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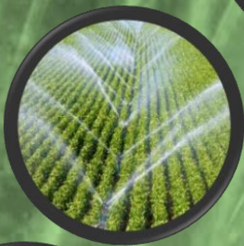


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Research Article
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DETERMINATION OF THE POTENTIAL BIODIESEL VOLUME OF SOYBEAN USED AS THE FIRST-GENERATION BIODIESEL FEEDSTOCK IN THE UNITED STATES

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Abstract: In the United States (U.S), biodiesel is produced from vegetable oils, animal fats, recycled restaurant oil, and waste oil. Soybean oil has been by far the most widely used feedstock for U.S biodiesel production, accounting for more than half of the nation's biodiesel feedstock. This study aimed to determine the potential biodiesel volume of the soybean plant, which is the most cultivated product as a first-generation biodiesel feedstock in the U.S. The potential biodiesel volume of the soybean plant, which was grown on an area of 30352150 hectares in the U.S in 2019, was calculated as 1020749343 liters. Biofuels can be produced domestically, which could lead to lower fossil fuel imports. As in the rest of the world, if the production and use of biofuels in the U.S reduce imported fossil fuel consumption, it may become less vulnerable to its adverse effects in terms of energy supply security. Reducing demand for petroleum could also reduce its price, generating economic benefits for U.S consumers. Knowing the potential of oilseed plants used as feedstocks in first-generation biodiesel production will accelerate efforts to identify products that should be used in second-generation biodiesel production and expand their cultivation. Studies should be planned to remove the threat on the food sector by replacing the first-generation biodiesel production feedstocks, which are mainly used as oil feedstocks in the food sector, with the second-generation inedible oil feedstocks that are not used in the food sector.

Keywords: Biodiesel volume, Soybean plant, Oil seed, Feedstock

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1. Introduction

Different biofuel feedstock sources and production processes have many other impacts, including greenhouse gas emissions, life cycle, air pollutants, land and water use. Therefore, policies on biofuel production and use are directly affected by this situation. Both biofuel technologies and other alternative power train technologies will determine the volume of biofuels and what types of transportation fuels they can integrated them. For the efficient integration of biofuels into the transport fuels market, must coordinate production, transport, distribution, and automobile infrastructure (Mishra and Goswami, 2018; Elgharbawy et al., 2021).

First-generation biofuels are made from sugar crops (sugarcane, sugar beet), starch crops (corn, sorghum), oilseed crops (soybean, canola), and animal fats. Oils and animal fats can be processed into biodiesel. Second-generation biofuels, or cellulosic biofuels, are made from cellulose, available from non-food crops and waste biomass such as corn stover, straw, wood, and wood byproducts. Third-generation biofuels use algae as a feedstock. Commercial cellulosic biofuel production began in the U.S in 2013, while algae biofuels are not yet produced commercially (Huang et al., 2013).

Several laws and regulations at the federal, state, and local levels have been essential drivers of biofuel production and use in the U.S. The Environmental Protection Agency (EPA) has implemented mandates for how much renewable fuel must be blended with fossil fuels Renewable Fuel Standard (RFS) mandate was passed in 2005, and in 2007, an expanded mandate, known as RFS2, was passed to include cellulosic biofuels. The Renewable Fuels Standard (RFS2) requires an increase in biofuel use, which should nearly triple from 13.6 billion gallons per year to 36 billion gallons per year by 2022. According to RFS2, it is recommended to meet 90% of this amount from cellulosic biofuels and advanced biomass-based diesel.

In Figure 1, the energy resources of the United States, ranging from the 1700s to the present, are shown. As of 2020, 79% of the country's energy needs are met from fossil fuels and 21% from renewable energy sources and biofuels (EIA, 2021). In Figure 2, the usage rates of each of the renewable energy sources in U.S in 2020 and the sectors in which these sources are used are given (EIA, 2021).

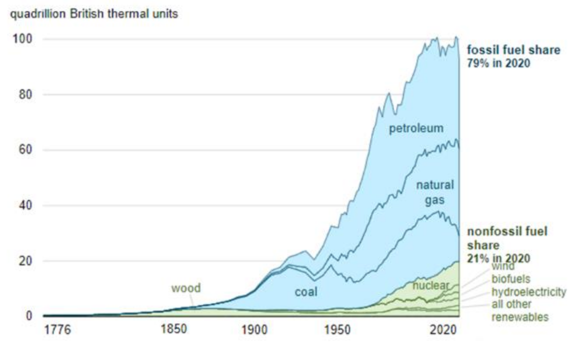

Figure 1. Energy consumption in the United States (1776-2020).

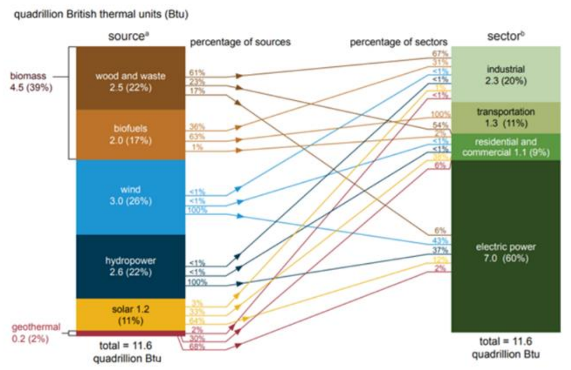

Figure 2. U.S. Renewable Energy consumption by source and sector.

According to the U.S Energy Information Administration (EIA) Annual Energy Report in 2021, renewable energy consumption in the United States increased for the fifth consecutive year, reaching 11.6 quadrillion British thermal units (Btu), accounting for 12% of U.S energy consumption. While renewable energy production increased, fossil fuel and nuclear energy consumption decreased.

Biodiesel is an alkyl ester produced from renewable raw materials such as vegetable oils, animal fat, and algae. Biodiesel is one of the biofuels used in large quantities and widely in the U.S, Brazil, Indonesia, Malaysia, France, Germany and other European countries. High cetane number, clean combustion, good lubrication, low aromatic content, low sulfur content, and low pour point are the main features of biodiesel that make it superior to petrodiesel (Agarwal, 2007; Singh and Singh, 2010; Moser, 2016; Živković and Veljković, 2018). In addition, the distinguishing features of biodiesel are that it reduces particulate matter (PM), carbon monoxide (CO), and hydrocarbon (HC) emissions in exhaust gas. Therefore, biodiesel is an environmentally friendly fuel (Mishra and Goswami, 2018; Rouhany and Montgomery, 2019; Elgharbawy et al., 2021).

A century ago, the soybean was practically unknown outside Asia. Today, hundreds of millions of people worldwide eat meat, eggs, and dairy products from animals fed on soy, and traces of soybean are found in countless processed foods. In the last 50 years, the production of soybean has grown tenfold, from 27 to 269 million tons. The total soybean area now covers over 1 million square kilometers – the total combined region of France, Germany, Belgium, and the Netherlands. This expansion shows no sign of stopping: the United Nations Food and Agriculture Organization (FAO) suggests soybean production will almost double by 2050. Markets in Africa and the Middle East are also expected to expand rapidly in the next decade.

Soybeans are grown throughout much of North America, South America, and Asia. In other words, soybeans are a global food crop. According to National Agriculture Statistics Service (NASS, 2021)'s statements The United States produces roughly 32% of all soybeans globally, followed by Brazil at 28%. Despite its relatively high price as a food crop, soybean is still a significant feedstock for biofuel production.

The use of soybean oil for biodiesel was greatly influenced by promotion from U.S. soybean farmers through the United Soybean Board (USB) and the subsequent creation of the National Biodiesel Board (NBB). Soybeans account for 80% or more of the edible fats and oils consumed in the U.S. Soybean oil is mainly used for food consumption and, more recently, for other uses such as biodiesel. Combined, soybeans and their derivatives are the most traded agricultural commodity, accounting for over 10% of the total value of global agricultural trade. Global trade in soybeans and soybean products has risen rapidly since the early 1990s and, in 2008/2009, surpassed international trade of wheat and total coarse grains (Pradhan et al., 2009; Huang et al., 2013). According to USDA Agricultural Projections, by 2025, world trade is projected to increase in soybeans by 22%, soybean meal by 20%, and soybean oil by 30%.

Soybean was the most produced oilseed crop in the world in the 2018-2019 sowing season, followed by rapeseed, sunflower, peanut, and cotton, respectively. The total amount of oilseed production in the world in the 2018-2019 season was 599.7 million tons. Three hundred fifty million tons of this belongs to the soybean plant. In the same production season, the country with the largest soybean production in the world was U.S (120.5 million tons), followed by Brazil (119.7 million tons), Argentina (55.3 million tons), China (15.9 million tons), and India (10.9 million tons). In this period, soybean production in Europe was 2.6 million tons. Figure 3 shows the increase in soybean production in the world and in the United States over the years (FAOSTAT, 2021).

While soybean production in the world was 20-30 million tons annually in the 1960s, the amount of production increased over the years and reached 350 million tons in the 2018-2019 production season. In this season, the production amount in U.S, the largest soybean producer globally, was 124 million tons (USDA, 2018; USDA, 2020). The diversity of biodiesel feedstock has led to a broader geographical distribution of biodiesel refineries. Figure 4 shows the locations of ethanol and biodiesel refineries currently produced in the U.S.

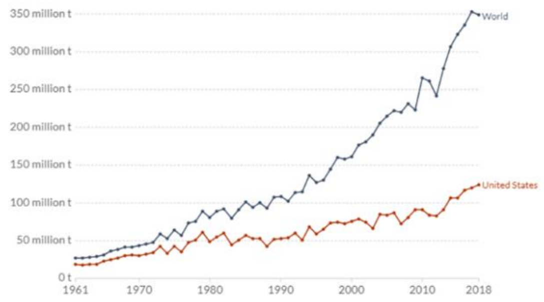

Figure 3. Soybean production amounts in the world and U.S.

Biodiesel refineries are, for similar reasons, located in close proximity to feedstock supplies, although the feedstocks used to produce biodiesel vary a great deal more than for ethanol. Biodiesel feedstocks include soybean oil, other vegetable oils, and animal fats, the latter typically byproducts from food production or preparation. The variability of biodiesel feedstocks has led to a wider geographic distribution of biodiesel refineries. Figure 4 shows the locations of ethanol and biodiesel refineries currently producing in the United States.

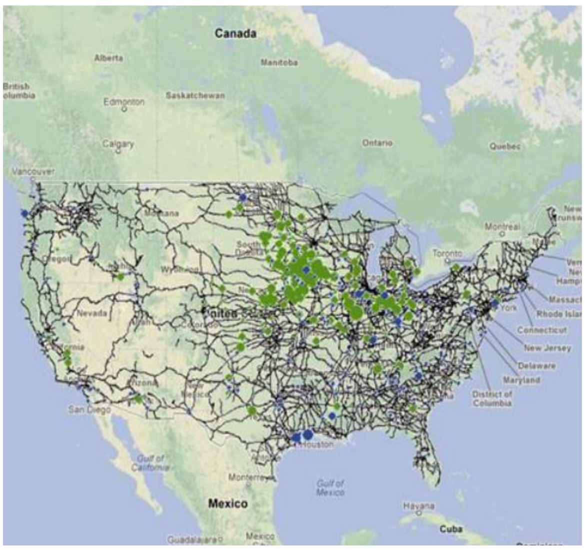

Figure 4. Locations of refineries producing biodiesel and ethanol in the U.S.

The blue dots on the map show the locations of the biodiesel refineries, and the green ones show the locations of the ethanol refineries. Biodiesel production in the U.S emerged in the early 2000s due to the need for energy independence and growing concern about reduced greenhouse gas emissions. As shown in Figure 4, production facilities are spread over a wide geographical area of the country. The top four states in biodiesel production capacity are Texas, Iowa, Illinois, and Missouri, respectively. These four states have more than half of the U.S production capacity. Texas has a large oil refining capacity that fits well with the need to blend biodiesel with petroleum-based diesel fuel. Three of the top four states are located in the center of the country's Soybean Belt and have significant sources of soybean oil for biodiesel production.

The feedstock is an essential element in the biodiesel industry, as feedstock costs make up the bulk of biodiesel. Today, the feedstock equates to at least 80% of the expenses associated with biodiesel production. Approximately 95% of the biodiesel production in the world is made from cooking oils, and it is seen as an unnecessary situation when the world has a food problem. Each country should prefer feedstocks with high oil yields, which can be grown at a low cost by their geographical and climatic conditions in biodiesel production (Mishra and Goswami, 2018).

The EIA, 2021 report provides monthly data on the number of different feedstocks used for biodiesel production. Soybean oil was the dominant feedstock accounting for more than half of the total feedstock used in the biodiesel industry in 2010 and 2020. Other feedstocks include canola oil, tallow, poultry oils, yellow grease, white grease, and a minimal amount of corn oil. Yellow grease is a term for recycled cooking oils. The main reasons soybean oil is preferred as an oil feedstock in biodiesel production are its abundant source and suitable fatty acid profile. More than 90 million acres of soybeans were planted in the United States in 2017, and in 2018, the acres planted for soybeans exceeded corn acreage for the first time since 1983. Soybean acreage fell to 76.1 million acres in 2019 (USDA, 2020). The United States is the world's largest producer of soybeans. Exports of oilseeds, especially soybeans, are an essential source of demand for U.S producers and make an enormous net contribution to the U.S agricultural trade balance.

This study aimed to determine the potential biodiesel volume of the soybean plant, which is produced in the highest amount as the first-generation feedstock in biodiesel production in the U.S.

2. Material and Methods

In this study, soybean was investigated as the oilseed plant with the largest cultivation area in America and globally. Data were taken from the public, online sources. Food and Agriculture Organization (FAO) of the United Nations Statistics Division (FAOSTAT) and U.S. Department of Agriculture (USDA) were used as the source. All biodiesel volumes is based on processed oils and fats export statistics from FAOSTAT 2021.

2.1. First-Generation Biodiesel Feedstock of the U.S

Table 1 shows the sources used in renewable energy production in the U.S between 2015 and 2018 and their usage amounts. In 2018, energy consumption from biofuels in the country totaled 2.283 quadrillion Btu.

