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Determination of Forage Yield and Other Characteristics of Cowpea (*Vigna unguiculata* L.) Cultivars Sown at Different Times

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A B S T R A C T

In this study, which was carried out in Erzurum conditions to utilize cowpea cultivars and a cowpea landrace sown at different times as feed crops and determine some of their characteristics, 5 genotypes including 4 different cowpea cultivars (Akkız-86, Karagöz-86, Karnıkara, and Ülkem) and 1 landrace (red cowpea) were used, and treatment groups with 3 different sowing times (25 April, 10 May, and 25 May) were formed. The study was conducted with the Random Full Block Design and 4 replicates. According to the results, after the sowing of the cowpea cultivars and landrace at different times, the ranges of the values were 21.50-90.50 cm for plant height, 11.50-25.25 cm for first pod height, 8.25-18.75 cm for pod length, 1.75-19.00 for number of pods, 1.50-13.75 for number of seeds per pod, 935.00-3537.55 kg/da for green herbage yield, 157.40-760.38 kg/da for dry herbage yield, 8.93-12.27% for crude protein ratio, 16.48-26.71% for ADF ratio, and 21.89-36.99% for NDF ratio. Among the sowing times, the dates 25 April and 10 May were prominent. Consequently, the treatment at the sowing time of 25 April was found optimal in terms of the green herbage yield, crude protein ratio, ADF, and NDF values in terms of the identification of sowing times of the plant as a feed crop in Erzurum conditions. Among the cultivars, the Ülkem cultivar and the red cowpea landrace provided the best results as feeds.

1. Introduction

Agricultural production is influenced by several factors. Some of the main factors may be listed as seeding, irrigation, fertilizers, mechanization, pest control, drought, and global warming. Among these factors, global warming will affect and cause trouble in the agriculture sector in addition to affecting several other sectors. Therefore, it is important to identify heat-tolerant species ahead of time. One of the heat- and drought-tolerant plants is the cowpea.

The cowpea (*Vigna unguiculata* L. *Walp*), which is one of the most significant legumes worldwide, is an annual plant that is widespread in Africa, South America, Asia, and the United States (Xiong *et. al.,* 2016). It is a preferable plant for crop rotation as it not only loosens the soil with its roots but also increases the yield of the next crop by nitrogen fixation. It also has the capacity to grow in poor soils (Miller *et. al.,* 1984; Pemberton and Smith, 1990; İdikut *et. al*., 2019). Cowpea cultivation covers an area of 14,447,336 ha globally, with a production quantity of 8.903.329 tons, and a yield of 6163 kg/ha. Its largest amount of production takes place in Nigeria with an area of 5.725.433 ha, followed by Burkina Faso at 1.354.100 ha and Mali at 454,274 ha (FAO, 2019). In 2020, 1,324 tons of cowpeas were produced in an area of 13,227 ha in Turkey, and the yield was 101 kg/da (Anonymous, 2020).

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The cowpea, which can also be utilized as a feed crop for animal nutrition, belongs to the legumes family and has 2.0-4.3% protein in its fresh pods and 4.5-5.0% protein in its fresh seeds. The protein content of matured cowpea seeds in their dry form varies in the range of 20.42-34.60% based on the cultivar and environmental conditions (Sehirali, 1988). Moreover, cowpea seeds contain 50-67% carbohydrates, 1.3% fats, 3.9% cellulose, and 3.6% ash. The protein content of its seeds is rich in terms of the amino acids Lysine and Tryptophan compared to cereal seeds and deficient in terms of the amino acids Methionine and Cystine compared to animal proteins (Davis *et. al.,* 1991).

Sowing time is one of the important agronomic factors that influence product development and yield (Kolte, 1985; Abdou *et. al.,* 2011). Environmental variables, especially temperature, play an important role in the selection of the sowing time. Sowing time is the key factor that affects the growth, development, and productivity of the plant (Kaleem *et. al.,* 2009; Kaleem *et. al.,* 2010). Selecting the appropriate sowing time is one of the most important factors that determine the yield of the cowpea plant. In general, in agricultural production economics, factors affecting the appropriate sowing time include climate parameters such as temperature, precipitation, day length, and wind, and environmental factors such as diseases, pests, weeds, and birds (Mazaheri and Majnoon, 2005). Among these, precipitation is the most significant determinant of sowing time (Lane and Jarvis, 2007; Adediran *et. al.,* 2018).

To achieve higher cowpea yield values per unit area, it is necessary to grow cultivars that adapt to the ecological conditions of the region better by using the appropriate cultivation techniques. For each plant species, adaptation studies should be carried out to determine the suitability of cultivars to the environmental conditions of the region (Ceylan and Sepetoglu, 1984). Therefore, in this study, it was aimed to investigate variations that could occur in some parameters of cowpea cultivars to be grown as feed crops for summer based on sowing times in the ecological conditions of the province of Erzurum in Turkey.

2. Materials and Methods

2.1. Material

The study was carried out in 2019 in the trial field of the Plant Production Application and Research Center at Atatürk University. The plant material consisted of 5 different genotypes, including the Akkız-86, Karagöz-86, Karnıkara, and Ülkem cultivars, and 1 landrace (red cowpea) (Table 1). DAP fertilizer was used at a quantity of 15 kg/da in the trial.

The trial was conducted in the province of Erzurum, which is in the Eastern Anatolia Region of Turkey and has an altitude of 1869 m. Erzurum is between the longitudes of E 40° 14' 15″ and E 42° 33' 35″ and the latitudes of N 40° 54' 57″ and N 39° 06' 10″. In Erzurum, winters are cold and have high precipitation, while summers are cool and dry. Some climate data of the province of Erzurum for the year 2019 are presented in Table 2.

The total precipitation in 2019 was 313.8 mm and lower than the long-term average (408.8 mm), and the average temperature in 2019 was 6.2°C and higher than the long-term average (5.6°C). The average relative humidity in 2019 was 65.9%, which was lower than the long-term average (67.7%). In May-July, when plants show active growth, temperatures are higher in Erzurum.

