited number of studies on the fertility of the soils where transitional and organic crops are grown in Turkey. Yılmaz and Bostan (2010) analyzed the soil characteristics of some hazelnut groves and found that the amount of organic matter was 10.37% in the 1st transition year and 13.65% in the 3rd transition year. Zincirlioğlu and Eryüce (2010) analyzed the soils, leaves and fruits of the olives grown with conventional and organic methods in Ayvacık/Çanakkale in terms of Ni contents and concluded that Ni value was below the reference value in conventional and organic farming.

The purpose of this study is to research the change of organic matter and other plant nutrient elements in transitional and organic farming soils. In this scope, samples were taken from the soils where transitional and organic crops were grown in Kocaeli, and soil fertility was analyzed.

MATERIALS and METHODS

In 2018, as part of the research, 17 soil samples (10 samples from the soils in transition period and 7 samples from the soils in organic agricultural production) were taken from different villages of Kocaeli.

Each sample was taken from a depth of 0-30 cm, and none of the soils had been newly fertilized. The soils in question had been used for growing vegetables, field crops and forage crops. The samples were taken to the fertilizer production facility located in Kocaeli for physical and chemical analyses. Of the samples, texture was determined using saturation (Richards, 1954), pH and EC using saturation extract and 1:2.5 soil-water extract (Richards, 1954), lime by the Scheibler calcimeter method (Çağlar, 1949), organic matter by the modified Walkley-Black method (Jackson, 1958), total N% by the Kjeldahl method (Kacar, 1972), and available P_20_5 (Olsen et al., 1954) and available K_20 using ammonium acetate (ICP) (Richards, 1954). Analysis results were evaluated in accordance with the measurements and standards for soil analysis evaluation.

RESULTS

Some physical and chemical analysis results of the samples taken from the soils which were in transition period and from the soils which had already transitioned to organic farming in different villages of Kocaeli are given in Table 1.

Table 1. Some physical and chemical analysis results of the soils in transition period and of the soils used for organic farming

Village of Sampling	Crop Status	Soil Texture	pH	EC (%)	Lime (%)	Organic Matter (%)	N (%)	P_2O_5 kgda^{-1}	K_2O kgda^{-1}
1.Çağırgan	Transition	Clay-Loam	5.61	0.01	0.00	2.28	0.11	13.38	30.22
2.Çağırgan	Transition	Clay-Loam	5.72	0.02	0.00	1.87	0.09	22.56	34.09
3.İnebeyli	Transition	Clay-Loam	7.21	0.04	2.12	1.46	0.07	32.51	90.41
4.İnebeyli	Transition	Clay-Loam	6.63	0.02	0.71	2.28	0.11	2.71	79.85
5.Babaköy	Transition	Clay	7.41	0.04	4.95	2.55	0.12	1.72	49.72
6.Babaköy	Transition	Clay	7.41	0.04	2.83	2.95	0.14	2.70	44.05
7.Babaköy	Transition	Clay-Loam	6.01	0.01	1.49	2.00	0.10	3.17	66.15
8.Babaköy	Transition	Clay	7.05	0.04	1.89	1.73	0.08	2.84	68.99
9.Babaköy	Transition	Clay	5.82	0.01	0.00	1.87	0.09	3.39	56.32
10.Babaköy	Transition	Clay	7.12	0.04	2.83	2.00	0.10	1.55	50.63
11.Kadriye	Organic	Clay	5.41	0.01	0.00	0.92	0.04	12.70	74.60
12.Kadriye	Organic	Clay-Loam	6.78	0.04	1.57	3.50	0.17	44.89	118.58
13.Hatipler	Organic	Clay-Loam	3.2	0.01	36.16	1.73	0.08	5.70	38.09
14.Hıdırlar	Organic	Clay	7.32	0.03	6.84	1.78	0.08	6.54	51.99
15.Babaköy	Organic	Clay	7.12	0.05	10.93	3.09	0.15	18.35	99.83
16.Babaköy	Organic	Clay	6.72	0.06	1.65	3.50	0.17	3.90	69.16
17.Babaköy	Organic	Clay	7.01	0.06	9.27	3.36	0.16	2.95	74.55

As seen in the table, soil samples were taken from 10 different lands located in the villages of Çağırgan, İnebeyli and Babaköy and used for growing transitional crops and 7 different lands located in the villages of Kadriye, Hatipler, Hıdırlar and Babaköy and used for growing organic crops.

Soil Texture: Both transitional farming soils and organic farming soils had a texture of clay and clay-loam. The percentage distribution ratios of the soils are given in Figure 1. As can be seen in the Figure, according to the Ülgen and Yurtsever (1974) classification system, 50% of the soils in transition period were clay and 50% were clay-loam, while 72.42% of the organic farming soils had a clay texture and 28.58% of them a clay-loam texture. Taşova and Akın (2013) conducted a study to determine the plant nutrient elements of the soils in the Marmara Region and reported that the provinces of İstanbul, Sakarya, Kocaeli and Yalova had predominantly clay and clay-loam soils.

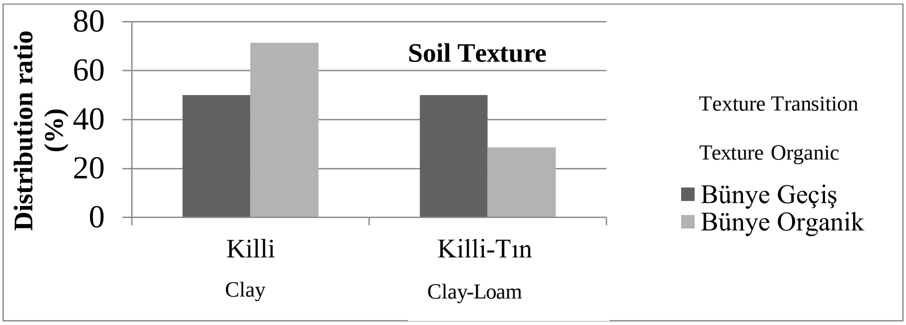

Figure 1: Texture of transitional and organic farming soils

pH: The pH value of the transitional farming soils ranged from 5.61 to 7.41, while that of the organic farming soils from 3.20 to 7.32. As can be seen from the percentage distribution ratios of the soils given in Figure 2, it was determined according to the Ülgen and Yurtsever (1974) classification system that 40% of the soils in transition period had low acidity and 60% were neutral and that 14.28% of the organic farming soils had strong acidity, 14.29% had medium acidity and 71.43% were neutral. These results suggest the pH value of the soils with strong acidity may need to be increased and approximated to low acidity and neutral in order to improve nutrient availability. Taşova and Akın (2013) stated that the northern parts of Kocaeli and Sakarya had vast amount of acidic soils.

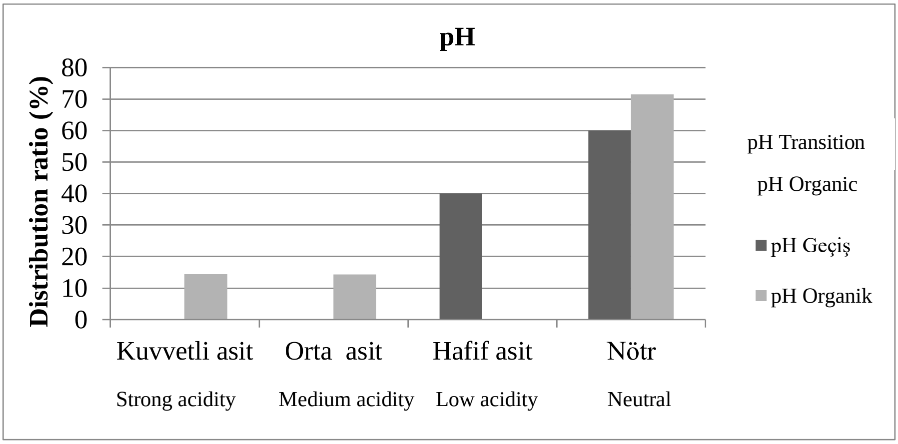

Figure 2: pH of transitional and organic farming soils

EC: The soils in transition period had an EC value ranging from 0.01% to 0.04%. On the other hand, the EC value of the soils used for organic crop production ranged from 0.01% to 0.06%. As seen in Figure 3, all of the soils were classified as non-saline (Ülgen and Yurtsever, 1974). Tümsavaş and Aksoy (2008) analyzed some characteristics of Bursa's rendzina great soil group and found that the soils had no salinity problems. Similar results were obtained by Başar (2001) for Bursa's soils and by Taşova and Akın (2013) for the Marmara Region's soils.

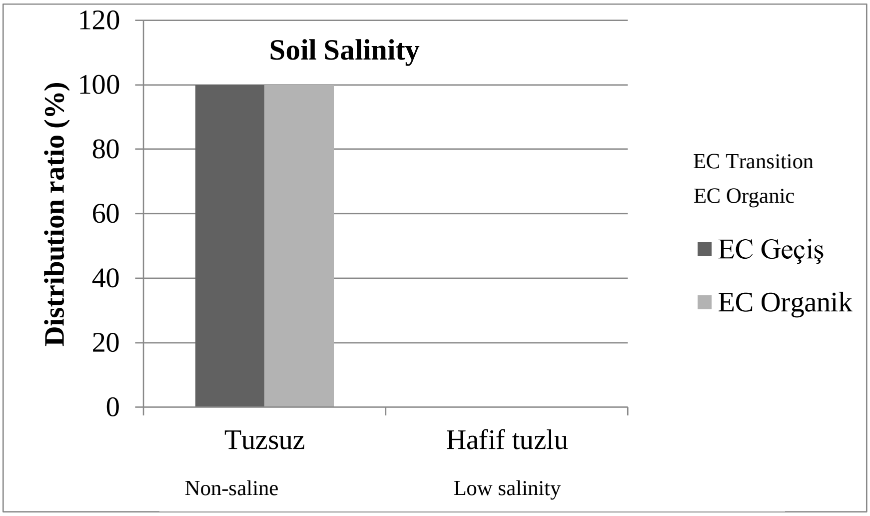

Figure 3. EC of transitional and organic farming soils

Lime: The lime content of the transitional farming soils ranged from 0.00% to 4.95%, while that of the soils used for organic farming from 0.00% to 36.16%. Figure 4 shows the percentage distribution ratios of the soils. According to the Ülgen and Yurtsever (1974) classification system, 40% of the soils in transition period were classified as low-lime soils and 60% as lime soils. On the other hand, of the organic farming soils, 28.57% were low lime soils, 14.29% lime soils, 42.86% medium lime soils and 14.28% very high lime soils. In their studies, researchers came up with similar results for the Marmara Region's and nearby regions' soils (Başar, 2001; Tümsavaş and Aksoy, 2008; Taşova and Akın, 2013).

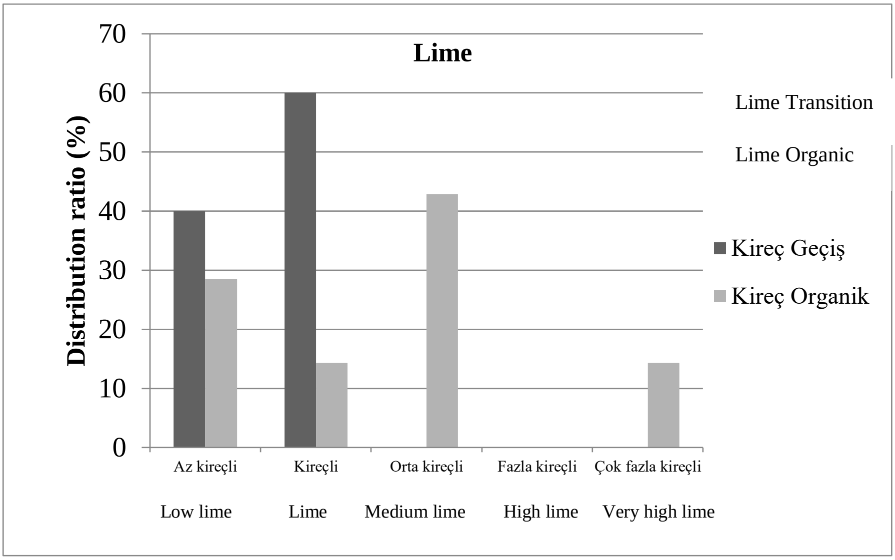

Figure 4. Lime content of transitional and organic farming soils

Organic Matter: The soils where transitional crops were grown had an organic matter content ranging from 1.46% to 2.95%. However, the organic matter content of the soils used for organic farming ranged from 0.92% to 3.50%. As can be seen from the percentage distribution ratios of the soils given in Figure 5, 60% of the transitional farming soils contained low level of organic matter and 40% medium level of organic matter, according to the Ülgen and Yurtsever (1974) classification system. Of the soils used for organic farming, however, 14.29% were classified as very low, 28.57% as low and 57.14% as adequate in terms of organic matter content. Eyüpoğlu (1999) reported that 43% of the soils in Turkey had an organic matter content of 1-2%. According to Gezgin et al. (2012), 75.6% of the Turkish soils contain low or very low level of organic matter. Diacono and Montemurro (2010) stated the long-term use of organic fertilizers not only improved soil characteristics but also had a positive role in minimizing climate change. Duman and Elmacı (2014) grew the combination of pre-crops and paste pepper under long-term organic conditions and concluded that the soil was poor in humus in the first three years of experiment, contained low humus in the following years and had a humus level of 3.97% in the final year.

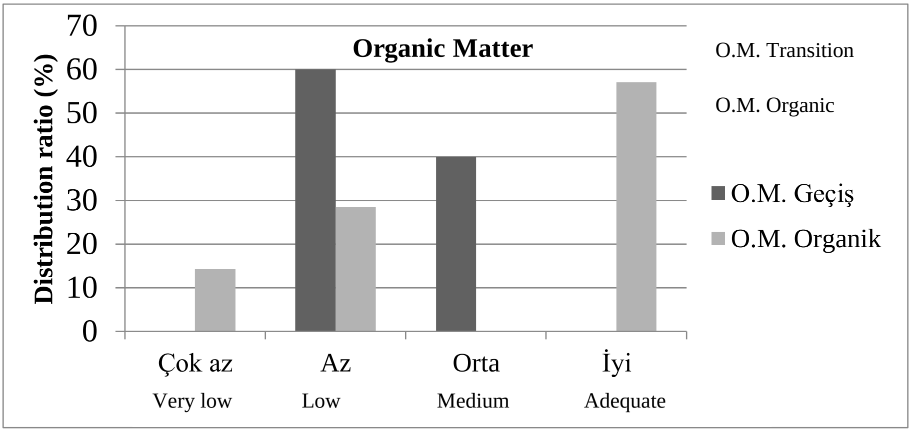

Figure 5. Organic matter content of transitional and organic farming soils

Nitrogen: The total nitrogen content of the soils in transition period ranged from 0.07% to 0.14%, while that of the organic farming soils from 0.04% to 0.17%. The percentage distribution ratios of the soils are given in Figure 6. According to the FAO (1990) classification system, of the soils in transition period, 40% contained low level of nitrogen and 60% contained adequate level of nitrogen. On the other hand, the level of nitrogen contained in the soils used for organic farming was very low for 14.29%, low for 28.57% and adequate for 57.14% of the soils. The soils which have low nitrogen content must be supplemented with nitrogen fertilizer. Chemical nitrogen fertilizer cannot be applied even though transitional crops are grown in the soil. For this reason, a good organic fertilizer source can be found for base dressing under the conditions permitted by the Regulation. Additionally, soil conditioners and fertilizers certified for use in organic farming such as leonardite, humic acid, vermicompost can be applied. In the studies conducted on different regions' soils, researchers found the level of nitrogen to be medium to adequate (Zengin et al., 2003), very low (17%), low (40.79%), medium (26.31%) and high (15.79%) (Yalçın and Çimrin, 2019). Martini et al. (2004) analyzed the soil characteristics of both transitional and organic farming soils and could not find any difference between them in terms of the amount of inorganic nitrogen.

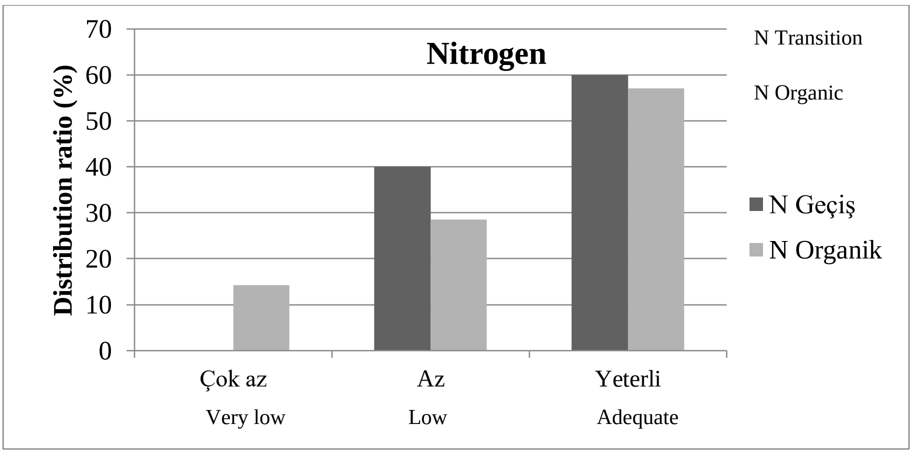

Figure 6. Nitrogen content of transitional and organic farming soils

Phosphorus: The soils in transition period had an available phosphorus content ranging from 1.55 kgda^{-1} to 32.51 kgda^{-1}, while the available phosphorus content of the soils used for organic farming ranged from 2.95 kgda^{-1} to 44.89 kgda^{-1}. As can be seen from the percentage distribution ratios of the soils given in Figure 7, of the soils in transition period, 50% contained very low available phosphorus, 20% contained low available phosphorus and 30% contained high available phosphorus, according to the Ülgen and Yurtsever (1995) classification system. On the other hand, available phosphorus content was very low in 14.28%, low in 28.58%, medium in 14.28% and high in 42.86% of the organic farming soils. In order to increase availability in the transitional and organic farming soils with very low, low and medium phosphorus content, which require phosphorus fertilization, soft rock phosphate can be applied under the conditions permitted by the Organic Farming Regulation (Anonymous, 2010) following pH balancing. Eyüpoğlu (1999) reported that approximately 56% of the soils in Turkey are inadequate in phosphorus and require phosphorus fertilization. After years of research, Mader et al. (2002) stated that, in organic farming areas, 20% yield loss occurred but fertilizer and energy inputs decreased by 34-53% and pesticide inputs by 97%.

