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EFFECT OF HARVEST TIME ON HERBAGE YIELD AND QUALITY OF ANNUAL GRASS CULTIVARS

Mehmet Aksan[1], Mahmut Kaplan[1*]

[1]Department of Field Crops, Faculty of Agriculture, University of Erciyes, 38039, Kayseri, Turkey

Abstract
This study was carried out to determine the effects of harvest time on herbage yield and quality of different annual grass cultivars harvested in different periods. A total of 10 different annual grass (Lolium multiflorum L.) cultivars supplied from an agricultural company were used as the plant material of the field experiments. Experiments were carried out in randomized blocks – split plots design with 3 replications.
Annual grass cultivars were harvested in booting, flowering and milky stage. Green and dry herbage yields, crude protein, crude ash, acid detergent fiber (ADF) and neutral detergent fiber (NDF) characteristics were investigated. Harvest periods had a significant (P≤0.01) effect on all parameters.
ADF-NDF ratios, green and dry herbage yields increased, and crude protein and crude ash ratios decreased with the progress of harvest time. The highest crude protein yield was obtained from the plants harvested in flowering stage. Based on present findings obtained under Central Anatolian conditions, Baqueona, Baqueona, Medaocus cultivars are recommended in terms of herbage and protein yields.

Keywords: Annual grass, harvest time, herbage yield, herbage quality

1. INTRODUCTION

Forage crops, so defined as roughage, are the cheapest feed sources for animal production. They have a highly significant place in animal performance as they contain necessary nutrients, minerals and vitamins (Anonymous 2013). One of the most important problems to be solved for the development of animal production in Turkey is to meet quality roughage needs. Roughage sources should be of good quality and cheap, as well as being suitable for animal feeding and physiology (Canbolat, 2012). Although the importance of the issue for Turkish livestock industry is constantly emphasized, desired levels have not been reached, yet. Low-cost roughage sources, such as fresh and dry grass and silage, increase the profitability of livestock operations (Alçiçek 1995, Bilgen et al. 1996). Feed inputs constitute about 60-70% of production costs in dairy or beef cattle farms and such a case is sufficient to explain the effect of feed cost on profitability of the livestock operations (Alçiçek et al., 1999, Alçiçek, 2002).

Annual grass *(Lolium multiflorum* Lam), which is one of the grass species, develops rapidly, can be harvested more than one time in a single vegetation period, produces abundant and high-quality grass, can easily be incorporated into crop rotations, responds positively to irrigation and fertilization, intercrops with various leguminous and graminae forage crops and can be used as green fertilizer plant. Therefore, it has a great potential to eliminate quality-roughage deficits. In

*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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addition, due to its high nutrient content, digestibility and taste, it is appetizingly consumed by animals (Kayaalp, 2019).

Annual grasses that can be used in the supply of quality hay and silage when grown in suitable ecologies are very important forage crops in this sense. Annual grasses are plants with extremely high feed efficiency and digestibility, especially when grown in irrigated areas, either alone or in combination with annual clovers. The quality of the grass is as good as the grass yield of the annual grasses that can be mowed at least 2 or 3 times when irrigated in Central Anatolian conditions. It does not become coarse quickly and preserves its period, which animals love to consume, during the vegetation period. It can be used successfully both as a fodder plant and an artificial pasture plant, especially in irrigated areas, in crop rotations.

For a successful field culture, it is very important to choose the appropriate cultivar, to know where and how to grow it (Arslan and Çakmakçı, 2004), because each cultivar has good and bad features, strengths and weaknesses. Knowing these characteristics well under different growing conditions and their adaptation to the regional conditions are of great importance in terms of yield and quality characteristics. Therefore, performance of newly developed cultivars should be determined in different regions. In determining the quality of the feeds, it is very important to determine the chemical composition and mineral substance content of the feed, as well as the energy and digestible nutrients (Canbolat, 2012). The quality of the feed varies with the harvest time, type and cultivar of the plant and the agronomic practices (Kaplan et al., 2014).