2.2. Soil properties of the research area

The texture class of the soil collected from the trial field was identified based on the Bouyoucos hydrometer method (Demiralay, 1993) and the soil was in the clayey-loamy class. Based on the methods described by Saglam (1994), the soil's pH was determined as 7.56. The carbonate ratio of the soil samples was measured as 1.14% using a Scheibler. The plant-available phosphorus ratio was found as 4.41 kg/da (Olsen and Summer, 1982).

Table 1. The cowpea plant and varieties used in the research and the companies from which they were supplied

Name	Latin Name	Variety	Institution of Supply
Cowpea	*Vigna unguiculata* L. *sinensis*	Akkız-86	Çoker Seeds
Cowpea	*Vigna unguiculata* L. *sinensis*	Karagöz-86	Çoker Seeds
Feed Cowpea	*Vigna unguiculata* L. w*alp*	Ülkem	19 Mayıs Univ.Agr. Fac.
Cowpea	*Vigna unguiculata* L. *sinensis*	Karnıkara	Agrogen Seeds
Red Cowpea	*Vigna unguiculata* L. *sinensis*	Population	Adana

Table 2. Some Climate Values of Erzurum Province in 2019*

Months	Monthly Average Temperature (˚C)		Monthly Average Relative Humidity (%)		Monthly Total Precipitation (mm)	
	2019	**LTA**	**2019**	**LTA**	**2019**	**LTA**
January	-8.0	-10.6	80.0	81.0	13.9	17.9
February	-8.4	-8.2	84.9	80.5	26.9	20.0
March	-3.1	-0.9	79.3	74.4	24.7	34.3
April	4.2	5.8	73.4	67.8	68.9	58.6
May	11.9	10.5	60.3	67.2	63.8	70.6
June	17.8	14.9	57.2	61.5	23.6	45.1
July	19.0	19.5	49.4	53.5	3.0	22.3
August	20.3	19.9	46.0	49.6	11.6	18.8
September	14.5	14.5	51.7	52.5	28.4	20.0
October	9.8	8.1	56.3	67.8	11.0	56.9
November	0.1	0.4	65.9	75.0	14.8	25.3
December	-3.5	-7.2	85.8	81.5	23.2	19.0
Tot./Mean.	6.2	5.6	65.9	67.7	313.8	408.8

* Taken from Erzurum Meteorology Regional Directorate data. LTA: Long Term Average

Using the Smith-Weldon method, the organic matter ratio of the soil collected from the trial field was determined to be 1.01% (Nelson and Sommers, 1982). Consequently, as seen in the data shown in Table 3, the soils of the trial field were mildly alkaline, limy, sufficient in phosphorus, lacking in organic matter, and moderate in terms of plant-available potassium (Ozyazıcı *et. al.,* 2016).

Table 3. Some Physical and Chemical Soil Properties of the Research Area

Physical characteristics	
Texture Class	Argillaceous-Loam
Clay (%)	35.78
Silt (%)	29.50
Sand (%)	34.72
Chemical characteristics	
pH	7.56
Lime ($CaCO_3$ %)	1.14
Phosphorus (kg P_2O_5/da)	4.41
Potassium (kg K_2O/da)	171
Organic matter (%)	1.01

This study was conducted with the factorial arrangement in the random full block design and 4 replicates to investigate some feed crop parameters of cowpea cultivars sown at different sowing times (25 April, 10 May, 25 May) for summer in the ecological conditions of Erzurum. Sowing was performed at a sowing depth of 4-5 cm. Weed control and hoeing processes were carried out according to the states of the plants in the plots at all sowing times.

The parameters that were investigated in the study included plant height (cm), first pod height (cm), pod length (cm), number of pods, number of seeds per pod, green herbage yield (kg/da), dry herbage yield (kg/da), crude protein ratio (%), ADF (%), and NDF (%). The obtained data were subjected to analysis of variance with the SPSS package program, and Duncan's multiple range tests were conducted to identify the sources of significant differences between mean values.

3. Results and Discussion

The mean plant height (cm), first pod height (cm), pod length (cm), number of pods, number of seeds per pod, green herbage yield (kg/daa), dry herbage yield (kg/daa), crude protein ratio (%), ADF (%), and NDF (%) values of the cowpea genotypes that were examined in the study by sowing at three different times (25 April, 10 May, 25 May) in Erzurum conditions are shown in Table 4.

3.1. Plant Height

The effect of different sowing times on the plant height values of the cowpea cultivars was found statistically significant ($p<0.01$) (Table 4).

At different sowing times, the plant height values varied in the range of 40.85-57.70 cm. Based on the sowing time x cultivar interaction, the highest plant height was found as 90.50 cm in the red cowpea sown on 10 May, while the shortest one was found as 21.50 cm (Akkız-86) in the plants sown on 25 April. Among the sowing times, the tallest plants were obtained in the treatments on 10 May and 25 May, and their mean values were respectively 57.70 and 53.35 cm. The lowest mean plant height value was found as 40.85 (cm) in the plants sown on 25 April (Table 4).