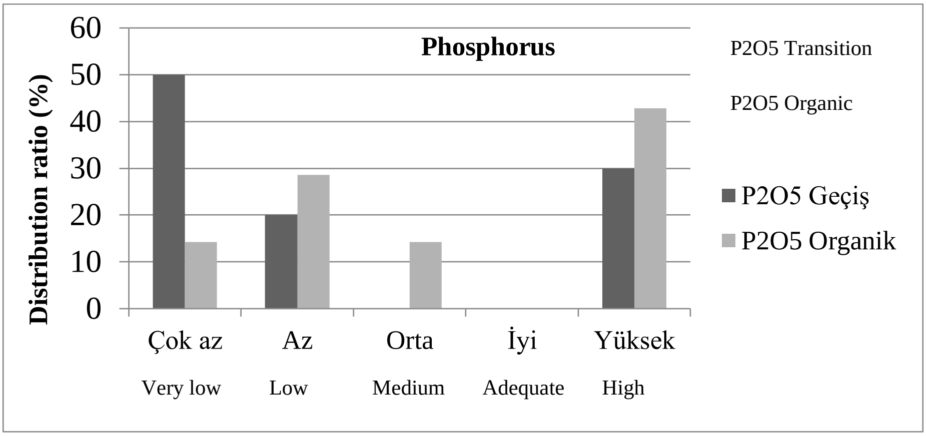

Figure 7. Phosphorus content of transitional and organic farming soils

Potassium: Available potassium content ranged from 30.22 $kgda^{-1}$ to 90.41 $kgda^{-1}$ in the soils used for transitional farming and from 38.09 $kgda^{-1}$ to 118.58 $kgda^{-1}$ in those used for organic farming. Figure 8 shows the percentage distribution ratios of the soils. According to the Ülgen and Yurtsever (1995) classification system, the level of available potassium content was adequate in 20% of the soils in transition period and excessive in 80% of them, while it was adequate in 14.28% of the soils used for organic farming and excessive in 85.72% of them. The studies carried out in nearby and different regions demonstrated that the soils' potassium content was mostly adequate and excessive (Zengin et al., 2003; Tümsavaş and Aksoy, 2008; Taşova and Akın, 2013; Yalçın and Çimrin, 2019). Çimrin and Boysan (2006), in the study they conducted on Van region's agricultural soils, found the variable potassium content of the soil samples (excluding Heybeli village) to be adequate and very high.

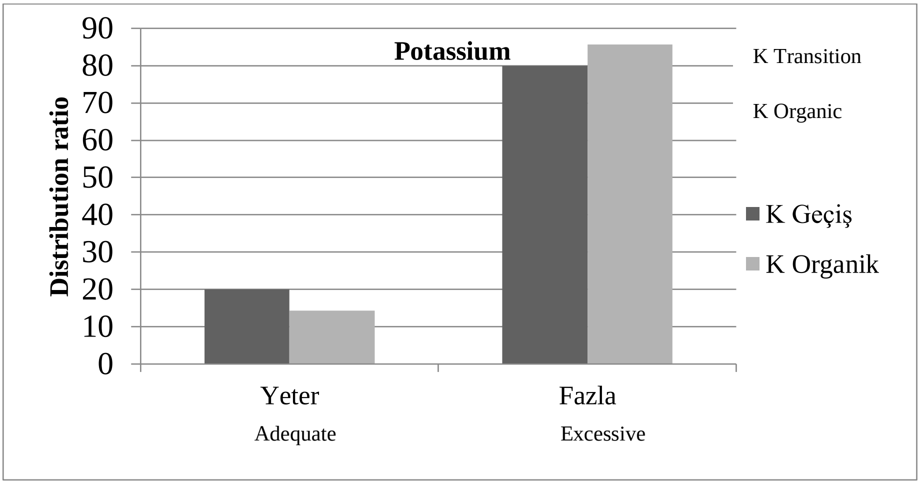

Figure 8. Potassium content of transitional and organic farming soils

The Economic Aspect of the Transition to Organic Agriculture

If we make a broad definition, organic agriculture; It includes human and environment-friendly production systems aimed at re-establishing the natural balance lost as a result of faulty practices in the ecological system. It is a production method that adopts the principle of increasing the quality of the product rather than increasing the quantity in production (Rehber and Turhan, 2001).

Manure is the substance which contains the required minerals for the plant nutrition and enables the plants to be nourished by the soil in an easier way by regulating the physical and chemical structure of the soil. Organic manure is the manure made up of animal waste, fossils and similar natural ways.

The excessive increase in the use of nitrogenous manure in agriculture has caused cancer risk for the people who eat food produced this way, due to the nitrate and nitrite increase in the food. Chemical manure is banned in many European countries.

The pesticides and artificial manure used to kill the apple worms harm not only the worms but also other bugs, birds and some beneficial microorganisms.

The organic manure gives resistance to the soil and the plants through the compounds it contains. It increases the yield. However, today there are different products used in our country so we strictly recommend you to do the Soil Analysis before using organic manure since different types of soil have different requirements.

According to the research conducted by the Ministry of Agriculture through 140.000 soil analyses excluding the Black Sea Shores and North Thrace (regions with high rainfall rates), it has been confirmed that the soil of Turkey has high rates of marl and Ph and it is very poor in organic substances. It has also been confirmed that some regions are rich in Phosphorus and Potassium but they cannot be received. Regarding the trace elements, it has been found out that Iron and Zinc is lacking as well.

The Advantages of Organic Manure

The organic manure has many benefits for the agriculture, the nature, the farmers and the consumers.

- Organic manure increases the cell divison and the growth in the plant. The plant will give a yield earlier.
- The cancellous quality and the water holding qaulity will develop. The resistance of the plant and the soil against drought increases through natural fertilization.
- It allows water to flow seperately from the surface of the soil by creating a thick fibrous structure on the surface. Therefore the plant needs less water.
- It creates a soil resistant against the threat of erosion.
- The plant gains resistance against the harmful pest and insects.

- The organic manure makes the soil fertile through the necessary minerals which are found in it. It increases the permeability of the soil and allows the soil receive the air and water easier.
- The organic manure darkens the color of the soil so the soil can absorb more sunlight.
- It increases the macro-nutrients such as nitrogen, phosphorus and potassium in a balanced amount. It spreads the nitrogen that's given to the soil in a balanced way.
- It enriches the soil bacteriologically.
- It melts the lime that the water can not melt and uses the carbondioxide that's released as a result of the melting(this is true for the sulphur reinforced organic manure).
- It transforms the iron in the soil in a way that the plant can receive.Abandoning the use of synthetic inputs causes a decrease in efficiency, but also provides significant cost savings. In an evaluation, it is stated that while there is a 6-17% decrease in gross product by switching to organic agriculture in plant production, the net income loss is around 13% at most due to the decrease in costs. Even though organic agriculture is seen as less advantageous financially than traditional agriculture, it seems to be superior, especially with its economic contributions to the protection of the environment and natural balance in the long term (Rehber, 1991). Again, studies have shown that organic agriculture requires more labor than traditional agriculture. Although this is true for areas with low ecological potential, the need for labor varies depending on the way the product is grown.

Berarcli (1976) in his research on wheat-grown areas in New York and Pennsylvania states that 21 hours/ha of labor is spent in an organically grown area, and 9 hours/ha of labor is spent in an area grown with traditional farming method. According to another study, organic production in wheat and corn production has less labor productivity, varying between 22-55% compared to traditional production (Atis, 2004). However, the fact that more labor is required in organic farming in developing countries can be seen as an advantage, as the amount of unused or unpaid family labor in these countries is high. The transition to organic agriculture seems to be more costly than traditional agriculture due to the high labor costs and low productivity per unit area. However, underdeveloped and developing countries have more advantages in this regard as they use less inputs in agriculture and have unused workforce (Turhan, 2005).

There is no need for large investments for irrigation, energy and external inputs in organic agriculture. In this respect, it can be considered economical.

Organic Agriculture is a production method that is used to protect human health and the environment, and to reduce the problems which stem from using chemicals. In this method; no chemical substances are used and from production to consumption every stage of the organic agriculture is certificated and under control.Nowadays an organic market with a rapid growth in trade volume and increasing demand has emerged. The demand on organic products concentrated especially in the northern hemisphere (Western Europe and Latin America). In order to compensate the increasing demand of organic products most of the supply has been provided from developing countries (Öztürk, Erhan Nuh, 2012).

CONCLUSION

The requirement to control inputs and use organic fertilizers in organic agricultural production serves as the guarantee of sustainability in soils. In our study, the characteristics of soils in some villages of Kocaeli province were analyzed, and the organic matter content was found to be low in 60% of the transitional farming soils and adequate in 57.14% of the organic farming soils. The reason for increased accumulation in the soil can be the use of organic fertilizers on annual basis and that the effects of organic fertilizers can last for up to 3 years. Total nitrogen level was found to be adequate in both transitional and organic farming soils by 50%.

The scope of studies intended to determine the fertility characteristics of transitional and organic farming soils in Turkey can be extended with comparison to conventional farming on product basis in different regions. It may become easier for growers to transition to organic farming as the sustainability and fertility characteristics of organic farming soils improve in time.

Chemical fertilizers are completely eliminated during and after the transition period for organic product production. This situation adds an economic value to the farmers as the sustainability of organic farming practices increases and the soil is enriched with organic matter and improves the soil structure. Improving soil structure and not using artificial fertilizers in organic product production reduces the production cost. When chemical fertilizer prices are compared with barn manure prices, barn manure is more economical. The long-term improvement in soils also indicates that the use of organic fertilizers is economic. This situation positively contributes to the determination of the price of organic products at a reasonable level and facilitates the marketing of the products. This situation will increase the market share of organic products and will have a positive effect on the demand increase.

As the demand for organic products increases, organic production will spread and become sustainable. By creating an incentive effect for the farmers in the region where the study is conducted, the widespread of organic agriculture will result in an increase in production and the determination of prices according to the purchasing power of consumers. Therefore, the consumer will be protected from high prices and will cause an increase in the market.

The study shows that the region is suitable for organic product production after completing the transition period.

Improving the trade in organic products between developing countries and the countries with high demand is subject to harmonizing the regional and international standards and the other legal regulations in importing countries by the exporting country. In order to have a great share from the market of organic products and increase its trade volume in European Union, Turkey have to make an effort in both political and practical sphere. In organic agriculture, investment is required for production, especially by giving importance to education and research.

Conflict of Interest: There is no conflict of interest between the authors.

Authors' Statement of Contribution: MU and MT contributed to the soil samples and analysis of the research, ETK contributed to the writing, control and preparation of the article for the journal**.**

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CHAPTER 5

A RESEARCH ON THE RELATIONSHIP BETWEEN AGRICULTURAL INCOME AND TRACTORIZATION IN TURKEY AS OF 2020

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INTRODUCTION

In Turkey, the agricultural population and manpower are gradually decreasing, the income per area, enterprise, and farmer is increasing gradually, and this increase is predominantly caused by the developments in animal production and the shift of plant production value from field crops to fruits and vegetables. While the number of agricultural enterprises is decreasing, the average size of an enterprise average is growing, albeit slightly. There is a change in favor of the share of animal products in the total agricultural production value, and gradually more of the production value created is marketed (Evcim et al., 2015). The ratio between “Product Value” and “Marketed Product Value” is a clear indicator of the extent to which agricultural products can reach the market (Evcim et al., 2015). According to sub-sectors, the marketing ratio differs sometimes due to priorities and sometimes due to the restrictive factors, and it also changes in years depending on the developments in the market. Since the portion of the produced value that remains at the farmer, in short “Net Profit”, will be decisive for the living standard and capital accumulation, this issue should also be considered in economic reviews. The reason is that the capital that can be converted into machinery investment will be taken from the “Net Profit” segment (Ulusoy et al., 2015)

Despite the Turkish agricultural machinery market has reached a relatively high volume, it is still not at a sufficient level when the number of agricultural enterprises and the average age of the machinery are considered (Anonymous, 2021a). The fact that the tractor park in

Turkey reached an amount of 1,442,909 units in 2020 according to records of TURKSTAT is not significant on its own. Of this park, 46% is over 25 years old and urgent need for renovation has been discussed in many platforms. High power groups gain priority in the production of new tractors and while 4WD production increases, the share of these tractor groups in the existing park is still very low (Anonymous 2017, Evcim et al. 2015, İleri 2019). On the other hand, according to some researchers, agriculture in Turkey has become full in terms of tractorization and the demand in this context has become for "renewal" purposes instead of "new" (Evcim et al., 2020).

In the present study, the aim is to determine whether the relationship between agricultural income and tractorization has changed when compared to previous years as of 2020, and if so, to determine the extent of the change and to obtain tips about future tractorization. There are two studies in the literature that examine the relationship between Agricultural Income and Tractorization (Evcim and Değirmencioğlu, 2017, Özoğul and Evcim, 2020). In the article of Evcim and Değirmencioğlu titled "The Relationship of Income and Tractorization in the Turkish Agriculture" published in 2017, "Agricultural Structure-Production, Price, Value-Year 2005" statistics of TURKSTAT were used as the source, and 2005 data of Turkish Statistical Institute (Agricultural Equipment and Machinery Statistics) were used for the statistics of the tractor park. In the article of Özoğul and Evcim titled "The Correlation Between Agricultural Income and Tractorization in Turkey by 2017" published in 2020, 2017 statistics of TURKSTAT were used as the source, and 2017 traffic records (transportation statistics) regarding the statistics of the tractor park. In both studies, “Marketed Value of Total Plant Production” was taken as basis as the “Agricultural Income”. As a result of the said studies, it was found that the marketed value of the plant production of the provinces is correlated with the tractor assets.

Due to the rapid development of animal production, the use of tractors in this field has been gradually increasing. In the present study, 2020 statistics of TURKSTAT were used as the latest official source and based on the fact that “Marketed Value of Total Plant and Animal Production” as the “Agricultural Income”. 2020 Agricultural Equipment and Machinery Statistics of the provinces were taken as a basis by depending on the fact that it defines the existing park for the information about tractor statistics more accurately. In the literature review, no study examining the “Marketed Value of Total Plant and Animal Production” as “Agricultural Income” on tractorization was found. In addition, there are findings in the literature that mechanization has not yet fully assumed its role in improving productivity in the agriculture of Turkey (Evcim and Değirmencioğlu, 2017). Within this scope, it is thought that examination of the marketed value of plant and animal production on the increase in tractor assets will provide an important outcome to the literature. Regarding this information, the aim is to investigate the relationship between agricultural income and tractor assets as of 2020 depending on the statistics on agricultural income and tractor assets at regional level.

Based on this relationship, formation of a basis for a more realistic interpretation of the differences at the level of mechanization (tractorization) between provinces and regions and for the prediction of possible developments in this regard are targeted. Such analyzes will produce tips for the future of the market.

1. MATERIAL and METHODS

Animal production has been rapidly developing in Turkey and the use of tractors is increasing in this regard. Together with the development of animal husbandry, an increase in the level of mechanization at the enterprises is also expected. Thus, the sum of the incomes in plant and animal production are considered. When it is deemed that all of this income is not reflected in the demand of the production inputs of the farmers, the sum of the marketed value (TL) of plant (field, garden, and vegetable) and animal (livestock and animal products) productions as “income” and the “Marketed values to the Area Unit” (TL/ha) calculated by dividing these values by the production areas are listed by provinces and regions, and they are used as the “independent variable” values for the comparisons regarding the regions and country-wide.

In the research, TURKSTAT statistics were used to determine the marketing value of plant and animal production. Calculations were made by using the statistical data that are both published and not published by TURKSTAT (for 2020, “Marketed Value of Total Plant Production” and “Marketed Value of Total Animal Production” on a provincial basis were requested from TURKSTAT). The provincial production values of these products could not be calculated by TURKSTAT, because there is no provincial production amount of red meat, white meat, egg, and leather for 2020. Thus, the total value of provincial production of animal products does not give the total value for Turkey.

The provinces of Trabzon, Rize, and Artvin were not taken into consideration due to the reason that the farmers in the Eastern Black Sea Region exhibited a small-scale economic structure, specialization on agriculture and animal husbandry could not be realized, almost no tractors were used in the production of tea with high production value, and the use of tractors in hazelnut production was very low. The provinces of Giresun, Gümüşhane, and Ordu, although they have a small number of production other than the said two products, were taken under review.

NUTS (Nomenclature of Territorial Units for Statistics) were adapted for the distribution of provinces by regions, and regions are shown in different colors for convenience (Table 1).

Table 1. Regions and Provinces According to Nomenclature of Territorial Units for Statistics (NUTS)

NUTS	Regions	Provinces	Color
TR	Turkey		
TR1	Istanbul	Istanbul	
TR2	West Marmara	Tekirdağ, Edirne, Kırklareli, Balıkesir, Çanakkale	
TR3	Aegean	İzmir, Aydın, Denizli, Muğla, Manisa, Afyonkarahisar, Kütahya, Uşak	
TR4	East Marmara	Bursa, Eskişehir, Bilecik, Kocaeli, Sakarya, Düzce, Bolu, Yalova	
TR5	West Anatolia	Ankara, Konya, Karaman	
TR6	Mediterranean	Antalya, Isparta, Burdur, Adana, Mersin, Hatay, Kahramanmaraş, Osmaniye	
TR7	Central Anatolia	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir, Kayseri, Sivas, Yozgat	
TR8	West Black Sea	Zonguldak, Karabük, Bartın, Kastamonu, Çankırı, Sinop, Samsun, Tokat, Çorum, Amasya	
TR9	East Black Sea	(Trabzon), Ordu, (Rize, Artvin), Giresun, Gümüşhane	
TRA	Northeast Anatolia	Erzurum, Erzincan, Bayburt, Ağrı, Kars, Iğdır, Ardahan	
TRB	Central East Anatolia	Malatya, Elazığ, Bingöl, Tunceli, Van, Muş, Bitlis, Hakkâri	
TRC	Southeast Anatolia	Gaziantep, Adıyaman, Kilis, Şanlıurfa, Diyarbakır, Mardin, Batman, Şırnak, Siirt	

Source: (Anonymous, 2021b).

Two different statistics are published by TURKSTAT for the tractor park: 1) Agricultural Equipment and Machinery Statistics (Anonymous, 2021c), 2) Transportation Statistics (Anonymous, 2021d).

The first statistics are compiled by the Provincial and District Directorates of the Ministry of Agriculture and Forestry and they directly belong to the tractors used in agricultural production. The second statistics consists of the data in the Traffic Records of the Ministry of Interior and includes all the tractors registered to the traffic without any distinction regarding their areas of use. There are great differences in the number of tractors in these two sources, and these differences are increasing every year (Evcim et al., 2020). As of 2020, this difference has reached to 515,818 units which cannot be underestimated. Due to the reason that the number of tractors is the determining factor for the examination of the mechanization situation in Turkey, one of these two sources should be preferred. While it is estimated in the Traffic Records that this difference is caused by the tractors used in non-agricultural activities at municipal services, transportation, construction, and industry sectors, there is no distinction or explanation in the relevant statistics (Özoğul and Evcim, 2020). It is clear that taking the park (traffic records) that includes all the tractors in the traffic records as a basis in the evaluations and analyzes for agricultural mechanization will cause erroneous results. Therefore, the first statistical data were taken as basis for the “Tractor Park” in our country's agriculture regarding the analyzes and evaluations with the results given below, contrary to the approach of the article of Özoğul and Evcim titled “The Correlation Between Agricultural Income and Tractorization in Turkey by 2017” that was published in 2020.

In the current study, the “Number of Tractors-Units” in 2020 TURKSTAT records of the provinces and the “Tractor Density-Number/1000 ha” values that were found by dividing this park by the relevant area were considered as mechanization criteria. These values were sorted by provinces and regions and used as “dependent variables” for the determination of correlation.

Evaluation of the data: The correlation between the marketed value of total plant and animal production of the provinces and the number of tractors was examined by the regression analysis. Quadratic model (trendline with a 2nd order polynomial) with a higher R^2 value and a higher correlation was preferred. Data analysis was conducted by the IBM SPSS Statistics 20 program.

Research Hypotheses

There are findings in the literature that there is a positive correlation between the agricultural incomes of the provinces and the number of tractors (Evcim and Değirmencioğlu, 2017, Özoğul and Evcim, 2020). A positive correlation between the number of tractors and the agricultural income is foreseen.

H1: The marketed value of the total plant and animal production of the provinces has a positive correlation with the number of tractors.

In the literature, it is stated that there is a correlation between the income density of the provinces and the tractor density, although it is not strong, it is worth considering (Evcim and Değirmencioğlu, 2017). Within this scope, it is foreseen that income density is positively correlated with the tractor density.

