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A Comparative Study of Crop Evapotranspiration Estimation by Three methods with Measured Crop Evapotranspiration in Konya Plain.

Sinan SÜHERI[1,*], Peter Addo AMARKAI[1], Duran YAVUZ[1]

[1]Selçuk University, Faculty of Agriculture, Department of Agricultural Structure and Irrigation, Konya, Turkey

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ABSTRACT

Evapotranspiration values are one of the basic data used in the planning, design, construction and operation of irrigation facilities. The irrigation water needs of several plants are calculated by using various empirical equations based on meteorological data and the system is designed according to the month in which the highest irrigation water is needed. The aim of this study is to compare ETc of several crops calculated with different ETc estimation methods as of FAO56-Penman-Monteith, Hergeaves - Samani and Radiation Equation with determined ETc values obtained from previously conducted researches in Konya. In the study, five commonly cultivated crops in Konya Province such as maize, sugar beet, sunflower, potato and wheat were considered. In most of the cases, it was found that radiation equation produced higher ETc values than the measured ETc values in the researches conducted at the region. As a result of this study, Penman-Monteith was close to most of the values obtained from other studies and therefore remains a highly recommendable method for estimating ETc for considered plants in Konya.

1. Introduction

Konya province located in the Central Anatolia has semi – arid climate with hot and dry summers. Annual precipitation in Konya is about 322.4 mm which is relatively low as compared to country average. A bit over 4 percent of the population are engaged in agricultural activities. Most of the crops cultivated in Konya require irrigation because of hot and dry summers.

Agriculture is one of the major ways to obtain nutrient, medicine, and other products for sustaining life and also contributes largely to the gross domestic product of most economies. Livelihood enhancement programs, food security, and other socioeconomic interventions over the years have targeted development in agriculture by increasing crop production through improvement in technology to be able to meet the needs of the world's increasing population. The World Bank (2018) has projected a world population of 9.7 billion by 2050 that is about 28% increase of the current population of 7.6 billion suggesting that food production in the future must be increased to be able to match this growth. Climate on the other hand is known to affect food production in many ways. Climate is made up of many parameters including wind, air temperature, humidity, solar radiation, atmospheric pressure, and precipitation. All of these parameters are likely to change due to instability in the atmosphere. Variations in these parameters directly or indirectly affect agricultural activities.

Water plays a crucial role in agriculture; however, it is required to meet household, energy, manufacturing and ecological needs. Although the need for water is increasing in other sectors, irrigation continues to be the main consumer of water. According to the FAO (2018), the usage of water for irrigation generally amounts to about 70% of all freshwater withdrawals. Irrigation is a reliable way of providing plants with the water needed for growth and plant yield depends largely on the amount of water available and can be used at a particular period. Additionally, determining the amount of water needed by plants, and the amount that can be used by the plant for growth is necessary to determine the amount of water needed for irrigation to avoid excessive use of water and ensure plant growth.

Efficient management of declining water resources is an essential factor in achieving high irrigation

* Corresponding author email: *ssuheri@selcuk.edu.tr*

efficiency, reducing drainage, decontamination of groundwater and desalination. The irrigation water efficiency can be increased by a proper irrigation program which includes the calculation of plant water consumption or crop evapotranspiration (ETc). Evapotranspiration is simply the amount of water lost through evaporation and transpiration and it can be expressed as a function of reference Evapotranspiration (ETo) and the crop coefficient (Kc).

Evapotranspiration values are one of the basic data used in the planning, design, construction and operation of irrigation facilities. When planning an irrigation system, possible crops that can be cultivated under irrigation are determined and the planting rates in the irrigation area are estimated. The irrigation water needs of these plants are calculated by using various empirical equations based on meteorological data and the system is designed according to the month in which the highest irrigation water is needed.

The aim of this study is to calculate ETc of several crops cultivated in Konya plain by using different ETc estimation methods and to compare estimated ETc values with determined ETc values obtained from previously conducted researches in the region.

2. Materials and Methods

2.1. Study Area

Konya where the research was conducted has arid climate conditions with hot and dry summers. According to long-term meteorological data (1929 – 2017), annual mean temperature, annual mean evaporation , annual mean precipitation are 11.6° C, 1324 mm and 322.4 mm, respectively.

Monthly measured data for 10 years (2000-2010) period were obtained from Konya meteorological station (latitude 37.9837 N, longitude 32.5740 E, elevation 1031 m) for calculation of ETo (reference crop evapotranspiration), (Table 1).

Table 1
Meteorological data of experimental area (2000-2010)

Months	Mean Max Temp (°C)	Mean Min Temp (°C)	Monthly Sunshine duration (n)(Hours/Month)	Monthly average wind speed (u2)	Monthly mean relative humidity (%)
January	5.65	-3.05	103.05	2.12	82.19
February	7.24	-2.39	136.03	2.82	76.87
March	13.79	1.05	196.02	3.22	64.65
April	17.4	4.78	208.6	3.04	63.3
May	23.07	9.26	267.49	2.9	56.64
June	28.1	14.06	296.69	3.36	46.97
July	31.3	17.37	328.17	3.68	41.49
August	31.69	17.6	319.18	3.32	39.5
September	26.43	12.37	266.11	2.75	49.62
October	20.32	7.35	213.3	2.48	62.38
November	13.25	1.42	158.38	2.2	75.73
December	6.75	-2.2	102.12	2.08	83.35

2.2. Reference ETo calculations.

Three ETo calculation methods as of FAO56-Penman Monteith, Hargreaves and Samani, and Radiation equation were used to calculate ETo. The methods used in this study are cited and described in Allen et al. (1998), Hargreaves and Samani (1985) and Doorenbos and Pruitt (1977) respectively.

The FAO56 Penman Monteith method as stated by Allen et al. (1998) is

$$ET_o = \left(\frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \right)$$

Where; Rn = net radiation at the crop surface [MJ m^{-2} day^{-1}], G = soil heat flux density [MJ m-^{2} day^{-1}], T = mean daily air temperature at 2 m height [°C], u_2 = wind speed at 2 m height [m s-1], es = saturation vapor pressure [kPa], ea = actual vapor pressure [kPa], es – ea = saturation vapor pressure deficit [kPa], Δ = slope vapour pressure curve [kPa $°C^{-1}$], γ = psychrometric constant [kPa $°C^{-1}$].

The Hargreaves and Samani method as stated by Hargreaves and Samani (1985) is,

$$ET_o = 0.0023Ra(T_{max} - T_{min})^{0.5}(T_{mean} + 17.8)$$

Where; Ra = extraterrestrial radiation (MJ m^{-2} day^{-1}/2.45), Tmin = monthly minimum air temperature (°C), Tmax = monthly maximum air temperature (°C), Tmean = monthly mean air temperature (°C).

The radiation method as stated by Doorenbos and Pruitt (1977) is

$$ET_o = c(W * Rs)$$

Where; ETo = reference crop evapotranspiration (mm day^{-1}), Rs = solar radiation in equivalent evaporation (MJ m^{-2} day^{-1}), W = weighting factor which depends on temperature and altitude, C = adjustment factor which depends on mean humidity and daytime wind conditions. W factor was calculated according to formula given by Doorenbos and Pruitt (1977)

$$W = \frac{\Delta}{\Delta + \gamma}$$

Where; Δ = slope of the saturation vapour pressure temperature relationship (kPa °C^{-1}), γ = psychrometric constant (kPa °C^{-1}), C factor was calculated according to formula given by Allen and Pruitt (1991)

$$C = 1.066 - 0.00128RH_{mean} + 0.045U_d - 0.0002RH_{mean}U_d - 0.0000315(RH_{mean})^2 - 0.001103(U_d)^2$$

Where; Rhmean=Mean relative 3umidity (%), Ud = mean wind speed at 2 m

2.3. Determination of Crop Evapotranspiration

The Crop evapotranspiration was calculated with following formula given by (Allen et al., 1998)

$$ETc = Kc \cdot ETo$$

Where; ETc = crop evapotranspiration (mm day^{-1}), Kc = crop coefficient, ETo = reference crop evapotranspiration (mm day^{-1})

The crop evapotranspiration of five different crops; maize (grain), sugar beet, sunflower, potato and wheat which are commonly cultivated on the region were calculated.

The Kc coefficients and planting periods were taken from Anonymous (2016). The Kc coefficients and growth periods of the crops for Konya meteorological stations are given in Table 2.

The Kc coefficients during initial and mid-season were considered as fixed. Kc coefficients for per month were determined graphically as stated by Allen et al. (1998).

Table 2
Kc coefficients and planting periods of the crops for meteorological stations Anonymous (2016).

Crops	Planting date	Planting Time (days)	Plating periods Kc coefficients			Length of growth stages (days)			
			Kc_{ini}	Kc_{mid}	Kc_{end}	I	II	III	IV
Maize	10/05	160	0.23	1.18	1.07	30	40	50	40
Potato	10/04	140	0.25	1.18	0.78	30	35	50	25
Sugarbeet	1/04	185	0.26	1.22	0.71	30	50	70	35
Sunflower	20/04	145	0.29	1.08	0.37	25	30	60	30
Wheat	20/10	270	0.63	1.16	0.27	170	30	40	30

3. Results and Discussion

ETo results calculated using FAO-56 Penman Monteith, Hargreaves and Samani, and Radiation equation as presented in Table 3 shows an annual sum of 41.82, 38.69 and 50.86 mm/day and averages 3.49, 3.22 and 4.24 mm/day respectively.

The Radiation equation produced the highest monthly ETo with a minimum of 0.95 mm/day and maximum ETo of 8.37 mm/day. FAO56-Penman Monteith method recorded a minimum of 0.70 mm/day and a maximum of 7.36 mm/day. Hargreaves and Samani method yielded values which are closer to FAO56-Penman Monteith in most months than the Radiation equation.

The highest ETo was 6.02 mm/day and a minimum value was 0.84 mm/day obtained by using Hargreaves and Samani estimation methods.

Table 3
ETo values (mm/day) calculated with different methods.

Months	FAO56 – Penman Monteith	Hargreaves and Samani	Radiation Equation
January	0.70	0.86	1.01
February	1.12	1.27	1.68
March	2.26	2.38	3.06
April	3.10	3.39	4.19
May	4.47	4.72	5.89
June	6.19	5.71	7.54
July	7.36	6.02	8.37
August	7.05	5.54	7.79
September	4.76	4.02	5.46
October	2.76	2.52	3.22
November	1.33	1.42	1.70
December	0.72	0.84	0.95

The calculated ETo was used to estimate the ETc of maize in this study as shown in Table 4. Maize plant has a growing period of 160 days that is from May to October and crop coefficient Kc of 0.22, 0.42, 1.06, 1.19, 1.16 and 1.10. The total ETc for maize was 817.83, 682.96, and 934.85 mm according to the different methods. The highest ETc was obtained when the radiation equation was used whereas the least value was recorded when the Hargreaves and Samani method was used.

The ETc of the maize crop determined in a research conducted by Kara (2011) in 2009 at Konya. Kara (2011), investigated the effects of four different irrigation levels and 7 day irrigation interval on maize yield and yield components. It was stated that total ETc of maize crop ranged between 590 mm and 781 mm in the study.

The researcher has indicated that the ETc was measured as 727.7 mm for the treatment where maximum yield was obtained.

In the another study conducted during the growing period in 2009 -2010, ETc values of maize were ranged between 555 mm and 779.1 mm for 2009, 602.4 mm and 812.5 mm for 2010. The ETc values of the treatment where the maximum yield obtained were 779,1 mm for 2009 and 812,5 mm for 2010 (Şahin et al., 2015).

Table 4
ETc of Maize calculated with different methods.

Months	Days	Kc	Penman Monteith		Hergeaves Samani		Radiation Equation	
			ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)
May	21	0.22	4.47	20.65	4.72	21.81	5.89	27.21
June	30	0.42	6.19	77.99	5.71	71.95	7.54	95.00
July	31	1.06	7.36	241.85	6.02	197.82	8.37	275.04
Aug	31	1.19	7.05	260.07	5.54	204.37	7.79	287.37
Sept.	30	1.16	4.76	165.65	4.02	139.90	5.46	190.01
Oct.	17	1.10	2.76	51.61	2.52	47.12	3.22	60.21
Total	160			817.83		682.96		934.85

When ETc values measured in Kara (2011) were compared with the ETc values estimated in this study, the ETc values calculated with FAO56-Penman-Monteith and Radiation Equation were higher than maximum ETc values calculated in Kara (2011). Hergeaves and Samani method produced closer ETc values to the measured ETc values.

It can be concluded that Radiation Equation overestimated the maize crop ETc in the region.

When ETc values measured in Şahin et al. (2015) were compared with the ETc values estimated in this study, it can be stated that Penman Monteith methods produced closer ETc values to the measured ETc values in the study.

Table 5
ETc of Sugar beet calculated with different methods.

Months	Days	Kc	Penman Monteith		Hergeaves Samani		Radiation Equation	
			ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)
April	29	0.26	4.47	34.87	4.72	36.82	5.89	45.94
May	31	0.60	4.47	83.14	4.72	87.79	5.89	109.55
June	30	1.12	6.19	207.98	5.71	191.86	7.54	253.34
July	31	1.23	7.36	280.64	6.02	229.54	8.37	319.15
Aug	31	1.23	7.05	268.82	5.54	211.24	7.79	297.03
Sept.	30	0.97	4.76	138.52	4.02	116.98	5.46	158.89
Oct.	3	0.73	2.76	6.04	2.52	5.52	3.22	7.05
Total	185			1020.01		879.75		1190.96

The ETc of sugar beet calculated in this study were 1020.01 mm, 879.75 mm, and 1190.96 mm using the Penman-Monteith, Hargreaves and Samani, and the Radiation equation as presented in Table 5. The growing period for sugar beet is 185 days. Higher ETc was recorded within the mid-season of the growing period.

Süheri et al. (2007) calculated the seasonal ETc of sugar beet throughout the development stages in 2005 and 2006. It was observed that ETc values ranged from 203 mm to 1177 mm in 2005 and 200 mm to 1002 mm in 2006 for the various seasons. The study also computed the ETc for the vegetative growth stage, root development stage, and ripening stage of sugar beet. ETc was mostly high during the root development stage.

Another study conducted in Konya by Poçan (2008) considered the calculation of seasonal and monthly ETc for sugar beet in 2006 and 2007. The total ETc ranged from 826 mm to 1135 mm in 2006 and 907 mm to 1182 mm in 2007.

Topak et al. (2016) conducted a study to compare partial root-zone drying with conventional deficit irrigation and full irrigation in Konya. The researches indicated that, the measured ETc values of sugar beet were ranged between 591.6 mm and 965.3 mm in the study.

When the total ETc results obtained from full irrigation treatments in this studies were compared with ETc measured with the three methods, the radiation equation was higher than the maximum ETc obtained in Süheri et al. (2007) study, the maximum ETc calculated by Poçan (2008) and the maximum ETc calculated by Topak et al. (2016). . Penman-Monteith and Hargreaves and Samani method had ETc values within the ranges observed in Süheri et al. (2007) , Poçan (2008) and Topak et al. (2016).

Table 6
ETc of Sunflower calculated with different methods.

Months	Days	Kc	Penman Monteith		Hergeaves Samani		Radiation Equation	
			ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)
April	10	0.23	4.47	10.28	4.72	10.86	5.89	13.55
May	31	0.36	4.47	49.89	4.72	52.68	5.89	65.73
June	30	1.00	6.19	185.70	5.71	171.30	7.54	226.20
July	31	1.09	7.36	248.69	6.02	203.42	8.37	282.82
Aug	31	0.95	7.05	207.62	5.54	163.15	7.79	229.42
Sept.	12	0.51	4.76	29.13	4.02	24.60	5.46	33.42
Total	145			731.31		626.00		851.13

The results of ETc for sunflower using Penman-Monteith, Hargreaves and Samani, and Radiation have been presented in Table 6. The total growing period for sunflower is 145 days and the planting period started from April and end in September. The total ETc are 731.31 mm, 626 mm, 851.13 mm.

Yavuz et al. (2016) calculated the ETc for sunflower cultivated in Konya with different irrigation interval in 2013 and 2014. The results of the study shows a total mean ETc ranging from 243.8 mm to 748.7 mm in 2013 and 2014.

ETc determined by the radiation equation in this study was higher than maximum ETc measured by Yavuz et al. (2016) The ETc values calculated with Hergeaves and Penman Monteith in this study were lower than maximum ETc values measured by Yavuz et al. (2016). However, Penman Monteith method produced closer ETc values to the ETc values measured by Yavuz et al. (2016).

Table 7
ETc of Potato calculated with different methods.

Months	Days	Kc	Penman Monteith		Hergeaves Samani		Radiation Equation	
			ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)
April	20	0.25	4.47	22.35	4.72	23.60	5.89	29.45
May	31	0.44	4.47	60.97	4.72	64.38	5.89	80.34
June	30	1.09	6.19	202.41	5.71	186.72	7.54	246.56
July	31	1.18	7.36	269.23	6.02	220.21	8.37	306.17
Aug	28	1.00	7.05	197.40	5.54	155.12	7.79	218.12
Total	140			752.36		650.03		880.64

Potato has a growing period of 140 days with crop coefficient Kc of 0.25, 0.44, 1.09, 1.18, and 1.00 were used to calculate the ETc using Penman-Monteith, Hargreaves and Samani, and radiation equation. The total ETc calculated using the methods are 752.36 mm, 650.03 mm, and 880.64 mm. In the mid-season stage of potato, the ETc values were high for each of the methods.

Yavuz et al. (2012) also measured seasonal ETc in 2008 and 2009 of different irrigation methods for potato in Konya. The study determined the ETc for a sprinkler irrigation, furrow and drip irrigation system. The seasonal ETc in Yavuz et al. (2012) study were 665.69 mm, 614.64 mm, and 581.54 in 2008 for each of the irrigation methods used. In 2009 the seasonal ETc estimated in Yavuz et al. (2012) study were 674.76 mm, 621.96 mm, and 562.79 mm.

The ETc calculated in this study using Penman-Monteith and the Radiation method had higher ETc for potato than the values obtained in Yavuz et al. (2012) study. The Hargreaves and Samani method was within the range observed in Yavuz et al. (2012) estimation.

Wheat is grown for 270 days and the results of ETc calculated with different methods have been represented in Table 8. Today ETc of wheat with Penman-Monteith method was 588.62 mm, Hargreaves and Samani method was 598.23 mm, and radiation equation was 758.85 mm in Konya. The estimation of ETc was higher when the radiation equation was used. Penman-Monteith method is the method with the least value of ETc for wheat.

Tari (2016) conducted a study to create deficit irrigation strategies for wheat. In the research, 22 experimental treatments were created based on the growth stages of wheat and water-deficit levels in Konya plain. The seasonal ETc was observed to be varied between 206 and 571 mm in the study.

When the results obtained from this study was compared to Tari (2016)'s, it was observed that Penman-Monteith method was about 18 mm higher than ETc determined in Tari (2016) study. The Hargreaves Samani was about 28 mm high when compared with the maximum ETc from Tari (2016) and the radiation equation was over 180 mm higher.

Table 8
ETc of Wheat calculated with different methods.

			Penman Monteith		Hergeaves Samani		Radiation Equation	
Months	Days	Kc	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)	ETo (mm/day)	ETc (mm/month)
January	31	0.63	0.70	13.67	0.86	16.80	1.01	19.73
February	28	0.63	1.12	19.76	1.27	22.40	1.68	29.64
March	31	0.65	2.26	45.54	2.38	47.96	3.06	61.66
April	30	0.93	3.10	86.49	3.39	94.58	4.19	116.90
May	31	1.16	4.47	160.74	4.72	169.73	5.89	211.80
June	30	0.9	6.19	167.13	5.71	154.17	7.54	203.58
July	7	0.38	7.36	19.58	6.02	16.01	8.37	22.26
October	21	0.63	2.76	36.51	2.52	33.34	3.22	42.60
November	30	0.63	1.33	25.14	1.42	26.84	1.70	32.13
December	31	0.63	0.72	14.06	0.84	16.41	0.95	18.55
Total	270			588.62		598.23		758.85

4. Conclusion

In conclusion, the results of this study suggest that the radiation method is not suitable in estimating plant water consumption in Konya because it produced the highest ETc in most cases, however, comparison with the other studies shows over estimated values which cannot be recommended for irrigation scheduling. Penman-Monteith was close to most of the values obtained from other studies and therefore remains a highly recommendable method for estimating ETc for considered plants in Konya.

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Improvement of Physical and Sensory Properties of Bread Containing Cereal-Legume Composite Flour

Elif YAVER[1], Nermin BİLGİÇLİ[1,*]

[1]Necmettin Erbakan University, Engineering and Architecture Faculty, Food Engineering Department, Konya, Turkey

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ABSTRACT

In this study, cereal-legume flour blend (CLFB) containing an equal amount of cereal (rye, barley and oat) and legume (chickpea, soy and lupin) were used in the formulations of commercial bread (CB) and traditional flat bread (TFB) at 25% level. The adverse effect of CLFB on technological quality of breads was tried to eliminate using different combinations of additives (vital gluten, fungal alpha amylase, sodium stearoyl-2-lactylate, ascorbic acid, transglutaminase, glucose oxidase, lipase, pentosanase and xylanase) in both breads. Combinations with vital gluten, sodium stearoyl-2-lactylate, fungal alpha amylase, ascorbic acid and xylanase or pentosanase provided the highest bread specific volume along with CB prepared with 100% wheat flour. The additive combination including xylanase also revealed the lowest hardness in CB, as well as resulted in a decrease in the spread ratio and hardness values of TFB. Crust colour values (*L**, *a** and *b**) were significantly (P<0.05) affected by all of the additive combinations in both CB and TFB. The combinations containing pentosanase or xylanase displayed a better improvement on the pore structure, appearance and overall acceptability scores of CB and TFB including 25% CLFB in comparison to other additives.

1. Introduction

Cereals such as rye, barley and oat are of great sources of carbohydrates, proteins, dietary fibres, phytochemicals, minerals and vitamins (B-complex and E) (Slavin, 2004). Legumes (chickpea, soy, lupin, etc.) have a remarkably high protein content, along with a good amount of lipid, dietary fibres, vitamins and minerals such as Ca, Fe, Zn, Mg, P and K (Garcia et al., 1997). Due to the rich nutritional composition of whole flours of cereals and legumes, they are used as functional ingredients in food formulations such as bread. Most common diseases such as obesity, diabetes, heart diseases and some type of cancer are associated with an unhealthy diet which lacks the beneficial nutrients for consumption. A number of studies have suggested that a high intake of whole flours of cereal and legume in diet might have a positive effect on human health and prevention of the diseases mentioned (Belski, 2012; Malkki and Virtanen, 2001). Although the nutritional and functional properties of breads improve in the presence of whole flours of cereal and legume, the technological properties of the end product are partially lost. Therefore, using some additives (vital gluten, oxidants, emulgators and enzymes) can help enhance the technological quality of the end-product.

Unique visco-elastic properties of vital wheat gluten improve bread volume and dough strength as well as mixing tolerance and handling properties of dough. It increases shelf life of the bread by increasing the water holding capacity of dough and gives softness to bread. Hence, vital gluten allows to enhance the nutritional value of refined wheat bread with various cereal and legume flours and renders it acceptable for consumers (Day et al., 2006).

Sodium stearoyl-2-lactylate (SSL) is an emulgator that is used as an anti-staling and dough improving agent (Stampfli and Nersten, 1995). Van Steertegem et al. (2013) reported that SSL interacts with gluten and strengthen dough structure. Ascorbic acid (AA) is another bread improving agent that also possess an anti-staling effect (Gujral et al., 2003).

Fungal alpha amylase (FAA), transglutaminase (TG), glucose oxidase (GO), lipase, pentosanase and xylanase are enzymes which can be used in bakery industry to enhance bread quality. FAA reduces staling

* Corresponding author email: *nerminbil2003@hotmail.com*

rate, increases bread volume and improves handling properties, pore structure, crust and crumb colour (Maeda et al., 2003). TG enzyme changes chemical and functional properties of glutenin fraction and improves dough properties. Numerous studies have been reported that TG is used as a dough strengthener, loaf volume and crumb softness enhancer, handling properties improver (Gerrard et al., 1998; Seravalli et al., 2011). GO is an enzyme that catalyses D-glucose to D-gluconic acid and hydrogen peroxide. The hydrogen peroxide causes the formation of disulfide bonds and increases gelling properties of water-soluble pentosanes (Gujral and Rosell, 2004). Zeng et al. (2011) showed that alpha amylase and GO enzymes improved specific volume and pore structure of bread, with a delay in bread staling. Lipase enzyme provides in the formation of emulgators by hydrolyzing lipids. This enzyme has an anti-staling effect, and it improves rheological properties of dough, as well as increases bread volume (Castello et al., 1998; Olesen et al., 2000). Pentosanase hydrolyses high molecular weight arabinoxylans and affects dough and bread quality, provides a higher specific volume, softer dough structure and more sulphydryl groups (Rouau and Surget, 1998; Steffolani et al., 2010). Xylanase increases moisture content, volume, specific volume and overall acceptability while used in breadmaking (Shah et al., 2006). Hemalatha et al. (2014) reported that xylanase and amylase enzyme combination delays bread staling and alters rheological properties of bread.