Table 1. U.S Renewables consumption and sources

Energy Sources (Quadrillion Btu)	2015	2016	2017	2018
Hydroelectric power	2.321	2.472	2.767	2.667
Geotermal	0.212	0.210	0.210	0.209
Solar	0.427	0.570	0.777	0.917
Wind	1.777	2.096	2.343	2.486
Wood biomass	2.312	2.224	2.278	2.360
Biofuels	2.153	2.287	2.304	2.283
Waste biomass	0.518	0.503	0.495	0.487
TOTAL	9.720	10.362	11.173	11.409

Figure 5 shows the proportions of plants used as first-generation biodiesel feedstock based on the amount of oil extracted in North and South America. While soybean oil production is 84%, especially in South America, this rate is 19% in North America. In North America, the major biodiesel feedstock is rapeseed with a proportion of 50% (Chong et al., 2021).

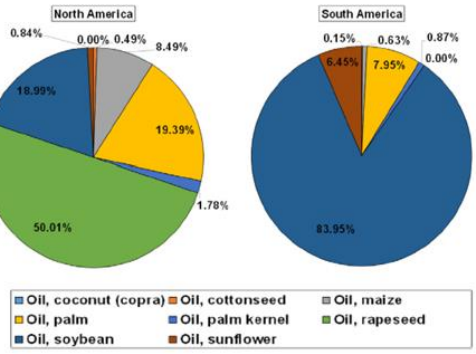

Figure 5. Proportion of potential first-generation feedstock at continental level for North and South America.

2.2. Potential Biodiesel Volume Calculations

The potential biodiesel volume (PBV) for soybean feedstock was calculated using the equation 1 and 2.

$$PBV=LV\times CR \quad (1)$$

$$LV=\frac{EQ\times 1000}{OD} \quad (2)$$

where LV is the lipid volume of soybean seed biodiesel feedstocks in U.S, and CR (0.98) is the volumetric conversion ratio from oil to biodiesel. EQ is the export quantity of feedstock, and OD is the oil density (Johnston and Holloway, 2007; Chong et al., 2021). A minimum threshold value of 10000 tons has been set for the export quantity. Any export quantity of vegetable oils lower than the threshold is considered inadequate for potential biodiesel production. The threshold value is based on a generic biodiesel plant with a capacity of 10 million liters per annum. The export quantity which reaches the threshold value is used in the calculation of the potential biodiesel production (USDA, 2017; Chong et al., 2021).

3. Results

Soybean, rapeseed, and palm take the first three places as the first-generation feedstocks sources in biodiesel production in the U.S. Table 2 shows the oil and fuel properties of soybean plant.

Table 2. Vegetable oil and fuel properties of soybean plant

	Soybean	References
Oil content (wt%)	17.5	Agarwal (2007), Altın et al. (2001), Karmakar et al. (2010)
Oil density (kg/L)	0.914	Sinha et al. (2008), Altın et al. (2001), Karmakar et al. (2010)
Energy content (Mj/kg)	39.62	Altın et al. (2001), Karmakar et al. (2010)
Biodiesel density (kg/L)	0.885	Chong et al. (2021), Viola et al. (2011)
Cetane number	51	Giakoumis (2013), Chong et al. (2021)
Kinematic viscosity (mm^2/s)	4	Chong et al. (2021), Viola et al. (2011)
Oxygen content (wt%)	11.50	Chong et al. (2021), Giakoumis (2013)

In 2019, soybean harvest was carried out with a yield of 31890 kg/ha in 30352150 hectares in U.S. At the end of this harvest, obtained 96 793 180 tons of products. Table 3 shows the change in the export quantity amount of soybean oil in the U.S between 2015 and 2019. The lowest soybean oil export quantity these years was in 2019 (FAOSTAT, 2021).

Table 3. Export quantity of soybean oil in U.S

Years	Export Quantity (tons)
2015	958146
2016	1004075
2017	1069627
2018	1105423
2019	952005

Table 4 shows the statistical and computational values of the parameters used to calculate the potential biodiesel volume of the soybean feedstock that the U.S operates in the first place in biodiesel production. Equations 1 and 2 were used in the calculations.

4. Conclusion

There are four main factors limiting biodiesel production, in general, all over the world. These factors are water stress, food stress, feedstock quantity, and crude oil price.

Table 4. Statistical and computational values of soybean feedstock for potential biodiesel volume

Feedstock	PQ (tons)	EQ (tons) (2019)	OD (kg/L)	LV	PBV (L)
Soybean	96793180	952005	0.914	1041580963	1020749343

PQ= production quantity, EQ= export quantity, OD= oil density, LV= lipid volume, PBV= potential biodiesel volume

In this study, the potential biodiesel volume of the U.S, which is the country that produces the most soybean crops in the world, was determined. While the total soybean harvest amount in the world was 350 million tons in the 2018-2019 sowing season, 124 million tons of this amount belongs to the U.S. With the calculations made, the potential biodiesel volume of the soybean plant in the U.S was found to be 1 020 749 343 liters. Soybean can three categories (direct human food, animal feed, and industrial processes) be used. According to the data of the University of Oxford's Food Climate Research Network (FCRN), the industrial usage rate of soybean in the world is 4%. The share of use only for biodiesel production at this rate is 2.8%. The remainder are used as lubricants and in other industrial processes. In this respect, since the amount of soybean used for energy production is limited, there is no threat to the food sector. The primary factor limiting the potential biodiesel production in the U.S will be feedstock quantity. It can say feedstock quantity and crude oil price will be the factors that restrict biodiesel production globally, and biodiesel sustainability will be primarily interrupted by water stress.

Author Contributions

All task made by single author and the author reviewed and approved the manuscript.

Conflict of Interest

The author declared that there is no conflict of interest.

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Research Article
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USE OF MULTIVARIATE STABILITY STATISTICS TO IDENTIFY SUPERIOR TEF (*Eragrostis tef [Zucc.] Trotter*) GENOTYPES IN NORTHEAST ETHIOPIA

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Abstract: Tef (*Eragrostis Tef* [Zucc.] Trotter) is a tiny-seeded cereal with huge importance in Ethiopia. Creation of variability by hybridization and the subsequent selection of Recombinant Inbred Lines (RILs) is very important towards variety development. In order to identify superior Tef genotypes, evaluation of RILs was performed on eight environments using three times replicated randomized complete block design. The result revealed that genotypes (G), environments (E) and genotype-environment interaction (G×E) significantly (P < 0.01) influenced grain yield of Tef. Considering the yield of genotypes on individual locations, the highest grain yield (4.27 t/ha) was recorded by the genotype RIL273. The AMMI analysis showed that environment was the major contributor of the variation in grain yield; it also revealed that the best fit model was AMMI2 as the G×E was partitioned into two significant (P < 0.01) Interaction Principal Component Axes (IPCAs). The two IPCAs explained 67.56% of the G×E variance. The GGE biplot identified genotype RIL273 as the most desirable (high-yielding and stable) genotype. RIL273 is as early maturing, significantly taller and had higher yield (biomass and grain) than the checks. The genotype was released for the Northeastern part of Ethiopia and named as Lakech. It has very white seed, more preferred by consumers and have premium price at the market. Being adapted to the semi-arid areas, having higher yield and very white seed color, this variety will contribute to food security of the area.

Keywords: *Eragrostis tef*, Genotypes, Environments, Genotype-environment interaction, Multivariate stability

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1. Introduction

Tef (*Eragrostis tef* [Zucc.] Trotter), a tiny-seeded cereal with huge importance, has originated and diversified in Ethiopia (Vavilov, 1951). Although the crop is not as such known in the outside world, relatively large cultivable land is allotted for its production in Ethiopia. In 2018 main cropping season, 6.7 million growers cultivated 3 million ha of land and produced 5.4 million tons of Tef with a yield of 1.76 t/ha (CSA, 2019). Tef is not that much attacked by diseases and insect pests than the rest of cereal crops grown in Ethiopia (Ebba, 1969), does not need chemicals for controlling storage pest, and can easily be stored under any local storage conditions (Ketema, 1993). Because of its suitability to be grown on moisture deficit and waterlogged areas where other crops cannot successfully grow, Tef has a complementary role in Ethiopian agriculture (Ketema, 1993).

Tef has high mineral content than wheat, barley, or sorghum (Mengesha et al., 1965). The fact that it is gluten-free makes the crop preferable for celiac disease patients (Spaenij-Dekking et al., 2005). Farmers in the Northeastern part of Ethiopia grow very early-maturing local varieties during short rainy season (Belg; from February to April) and late-maturing varieties during long rainy season (Meher; July to October), and cultivation of Tef under irrigation is not uncommon production system in the area. Tef can be intercropped with a number of oil crops (Bayu et al., 2007; Molla and Muhie, 2011), cereals (Worku, 2004; Molla and Muhie, 2011) and pulses like faba bean (Agegnehu et al., 2006). Although, Tef has the capacity to yield 4.6 t/ha when lodging is mechanically controlled by supporting the plants by mesh or nets (Teklu and Tefera, 2005), the yield attained so far in the Northeast Ethiopia is way below its yield potential. It is, therefore, necessary to continually identify high-yielding Tef varieties than the existing ones.

The small size of Tef floret, its autogamous nature (Ketema, 1997) and an hour window of flower opening time at down, 6:45 and 7:45 a.m. (Berehe, 1976), made Tef hybridization cumbersome. Moreover, the fact that the crop is endemic to Ethiopia, made the variety development process to depend on local breeders, local germplasm and naturally existing variability. Regardless of the difficulties, some works, both on intra- and inter-specific hybridization, have been successful. With this regard, an effective crossing was done between varieties *Dukem* (DZ-01-974) and *Magna* (DZ-01-196) by Debre Zeit Agricultural Research Center to combine the very white color of *Magna* and the high yield of *Dukem* into one elite variety. Consequently, intraspecific Recombinant Inbred Lines (RILs) have been developed and multi-stage multi-location evaluation of the lines have been conducted. The objective of the research was to evaluate and identify high-yielding Tef genotypes which are preferred by farmers and adapted to the semi-arid areas of Northeast Ethiopia by employing multivariate stability statistics.

2. Materials and Methods

The experiment was conducted in Northeastern part of Ethiopia at four sites of Sirinka Agricultural Research Center: Sirinka, Kobo, Jari and Chefa in 2006 and 2007. The general descriptions of the locations are depicted in Table 1.

Table 1. The geographic, edaphic and climatic descriptions of the study areas

Location	Altitude (m)	Soil type	Rainfall (mm)	Temperature		Global position	
				Min (˚C)	Max (˚C)	Latitude	Longitude
Kobo	1450	*Eutric fluvisol*	637	15.8	29.1	12⁰8’21’’	39⁰18’21’’
Sirinka	1850	*Eutric vertisol*	945	13.6	27.3	11ₒ45’ 00’’	39ₒ36’36”
Jari	1680	*Vertisol*	NA	NA	NA	11⁰21′	39⁰38’
Chefa	1600	*Vertisol*	850	11.6	30.4	10⁰57’	39⁰47’

NA= not available

Fourteen RILs of Tef developed from a cross of *Dukem* (DZ-01-974) and *Magna* (DZ-01-196) were evaluated together with a farmers’ variety and an improved variety *Genete* (DZ-01-146). A randomized complete block design (RCBD) with three replications was employed. Seeds of each genotype were broadcasted on 4 m^2 plot of land at the rate of 30 kg/ha (12 g per plot). Distances between plots and between blocks were 1 m and 1.5 m, respectively. Fertilizer was applied at the rate of 41 N and 46 P_2O_5 kg/ha (50 kg/ha Urea and 100 kg/ha DAP). Weeding was done as needed uniformly on all plots. Phonological, agronomic and yield-related data were collected both on plot and plant basis, depending on the nature of the trait. Days to maturity, biomass yield (t/ha) and grain yield (t/ha) were collected on plot basis. In the case of plant height (cm) and panicle length (cm), five randomly selected plants were measured and means were computed for each plot.

The Additive Main-effect and Multiplicative Interaction (AMMI) analysis was done according to Zobel et al. (1988) and Genotype plus Genotype-Environment interaction (GGE) analysis was performed as per Yan et al. (2000). Analysis of variance for both individual location and combined data for all traits, AMMI and GGE analyses were worked out by using GenStat 16 software.

3. Results and Discussion

3.1. Genotype Performance

The result of the RILs evaluation on eight environments (4 locations and 2 years) showed a range of mean values for the studied traits (Table 2). Days to maturity ranged from 87.4 for RIL374 to 92.4 for RIL30 and RIL52 with a mean of 89.65. Plant height varied from 87.41 cm for RIL374 to 101.8 cm for RIL273 with a mean value of 94.76 cm. Similarly, panicle length ranged from 37.5 cm for DZ-01-146 to 42.7 cm for RIL40 having a mean of 40.24 cm. The genotype RIL273 was the highest both in biomass- (10.89 t/ha) and grain-yield (2.24 t h^{-1}). The highest grain yield reported in this study was lower than the one reported by Jifar et al. (2019) whereas it was higher than the grain yield reported by Worede (2020) and Balcha (2020); nonetheless, it was comparable with that of Worede et al. (2020). Genotype RIL374 and the local check were the lowest in biomass- (9.29 t/ha) and grain-yield (1.86 t/ha), respectively. The result is in harmony with the findings of Worede et al. (2020).

Considering the yield of genotypes on individual locations, the highest grain yield (4.27 t/ha) was recorded by the genotype RIL273 at SR07 (Table 3). In harmony with the present finding, highest yield of 3.349 t/ha was documented on same environment (Worede, 2020). The environment SR07 was the highest yielding (3.09 t/ha) whereas SR06 was the lowest yielding (1.45 t/ha) environment. In congruence with the present findings, Jifar et al. (2019) reported environmental mean grain yield of 4.29 t/ha and 1.7 t/ha; Worede et al. (2020) demonstrated mean yields of 4.14 and 1.29 t/ha at the highest and lowest yielding environments, respectively. At environment SR06, the highest grain yield of 1.75 t/ha was recorded by genotype RIL205. Hence, RIL273 and RIL205 were the high yielding genotypes in the highest- and lowest-yielding environments, respectively (Table 3).

The genotype RIL273 was the winner at environments KB06 and SR07. The genotype RIL205 won at SR06 and KB07. Likewise, RIL154 won at CH07; while RIL73 was first at CH06 (Table 3). This differential response of genotypes across environments shows the presence of appreciable genotype-environment interaction.