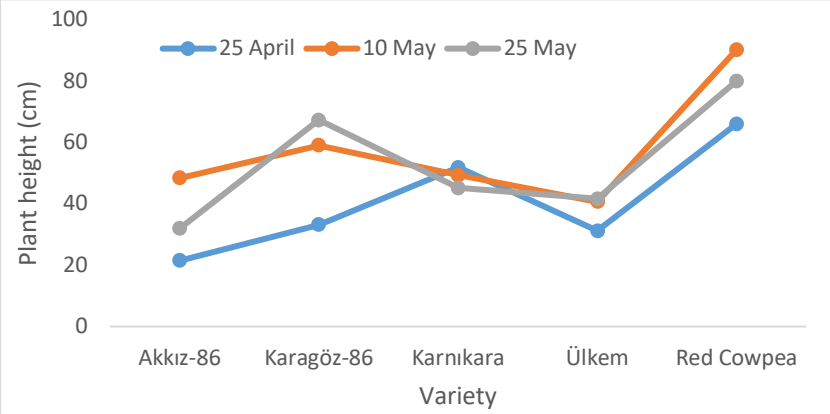

Figure 1. Effect of sowing time x variety interaction on plant height

The highest plant height in Akkız-86 was obtained on 10 May. The shortest plant height was taken in October 25th. In the Karagöz-86 genotype, the highest plant height was obtained on May 25, while the shortest plant height was obtained on April 25. Although there is not much difference according to the sowing times in Karnıkara variety, the highest plant height was obtained on April 25, while the shortest plant height was obtained on May 25. The shortest plant height was obtained on April 25 in Ülkem cowpea forage variety. On May 25, Ülkem gave the longest plant height. Red cowpea population showed the longest plant height in October 10, and the shortest plant height in October 25th. Considering the variety characteristics of red cowpea, it was determined that it formed more plant height in hot months. The effect of sowing time on plant height was different. (Figure 1.)

Plant height is a property that can be substantially influenced by the genetic properties of cultivars, environmental conditions, and cultivation conditions. While the results that were obtained in this study were higher than those reported by Toğay et al. (2014) and Karasu (1999), they were lower than those reported by Peksen and Artık (2004), Futuless and Bake (2010), Başaran et al. (2011), İdikut et al. (2015), Beycioğlu (2016), and İdikut et al. (2019), and they were similar to those reported by Sert and Ceyhan (2012), Magashi et al. (2014), and Ozçelebi (2021). Different results obtained regarding plant height could be attributed to the different climate and soil conditions, cultivars that were used, and cultivation conditions used by the researchers in different studies.

3.2. First Pod Height

The effect of the sowing time x cultivar interaction on the first pod height values of the cowpea cultivars was found statistically significant ($p<0.01$) (Table 4). At different sowing times, the first pod height values varied in the range of 14.35-19.55 cm. Among the cultivars, the highest mean first pod height was found as 21.83 cm in the Karnıkara cultivar, and the lowest mean first pod height was found as 14.08 cm in the Akkız-86 cultivar. Among the sowing times, the highest mean value of first pod height was determined to be 19.55 cm in the plants sown on 25 May, while the lowest value was 14.35 cm in those sown on 25 April. In terms of the cultivars, the highest mean value was found as 25.25 cm in the Karnıkara cultivar sown on 25 May, while the lowest value was found as 11.00 cm in the Ülkem cultivar sown on 25 April (Table 4).

Akkız-86 and red cowpea had the longest first pod height on 10 May and the shortest first pod height on 25 April. Karagöz-86, Karnıkara and Ülkem varieties showed similarity by giving the longest first pod height on 25 May. Karagöz-86 gave the shortest first pod height on May 10, while Karnıkara and Ülkem varieties gave on April 25 (Figure 2).

The results on the first pod height parameters in this study were similar to those reported by Atış (2000), Büyükkılıç (1995), Karasu (1999), Pekşen and Artık (2004), Pekşen (2007), Beycioğlu (2016), and Ozçelebi (2021), while they were lower than those reported by Başaran et al. (2011) and İdikut et al. (2019). These differences in different studies may be explained by ecological conditions and cultivars.

Table 4. Averages of Investigated Traits of Cowpea Varieties at Different Sowing Times

Sowing Times	Plant Height (cm)						First Pod Height (cm)					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Kırmızı Börülce	Mean **
25 April	21.50	33.25	52.00	31.25	66.25	40.85 b	11.50	18.50	18.75	11.00	12.00	14.35 b
10 May	48.50	59.25	49.50	40.75	90.50	57.70 a	17.25	16.00	21.50	17.00	19.50	18.25 a
25 May	32.00	67.50	45.25	41.75	80.25	53.35 a	13.50	23.50	25.25	19.75	15.75	19.55 a
Mean**	34.00 c	53.33 b	48.92 b	37.92 c	79.00 a	50.63	14.08 b	19.33a	21.83 a	15.92 b	15.75 b	17.38
Sowing Times	**Pod Length (cm)**						**Pod Number (number)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **
25 April	9.25	11.00	8.25	8.00	8.00	8.90 c	1.75	4.75	2.00	1.75	4.50	2.95 b
10 May	11.25	12.00	8.75	18.50	18.75	13.85 a	19.00	5.75	6.75	10.75	12.00	10.85 a
25 May	8.25	13.75	9.50	12.00	15.25	11.75 b	11.50	7.25	5.00	12.25	14.75	10.15 a
Mean**	9.58b	12.25a	8.83 b	12.83 a	14.00 a	11.50	10.75 a	5.92 c	4.58 d	8.25 b	10.42a	7.98
Sowing Times	**Number of seeds per pod (number)**						**Green Grass Yield (kg/da)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **
25 April	1.50	4.25	3.50	4.50	3.75	3.50 b	1137.05	1540.43	1340.73	1963.53	3537.55	1903.86 a
10 May	7.75	7.00	8.00	4.75	11.00	7.70 a	1158.25	1773.85	1448.75	935.00	1617.38	1386.65 b
25 May	6.75	6.50	7.25	4.50	13.75	7.75 a	1137.93	1992.88	1151.48	1396.75	1429.50	1421.71 b
Mean**	5.33 bc	5.92 b	6.25 b	4.58 c	9.50 a	6.32	1144.41d	1769.05b	1313.65 c	1431.76 c	2194.81 a	1570.74
Sowing Times	**Hay Yield (kg/da)**						**Crude Protein (%)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **
25 April	447.35	345.40	157.40	309.43	571.68	366.25 b	11.50	18.50	18.75	11.00	12.00	14.35 b
10 May	440.88	402.25	535.25	354.38	532.13	452.98a	17.25	16.00	21.50	17.00	19.50	18.25 a
25 May	427.33	760.38	399.00	349.00	607.38	508.62 a	13.50	23.50	25.25	19.75	15.75	19.55 a
Mean**	438.52 c	502.68b	363.88 d	337.60 d	570.3a	442.61	14.08b	19.33a	21.83 a	15.92b	15.75 b	17.38
Sowing Times	**ADF (%)**						**NDF (%)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **
25 April	21.13	21.93	20.63	25.40	26.66	23.15 b	36.99	25.27	21.89	30.38	25.04	27.92 b
10 May	24.48	22.17	22.13	29.73	26.65	25.03 a	32.72	29.65	29.43	28.97	35.90	31.33 a
25 May	16.48	26.71	19.93	28.61	23.85	23.12 b	22.35	34.33	27.93	31.11	33.20	29.78 a
Mean**	20.69 d	23.60 c	20.89 d	27.92 a	25.72 b	23.76	30.69ab	29.75 b	26.41 c	30.15 b	31.38 a	29.68