The main objective of this study is therefore to evaluate the effects of different additive combinations on the physical and sensory properties of commercial bread (CB) and traditional flat bread (TFB) including 25% of cereal-legume flour blend (CLFB).

2. Materials and Methods

2.1. Materials

Wheat flour (commercial wheat flour contains 0.79% ash and 12.41% protein), baker's yeast, salt, chickpea and defatted whole soy flour were purchased from a local market in Konya, Turkey. Hull-less barley, hull-less oat and rye were obtained from Sağlık Tarım (Konya, Turkey). Traditionally debittered lupin seeds were provided by Doğanhisar, Konya, Turkey. Cereals and legumes (except soy) were milled (<500 µm) on a hammer mill (Perten 3100, Huddinge, Sweden) with 100% extraction ratio. Vital gluten, FAA, SSL, AA, TG, GO, lipase, pentosanase and xylanase were supplied from Vatan Gıda (İstanbul, Turkey).

2.2. Preparation of CLFB and bread samples

CLFB was prepared by mixing an equal amount of barley, oat, rye, soy, chickpea and lupin flours. CLFB was replaced with refined white wheat flour of 25% ratio (w/w) for preparation of bread formulations.

For the preparation of control-1 (C1) CB; 100 g wheat flour, 3 g baker's yeast, 1.5 g salt and water (determined by the farinograph absorption) kneaded in the mixer (Kenwood KMX750RD, Hampshire, UK) until obtaining a homogenous dough. The dough was left in bulk to fermentation (30+30 min, 30°C) and then rest at 30°C for 60 min. At the end of this period, dough samples were baked at 240°C for 15 min in an oven (Beko MF6, İstanbul, Turkey). In control-2 (C2) CB sample, wheat flour was replaced with CLFB of 25% ratio. To produce CB with 25% of CLFB and additives (from C3 to C9); vital gluten (2.5%), FAA (0.003%), SSL (0.5%), AA (0.01%), TG (0.5%), GO (0.001%), lipase (0.001%), pentosanase (0.004%) and xylanase (0.004%) were supplemented into bread formulations. Table 1 shows the enzyme combinations used in this study. The same procedure applied for C1 was also employed for C2-C9 CB.

Table 1
Combinations of additives used in CB[1] and TFB[2] formulations.

Formulations	Combinations of additives
C1 (Control-1)	0 % CLFB[3] (without additives)
C2 (Control-2)	25 % CLFB (without additives)
C3	25 % CLFB (Gluten+SSL[4]+FAA[5])
C4	25 % CLFB (Gluten+SSL+FAA+AA[6])
C5	25 % CLFB (Gluten+SSL+FAA+TG[7])
C6	25 % CLFB (Gluten+SSL+FAA+GO[8])
C7	25 % CLFB (Gluten+SSL+FAA+Lipase)
C8	25 % CLFB (Gluten+SSL+FAA+AA+Pentosanase)
C9	25 % CLFB (Gluten+SSL+FAA+AA+Xylanase)

[1]CB: Commercial bread. [2]TFB: Traditional flat bread. [3]CLFB: Cereal-legume flour blend. [4]SSL: Sodium stearoyl-2-lactylate. [5]FAA: Fungal alpha amylase. [6]AA: Ascorbic acid. [7]TG: Transglutaminase. [8]GO: Glucose oxidase

TFB was prepared according to the method given by Akbaş (2000). For the preparation of C1 TFB; 100 g wheat flour, 2.5 g baker's yeast, 1.5 g salt, 1 g sugar and water were kneaded until obtaining a homogeneous dough. After the dough was allowed to ferment at 30°C for 60 min, dough rounded into a ball shape and allowed to rest for 6 min at room conditions. The dough was flattened to the final thickness of 10 mm by a stainless steel circle of 17 cm diameter and then baked for 5 min on sac (metal plate heated by electrical resistances, 1500 W). To produce C2 TFB; wheat flour was replaced with 25% of CLFB. The enzyme combinations given in Table 1 were used from C3 to C9 TFB. The same method that was used in C1 TFB was also applied for the production of C2-C9 TFB.

2.3. Bread analyses

All bread samples were cooled at the room temperature (25±2°C) for 60 min, then the weight and volume of CB was measured (Elgün et al., 2001). The specific volume of CB was calculated by dividing the volume value by the weight. Diameter and thickness values of TFB samples were measured. The spread ratio was obtained by dividing the diameter values to the thickness values. Colour values (L^*, a^* and b^*) of breads were obtained by the colourimeter Minolta CR 400 (Konica Minolta Inc., Osaka, Japan). Saturation index (*SI*) was calculated by $(a^{*2}+b^{*2})^{1/2}$ formula and *hue* angle (if $a^*>0$ and $b^*>0$, arctan $[b^*/a^*]$; if $a^*<0$ and $b^*>0$, arctan $[b^*/a^*] + 180°$) was calculated using a^* and b^* values (Francis, 1998). Hardness values of both breads were measured using an aluminum 36 mm diameter cylindrical probe (P36/R) via a texture analyzer (Stable Micro Systems TA-XT.Plus, Surrey, UK) according to AACC 74-09 method at the end of 24 h and 72 h (Anon., 2002).

Sensory evaluation of the bread samples was performed by 25 panellists from the Food Engineering Department of Necmettin Erbakan University. Sensory properties (symmetry, pore structure, taste, odour, appearance and overall acceptability) of breads were evaluated using the hedonic scale 1-7 (1= dislike very much, 7 = like very much).

JMP (SAS Institute Inc., NC, USA) software was used to perform the statistical analyses. The averages of the data obtained were compared with each other and listed in the tables. All analyses were the average of triplicate measurements on the duplicate samples.

3. Results and Discussion

Physical properties of CB are presented in Table 2. Volume and specific volume of C2 CB reduced in comparison to C1 CB. The utilisation of 25% of CLFB in bread formulation decreased the bread volume due to the diluted gluten content as well as deterioration of the gluten network with CLFB. All the additive combinations had a positive effect on the volume and specific volume of breads compared to C2 CB. Combination of "vital gluten, SSL and FAA" (C3) markedly improved bread volume compared to C2 CB. SSL is considered as a dough strengthener and an emulsifier agent which provides a high volume and specific volume due to the formation of lamellar liquid films at the interfaces between starch and gluten (Gomes-Ruffi et al., 2012). FAA improves the gas holding capacity of dough during fermentation, thus it can increase the bread specific volume (Leon et al., 2002). At the same time, the combinations of "vital gluten, SSL, FAA, AA and pentosanase" (C8) and "vital gluten, SSL, FAA, AA and xylanase" (C9) provided the highest volume and specific volume results among additive combinations. Xylanase increases water absorption by dissolving water-insoluble arabinoxylan, thereby improves bread volume (Jeffries et al., 1998). The hardness values of at the end of 24 and 72 h have varied in the range of 2004 to 5321 g and 3059 to 5975 g, respectively. C8 and C9 showed a most positive effect on the hardness of CB. Similar results were also reported by Caballero et al. (2007) who studied the effects of enzyme combination (amylase and xylanase) on dough rheology, bread quality and shelf-life.

Table 2
Physical properties of CB samples.[1]

Formulations	Weight (g)	Volume (ml)	Specific volume (ml/g)	Hardness 24 h (F, g)	Hardness 72 h (F, g)
C1	139±0.85[c]	372±2.83[a]	2.67±0.03[a]	2726±8.7[e]	3555±9.3[f]
C2	143±0.85[a]	255±1.41[f]	1.78±0.05[d]	5321±8.3[a]	5975±10.5[a]
C3	142±0.42[abc]	322±1.41[e]	2.28±0.04[c]	3181±8.7[c]	4499±8.1[b]
C4	141±0.57[abc]	337±0.71[c]	2.39±0.04[bc]	3103±4.9[d]	4335±9.2[c]
C5	141±0.71[abc]	325±1.41[de]	2.30±0.06[c]	3250±11.1[b]	4521±10.9[b]
C6	142±0.57[abc]	327±2.83[de]	2.31±0.06[c]	3062±9.9[d]	3871±16.2[d]
C7	142±0.57[ab]	330±0.71[cd]	2.33±0.03[c]	2695±15.3[e]	3752±9.6[e]
C8	141±0.42[bc]	355±1.41[b]	2.52±0.02[ab]	2090±9.8[f]	3132±12.5[g]
C9	140±0.42[bc]	362±2.83[b]	2.58±0.05[a]	2004±14.6[g]	3059±12.5[h]

[1]Means followed by the same letter within a column are not significantly different (P < 0.05). Values are the average of triplicate measurements on the duplicate samples. CB: Commercial bread.

Physical properties of TFB are given in Table 3. The diameter values of TFB have varied in the range of 15.22 to 16.58 cm. The combination of C3 demonstrated a very close diameter result to C1 TFB. However, C9 combination showed the lowest diameter value. Compared to C1 TFB, replacement of wheat flour with CLFB was significantly (P<0.05) reduced thickness value of C2 TFB. On the other hand, the combinations of C8 and C9 provided the highest thickness values. The spread ratio values of TFB changed between 10.71 and 15.46. The combinations of "vital gluten, SSL, FAA and AA" (C4), "vital gluten, SSL, FAA and lipase" (C7), C8 and C9 presented lower spread ratio values than C1 TFB. This result may also be related to dough strengthener effects of AA, lipase, pentosanase and xylanase. In literature, there are many studies on improvement of dough with supplemented of these enzymes in bread formulations (Gujral et al., 2003; Olesen et al., 2000; Shah et al., 2006; Steffolani et al., 2010). The combinations of additives using in CB and TFB presented similar effects on hardness values of bread at the end of 24 h and 72 h. Compared to C2, the additives displayed significant (P<0.05) decrease in hardness values of TFB, at the end of 24 and 72 h. Armero and Collar (1998) found that a combination of SSL and alpha amylase revealed lower hardness values in bread than control. Similar results were obtained in studies with pentosanase (Renzetti et al., 2010), GO, amylase and xylanase (Caballero et al., 2007), gluten and TG (Gerrard et al., 1998; Salmenkallio-Marttila et al., 2004).

Table 3
Physical properties of TFB samples.[1]

Formulations	Diameter (cm)	Thickness (cm)	Spread ratio	Hardness 24 h (F, g)	Hardness 72 h (F, g)
C1	16.56±0.04^{ab}	1.21±0.04^{c}	13.70±0.05^{d}	5194±13.7^{d}	9483±12.6^{e}
C2	15.77±0.07^{e}	1.02±0.06^{d}	15.46±0.03^{a}	7223±13.4^{a}	14091±14.4^{a}
C3	16.58±0.04^{a}	1.18±0.04^{cd}	14.05±0.04^{c}	5744±9.8^{b}	10342±17.2^{b}
C4	16.39±0.04^{bc}	1.23±0.05^{bc}	13.30±0.05^{e}	4234±15.7^{i}	8588±12.3^{g}
C5	16.36±0.04^{c}	1.11±0.04^{cd}	14.69±0.06^{b}	5429±14.6^{c}	9897±15.7^{c}
C6	16.07±0.04^{d}	1.11±0.04^{cd}	14.54±0.04^{b}	5034±13.8^{e}	9307±10.6^{f}
C7	16.05±0.04^{d}	1.21±0.04^{c}	13.26±0.02^{e}	4920±11.5^{f}	9555±10.0^{d}
C8	15.58±0.03^{f}	1.39±0.04^{ab}	11.22±0.05^{f}	4510±11.5^{g}	7850±13.2^{h}
C9	15.22±0.03^{g}	1.42±0.04^{a}	10.71±0.06^{g}	4426±13.1^{h}	7405±10.9^{i}

[1]Means followed by the same letter within a column are not significantly different (P < 0.05). Values are the average of triplicate measurements on the duplicate samples. TFB: Traditional flat bread.

Colour values of CB are demonstrated in Table 4. Crust *L** values of CB changed between 54.32 and 65.94. All the additive combinations in CB caused lower crust *L** values than C1 and C2. Usage of 25% ratio of CLFB in C2 significantly (P<0.05) reduced crust *a** values of CB. The highest *a** values were obtained using the combinations of C3 or "vital gluten, SSL, FAA and GO" (C6) in CB. Compared to other bread samples, the combination of C9 (xylanase) showed more decrease in terms of crust *b** value in CB. It was reported that TG increased crust *L** and *b** values, GO and TG decreased *a** value, and xylanase enzyme showed a decrease on all of the colour parameters in wheat-soy breads compared to control bread (Roccia et al., 2012). Usage of C9 combination in CB resulted in the lowest *SI* and *hue* values. Usage of 25% CLFB increased crumb *L**, *a** and *b** values of CB, and so, the lowest crumb *L**, *a**, *b** and *SI* values were found in C1 CB. However, C1 CB had the highest *hue* values. Among additive combinations, C4 and C9 provided higher crumb *L** values and the combinations of C6 and C9 revealed greater result in terms of crumb *b** and *SI* values after C2 CB.

Table 4
Colour values of CB samples.[1]

Formulations	*L**	*a**	*b**	*SI*	*Hue*
Crust					
C1	61.98±0.04^{b}	9.85±0.04^{f}	30.54±0.06^{a}	32.09±0.04^{b}	72.12±0.10^{b}
C2	65.94±0.05^{a}	7.79±0.04^{g}	29.26±0.04^{d}	30.28±0.05^{e}	75.09±0.06^{a}
C3	57.98±0.06^{e}	12.87±0.02^{a}	29.87±0.04^{b}	32.52±0.05^{a}	66.70±0.01^{ef}
C4	60.00±0.06^{c}	12.10±0.03^{d}	29.54±0.06^{c}	31.92±0.04^{b}	67.73±0.08^{d}
C5	59.32±0.04^{d}	11.30±0.04^{e}	28.70±0.04^{e}	30.85±0.05^{d}	68.50±0.04^{c}
C6	56.22±0.06^{f}	12.92±0.03^{a}	28.48±0.04^{f}	31.27±0.03^{c}	65.60±0.08^{g}
C7	57.88±0.03^{e}	12.47±0.04^{c}	28.71±0.04^{e}	31.30±0.06^{c}	66.52±0.04^{f}
C8	56.21±0.04^{f}	12.20±0.04^{d}	28.52±0.06^{ef}	31.02±0.07^{d}	66.84±0.03^{e}
C9	54.32±0.04^{g}	12.65±0.03^{b}	27.07±0.06^{g}	29.88±0.06^{f}	64.95±0.00^{h}
Crumb					
C1	66.12±0.06^{g}	0.68±0.01^{d}	18.75±0.06^{f}	18.76±0.06^{f}	87.92±0.05^{a}
C2	67.13±0.05^{f}	2.12±0.06^{a}	20.89±0.05^{a}	20.99±0.04^{a}	84.20±0.17^{cd}
C3	69.26±0.04^{c}	2.06±0.05^{ab}	19.68±0.05^{c}	19.79±0.04^{c}	84.01±0.15^{d}
C4	70.01±0.02^{ab}	2.03±0.06^{ab}	19.05±0.04^{e}	19.16±0.05^{e}	83.92±0.15^{d}
C5	69.09±0.05^{cd}	2.13±0.04^{a}	19.66±0.04^{c}	19.78±0.05^{c}	83.82±0.11^{d}
C6	68.48±0.06^{e}	1.91±0.06^{b}	19.96±0.06^{b}	20.06±0.06^{b}	84.54±0.19^{c}
C7	69.06±0.05^{d}	2.07±0.04^{ab}	19.37±0.04^{d}	19.48±0.05^{d}	83.90±0.11^{d}
C8	69.91±0.06^{b}	1.70±0.03^{c}	19.75±0.04^{c}	19.82±0.04^{c}	85.09±0.08^{b}
C9	70.21±0.05^{a}	1.63±0.03^{c}	20.05±0.04^{b}	20.12±0.04^{b}	85.36±0.08^{b}

[1]Means followed by the same letter within a column are not significantly different (P < 0.05). Values are the average of triplicate measurements on the duplicate samples. CB: Commercial bread.

Crust colour values of TFB are reported in Table 5. Crust *L** values of TFB ranged between 55.19 to 68.72. The combinations of "vital gluten, SSL, FAA and TG" (C5) or C7 in TFB resulted in higher crust *L** values among all the additive combinations after C1 and C2 CB. The highest crust *a** values were observed in C6 and C9 TFB. Moreover, the combinations of C6, C7 and C9 resulted in higher crust *b** values in TFB than other additive combinations. Su et al. (2005) reported that *L**, *a** and *b** values of control bread were 90.49, 0.68 and 20.64, respectively, and the same values of bread containing xylanase were 88.26, 0.75 and 20.39, respectively. Crust *SI* and *hue* values of TFB changed between 26.31 and 30.04 and 64.14 and 81.40, respectively. C2 TFB had the lowest *SI* value, and also the highest *hue* result was obtained in C2. Compared to C2, the additive combinations increased *SI* values while decreased *hue* values in TFB.

Table 5
Crust colour values of TFB samples.[1]

Formulations	*L**	*a**	*b**	*SI*	*Hue*
C1	63.47±0.04^{b}	10.55±0.05^{f}	26.87±0.04^{bc}	28.87±0.02^{d}	68.57±0.11^{b}
C2	68.72±0.04^{a}	3.93±0.04^{g}	26.01±0.04^{e}	26.31±0.05^{g}	81.40±0.07^{a}
C3	57.23±0.11^{e}	12.76±0.04^{bc}	26.74±0.07^{c}	29.63±0.08^{b}	64.49±0.01^{e}
C4	56.13±0.07^{f}	12.07±0.04^{d}	25.57±0.06^{f}	28.27±0.04^{e}	64.73±0.13^{e}
C5	59.10±0.11^{c}	11.19±0.04^{e}	25.24±0.06^{g}	27.61±0.03^{f}	66.09±0.13^{d}
C6	55.52±0.06^{g}	13.10±0.06^{a}	27.03±0.07^{ab}	30.04±0.09^{a}	64.14±0.04^{f}
C7	59.12±0.07^{c}	11.04±0.06^{e}	26.94±0.04^{abc}	29.11±0.06^{cd}	67.72±0.07^{c}
C8	57.67±0.07^{d}	12.59±0.04^{c}	26.43±0.05^{d}	29.28±0.07^{c}	64.53±0.02^{e}
C9	55.19±0.05^{h}	12.94±0.04^{ab}	27.12±0.10^{a}	30.05±0.11^{a}	64.49±0.01^{e}

[1]Means followed by the same letter within a column are not significantly different ($P < 0.05$). Values are the average of triplicate measurements on the duplicate samples. TFB: Traditional flat bread.

Sensory properties of CB are given in Figure 1. Generally, additive combinations positively influenced the pore structure, appearance and overall acceptability parameters in CB when compared to C2. Especially, the combinations of C8 with pentosanase and C9 with xylanase in CB provided a greater increase in terms of overall acceptability score in comparison to C2. Similar positive effects of xylanase on the sensory properties (symmetry, texture, flavour, taste and total score) were reported on whole wheat bread (Shah et al., 2006).

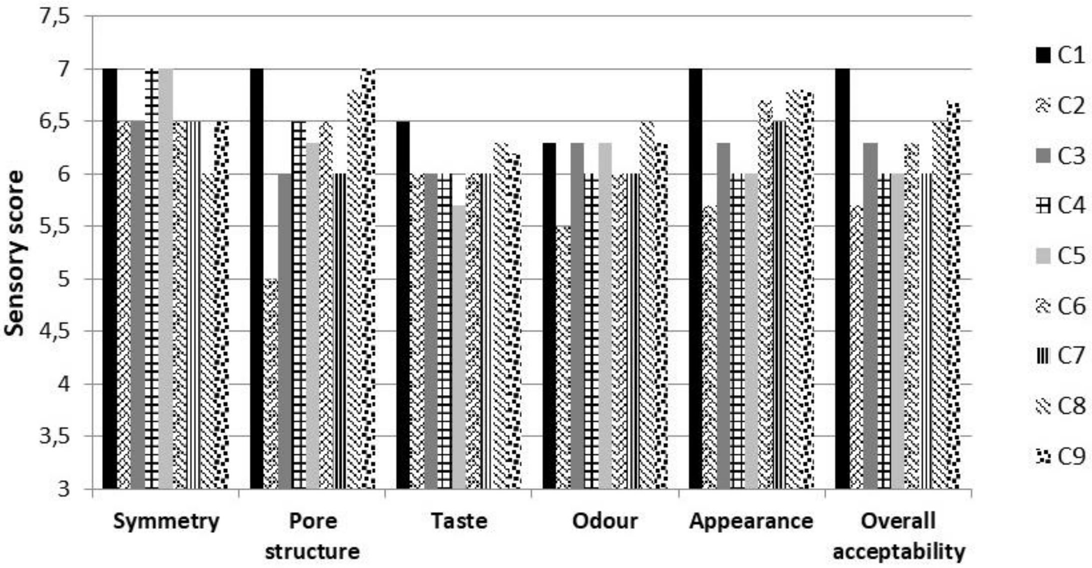

Figure 1
Sensory scores of CB samples.

Sensory properties of TFB are presented in Figure 2. The combination of C8 showed similar symmetry to C1 TFB. In terms of pore structure, appearance and overall acceptability, the additives displayed remarkably increase in TFB compared to C2. The highest overall acceptability scores were obtained with the combinations of C8 and C9 in TFB.

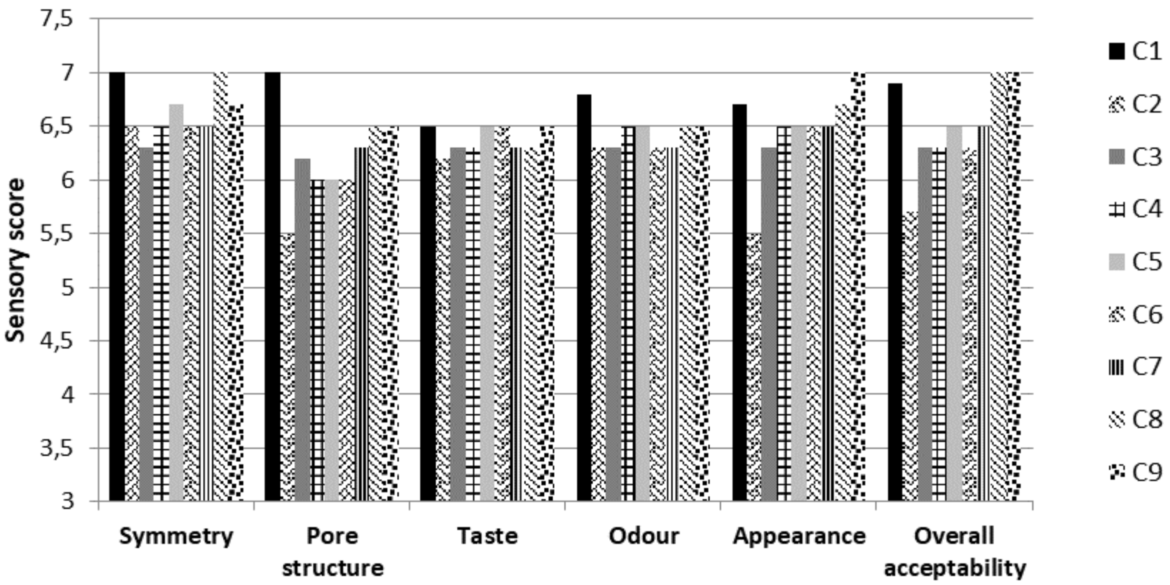

Figure 2
Sensory scores of TFB samples.

4. Conclusions

The utilisation of CLFB in bread formulation resulted in undesirable effects on some technological properties such as dough structure, volume and texture. Different additives were combined to overcome these effects and make the end products more acceptable by consumers. Among all the additive combinations, C8 and C9 had the greatest action on volume and specific volume parameters of CB. In addition, the combination of C9 showed the lowest hardness values at the end of 24 h and 72 h in both CB and TFB. The additive combinations altered crust L*, a* and b* values of CB and TFB including composite flour. In terms of overall acceptability, C9 was the best additive combination that was followed by C8 (gluten, SSL, FAA, AA and pentosanase) > C6 (gluten, SSL, FAA and GO) > C3 (gluten, SSL and FAA) > C4 (gluten, SSL, FAA and AA), C5 (gluten, SSL, FAA and TG) and C7 (gluten, SSL, FAA and lipase) in CB. In TFB, C8 had the similar overall acceptability score to that of C9 which was followed by the combinations of C5 and C7 > C3, C4 and C6. As a result, xylanase or pentosanase enzymes combined with gluten, SSL, FAA and AA could be used to improve the technological quality of bread formulations containing cereal-legume composite flour. Production of breads with superior nutritional, technological and sensory qualities could be provided using those combinations of additives.