3.2. Additive Main-effect and Multiplicative Interaction analysis

The AMMI analysis of variance showed that genotypes (G), environments (E) and genotype-environment interaction (G×E) significantly ($p<0.01$) influenced grain yield of Tef (Table 2). The result is in agreement with earlier findings reported in Tef (Jifar et al., 2019; Worede

2020; Balcha, 2020; Worede et al., 2020). The G, E and G×E effects explained 2.27%, 85.54% and 12.19% of the treatment variance. The result agrees with the findings of Worede et al. (2020) and Balcha (2020) who reported E explained 82.67% and 87.30% of the treatment variance, respectively. Environment explained the lion's share of the total treatment variance suggesting that the environments were so varied to cause most of the variation in Tef grain yield. The extent of the G×E variance was about five times larger than that of genotypes, indicating the presence of considerable differences in the response of Tef genotypes across environments. In line with the present finding, Jifar et al. (2019) reported environmental variance about four times higher than that of G and G×E.

Table 2. Mean grain yield and other agronomic traits of Tef genotypes grown at Sirinka, Kobo, Jari and Chefa in 2006 and 2007.

Identification	Days to maturity	Plant height (cm)	Panicle length (cm)	Biomass yield (t/ha)	Grain yield (t/ha)
RIL129	88.8	94.4	40.0	9.88	1.91
RIL40	89.5	98.2	42.7	10.51	1.92
RIL273	90.2	101.8	40.1	10.89	2.24
RIL37	87.6	91.1	38.6	9.58	1.91
Local check	90.5	96.5	39.1	9.55	1.86
RIL374	86.9	87.4	38.7	9.29	2.07
RIL351	88.3	94.5	38.9	9.68	1.97
RIL154	90.7	95.3	41.1	10.19	2.03
RIL52	92.4	92.5	38.0	10.02	1.97
RIL195	89.2	96.1	41.1	10.63	1.88
DZ-01-146	92.3	91.0	37.5	9.74	1.95
RIL60	89.1	96.6	41.2	9.79	1.98
RIL73	88.5	98.0	41.9	10.65	1.96
RIL30	92.4	96.7	41.4	10.21	1.87
RIL32	87.3	94.9	41.8	10.05	1.98
RIL205	90.7	95.4	41.6	9.71	2.02
Mean	89.65	94.76	40.24	10.02	1.97
CV (%)	2.58	7.72	9.98	12.48	15.88
LSD (5%)	1.32	4.16	2.28	0.712	0.178

Table 3. Mean grain yield (t/ha) of 16 Tef genotypes grown on eight environments.

Identification	Environments							
	SR06	KB06	CH06	JR06	SR07	KB07	CH07	JR07
RIL129	1.49	1.86	1.85	1.57	2.85	1.89	2.33	1.40
RIL40	1.50	1.51	2.00	1.24	3.00	2.24	2.51	1.37
RIL273	1.73	1.89	2.13	1.67	4.27	2.25	2.35	1.64
RIL37	1.40	1.23	2.21	1.43	3.32	1.86	2.38	1.46
Local check	1.33	1.51	1.90	1.55	2.66	1.92	2.46	1.56
RIL374	1.44	1.50	2.12	1.74	3.31	2.27	2.71	1.49
RIL351	1.42	1.64	2.26	1.87	2.61	2.24	2.36	1.38
RIL154	1.31	1.38	2.13	1.57	3.07	2.29	2.93	1.59
RIL52	1.42	1.54	1.98	1.83	3.10	2.01	2.09	1.77
RIL195	1.29	1.29	1.64	1.71	3.12	2.18	2.45	1.37
DZ-01-146	1.42	1.30	2.06	1.44	3.43	1.56	2.73	1.68
RIL60	1.42	1.71	2.32	1.54	3.08	1.96	2.51	1.30
RIL73	1.32	1.30	2.17	1.46	3.33	1.95	2.46	1.69
RIL30	1.48	1.27	1.90	1.56	2.51	2.29	2.49	1.48
RIL32	1.52	1.09	1.73	1.57	3.22	2.29	2.89	1.52
RIL205	1.75	1.71	2.05	1.46	2.54	2.43	2.82	1.42
Mean	1.45	1.48	2.03	1.58	3.09	2.10	2.53	1.51
CV (%)	14.37	24.36	20.96	14.83	13.24	14.87	11.52	10.28
LSD (5%)	0.151	0.265	0.307	0.169	0.295	NS	NS	0.112

CH06= Chefa 2006, CH07= Chefa 2007, JR06= Jari 2006, JR07= Jari 2007, KB06= Kobo 2006, KB07= Kobo 2007, SR06= Sirinka 2006, SR07= Sirinka 2007

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The AMMI analysis also showed that the best fit model was AMMI2 in this experiment, as the G×E was partitioned into two significant ($p<0.01$) Interaction Principal Component Axes (IPCAs). The two IPCAs explained 46.53 and 21.03%, totally 67.56%, of the G×E sum of squares (Table 4). In agreement with the present finding, 72.5% (Jifar et al., 2019) and 66.06% (Worede, 2020) of the total G×E were reported to be explained by the first two IPCAs. In AMMI1 biplot, distances along the abscissa shows differences in main effects, both genotype and environment. Accordingly, the AMMI1 biplot showed that most of the in breed lines, except RIL273, had more or less similar genotypic main effect, as they are vertically arranged in the two-dimensional plane (Figure 1). The result is in harmony with the findings of Worede (2020). Gauch and Zobel (1996) stated that genotype IPCA scores show the stability of cultivars over environments; genotypes with near-zero IPCA scores are considered to be more stable over all the environments considered. With this regard, the genotypes considered in the present study were very much different in their interaction to the environment. Genotypes RIL273, RIL205, DZ-01-146, RIL30 and RIL351 had relatively higher IPCA1 score, meaning comparatively higher G×E interaction, hence highly influenced by the environments. Nonetheless, genotypes RIL60, RIL32, RIL195 and RIL374 were least influenced by the environment as they had minimum IPCA1 score or G×E (Figure 1).

Table 4. AMMI analysis of variance for grain yield of 16 Tef genotypes

Sources of variation	df	SS	MS	Variance explained (%)	G×E explained (%)
Treatments	127	46.006	0.362		
Genotypes (G)	15	1.046	0.0697	2.27	
Environments (E)	7	39.353	5.6218**	85.54	
Interactions (G×E)	105	5.607	0.0534**	12.19	
IPCA 1	21	2.609	0.1242**		46.53
IPCA 2	19	1.179	0.0621**		21.03
Residuals	65	1.819	0.0280		

**= significant at 0.01 probability level. df= degrees of freedom, SS= sum of squares, MS= mean squares

The environmental main effect, nevertheless, didn't show any pattern, as the environments are scattered in the two-dimensional plane (Figure 1). Environments SR06, KB06, JR06 and JR07 had below average grain yield; whereas SR07, CH07, KB07 and CH06 had above average grain yield. Environment SR07 was the highest-yielding environment, and it also exerted the highest interaction effect. Likewise, KB06, SR06 and JR06 had more or less similar interaction pattern; while CH06 and JR07 exerted minimum interaction effects (Figure 1).

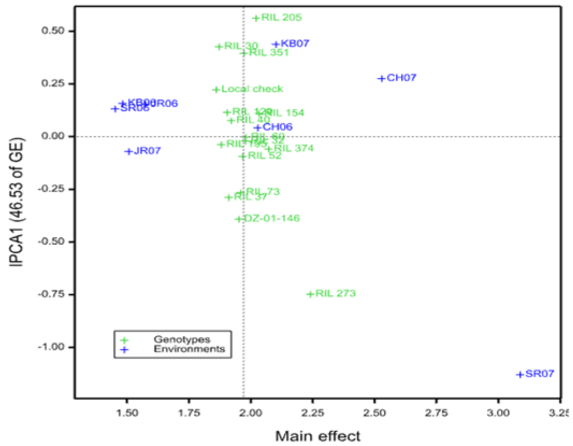

Figure 1. AMMI biplot of main effects of Tef genotypes and environments, and IPCA1. CH06= Chefa 2006, CH07= Chefa 2007, JR06= Jari 2006, JR07= Jari 2007, KB06= Kobo 2006, KB07= Kobo 2007, SR06= Sirinka 2006, SR07= Sirinka 2007

The result is in general agreement with the findings of Worede (2020). In the AMMI2 biplot, environment SR07 followed by CH07 and KB06 exerted comparatively higher interaction to the G×E variance; consequently, they are more discriminating. Environment JR07 followed by SR06, CH06 and JR06 exerted minimum interaction, hence less discriminating; while that of KB07 was moderate (Figure 2).

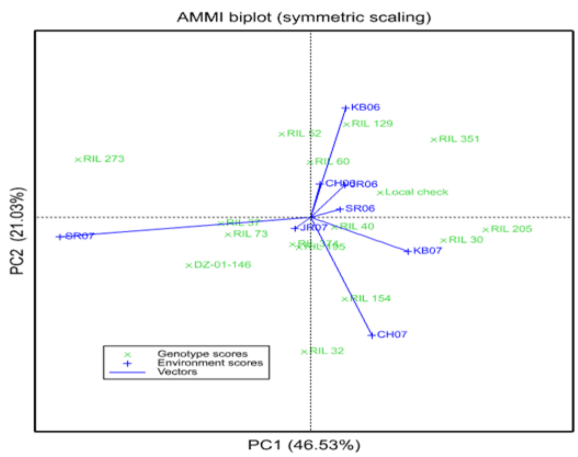

Figure 2. AMMI biplot of Tef genotypes and environments plotted against PCA1 and PCA2. CH06= Chefa 2006, CH07= Chefa 2007, JR06= Jari 2006, JR07= Jari 2007, KB06= Kobo 2006, KB07= Kobo 2007, SR06= Sirinka 2006, SR07= Sirinka 2007.

3.3. Genotype plus Genotype-Environment Interaction Analysis

The GGE biplot showed that 62.16% of the GGE variance was explained by the first (44.29%) and the second (17.88%) interaction PC axes (Figure 3 and 4). The central point of the concentric circles (pointed by an arrow) of GGE biplot (Figure 3) signifies an ideal genotype (Yan and Tinker, 2006). Genotype RIL273, which is proximal to the ideal genotype, is the most desirable (high-yielding and stable) genotype. Jifar et al. (2019) and Worede (2020) also recommended a variety of Tef by employing the same methodology. In contrast, RIL30 and RIL205 situated very far from the ideal genotype regarded as undesirable genotypes (Figure 3).

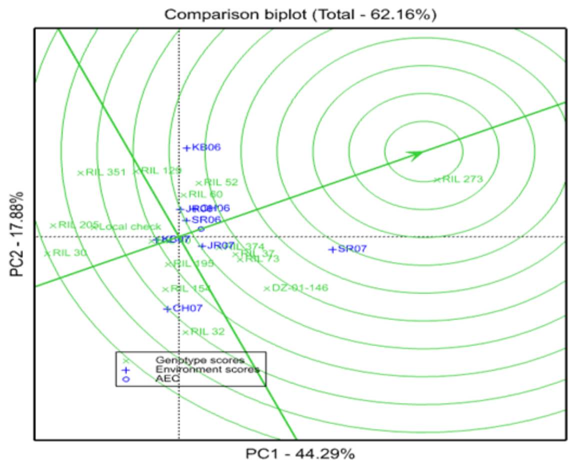

Figure 3. GGE biplot of 16 Tef genotypes on eight environments using genotype-centered scaling. CH06= Chefa 2006, CH07= Chefa 2007, JR06= Jari 2006, JR07= Jari 2007, KB06= Kobo 2006, KB07= Kobo 2007, SR06= Sirinka 2006, SR07= Sirinka 2007.

By the same fashion, the arrow at the center of the concentric circles of Figure 4 shows the ideal environment. Environment SR07, which is closer to the ideal environment, is the most desirable environment. The finding is in concurrence with Worede (2020) who identified an environment by employing same methodology. Nevertheless, CH07 which is located very far from the ideal environment regarded as least desirable environment (Figure 4).

Based on the results of the multivariate stability (AMMI and GGE) analyses, RIL273 could be recommended as a suitable genotype for the locations (environments) considered. RIL273 is a recombinant inbred line developed from the cross of DZ-01-974 × DZ-01-196. One of the parents, DZ-01-974, is a high-yielding variety well adapted to the test locations (Worede et al., 2007). The genotype RIL273, together with the checks, was evaluated by farmers and they ranked it first based on its very white color, higher grain- and biomass-yield and early maturity. The genotype was released in 2010 and dubbed as *Lakech*.

Lakech is as early as the checks (matures within three months), is significantly taller, and had higher biomass- and grain-yield than the checks. It is adapted to low- and dry-land areas of Northeast Ethiopia, and possibly to similar agro-ecologies. It is one of the varieties developed by cross breeding or hybridization. This variety is a sister line to the famous Tef variety in Ethiopia known as *Quncho* (Assefa et al., 2011). Like *Quncho* (RIL355), *Lakech* has a very white seed and brown lemma color. Varieties with very white seed color are more preferred by consumers and have premium selling price at the local market. Being adapted to the semi-arid areas, having higher yield (both grain and biomass) and very white seed color, this variety will contribute to food security of the area.

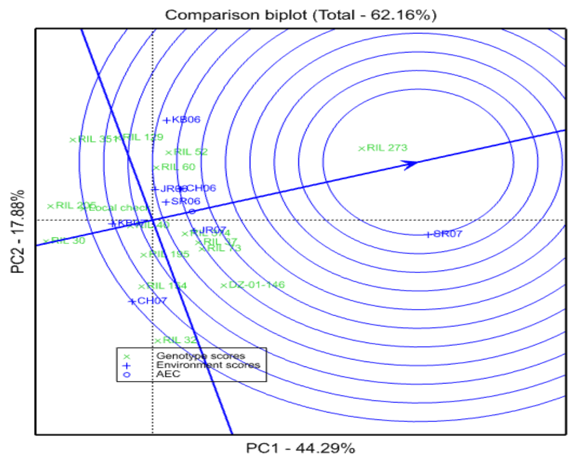

Figure 4. GGE biplot view to rank the eight Tef growing environments using environment-centered scaling. CH06= Chefa 2006, CH07= Chefa 2007, JR06= Jari 2006, JR07= Jari 2007, KB06= Kobo 2006, KB07= Kobo 2007, SR06= Sirinka 2006, SR07= Sirinka 2007.

Author Contributions

FW; initiated the research idea, suggested the research methods, analyzed and interpreted the result and wrote the manuscript. TM; implemented the research, collected and encoded the data.

Conflict of Interest

The author declare that there is no conflict of interest.