H2: Income density of the provinces (TL/ha) has a positive correlation with the tractor density (Number/1000ha).

2. RESULTS and DISCUSSION

2.1. The Marketing Value of Plant and Animal Production

In the agriculture of Turkey, the marketing rates in a land of 23 million 145 thousand 134 hectares in 2020 are 84% in plant products, 52% in animal products, and 67% in total (Table 2). Of the income in plant production, 37% was obtained from field, 39% from garden, and 24% from vegetable production, respectively. On the other hand, the shares of field, garden, and vegetable production in the total cultivated area were 84.6%, 12%, and 3.4%, respectively (While production was conducted in 67.5% of the field areas covering 84.6% of the total cultivated area, the remaining 13.7% was fallowed). In the 2010-2020 period, the marketing rates remained the same in plant production, while there were some more outstanding changes in animal production. Within this period, when it is considered that there was a 3.1-fold increase in the marketed value of plant production and a 3.2-fold increase in animal production, it can be seen that there are serious increases.

Table 2. Agricultural Product Values and Marketed Shares (2010-2020 Year)

Years	Agricultural Production Value			Plant Production Value			Animal Production Value		
	Total Production Value (Thousand TL)	Total Marketed Value (Thousand TL)	%	Total Production Value (Thousand TL)	Total Marketed Value (Thousand TL)	%	Total Production Value (Thousand TL)	Total Marketed Value (Thousand TL)	%
2010	165.039.291	116.710.776	71	80.038.126	67.393.773	84	85.001.165	49.317.003	58
2015	248.925.103	172.305.827	69	120.152.079	100.363.685	84	128.773.024	71.942.142	56
2016	271.269.945	184.142.973	68	119.237.661	99.756.777	84	152.032.284	84.386.196	56
2017	323.608.353	214.842.333	66	135.885.136	113.811.708	84	187.723.217	101.030.624	54
2018	384.476.442	253.550.336	66	159.142.178	134.401.938	84	225.334.264	119.148.398	53
2019	456.691.436	304.402.757	67	197.455.884	166.794.569	84	259.235.552	137.608.188	53
2020	549.853.927	366.621.292	67	246.016.799	207.763.250	84	303.837.128	158.858.042	52

Source: The values were calculated based on Values of Crop and Animal Production (Turkstat 2021).

The positive change in marketed values as also stated by Evcim et al. (2015), reveals that access to the market has become easier due to the construction/improvement of the roads and logistics developments in Turkey in recent years. This change is especially attracting in animal production. It is evident that mechanization support is required in the issues such as processing, storage, and transportation of animal products.

2.2. The Marketing Value of Plant and Animal Production and Number of Tractors

In 2020, a total marketed value of 314 billion 491 million (TL) in plant and animal production was obtained in the provinces excluding the in Eastern Black Sea region (Trabzon, Rize, and Artvin), which were not included in the assessment. The provinces included in the evaluation are listed as in Table 3 according to their shares in the total. The number of tractors used for productions in the provinces and their shares in the total tractor park are also given in the same table.

Table 3. Marketed Value of Total Plant and Animal Production (TL) and Number of Tractors (Number) (2020 Year)

NUTS	Provinces	Total			Number of Tractors (Units)	(%)	Ordinal
		Value (TL)	(%)	Ordinal			
TR	Turkey	314.491.169.120	100		1.442.909	100	
TR521	Konya	19.073.961.024	6,07	1	72.820	5,05	2
TR611	Antalya	16.030.521.627	5,1	2	36.483	2,53	7
TRC21	Şanlıurfa	14.124.946.867	4,49	3	18.074	1,25	33
TR622	Mersin	13.418.331.470	4,27	4	26.310	1,82	19
TR310	İzmir	11.082.981.992	3,52	5	34.932	2,42	9
TR621	Adana	9.937.241.483	3,16	6	30.676	2,13	13
TR510	Ankara	8.587.405.428	2,73	7	33.801	2,34	11
TR331	Manisa	8.192.999.081	2,61	8	82.461	5,71	1
TR411	Bursa	8.090.074.746	2,57	9	51.331	3,56	4
TRC22	Diyarbakır	8.051.345.713	2,56	10	10.114	0,7	51
TRC11	Gaziantep	6.715.177.914	2,14	11	15.458	1,07	37
TR221	Balıkesir	6.617.703.421	2,1	12	65.296	4,53	3
TR831	Samsun	6.498.715.053	2,07	13	43.298	3	5
TR322	Denizli	6.458.951.441	2,05	14	36.005	2,5	8
TR321	Aydın	6.269.777.107	1,99	15	30.571	2,12	14
TR222	Çanakkale	5.947.092.889	1,89	16	27.059	1,88	17
TR332	Afyonkarahisar	5.744.467.861	1,83	17	26.776	1,86	18
TR323	Muğla	5.335.937.836	1,7	18	34.235	2,37	10
TR902	Ordu	4.879.948.311	1,55	19	12.873	0,89	44
TR721	Kayseri	4.783.206.526	1,52	20	21.144	1,47	26
TR631	Hatay	4.687.662.258	1,49	21	20.775	1,44	27
TRA11	Erzurum	4.684.246.624	1,49	22	11.909	0,83	48
TR712	Aksaray	4.642.091.393	1,48	23	19.380	1,34	31
TR713	Niğde	4.629.100.198	1,47	24	18.258	1,27	32
TR632	Kahramanmaraş	4.492.178.313	1,43	25	14.786	1,02	39
TR212	Edirne	4.374.171.636	1,39	26	24.066	1,67	22
TR832	Tokat	4.270.619.803	1,36	27	31.999	2,22	12
TR722	Sivas	4.255.015.637	1,35	28	27.321	1,89	16
TR412	Eskişehir	4.116.290.678	1,31	29	17.958	1,24	35
TR612	Isparta	3.880.045.517	1,23	30	18.038	1,25	34
TR522	Karaman	3.829.975.189	1,22	31	12.495	0,87	46
TR422	Sakarya	3.782.245.532	1,2	32	25.757	1,79	21
TR211	Tekirdağ	3.667.578.565	1,17	33	20.246	1,4	29
TR833	Çorum	3.636.586.469	1,16	34	40.000	2,77	6
TR904	Rize		0	35	11	0	81
TRC31	Mardin	3.450.488.652	1,1	36	6.409	0,44	60
TR723	Yozgat	3.371.572.028	1,07	37	29.343	2,03	15
TRB11	Malatya	3.300.077.425	1,05	38	13.474	0,93	43
TRC12	Adıyaman	3.195.420.056	1,02	39	14.490	1	41

Table 3 continuous

NUTS	Provinces	Total			Number of Tractors (Units)	(%)	Ordinal
		Value (TL)	(%)	Ordinal			
TR834	Amasya	3.068.252.894	0,98	40	22.727	1,58	24
TR821	Kastamonu	2.993.706.820	0,95	41	21.170	1,47	25
TRA22	Kars	2.865.543.648	0,91	42	20.005	1,39	30
TRB21	Van	2.835.894.468	0,9	43	7.006	0,49	59
TR613	Burdur	2.723.508.817	0,87	44	23.078	1,6	23
TR213	Kırklareli	2.717.236.048	0,86	45	15.211	1,05	38
TR901	Trabzon		0	46	909	0,06	79
TRC34	Siirt	2.613.950.363	0,83	47	2.619	0,18	71
TRB22	Muş	2.605.609.964	0,83	48	12.657	0,88	45
TRB12	Elazığ	2.605.180.083	0,83	49	6.154	0,43	61
TRA21	Ağrı	2.469.585.848	0,79	50	8.591	0,6	53
TR633	Osmaniye	2.436.193.373	0,77	51	9.441	0,65	52
TR903	Giresun	2.426.620.546	0,77	52	3.560	0,25	67
TR714	Nevşehir	2.411.418.023	0,77	53	17.534	1,22	36
TR333	Kütahya	2.359.500.998	0,75	54	25.817	1,79	20
TR715	Kırşehir	2.306.731.535	0,73	55	11.850	0,82	49
TR334	Uşak	2.151.526.048	0,68	56	20.315	1,41	28
TRA23	Iğdır	1.922.785.618	0,61	57	3.710	0,26	66
TRC32	Batman	1.660.029.447	0,53	58	1.617	0,11	76
TRB23	Bitlis	1.608.908.505	0,51	59	3.097	0,21	70
TRA12	Erzincan	1.496.421.113	0,48	60	7.642	0,53	57
TRC33	Şırnak	1.333.940.487	0,42	61	1.765	0,12	75
TRA24	Ardahan	1.326.732.200	0,42	62	5.933	0,41	63
TR421	Kocaeli	1.276.202.285	0,41	63	7.632	0,53	58
TR100	İstanbul	1.265.243.154	0,4	64	5.228	0,36	64
TRB13	Bingöl	1.227.487.699	0,39	65	1.245	0,09	77
TR423	Düzce	1.168.454.757	0,37	66	14.575	1,01	40
TR424	Bolu	1.093.900.501	0,35	67	13.535	0,94	42
TR905	Artvin		0	68	1.826	0,13	74
TR413	Bilecik	1.077.509.752	0,34	69	8.250	0,57	54
TR811	Zonguldak	1.064.537.222	0,34	70	8.048	0,56	55
TR822	Çankırı	1.025.652.299	0,33	71	10.823	0,75	50
TR711	Kırıkkale	994.612.565	0,32	72	7.692	0,53	56
TR823	Sinop	829.901.762	0,26	73	4.942	0,34	65
TRC13	Kilis	749.966.798	0,24	74	2.173	0,15	72
TRB24	Hakkâri	729.657.866	0,23	75	468	0,03	80
TR906	Gümüşhane	656.221.927	0,21	76	3.107	0,22	69
TR813	Bartın	556.885.864	0,18	77	12.301	0,85	47
TRA13	Bayburt	504.255.132	0,16	78	3.316	0,23	68
TRB14	Tunceli	441.922.044	0,14	79	1.092	0,08	78
TR812	Karabük	416.777.289	0,13	80	5.966	0,41	62
TR425	Yalova	366.549.595	0,12	81	1.850	0,13	73

Source: Calculated using (Anonymous, 2021 e).

According to the table, there are differences between the provinces in terms of their contribution to the marketed value of plant and animal production and their share in the total tractor park. While Konya provides 6.07% of the marketed value of total plant and animal production, the contribution of other provinces to this value regresses to 0.12%. Similarly, while the tractor assets of some provinces approach 6% of the total park, the tractor assets of some provinces remain at the level of 0.03% of the total park.

As of 2020, it can be observed that the top 10 provinces providing 37% of the marketed value of total production, have 34% of the total tractor park. The top 20 provinces that provide 56% of the marketed value of the production counts for 55% of the park, and the top 30 provinces that provide 70% of the marketed value have 70% of the park. As can be seen from this evaluation, there is a close correlation between the marketed production value and the tractor assets. Considering the marketed value of plant production, the aliasing between the results of the study of Evcim and Değirmencioğlu conducted by using 2005 TURKSTAT data and the study conducted by Özoğul and Evcim by using the 2017 Traffic Records reveals that there is no difference in this sense.

According to Evcim and Değirmencioğlu (2017), it is stated that the major differences between the numbers of tractors of the provinces having approximately the same income can be explained by the differences between the values of product pattern, yield, enterprise scale, and average power level of the tractor park. As an example, the fact that only 44% of the tractors in Manisa, having an income that is 51% lower, are present in Antalya, which has the second highest income, can be explained by the prevalence of greenhouse cultivation, which provides high income and efficiency, however, it has limited use of tractors.

Figure 1 shows the distribution of the provinces in terms of the marketed value of plant and animal production and the number of tractors, as painted with the color codes of the regions they belong. Thus, below mentioned issues have drawn attention:

- Relatively limited number of tractors despite the high incomes of the provinces of Mediterranean Region (Antalya, Mersin, and Adana),
- High number of tractors despite the relatively low income of Aegean (Kütahya, Uşak), Western Marmara (Kırklareli) and Eastern Marmara (Düzce, Bolu, Bilecik), Western Black Sea (Çorum, Amasya, Kastamonu),
- Low number of tractors despite relatively good income of Şanlıurfa, Diyarbakır, and Gaziantep provinces from the Southeastern Anatolia Region.
- The high number of provinces with low values in terms of income and number of tractors also draw attention.

The aliasing of the above results with the results of the previous studies of (Evcim & Değirmencioğlu, 2017) and (Özoğul & Evcim, 2020) shows that there is no difference in this regard.

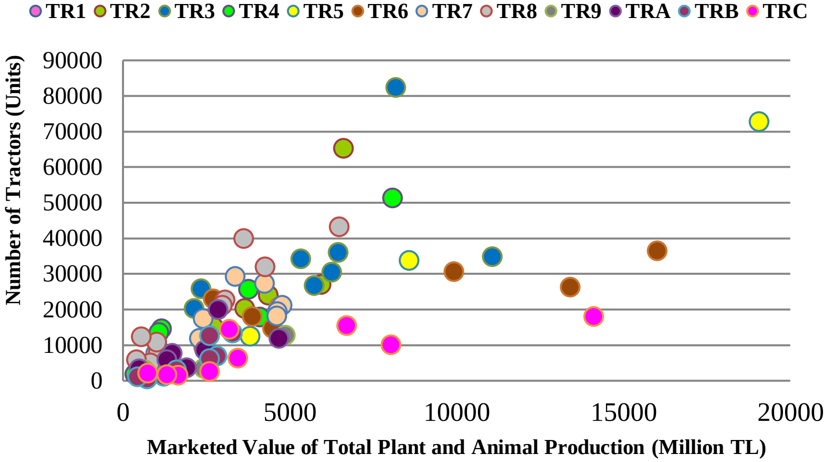

Figure 1. Marketed Value of Total Plant and Animal Production of Provinces and Tractor Numbers (Region Color Codes) (2020 Year)

Figure 2 shows the results of the regression analysis, which were carried out to more closely evaluate the relationship between the total marketed value of plant and animal production of the provinces and the number of tractors. Accordingly, as of the 2020 values, it can be understood that there is a statistically significant correlation between the marketed value of total plant and animal production (Million TL) of the provinces and the number of tractors (units), and this correlation can be defined by the second-order function equation with a coefficient of determination of (R^2=0.5097):

$$Y= -0,0002x^2+5,4234x+1266,5$$

X: Marketed Value of Total Plant and Animal Production (Million TL)

Y: Number of Tractors (Units)

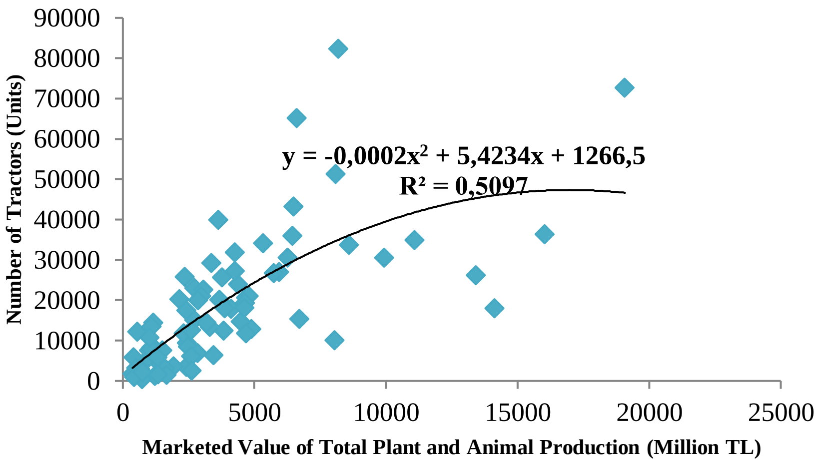

Figure 2. The Relationship Between Marketed Value of Total Plant and Animal Production of the Provinces and Number of Tractors (2020 Year)

The reason why this relationship is slightly lower than the coefficient found by Evcim and Değirmencioğlu, who used 2005 TURKSTAT statistics (R^2 =0.6034), and the coefficient of determination found by Özoğul and Evcim, who used 2017 traffic records (R^2 =0.6521), is the reason for the animal production in the current study. When the great differences between the provinces in terms of climate soil-water resources, human labor, capital, mechanization, farm size, type of farms and production infrastructure, and also the pandemic process, when the tractor sales sharply decreased, as in all goods, are considered, it was seen that this correlation was at a level that could be considered as significant.

Income-Tractorization relationship provides “more increase in the tractor park with less income increase” at the provinces with low income and tractor assets, and “less increase in tractor park with more income" at the provinces that are rich in both aspects. This result is compatible with the results of the previous studies conducted by Evcim and Değirmencioğlu (2017) and Özoğul and Evcim (2020).

2.3. Production Value and Number of Tractors Marketed to Area Unit

The marketed production value and the number of tractors of the inspected provinces are both directly dependent on the "area" input. Thus, the investigation of the correlation between the two variables via the values of the variables reduced to area units ensures that the area effect in this correlation can be eliminated (Evcim and Değirmencioğlu, 2017).

Depending on this idea, the marketed values of plant and animal production per area unit of the provinces (Income Density - TL/ha) and the number of tractors (Tractor Density - the number of tractors per 1000 hectares) were calculated and the results are given in Table 4. According to this, as of 2020, the marketed value of plant and animal production per hectare varies between 43,929 and 3,314 TL/ha for the provinces, and the average of the country is 13,588 TL/ha. It has been found that 38 of the 78 provinces evaluated have an income density above and 40 provinces below the average of the country.

Tractor density values vary between 317 and 11 tractors per 1000 hectares according to the provinces, and the average of the country is 62 tractors per 1000 hectares. Of the provinces, 38 have tractor density values above the average and 40 below the average.