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Effects of Bacterial Inoculation and Molybdenum Application on Nutrient Element Content of Beans

Ummahan ÇETİN KARACA[1,*], Emel ATMACA[1]

[1]Selçuk University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Konya, Turkey

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ABSTRACT

This study was carried out to determine the effect of different doses of molybdenum with bacterial inoculation on macro and micro- elements content of bean grains. In this study, Akman 98 dry bean variety was used as plant material, Molybdenum dosages were Mo0 = Molybdenum free, Mo1 = 0.05 mg/kg, Mo2 = 0.10 mg/kg and *Rhizobium tropici* (CIAT899), bacterium of *Phaseolus* plant, was used as inoculation material. The study was planned according to the randomized complete blocks in factorial design with three replicates. Following the performed field trial, nutrient elements (N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn) of bean grains were determined. According to the results obtained from the study, the effect of molybdenum application and inoculation on nutrient elements of bean grains was different and statistically significant. This effect on nutrients showed that the nutrients in the bean grains generally increased due to the increase in molybdenum doses. Mineral content of bean grains were determined as nitrogen (N) 3.59-4.39, protein content 22.44-27.44, phosphorus (P) 0.36-0.46 potassium (K) 1.83-2.33 magnesium (Mg) 0.17-0.20 calcium (Ca) (%), as mg/kg (Fe) 37.59-65.25 copper (Cu) 5.27-7.69 manganese (Mn) 14.98-16.96 zinc (Zn) 14.77-27.28. The nutrient contents of inoculated bean grains were found to be higher than the non-inoculated ones. Nutrient contents were different depending on the inoculation and dose applications, and this difference was found to be statistically significant.

1. Introduction

The beans enrich the soil with nutrients by removing the nutrients found in the lower layers of the soil to the soil surface through the advanced root systems. Beans meet most nitrogen needs from the soil air by utilizing the free nitrogen of the air through the bacterium *Rhizobium phaseoli* with a common life feature in its roots, and it enriches the soil in which they grow with nitrogen. In this way, an average of 5 kg /da of nitrogen per year are able to fixed. The loss of nitrogen in this way is less than that of nitrogenous fertilizers, it does not lead to pollution of drinking water and does not cause the quality deficiency resulting from chemical fertilization (Akçin, 1976).

When the microorganisms, which bind the free nitrogen of the air to the soil by establishing symbiotic life with leguminous plants and generally known as *Rhizobium* spp. are not given to the soil, they are generally found in the soil in limited number or they are not effective. For this reason, the amount of nitrogen bound to the soil by biological means is low in the situations without inoculation (Gök and Onaç, 1995). If the seed is cultivated by inoculation with effective bacterial strains, nodosites will occur early in the development of the plant roots and the plant may complete its development without being affected by lack of nitrogen in the soil. The nitrogen supplied to the plant through nodosites enters the plant metabolism as organic compounds and the plant can easily benefit from these compounds (Haktanır and Arcak, 1997).

Bergersen (1971) reported that molybdenum plays a role in the basic mechanism of nitrogen fixation by activating nitrogenase enzyme and it is an important element for bacteria that co-live with high plants and fix nitrogen. Many investigators have shown that bacterial inoculation in legumes affects nitrogen content in vegetative growth, dry matter formation, grain yield, nodulation, vegetative growth, nodule and granule (Gök and Onaç, 1995).

Molybdenum deficiency is observed in plants grown in soil with molybdenum below 0.025 kg in decadence (Aydemir, 1985). Some plants have higher requirements for molybdenum. For example, in terms of nitrogen determination, *Leguminous* plants and *Cruciferae* family plants, especially cauliflower and cabbage, have higher need for molybdenum. This research was carried out to determine bacterial inoculation,

* Corresponding author email: *ucetin@selcuk.edu.tr*

which is important in protein rich grain yield, and to determine the effect of different molybdenum doses on nutrient content of bean grains due to increased nodulation and nitrogen detection in plants.

2. Materials and Methods

In this study, Akman 98 bean (*Phaseolus vulgaris L.*), which is the registered product of Anatolia Agricultural Research Institute, was used as bean variety and, as bacteria, *Rhizobium tropici* (CIAT899) was used, which was provided from the biological laboratories of Soil, Fertilizer and Water Resources Central Research Institute Directorate, Ankara. The trial was set up according to randomized block experimental designs with three replications and it was carried out in field conditions as a two-year study. In the experiment, each plot size was 2.5 m x 2 m, row spacing was 50 cm, and row top was 20 cm. This is a complete factorial treatments design, with factor A (2 levels: inoculated and non-inoculated) and factor B (3 levels: Mo_0= without molybdenum, Mo_1=0.05 mg/kg, Mo_2=0.10 mg/kg).

After these plots were made ready for planting and after the surface sterilization of the seeds was made with 0.5% sodium hypochlorite, they were sown by inoculation of *Rhizobium tropici* bacteria developed in YMB (Yeast mannitol broth). The study was carried out on a total of 24 plots including 3 molybdenum dozes, 2 inoculation factors and 4 replications. The amount of seed was calculated for each plot, and placed in a polyethylene bag. Seed surfaces were soaked by adding 10% sucrose solution in 1% ratio to the bean seeds in the polyethylene bags which were going to be used in the parcels to be inoculated. 1% inoculant was added to the bag, and the bags were swayed gently, allowing the inoculant to stick to the seeds. The seeds were dried in the shade and then planted immediately. So as to prevent contamination, first the control was done and the parcels with bacterial inoculation were planted. The planting was made in a plant population of 50 cm between rows and 20 cm row top. It was made in the evening to avoid the negative effects of sun rays on bacteria. In the field trial macro element base fertilizer was applied to all parcels during sowing as 4 kg N/da $(NH_4)_2SO_4$ (%21 N), 6 kg P_2O_5/da TSP (% 45 P_2O_5), 5 kg K_2O/da K_2SO_4 (% 50 K_2O) and micro element base fertilizer was given as 5 mg kg^{-1} Fe, 12 mg kg^{-1} Mn, 2 mg kg^{-1} Zn, 1 mg kg^{-1} Cu.

The analysis of the soil sample used in the test was performed according to texture: Bouyocous (1951), pH: Richards (1954), EC: U.S. Salinity Lab. Staff (1954), organic matter: Smith and Weldon (1941), $CaCO_3$: Hızalan and Ünal (1966), total nitrogen: Bremner (1965), phosphorus: Olsen et al., (1954), changeable cations: Knudsen et al. (1982), trace elements Soltanpour and Workman (1981). Some physical and chemical properties of the research soil are given in Table 1. After 90 days of vegetation, plants were harvested by hand. Following the harvest, nutrient element (N, P, K, Ca, Mg, Fe, Cu, Mn and Zn) analysis of plant seeds was performed using method of wet decomposition (Bayraklı 1987) with sulphuric acid (Lindsay and Norwell 1978).

Table 1
Some physical and chemical characteristics of soil used at experiment.

Properties	Value	Properties		Value
pH	7.67	Fe	mg kg^{-1}	3.42
EC (dSm^{-1})	0.313	Cu	mg kg^{-1}	5.88
% $CaCO_3$	22.42	Mn	mg kg^{-1}	36.18
% Organic Matter	1.20	Zn	mg kg^{-1}	2.46
% Clay	24.2	B	mg kg^{-1}	3.92
% Silt	32.6	Mo	mg kg^{-1}	0.015
% Sand	43.2	Ca	me /100g	1.8
Class	Loam	Mg	me /100g	1.6
N (mg kg^{-1})	111.23	K	me /100g	0.99
P (mg kg^{-1})	13.60			

Statistical Analysis

Data were analyzed as a factorial experiment in a completely randomized manner with three replications using the JMP statistical software version 5.1 (SAS Institute INc., Cary, NC, USA). Sources of variation were treatments, incubation day and their interaction. Means were compared by Student's t-test at a significance level of 0.05.

3. Results and Discussion

In order to determine the effect of bacterial inoculation and molybdenum application of Akman 98 bean variety on the nutrients of the beans, nutrients were determined as (N, P, K, Ca, Mg, Fe, Cu, Mn, Zn) in the bean grains in this study. According to the results obtained from the study, the effect of molybdenum application and inoculation on nutrient elements of the bean grains was different and statistically significant (Table 2). It was found that with the increase of the molybdenum doses of this effect to the nutrients, the nutrients in the bean grains were generally increased. Mineral content in bean seeds were as following; (Fe) 37.59-65.25 (mg / kg) in the form of calcium (Ca) 0.17-0.20 (%), magnesium (Mg) 0.17-0.20 (%), copper (Cu) 5.27-7.69 (mg/kg) manganese (Mn) 14.98-16.96 (mg/kg) zinc (Zn) 14.77-27.28 (mg/kg). The nutrients in the bean grains of the plants that were inoculated were found to be higher than those that were not inoculated. In addition, the effect of molybdenum doses on the nutrients of the plant was also found to be statistically significant. Mo is an important micronutrient element for biological N-fixation in soil and acts as a central metal ion for both NA (Neuraminidase) and NR (Nitrat redüktaz) enzymes in cofactors (Mendel and Hänsch 2002).

Table 2
The results of variance analysis of rhizobium inoculation and Mo application on the macro and micro nutrient element content of beans seed

Sources	DF	N		P		K		Ca		Mg	
		MS	F	MS	F	MS	F	MS	F	MS	F
Inoculation	1	0.279	18.41**	0.0018	3.00	0.033	0.58	0.0002	0.67	0.0003	1.64
Dose	2	0.237	15.65**	0.0055	9.07**	0.146	2.57	0.0014	5.73*	0.0003	1.56
Ino. x Dose	2	0.193	12.77**	0.004	6.55*	0.064	1.13	0.0002	0.96	0.0005	2.27
Error	12	0.015	---	0.0006	---	0.057	---	0.0028	---	0.0002	---
Total	17	---	---		------	---	---	---	---	---	---

Table 2 (continuation)

Sources	DF	Fe		Cu		Mn		Zn	
		MS	F	MS	F	MS	F	MS	F
Inoculation	1	547.25	18.68**	3.467	15.49**	1.191	1.29	64.592	29.94**
Dose	2	242.69	8.28**	2.814	12.57**	2.254	2.45	80.91	37.50**
Ino. x Dose	2	140.34	4.79*	1.919	8.57**	0.588	0.64	24.96	11.57**
Error	12	29.30	---	0.224	---	0.922	---	2.16	---
Total	17	---	---	---	---	---	---	---	---

* : P<0.05 , ** : P<0.01

The effect of the application of inoculation and molybdenum on the nitrogen content of the bean stem was found to be statistically significant. The nitrogen content of bean ranges from 3.59 to 4.39%. Inoculation and molybdenum application increased the nitrogen content of the plant. The phosphorus contents (0.36%) of the plants which were not inoculated were lower than the inoculated plants (0.46%). The effect of the inoculation on the grain potassium content was different from the non-inoculated conditions, and this difference was statistically significant ($p<0.05$). The K content of non-inoculated plants was determined to be 1.83%, and the potassium content of the grafted plants was found to be higher (2.33%). By inoculation, the magnesium and calcium levels increased slightly and this increase was found to be statistically significant. The calcium and magnesium content of the bean ranges from 0.17 to 0.20%.

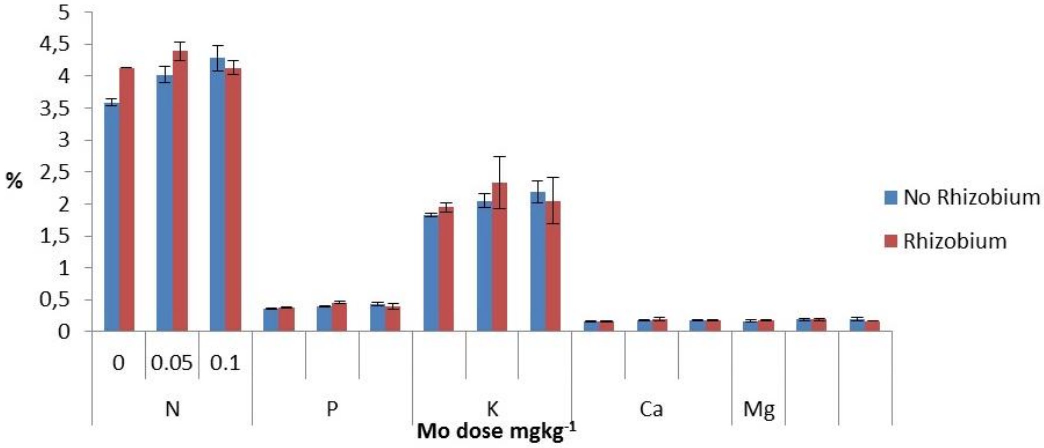

Figure 1
Effect of Rhizobium Inoculation and Mo Application on the Macro Nutrient Element Content of Beans Seed

According to the results obtained from the research, the effect of molybdenum application and micronutrient on micronutrient elements in bean was different and statistically significant. It was found that micronutrients generally increase in micronutrients in the bean by enhancing the molybdenum doses of this effect. The content of Fe in beans ranged from 37.59 to 65.25 mg/kg, and the application of grafting and molybdenum increased the content of iron in the grain. The copper content (7.69 mg/kg) of the bean grains of the grafted plants was found to be higher than the grains content of uninoculated plants (5.27 mg/kg). In addition, the effect of molybdenum doses on the copper content of the plant was also found to be statistically significant. Manganese content of bean was determined between 14.98-16.96 mg/kg, and the manganese contents of plants vaccinated were higher. The zinc content of the plant increased by grafting and molybdenum application and this increase was found statistically significant. The amount of zinc after non-inoculated plants was determined to be 14.77 mg/kg, which increased to 27.28 mg/ kg by inoculation.

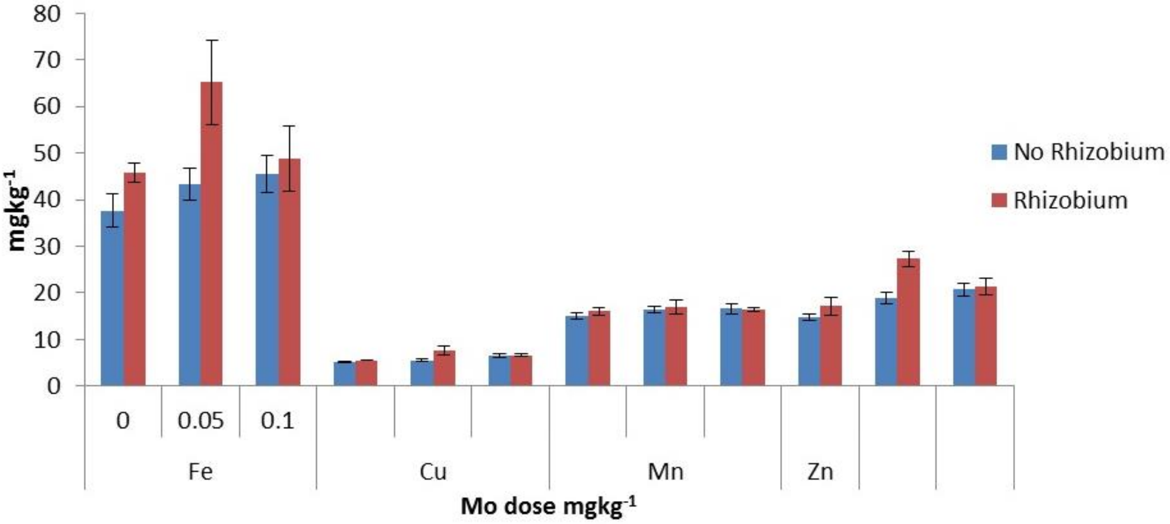

Figure 2
Effect of Rhizobium Inoculation and Mo Application on the Micro Nutrient Element Content of Beans Seed

Molybdenum is found in the structure of nitrogenase and every bacterium that binds to nitrogen needs molybdenum during fixation. Molybdenum nitrogenase is a necessary component of two important enzymes such as nitrate reductase. It was determined that nodules did not detect nitrogen even though they were formed in plants grown in soil with molybdenum deficiency. Manganese deficiency inhibits chlorophyll formation of the plant (Kızıloğlu 1995). On the other hand, Şehirali et al. (1981), Aydemir (1985), Akçin 1976, Bozoğlu et al. (1997), Gür (2002), Mut and Gülümser (2003), Nadeem et al. (2004), Önder et al. (2003), Kacar et al. (2004), Gök et al. 2003, Doğan et al., (2007), Küçük and Kıvanç (2008) have obtained similar results in their studies on this subject.

4. Conclusion

As a result, the common nitrogen of the leguminous *Rhizobium* bacterium is presented to the free nitrogen plant in the air. In this way, nitrogen binding is an important resource for agriculture. At the same time, environmental pollution from chemical fertilizers will be reduced. However, many factors such as temperature, soil moisture, salinity, soil reaction, nutrients in the soil and strains affect the nitrogen amount bound in this way, in other words, the successful *Rhizobium* legume plant symbiosis. Depending on these factors, the amount of nitrogen that is fixed is significantly affected. According to the obtained data, seed inoculation and micro fertilization increased the amount of the crop and the nutrient content of the grains. For this reason, it is necessary to apply molybdenum with inoculation and to apply 0.05 mg kg^{-1} Mo as the optimum dose to increase the content of nutrients in the bean grains.

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Investigation of the Last Irrigation Timing for Grain Corn under Konya Basin Conditions

Çağlar YAŞAR[2], Ramazan TOPAK[1,*]

[1]Selçuk University, Department of Irrigation, Faculty of Agriculture, Konya, Turkey
[2]Aksaray Agriculture Credit Cooperative, Aksaray, Turkey

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ABSTRACT

In this study performing at Konya basin conditions, the aim was to determine the last irrigation time for grain maize production. For this purpose, the effects of five different irrigation-ending times [at milking stage (S1); 6 days after S1 (S2); 12 days after S1 (S3); 18 days after S1(S4) ; and 24 days after S1 (S5)] on grain yield were researched under field conditions. By comparison to first irrigation-ending treatment of S1, 80 mm more irrigation water was applied to the latest terminated treatment of S5. The results of the study showed that, effect of different irrigation-ending times on grain yield and gross income was found not statistically significant. However, maximum grain yield and gross income were obtained from S5 treatment.

1. Introduction

Among the cereals, maize is the third crop over the agricultural fields of Turkey after wheat and barley. It is grown either as the main crop or as the second crop. There is a distinctive increase in maize production of Turkey after 1980s. According to TÜİK (2018) data, in 2017, grain corn production was practiced over 640.000 ha land areas in Turkey and about 5.9 million tons of kernel was produced. Konya basin has a significant place in maize production of Turkey. Again according to TÜİK (2018) data, in 2013, grain corn production was practiced over 49.000 ha land area of Konya basin (including Konya, Karaman, Aksaray, Niğde provinces) and about 497.000 tons of kernel was produced. In 2017, 950.000 tons of kernel was produced from 100.000 ha maize fields of especially Konya (64.000 ha), Karaman (28.000 ha) and Aksaray (7.000 ha) provinces. Of this quantity of total production, 620.000 tons were produced in Konya province. All these data indicate that about 16% of total maize production of Turkey came from Konya basin. Konya province alone constitute about 11% of grain corn production of Turkey.

* Corresponding author email: *rtopak@selcuk.edu.tr*

Konya basin is the least precipitated region of Turkey and has a semi-arid climate. The basin has about 12% of arable lands of Turkey, but has only 3% of available water resources. Such a number indicate quite limited nature of water resources in the basin. For a successful and sustainable agricultural production in Konya basin and similar fields, irrigation is essential. Besides, it is quite hard to achieve sustainable water resources use in such areas. Together with current global warming and environmental pollution, solutions are sought to reduce agricultural water use in several parts of the world. In this sense, current researches mostly focus on development of drought-resistant plant cultivars and water-saving irrigation technologies.

Maize kernels should have a moisture content of around 14-15% before to store them. Kernels have a moisture content of 30-35% in the field when they reached to physical maturity stage. Such moisture levels are not appropriate for machine-harvest of the plants because of high yield losses. Even they harvested at these moisture levels, kernels should be dried before storage as to reduce the kernel moisture levels to 14-15%. Drying brings about an extra cost and thus reduces grower incomes. In sweet corns, kernel moisture level should be around 20% for machine-harvest of the plants. Irrigation constitutes an essential component of maize culture under Konya provincial conditions. However, irrigations beyond a point do not have significant effects on yields. Such irrigations even slow down decreases in kernel moisture levels, thus delay potential harvest times until winter months. Since the fields are wet and muddy in winter months, machine-harvest will not be possible, then growers have to manually harvest their fields. Manual harvests then increase the costs of production. The most appropriate way to overcome such problems is to terminate irrigations early. Early termination of irrigations in maize culture requires well-comprehension of water-yield relations. There is a limited information about early termination of irrigations in maize culture. Previous researches on early-termination of irrigations revealed that termination of irrigations at dough and physiological maturity stages did not have significant effects on yields of popcorn (Thanomsub et al., 2001; Sweeney and Marr, 2005; Yerdoğan and Gözübenli, 2015) and grain corn (Şahin, 2015). There aren't any researches conducted about early-termination of irrigation in maize culture of Konya basin. Therefore, the present study was conducted to determine the timing of the last irrigation in grain corn production for an economic production under Konya basin conditions.

2. Materials and Methods

This study was conducted over the maize fields of a farmer in Kazımkarabekir town of Karaman province. The town is located at 37º 14' North latitudes and 32º 57' east longitudes and has an altitude of 1030 m (Anonymous, 2015). Terrestrial climate is dominant in Central Anatolia region including Kazımkarabekir town. Summers are hot and dry and winters are cold and harsh. Climate data of Kazımkarabekir town were started to be measured from the year 2014 and measured climate parameters are provided in Table 1. As can be seen from the table presenting meteorological data of 2014-2017 period, annual average temperature is 12.6 ^{0}C, average relative humidity is 58.7%, average wind speed is 3,3 m/s and annual total precipitation is 419.5 mm. Present study was conducted throughout the initial 9 months of 2018 and total precipitation for that period of experiments was 256,8 mm. Some irrigation-related soil characteristics of the experimental fields are provided in Table 2.

Table 1
Climate parameters for Kazımkarabekir town (Anonymous, 2018).

Year	Meteorological Data	Months											
		1	2	3	4	5	6	7	8	9	10	11	12
2018	Nisbi nem (%)	84.2	69.6	56.9	49.8	58.6	51.9	39.3	35.9	39.5	-	-	-
	Temperature (°C)	1.5	6.6	10.6	13.5	17.3	21	24.8	24.4	20.3	-	-	-
	Precipitation (mm)	59.6	15.5	42.3	13.2	33.4	68.4	8.5	8	7.9	-	-	-
	Wind Speed (ms^{-1})	3.8	3.4	4.2	3.1	2.7	2.9	3.9	3.6	3	-	-	-
2014-2017	R. Humidity (%)	81.7	73	64	53.3	55.5	53.9	36.7	41	42.9	56.4	65.2	80.5
	Temperature (°C)	-0.4	3.1	7.3	12	16.2	20.3	24.7	24.9	20.5	13.9	6.9	2
	Precipitation (mm)	51.6	24.8	48.5	25.4	40.6	58.8	6.5	13.4	20.6	49.1	36.7	43.5
	Wind Speed (ms^{-1})	3.9	3.4	3.8	3.4	3.3	3.1	3.7	3.3	2.7	2.9	2.6	3

Table 2
Irrigation-related soil characteristics of the experimental plots.

Soil layer (cm)	Clay (%)	Silt (%)	Sand (%)	Texture Class	Field Capacity (%)	Wilting Point (%)	Bulk Density (g cm^{-3})
0-30	36.1	26.25	37.65	CL	30.41	15.41	1.57
30-60	40.2	18.75	41.05	C	33.67	14.34	1.52
60-90	35.2	20.00	44.80	CL	33.54	14.23	1.37

A deep well located within the experimental fields was used as irrigation water supply. Well discharge was about 85 m^3h^{-1}. Seeds of 0573 Pioneer grain corn were sown. Dough stage was taken into consideration in experimental design, thus the first irrigation termination treatment was conducted at milk stage. There were 5 different irrigation termination dates in experimental design. Experiments were conducted in randomized plots design with three replications. Present treatments and explanations of the treatments are provided in Table 3. There were 6 days between consecutive irrigation-termination dates and 20 mm irrigation water was applied at the last irrigation of each irrigation-termination treatment.

Table 3
Experimental treatments

Treatments	Explanation
S1	Last irrigation, at milk stage.
S2	Last irrigation, 6 days after S1.
S3	Last irrigation, 12 days after S1.
S4	Last irrigation, 18 days after S1.
S5	Last irrigation, 24 days after S1.