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Research Article
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SCREENING FOR INVERDALE ($FECX^{I}$) MUTATION IN BMP15 GENE IN PROLIFIC TURKISH AWASSI SHEEP

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Abstract: In the early 1980s, by the determination of the Boorola gene (FecB) in Booroola sheep with high ovulation rate, there has been a great interest for identification of genes that are responsible for prolificacy and their use in breeding programs. The mutation occurred in Bone morphogenetic protein 15 (BMP15), Bone morphogenetic protein-1B (BMPR-1B) and Growth differentiation factor 9 (GDF9) genes have been found to increase the ovulation rate. Additionally some others genes are known to exist based on expressed inheritance patterns although the location of mutations has yet to be found. In the BMP15 gene, with almost the same phenotypic expression eight distinct mutations have been recognized, among them Hanna ($FecX^{H}$) and Inverdale ($FecX^{I}$) were identified first in Romney sheep in New Zealand. X-linked dominant genes with sterility in homozygous females are the modes of inheritance of the BMP15 gene. A total of 88 prolific Awassi sheep were screened for the presence of the $FecX^{I}$ mutation in the BMP15 gene and $FecX^{I}$ mutation was not found in any of the sheep tested.

Keywords: Awassi, BMP15 gene, Inverdale, PCR-RFLP

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1. Introduction

The fact that first time some genes or mutations could be related to the reproductive characteristics of sheep have been started to study with the identification of the Boorala gene in Boorola sheep in the early 1980s. Since then, there has been a growing interest in the determination and utilization of major genes for sheep prolificacy. In sheep, litter size is regulated by ovulation rate, which is further influenced by the quantity of fertilized oocytes. The higher the ovulation rate, the more oocytes are accessible for fertilization during estrous, increasing the chances of larger litters (Drouilhet et al., 2013). Ovulation is a complicated process that varies by species and is regulated by both genetic and environmental factors. The number of oocytes produced during ovulation varies in sheep breeds, ranging from one to ten (Jansson, 2014). Mutations in the genes of superfamily ovary-derived transforming growth factor-β (TGFβ) considerably enhance the rate of ovulation in sheep (Davis, 2005). They are BMP15, BMPR-1B and GDF9 genes, which code for proteins that are important growth factors and receptors in ovarian follicular growth (Pramod et al., 2013). The effects of these mutations are dominant in nature thus the heterozygous state is sufficient to express as phenotype (Jansson, 2014). Eight distinct mutations (Inverdale, Galway, Belclare, Hanna, Lacaune, Aragonesa, Grivette, Rasa and Olkuska) have been reported in the BMP15 gene in various sheep breeds differ slightly in type and effect (Jansson, 2014).

The Inverdale ($FecX^{I}$) mutation affecting prolificacy was first identified in one Romney (A281) ewe in an industry flock in New Zealand. Further progeny test and inheritance pattern indicated its location on the X chromosome (Davis et al., 1991). The heterozygous carriers (I+) show higher ovulation rates at about one unit higher than non-carriers, but homozygous (II) ewes are infertile and show no follicular activity due to ovarian hyperplasia (Davis et al., 1992). The $FecX^{I}$ allele results in a non-conservative replacement of valine with aspartic acid in a highly conserved region of protein at position 31 of the mature peptide due to a single T to A (GTC> GAC) mutation in the BMP-15 (Galloway et al., 2000).

Awassi, currently found in more than thirty countries, originated from the Middle East. Awassi has many desirable traits as far as resistance to diseases and parasites, tolerance to extreme temperatures and poor feeding conditions besides its high milk production and growth abilities (Yetiskin and Sen, 2020). This well-adopted sheep breed is mainly known for dairy purposes, it is often used for triple purposes, meat, milk, and wool production, in many countries. In Turkey, this breed accounts for 3.5% of the total sheep population (Aksoy et al., 2019). Birth weight is 4.4 kg and 3.8 kg, adult weight is 73.9 kg, and 58.2 kg, were reported in Turkey in male and female sheep respectively (Galal et al., 2008). The reproductive parameters such as fertility, twinning rate, lambing rate were found 89.8%, 20.3%, and 1.20% respectively. In 184.3 ± 2.11 days of the lactation period, milk production accounted for 196.5 ± 5.60 kg in ewes (Üstüner and Oğan, 2013). The litter size of Awassi sheep in Turkey was estimated at 1.30-1.40 (Gürsel, 2011). The aim of this study was to identify the $FecX^I$ mutation in the BMP-15 gene in the prolific Awassi sheep in Turkey.

2. Materials and Methods

2.1. Animal Materials

No animals were used as experimental material in this study. A total of eighty-eight blood samples taken from Awassi sheep raised in Şanlıurfa province, which were previously taken for another project, were used as a material in this study (Meydan et al., 2013). The genomic DNA was extracted from the blood samples, which were stored at -20 ˚C until DNA isolation, by standard salting-out extraction method. The quality and quantity of extracted DNA were checked on 1 % agarose gel electrophoresis and spectrophotometer at A260 / A280 nm respectively.

2.2. PCR Condition and Digestion with the Enzyme

The PCR-RFLP method reported by Galloway et al. 2000 was used to analyze samples for the $FecX^I$ mutation in the BMP15 gene. The forward primer used is to create a recognition site (T↓CTAGA) for *Xba*I restriction enzyme in PCR products from carriers of the mutation but this site is absent in products of non-carriers. Genomic DNA was amplified using the following forward (FecCF1) and reverse (FecCR1) nucleotide sequences; FecCF1: 5'-GAA GTA ACC AGT GTT CCC TCC ACC CTT TTC T-3' and FecCR2: 5'-CAT GAT TGG GAG AAT TGA GAC C-3'. For amplification of 154 bp fragment, a total 25 µl of reaction mixture was prepared by adding 10 X PCR buffer, 1.5 mM $MgCl_2$, 0.2 mM of each dNTP, 1 pM of each primer, 1 U of *Taq* polymerase, and 100 ng DNA. The amplification was performed using 35 cycles of 94 ˚C for 30 s, 60 ˚C for 40 s and 70 ˚C for 30 s, followed by 72 ˚C for 4 min. After PCR amplification, the 154 bp products were digested with *Xba*I, and the products were separated by electrophoresis on 2% agarose gel and visualized with ethidium bromide. Visualization of bands was carried out under ultraviolet transillumination, and the size of the amplified fragments was compared with the 100 bp DNA ladder.

3. Results

In the current study, 154 bp DNA fragments containing Inverdale mutation was successfully amplified. These PCR products were subsequently digested with the restriction enzyme *Xba*I and separated on a 2% gel electrophoresis. Since the mutation creates an *Xba*I recognition site, the heterozygous carrier animals' amplicons are cut to 124 and 30 bp. Non-carrier animals lacking the *Xba*I recognition site yield a single band of 154 bp. After digestion with XbaI, no restriction was detected; all samples gave a single band at 154 bp and showed a negative result for the $FecX^I$ mutation (Figure 1).

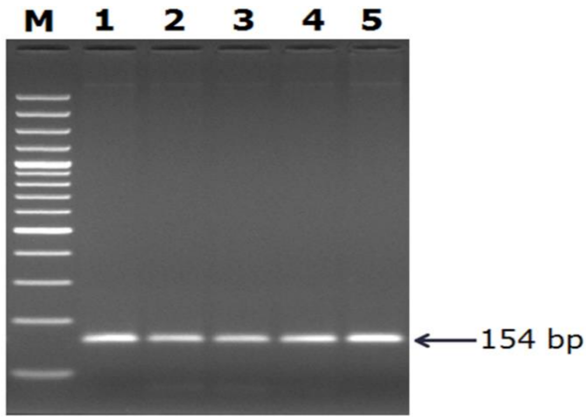

Figure 1. Screening of *$FecX^I$* mutation on %2 agarose gel by PCR- RFLP. Line 1-5 are *Xba*I digestion products. M; Fermentas GeneRuler™ 100 bp DNA Ladder.

4. Discussion

This study was unable to prove the presence of $FecX^I$ mutation in Turkish Awassi sheep. The result of this study is consistent with previous studies conducted in Chios, Kivircik, Awassi and Imrose breeds by Gürsel et al 2011, and in Sakız breed by Dinçel et al. 2015. They are both reported no inverdale mutation in sheep of Turkey. Also, researches on other mutations related to fecundity have been conducted in different Turkish sheep breeds. A study by Karsli et al., (2011) was conducted to identify FecB, $FecX^G$, $FecX^H$ allele in Kangal and Güney Karaman breeds however did not find existence any of the mutations. Conversely a recent study in a local sheep breed namely Of revealed higher heterozygous genotype frequency (GA=0.92) in GDF9 gene ($GDF9^1$) was linked with increase litter size (Kırıkçı and Çam, 2020).

$FecX^I$ mutation was absent not only in Turkish sheep breeds but also in different prolific breeds tested worldwide. Two Indian high prolific breeds Bonpala and Garole were tested negative for this mutation although another gene responsible for increasing litter size FecB was tested positively only in Garole breed (Davis et al., 2002; Roy et al., 2011). A list of breeds from different countries such as Javanese sheep in Indonesia, Thoka sheep in Iceland, Woodlands sheep in New Zealand, Olkuska sheep in Poland, Lacaune sheep in France, Belclare and Cambridge in Ireland (Davis et al., 2002), and Egyptian sheep (Abulyazid et al., 2011) also do not carry $FecX^I$ mutation underlying their increased prolificacy. Furthermore, exploration in 21 different high prolific sheep breeds and strains from 13 countries revealed that the reason for their large litter size is unrelated to the $FecX^I$ mutation in the BMP15 gene (Davis et al., 2006).

5. Conclusion

The $FecX^I$ mutation has no effect on the prolificacy of Turkish Awassi sheep were used in this study. Despite the absence of the $FecX^I$ mutation, other loci of the BMP15 gene and a major gene for fecundity may provide the genetic explanation for the Awassi sheep's multiple birth traits. Identifying major genes that determine litter size is crucial from an economic standpoint. As a result, a well-thought-out initiative to introduce mutant alleles into Turkish sheep breeds could result in larger litter sizes, which would increase breeder income.

Author Contributions

All tasks have been done by the single author. The author reviewed and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Consideration

A retrospective ethics permit is not required for the study due to the experimental material were previously taken for another project (Scientific Research Projects (BAP) of Ankara University, Project No: BAP-09B4347007; Project coordinator: Dr. Mustafa Muhip ÖZKAN) and carried out before 2020.

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Research Article
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THE EFFECTS OF DIFFERENT ORGANIC FEED ON THE REPRODUCTIVE PERFORMANCE OF KARAYAKA SHEEP

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Abstract: This research was carried out to investigate the effects of different organic feeds (1. Traditional barley (control), 2. Organic barley (OB), 3. Organic triticale (OT)) and 4. Organic corn (OC) on reproductive performance in Karayaka sheep. Trial feeds were given from 21 days before the mating with rams to 10 days after the rams were added in the pasture period of the sheep. The animals used in the experiment were 3-4 years old, their average live weight was 56±0.5 kg and 10 heads in each trial group, a total of 40 Karayaka sheep has been carried out. The highest fertility rate in sheep was in the organic triticale group; followed by control, organic barley and organic corn (P=0.06). According to these results, the highest lamb yield was obtained from the organic triticale group.

Keywords: Karayaka, Organic sheep feeding, Reproductive performance, Fertility

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1. Introduction

The purpose of organic agriculture is to establish systems within the concept of "functional integrity" based on soil-plant, plant-animal and animal-soil interdependence and a sustainable agro ecological local resources (Thompson and Nardone, 1999). Organic production systems are based on native animal breeds that contribute to the ecological cycle, have developed local and regional adaptation, are resistant to diseases, use natural forage resources such as meadows, pastures and plateaus, and increase and protect biological diversity in every sense organic sheep breeding within organic sheep and goat farming is showing a growing trend in Europe (FAO, 1999). The number of organic dairy sheep farms is increasing in Mediterranean countries and Northern Europe. Yavuzer and Bengisu, (2015) stated that there is a form of breeding that is not far from organic livestock rules in the field of extensive sheep breeding, which is applied in various countries, especially in the Mediterranean countries. It has been reported that the Mediterranean climate zone has not been treated with artificial fertilizers and chemicals, and is not used for other agricultural activities other than grazing. In this respect, it has been argued that extensive sheep and goat production systems are closer to the organic system and can transition from the conventional system to the organic system more easily (Koyuncu and Taşkın, 2013). In addition, in a study investigating the possibilities of lambing twice a year without applying hormones in the organic livestock system, it was determined that an increase of 40% in pregnancy rate and 40-44% in lamb yield was achieved in Awassi sheep (Yavuzer, 2005).

This study was carried out to investigate the effects of some organic feeds on reproductive performance in Karayaka sheep.

2. Material and Methods

2.1. Research Site and Climate Characteristics

The research was carried out on the Akbelen plateau in the north, at 40°26'42" latitude, 36°40'53" longitude (east) coordinates, connected to the center of Tokat. The long-term average annual temperature and precipitation data of this region are 12.6 °C and 431.7 mm, respectively (MGM, (2017). The grazing pasture is 1679 m above sea level, covered with slightly inclined (20-30%), clayey, salty and slightly acidic, non-calcareous, brown forest soils.

2.2. Animal Material

In this study, 40 Karayaka sheep, 3-4 years old, with an average live weight of 56±0.5 kg, were randomly distributed into 4 groups, with 10 sheep and 1 head ram in each experimental group. Concentrated feeds were prepared isocalorically and isonitrogenically in Yazıcıoğlu feed processing unit (NRC, 2001).

2.3. Trial Feeds

With grazing, the experimental groups were fed with 600 g of concentrated feed per day, starting 21 days before mating and until 10 days after mating, and the mineral substance requirement of the experimental animals was met from organic rock salt NRC (2001) (Table 1, Table 2).