There are many factors that affect the quality values of feeds. One of the most important of these is harvest time. Studies on this subject are important for determining the most appropriate time for both yield and feed quality. Although there are several studies on potential harvest times of different plant species, there are many other plants waiting to be investigated (Kamalak et al., 2011; Kaplan et al., 2014).

Within the scope of this study, effect of harvest time (booting, flowering and milk stages) on yield and forage quality characteristics of 10 registered annual grass cultivars was determined.

2. MATERIALS AND METHODS

In this study, 10 different annual grass (*Lolium multiflorum*) varieties (Hellen, Medaocus, Kartetra, Master, Braulia, Baqueona, Caramba, İlkadım, Devis and Big Boss) were used as the primary material. Experiments were conducted under Central Anatolian conditions. Seeds were sown manually (2 kg/da) in 6 rows of 5 m long with 20 cm row spacing. Experiments were conducted in randomized blocks – split plots experimental design with 3 replications. Cultivars were placed in main plots and harvest times were placed in subplots. At sowing, 10 kg/da N and 10 kg/da P_2O_5 fertilizers were applied and 5kg/da N fertilization was applied as dressing fertilizer during the stem elongation period of the plants. Plants were irrigated weekly according to the water requirement of the plant. Plants were harvested in three different periods as booting, flowering and milk stage.

Statistical Analyses

Experimental data were subjected to variance analysis using SAS (SAS Inst. 1999) statistical software in accordance with randomized blocks – split plots experimental design. Significant means were compared with the use LSD multiple range test.

3. RESULTS AND DISCUSSIONS

Average values for fresh herbage yields of annual grass cultivars harvested in different periods are given in Table 1. Effect of cultivars and harvest periods and cultivar x harvest period interactions on

*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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green herbage yields was found to be significant at 1% level. Herbage yields increased in all cultivars with the progress of the harvest period. The green herbage yield of 1041.48 kg/da in the first period increased to 2189.947 kg/da in the third period. According to the average of all cultivars, the green herbage yields ranged between 1399.96 - 1995.56 kg/da with the lowest yield from Ilkadım cultivar and the highest yield from Medaocus cultivar. In terms of cultivar x harvest period interactions, the highest green herbage yield (2785.76 kg/da) was obtained from the 3rd period of Medaocus cultivar and the lowest green herbage yields were obtained from the 1st period of BigBoss (783.24 kg/da) and Devis (840.71 kg/da) cultivars.

Table 1. Green herbage yields of annual grass cultivars harvested in different periods (kg/da)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	1091.95^{lm}	1449.74^{j}	2401.26^{b}	1647.65^{DE}
Medaocus	1024.98^{m}	2175.94^{d}	2785.76a	1995.56^{A}
Kartetra	1048.42^{m}	1938.20^{e}	2249.89^{cd}	1745.51^{C}
Master	1057.75^{m}	1686.13^{gh}	2300.74^{c}	1681.54^{CD}
Braulia	922.95^{n}	1059.23^{m}	1456.56^{j}	1146.24^{I}
Baqueona	1590.04^{i}	1639.78^{hi}	2313.36^{c}	1847.73^{B}
Caramba	896.77^{n}	1346.16^{k}	1956.96^{e}	1399.96^{H}
İlkadım	1157.99^{l}	1765.72^{fg}	1790.30^{f}	1571.34^{FG}
Devis	840.71^{no}	1455.86^{j}	2229.74^{cd}	1508.77^{G}
Big Boss	783.24^{o}	1553.28^{i}	2414.91^{b}	1583.81^{EF}
Average	1041.48^{C}	1607.00^{B}	2189.95^{A}	

Dry herbage yields of annual grass cultivars harvested in three different periods are given in Table 2. Effect of cultivar, harvest period and cultivar x harvest period on dry herbage yields were found to be highly significant ($p \leq 0.01$). Average dry herbage yield was determined as 533.22 kg/da in the 1st period, 755.85 kg/da in the 2nd period and 874.36 kg/da in the 3rd period. Based on average of all periods, the lowest dry herbage yield was obtained from Braulia cultivar (531.29 kg/da) and the highest dry herbage yield was obtained from Medaocus cultivar (937.86 kg/da). According to cultivar x harvest period interactions, the highest dry herbage yield was obtained from the 3rd period of Medaocus cultivar (1307.44 kg/da) and the lowest from the 1st period of Braulia cultivar (415.56 kg/da). In addition, the 1st period dry herbage yields of Hellen, Caramba and Devis cultivars were also placed into the lowest group.