The farmer divided experimental fields into 5 equal plots (300 x 72 m = 21.6 da) based on available discharge of the water well and installed drip irrigation units accordingly. Within the scope of this study, a lateral line was closed in each operational unit at the time of irrigation termination and the other lines continued operation. In this way, 5 different irrigation termination times were generated. Irrigation area of the initial 100 m section of the lateral line closed in each drip irrigation unit constituted an experimental treatment. Then, this 100 m section was divided into three equal parts as to represent the replications of each treatment.

Before sowing, 32.8 kg da^{-1} DAP fertilizer (18% N-46% P) and 10 kg da^{-1} Ammonium Sulphate fertilizer (21% N – 24% S) were broadcasted to experimental fields with a fertilizer distributor machine as base fertilizer and then incorporated into the soil. Sowing was performed over 108 decare land area on 26 April 2018. Sowing was performed with a 6-row grain drill as to have 70 cm row spacing and 15.3 cm on-row plant spacing. A sprinkler irrigation was performed as to have homogeneous emergence. Drip irrigation system was installed over the experimental fields on 8-9th of July. A lateral line (300 m long and Ø25 mm diameter) was installed for two plant rows (140 cm lateral spacing). Drippers were 30 cm apart and had a discharge of 1.6 Lh^{-1}. Following the installation, the first drip irrigation was performed. Dressing fertilizer was applied through irrigation lines (fertigation). With the initial two irrigations, a total of 8.5 kg da^{-1} urea (46% N) was applied as dressing fertilizer. Also, 2.8 kg da^{-1} Potassium Sulphate-powder and 2.8 kg da^{-1} Mono Ammonium Phosphate (MAP)-powder fertilizers were applied to plants. During the period from sowing to initiation of the experiments, drip irrigation treatments were started on 9th of June, irrigations were performed in 3 or 5 day intervals for 3-5 hours. Considering the initial irrigation-termination treatment, a total of 440 mm irrigation water was applied to the entire plot for 550 hours of drip irrigation from 85 m^3 h^{-1} discharge deep well. Since the entire filed was divided into five equal-size plots (21.6 da), each plot was irrigated for 110 hours. During the harvest, initial 100 m section of closed lateral line was divided into three equal sections as to create replications. From the mid-sections of each plot, 5 m sections were considered as harvest plot and ears of this section were harvested. In other words, harvest plot had a size of 3.5 m^2 (5 x 0.7 m). Kernel moisture contents were measured and harvest was performed manually. Harvested ears were placed into sacks. They were counted and number of ears per harvest plot of each treatment was determined. Ears were husked and kernels were trashed manually. Resultant kernels were weighed to get harvest plot kernel yields of each treatment. Then, these plot yields were converted into yield per decare. Treatment yields were corrected for 15% moisture content. Corrected yield per decare was then calculated as (CYD) = Yield (kg da^{-1}) x (100 - % Moisture) / 85.

To determine yield components, ears harvested from randomly selected 5 plants of each plot were used. Husked ear weight, husked ear length, number of kernel rows, number of kernels per row, 100-kernel weight were determined and resultant values were corrected for 15% moisture content.

Resultant data were subjected to analysis of variance and significant means were compared with the aid of Duncan's multiple range test at 5% level of significance. Statistical analyses were performed with the use of SPSS 22.0 statistical software.

3. Results and Discussion

3.1. Irrigation treatments

Amount of irrigation water applied in each treatment is provided in Table 4. A sprinkler irrigation was performed for homogeneous emergence throughout the field and a total of 48.6 mm water was applied through sprinklers. The initial drip irrigation was performed on 9th of June. Irrigations were repeated at 3 or 5 day intervals for about 3 or 5 hours until 11th of August when the designed irrigation treatments were initiated. Total precipitation between sowing and harvest (26th of April – 26th of September) was 126.2 mm. Of such an amount, 54.2% was received in June and 26.5% was received in May.

Table 4
Total amount of irrigation water applied to treatments

	Treatments				
	S1	S2	S3	S4	S5
Sprinkler irriation (mm)	48.6	48.6	48.6	48.6	48.6
Drip irrigation (mm)	440.5	460.5	480.5	500.5	520.5
Total irrigation water (mm)	489.1	509.1	529.1	549.1	569.1
Rainfall (mm)	126.2	126.2	126.2	126.2	126.2

With the irrigation performed on the first irrigation termination date of 11.08.2018 (S1 treatment), all treatments had equivalent quantity of irrigation water. On 11.08.2018, S1 treatment was irrigated for the last time. By this date, all treatments received 489.1 mm (440.5 mm through drip lines and 48.6 mm through sprinklers) irrigation water. Within the scope of this study, 509.1 mm water was applied to S2 treatment, 529.1 mm to S3 treatment, 549.1 mm to S4 treatment, 569.1 mm to S5 treatment. Irrigations were terminated 107 days after sowing in S1 treatment, 113 days in S2, 119 days in S3, 125 days in S4 and 131 days in S5 treatment. As compared to S1 treatment, 20, 40, 60 and 80 mm more irrigation water was applied in S2, S3, S4 and S5 treatments, respectively.

3.2. Kernel yields

Total growing season of sweet corn was about 150 days. Ear harvest was performed on 21st of September in S1, S2 and S3 treatments and on 26th of September in S4 and S5 treatments. Number of ears harvested from each harvest plot was counted and results are provided in Table 5.

Table 5
Number of ears harvested from the harvest plots of each irrigation-termination treatments

Treatments	Replications			Average (Number)
	1	2	3	4
S1	34	33	32	33
S2	30	31	30	30
S3	29	30	31	30
S4	34	32	30	32
S5	28	30	32	30

As can be seen from the table, there were not significant differences in number of ears of both the treatments and treatment replicates. Such a case indicated a homogeneous nature of number of ears of the treatments. Kernel yields of the experimental treatments are provided in Table 6. Variance analysis revealed that different irrigation-termination dates did not have significant effects on kernel yields. The greatest kernel yield (1422.8 kg da^{-1}) was obtained from the last irrigation-termination date (S5 treatment) and the least kernel yield (1141.8 kg da^{-1}) was obtained from the first irrigation-termination date (S1 treatment). As compared to S5 treatment, respectively 14 and 10.5% water saving was achieved, but 20 and 15% yield decrease was observed in S1 and S2 treatments. In other words, the rate of decrease in yield was greater than the rate of water saving. Although the differences in yields of treatments were not significantly different, it can still be stated that early termination of irrigation ended up with a yield loss as compared to late termination dates. Former field experiments on applying different irrigation termination in some field crops, such as maize (Thanomsub et al., 2001; Alam et al., 2002; Sweeney and Marr, 2005; Şahin, 2015; Yerdoğan and Gözübenli, 2015), tomato (Marouelli et al., 2004), cotton (Buttar et al., 2007), cowpea (Daneshnia et al., 2013), have shown that early irrigation termination plays an important role in decreasing yield compared to late termination.

Table 6
Kernel yields of the experimental treatments (corrected for 15% moisture level)

Treatments	Amount of irrigation water (mm)	Water saving (%)	Grain yield (kg da^{-1})	Relative graint yield (%)
S1	489.1	14	1141.8	80.24
S2	509.1	10.5	1235.4	86.82
S3	529.1	7	1321.9	92.90
S4	549.1	3.5	1382.4	97.15
S5	569.1	-	1422.9	100

3.3. Yield components

Measurements were made to assess the effects of experimental treatments on yield components (husked ear length, number of kernel rows, number of kernels per row and 100-kernel weight). Results for yield components are provided in Table 7. While the experimental treatments had significant effects on husked ear lengths ($p<0.05$), effects of irrigation-termination treatments on the other yield components were not found to be significant.

According to data provided in Table 7, the shortest husked ear length (12.76 cm) was observed in the earliest irrigation-termination treatment (S1). Ear lengths of the other treatments varied between 14.86 - 15.83 cm and the differences in ear lengths were not found to be significant. The 100-kernel weights of the treatments varied between 26.36 - 34.56 g with the lowest value in S1 treatment and the greatest value in S5 treatment. The lowest number of kernels per row (30.86 kernels) was obtained from the earliest irrigation termination date (S1) and the values of the other treatments varied between 34.4 - 35.53 kernels. Number of kernel rows (number of kernels around a vertical row) varied between 15.33–16.

Table 7
Data on yield components

Treatments	100-tseed weight (gr)	Cob length (cm)	Number of grain per row (Adet)	Number of rows per cob (Adet)
S1	26.36	12.76b	30.86	15.33
S2	31.30	15.63a	35.53	16.00
S3	28.20	14.86a	34.40	15.33
S4	28.76	15.00a	34.40	15.73
S5	34.56	15.83a	34.73	15.73

*:P<0.05

3.4. Gross production values corrected for irrigation electricity costs

The early irrigation-termination treatments (S1, S2 and S3) were harvested on 21st of September and the other treatments were harvested a day before regular harvest date of the farmers on 26th of September. On the date of harvest of the experimental treatments, sweet corn unit prices (TL da^{-1}) based on 15% kernel moisture content were taken from Turkish Agricultural Credit Cooperatives, Konya Commodity Exchange, Konya Sugar Co. and private sector (recorded as the others) and summarized in Table 8.

Table 8
Sweet corn prices at the date of harvest in Konya region (TL da^{-1}).

Date of harvest	Agricultural Credit Cooperatives	Konya Commodity Exchange	Konya Sugar Co.	Others	Average
21.09.2018	1.10	1.04	-	1.05	1.063
26.09.2018	1.00	1.04	1.038	1.00	1.020

Kernel yields of the treatments were multiplied by unit prices to get gross product per unit area. Resultant values are provided in Table 9.

Table 9
Unit-area production values of the experimental treatments (TL da^{-1})

Treatments	Replication			Average
	1	2	3	
S1	1073.02	1049.94	1518.27	1213.74
S2	1595.11	1237.02	1107.65	1313.26
S3	1422.44	1276.61	1517.83	1405.62
S4	1380.78	1500.86	1348.44	1410.03
S5	1481.34	1363.02	1509.60	1451.32

Based on the early irrigation-termination treatment (S1), irrigation electricity costs were calculated for the other treatments (S2, S3, S4 and S5). Monthly electricity cost of the well (utility bill) was divided by monthly operational time of the well to get unit-time (h) electricity cost. Then, unit electricity costs (24 TLh^{-1}) was divided by irrigation unit size (21.6 da) to get unit-time electricity cost per decare (1,11 TL). This value was multiplied by extra irrigation times to get the electricity costs of the other treatments. Resultant data are provided in Table 10.

Table 10
Electricity costs of the experimental treatments

Treatments	Irrigation duration (h da^{-1})	Electricity cost for irrigation (TL da^{-1})
S1	0	0
S2	5	5.55
S3	10	11.1
S4	15	16.65
S5	20	22.2

Irrigation electricity costs were then subtracted from total production values of irrigation-termination treatments to get adjusted unit-area production values. Resultant data are provided in Table 11.

Table 11
Adjusted gross products of the experimental treatments

Treatments	Gross income (TL da^{-1})	Electricity cost for irrigation (TL da^{-1})	Adjusted gross income (TL da^{-1})
S1	1213.74	0	1213.74
S2	1313.26	5.55	1307.71
S3	1405.62	11.1	1394.52
S4	1410.03	16.65	1393.38
S5	1451.32	22.2	1429.12

Variance analysis revealed that different irrigation-termination dates did not have significant effects on adjusted gross product. As can be seen from the gross products provided in Table 11, the greatest value (1429 TL da^{-1}) was obtained from the latest irrigation-termination date (S5 treatment) and the lowest value (1231 TL da^{-1}) was obtained from the earliest irrigation-termination date (S1 treatment). As compared to the latest irrigation-termination date (S5), adjusted gross product in S1 and S2 treatments was respectively 216 and 122 TLda^{-1} less and reduction in S3 and S4 treatments was about 35 TL da^{-1}. Although the differences in kernel yields and adjusted gross products of the treatments were not significant, it was observed that prolongation of irrigation-termination dates relatively increased both the kernel yields and adjusted gross products (Figure 1).

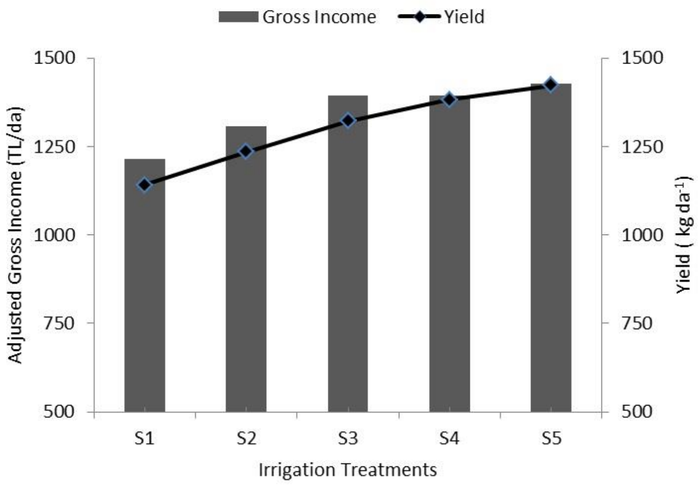

Figure 1
Effects of irrigation-termination dates on kernel yield and adjusted gross income

4. Conclusion

Present findings revealed that different irrigation-termination dates after milk stage did not have significant effects on kernel yields and adjusted gross products of grain corn. Besides, partial increases were observed in yield and gross products with the prolongation of irrigation-termination dates. As it was stated earlier, this study was conducted over the production fields of a farmer. Therefore, entire conditions of an irrigation-termination study were not able to be achieved. Thus, further research is recommended under more comprehensive and controlled conditions in Konya basin.

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Determination of Cold Resistance of Buds and Flowers on Kütahya Sour Cherry Cultivar

Omar Mohammed Ghanim ALNUAIMI[1*], Lütfi PIRLAK[1]
[1]Selçuk University, Faculty of Agriculture, Department of Horticulture, Konya, Turkey

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ABSTRACT

This study was carried out in 2018 in order to determine the resistance of flower buds and flowers to low temperatures in winter and spring periods in Kütahya sour cherry cultivar, in Konya's conditions. In order to determine the temperature of the flower buds and flowers, the samples taken at different periods were gradually placed in the temperature-lowered cabinet and tested. The buds were tested, held at temperatures between 0 and -22^{o}C. After the application, 70% or above of damaged buds were considered dead. In addition, total, bound and free water, dry matter, total carbohydrate, protein, proline and nutrient levels were determined. Differences between the mortality rates of buds and flowers at different temperatures were statistically significant. In the winter season, buds with high frost resistance started to lose this resistance towards the spring season. Temperatures of more than 50% of buds are observed at -16°C on 29.01; 20.02 and 06.03 at -15°C; 20.03 at -11°C; it was determined as -10°C on 05.04 and 20.04. According to this, in the city center of Konya cherry flower buds are damaged by frost until the end of March and the probability of damage after this period is reduced. With the emergence of winter season, the water content of the buds has increased significantly. A rapid decrease in the amount of bound water was found in the buds with the emergence of winter and a rapid increase in the amount of free water. On the other hand, the dry matter contents remained stable between 29.01 and 05.03, and a rapid increase occurred on 19.03. The differences between the nutrient amounts were found to be statistically significant. According to this, the content of N in buds has decreased continuously between 29.01 and 20.04. The amounts of P, K, Mn, Zn and S increased from 29.01 to 20.03 and started to decrease after this date. Mg and Fe amounts increased regularly until 20.03 and remained stable after this date. Ca and Cu levels increased until 06.03, then began to fall. The B content increased continuously. The amount of Zn increased regularly until 05.04 and then decreased. S content fluctuated on different dates. Significant differences were determined in terms of carbohydrate content in buds. According to this, the carbohydrate content decreased regularly from 29.01 until 05.04 and started to rise again in 19.04. Bud's protein contents showed a steady decrease in successive sampling periods. The differences between the contents of the proline were not statistically significant.

1. Introduction

Sour cherry (Prunus cerasus L.) is a member of the Rosaceae family. The origin of the sour cherry is the North Anatolian Mountains stretching between Asia, Istanbul and the Caspian Sea. Sour cherry Cherry is well adapted to different climatic conditions. The continental climate prevailing in the inner regions of Anatolia is based on hot and dry summers and cold winters. For this reason, it is mostly grown in the inner and transition regions of Anatolia (Özçağıran et al., 2003).

The world sour cherry production is 1,378,216 tons, 192.500 tons with Turkey ranks 3rd after Russia and Poland (FAO, 2018). The province which is the first in the cherry production in our country is Afyonkarahisar and then it comes from Kütahya, Konya, Ankara and Isparta (Tuik, 2018). Low temperature is considered to be the most important factor determining the distribution of plant species on the earth and may limit the yield and distribution of horticultural crops (Kalberer et al., 2006). Gardeners are constantly confronted with the problem of cold tolerance in relation to high quality fruit production (Nybom, 1992). The resistance of fruit trees to cold is primarily affected by genotype. Critical

* Corresponding author email: *pirlak@selcuk.edu.tr*

temperatures that damage reproductive organs are different between species and varieties. However, it is not easy to distinguish genotype effects from other factors. As a result, it has been observed that critical temperatures change not only with the phenological stage of flower buds but also with species, cultivars, orchards and even trees (Westwood, 1993).

While the flower buds of the fruit trees are resistant to the low temperature effects, in the spring after the rest, the dormancy period ends, the plants begin to grow and the resistance to cold decreases (Iezzoni and Hamilton, 1985). Damage to open generative buds and ovaries depends not only on temperature but also on freezing time. Data on factors determining the resistance and resistance of sour cherry generative organs to spring frosts are insufficient. The aim of this study was to investigate the resistance of sour cherry buds and flowers to winter and spring frosts.

Due to the climate zone in which our country is located, fruit species are sometimes damaged by spring frosts. Previously, these damages were more common in early flowering almonds, apricot and peach fruit species, but in recent years they caused losses in late flowering fruit species due to global climate change. In the observations made in Central Anatolia and Konya province, spring frosts have been found to cause damage in late blooming fruit species such as apple, pear, quince and sour cherry in recent years.

By determining the types and varieties of fruit suitable for the regions, it may be possible to reduce the frost damage that constitutes a financial burden on the producers, the country's economy and the institutions and organizations insuring agricultural products. For this purpose, it is possible to determine the variety and variety of fruit species and varieties suitable for each region by determining the susceptibility of the fruits species and varieties to the cold in different phenological periods. Thus, the effect of frost events that lead to large yield losses can be reduced to a certain extent. The aim of this study is to determine the cold tolerance of buds and flowers in cherries which are an important part of our country's agriculture and to examine some factors affecting cold tolerance.

2. Materials and Methods

2.1. Materials

The research was conducted in 2018 in the Department of Horticulture, Faculty of Agriculture, Selçuk University. At 13 years of age, Kütahya sour cherry cultivar were used as the plant material. Kütahya sour cherry variety is the most important cherry variety of our country. Flowers in April-May. The leaves are bright, glabrous and short-handled. The fruit is shiny dark red, roundish in heart shape and the end side is cut. Juicy and flavored. Very good quality. Trees are very efficient (Özçağıran et al., 2003).

2.2. Methods

Studies and practices were made on the shoots taken from the plants in the fruit-making period and under the same climate and maintenance conditions. Exemplary plants are inoculated on the same rootstock, the same age and size. 25 plants were selected from Kütahya sour cherry cultivar and samples were taken from these plants. The study was carried out to cover 1 winter and spring period, and samples were taken every 15 days (Felipe, 1977). Specimens were taken from the middle of the trees at a height of at least 1 m from the ground and between 10-11 in the morning (Pramsohler and Neuner, 2013). The samples were taken as much as possible from the same regions of all trees and with the same length. The samples were kept at a temperature of +4°C (Quamme, 1983) in order not to change the exothermic temperature until the application time of cold application (Quamme, 1983). In each period, frost and vitality tests, in order to determine the organic and inorganic substances 300 flower bud and flower was taken.

Determination of the Temperature at which the Buds Die

In order to determine the temperature of the flower budsand flowers, the samples taken at different periods were gradually placed in the temperature-lowered cabinet and tested. The buds were placed in aluminum foil to prevent the buds from being affected by temperature fluctuations during testing (Wheeler et al., 2014). The test buds and flowers were made at temperatures between 0 and -22°C for 1 hour (Reig et al., 2013). After the application, 70% of damaged buds were considered dead. Damage detection was done by cutting the buds. The color of the buds was taken as cross section, the light yellow and green ones were alive, and their color was darkened and returned to brown (Felipe, 1977; Reig et al., 2013).

Determination of Total, Bouned and Free Water Quantities

Fresh weight, air dried and oven dry weights were taken from 50 buds taken at each stage. The obtained values were processed in the following formulas and thus, the free, bound and total water contents of flower buds and flowers were determined (Buchner and Neuner, 2011).

Total Water Amount = (Fresh Weight - Oven Dry) / Oven Dry

Amount of Bound Water = (Air Dry - Oven Dry) / Oven Dry

Free Water = Total Water Amount - Bound Water Amount

Total Dry Matter Determination

In order to determine the dry matter ratios of the buds and flowers, 50 buds and flower were taken from different points of the shoot and dried in the oven set to a temperature of 70°C until complete drying was achieved (Reig et al., 2013).

Plant Nutrient Determination

For plant nutrient analysis, 100 buds and flowers were dried at room temperature. Then, in the samples which were pulverized using mortar, analysis was performed to determine the amounts of nitrogen, phosphorus, potassium, calcium, sulfur, boron, iron, copper, zinc, manganese, magnesium and molybdenum. P, K, Ca, Mg, Fe, Mn, Zn, Cu, B and S contents of plant samples in 3 different steps with nitric acid-hydrogen peroxide (2: 3) acid:

1st step; 75% at 145ºC at microwave power for 5 m.

2nd step; 90% at 180ºC at microwave power for 10 m.

3rd step; 40% at 100ºC at microwave power for 10 m.

For 40 bar pressure resistant microwave was kept in the incineration unit, P, K, Ca, Mg, Fe, Mn, Zn, Cu, B and S were determined by spectrophotometer, N determination was determined by micro Kjeldahl method (Mertens, 2005).

Total Carbohydrate Determination

Total carbohydrate analysis was performed according to Daniels et al. (2007). To this end, dry bud samples (0.1 g) were placed in a test tube in a 10-5 ml NaOH water bath. After 10 minutes, 5 ml of distilled water was added and the protein content was obtained. The residues were washed with water and extracted twice with 10 ml of 67% H2SO4 for 30 min at room temperature. Appropriate dilution of the samples was carried out and the diluted samples filtered. To 1 ml sample, 1 ml phenol 5% reagent was added and then 5 ml concentrated. H2SO4 was mixed with the sample and allowed to stand at room temperature for 30 minutes. The resulting color was measured at 490 nm using a spectrophotometer against a reactive paper and the total carbohydrates were calculated using the standard glucose curve.

Protein Determination

Protein determination was made according to the Bradford method using 0.5 g samples where taken from the plant's buds. The results were calculated in terms of edil (mg protein / g) fresh texture. In each treatment plant, where 0.5g of the small fragmented organs was taken and 10 pieces homogenisation was performed by crushing it in 0.05 M phosphate buffer (pH: 6.5). The homogenate was filtered through a four-layered web and the filtrate was taken to centrifuge tubes and centrifuged at 15,000 rpm for 20 min. The liquid phase (supernatant) at the top of the tubes was used for protein determination and the amount of protein was determined by spectrophotometric method (Brasford, 1976).

Proline Determination

Proline determination was determined spectrophotometrically by acid-ninhydrin method (Bates et al., 1973). A standard graph was drawn using pure proline for this process. From the stock solution containing 200 µg of proline in 1 ml to the tubes, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 ml of each tube was taken up to 2 ml with distilled water. 2 ml of glacial acetic acid and 2 ml of acid-ninhydrin solution were then added to the tubes. These samples were taken immediately to a 100°C. After 1 hour, the reaction was stopped by keeping in an ice bath for 10 min. 4 ml of toluene were added to each tube and mixed with a vortex for 20-30 sec. Then, in each tube, the supernatant was taken by an automatic pipette and the absorbance at 520 nm was measured. The standard graph is plotted using these values. For the determination of proline in the samples, 0.1g of texture was homogenized in a porcelain mortar in 10 ml of 3% sulfosalicylic acid and filtered through a funnel. 2 ml of the filtrate was taken and processed for the above standard graph. Then, A520 values obtained were determined as lerig proline on standard graph. These values were replaced with the following formula and calculated as (µ molar / g fresh leaf) proline.