Table 4. Income Density and Tractor Density (2020 Year)

NUTS	Provinces	Total Production Unit Value Marketed		Tractor Density		Group
		TL/ha	Ordinal	Number/1000ha	Ordinal	
TR	Turkey	13.588		62		0
TR611	Antalya	43.929	1	100	19	1
TRB13	Bingöl	40.960	2	42	52	3
TR622	Mersin	40.703	3	80	30	1
TR310	İzmir	34.028	4	107	16	1
TR425	Yalova	31.866	5	161	7	1
TRA24	Ardahan	31.000	6	139	13	1
TRC34	Siirt	27.930	7	28	66	3
TR411	Bursa	27.181	8	172	3	1
TR323	Muğla	23.763	9	152	10	1
TR422	Sakarya	22.245	10	151	11	1
TR811	Zonguldak	21.884	11	165	5	1
TR631	Hatay	20.666	12	92	23	1
TR621	Adana	20.607	13	64	37	1
TR633	Osmaniye	20.463	14	79	31	1
TR821	Kastamonu	20.325	15	144	12	1
TR222	Çanakkale	20.010	16	91	26	1
TR612	Isparta	19.793	17	92	24	1
TRA23	Iğdır	19.774	18	38	55	3
TR902	Ordu	19.305	19	51	47	3
TRC11	Gaziantep	19.248	20	44	51	3
TR613	Burdur	18.135	21	154	9	1
TR321	Aydın	17.736	22	86	28	1
TR322	Denizli	17.695	23	99	20	1
TRC32	Batman	17.601	24	17	76	3
TR831	Samsun	17.331	25	115	15	1
TR100	İstanbul	17.083	26	71	34	1

Table 4 continuous

NUTS	Provinces	Total Production Unit Value Marketed		Tractor Density		Group
		TL/ha	Ordinal	Number/1000ha	Ordinal	
TR221	Balıkesir	16.957	27	167	4	1
TRB24	Hakkâri	16.937	28	11	79	3
TR713	Niğde	16.785	29	66	35	1
TR331	Manisa	16.156	30	163	6	1
TR421	Kocaeli	16.049	31	96	22	1
TR903	Giresun	15.746	32	23	71	3
TR423	Düzce	15.637	33	195	2	1
TRC22	Diyarbakır	14.506	34	18	75	3
TR813	Bartın	14.366	35	317	1	1
TR212	Edirne	14.070	36	77	32	1
TRB12	Elazığ	13.951	37	33	63	3
TR832	Tokat	13.823	38	104	17	1
TRA11	Erzurum	13.498	39	34	61	2
TRC12	Adıyaman	13.458	40	61	40	2
TRC21	Şanlıurfa	13.457	41	17	77	2
TR834	Amasya	13.283	42	98	21	4
TR413	Bilecik	13.167	43	101	18	4
TRA22	Kars	12.983	44	91	27	4
TR632	Kahramanmaraş	12.500	45	41	53	2
TRC33	Şırnak	12.497	46	17	78	2
TRB23	Bitlis	12.282	47	24	68	2
TR712	Aksaray	12.220	48	51	48	2
TR332	Afyonkarahisar	12.117	49	56	42	2
TRA12	Erzincan	11.913	50	61	41	2
TRB11	Malatya	11.753	51	48	49	2
TR213	Kırklareli	11.735	52	66	36	4
TR522	Karaman	11.634	53	38	56	2
TR812	Karabük	11.074	54	159	8	4
TRC31	Mardin	10.988	55	20	74	2
TR823	Sinop	10.815	56	64	38	4
TRB22	Muş	10.717	57	52	44	2
TR521	Konya	10.260	58	39	54	2
TRB21	Van	9.805	59	24	69	2
TR424	Bolu	9.700	60	120	14	4
TR334	Uşak	9.691	61	92	25	4
TR211	Tekirdağ	9.337	62	52	45	2
TRB14	Tunceli	9.130	63	23	72	2
TR721	Kayseri	8.365	64	37	57	2
TR906	Gümüşhane	7.739	65	37	58	2
TR333	Kütahya	7.577	66	83	29	4
TR510	Ankara	7.452	67	29	65	2
TR412	Eskişehir	7.369	68	32	64	2
TRC13	Kilis	7.348	69	21	73	2
TR714	Nevşehir	7.335	70	53	43	2
TR715	Kırşehir	7.041	71	36	59	2
TRA21	Ağrı	6.992	72	24	70	2
TR833	Çorum	6.822	73	75	33	4
TR723	Yozgat	5.412	74	47	50	2

Table 4 continuous

NUTS	Provinces	Total Production Unit Value Marketed		Tractor Density		Group
		TL/ha	Ordinal	Number/ 1000ha	Ordinal	
TR722	Sivas	5.399	75	35	60	2
TRA13	Bayburt	5.189	76	34	62	2
TR822	Çankırı	4.939	77	52	46	2
TR711	Kırıkkale	3.314	78	26	67	2
TR904	Rize	0	80	0	81	
TR905	Artvin	0	79	62	39	
TR901	Trabzon	0	81	10	80	

Source: Calculated using (Anonymous, 2021e).

Income and tractor density values of 78 provinces evaluated show a distribution as seen in Figure 3.

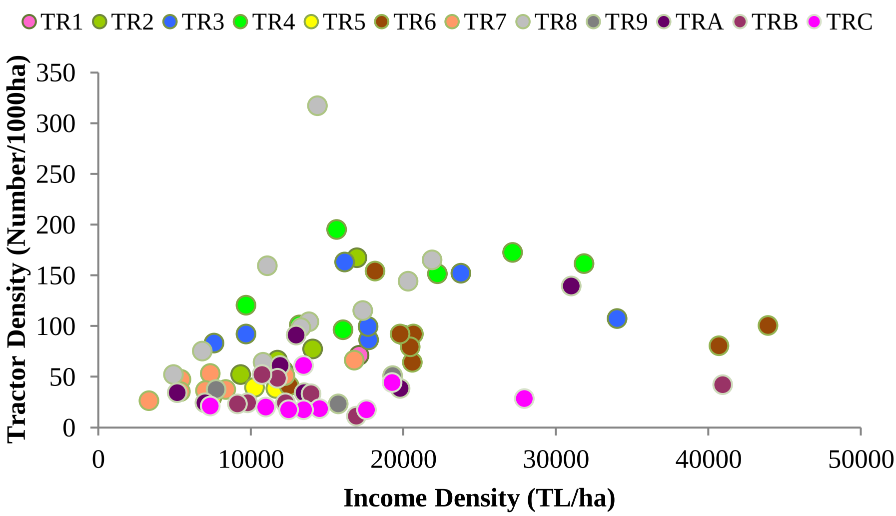

Figure 3. Income Density and Tractor Density Values of Provinces (Region Color Codes) (2020 Year)

Quadrant analysis, which is frequently used in marketing, is a technique that presents the correlations between the variables in graphics and produces visualized data/information. Visual results are obtained by the

Quadrant analysis for easier communication, understanding, and interpretation purposes. These results are important for strategic planning and decision making (Hernon and Altman, 1998). Figure 4 shows in which quadrant the income and tractor density variables of the provinces take place.

Accordingly, it is possible to divide the provinces examined into four groups due to their differences from the average of the country in terms of income and tractor density:

- 1st group: (Quadrant 1): Provinces which are above the national average in both values income density and tractor density
- 2nd group (Quadrant 4): Provinces which are below the national average in both values income density and tractor density
- 3rd group (Quadrant 2): Provinces with a higher income density than the national average, but with a low tractor density
- 4th group (Quadrant 3): Provinces with a lower income density than the country average, but with a high tractor density

There are 28 provinces in the first group. Mediterranean (Antalya, Mersin, Hatay, Adana, Osmaniye, Isparta, Burdur), North East Anatolia (Ardahan), Aegean (Izmir, Muğla, Aydın, Denizli, Manisa), East Marmara (Yalova, Bursa, Sakarya, Kocaeli, Düzce) , Istanbul, West

Marmara (Çanakkale, Balıkesir, Edirne), West Black Sea (Zonguldak, Kastamonu, Samsun, Bartın, Tokat) and Central Anatolia (Niğde) regions.

The second group includes 30 provinces. These are from regions other than Istanbul. Aegean (Afyonkarahisar), Southeast Anatolia (Adıyaman, Şanlıurfa, Şırnak, Mardin, Kilis), Central East Anatolia (Bitlis, Malatya, Muş, Van, Tunceli), Mediterranean (Kahramanmaraş), East Black Sea (Gümüşhane), West Anatolia (Karaman, Konya, Ankara), West Marmara (Tekirdağ), Central Anatolia (Aksaray, Kayseri, Nevşehir, Kırşehir, Yozgat, Sivas, Kırıkkale), West Black Sea (Çankırı), East Marmara (Eskişehir) and Northeast Anatolia (Erzurum, Erzincan, Ağrı, Bayburt) regions.

The third group includes 10 provinces. These are from the Central East Anatolia (Bingöl, Hakkari, Elazığ), South East Anatolia (Siirt, Gaziantep, Batman, Diyarbakır), North East Anatolia (Iğdır) and East Black Sea (Giresun, Ordu) regions.

The fourth group includes 10 provinces. These are from the Aegean (Uşak, Kütahya), West Marmara (Kırklareli), East Marmara (Bilecik, Bolu), West Black Sea (Amasya, Karabük, Sinop, Çorum) and North East Anatolia (Kars) regions.

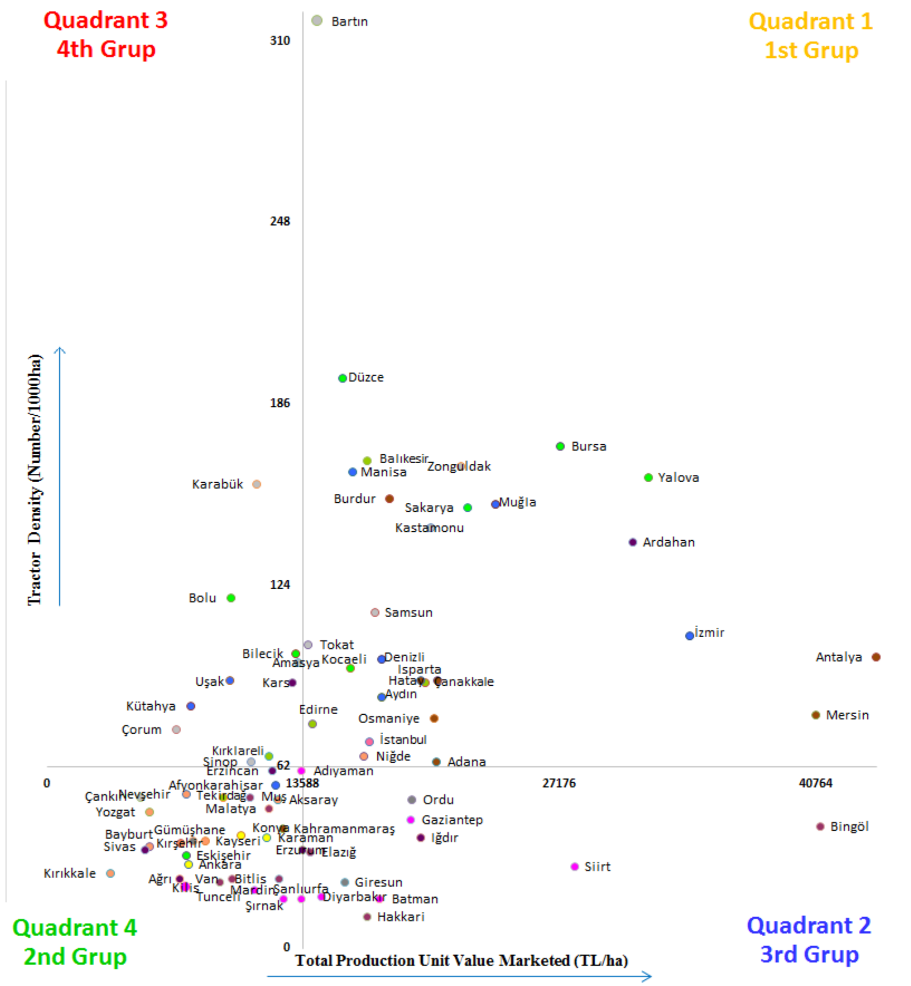

Figure 4. Income Density and Tractor Density Quadrant Analysis of Provinces (2020 Year)

In the first group, Adana, Hatay, Osmaniye, and Istanbul provinces take place, where intensive agriculture is dominant with the use of tractors above the average of the country (500< hours), and Ardahan, Burdur, Kocaeli, and Samsun provinces with the use of tractors below the average of the country (<400 hours). According to Evcim and Ertuğrul

(2017), the fact that the provinces having intensive agricultural activities such as Bursa, Yalova, Muğla, Sakarya, and Tokat, having an annual usage time of tractors vary between 300 and 399 hours, are also in the first group, however, this can be explained by the majority of small enterprises and tractors in these provinces. In some of the provinces in this group, income and tractor density values despite the agricultural production and operating infrastructure have approached the EU average. The increase in the income and tractor assets in other provinces is open to improvement.

Considering the soil water resources of the provinces at Southeast Anatolian region, which are in the second group, where agricultural production and mechanization are still at very low levels, the opinion that they have a great development potential in terms of both income and tractorization and the current backwardness should be interpreted as the dynamic of the mentioned potential development coincide with the results of Evcim and Değirmencioğlu (2017), Özoğul and Evcim (2020), and Sessiz et al. (2006).

The provinces in the third group, especially Bingöl and Gaziantep, draw attention with their low tractor density despite their relatively high-income density. The reasons for this unexpected correlation at the provinces in the third group should be investigated and evaluated in terms of mechanization efficiency. This group has the highest sales potential and also consists of an opportunity for tractor dealers. Raising awareness in alternative solutions and applications suggested by the dealers, as well as perceiving the psychological behavior of the consumer will also be reflected in the tractor sales.

The provinces in the fourth group, which draw attention with their high tractor densities despite their relatively low-income densities, either have the ingenuity of tractor dealers or there is a weakness in mechanization. The situation of the provinces in the 4th group should be evaluated in terms of business structure, product patterns, and the power level of the tractor park.

The study of Evcim and Değirmencioğlu titled "The Relationship of Income and Tractorization in the Turkish Agriculture" has a meaning for the comparison of the change in income and tractor density of the provinces from 2005 to 2020, although the production values are different. There is a difference of 515,818 units that should not be underestimated, in terms of tractor difference between the 2020 TURKSTAT records and 2005 data. Table 5 shows the changes in the income density of the provinces (plant according to 2005, plant+animal according to 2020) and tractor density according to the groups in terms of the differences from the average of the country. It can be seen that there are many different developments in the intervening period.

Table 5. Change According to the Groups in Terms of Differences from the Country Average with Income and Tractor Density of the Provinces According to the 2005 and 2020 Years.

2005	2020	Change from 2005 to 2020	Provinces
1. Group	**4. Group**	Income ↓	***Bilecik, Amasya***
3. Group	**1. Group**	Tractor ↑	Adana
3. Group	**2. Group**	Income ↓	Malatya, Kilis, Kahramanmaraş, ***Karaman***
4. Group	**1. Group**	Income ↑	Bartın, ***Burdur, Kocaeli, Kastamonu, Ardahan***
4. Group	**2. Group**	Tractor ↓	Tekirdağ, Nevşehir, Çankırı, ***Afyonkarahisar***
2. Group	**4. Group**	Tractor ↑	Sinop, ***Çorum,*** Kars
2. Group	**3. Group**	Income ↑	***Siirt, Diyarbakır, Elazığ, Batman, Bingöl, Iğdır, Hakkari,*** Gaziantep

In the provinces of Bilecik and Amasya where income and tractor density are higher than the country average, there has been a decrease in income density.

In the province of Adana, where the income density is higher than the country average, but the tractor density is low, there has been an increase in tractor density.

Income density is higher than the country average, but there has been a decrease in income density in Malatya, Kilis, Kahramanmaraş and Karaman where tractor density is low.

Income density increased in Bartın, Burdur, Kocaeli, Kastamonu and Ardahan, where the income density is lower than the country average, but the tractor density is high.

In the provinces of Tekirdağ, Nevşehir, Çankırı and Afyonkarahisar, where income density is lower than the country average, but tractor density is high, there has been a decrease in tractor density.

There has been an increase in tractor density in Sinop, Çorum and Kars where income and tractor density are below the country average.

Income density has increased in Siirt, Diyarbakır, Elazığ, Batman, Bingöl, Iğdır, Hakkari and Gaziantep where income and tractor density are below the country average.

In the study of Özoğul and Evcim titled "The Correlation Between Agricultural Income and Tractorization in Turkey by 2017", it has a meaning to compare the change in income and tractor density of the provinces from 2017 to 2020, despite the statistics of production values and tractor park are based on different records. There is a difference of 395,313 units that cannot be underestimated in terms of tractors between the traffic records of 2017 and 2020 TURKSTAT data. Table 6 shows the changes in the income density of the provinces (plant according to 2017, plant+animal according to 2020) and tractor density according to the groups in terms of the differences from the average of the country.

Tables 5 and 6 show the provinces showing the same change according to the groups in terms of the differences in the income and tractor density of the provinces from the average of the country from 2005 to 2020 and from 2017 to 2020, in bold and italics.

Table 6. Change According to the Groups in Terms of Differences from the Country Average with Income and Tractor Density of the Provinces According to the 2017 and 2020 Years.

2017	2020	Change from 2017 to 2020	Provinces
1. Group	4. Group	Income ↓	***Bilecik, Amasya,*** Sinop
3. Group	1. Group	Tractor ↑	Niğde
4. Group	1. Group	Income ↑	Istanbul, ***Burdur, Kocaeli, Kastamonu, Ardahan***
1. Group	2. Group	Income ↓ Tractor ↓	Malatya
3. Group	2. Group	Income ↓	***Karaman,*** Mardin
4. Group	2. Group	Tractor ↓	***Afyonkarahisar***
2. Group	3. Group	Income ↑	***Siirt, Diyarbakır, Elazığ, Batman, Bingöl, Iğdır, Hakkari***
2. Group	4. Group	Tractor ↑	***Çorum***
4. Group	3. Group	Income ↑ Tractor ↓	Gaziantep

Income density has decreased in Bilecik, Amasya and Sinop where income and tractor density were above the country average.

In the province of Niğde where income density is higher than the country average, but tractor density is low, there has been an increase in tractor density.

Income density has increased in Istanbul, Burdur, Kocaeli, Kastamonu and Ardahan where income density is lower than the country average but tractor density is high.

In the province of Malatya where income and tractor density are above the country average, there has been a decrease in income and tractor density.

In the provinces of Karaman and Mardin where the income density is higher than the country average, but the tractor density is low, there has been a decrease in the income density.

In Afyonkarahisar province where income density is lower than the country average, but tractor density is high, there has been a decrease in tractor density.

Income density has increased in Siirt, Diyarbakır, Elazığ, Batman, Bingöl, Iğdır and Hakkari where income and tractor density are below the country average.

In Çorum where income and tractor density are below the country average, there has been an increase in tractor density.

In Gaziantep where the income density is lower than the country average, but the tractor density is high, there has been an increase in income density and a decrease in tractor density.

Figure 5 shows the statistical evaluation results of the correlation between the marketed value of total plant and animal production of the provinces and the number of tractors per area unit (ha) where these productions are conducted.

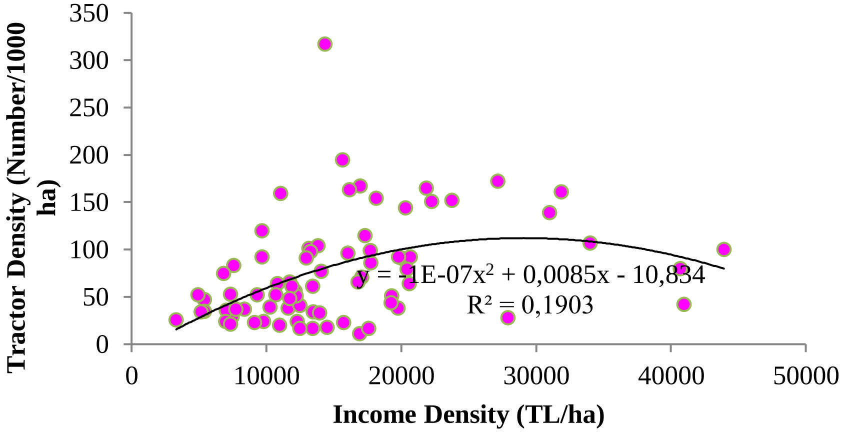

Figure 5. Relationship Between Income Density (TLha) and Tractor Density (Number/1000ha) (2020 Year)

Accordingly, it is concluded that there is a statistically weak correlation between the income and tractor density values of the provinces as of 2020 values, and this correlation can be defined by using the following second-order function equation with a coefficient of determination (R^2=0.1903).

$Y=-1E-07x^2+0,0085x-10,834$

x= Income density (TL/ha)

y= Tractor density (Number/1000 ha)'dır.

It shows that the income density-tractor density correlation of a model with a coefficient of determination of R^2=0.1903 is not worth considering. Among the reasons why the correlation between the income of the provinces and tractor density is lower than the (R^2=0.4801) coefficient of determination found in the study by Evcim and Değirmencioğlu conducted by using 2005 TURKSTAT records, and the coefficient of determination (R^2=0,3723) found in the study of Özoğul and Evcim by using 2017 traffic records, the fact that the marketed value of total animal production was considered in this study, Giresun province was included in the scope of the evaluation, and the number of the tractor assets having low power levels at the tractor park of Bartın and Düzce was high in number.