Crude protein yields of annual grass cultivars harvested in different periods are given in Table 3. Effects of cultivar, harvest period and cultivar x harvest period interactions on crude protein yields were found to be significant at 1% level. Crude protein yields varied between 59.37 - 97.82 kg/da with the highest value from Baqueona cultivar and the lowest value from Hellen cultivar and Kartetra cultivar was also placed into the lowest group. The highest crude protein yield was obtained from the 2nd period, followed respectively by the 1st and 3rd periods. According to cultivar x harvest period interactions, the highest value was obtained from the 2nd period of Baqueona cultivar (129.55 kg/da), respectively followed by the 3rd period of Hellen, Kartetra and İlkadım cultivars and the 2nd period of Kartetra cultivar.

*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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Table 2. Dry herbage yields of annual grass cultivars harvested in different periods (kg/da)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	502.03^{mno}	818.91efg	842.63^{def}	721.19^{CDE}
Medaocus	546.24^{klm}	959.90c	1307.44^{a}	937.86^{A}
Kartetra	617.05^{jkl}	736.41ghi	865.99^{de}	739.82^{C}
Master	542.04^{lm}	631.71jkl	863.42^{de}	679.06^{E}
Braulia	415.56^{o}	633.47jkl	544.84^{klm}	531.29^{F}
Baqueona	657.25^{ij}	931.67cd	995.60^{bc}	861.51^{B}
Caramba	475.07^{mno}	551.09klm	703.78^{hij}	576.65^{F}
İlkadım	636.01^{jk}	795.23e-h	765.99^{fgh}	732.41^{CD}
Devis	429.95^{no}	844.46def	787.01^{e-h}	687.14^{DE}
Big Boss	511.03^{mn}	655.68ij	1066.87^{b}	744.53^{C}
Average	533.22^{C}	755.85^{B}	874.36^{A}	

Table 3. Crude protein yields of annual grass cultivars harvested in different periods (kg/da)

Cultivars	Harvest Period			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	63.38^{ijk}	68.17^{hij}	46.55^{n}	59.37^{G}
Medaocus	62.96^{ijk}	78.13^{efg}	91.87^{c}	77.65^{BC}
Kartetra	76.91^{fg}	53.37^{mn}	53.09^{mn}	61.12^{G}
Master	64.78^{ijk}	70.94^{ghi}	92.96^{c}	76.23^{BCD}
Braulia	76.80^{fg}	88.28^{cd}	56.65^{klm}	73.91^{CDE}
Baqueona	103.62^{b}	129.55^{a}	60.30^{j-m}	97.82^{A}
Caramba	91.96^{c}	85.42^{cde}	64.43^{ijk}	80.60^{B}
İlkadım	78.42^{efg}	82.40^{def}	53.92^{lmn}	71.58^{E}
Devis	62.03^{jkl}	91.07^{c}	64.16^{ijk}	72.42^{DE}
Big Boss	74.13^{fgh}	63.08^{ijk}	63.20^{n}	66.80^{F}
Average	75.50^{B}	81.04^{A}	64.71^{C}	

Average ADF ratios of annual grass cultivars harvested in different harvest periods are given in Table 4. When the average values of the cultivars are examined, it was seen that the ADF ratios varied between 29.88 - 37.95%. While Master and Devis cultivars perioded the lowest ADF group, Braulia (37.38%), Baqueona (37.55%), Caramba (37.95%), Ilkadım (37.36%) and Big Boss (37.76%) cultivars perioded the highest ADF group. According to the harvest periods, the highest ADF ratio was obtained from the 3rd period (38.86%) and the lowest ADF ratio was obtained from the 1st period (31.68%). According to cultivar x harvest period interactions, the highest ADF ratios were obtained from the 3rd period of Caramba (42.10%) and Baqueona (41.79%) cultivars. The lowest ADF ratio was obtained from the 1st period of Master cultivar (21.97%).