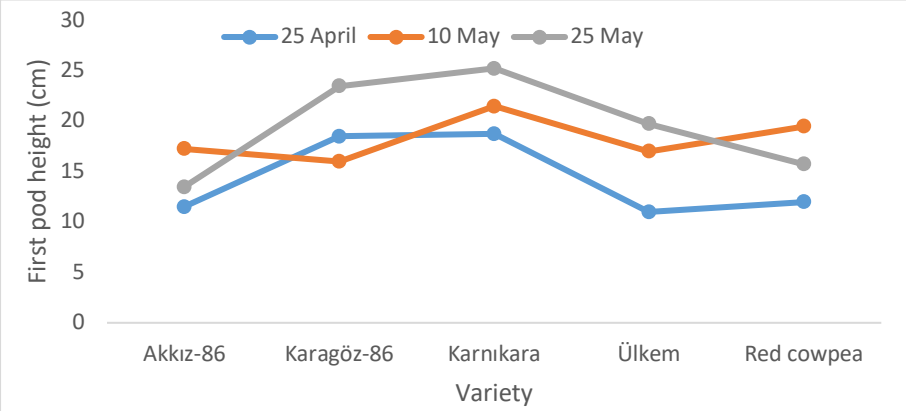

Figure 2. Effect of sowing time x variety interaction on first pod height

3.3. Pod Length

The effect of different sowing times on the pod length values of the cowpea cultivars was found statistically highly significant ($p<0.01$).

The pod length values varied in the range of 8.83-14.00 cm. Among the cultivars, the highest mean pod length value was 14 (cm) in red cowpea and the lowest one was 8.83 in the Karnıkara cultivar. In terms of the sowing times, the highest mean pod length value was 13.85 cm in the plants sown on 10 May, and the lowest one was 8.90 cm in those sown on 25 April. Considering all values, the highest mean value was found in the red cowpea plants sown on 10 May (18.75 cm).

Addo-Quaye et al. (2011), who stated that pod length is hereditary by 75.2%, found that environmental conditions have little to no effect on

pod length in the cowpea plant. Previous studies reported pod length values of 7.40-14.76 cm (İdikut et al., 2015), 10.97-18.47 cm (Ünlü, 2004), 11.8-14.4 cm (Başaran, 2011), 12.62-16.06 cm (Peksen and Artık, 2004), 13.23-20.03 cm (Futuless and Bake, 2010), 13.35-38.81 cm (Oztokat and Demir, 2010), 9.60-12.36 cm (Akdag et. al., 1998), 13.77-17.63 cm (Magashi et. al., 2014), and 12.3-18.7 cm (Ozçelebi, 2021).

Varieties reacted differently to planting times. In Akkız-86, Ülkem and red cowpea, the highest pod length value was obtained on May 10, while the lowest value of Akkız-86 was on May 25; Ülkem and red cowpea yielded in October 25th. Karagöz-86 and Karnıkara cultivars showed similar development and gave the highest pod length value on 25 May, and the lowest pod length value on 25 April. (Figure 3).

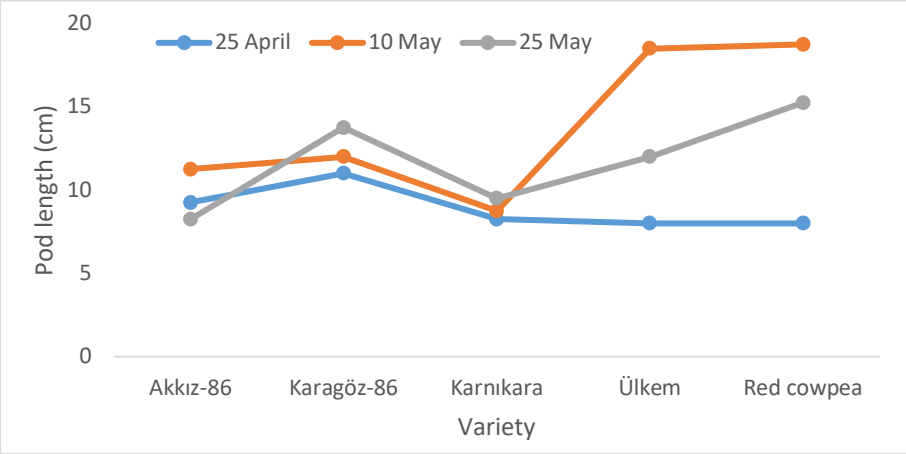

Figure 3. Effect of sowing time x variety interaction on pod length

3.4. Pod Number

The effects of the sowing times, cultivars, and the sowing time x cultivar interaction on the pod numbers of the cowpea cultivars were found statistically significant ($p<0.01$). The mean numbers of pods in the plants varied between 1.75 and 19.00. The mean numbers for different sowing times were in the range of 2.95 (25 April) - 10.85 (10 May). Among the cultivars, while the highest mean number of pods was 10.75 in the Akkız-86 cultivar, the lowest mean number of pods was 4.58 in the Karnıkara cultivar. Among all plants, the highest mean number of pods was found as 19.00 in the Akkız-86 cultivar sown on 10 May. The lowest mean numbers of pods in all cultivars were obtained in those that were sown on 25 April (Table 4).