Proline (µM) / Fresh Leaf (g) = (Proline (µM) / ml x ml toluene) / (115.5 µg / mM) / (g texture/ 5)

3. Results and Discussion

Determination of the Temperature at which the Buds and flowers die

The results of the mortality rates of sour cherry bud and flower samples taken at different times between 0 - -22°C are given in Table 1. The differences between the mortality rates of buds and flowers at different temperatures were found to be statistically significant in all bud intake periods. The resistance of the buds and flowers to the cold varies according to their development period. This is entirely due to metabolic changes in the plant. For example, the rate of sugar in the resting cells and the increase of proteins increase the frost resistance by decreasing the formation of ice in the cell (Küden et al., 1998). Accordingly, in the samples taken at 29.01, there was no death between 0 and -9°C. From -10 ° C, buds began to die; mortality rates from -10 to -12°C where % 1 only dead; -13°C where % 3; -14°C where % 8; -15°C where % 49; -16°C where % 97; -17°C where % 99 and finally at -18°C all buds where % 100 dead. In the samples taken at 20.02, there was no death until -11°C. Death occurred in buds from -11°C; mortality rates at -11°C where % 1; -12°C where % 2; -13°C where % 18; -14 and -15°C where % 77; -16°C all buds where % 100 dead. In the samples taken at 06.03, there was no death up to -7°C. Mortality rates were -8 and -9°C where % 2; -10°C where % 3; -11°C where % 16; -12 and -13°C where % 18; -14°C where % 31; -16°C where % 78; -18°C all buds where % 100 dead. In the samples taken at 20.03, there was no death between 0 and -5°C. From -6°C, buds began to die % 1; mortality rates from -7°C where % 7; -8°C where % 15; -9°C where % 34; -10°C where % 50; -11°C where % 51; -12°C where % 65; -13°C where % 92; -14°C all buds where % 100 dead.

The accuracy of buds to frost continued to increase in 05.04. As a matter of fact, the first damage temperature in the buds taken in this period is -4°C (1% death). As the temperature drops, the rate of damage has increased. Mortality rates are -5°C where % 2; -6°C where % 3; -7°C where % 8; -8°C where % 10; -9°C where % 34; -10°C where % 67; -11°C where % 90; -12°C all buds where % 100 dead. In the samples taken on 20.04, the first damage occurred at -4 ° C (9% death). Mortality rates are -6°C where % 13; -7°C where % 16; -8°C where % 24; -9°C where % 31; -10°C where % 52; -11°C where % 93; after this temperature all buds where % 100 dead. (Table 1).

With the decrease in the temperature in all sampling periods, the mortality rates of the buds have increased and this is an expected result. Similar results were obtained in the studies on the subject (Andrews and Proebsting 1987; Bartolini et al., 2001; Bartolozzi and Fontananza 1999; Burak 1989; Demirel 1997; Ertürk and Güleryüz, 2007).

In addition, buds with high frost resistance in winter started to lose this endurance towards spring season. This is a natural consequence of the warming of The atmosphere, while the buds waking up with water mobility. It is accepted that at least 50% of the flower buds should remain healthy for a safe product. More than 50% damage occurring temperatures, 29.01 where -16°C, 20.02 where -14°C, 06.03 where -16°C, 20.03, 05.04 and 20.04 where -10°C that been proved. In previous studies on temperate climate fruit species, frost resistance increased to the middle of winter and reached the highest level, and then began to decrease (Burak 1989; Demirel 1997; Aslantaş 1999).

According to the data of long years in Konya city center (1 January - 30 April), the lowest temperature values are given in Table 2 and 3. According to this, the sour cherry buds in the city center of Konya are damaged by frost in January. As a matter of fact, in our study, it was found that the samples taken on 29.01 were more than 50% damage from -15°C. According to the data of many years, there is a possibility that the temperature will fall below -15°C in every day of January in Konya city center (Table 2 and 3).

Likewise, there is a possibility of damaging the buds in February. In the samples taken at 20.02, more than 77% death was detected after -14°C. According to long-term data, the temperature for 14 days was lower than -14°C until the 20th of February. The buds received on 06.03 were started at -8°C. However, these mortality rates were below 50% at -17°C, and this rate was 87%. In the city center of Konya between 20 February and 6 March the temperature has fallen under -17°C for 4 days. As a result, the likelihood of damage to sour cherry buds in the period mentioned is still continuing. In the samples taken at 20.03, more than 50% damage occurred below -10°C. According to the meteorological data, it is also possible to damage the sour cherry buds during this period. Because the temperatures were below -10°C for 8 days. In the samples taken on 05.04, the rate of damage below -10°C exceeded 50%. During this period, as the weather continued to warm up to -10°C, the number of days was reduced to 3, so the likelihood of damage to the buds was reduced. Significant damages have occurred from -10°C in the samples taken on 20.04. According to the data of many years in the city center of Konya between 5-20 April, the temperature did not fall below -10°C. Accordingly, there is no risk of damage to cherry buds between these dates.

Total, Bound, Free Water and Dry Matter Amount in Buds

Water and dry matter contents of sour cherry buds in different periods are given in Table 4. As a results, the differences between water and dry matter contents of buds in different periods were found to be statistically significant. While the total water content in the buds was 86.60% in 29.01, it increased to 86.55% in 19.02, 87.50% in 05.03 and 97.74% in 19.03. Accordingly, it is evident that the water content in the buds increases with the emergence from the winter season. This is expected as a result of the warming of the atmosfer, consequently the arousal and growth of the buds. The water condition in plant texture generally indicates the frost damage potential. Frost damage occurs as a result of dehydration of plant cells related to freezing (Xin and Browse, 2000) and plant texture with high water content are more damaged by freezing (Hao et al., 2009).

A rapid decrease in the amount of bound water was found in the buds with the emergence of winter and a rapid increase in the amount of free water. The bound water, which was 0.084 mg on 29.01, fell to 0.080 in 19.02, 0.051 in 05.03 and 0.027 mg in 19.03. On the other hand, the bound water, which was 0.666 mg on 29.01, increased to 0.757 in 19.02, to 0.964 in 05.03 and to 1.879 mg on 19.03. Similarly, in the study conducted by Ertürk and Güleryüz (2007), it was determined that water content of buds increased from winter to spring and there was a negative correlation between water content and frost resistance. Increased water content in texture reduces the frost resistance of texture and increases the threat of damage. The higher the amount of water in the texture, the greater the durability. The cold acclimation period promotes the depletion of water in tissues as well as the accumulation of osmotically inactive protein and starch. As a result, a smaller amount of water in the tissues of the plants can provide a significant advantage for adaptation. In this way, less expansion and deterioration may occur in the intercellular spaces (Levitt, 1980).

The dry matter contents of the buds obtained at different dates were found to be almost the same between 29.01 and 05.03 and a rapid decrease was observed in 19.03. The flower buds that pass during the winter rest awaken with the warming of the weather in the spring. In this awakening, with the warming of the atmosfer, the movement of water in the soil and in the plant has an effect. With the movement of water in the plant, the stored nutrients move rapidly towards the buds. The amount of water and dry matter in the buds varied in the opposite direction to each other. With the increase of water, frost sensitivity is increased, buds gain more frost sensitivity strength with dry matter increase. Likewise, Aslantaş (1999) found a positive correlation between dry matter and almond resistance in almond buds.

Plant Nutrient Determination

Nutrient element analysis results of cherry buds taken at different dates are given in Table 5. The differences between the nutrient amounts were found to be statistically significant. According to this, the content of N in buds has decreased continuously between 29.01 and 20.04. Accordingly, P, K, Mn, Zn and S amounts increased from 29.01 to 20.03, and have started to decrease after this date. Mg and Fe amounts increased regularly until 20.03 and remained stable after this date. Ca and Cu levels increased until 06.03, then began to fall. The B content increased continuously. On 20.04 increased to 178 mg / kg. The amount of Zn increased regularly until 05.04 and then decreased. S content fluctuated on different dates. It was increased on 19.04 and started to decrease after this date. The N content, on the other hand, showed a constant decrease from the other elements.

Ion loss was determined in the cells as a result of freezing / thawing stress and this caused loss of membrane permeability. The main cation that disappeared from the doner cells is potassium (Aslantaş et al., 2010). With the exposure to low temperatures, the amount of calcium in the textures increases temporarily (Puhakainen, 2004). In this process, calcium transition from apoplast to cytoplase fluid occurs. The calcium channels in the plasma membranes serve as sensors against temperature drop (Smallwood and Bowles, 2002). In plants exposed to low temperatures, cell membrane fluidity decreases. This has been shown to be a signal for the functioning of cold-stimulated genes. Yigit and Güleryüz (1995) investigated the effects of potassium fertilization on cold resistance in Kütahya sour cherry variety. The potency of potassium in plants increases by affecting carbohydrate metabolism. determined that the potassium fertilizers applied at the appropriate doses lower the freezing point to lower temperatures by increasing sugar accumulation and osmotic pressure in the plant textures.

Total Carbohydrate, Protein and Proline Amount

Table 6 shows the total carbohydrate content of buds taken at different dates. Significant differences were determined in terms of carbohydrate content. According to this, the carbohydrate content decreased regularly from 29.01 until 04.04 and started to rise again in 19.04. This indicates that the tank carbohydrates in the buds are spent during the opening of the buds. On the other hand, as a result of photosynthesis, the extra carbohydrate production from 19.04 can be explained by the photosynthesis.

Carbohydrates are the basic cryoprotectants for cold resistance in plants. It has been reported that carbohydrate level increases up to 10 times during low temperature and this accumulation is effective on frost resistance (Guy, 1990). This effect is probably thought to occur when carbohydrates pull deadly intracellular freezing point to lower degrees. These substances also prepare the cells to tolerate freezing by acting as osmoprotectant to prevent dehydration from cytoplasm (Smirnoff, 1995). The relationship between the accumulation of carbohydrates in texture and resistance to cold was investigated in the rest period of different fruit species. In this context, Burak (1989) peach, Bolat (1993) and Demirel (1997) apricot, Palonen (1999) in the raspberry, the periodic change in carbohydrates and frost resistance have determined that there are important relationships.

Bud protein contents showed a steady decrease in successive sampling periods. The amount which was 1.423 on 29.01 decreased to 1.346 on 05.03 and to 1.215 on 19.04. This decrease is the result of the use of proteins as a source of nutrients during the opening of buds as in the total carbohydrate. Proteins play an important role in cold physiology of plants (Ertürk and Güleryüz, 2007). Many studies have shown that new polypeptides are synthesized in response to low temperatures. In recent years, studies have shown that there is a relationship between frost resistance and proteins (Aslantaş et al., 2010).

Burak (1989) stated that the high rate of protein in flower buds affects the frost resistance positively. Our results are similar to the results of Litvinova (1974), Tamássy and Zayan (1981), Burak (1989). It has important functions such as the incorporation of proteins into the membrane structure, the hydrophilic properties of water retention, the flowability of the protoplasm and its elasticity. For this reason, it is known that proteins contribute to cold resistance. The formation of ice crystals in the cell as a result of the exchange of soluble proteins is encouraged. The close relationship between soluble protein content and frost resistance is related to the increase in the amount of tRNA, mRNA and polysomes required for protein synthesis (Levitt, 1980). Proteins play a positive role in the growth of plants texture, apricots, peaches and olives were determined by the studies (Ashworth, 1983; Bartolozzi and Fontanazza, 1999; Bartolini et al., 2001). Amino acids and proteins have a role in the frost resistance physiology of plants. Generally, when the plants are exposed to low temperature, the amount of soluble protein in their bodies is increased relatively, it is stated that this rate is high in the frost resistant species and varieties and low in the non-resistant varieties (Ertürk and Güleryüz, 2007). Some of the special proteins accumulated during cold acclimation show antifreeze protein properties (Pearce, 2001). Antifreeze proteins (AFPs) have the ability to alter the shape and formation of the ice crystal and prevent the recrystallization of ice. As a result, they contribute to protecting the cells from frost damage. During the cold acclimation of barley, wheat, rye and canola, the accumulation of AFP was observed (Scebba et al., 1998). The total proline amount of buds taken at different dates is given in Table 6. The differences between proline content of the buds were not statistically significant. Proline, an amino acid, is synthesized and deposited in plants developed in response to many environmental stresses (Yeo and Flowers, 1989; Ashraf and Wu, 1994). The amount of proline increases in the stressed plants during the period of cold exposure (Hare and Cress, 1997). It has been determined that citrus plants, which have adapted to cold, accumulate 3 to 6 times more proline than un-plants (Yelenosky, 1979). In a study by Xin (1998), 30-fold proline increase was observed in Arabidopsis plants during cold acclimation. Other stress factors also change the amount of proline. Pırlak and Eşitken (2004), in a study with strawberry varieties, reported that the amount of proline increased significantly in plants under salt stress. Obtaining different results here may be due to the fact that the genetic structures of the species are different.

Table 1
Death rates of sour cherry buds at different temperatures.

Temperature (°C)	Mortality rates (%)					
	29.1.2018	20.2.2018	6.3.2018	20.3.2018	5.4.2018	20.4.2018
0°C	0 e	0 d	0 f	0 f	0 h	0 f
-1°C	0 e	0 d	0 f	0 f	0 h	0 f
-2°C	0 e	0 d	0 f	0 f	0 h	0 f
-3°C	0 e	0 d	0 f	0 f	0 h	0 f
-4°C	0 e	0 d	0 f	0 f	1 g	0 f
-5°C	0 e	0 d	0 f	0 f	2 f	9 e
-6°C	0 e	0 d	0 f	1 e	3 e	13 e
-7°C	0 e	0 d	0 f	7 d	8 d	16 d e
-8°C	0 e	0 c d	2 e	15 c	10 d	24 c d
-9°C	0 e	0 c d	2 e	34 b c	34 c	31 c
-10°C	1 d e	0 c d	3 e	50 b	67 b	52 b
-11°C	1 d e	1 c d	16 d	51 b	90 a b	93 a b
-12°C	1 d e	2 c	18 b c d	65 a b	100 a	100 a
-13°C	3 d	18 b	18 b c d	92 a	100 a	100 a
-14°C	8 c	77 a b	31 b c	100 a	100 a	100 a
-15°C	49 b	77 a b	36 b c	100 a	100 a	100 a
-16°C	97 a b	100 a	87 b	100 a	100 a	100 a
-17°C	99 a b	100 a	95 a b	100 a	100 a	100 a
-18°C	100 a	100 a	100 a	100 a	100 a	100 a
-19°C	100 a	100 a	100 a	100 a	100 a	100 a
-20°C	100 a	100 a	100 a	100 a	100 a	100 a
-21°C	100 a	100 a	100 a	100 a	100 a	100 a
-22°C	100 a	100 a	100 a	100 a	100 a	100 a

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Table 2
The lowest daily temperatures between January and May in Konya Province for many years.

Dates	Daily minimum temperatures (°C)			
	January	February	March	April
1	-23.9	-18.7	-15.8	-6.6
2	-22.4	-20.8	-15.5	-5.7
3	-21.8	-19.1	-16.4	-5.4
4	-23.2	-22.0	-12.0	-5.0
5	-27.8	-23.4	-15.0	-5.7
6	-28.2	-26.5	-14.6	-4.0
7	-23.1	-23.8	-15.4	-6.0
8	-25.7	-25.0	-11.9	-5.7
9	-21.5	-19.1	-10.6	-4.6
10	-19.5	-19.4	-9.9	-7.4
11	-16.5	-26.2	-12.8	-8.6
12	-16.2	-18.5	-10.0	-8.6
13	-16.6	-15.0	-11.1	-4.9
14	-18.1	-17.0	-11.6	-5.2
15	-20.5	-13.9	-11.4	-3.7
16	-17.5	-13.6	-11.8	-6.0
17	-14.5	-12.0	-9.5	-2.0
18	-22.8	-10.8	-7.5	-3.4
19	-19.2	-12.9	-9.3	-3.6
20	-19.7	-11.9	-10.0	-2.0
21	-18.0	-15.0	-8.0	-1.2
22	-18.2	-14.2	-7.5	-3.1
23	-20.0	-12.6	-12.6	-3.0
24	-22.0	-18.0	-7.8	-5.2
25	-25.8	-22.8	-10.4	-1.5
26	-23.7	-14.0	-7.3	-1.2
27	-21.0	-19.5	-7.5	-1.0
28	-18.0	-19.0	-7.4	-1.5
29	-18.4	-10.6	-7.9	-1.7
30	-19.4	-	-10.4	-1.3
31	-21.2	-	-6.0	-

Table 3
The lowest daily temperatures between January and May for 2018 in Konya Province.

Dates	Daily minimum temperatures (°C)			
	January	February	March	April
1	-1.4	-6.6	-0.2	3.8
2	-3.8	-6.8	-2.7	5.9
3	-1.5	-0.6	4.6	1.3
4	0.2	1.1	5.1	0.4
5	-1.1	2.6	3.7	2.1
6	-0.2	-0.8	6.0	2.2
7	-5.1	-1.6	7.5	3.0
8	-0.4	4.2	6.5	7.4
9	-0.2	5.1	6.2	6.3
10	-0.8	3.1	-0.2	6.5
11	-1.4	1.0	0.5	4.8
12	3.9	0.5	2.8	7.9
13	-0.6	2.0	1.6	8.7
14	1.9	-1.2	4.0	7.6
15	-0.9	0.2	4.6	9.5
16	-3.2	1.2	1.7	7.4
17	0.2	3.9	1.4	2.8
18	1.4	2.1	4.0	6.1
19	-2.6	-4.8	2.8	9.5
20	-7.6	-0.1	3.7	7.8
21	-2.5	3.1	1.1	5.0
22	1.5	-1.4	1.5	2.1
23	2.1	1.6	7.0	1.8
24	-1.1	-0.7	12.0	5.0
25	-5.0	2.1	0.1	5.2
26	-5.1	2.0	1.7	12.6
27	-2.8	1.7	2.0	10.6
28	-1.4	1.9	3.6	13.6
29	-	-	7.4	9.6
30	-	-	3.9	9.5
31	-	-	-1.2	-

Table 4
Determination of total amount of cherry buds, bound, free water and dry matter (%).

Period date	29.01.2018	19.02.2018	05.03.2018	19.03.2018
Free Water %	76.91 c	78.28 c	83.10 b	96.30 a
Bound Water %	9.69 a	8.27 a	4.39 b	1.38 c
Total Water %	86.60 b	86.55 b	87.50 b	97.74 a
Dry matter %	13.39 a	13.44 a	12.50 a	2.25 b

Table 5
Nutrient quantities in sour cherry flower buds at different dates.

Nutrients	29.01.2018	20.02.2018	06.03.2018	20.03.2018	05.04.2018	20.04.2018
N (%)	2.75 a	2.76 a	2.66 ab	2.45 ab	2.50 ab	2.31 b
P (mg/kg)	2540 c	3012 b	2979 b	3355 a	2544 c	2715.5 c
K (mg/kg)	20134 c	22243 b	22350 b	24350 a	21220 bc	21560 bc
Ca (mg/kg)	11230 b	11320 b	13450 a	12340 ab	12300 ab	11800 b
Mg (mg/kg)	1890 b	2034 b	2120 ab	2340 a	2310 a	2300 a
Fe (mg/kg)	134 c	145 bc	167 a b	176 a	175 a	178 a
Mn (mg/kg)	34.45 c	35.76 bc	36.74 bc	45.65 a	40.21 b	38.77 bc
Zn (mg/kg)	28.76 b	28.44 b	33.23 ab	34.35 a	36.54 a	32.24 ab
Cu (mg/kg)	44.56 d	47.68 cd	55.34 a	53.44 ab	52.23 bc	48.76 cd
B (mg/kg)	12.33 b	13.05 ab	12.24 b	13.43 ab	14.32 ab	15.46 a
S (mg/kg)	2012 a	2033 a	2045 a	2320 b	2243 b	2210 b

Table 6
Carbohydrate, protein and proline amounts of sour cherry buds on different dates.

Period Date	29/01	19/02	05/03	19/03	04/04	19/04
Carbohydrate (mg/g)	4.232 a	4.063 b	3.933 c	3.542 e	3.516 e	3.768 d
Protein (mg/g)	1.423 a	1.409 b	1.346 c	1.315 d	1.236 e	1.215 e
Proline (mg/g)	2.573	2.526	2.550	2.566	2.589	2.590

4. Conclusions

Differences in fatal temperatures and resistance to cold were observed in different developmental stages. The observed damage is highly dependent on the development stages of the flower bud. It has been observed that the buds have increased sensitivity to low temperatures. Flower tolerance is influenced by early flower bud stage and temperature fluctuation during flowering, while hot conditions increase flower sensitivity, low temperature reduces this requirement. Although the determination of the maximum durability can be obtained genetically, it is possible to explain the changes in strength; As a result of the strong climatic effect, more and more years of observation are needed. Flower buds are known to survive the cold damage that kills the tree; resistance varies widely throughout the year (Proebsting, 1982).

The softening, hardening time, fluctuations in the resistance of the flower bud were supported by observations in the middle of winter, according to changes in ambient air temperature (Andrews and Proebsting Jr, 1987). The deadly temperature for the sour cherry flower buds was -16 ° C, while the unopened flower bud increased rapidly to -11 ° C. Extremely low temperatures, which may occur during the rest period in the economic sour cherry cultivation in Konya city center, can damage the cherry flower buds. Therefore, it is advisable to avoid hollow areas where cold air is deposited as much as possible while closing gardens are preferred, and as far as possible, prefer protected areas.

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Effects of High Light Intensity on Egg Weight Loss, Hatchability, Embryonic Mortality, and Supply Organ Weight at Hatch in Quail Hatching Eggs during Incubation

Talha Seçim KAYA[1], Ali AYGÜN[1,*]

[1]Selçuk University, Faculty of Agriculture, Department of Animal Science, Konya, Turkey

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ABSTRACT

The aim of this study is to investigate the effects of high light intensity on egg weight loss, hatchability, embryonic mortality, and supply organ weights at hatch in Japanese quail (*Coturnix coturnix japonica*) eggs. A total of 640 hatching eggs were randomly distributed into 2 groups. The first group of eggs were continuously incubated in the dark (Control; C), the second group of eggs were incubated in continuous light(L), the third group of eggs were incubated in the dark for the first five days of incubation (D5), and the last group were incubated in the light for the first five days in the eggs (L5). The light intensity at the surface of the eggshell varied from 5000 to 6000 lux as measured with a luxmeter. No significant differences were found in egg weight loss, hatchability, and supply organ weight among treatments. Embryonic mortality were higher in the L5 group than in the control group at 10 to 16 days of incubation. These results demonstrate that high light application during incubation affected the embryonic mortality negatively except hatchability and egg weight loss.

1. Introduction

Hatching eggs are generally incubated in a dark environment condition in commercial incubators. However, in recent years, many studies have been carried out about lighting programs during incubation. There are studies reporting that hatchery lighting application has a positive effect on some properties such as reducing stress parameters (Ozkan et al. 2012a; Huth and Archer 2015), decreasing hatching time (Farghly and Abdelfattah 2018; Maman et al. 2018), improve hatchability (Huth and Archer 2015), behavioral traits (Sabuncuoğlu et al. 2018), optimum post-hatch performance (Rozenboim et al. 2004; Ozkan et al. 2012a; Farghly and Abdelfattah 2018). The light intensity applied at the incubation was 150 lux (Farghly and Abdelfattah 2018), 250 lux (Huth and Archer 2015; Archer 2017), 550 lux (Archer et al. 2009b; Archer and Mench 2013), 300 lux (Ozkan et al. 2012b), 1650 lux (Sabuncuoğlu et al. 2018), 1790 lux (Shafey 2004), 2080 lux (Shafey et al. 2005), 2900 lux (Maman et al. 2018). The aim of this study is to investigate the effects of high light intensity on egg weight loss, hatchability, embryonic mortality, and supply organ weights in Japanese quail (*Coturnix coturnix japonica*) eggs.

2. Materials and Methods

In total, fresh eggs were obtained from Japanese quail (*Coturnix coturnix japonica*) that were raised on a local commercial farm. The eggs were randomly assigned into 4 groups of 160 eggs. The first group of eggs were continuously incubated in the dark (Control; C), the second group of eggs were incubated in continuous light(L), the third group of eggs were incubated in the dark for the first five days of incubation (D5), and the last group were incubated in the light for the first five days in the eggs (L5). The light intensity at the surface of the eggshell varied from 5000 to 6000 lux as measured with a luxmeter. To determine the egg weight loss, a total of 40 eggs from each treatment was numbered and weighed at the beginning and on d 14 of incubation. Eggs containing dead embryos and unfertile eggs were excluded from the calculation percentage of egg weight loss. The eggs were turned 12 times a day until the last three days of incubation. The hatched chicks were checked and

* Corresponding author email: *aaygun@selcuk.edu.tr*

recorded every 3 h between 372 and 414 h of incubation. After completion of the hatching, unhatched eggs were opened, and embryos were assessed according to the method determined by Aygun et al. (2012) to establish the stage of embryonic mortality. Fertility was calculated as the percentage of set eggs. Hatchability was calculated as both set eggs and fertile eggs. After completion of the hatching, 7 chicks from each group every three hours were killed by cervical dislocation. The chick, yolk sac, liver, and heart weight were determined with a balance with sensitivity ± 0.01 g. Organ weights were expressed as a percentage of chick BW.