Table 1. Feed raw materials used in the experimental groups

Feed raw materials	Control (%)	Organic barley (%)	Organic triticale (%)	Organic corn (%)
Conventional barley	60			
Conventional grain vetch	29			
Conventional corn	10			
Rock salt	1	1	1	1
Organic barley		60		5
Organic grain vetch		29	24	34
Organic corn		10	10	60
Organic triticale			65	
	100	100	100	100
Organic alfalfa dry grass		Ad –libitum	Ad –libitum	Ad –libitum
Conventional alfalfa dry grass	Ad –libitum			
ME Mcal, kg^{-1}	2.63	2.63	2.66	2.67
Crude protein (%)	16.32	16.32	16.37	16.12

Table 2. Feed raw materials and chemical compositions

Feed raw materials / chemical ingredients	DM (%)	OM (%)	CP (%)	CF (%)	NDF (%)	ADF (%)	CA (%)	TDN g/100g
Conventional barley	88.91	85.54	12.44	2.41	18.44	7.13	3.37	81.70
Conventional grain vetch	88.30	82.85	28.02	0.82	15.05	13.79	5.45	76.80
Conventional corn	87.38	86.25	7.21	2.89	8.63	3.14	1.13	84.80
Organic barley	89.01	85.39	11.25	2.39	19.78	7.01	3.62	80.60
Organic grain vetch	89.15	85.86	29.76	0.77	10.75	9.34	3.29	80.50
Organic corn	87.18	85.92	8.76	4.61	7.62	3.42	1.26	86.5
Organic triticale	88.48	86.77	10.80	1.50	12.35	3.58	1.71	82.60
Organic alfalfa dry grass	92.89	86.84	14.28	0.38	63.28	54.05	6.05	47.90
Conventional alfalfa dry grass	92.82	85.06	12.21	0.93	61.92	48.04	7.76	46.01
Pasture grass	90.06	80.66	16.24	1.12	46.91	24.35	9.40	56.78

DM= dry matter, OM= organic matter, CP= crude protein, CF= crude fat, NDF= neutral detergent fiber, ADF= acid detergent fiber, CA= crude ash, TDN= total digestible nutrients.

2.4. Botanical Composition of Pasture

The composition of the forage plants that make up the pasture composition was determined by harvesting the plants from the pasture area. A metal circle with a diameter of 0.25 m^2 was randomly placed in different parts of the pasture where the animals grazed, and the pasture plants falling on an area of 0.25 m^2 from each of the 4 repeated plots were harvested with the help of scissors. Pasture plants were harvested 5 cm above ground level. The pasture where the experiment was carried out, 51% of which was grasses; *Festuta ovina*, *Fescuta pratenses*, *Poa pratensis*, *Poa bulbosadan*, *Dactylis glomerata* 14.06% are from legumes (*Trifolium repens*, *Potarium Sanguisorba*, *Trigonella foenum-graecum*, *Lotus corniculatus*) and 34.94% are from other species (*Trifolium repens*, *Potarium Sanguisorba*, *Lotus corniculatus* officinale, *Ranunculus asiaticus*, *Gazania rigens*) found to be covered. It is defined as a middle class pasture in the pasture classification.

2.5. Fertility Characteristics

Number of sheep under ram (head); The total number of sheep in mating ability, Pregnancy rates (%); Number of sheep giving birth/Number of sheep under Aries*100, Twinning ratio; Number of twin lambs/Total number of lambs born*100, Single born lamb rates (%); Number of single born lambs/Total number of lambs born*100, Prolificacy rates (%); Total number of lambs born/Number of sheep under ram*100, Total number of lambs born (head); It refers to all lambs born, Number of sheep giving birth; Number of sheep that conceived and gave birth, Falling number of lambs per ewe (head); Total number of lambs born/Number of sheep under ram*100.

2.6. Chemical Analysis

Green fodder samples from the pasture were dried at 70°C for 48 hours, ground and passed through a 1 mm sieve to determine the chemical composition. In addition, pasture samples were burned at 525°C for 8 hours to detect organic matter and raw ash. The crude protein

(CP) content of the feeds was determined by the Kjeldahl method using the Tecator Block fractionation and steam distillation method (total N multiplied by 6.25). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents of feed samples, AOAC (2012) by ANKOM fiber analyzer (F220/220 Operator's Manual, Ankom tech.) with the filter bag method. Total digestible nutrients were calculated according to the specified equations. Forage TDN = 0.479 NDF + 0.704 NFC + 1.594 EE + 0.714 CP. Concentrate TDN = 0.323 NDF + 0.883 NFC + 1.829 EE + 0.885 CP (Jayanegara et al., 2019).

2.6. Statistical Analysis

χ^2 (Chi-square) independence test was applied to investigate whether there was a difference between the experimental groups in terms of reproductive performance of sheep (Harvey, 2009; Önder, 2018).

3. Results and Discussion

Fertility performances of feed groups containing traditional and different organic energy feeds in Karayaka sheep, when the fertility rates of the different groups given in Table 3 and Figure 1 are examined; although it is not statistically significant, it was observed that it was the lowest in the organic corn group and all organic triticale and control group sheep kept offspring.

Table 3. Effects of different organic feeds on the reproductive performance of sheep

Fertility Properties	Control	Research groups			P value
		Organic barley	Organic triticale	Organic corn	
Number of sheep under ram (head)	10	10	10	10	
Pregnancy rates (%)	100	90	100	70	0.084
Prolificacy rates (%)	100	90	110	70	0.061
Twinning ratio (%)	0	0	18	0	0.400
Single born lamb rates (%)	100	100	82	70	0.099
Total number of lambs born (head)	10	9	11	7	
Falling number of lambs per ewe (head)	1.00	0.90	1.10	0.70	0.061

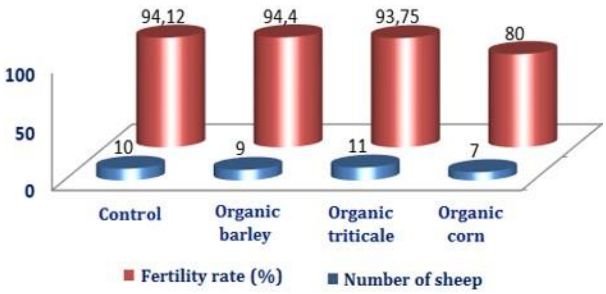

Figure 1. Fertility rates and the number of sheep giving birth (head).

Sauer et al. (2017) stated that they found the pregnancy rates in organic and traditionally raised Turcana sheep to be 97.94% in organically reared and 94.72% in conventionally bred sheep. In addition, in the study of Palacios and Abecia (2017), it was stated that the fertility rate in sheep fed with organic feed was higher than in those using hormones. In this study; the highest fertility rate in sheep was in the organic triticale group; followed by control, organic barley and organic corn (P=0.06). According to these results, lamb yield was obtained from the highest organic triticale group. Similarly, Sauer et al. (2017), in their study in Turcana sheep, stated that the fertility rates were 118.18% in organic production and 110.16% in traditional production. When Table 3 is examined in terms of twinning, there were no sheep that gave birth to twins except the organic triticale group, while 18% twinning rate was obtained in the triticale group, but the statistical difference between the groups was not significant. In addition, in the study of Bilik and Rusek (2010) on dairy cattle; they stated that there is no difference in fertility in cows fed with organic and conventional feeds. In terms of the number of lambs per ewe, it was observed that the number of lambs per organic triticale group was higher than the other experimental groups (P=0.06). As a result, it is thought that the use of triticale in concentrated feed of sheep will be an advantage in organic sheep breeding.

Author Contributions

All authors had equal contributions and all authors reviewed and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Consideration

This study, was carried out by Gaziosmanpaşa University Animal Experiments Local Ethics Committee with the approval of Animal Experiments Protocol (Protocol No: 2019-HADYEK-24) dated 07.11.2019 and numbered 51879863-229.

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Review
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EFFECTS OF CLIMATE CHANGE ON SHEEP AND GOAT BREEDING

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Abstract: Climate change is seen as a significant threat to the sustainability of many species, ecosystems and livestock production systems in many parts of the world. With the rise of average temperatures at the global level, a number of effects occur. These effects lead to different changes in climate, regionally and globally. Livestock sector in Turkey is the leading sector that is most affected by the global climate change due to the predomination of rural economic structure and industries based on developing livestock breeding. Health and welfare in animal production are an integral part of environmental sustainability. Extreme events and seasonal fluctuations affect the welfare of the animals and cause a decline in yield and reproductive performance. Sheep and goat are animals that can make the best use of pasture and use it in every season of the year. In addition to the effects of climate change on ecosystems, it is inevitable that it will create important problems on the natural resources that form the basis of animal production. Climatic characteristics such as temperature and precipitation patterns have a significant impact on the availability of pasture and other resources throughout the year of animals. In this study, it was aimed to reveal the effects of climate change on animal husbandry and especially on sheep and goat breeding.

Keywords: Climate change, Sheep, Goat, Heat stress, Animal health

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1. Introduction

One of the most important factors affecting life styles on earth is climate. The climate, which is formed by the effects of factors such as temperature, precipitation, humidity and wind in a particular region, affects the existence of living things, the geographical distribution and abundance of plant and animal species, the chemical structure of oceans, seas and lakes, and the formation of soil (Jackson, 2018). The change that occurs in the climate system as a result of natural factors or human activities is defined as "climate change" (IPCC, 2007). Climate changes; drought, desertification, imbalances and deviations in the speed and intensity of precipitation, floods, typhoons, storms, tornadoes, hurricanes, etc. manifests itself with increases in meteorological events. Climate change has emerged in the form of global warming, which is defined as the increase in the average temperature on the Earth's surface in recent years. The effects of global warming can be seen as a result of the greenhouse effect of the gases released into the atmosphere (Bozoğlu et al., 2003; Köknaroğlu and Akünal, 2010).

Greenhouse gases having an important place in climatic changes adsorb on long-wave infrared rays reflected back to the atmosphere and cause the atmosphere to warm. Greenhouse gases arise not only naturally but also as a result of various activities of people (Köknaroğlu and Akünal, 2010). Today, the world faces with climate change due to global warming caused by technological and chemical applications used to increase plant and animal production in meeting the needs of the increasing population as well as industrialization and urbanization (Koyuncu and Akgün, 2018). Although the events occurred due to these problems threatening the world are not fully understood yet, it seems inevitable that global warming will cause economic, ecological and sociological problems (Demir and Cevger, 2007).

Climate change threatens the welfare of present and future generations by changing the ecosystem of the planet. Climate changes caused or to be caused by global warming may be vary in different ways by different parts of the world. Turkey is included in the risk group of countries in terms of the potential effects of global warming due to increases in extreme values of eastern Mediterranean. In Turkey will be affected by the negative aspects of global warming such as the weakening of water resources, forest fires, drought and desertification, and ecological deterioration dependent on them (Yetisgin and Sen, 2020). According to Turkey's 2019 data, the total greenhouse gas emission was 506.1 million tons CO_2. Of this amount, 72% originated from energy, 13.4% agriculture, 11.2% industrial processes and product use, and 3.4% from the waste sector (TUIK, 2021). While the amount of greenhouse gas emissions per capita in Turkey was 6.07 tons of CO_2 in 2015, it increased to 7.30 tons of CO_2 in 2020. If measures are not taken in 2030, it is expected to be 13.29 tons of CO_2 (Anonymous, 2021a). It is estimated that the negative effects of climate change in Turkey can be seen in the next 10 or 20 years' time frame (Anonymous, 2021b). For example, arid and semi-arid regions such as South East and Central Anatolia under the threat of desertification, and semi-humid Aegean and Mediterranean regions that do not have adequate water will have been more affected. Climate changes will cause changes in the natural habitats of animals and plants in agricultural activities and important problems will arise (Öztürk, 2002; Atalık, 2005; Şen, 2014; Marino et al., 2016).

The fact that significant proportion of country economies like Turkey is based on the rural production such as agriculture and livestock causes to feel the effects of climate change much. Although certain improvements have been made in areas such as mechanization, productivity and health in animal feeding, the irregularity of the climate and unsettled market structure prevent sustainable production, decrease profitability and lead to rural migration. As a result of this, it becomes increasingly difficult to secure the supply in animal feeding due to increased production costs, and product prices are rising, while the import of livestock and meat frequently comes to the fore in order to meet the increasing demand. It is expected that climate change will completely affect the animal production systems in the world and cause an increase in the current demand for animal products in the coming years (Koyuncu, 2017; Sarıözkan and Küçükoflaz, 2020). This study aims to reveal the effects of climate change on animal and especially sheep and goat breeding and to present suggestions that can be made in this field.

2. Animal Production and Climate Change

The increase in gases, which are called greenhouse gases, due to reasons such as industrialization, energy production, population growth, urbanization and agriculture is the main factor that causes climate change. This interaction, which mostly takes place in a negative sense, causes many problems (Aydoğdu, 2020). With the release of greenhouse gases, climates on earth are changing and the number and frequency of extraordinary weather events are also increasing. Animal production is a factor that increases greenhouse gas emissions, and increasing greenhouse gases cause climate change on earth. Changing climates adversely affect animal production directly or indirectly. In other words, it is possible to talk about a two-way interaction between climate change and animal breeding. The animal breeding sector exhibits a structure that affects climate change due to animal-derived greenhouse gases and is also negatively affected by this changing climate (Dellal, 2008; Görgülü et al., 2009). A difference of 1°C above 30°C may cause stress in animals and animal production may be affected. The gas released as a result of feed intake and digestion is a factor that increases greenhouse gas emissions (Koç et al., 2016).

Agricultural production is largely dependent on climate, and the climate has been constantly changing in recent times. Scientific evidence points to climate change having an increasing impact on life on the planet. Climate change is not only the most important problem facing the realization of sustainable development, but also an important threat to the future of humankind. It will have far-reaching consequences within the context of animal production and particularly in regions of vital importance to the Earth's diet and livelihoods. While these impacts increase the vulnerability of livestock systems, phenomena such as drought can exacerbate the effects of emerging stresses. In addition to its impact on ecosystems, climate change will also create significant problems on natural resources that form the basis of animal production. In animal production, the most important effects of this can be listed as decreases in the amount and quality of production, increased sensitivity to diseases and pests, changes in the reproductive cycle, losses at birth, and regression in the conversion of feed into product (Koyuncu, 2017; Gökkür and Uysal, 2020; Demirbük, 2021; Koyuncu and Nageye, 2020).

Climate change represents a major global threat for ecosystems, and it is estimated that abnormal weather patterns could cause extinction of 8% animal species. Therefore, climate change is a major global threat for the sustainability of animal breeding. The most efficient production takes place under optimum environmental conditions and climatic factors such as ambient temperature, relative humidity, direct and indirect solar radiation and wind speed affect feed and water availability, feed quality and disease occurrence. Among these climatic variables, ambient temperature fluctuations have a considerable effect on livestock production and animal welfare (Pachauri and Meyer, 2014; Joy et al., 2020).

Studies show that hot and humid environments will cause heat stress in livestock as well as infectious diseases and changes in many physiological functions associated with a decrease in feed consumption, deterioration in health, reproductive efficiency and productivity while animals are trying to cope with temperature changes in the process of adaptation to climate change, behavioral and metabolic changes such as sensitivity (Thorne, 2007; Tirado et al., 2010). It is therefore essential to understand the mechanisms adopted by animals in extreme weather conditions, as well as a detailed study of the direct and indirect effect of climate change on livestock production.