CONCLUSIONS

From the results obtained, the findings regarding that there is a statistically significant correlation between the marketed values of total plant and animal production of the provinces and tractor assets are parallel with the results of previous studies (Evcim and Değirmencioğlu, 2017, Özoğul and Evcim, 2020) conducted with the marketed values of total plant production. Along with some deviations in the income-tractorization relationship, the number of tractors increases as the income of the provinces increases. It should also be considered that the deviations are caused by the structure of enterprises and change trends, agroecological constraints and irrigation possibilities, plant patterns and alternatives, and different watersheds. Such differences and the possibility of increasing the production potential elucidate the estimation of the tractor and agricultural machinery market volume of the watersheds and also determine the extent and direction of mechanization for supporting the agricultural sector.

A statistically poor correlation between income density and tractor density is parallel with the results of (Özoğul and Evcim, 2020).

It is considered that the results of the positive and significant correlation between the marketed value of total plant and animal production on the increase in tractor assets will provide an important outcome to the literature.

In the continuation of the relevant research, it is considered that the possible developments in the tractor park of the provinces can provide a significant contribution to the literature and the operators by evaluating in terms of factors such as tractor usage efficiency, enterprise scale, product pattern, and production techniques.

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CHAPTER 6

ENERGY BALANCE AND ENERGY ECONOMIC ANALYSES OF HONEY PRODUCTION

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INTRODUCTION

Sustainable development consists of the three factors of sustainability (economic, environmental and social). It is an improvement that satisfy the need of the present-day without compromising the meeting abilities their own needs of future generations (Shepherd et al., 2009; Purvis et al., 2018). Sustainability is the part and parcel of today's leading global framework for international cooperation. The United Nations' 17 Sustainable Development Goals (SDGs) are planned to achieve synergism between the welfare of mankind and the maintenance of environmental resources by 2030 (UN, 2015). Taking into consideration the possibility suggestions to improve food production systems from the most subsistence production methods to the highly developed technological systems, beekeeping, which defined as the feeding and maintenance of honey bee colonies and the production of bee products, is an activity that can have an impact on all 17 SDGs (UN, 2015; Aydın et al., 2020). Beekeeping activity known since ancient times and spread almost all over the earth has contributed to the well-being of the people, and it has been considered a valuable activity. It is a sustainable form of agriculture that does not require land, requires very little investment and is not harmful to the environment. It offers various opportunities for people who want to maintain their livelihood with landless, and it contributes to pollination of crops. Furthermore, beekeeping activity does not generate pollution or waste, and this makes it sustainable over time (Apimondia, 2019). Honey, which is one of the most important products of this activity, is a significant product in terms of a nutritive and an economic value. In ancient times, honey was the first bee product that is used by humankind. The history of the honey use is parallel to the history of mankind. The evidence may be found regarding its use as a nutritional source and a symbol in almost every culture (magic, religious etc.) (Oyerinde et al., 2014, Aksoy et al., 2018). Due to these characteristics of the beekeeping, it has an important role in rural development. According to 2020 data, there were 90,116,413 beehives in the world, the total honey production was 1,852,598 tonnes, and the average honey yield per hive was 20.6 kg (FAO, 2020). Turkey has a very advantageous position among the countries of the world for beekeeping, thanks to its geographical location and natural riches (Kekeçoğlu et al., 2007). In Turkey, like most countries of the world, the beekeeping has improved in recent years. Turkey takes second place in terms of total honey production amount in the world. In addition, it takes third place with total the number of beehive and the average honey yield per hive (Çevrimli and Sakarya, 2019; Subaşı et al., 2019; FAO, 2020). Turkey contains 20% of the bee races in the world. Also, it has 75% of honeyed plant species and varieties which are in existence in the world (Borum, 2017; Aydın et al., 2020). Hence, it has a significant potential for beekeeping in terms of suitable ecology, rich flora, colony existence and genetic variation in bee population. According to 2020 data, total number of beekeeping enterprises were 82,862 in Turkey, the total number of beehives were 8,179,085, the total honey production was 104,077 tonnes, and the average honey yield per hive was 13.5 kg

(TURKSTAT, 2020). The beekeeping has become a significant production activity today in terms of its contribution to the sustainable environment and society with its increasing economic returns and product range (Çevrimli et al., 2020).

Environment, economy and energy, which are the three interrelated items, may not be disregarded when assessing any agricultural production system (Kuswardhani et al., 2013). Energy, which is one of these factors, is an important input for agricultural production. Therefore, an effective use of the energy is one of basic necessities of sustainable agriculture (Omidi-Arjenaki et al., 2016; Soni and Soe, 2016; Aksoy et al., 2018). In other words, the energy use efficiently will decrease problems related to environmental and improve the sustainable of agricultural (Omidi-Arjenaki et al., 2016). Energy is a basic item of any agricultural production system, whether its source is human, animal or mechanical (Hatirli et al., 2006). Energy may be grouped as direct energy (DE) and indirect energy (IDE) by source. DE is the derivation of energy directly from sources such as human and diesel. IDE is the energy came from sources such as pesticide and fertilizer that do not release directly but by transition period (Singh and Mittal, 1992; Kuswardhani et al., 2013; Aksoy et al., 2018). Also, energy also may be grouped as renewable energy (RE) and non-renewable energy (NRE). RE includes sources such as human and manure. NRE involves resources such as diesel and chemicals (Singh and Mittal, 1992; Ozkan et al., 2007; Kuswardhani et al., 2013).

According to the regional classification of nomenclature of territorial units for statistics-2 of Turkish Statistical Institute, TR22 region also called as South Marmara covers Balıkesir province Sub-region, which is located under TR2 West Marmara Region that is one of the 12 statistical regions of Turkey's nomenclature of territorial units for statistics-2. TR22 South Marmara Region (TR22 region), which is located between the Marmara and Aegean Regions in the west of Turkey, consists of Balıkesir and Çanakkale provinces. The known history of the region was started with Troy. Kaz Mountains, which are located between two provinces along the northern coast of the Gulf of Edremit and called Mount Ida in ancient time, have witnessed mythological events. TR22 region, which has Aegean Sea shoreline on the west extending from Ayvalık to Edremit district and Saros Gulf and Marmara Sea shoreline on the north extending from Bandırma Gulf to the Dardanelles, is surrounded by İzmir and Manisa provinces on the south, and Bursa and Kütahya provinces on the east. This region has a total surface area of 24,423 km^2 and constitutes 3.1% of total surface area of Turkey (SMDA, 2014). This region, which has strategic importance in terms of topography, climate and location, also has suitable flora for beekeeping activities. For this reason, beekeeping activities continue intensively in this region. According to 2020 data, TR22 region had about 3.1% of the total number of beehives of Turkey and about 4.2% of total honey production of Turkey was provided from this region, also. About 66.8% of the total number of beehives in this region constitutes Balıkesir province, and 33.2% of this total constitutes Çanakkale province. In addition, the ratio of Balıkesir province in the total honey production is

60.8% and the ratio of Çanakkale province is 39.2% (TURKSTAT, 2020). Hence, it is an important to define ways that may lead to energy (efforts) use efficient, create the positive effect on the environment, and ensure economic efficiency in this region where beekeeping potential is high.

In literature, there are many studies conducted about reveal the energy use (input-output) of product and its energy economic analyses. In these studies, it was stated to the contribution of each energy input to production, the utilization of energy in production, energy productivity, energy ratio (output-input) and the contribution different forms of energy to production (direct, renewable, etc.). Also, in these studies, it was discussed about the energy balance and the economic analysis of energy to define the energy use in production of products such as apple in Greece (Strapatsa et al., 2006); palm-kernel oil in Nigeria (Bamgboye and Jekayinfa, 2007); sugarcane, kiwifruit, peach, honey in Iran (Karimi et al., 2008; Mohammadi et al., 2010; Royan et al., 2012; Omidi-Arjenaki et al., 2016); wheat in New Zealand (Safa et al., 2011); vegetables in Indonesia (Kuswardhani et al., 2013); rice in Myanmar (Soni and Soe, 2016); rice in Japan (Masuda, 2018); honey in Romania (Moraru et al., 2019); wheat, barley and oat production in Iraq (Nassir et al., 2021); greenhouse tomato, sugar beet, cotton, barley, black seed oil, organic grape, wheat, honey and its products in Turkey (Hatirli et al., 2006; Erdal et al., 2007; Dagistan et al., 2009; Baran and Gokdogan, 2014; Gökdoğan et al., 2015; Baran et al., 2017; Demir, 2018; Aksoy et al., 2018). As can be seen from previous research, the majority of these studies are related to the evaluation of energy that is used in crop production, and the number of studies conducted by researchers about energy use in honey production are limited. To the best of author's knowledge, there has been only one study conducted in Turkey about this issue (Aksoy et al., 2018). However, the present study is different from the previous study conducted in Turkey in terms of scope, content, the study area and method used. In addition, it has not been also coming across any study that is conducted using calculations related to the energy balance and the energy economic analysis to define energy use (efficiency) for honey production in TR22 region, which has a favorable location for beekeeping. In this context, it is thought that the present study will fill a gap regarding this issue in the relevant literature. These specifics related to the present study make the study unique, and thus this study may be a contribution for both the Turkish and international literature. Furthermore, the results of the present study were compared with the findings of existing studies due to the limited number of studies conducted on this subject. Considering the lack of study in TR22 region in this context, the purpose of the present study was to define the energy balance and energy economic analysis of honey production in this region. The findings to be obtained from this study are expected to contribute the region economy as well as researchers and policymakers, and the further emphasizing of the importance of beekeeping activities.

1. MATERIALS AND METHODS

1.1. The Study Area and Sample Size

The primary material of the present study was composed of answers obtained from interviews with beekeepers who made honey production in Balıkesir and Çanakkale provinces of TR22 region (Figure 1). In choice of these provinces located this region, it was taken into consideration features such as being has a strategic importance of this region about beekeeping, being of intensive beekeeping activity and being of no study that is conducted in the region concerning this study topic.

Figure 1: Map of The Study Area

The survey was conducted from May to September 2020. The face-to-face interview technique was used in data gathering. In the determining the total number of beekeepers who made beekeeping in Balıkesir and in Çanakkale provinces 2020 records of Directorate of Provincial Agriculture and Forestry were used (TURKSTAT, 2020). According to these data, the total number of beekeepers of these two provinces were 3086. 51.2 % of these beekeepers were in Balıkesir province and 48.8% of them were in Çanakkale province. Therefore, the target population of study was the beekeepers' number in these two provinces. In the selection of beekeepers to be surveyed from the sample population, the hive number was taken into consideration. Considering the frequency distribution of the beekeepers' number, the number of hives were divided into three groups. The stratified random sampling method was used to define the number of hives included sample from the number of beekeepers. The each size sample was determined through Neyman method (Yamane, 1967). This method is as follows;

$$n=\frac{(\sum N_h S_h)^2}{N^2D^2+\sum N_h S_h^2} \quad , \quad D^2=\frac{d^2}{z^2} \qquad [1]$$

where, the number of beekeepers representing the population is n, N is the total beekeepers' number in provinces (3086), N_h is beekeepers' number in the h stratum, S_h is the standard deviation for the h stratum, S_h^2 is the variance for h stratum, the desired absolute precision ($\overline{X}*0.05$; $\overline{X}$=70.44) is d, the desired confidence level (*1.96* for *95%*) is z, the acceptable error limit in population mean is D. The number of the beekeepers that is separated into three strata were 1-50 hives, 51-100 hives and 101 hives and above. Thus, the number of beekeepers to be surveyed were determined as 207 (Table 1).

Table 1. Sampling Size of Study

The number of hives	Groups	The number of beekeepers	(%)
≤50	First	53	25.6
51-100	Second	98	47.3
≥101	Third	56	27.1
Total		207	100.0

The survey questions in the current study were prepared inspired from some previous studies conducted about energy use efficiently and energy balance in honey production (Omidi-Arjenaki et al., 2016; Aksoy et al., 2018; Moraru et al., 2019). In the first section of the survey questions, there was information regarding the demographic characteristics (age, education, etc.) of the beekeepers. In the second section, the beekeepers were asked some questions on these data in order to determine the average quantity per hive of inputs and output used in honey production (human labour, fuel, drug etc.). In the third section, the beekeepers were asked some questions (price, yield, etc.) regarding these data to calculate gross return and net return values.

1.2. Data Analysis

Data analysis was performed in five section. In the first section, descriptive statistics was used to define the beekeepers' demographic characteristics. In the second section, it was calculated energy effeciency of inputs and output for honey production. The inputs in honey production were human labour, fuel, electricity, drug and sugar. In addition, honey was output. The quantities of these inputs and the output were determined per hive based upon the data of survey. Also, units of inputs and output were transformed to energy. Some indicators that is used in the present study regarding the inputs and output energy equivalents were used in some previous studies in the same topic, also. These indicators are summarized in Table 2.

Table 2. Energy Equivalent Indicators of Inputs and Output in Honey Production

Input/output	Unit	Equivalent of energy (MJ unit^{-1})	Reference
Inputs			
Human labour	Man-h	1.96	Singh et al. (2002), Ozkan et al. (2007), Omidi-Arjenaki et al. (2016), Aksoy et al. (2018), Moraru et al. (2019)
Fuel	l	56.31	Yilmaz et al. (2005), Heidari and Omid (2011), Omidi-Arjenaki et al. (2016), Moraru et al. (2019)
Electricity	kW h	11.93	Esengun et al. (2007), Shahan et al. (2008), Omidi-Arjenaki et al. (2016), Aksoy et al. (2018), Moraru et al. (2019)
Drug	kg	13.64	Omidi-Arjenaki et al. (2016), Aksoy et al. (2018), Moraru et al. (2019)
Sugar	kg	15.40	Coley et al. (1998), Omidi-Arjenaki et al. (2016), Aksoy et al. (2018), Moraru et al. (2019)
Output			
Honey	kg	12.72	Southwick and Pimentel (1981), Omidi-Arjenaki et al. (2016), Aksoy et al. (2018), Moraru et al. (2019)

They used to define the energy balance and energy economic analysis for the production of honey. In the present study, the values regarding energy efficiency ratio, energy productivity and specific energy were found based upon the energy values of inputs and output (Erdal et al., 2007; Heidari and Omid, 2011; Kuswardhani et al., 2013; Omidi-Arjenaki et al., 2016; Aksoy et al., 2018; Moraru et al., 2019). These equations are as follows:

Energy use (efficiency) ratio = Energy output $(\mathrm{MJ\ hive^{-1}})$ / Energy input $(\mathrm{MJ\ hive^{-1}})$ [2]

Energy productivity $(\mathrm{kg\ MJ^{-1}})$ = Honey output $(\mathrm{kg\ hive^{-1}})$ / Energy input $(\mathrm{MJ\ hive^{-1}})$[3]

Net energy $(\mathrm{MJ\ hive^{-1}})$ = Energy output $(\mathrm{MJ\ hive^{-1}})$ - Energy input $(\mathrm{MJ\ hive^{-1}})$ [4]

Specific energy $(\mathrm{MJ\ kg^{-1}})$ = Energy input $(\mathrm{MJ\ hive^{-1}})$ / Honey output $(\mathrm{kg\ hive^{-1}})$ [5]

In the third section, it was calculated energy demand for honey production. In this study, human labour, electricity and fuel inputs was included in DE, whereas drug and sugar inputs was in IDE. Human labour was included in RE, whereas fuel, sugar, electricity and drug was in NRE. In the fourth section, the relationship between energy input and honey yield was determined by Cobb-Douglas (C-D) production function. This function summarizes the transition period of input items into a particular commodity. Thus, the C-D production function was used in this study because it is a suitable function in terms of the statistical significance and the expected sign of parameters (Hatirli et al., 2006; Mohammadi et al., 2010; Heidari and Omid, 2011; Omidi-Arjenaki et al., 2016). This function is expressed as:

$$Y=f(x)=\exp(u) \qquad [6]$$

The equation (6) in linear form can be shown as:

$$\mathrm{In}Y_i = \alpha_0 + \sum_{j=1}^{n} \alpha_j \mathrm{In}(X_{ij}) + e_i \qquad i=1,2,....m \qquad [7]$$

where, the yield in honey production of the i-th beekeeper is Y_i, the vector of inputs used for production is X_{ij}, the constant term is α_0, the coefficient of inputs is α_j, and the error term is e_i. Assuming the yield is a energy inputs function, the equation may be expressed as:

$$\text{Model I} = \text{In}Y_i = \alpha_0 + \alpha_1 \text{In}X_1 + \alpha_2 \text{In}X_2 + \alpha_3 \text{In}X_3 + \alpha_4 \text{In}X_4 + \alpha_5 \text{In}X_5 + e_i \qquad [8]$$

where, the i-th beekeeper's yield in honey production is Y_i and X_j (j=1,..5) shows energy of inputs that include human labour (X_1), fuel (X_2), electricity (X_3), drug (X_4) and sugar (X_5). Since there is no meaningful production without any input of energy, the constant term a_0 in Eq. (7) is taken zero. The effects of DE, IDE, RE and NRE on honey production was explained by the following equations:

$$\text{Model II} = \text{In}Y_i = \beta_1 \text{InDE} + \beta_2 \text{InIDE} \qquad [9]$$

$$\text{Model III} = \text{In}Y_i = \gamma_1 \text{InRE} + \gamma_2 \text{InNRE} \qquad [10]$$

where, the i-th beekeeper's yield in honey production is Y_i, the coefficient of independent variables are β_i and γ_i. In the last section, gross return, net return and energy benefit-cost ratio were calculated to determine costs and returns of energy input sources in the honey production. Considering the effect of energy prices on production costs of agricultural products, the budget analysis for single product was used to determine beekeepers' production costs in this study. Costs and returns of energy input sources in the production of honey were analyzed to define the energy content of inputs. Thus, energy benefit-cost ratio was calculated to reveal the energy efficiency of honey production (Soni and Soe, 2016; Aksoy et al., 2018). This ratio was calculated as follows:

Energy benefit-cost ratio= Gross return ($\$\ hive^{-1}$) / Total cost of inputs ($\$\ hive^{-1}$)[11]

Since net returns influence farmers' production decisions, the determining of production costs in enterprises are important to farmers' profitability (net return). (Soni and Soe, 2016; Aksoy et al., 2018). In this study, input items such as land leasing, transportation, interest ratio were not taken into consideration. Fuel was used for the vehicles owned by the beekeepers. Net return was calculated as follows:

Net return ($\$\ hive^{-1}$)= Gross return ($\$\ hive^{-1}$) / Cost of inputs ($\$\ hive^{-1}$) [12]

These data were analyzed with using SPSS statistical analysis programme (SPSS, 2008).

2. RESULTS AND DISCUSSION

2.1. Beekeepers' Demographic Characteristics

In the study area, the demographic characteristics of beekeepers was explained in Table 3. These results showed that the average age, education level, household size and beekeeping experience of beekeepers were 48.6 years, 10.4 years, 3.1 persons and 16.6 years, respectively. In addition, it was determined that beekeepers with the most beekeeping experience were in third group. In a study conducted in İzmir province that is located another region of Turkey to determine the socio-economic structures of beekeepers, it was found that the average age, education level, household size and beekeeping experience of beekeepers were 54.7 years, 5.7 years, 4 persons and 18.1 years, respectively (Onuç et al., 2019). A study in Mediterranean region of Turkey was stated that the average age, education level, household size and beekeeping experience of beekeepers were 48.8 years, 8.3 years, 3.7 persons and 18.2 years, respectively (Subaşı et al., 2019). According to these results, it can be said that the age, household size and beekeeping experience of beekeepers in the study area are less than those of beekeepers in İzmir province and Mediterranean region. Also, the education level of beekeepers in the present study is more than those of beekeepers in İzmir province and Mediterranean region.