Statistical analysis

Data were analyzed using the One way analysis of variance (ANOVA). The significant differences between means were obtained by Tukey test. All analyses were carried out using Minitab Version 16.

3. Results and Discussion

The results of set egg weight, transfer egg weight, and egg weight loss during the incubation of 0 to 14 d of embryonic development are shown in Table 1. No significant differences were found in set egg weight, transfer egg weight, and egg weight loss among treatments. The egg weight loss during incubation is important for a good incubation management. During the incubation, high water loss from the egg has a negative effect on the development of the embryo (Geng and Wang 1990; Mo et al. 2007). The egg weight loss during incubation may vary from 6.5 to about 12% without affecting hatchability in poultry eggs (Hays and Spear 1951; Aygun et al. 2012; Caglayan et al. 2014; Yildirim et al. 2015; Alasahan et al. 2016).

Table 1
Effects of high light intensity on egg weight loss during incubation.

Treatment	Set egg weight (g)	Transfer egg weight (g)	Egg weight loss (%)
C	11.76	10.41	11.46
L	11.19	9.97	10.99
D5	11.65	10.21	12.43
L5	11.46	10.10	11.83
SEM	0.192	0.179	0.483
P-value	0.169	0.325	0.259

C: Eggs were incubated in dark until 14 d of incubation, L: Eggs were incubated in light until 14 d of incubation; D5: Eggs were incubated in dark until 5 d of incubation, and in light until 14 d of incubation; L5: Eggs were incubated in light until 5 d of incubation, and in dark until 14 d of incubation.

The treatment's effect on hatchability and embryonic mortality are presented in Table 2. There were no differences in the hatchability of set eggs (C, 64.61%; L, 56.23%; D5, 64.61%; and L5, 70.82%) or hatchability of fertile eggs (C, 88.42%; L, 80.85%; D5, 91.19%; and L5, 93.82%) among treatment groups. These results are similar to previous studies indicating that light application during incubation did not significantly affect the hatchability (Shafey et al. 2005; Huth and Archer 2015; Maman et al. 2018). We did not find significant increase in embryonic mortality at any stage of incubation among all treatment groups except the 10th to 16th day of incubation. The highest embryo deaths were detected in the L group at 10th to 16th days of incubation. This result is incompatible with the study of (Shafey 2004) reporting that light application (1230 to 1790 lux) during incubation decreases embryo mortality. On the other hand, there were similar studies in which light application did not affect embryo mortality (Archer et al. 2009a; Huth and Archer 2015; Maman et al. 2018). This difference may be due to the fact that the light intensity applied in our study is higher than the intensity and type of lighting applied in this study. No significant differences were found among C, D5, and L5 treatments groups at 10th to 16th days of incubation for embryonic mortality.

Hatching began at 387, 387, 384, and 390 h of incubation duration in C, L, D5, and L5 groups, respectively (Figure 1). Hatching ended in the C, L, and L5 at 408 h of incubation except D5 group. The hatching in D5 was completed at 405 h of incubation. No significant differences were observed among C (91.14%), L (89.93%) and D5 (44.78%) groups, but C and L had significantly higher hatching than L5 (32.62%) at 393 h of incubation. There were no significant differences between C, L, D5, and L5 groups at 384, 387, 396, 399, 402 and 405 h of incubation. Reducing the size of the spread is more important for poultry sectors because the chicks will have homogeneity. If the chick hatching times is longer, it will delay the time for the chicks to eat and access to water.

Table 2
Effects of high light intensity on fertility, hatchability, and embryonic mortality (%)

Treatment	Fertility (%)	Hatchability of set eggs (%)	Hatchability of fertile eggs (%)	Embryonic mortality (% of fertile eggs)		
				1 to 9 d	10 to 16 d	17 to 18 d
C	73.07	64.61	88.42	4.19	2.55[b]	0.81
L	69.24	56.23	80.85	8.02	9.11[a]	2.02
D5	70.97	64.61	91.19	5.46	3.35[ab]	0.00
L5	75.39	70.82	93.82	3.49	2.69[b]	0.00
SEM	3.767	4.460	3.520	2.190	1.402	0.725
P-value	0.691	0.200	0.106	0.503	0.017	0.212

[a,b] Means within a column with different superscripts differ significantly ($P<0.05$).
C: Eggs were incubated in dark until 14 d of incubation, L: Eggs were incubated in light until 14 d of incubation; D5: Eggs were incubated in dark until 5 d of incubation, and in light until 14 d of incubation; L5: Eggs were incubated in light until 5 d of incubation, and in dark until 14 d of incubation.

This may lead to negative results in dehydrated chicks, post-hatch performance and immune response (Becker 1960; Pinchasov and Noy 1993; Casteel et al. 1994; Bigot et al. 2003; Gonzales et al. 2003; Tona et al. 2003; Careghi et al. 2005).

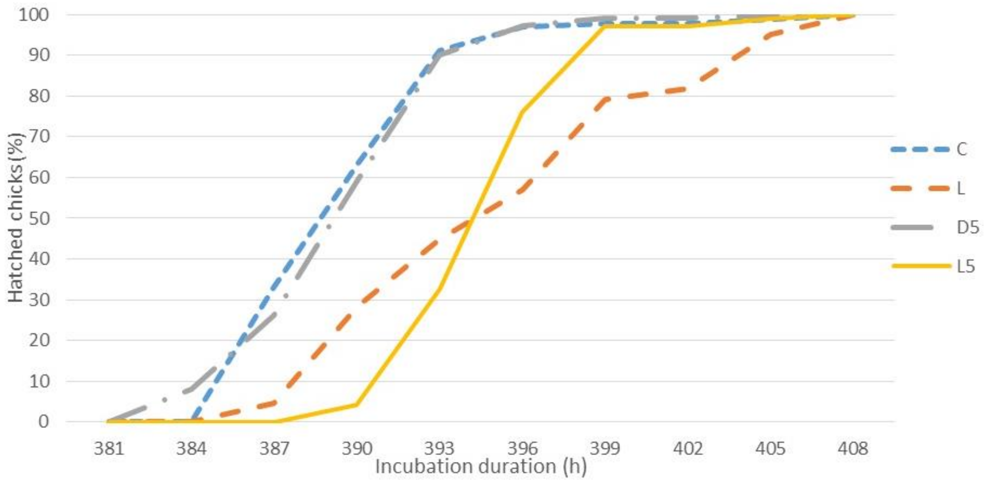

Figure 1
Effects of high light intensity on spread of hatch.
C: Eggs were incubated in dark until 14 d of incubation, L: Eggs were incubated in light until 14 d of incubation; D5: Eggs were incubated in dark until 5 d of incubation, and in light until 14 d of incubation; L5: Eggs were incubated in light until 5 d of incubation, and in dark until 14 d of incubation

There were significant differences among treatments for chick weight (C, 8.03 g; L, 8.35 g; D5, 8.32 g; L5, 8.07 g), yolk sac weight (C, 8.50%; L, 8.62%; D5, 7.59%; L5, 6.81%), heart weight (C, 0.93%; L, 0.92%; D5, 0.87%; L5, 0.81%), and liver weight (C, 2.62%; L, 2.26%; D5, 2.49%; L5, 2.41%; Table 3). Our result the chick hatching weight agree with the study of Bayram and Özkan (2010); (Sabuncuoğlu et al. 2018) about the effect of lighting application during incubation did not effect on the chick weight. Ozkan et al. (2012a) reported that lighting during incubation did not effect on yolk sac weight (%), heart weight (g), and liver weight (g).

Table 3
Effects of high light intensity on chick weight and supply organ weights

Treatment	Chick weight (g)	Yolk sac weight (%)	Heart weight (%)	Liver weight (%)
C	8.03	8.50	0.93	2.62
L	8.35	8.62	0.92	2.26
D5	8.32	7.59	0.87	2.49
L5	8.07	6.81	0.81	2.41
SEM	0.265	0.794	0.058	0.107
P-value	0.758	0.392	0.484	0.173

C: Eggs were incubated in dark until 14 d of incubation, L: Eggs were incubated in light until 14 d of incubation; D5: Eggs were incubated in dark until 5 d of incubation, and in light until 14 d of incubation; L5: Eggs were incubated in light until 5 d of incubation, and in dark until 14 d of incubation.

4. Conclusion

As a result, high light application during incubation has no negative effect on egg weight loss, hatchability, and supply organ weights. Continuous high light application increased embryo mortality compared to control group. Periodic light application may be more useful instead of continuous light application during incubation.

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A Study on Relationships between Various Quantitative Characteristics for Using Availability Quantitative Trait Loci Mapping[**], [***]

Özge ŞAHİN[1,*], Orhan KAVUNCU[2]

[1]Institute for Evolution and Biodiversity, Faculty of Biology, University of Münster, Hüfferstrasse 1, Müster, Germany
[2]Department of Genetics and Bioengineering, Faculty of Engineering and Architecture, Kastamonu University, Kastamonu, Turkey

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Edited by:
İbrahim AYTEKİN; *Selçuk University, Turkey*

Reviewed by:
Yasemin GEDİK; *Ankara University, Turkey*
Mehmet Cengiz BALOĞLU; *Kastamonu University, Turkey*

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ABSTRACT

In this study, *Tribolium confusum* Jacquelin du Val, 1868 (Coleoptera: Tenebrionidae) lines were selected as live material and they were used for quantitative trait locus analysis. The two of *T. confusum* lines were selected randomly and they were used for breeding process. During the experiments, the insects were held in the medium consisting of 95% flour and 5% yeast mixture which were placed in the incubators adjusted to suitable moisture and 32.5° C temperature. Pupal weight for the selected marker loci was examined whether there were effective on quantitative traits. The examination of the differences between pupae weight of generations were analyzed by ANOVA in Minitab 16 statistical software package. A significant difference in the pupal weight between these lines was not found. According to the results, it was concluded that the material used in this study was inconvenient to detect a quantitative trait locus and a mapping study. Still, in terms of examining for the implementations of methods further hybridizations and analysis could be carried out.

1. Introduction

Many features are controlled by multiple genes and environmental factors. Although these features are very simple as phenotypes, they are complex as genotypes. It is therefore also often referred to as complex features (Lander and Kruglyak, 1995). These complex features are often quantitative traits. Quantitative traits are features which have continuous distri[1]butions on phenotypes. The variations of these traits are controlled by segregation of many loci, and therefore they are studied via more complex methods because of segregation of a lot of loci. The concepts of the linkage between genes and marker loci have given rise to the term quantitative trait locus (Tanksley, 1993). Quantitative trait loci (QTL) can be a major gene or a small set of small genes that have effects on the phenotype together.

Utilization of the linked genes in indirect selection for any quantitative trait had been taken into account long before (Düzgüneş and Ekingen, 1983). Separation of each major gene and information about QTL presence by using the correlation of the quantitative phenotype with a single marker locus or a set of marker loci can potentially find many useful applications. For instance, the information on the QTL presence can be used to improve the effect of selective breeding for characteristics that can be observed in a single gender with lower heritability. Another important potential is that it can be applied transgenic technology for quantitative traits. It is known that identification of alleles predisposing to common multifactorial diseases such as heart disease or diabetes can help in the development of methods of preventing these diseases (Falconer and Mackay, 1996).

The study of genetic constructs of quantitative traits using molecular markers implies QTL mapping, in fact, by making use of the relationship between marker loci and quantitative traits (Xu, 2002). Many properties with economic and medical prescription in humans, animals or plants are polygenic. The presence of high amounts of polymorphic DNA markers in many species allows for the preparation of genetic maps well and the examination of genetic structures of

[*]Corresponding author email: sahino@uni-muenster.de
[**] This study was conducted as an MSc thesis (Şahin, 2016) in Ankara University Faculty of Agriculture, Department of Animal Science.
[***] Short communication

complex quantitative traits. Systematic screening of the entire genome for QTL by the use of molecular-linkage maps may account for a large portion of the total phenotypic variance (Zhong & Yan, 2003).

In this study, we have tried to review the QTL methods used in the literature and wanted to apply them in an example material to conceive the subject. So, the *Tribolium confusum* Jacquelin du Val, 1868 (Coleoptera: Tenebrionidae) was preferred just as an example and a model organism because its generation interval is very short and easy to measure the pupae weight. On the other hand, this model organism is a well-known pest for stored products. Therefore having more information about its genetic structure is very useful for future research studies.

The life cycle of *Tribolium* has four main stages including egg, larva, pupa and adult. The eggs are quite small, white and flexible. The larvae hatch out after 1-2 days in appropriate circumstances. After changing of six shirts, the larvae enter the pupal stage at 19th - 21st day. The pupal stage lasts 3-4 days. After pupal stage, adults access sexual maturity and reproductive capacity in 3-5 days. Adult beetles live for 1-2 years and can produce around 15 eggs each female per day at the appropriate conditions (Sokoloff, 1977).

2. Materials and Methods

2. 1. Tribolium confusum (Coleoptera: Tenebrionidae) and preparation of medium

Tribolium species are insects belonging to *Tenebrionidae* family of *Coleoptera* order and have many detrimental effects to food such as stored flour, semolina, chocolate, spices, and dried fruit. They can eat almost every type of stored food (Tribolium Genome Sequencing Consortium, 2008). In addition to this, some of them can have a flight capability and be found far from storage locations (Semeao et al., 2010).

There are several reasons for studying *Tribolium* species. One of the most important reason is that *Tribolium* is a model organism for classic genetic studies. It is also the only genetic model for medically and agriculturally significant coleopteran species (Brown et al., 2003).

In the study, *T. confusum* lines which were brought to Population Genetics Laboratory in Ankara University Faculty of Agriculture, Department of Biometry and Genetics in 1993 were used as live material in 2016. These beetles were held in the medium consisting of 95% flour and 5% yeast mixture which were placed in the incubators adjusted to suitable moisture and 32.5°C temperature.

2.2 Mating

Two of these *T. confusum* lines were selected randomly. They were named as *Tcf 181 NewYork* and *Tcf 117*. Firstly, 25 females of *Tcf 181 NewYork* line and 25 males of *Tcf 117* were selected randomly and their 21st day pupal weight was measured. The difference between the means of the lines was found to be insignificant. Although this situation, hybridizations were continued with the idea of finding a variation due to non-additive effects between and within QTL. According to this opinion, 40 numbers of F_1 progenies' pupal weight and 20 numbers of F_2 progenies' pupal weight were measured. Then, 20 numbers of F_1 progenies were selected randomly and were separated as 10 females and 10 males to hybridize with *Tcf 181 NewYork*. Reciprocal backcrosses were carried out.

2.3 DNA isolation and PCR

For isolation of the genomic DNA, the DNA isolation protocol reported by Hall (1986, 1990) was adapted to the laboratory conditions. After DNA isolation, different genotypes between ancestral lines were seen at AC154135 marker locus obtained from the NCBI GenBank database.

This marker locus was amplified by using the report which William et al reported in 1990. This report was adapted the laboratory conditions and 5' GTAGACCCGT 3' was used as primer. According to this report PCR conditions included 45 cycles of denaturation at 94^{o}C for 1 min, annealing at 36^{o}C for 1 min and extension at 72^{o}C for 2 min. It was also included pre-denaturation at 94^{o}C for 2 min and last extension at 72^{o}C for 10 min.

3. Results and Discussion

At the beginning of the study, selected *T. confusum* lines' descriptive statistics on pupal weight were calculated. These descriptive statistics are shown in Table 1.

Table 1
Descriptive statistics of *Tcf 181 New York* and *Tcf 117* on 21st day pupal weight (g)

Variation	N	Mean	SE of the Mean	Std Dev	Variance	Minimum	Maximum
Tcf 181	25	2.44	0.07	0.35	0.12	1.89	3.07
Tcf 117	25	2.39	0.06	0.32	0.10	1.87	3.02

There was not found any significant difference between the means of 21st day pupal weights of the lines. In this case, a QTL research and mapping study between these two lines which have different genotypes at marker loci, but have not any significant difference on pupal weight was unable to do. However, with the hope that there is a possibility of non-additive effects and in terms of being a practice on the implementation of the method the planned further hybridizations and analysis were performed.

Some of the descriptive statistics of the lines which were used for mating and their offspring were showed on Table 2.

Table 2
Descriptive statistics of the lines on 21st day pupal weight

Variation	*Tcf 181 NY*	*Tcf 117*	F_1	F_2	*Tcf 181 NY* (Female)/ F_1 (Male)	*Tcf 181 NY* (Male)/ F_1 (Female)
N	25	25	40	20	10	10
$\bar{X}$	2.44	2.39	2.27	2.43	2.35	2.24
$S_{\bar{X}}$	0.07	0.06	0.05	0.07	0.09	0.09
S_X	0.35	0.32	0.34	0.33	0.28	0.25
S	0.12	0.10	0.12	0.11	0.09	0.06
Minimum	1.89	1.87	1.54	1.85	1.92	1.82
Maximum	3.07	3.02	2.95	2.92	2.87	2.65

The differences between the means of pupal weights were examined with ANOVA in Minitab 16 statistical software package. The analysis was done to check out if there is a difference between the means of pupal weight on the generations which were included in the study. The results of variance analysis are shown in Table 3.

Table 3
Variance analysis

Source	DF	SS	MS	F	P
Factor	5	0.7075	0.1415	1.32	0.258
Error	124	13.2491	0.1068		
Total	129	13.9566			

There was not any significant difference between the groups in terms of mean pupal weight at the results of this variance analysis. In this case, it can be concluded that there is not a genetic variation present material obtained in terms of pupa weight. Therefore, it was decided that this situation was not suitable for studying QTL.

Consequently, in terms of quantitative aspects the lines to be crossed had to have phenotypic differences or at least F_1 had to be a significant difference from the parent lines. If these differences were observed, it could be examined quantity of the genotypic difference on the phenotypic difference and the places of these genes could be detected on the genome.

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Determination of Population Development and Infestation Rates of Codling Moth [*Cydia pomonella* (L.) (Lep.: Tortricidae)] in Apple Orchards in Konya Province

Dilek AYDOĞAN[1], Levent ÜNLÜ[1,*]

[1]Selçuk University, Faculty of Agriculture, Department of Plant Protection, Konya, Turkey

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ABSTRACT

The study was conducted to determine population development and infestation rates of codling moth (*Cydia pomonella* (L.) (Lep.: Tortricidae) in Selçuklu, Meram and Karatay districts in Konya Province. During 2017-2018, two apple orchards were selected from each district. Pheromone traps were used to monitor adult population development and infestation rates by counting weekly infested and not-infested apple fruits after fruit set stage of tree. Study results revealed that, in all districts, adult population peaks were observed four and three times in 2017 and 2018 in each year, respectively. It was determined that, codling moth might produce two-three generation depending on years and climate conditions, in Konya province.. Flight period of codling moth adults, in orchards, started in thr second week of May and lasted at the end of October. Infestation rates were calculated for 2017 and 2018 in Selcuklu district 10.5% and 16.45%, in Meram district 21.3% and 30.15%; and in Karatay district 20.5% and 33.9%, respectively.

1. Introduction

Apple is a commonly consumed fruit because of high antioxidant content and source of important nutrients and vitamins, as well as good taste. For this reason apple fruit is in demand at much higher than other temperate climate fruit species. Apple has found a wide range of ecological suitability of cultivation areas in Turkey. Most part of these produced apple fruits are consumed as a fresh in the local markets, and other parts used for fruit juice, fruit concentrate and so on as raw a material in industry (Taşcı, 2017).

The homeland of the apple extends to the South Caucasus, including Anatolia, among temperate climate fruit species and the culture dates back to the early centuries. Apple, which has the ability to adapt to different ecologies, showed a wide spread in the world. Today, apple production accounts for approximately 12% of the total fruit production in the world, and gets second place after banana (Taşcı, 2017).

Turkey is one of the most important apple producer countries in the world. Although the place in the ranking varies from year to year, Turkey finds its place among the top five countries in the world in terms of apple production area and amount. Apple production area in Turkey was 173.393,5 ha in 2018, from which Nigde Province took first place with its 23.409 ha, Isparta province took second place with 22.813 ha and Karaman District took third place with 19.556 ha area of production (TUİK, 2018).

Controlling diseases and pests is one of the main important problems during fruit growing. Among apple pests, codling moth has great importance for apple trees. Its larvae damage directly occurs on fruits, and larvae make galleries in the fruit through mesocarp and seeds. The wounds caused by codling moth lead to fruit rot. Thus, infested fruits fall to the ground; if the fruits can remain hung on the trees they lost the quality and quantity, therefore, the value of fruits in the market decreases. The damage of this pest may reach up to 60% or even 100% without controlling actions. Codling moth distributed in all apple growing areas in Turkey (Anonymous, 1995).

* Corresponding author email : *ulevent@selcuk.edu.tr*

Codling moth control methods mostly based on chemical control such as using wide spectrum insecticides, in the world as well as in Turkey. But recent studies have focused on biological and biotechnical control methods due to the known negative effects of chemical insecticides (Bulut and Kılınçer 1989). Sexual attraction pheromone traps are one of the methods of biotechnical control and have used mostly for monitoring specific pest species. These traps are used against many pest species around the world and in Turkey (Önder, 1987; Layık and Kısmalı, 1994; Hepdurgun *et al*., 1996; Kılıç et al., 1999; Kutinkova *et al*., 2009; Knight, 2010; Kakar *et al*., 2015).

When researches are examined from the open access literature on this topic, *Cydia pomonella* population development have been studied in Eğirdir district by İşci (2008), in Şanlıurfa province by Mamay and Yanık (2013), in Elazığ province by Ayaz and Yücel (2010) and in Beyşehir (Konya) district by Çelik ve Ünlü (2017) in apple orchards. Hantaş *et al.* (2014), also tested pheromone traps against codling moth in quince orchard in Marmara region.

The aim of this study was to investigate adult population development, infestation rates and some other biological properties of codling moth in apple orchards in central districts of Konya province.

2. Materials and Methods

The basic materials of this research were apple orchards located in Selçuklu, Meram and Karatay districts in Konya province and codling moth population in these orchards. Delta type pheromone traps were used to determine population development of codling moth. In all traps, sticky trays were used for catching and counting and species specific pheromone capsule (1,5 mg E.E-8.10-dodecadien-1-ol) for attract codling moth males to the traps. All orchards coordinates were obtained using a GPS device.

Selecting Trial Orchards

Two apple orchards were selected from Selcuklu, Meram and Karatay districts representing three central districts of Konya province. All orchards were at least 0.5 hectare in size and there was a interval of at least one kilometer between each orchards.

Table 1
Characteristics of the apple orchards of the study site

		Size (ha)	Orchard Age	Variety	Tree Number	Coordinates
Selçuklu	Çaltı	2	12	Fuji, Gala, Starking, Golden	1450	38°09'51.9"N 32°26'21.2"E
	Kampüs	4	14	Golden, Red Chif Braeburn	740	38°03'20.6"N 32°50'58.6"E
Meram	Hatıp	1.5	7	Starking, Golden	1500	37°46'26.1"N 32°26'21.2"E
	Kozağaç	5	8	Arjantin, Altın çekirdek, Gala	240	37°46'38.7"N 32°24'35.1"E
Karatay	Karaaslan1	5	17	Fuji, Gala, Starking	100	37°49'19.8"N 32°32'35.5"E
	Karaaslan2	7	6	Arjantin, Gala, Starking, Golden	500	37°49'43.5"N 32°32'50.4"E

Determination of Codling Moth Population Development

Researches on to monitore *C. pomonella* adult population development and infestation rates carried out in the same orchards in both 2017 and 2018 years, in Selçuklu, Meram and Karatay districts. Two pheromone traps placed in each orchard on 1 May in 2017 and 8 May in 2018 to monitor population development. The traps were hung at 1.5-2 m high from the ground in the south direction of the trees and in the direction of the dominant wind. Trap visits were performed twice a week until the first adult was captured, and once a week after the first adult was captured, the number of captured adults was recorded. The pheromone capsules of the traps were replaced every six weeks and old capsules were removed from the orchards. The sticky trays in the traps were replaced with new ones as needed depending on the loss of the adhesive layer.

Determination of Infestation Rates of Codling Moth

In order to determine the infestation rate of codling moth, the counting was started from the moment of the fruits were damaged in the sampling apple orchards. In all the orchards in which the study was conducted, to determine the number of infested fruits in 100 fruits which were randomly selected five trees from different parts from apple trees to represent the orchard every week. Infestation rates of codling moth in the apple orchards has been calculated by using mean of the infested fruits, which are counted each week on a regular basis.

3. Results and Discussion

The study conducted to determine the population development and the level of infestation of the codling moth revealed that the pest was found intensively and caused damage on apples in Konya province.