3. Animal Health and Reproduction

Livestock has a range of thermal comfort zones where they can produce optimally, and this varies according to the species, breed, age and physiological state (Nardone et al., 2010; Dangi et al., 2016). Climatic factors such as ambient temperature, relative humidity, direct and indirect solar radiation and wind speed affect the availability of feed and water, feed quality and pathogenesis where production is most efficient under optimum environmental conditions (Joy et al., 2020). Biological, physical and chemical environmental conditions or climate have a direct effect on animals. Extreme temperatures adversely affect production performance (growth, meat, milk, egg production, etc.), reproductive physiology, metabolism and the immune system (Batima et al., 2006; Koyuncu and Akgül, 2018).

Indirect effects of climate change may occur in the form of feed and water scarcity, food-borne diseases, resistance of infectious hosts, and the spread of vector-borne diseases which negatively affects the adaptation of animals to changing climatic conditions. While high temperature supports the growth of pathogens or parasites, changes in winds can lead to the spread of some pathogens and disease carriers over a wider area. While there may be changes in the spread of diseases during climate change, some severe diseases can also occur in herds with no previous disease (Petrovica et al., 2015; Koyuncu and Akgün, 2018). In many studies, hot and humid environments will cause temperature stress in livestock as well as infectious diseases and changes in many physiological functions associated with a decrease in feed consumption, deterioration in health, reproductive efficiency and productivity while animals are trying to cope with temperature changes in the process of adaptation to climate change, behavioral and metabolic changes such as sensitivity to disease (Thorne, 2007; Tirado et al., 2010; Koyuncu and Akgün, 2018). It has been reported that as the temperature increases, there is an increase in respiratory rate, body surface and rectal temperature (Aleena et al., 2018).

Some sheep and goat breeds have been found to adapt to warm environments providing acceptable productivity rates. The positive characteristics of these species are related to their relatively small body size, low water and feed requirements, good feed conversion rate, and the capacity to convert poor quality feed into quality products. Therefore, identifying tolerant breeds for higher adaptability in extreme environmental conditions (high temperature, feed shortage, water scarcity) is an applicable strategy to reduce the impact of climate change on sheep and goat production (Silanikove and Koluman Darcan, 2015; Joy et al., 2020).

High environmental temperatures endanger the productivity of lactating sheep and goats, and energy requirements increase partially due to the higher respiratory rate. Both heat stress and the progression of lactation can cause a decrease in milk yield and quality (Brasil et al., 2000; Peana et al., 2007; Sevi and Caroprese, 2012; Smith et al., 2013). Moreover, heat stress may endanger udder health and milk quality by causing more bacterial colonization in the udder in sheep (Sevi and Caroprese, 2012). Heat stress also affects meat yield and meat quality in sheep and goats. Some studies have reported higher pH and darker meat (Kadim et al., 2016; Archana et al., 2018). Increased body temperature in rams during heat stress causes testicular degeneration, a decrease in the percentage of normal and fertile spermatozoa, low ejaculate volume, high semen pH, decreased sperm motility and decreased sperm quality (Hamilton et al., 2016; Rahman et al., 2016). Temperature increases increased the risk of infection in the mammary glands of lactating animals (Koyuncu and Akgül, 2018), and caused a decrease in birth weight and viability of the offspring born in January, February and July, August of pregnant goats. It has been reported that mortality rates in the first month after birth increase in cold and warm months (Luo et al., 2020). Dairy-oriented breeds are more affected by heat stress than meat-yielding breeds (Bernabucci et al., 2010). In the research conducted in Saanen and Hair goats, a decrease in T3 (Triiodothyronine) and T4 (Thyroxine) hormones occurred when the temperature and humidity index value increased. This situation is associated with slowing down carbohydrate metabolism and reducing energy production in order to keep body temperature constant (Koluman Darcan et al., 2013). Heptaglobin, NEFA (Non-esterified fatty acids), T3 and T4 can be used as markers of metabolic adaptation to heat stress in livestock (Aleena et al., 2016).

3.1. Sheep and Goat Breeding and Climate Change

Animal production is a sub-sector that can mostly use family labor in the agricultural sector in Turkey, have high added value and contribute significantly to the adequate and balanced nutrition of the population. Sheep and goat breeding among animal breeding creates an important economic value in the geography where it has been carried out for many years (Gürer and Ulutaş, 2021). Sheep and goats are animals that can make the most of the pasture and use the pasture at all times of the year. It is inevitable that climate change will cause important problems on the natural resources forming the basis of animal production in addition to its effects on ecosystems. Climatological characteristics such as temperature and rainfall patterns have a major effect on the availability of animals for year-round pasture and other resources. Some regions in Turkey are dependent on animal breeding and animal breeding is dependent on the size of pasture areas (Gökkür and Uysal, 2020; Koyuncu and Nageye, 2020).

It is inevitable that climate change will cause a decrease in the productivity of pastures. A significant part of the amount and quality of feed is affected by the increase in CO_2 level and increase in the temperature (Chapman et al., 2012). Environmental stress that limits the availability of pasture and feed resources may arise from drought, high/low temperature, ozone, high carbon dioxide, soil water and salinity. Perennial plants have a limited yield but grow in barren soils with low rainfall or irrigation and high salt content. Heat stresses can reduce the amount of crop harvested, change nutritional value, and degrade the composition of the species (Chauhan and Ghosh, 2014). While this causes a decrease in available nutrients for animals, it causes losses in animal production by affecting food safety and incomes as a result of reduced milk and meat production for small herd owners (Koyuncu and Nageye, 2020). There are many ways that climate change affects grazing through thermal stress which changes especially the quality and quantity of meadows and increases the occurrence of pests and diseases. Each of these may endanger both livestock productivity and welfare (Baumgard et al., 2012; Stocker et al., 2013). Climate change has many direct and indirect effects on animal production. The main effects on animal breeding are submitted in the headings below.

3.2. Climate Change and its Effects on Biochemical Parameters in Sheep and Goats

Generally, climate change is associated with an increasing global temperature. Severe weather conditions (intense heat waves, floods, and drought) to which animals are exposed, in addition to production losses, can result in animal deaths, in extreme cases (Gaughan and Cawsell-Smith, 2015). Animals can adapt to warm climates, but response mechanisms helping survive can have adverse effects on their yield performance. Livestock perform their best between 10-30°C. It is stated that there is an average of 3-5% decrease in the feed consumption of cattle, sheep, goats and chickens with every 1°C increase in ambient temperature above 30°C (NRC, 1981; Koyuncu, 2017).

Heat stress will cause changes in nutrition by causing physiological effects on the digestive system of sheep and goat. It will decrease rumen fermentation and rumen volatile fatty acid production (Pragna et al., 2018) and cause metabolic (acid-base balance and cortisol release) changes (Wojtas et al., 2013). Changes will also be seen in the hormones NEFA (non-esterified fatty acids), T3 and T4 in the blood (Sejian et al., 2019). This may cause an increase in Streptococcus bacteria and a decrease in Fibrobactor bacteria. The response of goats to heat stress varies due to genetic differences (Pragna et al., 2018). Research is needed to detect genetic differences and to identify and breed breeds that are resistant to climatic changes in regions.

3.3. Pasture and Grazing

Desertification process caused by global warming causes a decrease in the carrying capacity of feed-based cultivated areas and the buffering capacity of agricultural systems (Koyuncu and Akgül, 2018). Light, temperature and rainfall are important factors for plant production, and these factors must be at a level to meet the needs of the plants. Prolonged temperature or rainfall above or below normal values can adversely affect plant life, causing a significant decrease in productivity or even complete destruction. Water, which is a very important element for vital activities, is provided by rainfall for natural pasture areas, and the reduction in the total amount of rainfall or anomalies in seasonal distribution is a very important factor for production in pasture areas, especially in arid and semi-arid regions. Climate changes, where the changes in the atmosphere have an accelerating effect, cause changes in the productivity of pasture areas, as in all plant production, abnormal climatic conditions occurring with misuse accelerate this change negatively and cause it to be disposed irrevocably (Herbel and Pieper, 1991; Pittock, 1995).

In Table 1, the change of pasture areas in Turkey by years, in Figure 1, the distribution of annual average temperature values in Turkey, and in Figure 2, the distribution of annual average total precipitation values in Turkey are given.

When Table 1 is examined, it is seen that there are significant decreases in our pasture areas in all regions. There are many reasons for this decline, such as the conversion of pasture lands to agricultural areas, misuse, faulty grazing, overcapacity and untimely grazing, covering the pasture by species with low fodder value, sparse vegetation and decreasing yield levels, and deterioration of the natural vegetation cover of the pasture.

Table 1. Change of rangeland in Turkey (Anonymous, 2021c)

Regions	1970	1991	2001	1998-2020 years change		Average hay yield (Kg/ha)
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	%	
Aegean	1027900	615900	802879	440166	0.56	600
Marmara	463600	564100	552662	287943	0.37	600
Mediterranean	1002400	434300	659334	569546	0.73	500
Central Anatolia	5884200	3890300	4570182	4297862	5.51	450
Black Sea	1993100	1556000	1533605	1315925	1.69	1000
Eastern Anatolıan	9162100	4573400	5485449	4976736	6.38	900
Southeast Anatolia	2165100	743600	1012576	1057158	1.36	450
Total	21698400	12377600	14616687	12945335		

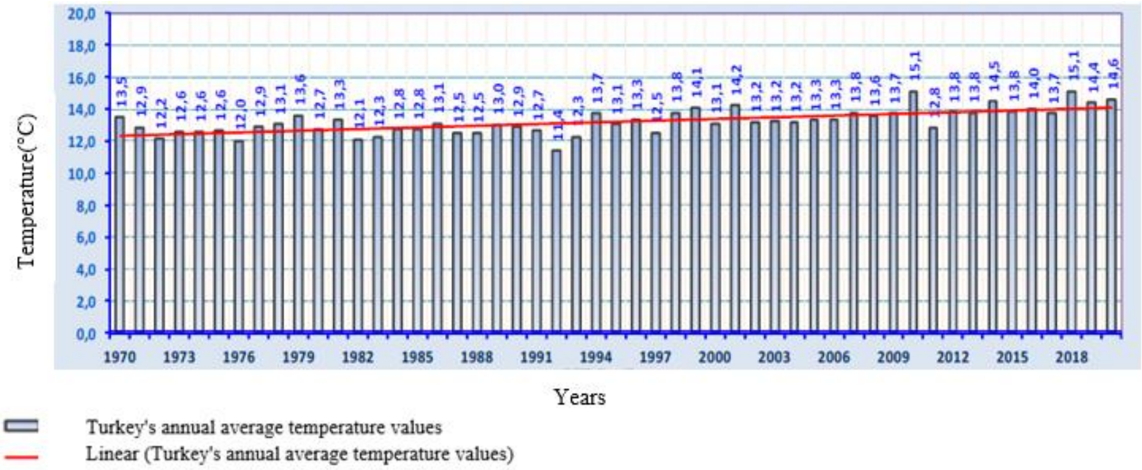

Figure 1. Turkey's annual average temperature values (Anonymous, 2021d).

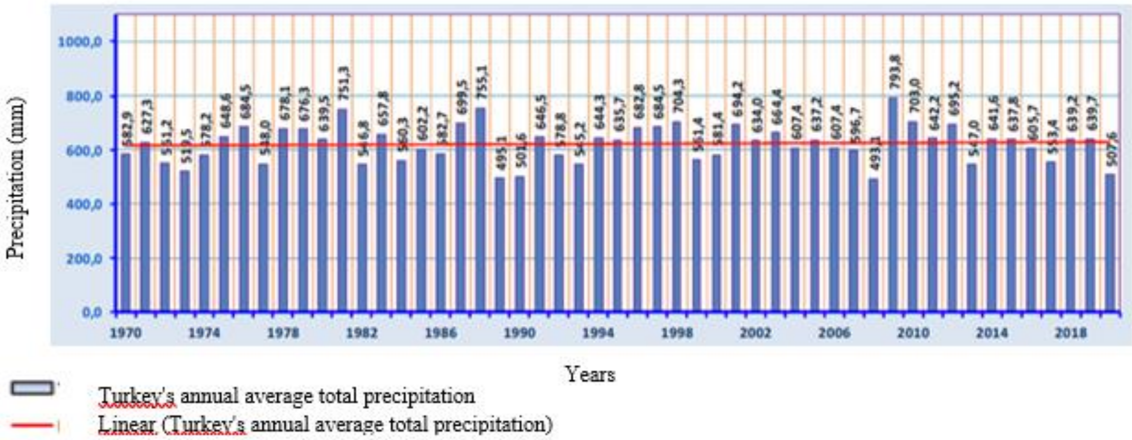

Figure 2. Turkey's annual average total precipitation (Anonymous, 2021d).

As a result of wrong applications, the productivity of the soil decreases, the soil is moved, erosion begins and the environment in which the plant will hold is destroyed. In addition to these, due to the effects of climate variability, the increase in temperature and the decrease in forage crops production due to drought also cause significant yield losses in pastures. In addition, the annual total precipitation is low, and the distribution and intensity of precipitation throughout the year directly affect the growth timing and duration of pastures. In addition to the decrease in plant production due to drought, the species composition of pasture vegetation and feed quality are also negatively affected (Peterson et al., 1992; Snyman and Fouche, 1993; Moldenhauer, 1998). On the other hand, rainfall has a direct effect on the yield of pasture areas, as well as on the performance of pasture-based agricultural activities. During periods of low rainfall, plant production decreases in pastures and animals cannot graze properly in the pasture area with the effect of high air temperature on days without rain (Tuvaansuren and Bayarbaatar, 2003; Holechek et al., 2004). The increase in the amount of rainfall generally causes a yield increase in meadows and pastures. However, the effect of excess rainfall as a result of global warming will be suppressed by water loss. Seasonal distribution and intensity of rainfall will have a greater effect on pastures than rainfall as it will affect seasonal soil water dynamics and plant water use efficiency (Giorgi et al., 1998). Heavy rains will cause an increase in runoff and erosion. The drying effect of global warming will be particularly important in arid and semi-arid regions of the world where climate change will not affect or decrease rainfall much. However, the increase in CO_2 concentration will cause an increase in water use efficiency (Hatipoğlu et al., 2019).