Table 3. Beekeepers' Demographic Characteristics

Characteristics	Beekeepers			General average
	First group (M[1])	Second group (M)	Third group (M)	
Age (year)	46.6	49.3	51.6	48.6
Education level (year)	12.7	10.6	9.7	10.4
Household size (person)	3.2	3.4	3.5	3.1
Beekeeping experience (year)	15.4	17.2	19.7	16.6

[1]*Mean (M)*

2.2. Analysis of Energy Use in Honey Production

The results regarding energy balance of honey production, equivalents of energy, the percentage of energy inputs, the energy efficiency ratio, the productivity of energy and the specific energy are presented in Table 4. The average values per hive of inputs used for honey production were 11.52 hours for human labour, 3.63 l for fuel, 0.16 kWh for electricity, 0.02 gr for drug and 13.22 kg for sugar. Aksoy et al. (2018) found that the average values of the inputs used in honey production were 16.04 h hive^{-1} for human labor, 0.05 kWh hive^{-1} for electricity, 0.01 gr hive^{-1} for drug and 8.23 kg hive^{-1} for sugar. In a study conducted in Romania, the values regarding human labour, fuel, electricity, drug and sugar were reported as 18.21 hours hive, 5.4 l hive, 0.39 kWh hive, 40 g hive and

16.02 kg hive, respectively (Moraru et al., 2019). The value found for human labour in the current study is higher than those of Aksoy et al. (2018) and Moraru et al. (2019). Also, the quantity of sugar that is determined in this study is higher than that of Aksoy et al. (2018) and is less than that of Moraru et al. (2019). The average honey yield in the study area was 17.65 kg hive^{-1}, and it increased in parallel with the number of hives. This quantity for first, second and third groups was 15.62, 17.83 and 19.25 kg hive^{-1}, respectively. In a study conducted in Turkey, this amount per hive was determined as 11.85 kg (Aksoy et al., 2018). Aydın et al. (2020) found that the average honey yield was 16.24 kg hive^{-1}. The quantity of honey yield that is determined in the current study is higher than that of Aksoy et al. (2019) and is similar with that of Aydın et al. (2020). In the study area, the total energy input and output values for honey production were 451.51 and 221.96 MJ hive^{-1}, respectively. The highest energy output was obtained from third group (241.52 MJ hive^{-1}). ln general, it can be said that since the main goal of beekeepers is to maximize production in groups with more than 50 hives, they have requested larger quantities of inputs. On the other hand, most beekeepers who have less than 50 hives make beekeeping to satisfy their own honey consumption and to gain extra incomes. Hence, they use small quantities of inputs. Sugar had the largest share among all energy inputs for honey production (48.5%). This was followed by fuel (45.7%). This result is justified by the climatic conditions with low temperatures and prolonged winters, the apiaries from the researched mountain area requiring more honey reserves than those in the plain and hill areas (Moraru et al., 2019). Hence, proper and enough use of sugar input may help to decrease the sugar energy that is consumed in the production of honey. The inputs used for honey production and the ratio of these inputs within the total energy inputs are presented in Table 4. These results showed that sugar was the largest energy input in the essential inputs in the production of honey. Furthermore, it was determined to be the highest total energy demand in the production of honey was in third group (529.36 MJ $hive^{-1}$) and the lowest total energy requirement (317.96 MJ $hive^{-1}$) was in the first group in this study area. In a study conducted in Iran, it was reported that sugar has the largest share among energy inputs used for honey production, and this was followed by electricity (Omidi-Arjenaki et al., 2016). In a study conducted in Romania, it was stated that fuel (40.4%) has the largest share in energy consumption for honey production, and this was followed by sugar (32.7%) (Moraru et al., 2019). The result of the present study, which indicated that the most important of energy input for honey production was sugar, was supported with finding of Omidi-Arjenaki et al. (2016). However, this result is different from that of Moraru et al. (2019), which concluded that the largest share in energy consumption for honey production was fuel. Energy efficiency uses as an optimality measure for assessment the efficiency of systems used in agricultural production (Akbolat et al., 2006; Moraru, 2019).

In the current study, the average energy use ratio for honey production was determined as 0.49, and this value explains that 0.49 units of energy output is obtained per unit input energy used in honey production (Table 4). According to this result, it can be said that the energy is used inefficiently in honey production. This value for first, second and third groups was determined as 0.62, 0.47 and 0.46, respectively. Thus, the group that has the highest energy efficiency ratio was the first group. According to these results, it can be said that this value may increase by enhancing the honey yield and by reducing the energy input consumption. Omidi-Arjenaki et al. (2016) stated that energy efficiency for honey production in Iran was 0.54. Aksoy et al. (2018) reported that the energy efficiency coefficient was 0.96 for beekeeping production. Moraru et al. (2019) explained that energy use efficiency was 0.47. Energy efficiency ratio determined for honey in the study area is higher than the value explained by Moraru et al. (2019). However, this ratio is lower than values determined by Omidi-Arjenaki et al. (2016) and Aksoy et al. (2018). The productivity of energy is an indicator of the economic output amount that is obtained from each unit of energy consumed (Moraru et al. 2019). In the study area, the average energy productivity for honey was found as 0.04 and this value means that 0.04 kilograms of honey can be produced with one unit of energy (Table 4). Energy productivity of first, second and third groups was 0.05, 0.04, and 0.03 kg MJ^{-1}, respectively. These results revealed that energy productivity in first group was higher compared to second and third groups. Omidi-Arjenaki et al. (2016) found that energy productivity for honey in Iran was 0.04 kg MJ^{-1}. Aksoy et al. (2018) stated that the energy productivity coefficient was 0.08 kg MJ^{-1} for honey. Moraru et al. (2019) reported that the productivity of energy was 0.04 kg MJ^{-1} for honey. Energy productivity value determined for honey in the present study was supported by findings of Omidi-Arjenaki et al. (2016) and Moraru et al. (2019). However, this value is lower than the value explained by Aksoy et al. (2018). Net energy defines the difference between the energy value of honey production and the energy amount spent in order to obtain this production (Moraru et al. 2019). In the current study, the average net energy in the production of honey was found as -229.55 MJ hive^{-1} (Table 4). When calculating this value, other bee products (royal jelly and propolis etc.) were not taken into account as well as pollination. Hence, the net energy was negative, and the average energy efficiency was low, also. This result revealed that more energy was needed in honey production. Furthermore, the net energy value in the first group was high compared to the second group and the third group. According to this result, it is important to remark that it can also obtain other bee products in beekeeping as well as the fact that it ensures a significant amount of output by the pollination of beekeeping. The net energy value calculated in the present study is congruent with the results obtained in similar studies conducted by Omidi-Arjenaki et al. (2016) and Moraru et al. (2019). Specific energy ensures data on how much energy that is spent in the production of 1 kg of honey (Moraru et al., 2019). The average specific energy quantity was calculated as 25.58 MJ kg^{-1} in the study area, and this value explains that 25.58 MJ kg^{-1} of the energy amount that is need to produce one kilogram of honey (Table 4). Specific energy value in first, second and third groups was found as 20.35, 26.88, and 27.50 MJ kg^{-1}, respectively. These results revealed that first group had less energy consumption compared to second and third groups in honey production. Aksoy et al. (2018) explained that the coefficient of specific energy was 13.4 MJ kg^{-1} for honey. Moraru et al. (2019) reported that this value was 27 MJ kg^{-1} for honey. Specific energy value determined for honey in the present study is more than the value explained by Aksoy et al. (2018). However, this value is lower than the value stated by Moraru et al. (2019).

Table 4. Energy Use in Honey Production and Energy Input-Output Ratio

Input/output (unit)	Quantity per hive (average)			General average (per hive)			Total energy equivalent ($MJ\ hive^{-1}$)			General average ($MJ\ hive^{-1}$)	
	*I	II	III	Quantity	(%)		I	II	III	Quantity	(%)
Inputs											
[a]Human labour (h)	9.31	12.22	14.71	11.52	40.38		18.24	24.97	27.04	23.81	5.27
Fuel (l)	2.82	3.63	4.72	3.61	12.65		150.50	217.03	240.93	206.46	45.73
Electricity (kWh)	0.02	0.20	0.33	0.16	0.56		0.22	2.72	3.10	2.18	0.48
Drug (kg)	0.01	0.02	0.04	0.02	0.07		0.12	0.32	0.39	0.29	0.06
Sugar (kg)	9.71	15.22	16.85	13.22	46.34		148.88	234.20	257.90	218.77	48.45
Total input	21.87	31.29	36.65	28.53	100.00	Total energy input	317.96	479.24	529.36	451.51	100.00
Output											
[b]Honey yield ($kg\ hive^{-1}$)	15.62	17.83	19.25	17.65		Total energy output	197.15	224.21	241.52	221.96	
Energy input-output ratio											
Energy efficiency ratio							0.62	0.47	0.46	0.49	
Energy productivity ($kg\ MJ^{-1}$)							0.05	0.04	0.03	0.04	
Net energy ($MJ\ hive^{-1}$)							-120.81	-255.03	-287.84	-229.55	
Specific energy ($MJ\ kg^{-1}$)							20.35	26.88	27.50	25.58	

**Beekeepers: first group (I), second group (II), third group (III)*
[a]Human labour (man labour unit): the average value of daily work hour and annually work day of labor were 11.52 h and 300 day (max: 15 h, min: 3 h daily)
[b]The average honey yield ($kg\ hive^{-1}$): 17.65 kg

2.3. Energy on The Basis of Sources

Total energy inputs in different forms for honey production are explained in Table 5. According to these energy forms, the average values of DE and IDE found as 232.45 and 219.06 MJ hive^{-1} in this study, respectively.

Table 5. Total Energy Input for The Different Energy Forms in Honey Production

[a]Type of energy (MJ hive^{-1})	Beekeepers						General average	
	First group	(%)	Second group	(%)	Third group	(%)	Quantity	(%)
DE	168.96	53.14	244.72	51.06	217.07	41.01	232.45	51.48
IDE	149.00	46.86	234.53	48.94	258.29	48.79	219.06	48.52
RE	18.24	5.74	24.97	5.21	27.04	5.11	23.81	5.28
NRE	299.72	94.26	454.28	94.79	502.32	94.89	427.70	94.72
Total energy input	317.96	100.00	479.24	100.00	529.36	100.00	451.51	100.00

[a]*Type of energy: DE (Direct energy); IDE (Indirect energy); RE (Renewable energy); NRE (Non-renewable energy)*

In addition, 51.48% of total energy input was in DE form. These results revealed that more than 50% energy used for honey production was in this energy form. Moraru et al. (2019) found that the ratio of indirect energy form in honey production was higher than direct energy form. Thus, the result of the present study is not congruent with that of Moraru et al. (2019). In the present study, the average values of RE and NRE found as 23.81 and 427.70 MJ hive^{-1}, respectively. In addition, 94.72% of total energy input was in NRE form. The RE form was only 5.28% of total energy input. These results showed that the total energy inputs used in the production of honey were mostly based upon NRE energy form. Moraru et al. (2019) stated that the structure of the inputs was dominated by non-renewable inputs, which accounted for 94.9% of the total. Thus, the result of the current study is congruent with that of Moraru et al. (2019).

2.4. Energy Input and Honey Yield Relationship in Honey Production

In the current study, the relationship between energy input and energy output was determined by C-D production function (Model I). Accordingly, the honey yield was assumed to be a function of inputs that is include human labour, fuel, electricity, drug and sugar (eq. (7)). The autocorrelation was calculated by using Durbin-Watson (DW) test (Hatirli et al., 2006; Heidari and Omid, 2011; Kuswardhani et al., 2013). Thus, it was found that DW value of honey was in 1.68 for Eq. (7). These results revealed that there was no autocorrelation ($p<0.05$). The relationship between energy inputs and energy output is presented in Table 6.

Table 6. The Relationship Between Energy Inputs and Energy Output

Inputs	Honey yield(output)			
	α_i	Std. Error	t-ratio	Sig.(p-value)
(Constant)	1.51	0.17	9.09	0.000^*
Human labour (InX_1)	0.92	0.03	27.53	0.000^*
Fuel (InX_2)	0.06	0.02	3.58	0.000^*
Electricity (InX_3)	-0.23	0.14	-1.63	0.105^{ns}
Drug (InX_4)	-0.14	0.01	-1.05	0.294^{ns}
Sugar (InX_5)	0.13	0.04	3.70	0.000^*

**Significant at 5% level ($p<0.05$);* ^{ns}*Not significant; Durbin-Watson=1.681;* R-square value=0.939; $F_{(5;201)}=619.99$, $p=0.000^*$ ($p<0.000$)

The R-square coefficient of honey was 0.94 for this model, this result showed the variability in the energy inputs of this model. Also, it was found that the production (energy) inputs including human labour, fuel and sugar were statistically significant ($p<0.05$) for honey production, whereas the impact of electricity and drug on honey yield was statistically insignificant ($p>0.05$) with a negative sign. These results showed that the inputs of human labour, fuel and sugar had significant impact on improving honey yield. Accordingly, it can be said that the possible yield response of human labour is 0.92%, sugar 0.13% and fuel 0.06% with increasing of any energy input by 1%, while keeping other inputs constant in honey production. Omidi-Arjenaki et al. (2016) found that the inputs of fuel and sugar had significant impact on yield of honey. In a study conducted in Romania, it was found that labour, drug and sugar inputs had significant impact on honey yield (Moraru et al., 2019). Accordingly, the results of this study are congruent with the findings of Omidi-Arjenaki et al. (2016) and Moraru et al. (2019). The relationship between both DE and IDE and RE and NRE on honey yield was estimated by models II and III, respectively. These results are shown in Table 7. Accordingly, the coefficients of DE and RE forms with a positive sign and those of IDE and NRE forms with a negative sign were statistically significant ($p<0.05$). DW values were found as 2.07 for model II and 1.58 model III. These results indicated that there is no autocorrelation ($p<0.05$) in the estimated models. The impacts of DE and RE on honey yield were estimated as 1.48 and 1.01, and the impacts IDE and NRE were estimated as -0.80 and -0.26. These results showed that all the energy forms had significant impact on honey yield. Also, human labour and fuel (DE form) and sugar (IDE form) are the most influencing energy inputs in honey production, whereas human labour (RE form) and fuel and sugar (NRE form) are the most influencing energy inputs. Moraru et al. (2019) stated that the regression coefficients of DE, IDE, RE and NRE forms for honey production were statistically significant ($p<0.05$) with a positive sign. Accordingly, the results of this study are congruent with the findings of Moraru et al. (2019), which reported that the coefficients of DE and RE forms were statistically significant ($p<0.05$) with a positive sign. However, it are not congruent with results regarding other coefficients (IDE and NRE forms) that is found by Moraru et al. (2019).

Table 7. The Relationships Between DE, IDE, RE, NRE Forms and Energy Output

Inputs	Honey yield (output)			
	β_i	Std. Error	t-ratio	Sig.(p-value)
(Constant)	1.65	0.12	14.43	0.000*
Direct energy (InDE)	1.48	0.09	16.34	0.000*
Indirect energy (InIDE)	-0.80	0.08	-9.24	0.000*
DW	2.07			
R^2	0.84			
$F_{(2;204)}$	545.61			0.000*
Inputs	Honey yield (output)			
	γ_i	Std. Error	t-ratio	Sig.(p-value)
(Constant)	3.76	0.19	19.66	0.000*
Renewable energy (InRE)	1.01	0.07	11.13	0.000*
Non-renewable energy (InNRE)	-0.26	0.06	-3.96	0.000*
DW	1.58			
R^2	0.85			
$F_{(2;204)}$	584.34			0.000*

**Significant at 5% level (p<0.05)*

2.5. Energy Cost, Energy Benefit-Cost Ratio and Net Return in Honey Production

The average costs of energy inputs in honey production, energy benefit-cost ratio and net return are presented in Table 8. In the study area, the total energy cost of honey production was found as 47.06 € hive^{-1}. This value for first, second third group was 35.43, 48.47 and 57.72 € hive^{-1}. These results revealed that the total energy cost of honey production in third group is higher than values in first and second groups. In the study area, it was found that human labour (71.5%) energy source cost was the highest in honey production, and this was followed sugar (21.3%) and fuel (6.33%), respectively. Thus, beekeeping activity, which is mostly carried out as a family farm, can be considered as an advantage because it provides labour force. In the study area, the gross return of output value was 154.97 € $hive^{-1}$, net return value was 107.91 € $hive^{-1}$ and the energy benefit-cost ratio of honey production was 3.29. This ratio explains the gross return for per unit of input energy. The gross return per unit input energy was 0.34 € MJ^{-1} and net return was 0.24 TL. The gross return obtained for per unit output energy was 0.70 € MJ^{-1} and the net return was 0.49 € MJ^{-1}. Aksoy et al. (2018) stated that the energy benefit-cost ratio was 1.87 for honey production. Accordingly, the energy benefit-cost ratio that is found in the present study is higher than that of Aksoy et al. (2018).

Table 8. Cost of Input Energy, Energy Benefit-Cost Ratio and Net Return in Honey Production

Inputs	Energy use (MJ hive^{-1})			General average (MJ hive^{-1})		*Cost of input (€ hive^{-1})			General average (€ hive^{-1})	
	[a]I	II	III	Quantity	(%)	I	II	III	Quantity	(%)
Human labour (h)	18.24	24.97	27.04	23.81	5.27	26.03	34.17	41.13	33.64	71.48
Fuel (l)	150.50	217.03	240.93	206.46	45.73	2.41	3.11	4.04	2.98	6.33
Electricity (kWh)	0.22	2.72	3.10	2.18	0.48	0.27	0.34	0.45	0.33	0.70
Drug (kg)	0.12	0.32	0.39	0.29	0.06	0.02	0.05	0.09	0.05	0.11
Sugar (kg)	148.88	234.20	257.90	218.77	48.45	6.70	10.80	12.01	10.06	21.38
Total	317.96	479.24	529.36	451.51	100.00	35.43	48.47	57.72	47.06	100.00

Cost and return components	I	II	III	General average
Honey yield (kg hive^{1})	15.62	17.83	19.25	17.65
Sale price (€ kg^{-1})	8.77	8.80	8.86	8.78
Gross return of output (€ hive^{-1})	136.98	156.90	170.56	154.97
Total cost of input energy (€ hive^{-1})	35.43	48.47	57.72	47.06
Net return (€ hive^{-1})	101.55	108.43	112.84	107.91
Energy benefit-cost ratio	3.87	3.24	2.95	3.29
Cost per unit of input energy (€ MJ^{-1})	0.11	0.10	0.11	0.10
Gross return per unit of input energy (€ MJ^{-1})	0.43	0.33	0.32	0.34
Gross return per unit of output energy (€ MJ^{-1})	0.69	0.70	0.71	0.70
Net return per unit of input energy (€ MJ^{-1})	0.32	0.23	0.21	0.24
Net return per unit of output energy (€ MJ^{-1})	0.52	0.48	0.47	0.49

**1 Euro=7.51 TRY (Turkish lira) in April 2020 (average); [a]Beekeepers: first group (I), second group (II), third group (III)*

CONCLUSION

In the study area, the most important energy inputs used in honey production were sugar, fuel and human labour. Particularly, sugar was the largest energy consumer. Therefore, proper and enough use of sugar input may help to decrease the sugar energy that is consumed in the production of honey. The highest energy output was obtained from third group. This situation can be explained that the main goal of beekeepers in groups with 50 or more hives is that they want to maximize their production with larger input demand. Since the energy efficiency ratio calculated for honey production was low, it can be said that the energy is used inefficiently in honey production. Accordingly, this value may be increased by decrease the energy input consumption.Total energy inputs used in honey production were mostly depended on non-renewable form of energy. The inputs of human labour, fuel and sugar had significant impact on improving honey yield. Human labour energy source cost was the highest in honey production. Hence, beekeeping activity, which is mostly carried out as a family farm, can be considered as an advantage because it provides labour force. As a result, from the essence of the findings explained above, it can be concluded that it can be said that the energy is not used efficiently in honey production, and thus it is expected that the adequate and proper use of inputs in honey production affect positively energy efficiency.