Codling Moth Population Development

In order to determine the population development of the codling moth, sexually attraction traps were hung in six different orchards in the first week of May when the average temperature reached 13℃. Figure 1 shows the development of adult population of the pest in Selçuklu district (Çaltı and Campus orchards) in 2017 and 2018.

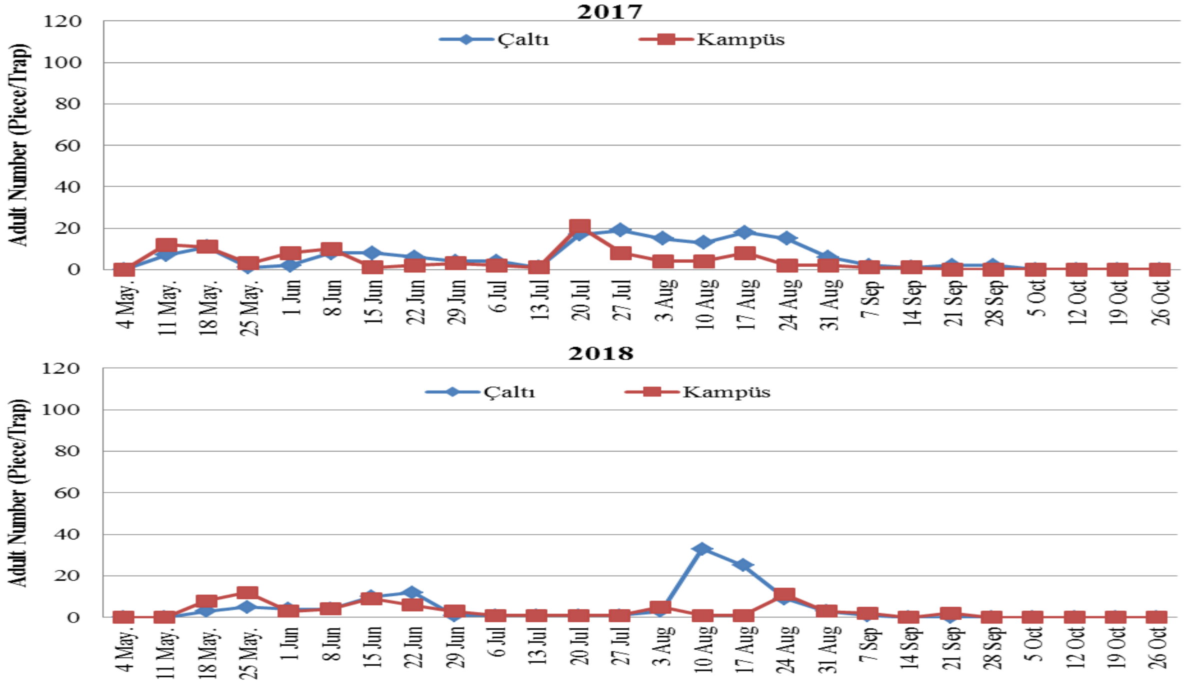

Figure 1
Population development of *Cydia pomonella* in Selcuklu in 2017-2018.

In 2017, the codling moth adults first captured by pheromone traps on 5 May in Çaltı. Codling moth formed four peaks in the season. The peak number of adults in pheromone traps, per week, was 11 on May 18, 8 on June 8, 20 on July 27 and 18 on August 17. The last adults captured by traps were observed on September 28. In 2018, the codling moth adults first captured by traps on 11 May in Çaltı. The pest formed three peaks in the season. The peak number of adults in pheromone traps per week was 5 on May 25, 12 on June 22, 33 on August 10 (Figure 1).

Population development of *Cydia pomonella* in the campus orchard was shown in Figure 1. In 2017, *Cydia pomonella* adults first captured on 8 May and formed four peaks. The peak number of adults in pheromone traps per week was 12 on May 11, 10 on June 8, 21 on July 20 and 8 on August 17. The last capture date of adults by traps was September 21. In 2018, *Cydia pomonella* adults first captured on 12 May and formed four times the peak. The peak number of adults in pheromone traps per week was 12 on May 25, 9 on June 15, 5 on August 3 and 11 on August 24.

The total number of adults caught in pheromone traps decreased in 2018 compared to 2017. In the two orchards where the study was carried out in Selçuklu district, the first adult capture of pheromone traps was recorded in the second week of May. The last adults in the traps were seen on September 28 in Çaltı and on September 21 in Campus (Figure 1).Figure 2 shows population development of *Cydia pomonella* in Meram district (Kozağaç and Hatıp orchards) in 2017 and 2018.

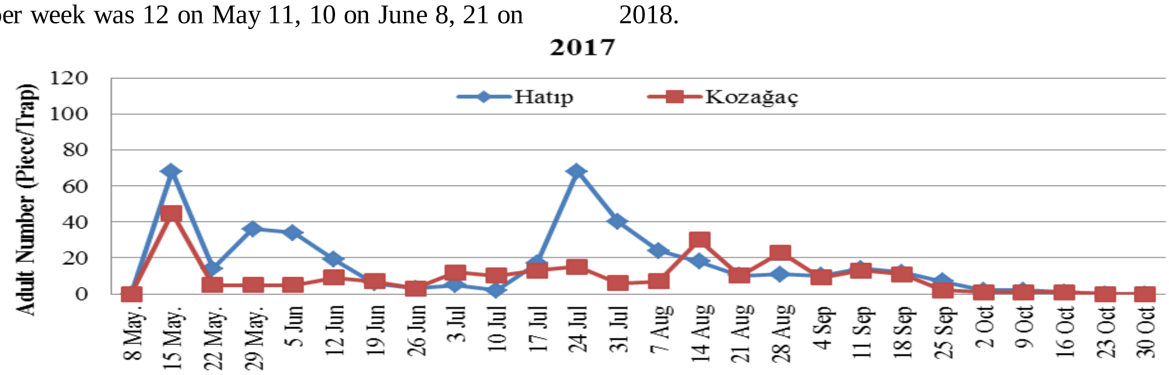

Figure 2
Population development of *Cydia pomonella* in Meram in 2017-2018.

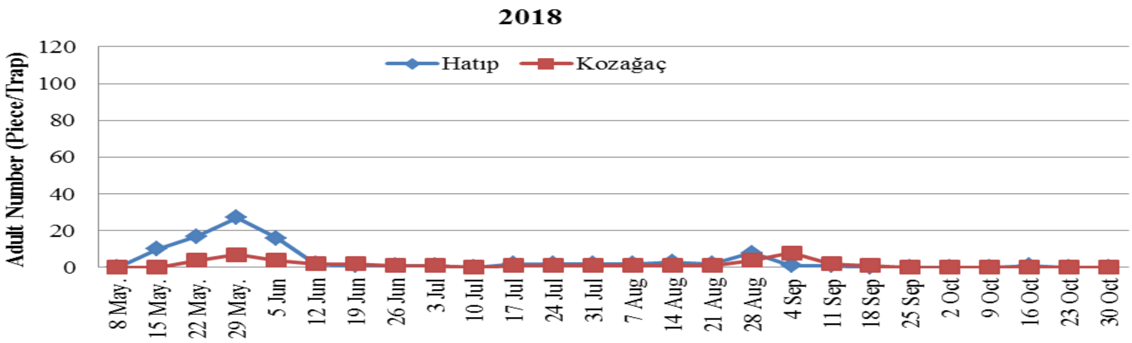

Figure 2(continuation)
Population development of *Cydia pomonella* in Meram in 2017-2018.

Cydia pomonella adults were first captured in the traps in Hatıp orchard on May 9 in 2017. The pest had four peaks in the season. The peak number of adults in traps per week was 68 on May 15, 36 on May 29, 68 on July 24 and 14 on September 11. However, in 2018 the first captures was detected on May 9, and peak number of adults in traps per week was 27 on May 29 and 8 on August 28, with two peak in the season.

In Kozağaç orchard, the first adults captured in the traps on May 9 in 2017. Codling moth had four peaks in the season. The peak number of adults in traps per week was 45 on May 15, 15 on July 24, 30 on August 14 and 23 on August 28. But in 2018, first adults captured on May 16. The peak number of adults in traps per week was 7 on May 29 and 8 on September 4, with only two time peak in the season in Kozağaç orchard (Figure 2).

The first adult capture in traps was recorded in the second week of May in both orchards in Meram district in 2017 and 2018. The last capture of adults was recorded on October 16 in 2017, but in 2018, the last capture of adults was in Hatıp orchard on October 16 and in Kozağaç orchard on September 18.

Figure 3 shows population development of *Cydia pomonella* in Karatay district (Karaaslan 1 and Karaaslan 2 orchards) in 2017 and 2018.

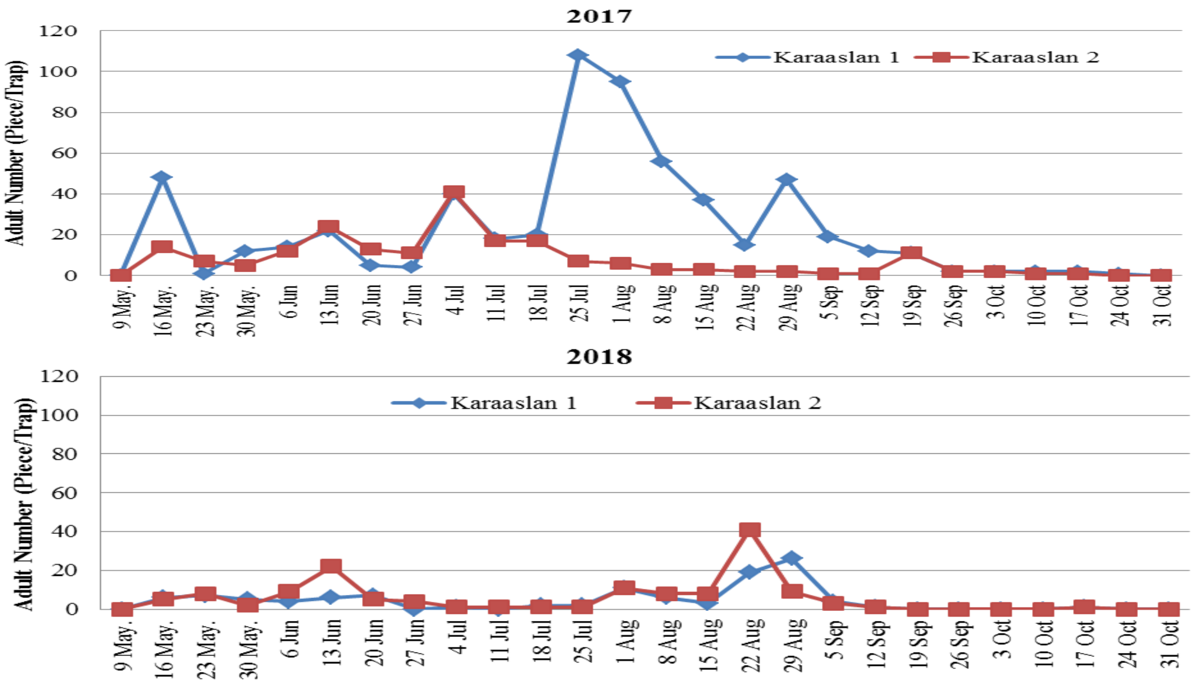

Figure 3
Population development of *Cydia pomonella* in Karatay in 2017-2018

In Karaaslan 1 orchard, the first adults captured in the traps on May 10 in 2017. Codling moth had four peaks in the season. The peak number of adults in traps rep week was 48 on May 16, 40 on July 4, 108 on July 25 and 47 on August 29. The last capture date was October 13. In 2018, first adults captured on May 12 in traps. The peak number of adults in traps per week was 7 on May 23, 7 on June 20, 11 on August 1 and 26 on August 29, with four peaks in the season (Figure 3).

In Karaaslan 2 orchard, adult moths were first captured in the traps on May 10 in 2017. The pest had four peaks in the season. The highest number of adults in traps per week was 16 on May 14, 24 on June 13, 41 on July 4 and 11 on September 19. The last capture of adults was detected on October 17. In 2018, first adults captured on May 12 in traps. The peak number of adults in traps per week was 8 on May 23, 13 on June 22, 11 on August 1 and 41 on August 22, with four time peak in the season (Figure 3).

The first adult capture in traps was recorded in the second week of May in both orchards in Karatay district and the last capture of adults was recorded on October 17.

In the study, it was determined that codling moth has two-three generation per year. Also, it has been detected that population peaks was four times in 2017 and three times in 2018. The first emergence of the *Cydia pomonella* adults was seen in mid-May and was active for five months in nature. Özbek et al. (1995), has been reported that codling moth is the most important apple pests and has two-three generation per year depending to the region in our country. Aydar et al. (2007), has been stated that population densities of codling moth were very high in Eğirdir (Isparta) district. Ayaz and Yücel (2010) also noted codling moth first emergence on May 10 in Elazığ province.

Mamay and Yanik (2013) determined adult population of codling moth in Şanlıurfa province. According to their results codling moth has three generation and four evident peaks (May, June, July and September) in the season and its active flight period in nature was determined for at least five months. Çelik and Ünlü (2017) also reported two-three generation and two and three population peaks of codling moth depending on the climate conditions in Beyşehir (Konya) district. Hantaş et al. (2014) stated that codling moth first emergence was seen on April 21 and produced four generations in the season in quince orchard.

Infestation Rates of Codling Moth

It is also important to estimate the infestation rate to determine the damage caused by the codling moth in the orchards. The infestation ratio of the codling moth in apples fruits indicates the financial loss of producers. Infestation rates of *Cydia pomonella* in 2017-2018 years is given in Table 2.

Table 2
Cydia pomonella infestation rate in Konya in 2017-2018 (%)

	Selçuklu		Meram		Karatay	
Years	Kampüs	Çaltı	Hatıp	Kozağaç	Karaaslan 1	Karaaslan 2
2017	10.50	6.25	36.10	6.50	36.10	4.90
2018	18.90	14.00	35.10	25.20	20.30	13.60

In 2017, in the Campus orchard, the infestation rates changed between 7% and 16% throughout the year and the average was 10.5%. While the infestation rate in Çaltı was low, apples were harvested from September 7 due to the damage of the hail on the apples in the orchard by 90%. In 2018, in the campus orchard *C. pomonella*'s infestation in fruits was 10% in July and increased gradually to 27% by the end of September. The average number of infestations in fruits was 18.9%. In Çaltı, infestation rate was 14% in 2018.

In 2017, the rate of infestation in fruits was found to be 36.1% in Hatıp orchard and 5% on August and 9% on September in Kozağaç orchard. Infestation rate in Karaaslan 1, which had higher in population density compared to other orchards, was found as 36.1% in 2017 and in Karaaslan 2, which had low in population density compared to other orchards, was found as 4.9%.

In 2018, there was no significant change in terms of infestation level compared to the previous year in Hatıp orchard and the infestation rate was 35.1%. In Kozağaç orchard, whilst low population density infestation rate was high as 25.2% in 2018. Infestation rate increased after mid-August in Karaaslan 1 orchard and was 20.3% in 2018. Karaaslan 2 orchard infestation rate was 13.6% and increased comparing previous year in 2018.

It was determined that the second generation in late August has more effect on infesting fruits by looking at the population density and infestation rates determined in the study.

In 2017, the population of the pest in Campus orchard was higher comparing to 2018, however, the rate of infestation was higher in 2018, the first year of the study there was spraying at the visit date by the Ministry of Agriculture. In the second year, no spraying was carried out.

Population density of the pest in Çaltı orchard was higher in 2017 than 2018. However, in 2017 the economic value of apple fruits was very low due to the hail damage and early harvest. In 2018, five days after the warning dates of the agricultural district directorate were applied. Despite, five time insecticides has been applied during the season, but rate of infestation is still high, this may be due to the use of the same insecticides for six years. It can be guessed that the pest has developed resistance against this active ingredient.

In Hatıp orchard, insecticides applied twice in 2017, but after spraying there was rainfall and the producer did not apply any more spraying after rainfall. In 2018 no spraying was carried out. This indicated that the farmer had experience that a very high financial loss when the insecticides was not applied against codling moth. Spraying five times in 2017 has increased considerably the chance of success against the pest in Kozağaç and infestation level was 6.5%. But, in 2018 there was no spraying and because of this infestation level was 25.2%. This indicates importance of spraying on time against codling moth.

In Karaaslan 1, without spraying in 2017 in the orchard the infestation rate was 36.1%, but in 2018, the infestation rate has little decreased due to spraying two times. But spraying dates was randomly on June 17 and July 27. In Karaaslan 2, four times spraying carried out in the orchard and farmer considered to the time of spraying. Therefore, the least infestation in Karaaslan 2 orchard compared to other orchards, indicating that it is necessary to apply spraying according to the time of control.

For the year 2018, three sprayings were carried out according to the ministry of agriculture stated spraying times. However, the fourth treatment, which was not carried out in August, indicated that the infestation rate of the codling moth increased.

In the study, it was observed that the infestation rate of codling moth in apple orchards in the Selçuklu, Meram and Karatay districts of Konya province changed between 5-40% in the first observation and in September it was seen between 4-43% in 2017. In the second year of the study, infestation rate was between 5-25% in July and 19-51% in October. Çelik and Ünlü (2017) reported infestation rates from orchard in Beyşehir (Konya) district in 2014-2015 year, which were 4-5% at the beginning of the first year and increased to 26-27% at the end of August, while in the second year adult numbers were between 4-7%.

During the study it was noticed that the reason for the increase of infestation rate in late season was caused by the second generation of codling moth. Isci (2008), stated that the early apple varieties affected only by the first generation of pest, remaining 35-50% infestation, and the mid-late or late apple varieties affected more by the second generation of pest and damage increased to 80%, with the advance of the harvest timefrom the apple orchard in Eğirdir Horticultural Research Institute,. Özbek et al. (1995), reported that, codling moth damage might reach up to 100% in some years and codling moth choose as a host not only apple, but quince, peach, walnut, plum, pear and apricot trees. Aydar et al. (2007) reported that the infestation rate was reached to 74.15% in the control plot without chemical application in Eğirdir (Isparta) district conditions. Kuyulu and Genç (2018), found the level of codling moth infestation between 5% and 95%, in their study on the spread of codling moth in apple orchards in Çanakkale province

4. Conclusion

In this study, which aimed to determine codling moth population development and infestation rates in apple orchards in Selçuklu, Meram and Karatay districts of Konya province, it was found that codling moth emerged in the second week of May. The population peaks of codling moth were three-four times in the season depending on the weather conditions. Based on the result of this study, we state that codling moth can produce two-three generation per year depending on climatic conditions of the season. Codling moth started to emerge and captured in traps from the second week of May and this continued until the end of October. Therefore, codling moth has active flight period for five months in a year in central districts condition of Konya province.

With increasing temperatures, the population of codling moth reaches its peak in July-August. In this month, due to the rising population, the rate of infestation was increased towards the end of the season. In the apple orchards where the study was conducted, the average infestation was in 2017 and 2018 in Selçuklu 10.5% and 16.45%; in Meram 21.3% and 30.15%; and in Karatay 20.5% and 33.9%, respectively.

In some orchards in which the study was carried out, no spraying was applied and in others the lack of spraying at the appropriate time caused the infestation level to occur high. It was observed that the chemical application against the codling moth is very important and the application should be applied on time.

The establishment of pheromone traps for codling moth at the beginning of May will ensure both the decreasing of the pest population density and the determination of the spraying times in Konya province conditions. It is known how important the timing of spraying is and how important to use pheromone traps because the pest enters into the fruits in a short time after the egg hatching.

For a long time, farmers couldn't obtain effective results with the chemical control because of random time of insecticides application. Appropriate time of spraying economically will remove a significant load from the farmers if they apply according to the changes in the population of the codling moth. It also helps to success spraying against codling moth. For this reason, it is important for farmers to apply sprayings properly announcements by official institutions.

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Tillage Effects on Energy Use Efficiency in Safflower Production in Middle Anatolia

Ergün ÇITIL[1,*], Kazım ÇARMAN[1], Tamer MARAKOĞLU[1]
[1] Selçuk University, Department of Agricultural Machineries and Technologies Engineering, Konya, Turkey

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ABSTRACT

In this study conducted in province of Konya, the effect on grain yield and energy productivity of three different tillage methods (conventional tillage, reduced tillage and direct seeding) in safflower production were investigated. Yield values obtained were 921 kg ha^{-1} for conventional tillage, 903 kg ha^{-1} for reduced tillage, and 822 kg ha^{-1} for direct seeding. In growing of safflower, it was found that the highest share in total input energy is fertilizer energy, followed by fuel-oil, seed, herbicide and machine energy respectively. In conventional tillage, reduced tillage and direct seeding, the share of fuel-oil energy in total input were 22.05%, 13.83%, 6.15% respectively. The highest value 5.63 of the energy output-input rate was obtained from direct seeding. This rate was 5.23 for reduced tillage, and 4.79 for conventional tillage. Of all these methods, direct seeding had the least energy consumption per safflower plant produced, which was found as 3.47 MJ kg^{-1}. The highest value was also obtained in conventional tillage as 4.03 MJ kg^{-1}.

1. Introduction

Energy, economics, and environment are mutually dependent. There is a close relationship between agriculture and energy. While agriculture uses energy, it also supplies it in the form of bio-energy. At present time, the productivity and profitability of agriculture depends upon energy consumption. Tillage is one of the highest power-required processes of the agricultural production. In addition, today, the high cost of energy forces the_farmers to find alternative economic tillage methods. Therefor, it is necessary to apply reduced tillage or no-tillage (Pimentel et al., 1994; Alam et al., 2005; Marakoglu and Çarman, 2008).

In intensive tillage (conventional tillage including inversion of soil), one of the main disadvantages is the loss in the topsoil from 0-20cm especially where agricultural land is exposed to water and wind erosion. The average wind erosion rate dropped 31 percent with protective farming practices in the world. Almost 1 billion tons of soil savings have occurred per year due to these changes in management. However, erosion is still occurring at a rate of 1.9 billion tons per year, and 108 million acres (29 percent of cropland) is still eroding at excessive rates (USDA- ARS, 1997).

Conservation of agriculture is a multi-dimensional approach the level of both energy usage and cost is minimized; and which involves the leaving of crop residues on surface to decompose in situ to protect water and soil. Direct seeding makes production profitable by decreasing the water and wind erosion. Although protecting of the soil is the main goal, soil moisture, energy usage, labor, and protection of machineries are also important (Köller, 2003).

Effective use of energy in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution reduction. Energy efficiency can be increased by decreasing the energy use from inputs such as fertilizer or tillage operations or by increasing the outputs such as crop yield. Aykas and Önal (1999) studied on how different tillage methods may affect both the yield of wheat and the amount of weed. According to results of the study, the highest yield value was 420 kg da^{-1} for reduced tillage, and the lowest was 350 kg da^{-1} for direct seeding.

When compared with conventional tillage, direct seeding has less water consumption. In years when winter rains were too little, in lands with no weed, and

* Corresponding author email: *ecitil@selcuk.edu.tr*

without even any seedbed preparation, robust oilseed crops with deep root system such as safflower and flax can be grown (Mandal et al., 1994). Bayhan et al., (2001) reported that the lowest fuel consumption among different practices belong to direct seeding, and the highest yield value belong to combined tillage. In a similar study carried out by Yalçın and Çakır (2006), it was found that fuel consumption was measured as 60 L ha^{-1} in conventional tillage, and in direct seeding; it was obtained as 7.5 L ha^{-1}.

Çarman and Marakoğlu (2007) reported the highest total fuel consumption (5.202 L da^{-1}) was belonged to conventional tillage whereas the lowest (0.972 L da^{-1}) was belonged to direct seeding. Additionally, seedling emergence degrees were obtained as 73.02% at conventional tillage, 64.29% at reduced tillage and 62.7% at direct seeding.

Many researchers have studied energy and economic analyst is to determine the energy efficiency of plant production such as sugarcane in Morocco (Mrini, et al., 2001), wheat, maize, soybean, sugarbeet, sunflower, barley, oat in Italy (Sartori et al., 2005), cotton crops in Turkey (Dagistan, et al., 2009), sunflower in Greece (Kallivroussis et al., 2002), winter oilseed rape in Germany (Rathke and Diepenbrock, 2006) and wheat in Iran (Safa and Tabatabaeefar, 2002).

Due to the wide adaptation limits of the safflower plant, it can be grown in different ecologies. In addition, the roots can go into deep layers within the soil. Prickly plant growth increases the resistance to drought and heat (Dajue and Mundel 1996). With these properties, safflower is gaining importance as an oil plant which can be located in the cultivation of fallow land in dry land (Machado 2004). The most important advantage of safflower is that it is drought resistant and its agriculture is suitable for mechanization (Pinarkara 2007). In this study, the feasibility of safflower cultivation with wheat-safflower rotation was investigated in the fallow lands in Central Anatolia and especially in Konya which has a fallow area of 5.6 million decares. In addition, the effects of two different conservation tillage on the seedling emergence degree and grain yield values after seeding and the energy balance of the safflower production have been determined.