Addo-Quaye et al. (2011), who reported that the production of more pods occurs in high-humidity conditions, determined that the mean number of pods in the plants in their study varied in the range of 6.9-8.3, differences among cultivars in terms of their numbers of pods were dependent on genetic factors, and the effect share of genetic factors was estimated to be 53.1%.

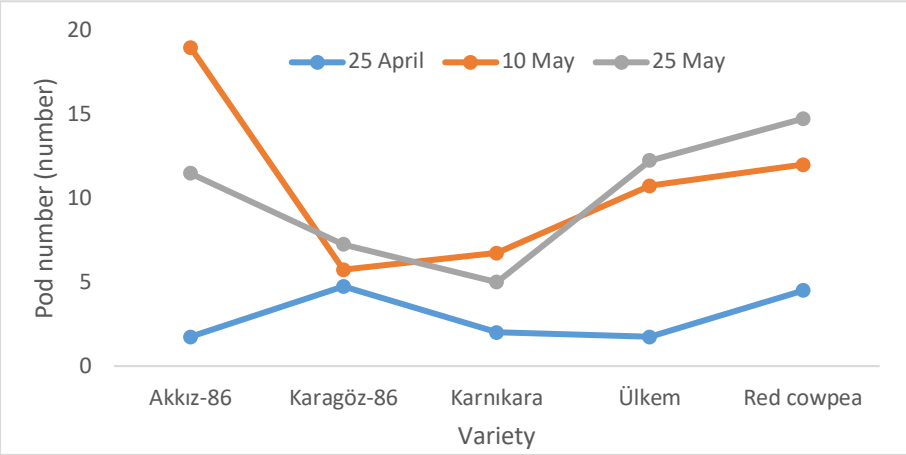

Figure 4. Effect of sowing time x variety interaction on pod number

The results that were obtained in our study were higher than those reported by Gülümser et al. (1989) (6.67-10 pods), Dhaka et al. (1992) (1.80-6.98 pods), Pekşen (2007) (3.2-8.0 pods), Addo-Quaye et al. (2011) (6.9-8.3 pods), and Beycioğlu (2016) (2.93-7.65 pods), whereas they were lower than those reported by Pekşen and Artık (2004) (8.20-16.06 pods), Pekşen (2005) (7.21-13.45 pods), Sert (2011) (2.0-14.59 pods), Ünlü and Padem (2005) (3.8-33.4 pods), Culha (2018) (8.33-17.92 pods), and Ozçelebi (2021) (16.3-35.8 pods). While the results of our study were similar to those in some studies, the differences between our results and those in other studies may be explained by different ecological conditions, cultivars, and cultivation parameters.

The least number of pods in all cultivars was obtained in 25 April sowing. Akkız-86 and Karnıkara varieties gave the highest number of pods on May 10; Karagöz-86, Ülkem and red cowpea cultivars yielded on May 25 (Figure 4).

3.5. Number of seeds per pod

The effect of different sowing times on the numbers of seeds per pod in the cowpea cultivars was found statistically highly significant ($p<0.01$). The mean numbers of seeds per pod were between 1.50 and 13.75. The mean numbers obtained for different sowing times were in the range of 3.50 (25 April) to 7.75 (25 May). Among the cultivars, the highest mean number of seeds per pod was 9.50 in red cowpea, while the lowest one was 4.58 in Ülkem. Among all plants, the highest mean number of seeds per pod (13.75 seeds) was found in the red cowpea sown on 25 May, while the lowest number (1.50 seeds) was found in the Akkız-86 cultivar sown on 25 April (Table 4).

The number of seeds per pod is a significant yield parameter in the cultivation of cowpea. Cultivation processes should aim to increase the number of seeds per pod (Ozkorkmaz, 2020). Among studies on numbers of seeds per pod, Sert (2011) reported these numbers in the range of 4.87-5.67 seeds, while Ceylan and Sepetoğlu (1983) reported them in the range of 2.27-8.57 seeds. While the results in our study were higher than those reported in the aforementioned studies, they were similar to those reported by Magashi et al. (2014) (8.73-10.70 seeds), Addo-Quaye et al. (2011) (11.6-11.7 seeds), Peksen and Artık (2004) (9-12 seeds), Futuless and Bake (2010) (13.14-17.11 seeds), Başaran et al. (2011) (9 seeds), Ünlü and Padem (2005) (5.9-11.1 seeds), Ozkorkmaz (2020) (10.76-11.53 seeds), and Ozçelebi (2021) (7.3-17 seeds).

In all genotypes, the minimum number of seeds per pod was obtained from 25 April sowing. In the red cowpea population, the maximum number of seeds was obtained on May 25, while the maximum number of seeds was determined on May 10 in other varieties (Figure 5).

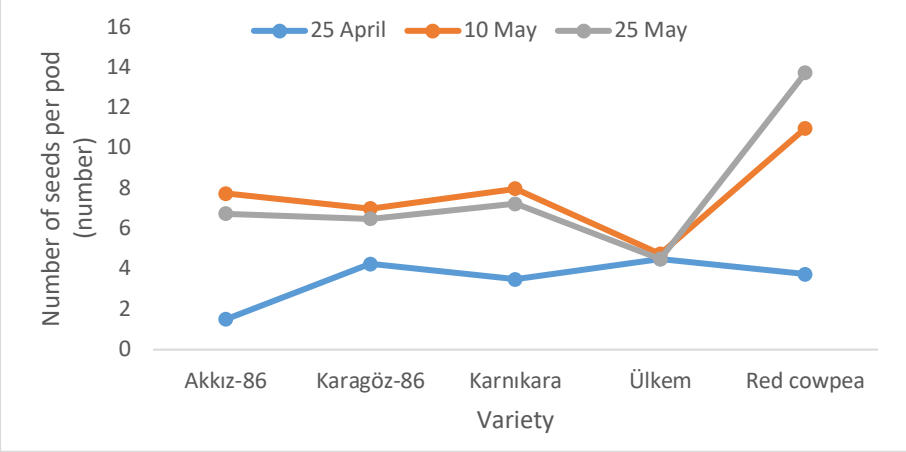

Figure 5. Effect of sowing time x variety interaction on number of seeds per pod number