3.4 Effects of Climate Change on Sheep and Goat Welfare

Livestock sector in Turkey is the leading sector that is most affected by the global climate change due to the predomination of rural economic structure and industries based on developing livestock breeding. While the agricultural sector has a structure directly affected by the climate, especially in terms of plant production, animal breeding is indirectly affected by its inter-sectorial interaction with agriculture in terms of forage plant production (Sarıözkan and Küçükoflaz, 2020). Extreme events and seasonal fluctuations affect the welfare of the animals and cause a decline in yield and reproductive performance (Sejian et al., 2015). Stress can lead to behavioral changes (decrease in feeding and rumination, increase in lying, standing and self-grooming behavior) in terms of animal welfare in sheep and goats (Ergul Ekiz et al., 2020). It also caused an increase in respiratory rate and water intake (Bernabucci et al., 2010) and an increase in water drinking frequency (Aleena et al., 2018). The behavioral response created by heat stress varies according to the perceived temperature threat. Heat stress is a phenomenon that negatively affects animal welfare, decreases productivity in animal production, increases health problems and causes economic losses (Ettinger and Feldman, 2009; Sucu et al., 2015). Improving the barn conditions according to the changing climatic conditions will prevent the loss of offspring and positively affect the productivity of the animals (Ünal et al., 2018).

In brief, heat stress affects various breeding characteristics and reproduction in sheep and goats, and timely interventions are required to improve animal welfare and production.

3.5. Climate Change and the Advantages of Sheep and Goat Breeding

Due to the high ability of sheep and goat to digest various plant species and feed sources that may be affected by climate change, they will come to the fore as species that will provide advantages in animal production in the future. Among the ruminant animals, the animal species with high resistance to diseases and adaptability to heat stress is the goat. The importance of sheep and goat breeding will increase, especially in meeting the needs of the dairy industry. Goats have lower metabolic requirements due to their low body mass, ruminant species due to their large salivary glands, large mucosal surface area that absorbs roughage, and anatomical and physiological features that increase the foregut volume. They can live in desert conditions (Silanikove and Koluman Darcan, 2015). More than 50% of goats in the world are bred in arid climates. This shows that goats are advantageous compared to other species in terms of adaptation to heat stress (Monteiro et al., 2018). The greenhouse gas emission share of goats among sheep and goat breeding is low compared to other species (Koluman Darcan and Silanikove, 2018). It is reported that HSP 70 (Heat shock protein 70) for heat tolerance in goats can be used safely as a genetic marker in determining the thermo tolerance capacities of domestic goat breeds (Aleena et al., 2018). In Figure 3, CO_2 emission values by species are given. Cattle account for approximately 62% of sector emissions, while pigs, poultry, buffalo, sheep and goat account for 7 to 11% of sector emissions.

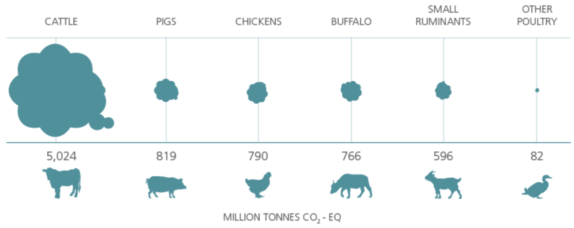

Figure 3. Emissions by species (FAO, 2021a).

When the figure is examined, it is seen that the greenhouse gas emission share of sheep and goats among farm animals is lower than other species (FAO, 2021a). In Table 2, global production, emissions and emission intensity values are given according to species. The average emission intensity from sheep and goats in the world was determined as 6.5 kg CO2-eq/kg product from milk production and 23.8 kg CO2-eq/kg product from meat production (Gerber et al., 2013; Opio et al., 2013; Macleod et al., 2013).

Table 2. Global production, emissions and emission intensity for species (Gerber et al., 2013; Opio et al., 2013; Macleod et al., 2013)

Species	Production (Million tons)		Emissions (Million tons CO_2-eq)		Emission intensity (kg CO_2-eq/kg product)	
	Milk	Meat	Milk	Meat	Milk	Meat
Cattle dairly	508.6	26.8	1419.1	490.9	2.8	18.4
Cattle beef	-	34.6	-	2345.9	-	67.8
Totals	508.6	61.4	1419.1	2836.8	2.8	46.2
Buffalo milk	115.2	2.4	389.9	40.4	3.4	16.6
Buffalo meat	-	0.95	-	139.9	-	143.9
Totals	115.2	3.4	389.9	180.2	3.4	53.4
Sheep	8.0	7.8	67.4	186.9	8.4	24.0
Goat	11.9	4.8	62.4	112.5	5.2	23.5
Totals	20.0	12.6	129.4	299.4	6.5	23.8
Pigs	-	110.2	-	668	-	6.1
	Eggs	Meat	Eggs	Meat	Eggs	Meat
Chickens	58.0	72	217	389	3.7	5.4

4. Conclusion

Pasture-based livestock systems are expected to be more affected by global warming than industrial livestock systems. Because solar radiation caused by global warming, high temperature, low precipitation and drought directly affect the pastures and plants. Pasture-based livestock is the preferred system mainly in developing countries, and a 25% loss in animal production due to global warming is predicted in these countries. After remaining virtually unchanged from 2014 to 2019, the prevalence of malnutrition (PoU) rose from 8.4 percent a year ago to 9.9 percent in 2020. In terms of population, taking into account the additional statistical uncertainty, it is estimated that between 720 and 811 million people worldwide are facing hunger in 2020 (FAO, 2021b). However, the increase in per capita consumption in parallel with the population growth in the coming years will also cause an increase in the demand for animal products (Nardone, 2002; Delgado, 2003). Therefore, the grazing capacity of pastures should be taken into account. The use of heat-resistant plant patterns and the use of agricultural wastes in animal nutrition can be increased by technological improvements. In addition, the production of forage crops that will capture methane, nitritoxide emissions and carbon dioxide, which have a significant effect on greenhouse gas emissions in pastures, can be encouraged (Durmuş and Koluman, 2019). Preventing the possible effects of climate change on animal breeding systems depends largely on the interactions of the components involved in this process. Transforming animal production into sustainable systems can significantly contribute to reducing the effects of climate change. It is necessary to establish specific and regional policies to ensure both humane and sustainable global food production. Native breeds are stronger and more durable than culture breeds raised in industrial enterprises. Therefore, our native breeds will provide an advantage in overcoming the problems caused by climate change (Koyuncu, 2017; Koyuncu and Akgün, 2018).

As a result, climate change poses a potential threat, directly or indirectly, for livestock and sheep and goat farming as well as humans. About half of the sheep and goat population are found in arid and semi-arid regions. Sheep and goats can adapt to stress factors better than other species due to the situation and physiological characteristics they are in. Studies show that sheep and goat adapt better to harsh environmental conditions and can be used for genetic improvement, especially in heat tolerance. By identifying genetic markers for heat tolerance, heat stress resistant breeds can be produced. However, it is known that the effects of climate change will vary in different regions, so region-specific studies are needed. In this direction, more studies should be done on genetic markers in addition to breeding studies on our native breeds. In order to prevent the negative effects of temperature changes, existing barns should be restructured and renewed with air conditioning systems. In order to reduce the possible effects of climate change on maintaining the production of sheep and goats, local breeds adapted to breeding programs that will be put forward by studies taking into account their environmental and genetic characteristics can be an alternative.

Author Contributions

All authors had equal contribution. All authors reviewed and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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UTILIZATION OF AGRICULTURAL WASTES FOR SUSTINABLE DEVELOPMENT

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Abstract: Embracing the idea of recycling wastes or changing waste to energy and other materials is an indispensable choice for sustainable development, and it is also a principal waste management mechanism. In whole world huge amount of wastes produced after harvesting. Those wastes can be a good source for alternative energy, new material like bio-composite and also for manure purposes. This study principally focuses on the utilization of agricultural wastes for sustainable development in areas related to organic manure usage, bioenergy production from the agricultural residues, and manufacturing of bio-composites. This article also addresses the potential of agricultural wastes in particular regions and the extent of their utilization to come up with a broader understanding of their effectiveness and practicality.

Keywords: Biomass, Agricultural wastes, Sustainability, Bioenergy

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1. Introduction

In the contemporary and dynamic world, population growth, technological advancement, food production abundance, and ultimately waste accumulation are expected outcomes. Bearing in mind the global population is increasing and it tends to rise, the core point is that how well the waste can be managed. This applies to agricultural wastes as well. Embracing the idea of recycling wastes or changing waste to energy is an indispensable choice for sustainable development, and it is also a principal waste management mechanism. Accordingly, this means guarantees the shift from a subsistence economy to a progressive economy.

The residues from the cultivation and processing of raw agricultural products such as field crops, fruits, vegetables, meat, poultry, dairy products, and crops are defined as agricultural wastes. They are the by-products of the production and processing of farm products that possibly comprise substances that profit users. Reasonably agro-wastes are having values inferior to the cost of gathering, transportation, and processing for useful purposes. Agricultural wastes exist in the form of liquids, slurries, or solids. The compositions of agricultural wastes greatly depend on the nature and kind of farm activities. They include animal manure, carcasses, food processing wastes and drops, and discarded fruits and vegetables. Although potential evaluations of agricultural waste are scarce, it is normally supposed that agricultural wastes contribute a substantial portion of the total waste materials in the developed world.

One-third of all edible components of food produced for human consumption is anticipated to be lost or wasted (FAO, 2015), with losses estimated to be worth $1 trillion USD (FAO, 2013). According to (Agamuthu, 2009) it is estimated that about 998 million tons of agricultural waste are produced annually. Out of which organic wastes covers up to 80 percent of the total solid wastes produced in any farm while manure amounts up to 5.27 kg/day/1000 kg live weight, on a wet weight basis (Obi et al., 2016). Indeed, an upsurge in agricultural production has resulted in an increased volume of livestock waste, crop residues, and industrial by-products. Similarly, there is a likelihood of a significant rise in agricultural wastes accumulation worldwide as developing countries keep on strengthening agricultural activities.

Innovation, science, and engineering have been the precursors for the rise in agricultural production that is considered a milestone as it meets the food demand due to the surge of population. Nonetheless, an increase in agricultural wastes accumulation continues to be a significant management challenge. This study principally focuses on the utilization of agricultural wastes for sustainable development in areas related to organic manure usage, bioenergy production from the agricultural residues, and manufacturing of biocomposites. This article addresses the potential of agricultural wastes in particular regions and the extent of their utilization to come up with a broader understanding of their effectiveness and practicality.

2. Agricultural Production in Turkey

In Turkey agricultural activities are at the forefront of the economy, agriculture has a great significance in meeting food demand, industrial raw materials and plays a huge role in exporting commodities and creating employment opportunities. Thus a huge amount of agricultural waste is generated annually. Agricultural wastes are residues from growing and processing agricultural products, which have no direct and considerable use. Crops and animals account for over 90% of Turkey's agricultural industry. Ecological and health issues associated with wastes produced by the agricultural industry are significantly high (Dumanli et al., 2007). Approximately three-fourths of total Turkey's cropland and annual production is covered by cereal products such as wheat and barley. Cottonseed and sugar beet are among the other important products of Turkey having an estimated annual production of approximately 2 million tons, and 10 million tons, respectively (Dumanli et al., 2007).

According to the sources from the Turkish Statistical Institute (TUIK) the total production from crops such as wheat, corn, nut, legumes, citrus, sunflower, tobacco, mulberry, cotton, rose, rice, sugar beet, olive, peanuts, tea, sesame, and fruits is presented in Table 1. Having the above agricultural production, the potential of agricultural residues from main crops is computed using the ratio of product to residues, and the averaged amount is represented in Table 2. Moreover, the potential of residues from main fruits has been computed as it appears in Table 3.

Similarly according to the data from TUIK, the potential of animal production in Turkey has been depicted in Table 4. By using the values provided in Table 5 the amount of waste from animals can be determined. For cattle, the body weight is taken as 400 kg, 50 kg for small ruminants, and 2 kg for poultry. Along with this, the daily amount of wet waste, as a percentage of body weight is chosen as 5% for cattle, 4% for small ruminants, and 5% for poultry (Onurbas and Türker, 2012). According to these values, daily amounts of wet waste are considered as 20 kg for cattle/day, 2 kg/day for small ruminant, and 0.1 kg for poultry/day.

Table 1. Crop production in Turkey

Types of produce	Year	Tons
Cereals	2019-2020	33401704
Rice	"	600000
Dried pulses	"	1230281
Potato	"	4979824
oil seed	"	2100000
Sugar beet	"	18054320
Nuts	"	1308701
Citrus Fruits	"	4301415
Other fruits	"	530723
Tea		1407448
Root and Tuber	"	3328051
Vegetables cultivated for their fruit	"	24336795
Leguminous vegetables	"	734342
Other vegetables	"	1788209
Total vegetables	"	26859346

Table 2. Agricultural residue potential in Turkey from main field crops (Ergudenler and Isıgıgur, 1995; Ozturk and Bascetincelik, 2006; Onurbas et al., 2011; Okello et al., 2013; Riva et al., 2014)

Agricultural crops	Residue types	Ratio of product Residue (RPR)	Production (Ton)	Residue (Ton)	Reference
Wheat	Straws	1.125	19000000	21375000	1,4
Barley	Straws	1.22	7600000	9272000	1
Maize	stalks	1.6	6000000	9600000	4
Rapeseed	Stalks	1.7	180000	306000	3
Sugar beet	Leaves	0.13	18054320	2347062	4
Rice	Straw	1.1	600000	660000	1
Soybean	Straws	2.13	150000	319500	1
Chickpea	Straws	1.3	630000	819000	2
Beans	Stems	1.45	225000	326250	5
Cotton	Stalks	2.3	1320000	3036000	1
Potato	Vines	0.4	4979824	1991929.6	5
Tubers	Leaves	0.5	3328051	1664026	1
Walnut	Shells	0.66	225000	148500	1
Hazelnut	Shells	0.87	776046	675160.02	1

Table 3. Agricultural residue potential in Turkey from main fruits (Ozturk and Bascetincelik, 2006; Okello et al., 2013; Riva et al., 2014)

Fruit Type	Residue types	Ratio of product Residue (RPR)	Production (Ton)	Residue (Ton)	Reference
Grape	Pruning	0.42	4100000	1722000	1
Lemon	Pruning	0.3	950000	285000	1
Mandarin	Pruning	0.29	1400000	406000	1
Orange	Pruning	0.35	1700000	595000	1
Banana	Stalk-Peels	2	548323	1096646	3
Fig	Pruning	0.21	310000	65100	2
Pear	Pruning	0.22	530723	116759.06	2
Cherry	Pruning	0.19	664224	126202.56	1
Peach	Pruning	0.4	830577	332230.8	2
Apricot	Pruning	0.19	863856	164132.64	1
Apple	Pruning	0.19	3618752	687562.88	1
Grape fruit	Pruning	0.11	249185	27410.35	1

Table 4. Number of farm animals in Turkey from TUIK for 2020

Animal Type	Number of Animals
Cattle	18157971
Sheep	42126781
Goat	11985845
Other	225713
Poultry	386 080 582

3. Potential of Agricultural Crop Residues in the European Union

Varying climatic features and agronomical practices across the member states are the leading reasons for great variations of yields, crop types, and arable areas, in the European Union. In terms of area cultivated and amount of production, cereals and oilseeds are of great significance. Likewise, depending on variability in rain-fed conditions, crop residues produced from annual crops are quite variable in yield from one year to another (Scarlat et al., 2010).