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CHAPTER 7

AN EMPIRICAL ASSESSMENT OF AGRICULTURAL PRODUCTIVITY IN TURKEY BASED ON CLIMATE CHANGE PERSPECTIVE

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Introduction

Agricultural production is largely dependent on climatic conditions (Doğan & Kan, 2016: 448). Therefore, changes in the main climate-related parameters such as temperature and precipitation; lead to differentiation of the amount, productivity, and pattern of plant products (Bayraç & Doğan, 2016: 34). The predicted results of climate change for the future differ according to the geographical locations of the countries, and scenarios are tried to be estimated using various empirical methods..

Econometric studies on the impact of climate change on agriculture in Turkey generally focus on ARDL, Cointegration, and Causality tests within the framework of time series, as well as staying at the national level. However, considering that Turkey does not have only one climate type, and the climate follows various temperature and precipitation trends according to regions and even provinces, more micro-level studies are needed. In this study, which was carried out to eliminate this deficiency in the literature, panel data analysis was applied by considering the data of 81 provinces of Turkey. Although meteorological data have been available at the provincial level since the 1970s; The fact that agricultural productivity data starts from 2004 is the main limitation of the econometric model. The general findings in the empirical literature reveal that an increase in precipitation increases agricultural productivity, while an increase in temperature decreases it (Başoğlu & Tatar, 2013; Bayraç & Doğan, 2016; Doğan & Kan, 2019). However, there are studies showing that increases in temperature up to a certain level can have a positive effect on agricultural productivity (Cline, 2007; Jaehyuk Lee vd. 2012; Dudu & Cakmak, 2018). On the other hand, it is expected that the climate scenarios that negatively affect agriculture in Turkey will take place gradually towards the end of 2035, 2050 and 21st century (Dudu & Cakmak, 2018: 282). In this direction, the findings obtained from the empirical model of this study gain importance in terms of showing that the temperatures are still developing in favor of agricultural productivity. In the first part of the study, the possible effects of climate change on agricultural activities are discussed within the framework of theoretical approaches. Then, the situation in Turkey is examined with descriptive statistics. In the second part, where the methodology is given, the regression model created on the data of Turkey's 81 provinces is estimated by the static panel data analysis method. In the third part, the results are interpreted in light of the findings obtained from econometric modeling, and policy recommendations are presented

Linkages between Climate Change and Agriculture

The increase in greenhouse gases causes the rays coming from the sun to hold in the atmosphere, causing temperatures to rise (TEMA, 2021: 4). The increase in temperatures has an effect on the growth and harvest dates of the grains. It is predicted that an increase of 1-3°C in mid and high latitudes will have positive effects on agricultural productivity in the short term (Cline, 2007: 20). Global warming prolongs the growing season of crops and prevents plant deaths from cold weather by providing warm winters (TEMA, 2015: 11). However, increased carbon dioxide (CO_2) emission is beneficial especially on rice, wheat, soybean and leguminous crops classified as C3 type plants (Cline, 2007: 24). Due to the carbon fertilization effect, the stomatal pores of the plants are reduced and the amount of water lost by the term is reduced, thus preventing water loss and gaining in productivity (Chauhan vd., 2014: 77).

The literature underlines that the short-term positive effects of the increase in temperatures due to climate change are not in question for tropical regions. Contrary to the benefits likely to be experienced in the middle and northern latitudes, increases in drought are expected to cause crop loss in parallel with the decrease in precipitation in the lower latitudes. (Kaya & Atsan, 2008: 159). Crop productivity in tropical and subtropical regions is predicted to decline even with 1-2°C increments (IPCC, 2007: 48). This situation also shows that the expected food security threat due to climate change will have more serious consequences in countries in lower latitudes.

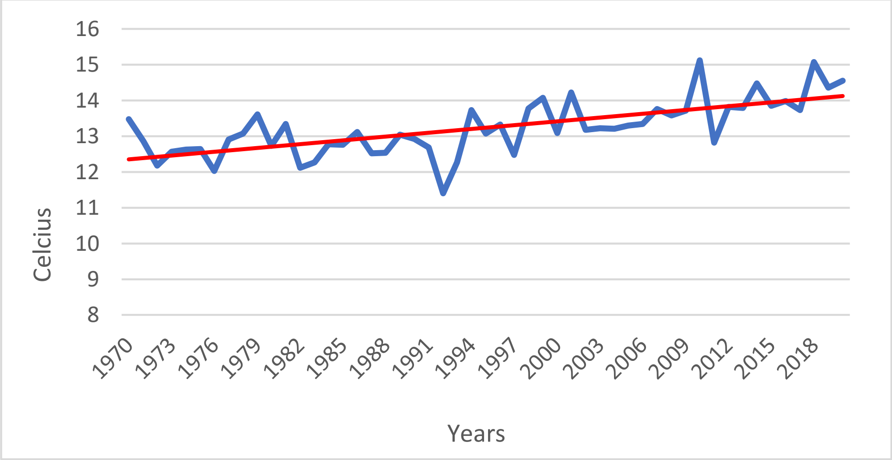
Despite its short-term possible positive effects, temperature increases above 3°C are threatening food production at the global level (IPCC, 2007: 48). In the long run, the effects of climate change are expected to be negative (Akalın, 2014: 354). Frequent droughts and precipitation increase the losses in agricultural production (Dellal vd., 2019). Increasing rainfall and droughts disrupt the ideal moisture structure of the soil, reducing productivity (Zaimoğlu, 2019: 21).

Climate Change in Turkey

The emission of greenhouse gases, which continues to increase rapidly due to human activities, brings global warming with it. (IPCC, 2018: 4). The global average temperature was found to be approximately 1.5°C higher than in the pre-industrial period (WMO, 2020: 6). Towards the end of this century, global temperatures are expected to increase in the range of about 1-3.5°C (Türkeş vd. 2000). Climate scenarios showing that the amount of precipitation will decrease from 1.57 mm to 1.3 mm per day (Akyüz & Atis, 2016: 122). Changes in the climate also directly affect agricultural production negatively by triggering events such as floods and droughts (FAO, 2021: 188). Optimistic scenarios predict that 1-3°C increase in mid and high latitudes may lead to modest productivity increase in agriculture in the short term. (TEMA, 2021:12). Increasing temperature and CO_2 shortens the growth phase of the plant, reduces water loss and provides an early harvest opportunity (Bayraç & Doğan, 2016: 36). Increasing temperature and CO_2 shortens the growth phase of the plant, reduces water loss and provides an early harvest opportunity (Kaya & Atsan, 2008). Warming also causes the plant pattern to change. Studies have shown that summer crops grown in temperate latitudes such as maize; It shows that it can easily grow in high latitudes towards 2050 (Özer & Özer, 2003: 289).

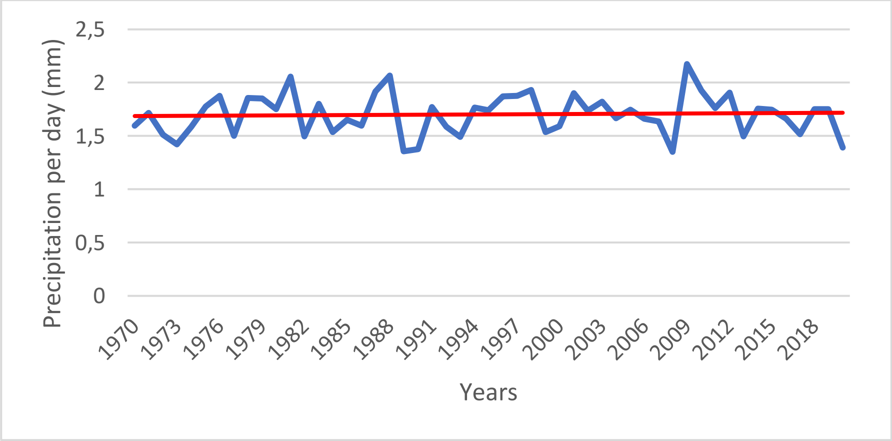
Turkey is a country that hosts a wide variety of climate types due to its location between temperate and sub-tropical zones. (Çaltı & Somuncu, 2019). Having regions with semi-arid climate makes Turkey one of the main countries that are expected to be affected by climate change. In Graph 1, which was created by adapting the data obtained from the Turkish Meteorology General Directorate, the change in temperature between 1970-2020; Graph 2 shows the change in daily precipitation.

Graph 1: Temperature in Turkey, °C (Annual Average)



Resource: Turkish State Meteorological Service

Grafik 2: Precipitation in Turkey, mm (per day)

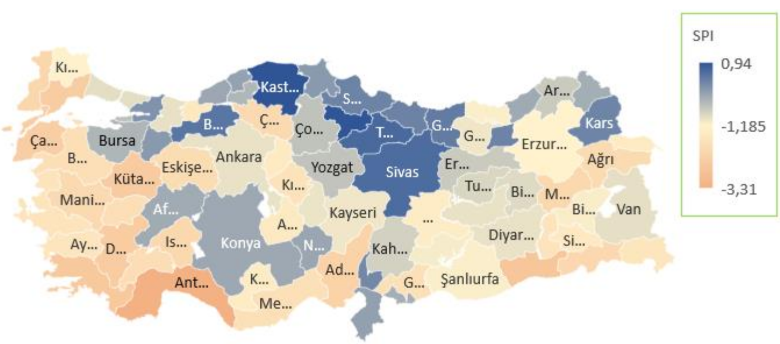


Resource: Turkish State Meteorological Service

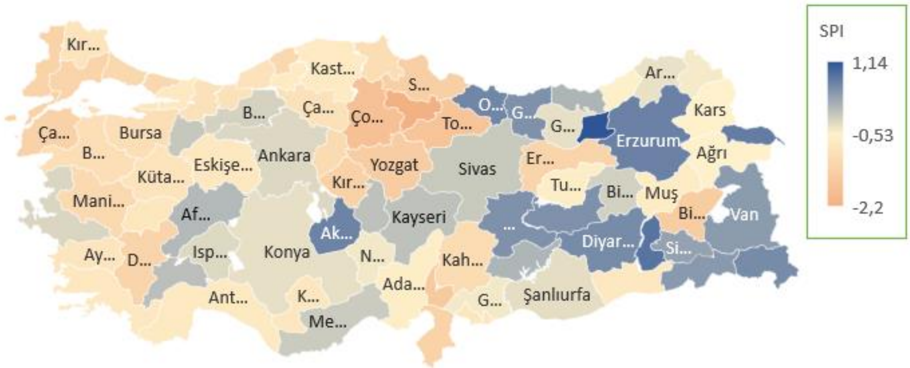
According to Graph 1, average annual temperatures in Turkey are in an increasing trend. While the average annual temperature was about 12.8°C between 1970-99, it is understood to be about 13.8°C in the period 2000-20. Towards the end of the 21st century, this indicator is expected to reach approximately 16.14°C (Cline, 2007: 41). In studies on climate simulation for Turkey, towards the end of this century, about 5-7°C for the summer season in the west of the country; In the east, approximately 3.5°C increases are expected for the winter seasons (Sen et al., 2012: 181).

According to Graph 2, although the daily precipitation in mm in Turkey shows irregularity in annual frequency, it has not shown a decreasing trend yet. The annual average daily precipitation for the period 1970-2020 is 1.70 mm. It is predicted that this amount will decrease to 1.30 mm per day in the period of 2070-99 (Cline, 2007: 41). While precipitation is expected to decrease in the Aegean and Mediterranean regions in the future, it is expected to increase along the Black Sea coasts. (Bayram & Öztürk, 2021: 447).

Şekil 1: Standardized Precipitation Index (SPI), Turkey, 2008



Şekil 2: Standardized Precipitation Index (SPI), Turkey, 2020



Resource: Turkish State Meteorological Service

The Standard Precipitation Index (SPI) is one of the drought indices widely used in the literature. When the index value is between -0.99 and 0.99, it is considered as "normal", when it goes from 0.99 to 2 and above, it is "humid", when it goes from -0.99 to -2 and below, it is described as "arid". (WMO, 2012: 4). SPI has been calculated by the Turkish Meteorology General Directorate at the provincial level since 2008. When Figures 1 and 2 are examined, given the irregularity of precipitation over the years in Turkey; It is estimated that the Aegean, Mediterranean and Southeastern Anatolia regions will have a higher tendency to drought with global warming. The index values in these regions are close to the values where the index is more arid rather than humid in both years.

Agricultural productivity is expected to increase in the Mediterranean and Aegean regions and decrease in Southeastern Anatolia due to a moderate temperature increase until 2035. (Dudu & Cakmak, 2018: 285). The main deterioration in agricultural production scenarios is experienced towards the end of the 21st century. By the 2100s, it is predicted that the Aegean, Mediterranean and Southeastern Anatolia regions will experience temperature increases of up to 5°C in summer and continuous droughts due to the increase in heat waves. (TGDF, 2017: 6). It is expected that relatively hot summers will occur in the northeast of the Black Sea and Anatolia, and precipitation in the Black Sea will increase. (Sen vd., 2012: 181). Following these changes in the climate, there will be a rapid decrease in pasture areas and an increase in the cultivation of summer plants such as corn, sunflower and clover suitable for hot climates. (TGDF, 2017: 7). By 2080, wheat, barley, rye, oats and legumes are among the priority product groups whose productivity is expected to decrease. (Dellal vd., 2019: 42).

Literature

While the international literature to empirically measure the impact of climate change on agriculture uses various econometric modeling methods, studies on Turkey have generally focused on estimation methods such as ARDL approach and Causality tests over time series data sets. Chandio et al. (2013), Bayraç and Doğan (2016), Dumrul and Kılıçarslan (2017) reached similar findings by using ARDL analysis in their studies involving different periods. Accordingly, the increase in CO2 and temperature is inversely related to grain yield; The increase in precipitation, on the other hand, proceeds linearly. Başoğlu and Tatar (2013) obtained similar results using the Ordinary Least Squares (OLS) estimator. Doğan and Kan (2019), another study that reached similar results on precipitation and temperature variables, estimated with panel data analysis by forming a sample with 10 provinces representing mildly arid regions, 8 provinces representing moderately arid regions and 9 provinces representing severe drought.

There are studies showing that not only precipitation but also the increase in temperature can increase agricultural productivity. Jaehyuk Lee et al. (2012) tested the climate effects on agricultural production in selected Asian countries for the 1998-2007 period using the Fixed Effects estimator with panel data analysis method. According to the results, increases in temperature and precipitation in summer increase agricultural production; Increasing temperatures in autumn reduce production. Dudu and Cakmak (2018) aimed to quantitatively reveal the effects of climate on agriculture and economy by using the Product-Water Demand Model. In addition to the fact that the losses to be experienced due to climate change in the 2010-2035 period, which is the first of the analysis results consisting of three periodic periods, are quite modest; They state that productivity increases can be seen in agriculture in the Mediterranean and Aegean regions depending on the increases in temperature and precipitation. They claimed that the main negative effects of climate change will be seen in the 2035-2060 and 2060-2099 periods. They point out that the decrease in agricultural supply due to the decrease in agricultural productivity in the second and third periods will suppress prices upwards.

Methodology

Data and model

This study, which empirically tests the effect of changes in climatic conditions on agricultural productivity in Turkey, considers agricultural activities in all provinces of Turkey, unlike other studies in the literature. Panel data analysis method for this study allows to observe 81 provinces of Turkey during the years 2004-2019. The regression model is as follows:

$$\text{lnvadd}_{it} = \beta_0 + \beta_1.\text{temp}_{it} + \beta_2.\text{lnprec}_{it} + \beta_3.\text{lnland}_{it} + u_{it}$$

The fact that the agricultural value added has been calculated at the provincial level in Turkey since 2004 is a limitation of this study. While the logarithm of agricultural value added, which is the dependent variable of the model, is expressed with "lnvadd"; "temp" represents the annual average temperature in °C, "lnprec" represents the logarithm of the annual total precipitation in millimeters, and "lnland" represents the logarithm of the annual harvested agricultural area in hectares.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
vadd	1.296	1548762	1660904	79220	1.68E+07
temp	1.296	138.711	3.344627	3.42	21.53
prec	1.296	646.0009	325.3888	179.6	3097.1
land	1.296	201706.8	204710.5	221	1471375
lnvadd	1.296	13.81751	0.9461223	11.27998	16.63911
lnprec	1.296	6.372873	0.4285801	5.190732	8.038221
lnland	1.296	11.69795	1.237545	5.398163	14.20171

It was preferred to take the logarithms of the variables of agricultural value-added, precipitation, and harvested area in order to make the difference between the minimum and maximum values very high and to eliminate the scale differences. When the descriptive statistics are examined, it is seen that the agricultural productivity is the lowest added value of 79,200 TL and when the data set is examined, it was realized in Tunceli in 2004. The province with the highest agricultural productivity was Konya in 2019 with an added value of 16,837,408 TL. While the province with the lowest average annual temperature was Ardahan in 2007; The highest temperatures were experienced in Mersin in 2018. The province with the highest annual total precipitation per millimeter was Rize in 2016; The province with the lowest is Şanlıurfa in 2017. The lowest harvested agricultural area was Rize in 2019 with an area of 221 hectares; The highest harvested area is recorded as Konya in 2019. These data roughly give information about the climatic conditions and agricultural production of Turkey. Average annual precipitation falls mostly in the Northern part of the country; It is understood that the precipitations were relatively low and the region is Southeastern Anatolia. The region with the highest temperatures is the Mediterranean; the lowest region is Eastern Anatolia. While agricultural productivity is relatively higher in Western Anatolia, it is low in the north of the country.

Results

Table 2: Unit-root Test

	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value	Lags
lnvadd	2.810	-2.000	-2.070	-2.180	-9.435	0.000	lags(0)
temp	3.120	-2.000	-2.070	-2.180	-12.147	0.000	lags(0)
lnprec	-3.225	-2.000	-2.070	-2.180	-13.066	0.000	lags(0)
lnland	2.243	-2.000	-2.070	-2.180	-4.479	0.000	lags(0)

According to the results of the Pesaran's CADF Test, which allows unit root control, all the variables used in the model were found to be stationary at the level. Variables in the model do not have a unit root.

Table 3: Hausman & Robust Hausman Test

Hausman Test	
chi2(3) =	347.7
Prob>chi2 =	0.0000
Cluster-Robust Hausman Test	
chi2(3) =	82.47
Prob>chi2 =	0.0000

Hausman is a test for choosing an estimator so that the model can be predicted correctly. However, if the model deviates from at least one basic assumption such as heteroskedasticity, autocorrelation or cross-sectional independence, the Hausman test results alone cannot be trusted and re-estimated with the robust-cluster Hausman test. Here, both test results overlap with each other and show that the model should be estimated with the Fixed Effects estimator.