3.6. Green Forage Yield

The effect of different sowing times on the green grass yield values of the cowpea cultivars was found statistically highly significant ($p<0.01$). The mean green grass yield values varied between 935 and 3537 kg/da. In the groups formed for different sowing times, these values were between 1386 kg/da (10 May) and 1904 kg/da (25 April). In the groups formed with different cultivars, the highest mean green grass yield was 2195 kg/da in red cowpea, while the lowest mean green grass yield was 1144 kg/da in Akkız-86. Among studies on green grass yield in cowpeas, yield values were

reported by Etana et al. (2013) as 11.10-29.10 ton/ha, by Sallam and İbrahim (2016) as 3900-11900 kg/ha, by Jatasra et al. (1989) as 2865-3775 kg/da, by Atış (2000) as 2395-3133 kg/da in Hatay, by Beycioğlu (2016) as 2047.49-4466.25 kg/da in Kahramanmaraş, by Alaca (2017) as 2786 kg/da, and by Omar (2018) as 3013.54-4773.50 kg/da in Samsun. The green herbage yield results that we obtained in our study were lower in comparison to those reported in previous studies. The reason for this difference may be that other studies have used different procedures for different climate and soil properties. In our study, the cultivars that were sown early provided higher green grass yield values, while these values decreased as sowing was made later. Similarly, İdikut et al. (2019) also found that yield was higher at earlier sowing times and lower at later ones.

Although Akkız-86 did not react much to the planting time, it gave the highest green grass yield on 10 May and the lowest green grass yield on 25 April. Karagöz-86 gave the lowest yield on April 25 and the highest yield on May 25. The highest green grass yield was obtained on May 10 and the lowest grass yield was obtained on May 25 from Karnıkara variety. The highest green grass yield of Ülkem cultivar and red cowpea population was obtained in 25 April sowing, and the lowest green grass yields were obtained from 10 May and 25 May plantings, respectively (Figure 6). Green grass yields were found to be higher in cultivars with early sowing. It was determined that the yield decreased with the delay of sowing. As a matter of fact, Idikut et al. (2019) reported that the yield was high in early sowing and decreased in late sowing in their study (Figure 6).

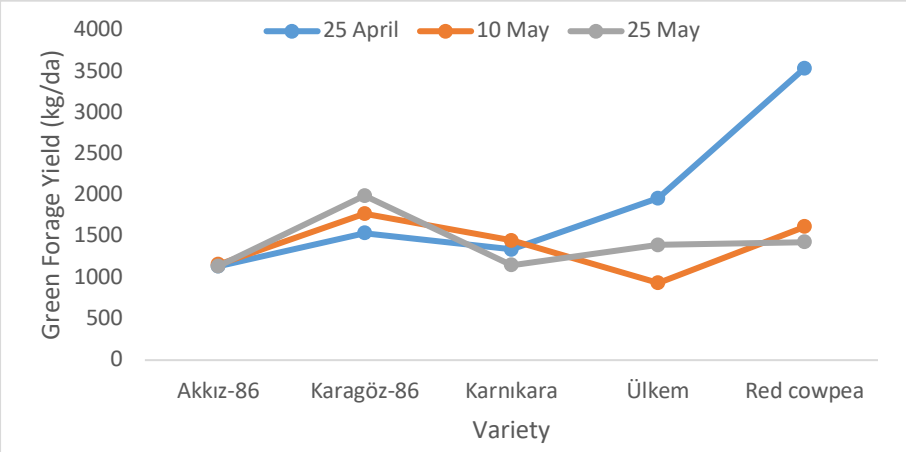

Figure 6. Effect of sowing time x variety interaction on green forage yield

3.7. Hay Yield

The effect of different sowing times on the hay yield values of the cowpea cultivars was found statistically highly significant ($p<0.01$). The mean hay yield values varied between 157 and 760 kg/da. In the groups formed for different sowing times, these values were between 366 kg/da (25 April) and 509 kg/da (25 May) The highest mean hay yield value was 570 kg/da in red cowpea, and the lowest value was 338 kg/da in Ülkem.

In studies on hay yield in cowpea plants, yield values were reported by Atış (2000) as 458-639 kg/da in Hatay, by İdikut et al. (2015) as 1228-2053 kg/da in Kahramanmaraş, by Beycioğlu (2016) as 451.40-1338.00 kg/da in Kahramanmaraş, by Alaca (2017) as 672.5 kg/daa, and by Omar (2018) as 507.09-687.77 kg/da in Samsun. İdikut et al. (2015) and Beycioğlu (2016) specified that their hay yield values were high because they harvested the plants by picking them with their roots. In previous studies investigating the cowpea as a first crop, hay yields were revealed by Jatasra et al. (1989) as 398.00-473.00 kg/da, by Thiaw et al. (1993) as 227.6-438.8 kg/da, by Boz (2006) as 148.00-476.00 kg/da, by Ayan et al. (2012) as 586-876.00 kg/da, by Etana et al. (2013) as 2.78-7.67 ton/ha in 2005 and 4.89-7.12 ton/ha in 2006, by Sallam and İbrahim (2016) as 600-1800 kg/ha, by Polat (2017) as 162.25-791.00 kg/daa, and by Ayan et al. (2017) as 978.0-1587.0 kg/da. The hay yield values that we found were similar to the values found by many researchers.

Akkız-86 variety gave the highest hay yield on 25 April and the lowest hay yield on 25 May. The highest hay yields of Karagöz-86 and red cowpea were obtained on 25 May, and the lowest hay yields were obtained from 25 April and 10 May, respectively. Karnıkara and Ülkem varieties gave

the highest hay yields on May 10, while the lowest hay yields were on April 25 (Figure 7).