As a common agricultural practice, some portion of the substantial amount of agricultural residues is left in the field after harvest. The amount of residue production depends on several factors such as the types of crops, crop rotation, crop mix, and agricultural practices (Summers et al., 2003). The amount of residues is directly related to crop yield, total arable area. Along with these all reasons the availability of residues is also affected by the amount that can be used for agricultural or industrial purposes.

According to the data from the Food and Agricultural Organization FAO database, the agricultural production of the European Union for the year 2019 is shown in Table 6. The estimate of agricultural residues is directly related to crop production thus, depending on the crop yield and type the potential of residues of specific crop that can be employed for different purposes by using data and the ratio of product to residue is as follows.

Similarly the potential of residues from fruit crops has been summarized in Table 7 by applying the same approach used in assessing the amount of residues in Turkey. The European Union is characterized by the production of large of amount of livestock. According to the FAOSTAT the animal population is represented as it follows in Table 8. By employing the data given in Table 8 the total wet waste in daily basis is estimated with the approach of body mass ratio and has been summarized in Table 9.

Table 5. Wet waste estimation from the population of animals in Turkey

Animal Type	Body weight (kg)	% of weight	Number of Animals	Wet waste 10^3kg/day
Cattle	400	5	18157971	363159.42
Sheep	50	4	42126781	84253.56
Goat	50	4	11985845	23971.69
Poultry	5	5	386 080 582	96520.14

Table 6. Agricultural residue potential in the European Union from selected crops

Crops	Yield (Ton)	RPR	Residue (Ton)
Barley	63618190	1.22	77614191
Beans, green	995526	1.45	1443512
Hazelnuts	132410	0.87	115196
Maize	70092950	1.6	112148720
Potatoes	56403790	0.4	22561516
Rapeseed	17040880	1.7	28969496
Rice, paddy	2849130	1.1	3134043
Sorghum	1022120	1.25	1277650
Soybeans	2813260	2.13	5992243
Sugar beet	120577650	0.13	15675094
Walnuts	169730	0.66	112021
Wheat	155641710	1.125	175096923
Pulses	4916439	1.3	6391370
Tubers	56403790	0.5	28201895
Tree-nuts	1105770	0.66	729808
Vegetables	55295312	0.4	22118124

Table 7. Agricultural residue potential in the European Union from fruit crops

Crops	Yield (Ton)	RPR	Residues (Ton)
Apples	12044780	0.19	2288508
Apricots	771200	0.19	146528
Bananas	643610	2	1287220
Cherries	578055	0.19	109830
Cherries, sour	295790	0.19	56200
Figs	92420	0.21	19408
Grapefruit	103190	0.11	11351
Grapes	24216454	0.42	10170911
Oranges	6096740	0.35	2133859
Pears	2080036	0.22	457608

Table 8. Number of farm animals in the EU for 2019 according to FAOSTAT

Animal Type	Number of Animals
Buffaloes	459100
Cattle	86877723
Poultry	1280598
Goats	12219237
Horses	2879538
Pigs	148236856
Sheep	97272502

Table 9. Wet waste estimation from the population of animals in the EU

Animal	BW (kg)	NA	WW
Buffaloes	400	459100	9182
Cattle	400	86877723	1737554.5
Poultry	50	1280598	2561.2
Goats	50	12219237	24438.5
Sheep	5	97272502	243181.2

BW= body weight, NA= number of animals, WW= wet waste, 10^3 kg/day

4. Organic Manure

Organic fertilizers are mineral sources that are found in nature having an adequate amount of plant nutrients. They are capable of resolving issues caused by artificial fertilizers. They minimize the need to apply chemical fertilizers on a regular basis to preserve agricultural productivity. Organic fertilizers gently discharge nutrients into the soil, maintaining nutrient balance for plant growth and development. Organic fertilizers obtained from animal waste and plant residue serve as an effective energy source of soil microbes which play a great role in improving soil structure and crop growth.

Although better than chemical fertilizers when used improperly organic fertilizers can cause over-fertilization or nutrient deficiency in the soil (Lewu et al., 2021). Thus, the application of organic manure and residues is advantageous and has a positive impact to attain a sustainable agricultural industry. Using livestock manure as a fertilizer has a substantial effect on agricultural input energy demands (Obi et al., 2016). Manure can contribute a considerable amount of nitrogen, phosphorus, and potassium. Poultry manure is rich in phosphorus and has a favorable impact on crop growth and productivity. It is also important for agricultural use when mixed with mineral phosphorus fertilizer. Moreover, manure enhances soil fertility by increasing action exchange capacity, as well as improving water-holding capacity, and soil structural stability (Andong et al., 2019; Mokwunye, 2000).

According to (Jacinthe et al., 2011) manure applied to cultivated increases soil nutrients, and helps to absorb carbon in the soil. Comparing to traditional farming practices, Organic farming practices expand the size of the soil microbial population, additionally, the organic farming process enhances carbon substrate more effectively than conventional farming. Organic manure has a major role in facilitating composting. In the process of rapid composting of dairy manure with rice chaff changes in biochemical and microbiological parameters were found to be feasible for treating agricultural wastes, where dairy manure to rice chaff 3:1 volumetric ratio exhibited the most rapid temperature increase, the highest microbial population, and enzymatic activities, and hence the highest compositing rate (Liu et al., 2011).

5. Agricultural Wastes as Biofuels

The total energy consumption of the world was estimated at about 524 exajoules per year and has been anticipated to increase by about 65% by 2040 (Kambo and Dutta, 2015). In energy summits depletion of resources, the surge in price, and adverse ecological concerns related to the use of fossil fuels are the main discussion subjects. Decreasing consumption by replacing it with a sustainable and renewable energy resource would be among the most efficient lines of tackling these concerns. Biomass is a material of plant and animal origin including the materials acquired as a result of natural and artificial conversion. Materials including animal and municipal solid wastes are also labeled as biomass (Demirbaş, 2001). Biomass is the only renewable energy source that can be transformed into solid, liquid, and gaseous fuel (Özbay, 2001).

In their study (Hamawand et al., 2016) discovered that cotton waste represents a large percentage of the agricultural waste created as a by-product in Australia. Due to its woody structure, cotton stalk is found to be more appropriate for the production of energy pellets. Likewise, the difficulty, capital, and operating costs of such appellation are lower than the other alternatives. What is more important is that these palettes have the potential to be used in power plants to generate electricity. Agricultural wastes comprise lingo-cellulosic, which may be converted into biofuel using biochemical or thermochemical techniques, as shown in Table 10 below. For biochemical conversion for biofuel generation, feed-stocks with moisture content more than 30%, their C/N ratio of less than 30%, and high cellulose and hemicellulose content are required. While, Materials with less than 30% moisture, a C/N ratio of more than 30%, and a high lignin content are preferable for thermochemical conversion and subsequent treatment for biofuel generation.

In the biochemical method, various microorganisms are involved and the application of enzymes is essential to break down the feedstock into intermediate components such as sugars and amino acids before its conversion into liquid or gaseous fuel, such as biogas, bioethanol, and biodiesel. On the contrary, the thermochemical process is characterized by the application of heat and chemicals to produce synthesis gas or syngas, bio-oil, biochar, and biocoal. Even though thermochemical path uses a broad spectrum of wastes, from the standpoint of fossil fuel consumption and greenhouse gas emissions, the biochemical route is more preferable to the thermochemical route (Mu et al., 2010).

Table 10. Methods for Biofuel production

	Conversion Pathways	Methods	Biofuels		
Agricultural Waste	Biochemical Conversion	Fermentation	Bioethanol		
		ABE Fermentation	Bio-butanol		
		Anaerobic Digestion	Biogas		
		Dark Fermentation	Biogas		
	Thermochemical Conversion	Pyrolsysis	Syngas	Bio-oil	Char
		Gasification	Syngas		
		Torrefaction	Bio-oil		

6. Biogas

In Turkey imports of energy are expected to rise from nearly 70% to 90% of the total energy demands as the total energy demand is expected to double in the next decade. Meanwhile, it is predicted that the total biomass energy production will reach 52.5 Mtoe by 2030 (Balat, 2011). The biogas potential in a volume equal to animal-based waste potential in Turkey is said to be about 1.7 billion m3 per year. While biomass-based energy potential contributes to sustainable development, further investigation is necessary to figure out and formulate solutions at all levels to accelerate biomass usage (Ozturk et al., 2017). The poultry industry is one of the promptly growing industries in turkey. Most of the provinces engaged in large-scale poultry farming have over 1PJ biogas potential. The industry has a faster pace than the typical pace in the globe which proves the efficiency of the sector. Nevertheless, one of the major challenges of this industry is eliminating wastes (Avcioglu and Turker, 2012).

Generating biogas from farm residues makes an effective decrease of non-renewable energy consumption and particularly greenhouse gas release because of the reduction of methane emission that would have occurred due to manure storage. Thus designing biogas systems as per the climatic features and production facilities for low investment costs, high efficiency, and easy installation, operation and maintenance would certainly strengthen the growth of the biogas industry.

7. Biocomposites

Bio-composites are materials manufactured using renewable resources which are abundantly available. Bio-composites are ecologically friendly and decomposable, having characteristics that can be easily manipulated as per their particular application (Vinod et al., 2020). They are well-matched in the biomedical, automotive, and food industry. From the manufacturing industries' perspectives as bio-composites are multipurpose materials, farming for the production of raw materials is much encouraged, which consequently decreases the greenhouse effect (Ferreira et al., 2019).

Using residues or organic wastes in the formulations of composite is also a different method. For instance, improving the properties of the composites using biochar in polymer composites is a relatively new approach (Das et al., 2015). Through the process of pyrolysis, organic wastes can be changed into biochar, liquids and non-condensable gases as the feedstock are subjected to high temperatures. Biochar, charcoal-like material which is produced by burning organic matter, can play a great role in reducing toxic emissions because of its bulk surface area, pore size distribution, particle size distribution, packing, and density. Additionally, it is also helpful in reducing pollution by binding the heavy metals in soils and liquids (Väisänen et al., 2016). Nowadays finding novel and innovative ways of utilizing wastes and residues evolving from industrial and agricultural practices is one of the alarming ecological challenges. According to Sun et al., 2013 biomass residues are the potential raw material for biochar production. In addition to pyrolysis through pyrolytic processes, such as torrefaction biomass can be transformed into biochar. Nearly all forms of biomass can be changed into biochar. Biochar tends towards being cheap adsorbent, because of its capability to store some of the most familiar ecological contaminants.

Waste biomass streams have the highest potential to be economically feasible sources of biochar, On the other hand, being cost-effective farm residues have high potential in the area of energy generation and pollutant reduction (Roberts et al., 2009). Research on the development of composites made of different waste materials is being dynamically undertaken as the result of the worldwide demand for fibrous resources, wide range scarcity of trees, and growing ecological alertness. Developing composites using agricultural residuals such as stalks of most cereal crops, husks, cobs, shells, and other wastes has been among the promising options (Wang et al., 2009). Because they are abundant, prevalent, and easily accessible farm residues are one of the best alternative materials to replace wood. Apart from their availability and renewability, from an economic, environmental, and technological point of view utilization of agricultural residues is beneficial (Çöpür et al., 2007). Pyrolysis is a potential process for producing biochar and biofuels from digestates. Through intermediate pyrolysis, (Neumann et al., 2015) obtained bio-oil, pyrolysis char, and non-condensable gases from digestates obtained from an anaerobic digestion unit. They were able to transform approximately 91 percent of the biomass's initial energy content into products that could be used. Apart from plant fibers, biochars can be created from cow or chicken (Schouten et al., 2012; Hass et al., 2012) manure. Schouten et al. (2012) applied cattle manure to make biochar in an attempt to see whether anaerobically generated digestate and biochar had more carbon sequestration capacity than the manure. The study anticipated that the nitrogen mineralization of digestate and biochar would be lower than that of manure. According to the findings, the release of nitrogen in soil produced from the by-product decreased with anaerobic digestion and much more following pyrolysis.

According to a study, applying chicken dung biochar to a typical acid and severely weathered soil raised pH, enhanced nutrient availability, and lowered harmful and non-essential element levels (Hass et al., 2012). To conclude, the energy conversion industry is heavily focused on the use of organic matter and residues by traditional or even novel methods, yet there is an excess of underutilized or even completely unutilized residual material. Thus, instead of employing these materials as a local source of energy, their potential use could be considerably expanded by integrating them further into alternative technologies (Väisänen et al., 2016).

The potential of using organic materials and residues as ingredients or reinforcements in natural fiber-polymer composites NFPCs has been a center of interest, particularly in the last decade. The use of organic wastes in NFPCs has many advantages. Organic wastes and residues may be integrated into NFPCs in a variety of ways. For instance, relative levels of materials generated from non-renewable sources, such as matrix polymers and certain additives, can be reduced. As a result, the proportion of raw materials derived from renewable sources will rise, potentially lowering composites' overall raw material prices. The use of straw and other agricultural waste for composite material production has become a global interest. A study aimed at utilizing rice straw and corn-based adhesives for the development of eco-friendly materials composites made from hot-water treated straw and cornstarch showed a better interface and greater flexural characteristics (Liu et al., 2012).

8. Conclusion

Out of the ever-growing agricultural industry, a huge amount of agricultural waste is generated annually. Practically agro-wastes are having values inferior to the cost of gathering, transportation, and processing for useful purposes. Though part of residues is employed for immediate purposes, managing or eliminating agricultural wastes is one of the principal challenges of the modern agricultural industry and environmental safety. In handling the issue making estimates and knowing the potential application of every agricultural waste source is vital. Thus, it has been clear that the role of utilizing agricultural wastes in sustainable development is significant from organic manure to bioenergy and biodegradable materials.

Author Contributions

All authors had equal contribution and all authors

reviewed and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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