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Table 4. ADF ratios of annual grass cultivars harvested in different periods (%)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	31.05^{kl}	32.41^{j}	40.30^{b}	34.59^{C}
Medaocus	31.96^{jk}	34.83^{gh}	38.57^{de}	35.12^{C}
Kartetra	34.73^{gh}	36.47^{f}	38.94^{cd}	36.71^{B}
Master	21.97^{n}	32.18^{j}	35.49^{g}	29.88^{D}
Braulia	34.90^{g}	38.29^{de}	38.96^{cd}	37.38^{A}
Baqueona	31.19^{kl}	39.66^{bc}	41.79^{a}	37.55^{A}
Caramba	33.86^{hi}	37.89^{e}	42.10^{a}	37.95^{A}
İlkadım	33.62^{i}	38.63^{de}	39.82^{bc}	37.36^{AB}
Devis	28.38^{m}	30.32^{l}	32.30^{j}	30.34^{D}
Big Boss	35.18^{g}	37.74^{e}	40.35^{b}	37.76^{A}
Average	31.68^{C}	35.84^{B}	38.86^{A}	

The effect of cultivars, harvest periods and cultivar x harvest period interactions on NDF ratios was found to be highly significant ($p \leq 0.01$) (Table 5).

Table 5. ADF ratios of annual grass cultivars harvested in different periods (%)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	35.54^{p}	36.89^{o}	48.96^{fgh}	40.47^{H}
Medaocus	39.55^{n}	41.30^{m}	47.86^{hi}	42.90^{G}
Kartetra	44.07^{l}	47.60^{ij}	50.18^{def}	47.28^{D}
Master	35.32^{p}	46.14^{k}	48.48^{ghi}	43.31^{FG}
Braulia	41.95^{m}	45.73^{k}	50.66^{cd}	46.11^{E}
Baqueona	41.93^{m}	45.34^{k}	50.92^{cd}	46.06^{E}
Caramba	46.58^{jk}	50.29^{de}	52.90^{b}	49.92^{B}
İlkadım	49.35^{efg}	51.71^{bc}	55.19^{a}	52.08^{A}
Devis	36.19^{op}	47.41^{ij}	48.00^{hi}	43.87^{F}
Big Boss	43.97^{l}	50.11^{def}	51.13^{cd}	48.41^{C}
Average	41.45^{C}	46.25^{B}	50.43^{A}	

The lowest NDF ratios were obtained from the 1st period (41.45%) and the 2nd period (46.25%) and the highest NDF ratio was obtained from the 3rd period (50.43%). When the average values of the cultivars are examined, it was seen that the lowest NDF ratio was obtained from Hellen cultivar (40.47%) and the highest from Ilkadım cultivar (52.08%). According to cultivar x harvest period interactions, the highest value was obtained from the 3rd period of Ilkadım cultivar (55.18%) and the lowest values were obtained from the 1st period of Devis (36.19%), Hellen (35.55%) and Master (35.32%) cultivars (Table 5).

Average values for crude ash ratios of annual grass cultivars harvested in three different harvest periods are given in Table 6. The effect of cultivar and harvest period on crude ash ratios was found

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to be significant at 1% level. When the crude ash ratios of the cultivars were examined, the lowest ash ratio was obtained from Hellen cultivar (5.75%) and the highest value was obtained from Baqueona cultivar (8.34%). The raw ash ratios of annual grasses for the 1st, 2nd and 3rd harvest periods were determined as 7.74%, 6.82% and 5.71%, respectively. In terms of cultivar x harvest period interactions, the lowest value was obtained from the 3rd period of Big Boss cultivar (4.56%) and the highest value was obtained from the 1st period of Baqueona cultivar (8.87%).