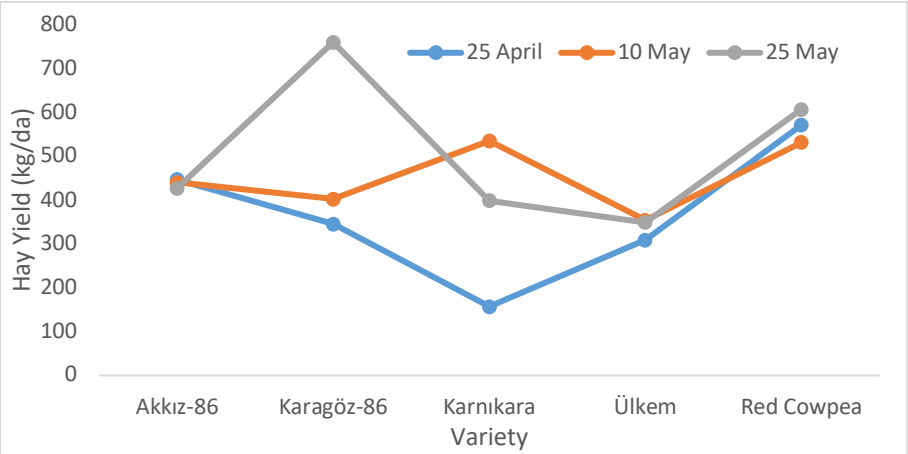

Figure 7. Effect of sowing time x variety interaction on hay yield

3.8. Crude Protein

In this study, among the cowpea cultivars, the highest crude protein ratio was found as 10.77% in the Ülkem cultivar, while the lowest crude protein ratio was found as 9.52% in the Karagöz-86 cultivar. Considering the sowing times, the highest crude protein ratio was found as 10.81% in the cultivars sown on 25 April, while the lowest crude protein ratio was found as 9.66% in the cultivars sown on 10 May. Overall, the highest value was determined to be 12.27% in the Ülkem cultivar sown on 25 April.

For the Akkız-86 cultivar, in particular, the highest and lowest crude protein ratios were found in the plants that were sown on 10 May and those that were sown on 25 May, respectively. For the Karagöz-86 cultivar, the highest and lowest crude protein ratios were obtained on 25 April and on 10 May, respectively. The highest crude protein ratios were obtained in the plants that were sown on 25 April for the Karnıkara cultivar, the Ülkem cultivar, and the red cowpea landrace. While the Karnıkara cultivar showed the lowest ratio when it was sown on 25 May, the Ülkem cultivar and the red cowpea landrace had the lowest ratios when they were sown on 10 May (Figure 8). In all plants, the crude protein ratios varied between 8.93% and 11.26%. These ratios declined as the sowing times progressed. It has been similarly reported that the crude protein ratio decreases in the further developmental phases of the plant.

Crude protein ratios in cowpea plants were reported by Jatasra et al. (1989) as 13.6-17.9%, by Boz (2006) as 25.60-28.10% in the leaves, by Gebreyowhans and Gebremeskel (2014) as 14.7-15.6%, and by Omar (2018) as 11.04-15.24%. The results of our study were similar to those revealed in some other studies.

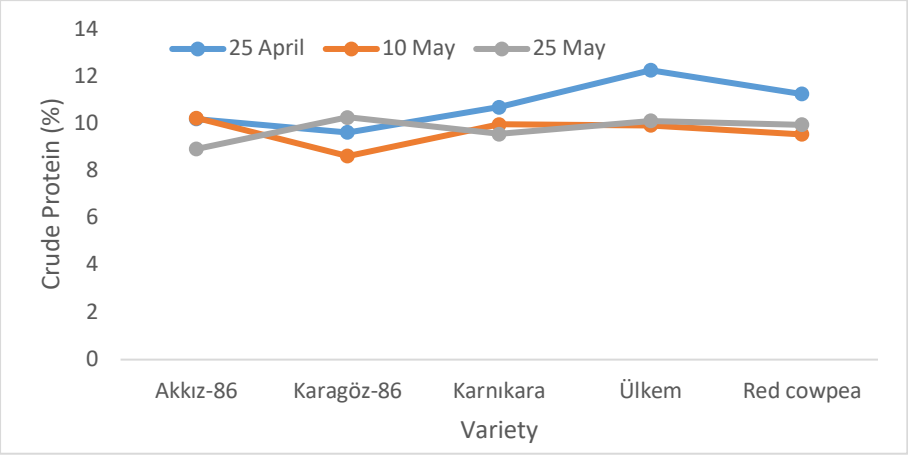

Figure 8. Effect of sowing time x variety interaction on crude protein

3.9. ADF (Acid Detergant Fiber)

According to the comparisons of different cultivars, the highest mean ADF value was 27.92% in the Ülkem cultivar, while the lowest one was 20.69% in the Akkız-86 cultivar. The ADF results of the Akkız-86 cultivar were within acceptable values. According to the comparisons of different sowing times, the highest mean ADF value was 25.03% in the cultivars sown on 10 May, while the lowest one was 23.12% in the cultivars sown on 25 May, which was determined to be acceptable. According to the results of our study, ADF ratios varied from cultivar to cultivar. Considering the sowing times, the best results were obtained in the 25 May treatment. Among all values, the best acceptable mean ADF ratio was determined as 16.48% in the Akkız-86 cultivar sown on 25 May (Table 4).

Cowpea fodder is rich in proteins (Khan *et.al.,2010*). ADF (acid detergent fiber), which contains cellulose and lignin, two of the main constituents of the cell walls in roughages, is used in feeding ruminants. In the identification of digestibility, the ADF ratio is an important criterion in roughages (Rayburn 2004).

NDF and ADF are parts of the cell wall that are very difficult to digest, and they affect feed quality negatively (Collins and Fritz 2003). It has been reported that ADF and NDF ratios in plants differ based on the developmental period of the plant, plant parts, cultivation practices, and environmental conditions (Cassida *et al.* 2000; Markovic *et al.* 2007).