2. Materials and Methods

Experiments were conducted in 2016 at Agricultural Research and Education Center of Selcuk University in the province of Konya (Seeding: 20th February 2016, Harvest: 2nd August 2016). The average monthly temperature and rainfall values in the experiment area are given in Table 1. Some of the important physical properties of the experiment field soils are given in Table 2.

Table 1
The meteorological data taken during the vegetation at the experiments

Month	Temperature ^oC			Rain (mm)	Wind Speed ($m\ s^{-1}$)
	Maximum	Minimum	Mean		
February	20.6	-8.3	6.6	3.4	1.0
March	25.6	7.8	-5.6	37.2	1.3
April	27.9	4.4	0.7	10.2	1.3
May	30.3	5.2	15.7	31.2	1.4
June	33.7	7.5	21.9	36.4	1.6
July	36.6	11.5	24.3	2.8	1.4
Mean/Total	29.1	4.6	10.6	121.2	1.3

Table 2
Some of the important physical properties of the experiment field soils

Textural class	33.2 % Salt; 31.5 % Silt; 35.3 % Clay Clay-Loam		
Method	Conventional tillage	Reduced tillage	Direct seeding
Volumetric weight ($g\ cm^{-3}$) (0-20 cm)	1.11	1.25	1.40
Gravimetrical soil moisture (%) (0-20 cm)	39.7	40.1	43.9
Porosity (%)	54	51	43
pH	7.52	7.52	7.52
Organic substance (%)	1.35	1.35	1.35

Conventional and two conservation tillage treatments were performed on February. The treatments included:

- (CT) Conventional tillage (plough + Cultivator – float (2 times) + Seeding
- (RT) Reduced tillage: Vertical rotary tiller + Seeding
- (DS) No tillage: Direct Seeding

The equipments used in this study were operated with the standard tractor (Erkunt-Haşmet 110) of 80 kW. Some of the machine’s technical properties are given in Table 3. Safflower seeds (Dinçer) of 47.4 $g.1000^{-1}$ seeds were used in this study. Safflower seeds were sown for the experiment with 40 kg ha^{-1} seed rate and at 40 mm sown depth. Row spacing was 12.5 cm, seeding machine had a variable rate speed transmission system and toothed metering rollers that were used for seeding of different seeds. The speeds of the metering rollers of the seed drill were set at 10 rpm at travelling speed of 1.75 m s^{-1}. The direct seeder has a press wheel of 400x75 on the back of each seeder disc.

In order to determine the pulling force requirements of the machines, the draw pin of 30,000 N has been attached to three-point link arms of the tractor. The data logger that collects 20 data per seconds was used. In trials, nitrogen of 86.8 kg ha^{-1} and phosphorus of 59.8 kg ha^{-1} were applied together with seeding. In addition, 2.5 kg ha^{-1} herbicide was applied for weed control.

Table 3
Some technical specifications of used machines

Machine	Number of tide or body	Working width (cm)	Working depth (cm)	Travel speed (km/h)	Type
Plough	5	170	30	5.8	3 pt hitch
Cultivator + Float	13/2	310	20	6.7	3 pt hitch
Vertical Rotary Tiller	10	250	25	2.7	3 pt hitch
Combined Seeder	21	262	4	6.3	3 pt hitch
Direct Seeder	20	284	4	6.3	Pull-type
Spraying machine	-	1000	-	6.5	3 pt hitch

To measure the fuel consumption, measurement device brand Rudolf Schmitt (0.5% - accuracy) was used.

Surface relief was measured by using surface profile meter. This consisted of a set of vertical rods, spaced at 2.5 cm intervals, sliding through an iron bar of 100 cm length. The soil surface roughness was calculated by using the Kuipers equation; (Abo–Habaga 1990)

$$R = 100\log_{10} S$$

Where R is the surface roughness (%) and S is the standard deviation (mm).

The standard deviation was estimated by measuring the distance between a constant horizontal surface and the soil surface over a set of 100 cm.

In order to determine the penetration resistance, an Eijkelkamp analog penetrometer with 60° cone angle was used. Measurements were made at the depth of 20 cm in 5 cm increments with five replications in each plot before and after soil tillage.

The soil shear testing device was used in order to determine the soil shearing strength which has a 10 cm diameter (D) and 12 cm height (h). Torque arm having a measuring range of 0-80 Nm was impaled on shear vane. The maximum torque (T) was obtained via soil shear testing device as shear stress (τ) was obtained by the following equation (Okello 1991):

$$\tau = \frac{T}{\pi D^2\left(\frac{h}{2}+\frac{D}{6}\right)}$$

In order to determine seedling emergence, the experiment field was observed throughout the emergence time and along with the beginning of the emergences, emergence counts were taken at two days intervals at the distance of 300 cm from three separate rows. The values of average emergence day (MED), emergence rate index (ERI), and seedling emergence degree (PE) were calculated by using the values obtained from the counts in the equations given in Bilbro and Wanjura, (1982):

$$MED = \frac{N_1D_1 + N_2D_2 + \ldots + N_nD_n}{N_1 + N_2 + \ldots + N_n}$$

$$ERI = \frac{Total\ emergence\ in\ 1\ meter\ long\ band}{MED}$$

$$PE = \frac{Total\ emergence\ in\ 1\ meter\ long\ band}{Number\ of\ seeds\ sowed\ in\ 1\ meter\ long\ band} \times 100$$

Where MED is mean emergence day; ERI is emergence rate index, seedlings $day^{-1}m^{-1}$; PE is percentage of emergence, %; N_1…n is number of seedlings emerging since the time of previous count; D_1…n is number of days after the seeding.

In order to determine the number of seeds sown in a 1 meter line length, the machines were set to give 40 kg ha^{-1} seed rate. The number of seeds dropped from different furrow opener was determined as 5 replications. The average seed number dropped from a furrow opener to the 1m line length was found to be 11.

The safflower seed and biomass energy equivalent were measured by a calorimeter. For this EN 61010, EN 50082, EN 55014 and EN 60555 standards are taken into account.

Randomized Complete-Block Design with three replicates has been performed in this study. Human labor, machinery, chemical fertilizers, diesel fuel and seed energy have been computed inputs. In order to evaluate energy efficiency of agricultural production, energy equivalents of the inputs and outputs used in the safflower production are given in Table 4. Energy parameters are given in Table 5.

Table 4
Equivalent energies

Properties	Unit	Equivalent energy Mj/unit	Reference
Inputs			
Labor	h	2.3	Kızılaslan (2009), Barut et al. (2011)
Tractor	h	158.3	Doering (1980), Barut et al. (2011)
Machine	h	121.3	Doering (1980), Barut et al. (2011)
Fuel-Oil	L	41	(Reinhardt., 1993)
Herbicide	kg	120	(Çanakçı et al., 2005)(Mandal et al ., 2002) (Singh,2002)
Fertilizer (N)	kg	60.6	(Bojaca and Shrevens.,2010) (Öztürk.,2011)
Fertilizer (P)	kg	15.7	(Kaltschmitt and Reinhardt., 1997)
Seed	kg	24.37	
Outputs			
Yield	kg	23.99	
Biomass	kg	17.18	

Table 5
Energy parameters (Tabata baeefar, et al., 2009; Zangeneh, et al., 2010; Mousavi-Avval et al., 2011; Öztürk, 2011)

Parameter	Unit	Definitions
Total energy input	MJ/ha	EI
Total energy output	MJ/ha	EO
Yield of net energy	MJ/ha	$Total\ energy\ output - Total\ energy\ input$
The rate of output/input	%	$Total\ energy\ output/Total\ energy\ input$
The rate of net energy	%	$Net\ energy\ efficiency/Total\ energy\ input$
Energy efficiency	kg/MJ	Grain and biomass yield/ $Total\ energy\ input$
Energy required for the unit product	kg/MJ	$Total\ energy\ input$ /Grain and biomass yield

3. Results and Discussion

Before the trial, the amount of stubble was 885-920 m^2 in the plots. The weed coating rate was found to be between 1-1.3% in the field, and this rate will not affect the efficiency negatively, thus weed struggle has not been done directly before planting, while not economical to fight with chemical methods was thought.

When the applications were evaluated in terms of the effect of penetration resistance in 0-20 cm depth region of soil, the greatest penetration resistance was seen in direct seeding as expected, while the lowest value was observed in reduced tillage application (Figure 1). The penetration resistance of the soil varied between 0.91 MPa and 1.07 MPa depending on the application of soil tillage.

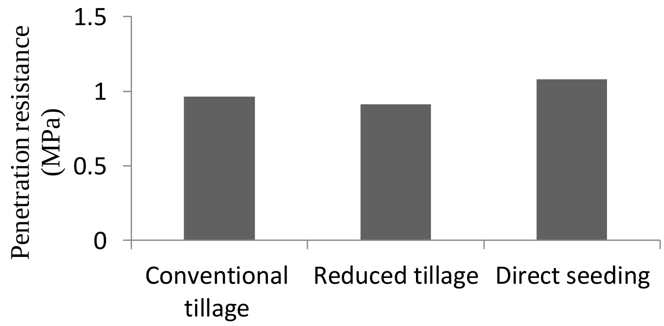

Figure 1
The effects on penetration resistance of different applications.

The values of soil cut resistance ranged from 1.11 to 1.99 Ncm^{-2}. The soil cut resistance values obtained from the applications are given in Figure 2.

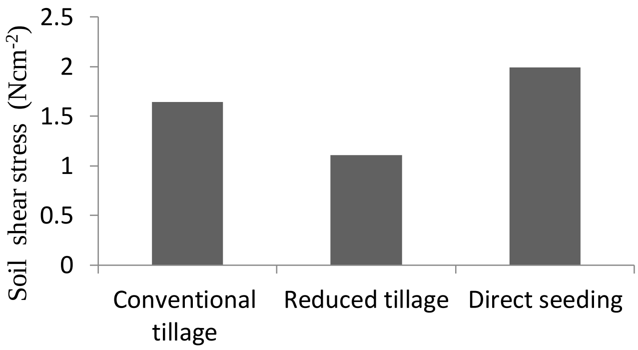

Figure 2
The effects on soil shear stress of different applications

Surface roughness's values of the application soil ranged from 7.78% to 25%. (Figure 3). In conventional application, according to the surface roughnessü, values were 221.3% higher than reduced tillage. In addition to this, these were 138.6% higher than direct seeding.

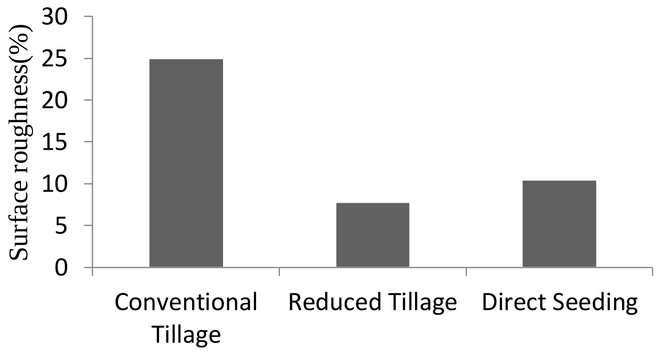

Figure 3
The effects on surface roughness values of different applications

The specific draw force requirements of the machines used in the three different applications of safflower production is given in Figure 4. The highest value in terms of specific draw force is obtained in the plough, while the lowest value is obtained in the classic combined seed drill.

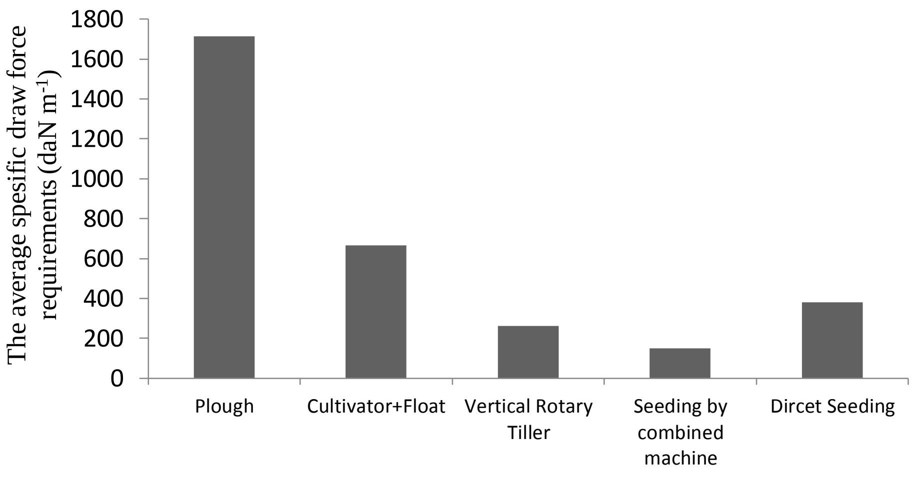

Figure 4
The average specific draw force of equipments

According to Marakoğlu and Çarman (2008), because of the two years of studies on reduced tillage and direct seeding applications in wheat production, the highest specific draw force value of the machines used was reported on the plow and the lowest value was obtained from the classic combined grain seeding machine.

The fuel consumption values of the tractor in working with different equipments are given in Table 6. The highest fuel consumption was obtained with 20.8 L ha^{-1}

application in vertical rotary tiller and the lowest consumption was obtained with 3 L ha^{-1} application from spraying machine. By using the direct seeding machine, the fuel consumption of the tractor was 11.76% higher than the classic seeding machine. and Çarman ve Marakoğlu (2007) reported that in a two-year study of reduced tillage and direct seeding applications in wheat production, the highest fuel consumption was 19.9 L ha^{-1} from vertical rotary tiller machine, the lowest fuel consumption was 8.1 L ha^{-1} from a minimum combined seeding machine and the fuel consumption of the direct seeding machine was higher than 2.3% to the classic seeding machine.

Table 6
Total fuel consumption values of used equipment and applications

Equipment	Conservational Tillage L ha^{-1}	Reduced Tillage L ha^{-1}	Direct Seeding L/ha^{-1}
Moldboard plought	20,7	-	-
Cultivator + Float (two times)	12.3 x 2	-	-
Vertical Rotary Tiller	-	20.8	-
Combined Seed Drill	8.5	8.5	-
Direct Seed Machine	-	-	9.5
Spraying machine	3	3	3
Total	56.8	32.3	12.5

When the applications were evaluated in terms of total fuel consumption, the highest fuel consumption was seen in the conventional application and the lowest was in the direct seeding application. In conventional application, the total fuel consumption was 4.54 times higher than direct seeding. According to *Akbarnıa* and *Fahranı* (2014), they analyzed the fuel consumption of different tillage applications and in conventional tillage, reduced tillage and direct seeding it was found 59.33 L ha^{-1}, 29.67 L ha^{-1}, 14.33 L ha^{-1} respectively. Marakoğlu and Çarman (2017) reported that fuel consumption values were 50% decreased in reduced tillage application in wheat.

Bonari et al. (1995) insisted on their research to determine the yield and soil's physical properties by using the combined machines for different tillage methods in order to investigate the level of energy consumption under different conditions for tillage methods. Reduced tillage method provided less than 55% fuel consumption but there was no importance for yield in tillage methods. Similarly, Craciun et al. (2004) reported 60% reduction in fuel consumption by reduced tillage applications.

Mean germination time (MED) values ranged from 38.3 days to 43.3 days. The germination ratio value was found between 0.42 and 0.71 m^{-1} day^{-1}. While comparing percentage of emergence applications, the highest percentage of emergence was found in conventional application with 76.8% and the lowest in direct seeding application was 61.2%. (Figure 5). The effect of the applications on the percentage of emergence was found to be significant (P <0.01).

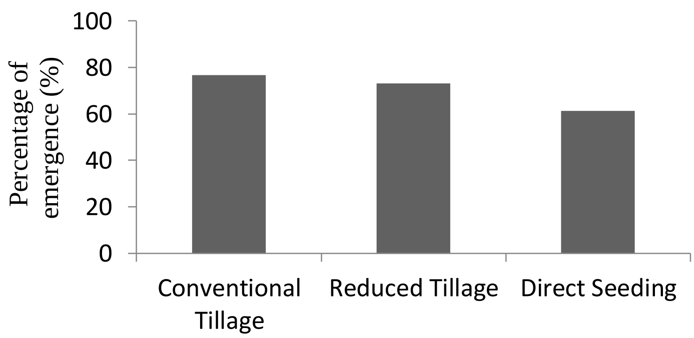

Figure 5
Percentage of emergence of applications

The grain yield values of the applications ranged between 822-921 kg ha^{-1} (Figure 6). The highest grain yield was obtained in the conventional application, while it decreased by 1.95% in reduced tillage and by 10.7% in direct seeding method. According to Meral (1996), depending on Çukurova conditions, seed yield was 1.258 kg ha^{-1} which was observed in Yenice, Dinçer and 5-154-2 varieties in barren and sole conditions; therefore, the seed yield was dropped to 172 kg ha^{-1} in the base area. Öztürk et al., (2009) stated that the average seed yield value was 1,899 kg ha^{-1} but it decreased to 928 kg ha^{-1} in dry and aqueous conditions. In the production year of the experiments, if the average yield values are low, the plants may suffer from low rainfall in the vegetation periods (121.2 mm). The effect of the applications on grain yield was found to be significant (P <0.01). Prihar et al., (1975) defined that high yield in conventional tillage method is related to good root growth and high amount of water used, and the hard soil layer under working depth in reduced tillage area may prevent root growth and water use.

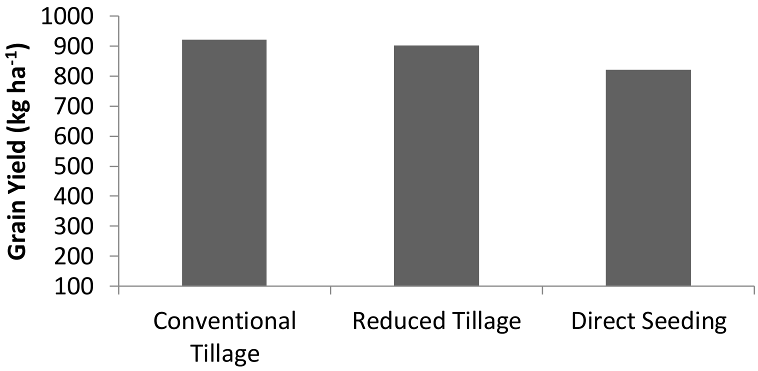

Figure 6
Grain yield values of applications

Akbarnia and Farhani (2014) investigated the effects of different tillage applications on wheat yield. The grain yield values were 8.07 t ha^{-1} in conventional soil tillage and 7.90 t ha^{-1} in reduced tillage, in addition to these, it was 6.33 t ha^{-1} in direct seeding.

When Table 7 is examined, the share of the most production inputs in the applications are followed by the fertilizer energy, and the fuel, seed, herbicide and machinery energies respectively. In direct sowing the seed energy input is higher than the fuel energy input. Hamedani et al., (2011) stated that energy consumed in production of grapes was 45,213. 66 MJ ha^{-1} and this energy is dividing to outputs so the highest level was 37.25% for fertilizer. Konak et al., (2004) stated that the highest rate of total energy inputs in maize production is fertilizer energy followed by the seed, instrument-machine and fuel-oil energies.

Baran and Ark. (2016) stated while comparing the different tillage and seeding methods in the production of silage corn, fertilizer inputs were the highest value of the production inputs in Cukurova region.

Baran ve Karaağaç (2014) determined that irrigation energy has the highest value in consumption rate and it was 30.36% in the second product sunflower production. In addition, fertilizer energy rate was 28.78 % and fuel-oil energy rate was 24.74%.

In reduced tillage application and direct seeding application, the share of the fuel-oil energy values in the total energy input was determined as 22.05%, 13.83% and 6.15% respectively for conventional application. Moreover, the conventional application has about 4.54 times more fuel-oil energy input than the direct seeding method. When the applications were examined in terms of the energy value required for the production of one kg of product, the best result was obtained by direct cultivation with 3,47 MJ kg^{-1}, followed by reduced tillage application and conventional application, respectively. Direct seeding application has the lowest energy input in terms of labor, tractor and machinery inputs. According to Marakoğlu and Çarman (2017), same results were observed from wheat production at direct seeding in Middle Anatolia.

In agricultural mechanization applications, unit energy consumption can be reduced by using machines such as combined machines and direct seeding machines. However, the application of protective soil tillage methods helps to protect the soil's organic structure and prevents soil erosion. ($Hargrave$ 1982).

The highest value of net yield energy obtained from reduced tillage was 40,539.42 MJ ha^{-1} and from conventional applications was 40,049.75 MJ ha^{-1}, in addition to these, from direct seeding it was 38,533.03 MJ ha^{-1}. In other words, the highest value of energy obtained from direct seeding was 0.29 kg MJ^{-1} and from reduced tillage it was 0.27 kg MJ^{-1}; in addition to these, from conventional applications it was 0.24 kg MJ^{-1}. Marakoğlu and Çarman (2017) stated that the value of yield energyobtained from reduced tillage in wheat production was 0.82 – 0.93 kg MJ^{-1} and from conventional applications it was 0.83 kg MJ^{-1}. Moghimi et al., (2013) found that the value of net yield energy was 54 937.18 MJ ha^{-1} and the yield energy was 0.13 kg MJ^{-1} in production of wheat.

Table 7
Energy balance

A.Input	Conventional Tillage		Reduced Tillage		Direct Seeding	
	MJ ha^{-1}	%	MJ ha^{-1}	%	MJ ha^{-1}	%
Labor	8.39	0.08	6.90	0.07	3.50	0.04
Tractor	519.51	4.92	517.13	5.40	112.68	1.35
Machine	232.68	2.20	250.84	2.62	225.87	2.71
Fuel-oil	2328.80	22.05	1324.30	13.83	512.50	6.15
Herbicide	300.00	2.84	300.00	3.13	300.00	3.60
Fertilizer (N)	5260.80	49.80	5260.80	54.95	5260.80	63.16
Fertilizer (P)	938.86	8.89	938.86	9.81	938.86	11.27
Seed	974.80	9.23	974.80	10.18	974.80	11.70
Total İnput	10563.84	100.00	9573.63	100.00	8329.01	100.00
B. Output						
Yield grain	22094.79		21662.97		19719.78	
Yeld biomass	28518.80		28450.08		27144.4	
Total Output	50613.59		50113.05		46864.18	
Parameters						
EI	10563.84		9573.63		8331.15	
EO	50613.59		50113.05		46864.18	
Yield of net energy (Mj ha^{-1})	40049.75		40539.42		38533.03	
The rate of output / input (%)	4.79		5.23		5.63	
The rate of net energy (%)	3.79		4.23		4.63	
Energy efficiency (kg MJ^{-1})	0.24		0.27		0.29	
Energy requirement per product unit (MJ kg^{-1})	4.09		3.74		3.47	

Obtaining from the reduced tillage application in the unit area the net yield energy was 1.2% more than conventional application and 5.2% more than the direct seeding applications. When the applications are evaluated in terms of energy efficiency, it was determined that direct seeding application rate was 20.8% higher than the conventional applications and it was 7.4% higher than the reduced tillage applications.

Çanakçı et all (2005), estimated that the energy rate of wheat production was 2.8 and of maize production was 3.8 in Antalya.

Karaağaç et all (2011), tried to make the energy balance of wheat and maize in a company, and the number of values related to wheat, specific energy, energy sources of these plants is 3.50, 4.20 MJ kg^{-1} and 0.24 kg MJ^{-1}, corn 6.54, 2.25 MJ kg^{-1} and 0.44 kg MJ^{-1}.

The following evaluations can be made from these assessments.

-The output/input ratio obtain from direct seeding was 17.5% higher than the conventional application and 7.6% higher than the reduced tillage application.

-Although low yield was obtained from direct seeding method, the input quantity was less than other methods, in direct seeding the net energy ratio was 22.1% higher than the conventional applications and it was 9.4% higher than the reduced tillage.

-Net energy yield was at the highest rate at reduced tillage application and it was ordered by direct seeding and conventional application, respectively. Thus it is important for the spreading of protective soil tillage methods.

-In conventional application, energy consumption for the unit product was detected to be 17.8% higher than direct seeding and 9.3% higher than reduced tillage.

- The fact that the energy required for the unit product amount was less than the other applications of direct seeding application, it was effective in the possibility to enable the establishment of an alternative application in the economic conditions.

- If the yield values are low from applications in one year, the average rainfall and temperature values of the region may be low during the vegetation period and year.

-It is possible that direct seeding method is more advantageous than other methods according to the fuel consumption, time, labor and work success and at large production areas works can be done in a timely manner, depends on it, waste of time can be reduced.

-Production of safflower can be done in dry agricultural regions of Middle Anatolia where fallow application is done in agricultural production.

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