Table 6. Crude ash ratios of annual grass cultivars harvested in different periods (%)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	6.41^{k}	6.01^{lmn}	4.82^{q}	5.75^{I}
Medaocus	8.20^{c}	7.51^{fg}	4.78^{q}	6.83^{DE}
Kartetra	7.41^{g}	6.85^{i}	6.01^{lmn}	6.76^{E}
Master	8.49^{b}	7.06^{h}	6.10^{lm}	7.22^{B}
Braulia	7.75^{de}	6.14^{lm}	5.52^{o}	6.47^{F}
Baqueona	8.87^{a}	8.30^{c}	7.85^{d}	8.34^{A}
Caramba	8.12^{c}	6.54^{jk}	6.19^{l}	6.95^{CD}
İlkadım	7.78de	7.37^{g}	5.99^{mn}	7.05^{C}
Devis	6.70^{ij}	5.85^{n}	5.23^{p}	5.93^{H}
Big Boss	7.62^{ef}	6.55^{jk}	4.56^{r}	6.24^{G}
Average	7.74^{A}	6.82^{B}	5.71^{C}	

Crude protein values of annual grass cultivars harvested in different harvest periods are given in Table 7. The effect of cultivar, harvest period and cultivar x harvest period interaction on crude protein ratios was found to be highly significant ($p \leq 0.01$). According to harvest period averages of the cultivars, the lowest crude protein values were obtained from Kartetra (8.61%) and Hellen (8.82%) cultivars and the highest crude protein values value was obtained from Caramba cultivar (14.67%). The average crude protein ratio of the cultivars was determined as 14.34 % in the 1st period, 10.90% in the 2nd period and 7.61% in the 3rd period. In terms of cultivar x harvest period interactions, the lowest crude protein ratio was obtained from the 3rd period of Hellen cultivar (5.53%) and the highest crude protein ratio was obtained from the 1st period of Caramba cultivar (19.35%).

New plant cultivars are being improved and introduced into field agriculture every day. It is of great importance for agriculture and animal production that these new cultivars are tested in terms of yield and quality characteristics under different climate and soil conditions (Harmanlıoğlu and Kaplan 2020). The yields of annual grass vary considerably with the cultivar and the region where it is grown (Kurt and Başaran, 2021). Present findings on green herbage yields were similar with the values of İnce (2000) and Aktar et al. (2021) and lower than the values of Göktepe (2015), Özdemir (2017) and Lale and Kokten (2020). Present dry herbage yields were greater than the values of Kuşvuran et al. (2014), Cetin (2017), Aktar et al. (2021) and Özelçam et al. (2015).

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Table 7. Crude protein ratios of annual grass cultivars harvested in different periods (%)

Cultivars	Harvest Periods			Average
	1st Period (Booting)	2nd Period (Flowering)	3rd Period (Milk Stage)	
Hellen	12.61^{f}	8.32^{m}	5.52^{p}	8.82^{FG}
Medaocus	11.51^{h}	8.14^{m}	7.01^{n}	8.89^{F}
Kartetra	12.46^{f}	7.25^{n}	6.13^{o}	8.61^{G}
Master	11.95^{g}	11.23^{h}	10.76^{i}	11.31^{D}
Braulia	18.48^{b}	13.94^{e}	10.39^{j}	14.27^{B}
Baqueona	15.76^{c}	13.90^{e}	6.05^{o}	11.91^{C}
Caramba	19.35^{a}	15.50^{c}	9.15^{l}	14.67^{A}
İlkadım	12.33^{f}	10.36^{j}	7.04^{n}	9.91^{E}
Devis	14.42^{d}	10.78^{i}	8.15^{m}	11.12^{D}
Big Boss	14.51^{d}	9.62^{k}	5.93^{o}	10.02^{E}
Average	14.34^{A}	10.90^{B}	7.61^{C}	