Table 4: Diagnostic Tests

<table>
<tr><td colspan="2"></td><td colspan="2">Jarque-Bera Normality Test</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td>Chi(2)</td><td>0.3286</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Fixed Effects</td><td>Heteroskedasticity</td><td colspan="2">Serial Correlation</td><td colspan="2">Cross-Sectional Independence</td></tr>
<tr><td>Modified Wald</td><td>Durbin-Watson</td><td>Baltagi-Wu LBI</td><td>Pesaran CD</td><td>Friedman</td></tr>
<tr><td>chi2 (12) = 182.96
Prob>chi2 = 0.0000</td><td>0.74108803</td><td>1.0235023</td><td>Pr = 0.0000</td><td>Pr = 0.0000</td></tr>
</table>

Table 4 presents the diagnostic test results, or in other words, the test results of whether the model fulfills the basic assumptions. The Jacque-Berra test result shows that the model is normally distributed. However, there are deviations in the model such as heteroskedasticity, serial correlation, and correlation between units, which impair the effectiveness of the model. In order to eliminate these problems, the model was re-estimated with the Feaseble Generalized Least Squares (FGLS) estimator.

Table 5: Feaseble Generalized Least Squares (FGLS) Estimator Results

Variables	(1) **lnvadd**	(2) **lnvadd**	(3) **lnvadd**
temp	0.02946*** (0.008)	0.02412*** (0.007)	0.01882** (0.007)
lnprec		-0.01503 (0.017)	0.03170* (0.017)
lnland			0.33071*** (0.017)
Constant	12.51463*** (0.138)	12.78605*** (0.144)	9.00004*** (0.256)
Observations	1,296	1,296	1,296
Number of state	81	81	81

In Table 5, where the results of three alternative models are shown, average annual temperatures have a significant and positive effect on each of them. Annual total precipitation negatively affects agricultural production in the second model, but this relationship is not significant. According to the results of regression number three, which constitutes the main model of this study, each °C increase in annual average temperatures increases agricultural productivity by approximately 0.0002%. It is supported by the empirical and theoretical literature that an increase in temperatures can positively affect agricultural production in the short run (Dudu & Cakmak, 2018; Jaehyuk Lee et al., 2012; Cline, 2007; Adams et al., 1998). However, it is noteworthy that the effect of temperature on efficiency is quite limited. Every 1% mm increase in the annual total precipitation increases productivity by 0.03%. It is understood that precipitation in Turkey is still in favor of efficiency (Chandio et al., 2020; Dumrul & Kılıçarslan, 2017; Bayraç & Doğan, 2016; Başoğlu & Teratar, 2013). Each 1% hectare increase in the area where the agricultural product is harvested increases the agricultural productivity by 0.3%.

Conclusion

The climate change process is not progressing similarly in every region of Turkey as it is in the whole world. While frequent and severe droughts are expected to occur in the west, south and southeast of Turkey in the future, it is expected that the temperate climate will shift to the north and precipitation will increase in the north and northeast. In this context, it is underlined that studies on identifying disasters and agricultural losses that may occur not only at the national level but also at the regional level should be increased. In this study, climatic conditions and agricultural activities in all provinces of Turkey were taken into account thanks to the panel data analysis method. Our results show that changing temperature and precipitation conditions have not yet adversely affected agricultural productivity. However, it is known that losses due to increasing droughts, decreasing soil quality and increasing precipitation in the long term are inevitable.

There is a need to reduce greenhouse gas emissions that cause climate change. Serious measures should be taken for the protection and reproduction of forested lands, which have the characteristics of capturing and storing carbon emissions. On the other hand, in order to ensure low carbon emissions, it is necessary to reduce the use of fossil fuels and increase the infrastructure expenditures allocated to renewable energy sources such as wind and solar energy. Although the steps to prevent carbon emissions are costly, they will prevent the emergence of larger problems such as hunger and poverty due to possible food security in the future.

In the scenarios predicted for Turkey, productivity declines are expected towards the end of this century, especially in cereals and legumes. In this context, it is recommended to develop drought-resistant seed species by focusing on R&D technologies in agriculture. On the other hand, Turkey is in the group of countries that are expected to experience high water stress due to increases in drought. In order to prevent damage to crops that are largely dependent on water resources, the closed agricultural irrigation network should be expanded.

It is estimated that there will be interregional shifts in agricultural product patterns due to climate change. At this point, determinations should be made on which geographies the crops will be more productive in new climatic conditions, and farmers should be given training on the subject. All actors in the food production chain should be informed within the framework of harmonization policies.

Considering that the rural sector will be the most affected by the losses in agricultural activities, it should not be ignored that climate change will lead to rural poverty. For this reason, the measures taken for climate change should not be carried out independently of the policies against poverty.

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CHAPTER 8

THE IMPORTANCE OF BARLEY IN FORAGE PRODUCTION

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Introduction

Population growth, drought and pollution in catchment basins, increasing demand for clean water (Anonymous, 2020), depletion of lands that can be used in agricultural production, use of agricultural lands for non-agricultural purposes, decrease in the roughage acreages has resulted in an increase in the cost of roughages and animal products prices. Sustainable animal production is possible by providing quality roughage at a lower cost. Approximately 70% of the costs in animal production are composed of feed expenses (Alçiçek et al., 2010; Kuşvuran et al., 2011; Turan et al., 2015; Bıçakçı and Açıkbaş, 2018). The current roughage production in Turkey can only meet a part of the needs of farms and economically important animals.

In developed countries, plant and animal production is carried out in an integrated manner. Therefore, animal producers produce their own roughage in rotation. In underdeveloped countries, animal production is carried out not as modern and large enterprises, instead as traditional and small enterprises. In addition, when plant and animal production are not carried out together, roughage is needed to be purchased which increase costs of enterprises.

Forage crops agriculture is not developed enough to meet the feed requirement in Turkey. In recent years, incentives have been made to meet the need for roughage in Turkey. Although these incentives increase feed production, these are not sufficient to meet the feed requirement. Today, there is a shortage of roughage in Turkey. In recent years, as a result of the subsidies made by the state, the rate of forage field crops cultivation has increased from 3-4% to 8-9%, but this level is still not sufficient. Therefore, new sources or new soilutions are needed to close roughage gap of Turkey.

Cool season cereals are used as an alternative source to existing leguminous and cereal forage crops. The use of cereals as an alternative feed will bring a different and effective perspective to the feed problem. Grains, which are widely used as roughage and have great importance in animal nutrition, are widely grown in Turkey as well as all over the world. Good adaptability, improved mechanization, tolerance of species such as triticale and rye to abiotic stress conditions (drought, temperature, etc.), tolerance of barley to salty areas, rapid development after germination and high biomass production to be grazed in a short time are advantageous features that popularizes their use. Winter cereals such as wheat, barley, oats, rye and triticale are mostly grown for their grains and used as human food, but are also cut as grass and used as roughage. As in the world, the use of grains for animal consumption is common in Turkey. Grass obtained from cereals can be fed to animals as fresh, dry or in silage form (Tan and Serin, 1997). In arid regions, cereals can be grown for hay production.

Although all cereals can be used as roughage, barley is the most important cereal preferred as forage. 68% of the barley produced in the world is used for feed purposes, 21% for industrial purposes and 5% as food (Açıkgöz, 2013). The ability of barley to grow in salty soils is its important feature. Use of this plant is mostly common in semi-arid regions. It has been reported that barley has better forage quality compared to oats due to its high digestibility when harvested during flowering period (Cherney and Martin, 1982). Brink and Martin (1986) found higher digestibility in barley compared to oats, but this did not translate into higher digestible dry matter yields.

Lyons et al. (1999) reported that the nutritional content of barley did not show a significant change according to the stubble height left. It is recommended to cut cereals in the milk production phase for grass. For quality grass production, cereals should be mown at early stages. Cereals are very tasty and nutritious for animals in their vegetative period. It has been stated that cereals in the vegetative period are very suitable especially for young animals and dairy cattle (Açıkgöz, 2001). Depending on the field productivity and care, from 5 t to 15 t/ha dry grass yield is obtainable (Açıkgöz, 2013). The most important problem in using cereals as a source of forage is the degree of digestibility of the grass due to very high cellulose and lignin content. However, among the cereals, barley has the highest digestibility. In previous studies, it has been determined that barley and triticale are more easily digestible than wheat and oats, and this characteristic positively affects the daily milk and meat yield of farm animals (Cherney and Marten, 1982; Droushiotis, 1989).

Digestion rate is related to crude protein ratio, especially during grain filling. Plant composition and digestion are also related to the plant development age. As maturation increases, the ratio of cellulose and lignin increases and digestibility decreases. For this reason, it is important to cut the cereals for forage production at the right time. It is recommended to include cereals while preparing quality roughage rations (Anonymous 2021).

In recent years, the use of cereals as green grass forage crop has begun to increase. However, the amount of straw obtained from cool climate cereals in Turkey is 40 million tons according to the 40% harvest index, where about 10 million tons of this is used as a filler in animal nutrition (Sancak, 2011). Cereals have an important potential in terms of yield, quality and mineral content in animal feeding as a roughage (Yolcu, 2008).

ADF, NDF and Crude Protein of Roughage

The criteria determining the digestibility of cellulose in roughage are the ratios of NDF (Neutral Detergent Fiber/Neutral Detergent Cellulose) and ADF (Acid Detergent Fiber/Acid Detergent Cellulose). The soluble substances in NDF are mostly composed of starch, sugar, crude protein and fat and 98% are digestible. However, as the amount of NDF increases, the soluble substances in the NDF decrease. Based on these considerations, the total NDF content of a forage is the value that reveals the overall quality and digestibility of the forage. A roughage with 40% NDF value is more digestible than roughage with 60% NDF value.

Neutral Detergent Fiber (NDF): It expresses the amount of hemicellulose cellulose, lignin, cutin and insoluble protein in the plant cell wall structure. The NDF ratio is often used as an indicator of the plant's development or maturity. The lower the NDF ratio in the feed, the higher the animal's feed intake (Van Soest et al., 1991).

Acid Detergent Fiber (ADF): It expresses the amount of cellulose, lignin and insoluble protein in the plant cell wall structure. As the rate of ADF increases in a feed, the rate of digestion decreases (Van Soest et al., 1991).

Raw Protein Ratio: The expression “raw” is used because of the presence of real protein and nitrogenous compounds that are not in protein structure in feeds. Crude protein is found by multiplying the total nitrogen in a feed with a coefficient of 6.25 (Emerick, 1993).

Acid detergent insoluble fiber (ADF), Neutral detergent insoluble fiber (NDF) are the compounds that make up the plant cell wall, and since the high of these parameters reduces the digestion of the feed, they are desired to be low. It was stated that the ideal quality values of ADF and NDF should be 30% and 40%, respectively (Emerick, 1993).

One of the most important indicators of the nutritional value of the roughage fed to the animals is the crude protein content which should be at least 6% in the feed rations of the animals (Şenel, 1986). It should be noted that these protein ratios are very closely related to the development periods of the plant and the nutritional values decrease with the progress of the period (Tan and Serin, 1997; Keleş, 2014). In studies related to crude protein ratio of different cereal species and varieties; Kaplan et al. (2011) reported 6.93-10.67% for triticale, Göçmen and Özaslan Parlak (2017) reported 7.34% for triticale, 7.29% for barley, and Keleş (2014) reported 13.8% for triticale. On the other hand, the crude protein rate in the study of Yolcu (2008) was 12.50-14.23% for barley and 11.98% for wheat. Young tissues in plants have higher protoplasm and lower cell wall materials, and accordingly, their digestion rates vary. As the protein content of the grass increases and the NDF ratio decreases, the digestibility rate also increases (Jung and Allen, 1995).

Çaçan and Kökten (2019) carried out a study for two years in 2015-16 and 2016-17 growing seasons to determine the yield and nutrition values of grass obtained from cereals where 3 bread wheat, 3 durum wheat, 3 triticale, 2 row barley and 2 six row barley varieties were used as material. The barley cultivars used in the experiment were Erginel-90, Kral-97, Şahin-91 and Sur-93. The experiment was set up in a randomized block design with three replications. Protein ratio varied between 10.4 (Sur-93) and 13.4 (Şahinbey-91), NDF value was 56.1 (Erginel-90), 59.5 (Sur-93) ADF value was 29.7 (Şahin-91) 32.95 (Sur-93).

In the study conducted in Kelkit, the ADF ratio of barley varied between 33.70-34.91% and the NDF ratio between 55.85% and 61.36% (Yolcu, 2008). In the study conducted in Çanakkale, Göçmen and Özaslan Parlak, (2017) reported that the ADF value of barley was 43.22% and the NDF value was 62.78%.

Kerimbek and Mülayim (2003) obtained a plant height of 63.24 cm vetch and 74.75 cm for barley from sole sowings in Konya region., 1204 kg/da of vetch and 2308 kg/da of barley green grass were obtained. 24.28% vetch and 25.77 barley hay rations were obtained, while hay yields were 291.60 kg/da for vetch and 586.70 kg/da for barley. They found the protein rate as 15.62% for vetch and 8.38% for barley.

In their study conducted for examining the forage yield and quality of forage peas with barley and oat mixtures, Carr et al. (1998) reported that green grass and hay yields increased with the increase in the grain ratios in the mixtures, whereas crude protein ratios increased with the increase in the pea ratio in the mixtures.

The most obvious indicator of the nutritional values of roughage is the crude protein ratios. Crude protein should be at least 6% in rations (Senel, 1986). According to this principle, the crude protein ratio of small grain cereals is sufficient. However, it should be considered together with development periods of crops. Because the most effective factor on the feeding value is the developmental period at cut. Since the maturation of cereals is fast, crude protein ratio decreases rapidly with development (Tan, 1995; Damage and Tükel, 1993 and Bishnoi et al., 1978). This decline decreases from 30-35% level to 8-10% level until from the leafy stage to maturity (Kilcher and Troelsen, 1973 and Smith, 1976). Crude protein ratio in wheat was 9.94% at booting period, decreased to 4.56% in the dough stage (Twidwell et al., 1987).

In their study comparing some cereal types planted at different times in terms of forage yield and quality, Karabulut and Çaçan (2018), was found that the protein ratio in two-row barley varied between 13.1-12.5% and 11.7%-14.5% in six-row barley; NDF ratio varies between 56.3-58.5% in two-row barley and 60.3-62.2% in six-row barley; the ratio of ADF varied between 31.0-33.6% in two-row barley and 32.9-34.3% in six-row barley depending on the sowing time.

The rates of ADF in barley were 47.3% and 45.3% in studies of Sehu et al. (1996 and 1998), respectively. The rates of NDF in barley were found it to be 58.7% and 85.89% in studies of Sehu et al. (1996 and 1998), respectively.

Kutlu 2008 reported that ADF, which expresses the amount of cellulose, lignin and insoluble protein in the plant cell wall structure, is a good indicator that also gives an idea about feed digestibility and energy intake of the animal. It has been reported that the digestibility and energy value of feeds with high ADF content are low. A high NDF ratio is a desirable parameter in terms of animal nutrition.

The 2-year average of protein values of the cultivars included in the experiment varied between 12.73-15.65%. While the highest protein content was obtained from Akhisar-98 variety with 15.65%, this variety was followed by Epona (15.61%), Martı (15.27%) and Avcı-2002 (15.26%). ADF values of cultivars vary between 5.52% and 8.65%. The highest ADF value was obtained from the Kıral-97 variety with 8.65%, while the lowest ADF value was obtained from the Meriç variety with 5.52%, followed by Lord (5.82%), Avcı-2002 (5.90%) and Epona (5.99%). Neutral detergent-insoluble fiber (NDF) value has a direct effect on animal nutrition (feed), and as this value in feed content decreases, animal nutrition increases (Van Soest et al., 1991, Mut et al., 2017). Therefore, low NDF ratio is a desirable parameter in terms of animal nutrition.

Han et al. (2003) found in their study that the ADF values of the grains of three barley lines varied between 7.52% and 7.91%. In other studies, the amount of ADF was between 3.6% and 4.1 (Brand et al., 2003); 2.5% to 3.1 (Rakha et al., 2013); 7.03% to 9.07 (Alkan and Kandemir, 2015). It has been reported that it varies between 2.5% and 2.9% (Alijosius et al., 2016), 1.43% and 3.47 (Erbaş Köse and Mut, 2019).

Coskun et al. (2014) reported that, in their study with barley, wheat, rye, oats and triticale, they found 42% decreases in crude protein content of the grass, depending on the growth progress. Jung and Allen (1995) reported that as the protein content of the grass increases and the NDF ratio decreases, the digestibility rate also increases. Sirat (2014), in his study conducted in Samsun and Amasya, reported that the protein ratio of barley varies between 11.3% and 12.7% in Samsun, and between 12 and 13.4% in Amasya, depending on climatic conditions and variety. Ross et al. (2004), according to the results of their research for 4 years in Alberta, Canada; found the crude protein, ADF and NDF ratios in barley to be 14%, 34.5% and 58.0%, respectively. Karahan and Sabancı (2010), in Southeastern Anatolia Region (Diyarbakır, Ceylanpınar), tested 9 barley varieties (Akhisar-98, Bilgi-91, Bornova-92, Kaya, Sur-93, Süleymanbey-98, Şahin-91, Şerifehanım- 98 and Vamıkhoca-98) and found that the grain yield decreased by 40% in Ceylanpınar, but the protein rate in the grain increased, and the climatic characteristics of the barley growth region had a very important effect on the protein rate.

Forage production in Turkey can be increased with the following practices

Different technological processes should be used to increase the nutritional value of forages and to protect them for a long time. The arable land of Turkey is reducing every year. Therefore, studies on new feed sources should be conducted.

Studies should be carried out in arid agricultural areas on the feed resources.

In order to meet the roughage requirement, production of forage crops should be increased. To expand the cultivation areas of forage crops in our country, breeding studies and development of new varieties adapted to different regional conditions is requirement. For this purpose, wild populations or existing varieties can be used as parent material in breeding programs.

Although potentially there are many types and varieties of roughage that can be crppoed in Turkey, roughage diversity is very limited. In order to reach the global norms and contribute to the economy, alternative feed sources should be searched to increase the roughage production in the country.

Cereal forages are widely adapted (wheat, triticale, barley, oat and rye) for versatile use as meadow, chopped green grass, silage and hay. In Turkey, the use of grains as an alternative source to a certain extent may be a partial solution to the feed problem. In order to increase animal production, feed sources that are cheap, east to access and available in desired amounts are required for the producers. Cereals can make an important contribution to this increase.

Conclusion

Cereals are one of the most cultivated plant groups in the world. Since ancient times, they have been the main food source of human on all continents. They are still cultivated and used in a wide geography. In addition to these important features, it can be cut as grass and used as roughage. As in the world, the usage of cereals as animal feed has started to become widespread in Turkey. For this purpose, the plants are used alone as a support plant with vetch or as a cover crop with clover. Grass obtained from cereals in these ways is fed to animals as fresh, dry or silage. Cereals especially barley, due to their features such as fast and strong growth, high yield capacity and short vegetation period. They are important in terms of producing cheap and low cost roughage. In many different parts of the world, animal growers face various problems in producing required feed during winter months when meadows and pastures are not productive. For the elimination of these problems, cool season cereals can be grown in winter as an alternative. Considering the previous studies, it can be said that all cereal products have an important potential in ruminant nutrition. For this reason, it is beneficial to use these resources to eliminate the quality roughage deficit. In addition, the opportunity to benefit from grain yields should be increased by selecting suitable mixtures (grain-legume) in the existing forage crops cultivation areas with using scientific cultivation techniques. Animal production based on cheap roughage will help to provide the quality animal products needed by public at an affordable price.

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