Crude protein ratio is an important indicator of herbage quality of forage crops (Assefa and Ledin, 2001). It has been reported that plant genetics, leaf, spike and stem ratios, maturation period, temperature and fertilization were effective in dry matter and protein ratios of different cultivars (Ball et al., 2001). Present crude protein values were similar with the values of Kurt and Başaran (2021), Yavuz et al. (2017), Şimşek, (2015) and Aktar et al. (2021), lower than the values of Yavuz et al. (2017). Present crude protein yields were similar with the values of Kesiktaş (2010), Çolak and Sancak (2016) and Çetin (2017).

The NDF and ADF ratios have significant effects on feed digestibility and consumption. Therefore, it is desired that the ADF and NDF values of the feeds used in the rations should be at ideal levels (Bozkurt, 2011). Although ADF and NDF ratios of present cultivars varied with the harvest time, they were classified as the first quality and second quality roughage (Van Soest, 1994). Present ADF and NDF ratios were similar with the values of Çolak and Sancak (2016), Yavuz et al. (2017) and Özdemir (2017).

In present study, green and dry herbage yields increased with the progress of harvest time. With the progression of maturity, the structural substances in plants increase and new tissues are formed. Therefore, increases are expected to be seen in biomass (Temel and Tan, 2002; Kaplan et al., 2016). Significant decrease in crude protein, crude oil, crude ash and condensate tannin content and increase in dry matter, ADF and NDF ratio with the progress of maturity are consistent with the findings of previous studies conducted on various forage crops. Similar findings were also reported for quinoa plant by Uke et al. (2016), teff grass by Kaplan et al. (2016), *Bituminaria bituminosa* grass by Durmaz and Kamalak (2019), common vetch cultivars by Kaplan (2013), *Onopordum acanthium* grass by Ceylan and Kamalak (2019), *Chenopodium album* grass by Atalay and Kamalak (2019), *Silybum marianum* grass by Kurt and Kamalak (2020) and *Trigonella foenum-graecum* grass by Akbay et al. (2020).

With the progress of harvest period, a significant decrease was encountered in crude protein ratios. Depending on the harvest time, there is a decrease in the leaf/stem ratio of mature plants. It is

*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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thought that the decrease in protein-rich leaves, the increase in the protein-poor stem (Buxton, 1996) and the conversion of proteins into structural elements decrease the protein ratios (Kamalak et al., 2005).

ADF and NDF contents are important quality indicators of forage crops (Aydın et al., 2010) and should be low in quality roughage as such contents prevent digestibility, reduce feed consumption and therefore reduce the quality of roughage. ADF and NDF ratios increase with the progress of maturity (Kamalak et al., 2005). It has been reported that the increase in ADF and NDF content for different forage crops decreases the crude protein, crude oil, crude ash and condensed tannins of forage crops with the progression of the maturity stage (Kaplan et al., 2014).

The raw ash ratio, which is an indicator of the amount of mineral matter in the feed, is the remainder of the dry matter burning (Gençtan, 1998). Mineral substances control the synthesis of hormones in the animal, their entry into the structure of enzymes, and the functioning of enzymes. Since minerals cannot be synthesized in the animal body, they must be taken from outside (Ülger and Kaplan, 2016). The amount of crude ash in the feed varies depending on whether the feed is roughage or concentrate, the type and cultivar of the plant and the climate and soil characteristics of the region where it is grown (Gralak et al., 2006).

4. CONCLUSIONS

All annual grass cultivars have been considered as an important feed source for animal feeding. Herbage yields and ADF and NDF ratios increased as the harvest time progressed, while the crude protein ratios decreased. The highest crude protein yield was obtained from the plants harvested in flowering period. Based on present findings obtained under Central Anatolian conditions, Baqueona, Baqueona, Medaocus cultivars are recommended in terms of herbage and protein yields.

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*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com

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*Corresponding author, E-mail address: mahmutkaplan5@hotmail.com