In our study, the Karagöz-86 cultivar showed the highest ADF ratio when it was sown on 25 May and the lowest ADF ratio when it was sown on 25 April. The highest ADF ratios in the Akkız-86, Karnıkara, and Ülkem cultivars were obtained when they were sown on 10 May, and the highest ratio in the red cowpea landrace was obtained when it was sown on 25 April. While the lowest ADF ratios in the Akkız-86 cultivar, the Karnıkara cultivar, and the red cowpea landrace were obtained when they were sown on 25 May, the lowest ADF ratio in the Ülkem cultivar was obtained when it was sown on 25 April (Figure 9).

In studies on ADF ratios in cowpea plants, these ratios were reported by Ayan et al. (2012) as 26.50-30.20%, by Beycioğlu (2016) as 26.21-36.54%, by Ayan et al. (2017) as 25.27-34.09%, and by Omar (2018) as 20.05-28.00%. Gebreyowhans and Gebremeskel (2014) reported these ratios in the range of 47.00-57.2%.

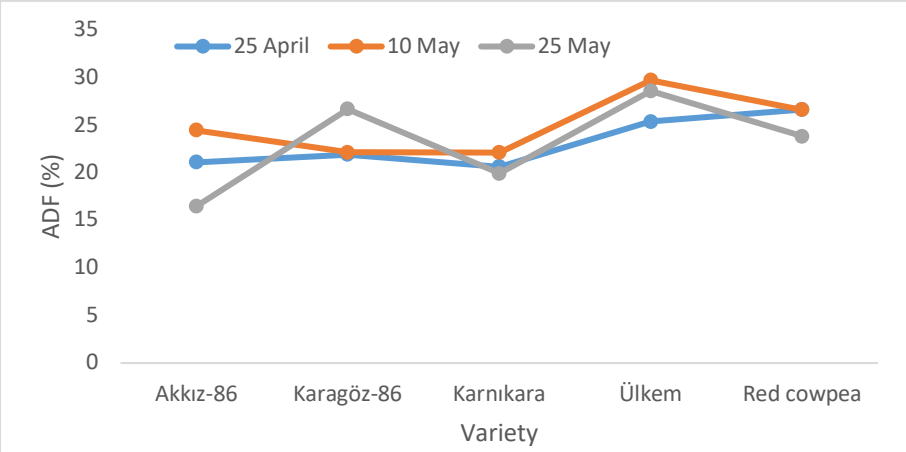

Figure 9. Effect of sowing time x variety interaction on ADF

3.10. NDF (Neutral Detergant Fiber)

According to the comparisons of different cultivars, the highest mean NDF value was 31.38% in the red cowpea landrace, while the lowest one was 26.41% in the Karnıkara cultivar. According to the comparisons of different sowing times, the highest mean NDF value was 31.33% in the cultivars sown on 10 May, while the lowest one was 27.92% in those sown on 25 April. The highest value among the genotypes was 35.90% in the red cowpea landrace. According to the results of our study, NDF ratios varied from cultivar to cultivar. Considering the sowing times, the best results were obtained in the 10 May treatment (Table 4).

The highest NDF ratios in the Akkız-86, Karnıkara, and red cowpea genotypes were obtained when they were sown on 10 May, whereas the highest ones in the Karagöz-86 and Ülkem cultivars were obtained when they were sown on 25

May. The lowest NDF ratio in the Akkız-86 cultivar was obtained when it was sown on 25 May, while these sowing times were 10 May for the Ülkem cultivar and 25 April for the Karagöz-86, Karnıkara, and red cowpea genotypes (Figure 10).

The NDF ratios that were determined in this study were lower than 41%. Studies on the topic reported NDF ratios for cowpea fodder in ranges of 24.51-42.55% (Beycioğlu, 2014), 48-55% (İdikut et al., 2015), 56.3-60.7% (Gebreyowhans and Gebremeskel, 2014), 29.43-35.62% (Ayan et al., 2017), and 24.48-36.64% (Omar, 2018).

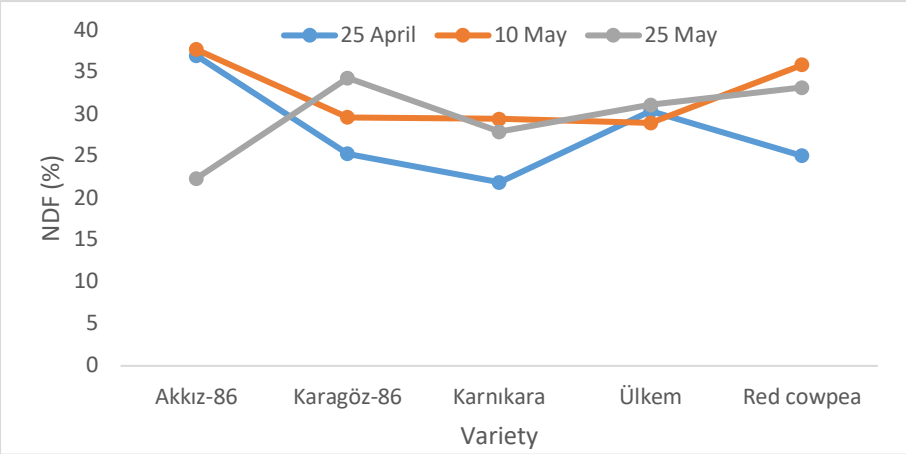

Figure 10. Effect of sowing time x variety interaction on NDF

4. Conclusions

Consequently, in this study, differences were observed in yield values and other yield-related parameters based on the sowing times and genotypes that were examined in Erzurum conditions. Accordingly, considering that the most favorable green herbage yield results were obtained in the red cowpea landrace in the 25 April treatment, the most favorable dry herbage yield results were in the red cowpea landrace in the 25 May treatment, the most favorable crude protein ratio results were in the Ülkem cultivar in the 25 April treatment, and the most favorable ADF and NDF results were respectively in the Akkız-86 and Karnıkara cultivars in the 25 May treatment, it may be stated that the Akkız-86 and Karnıkara cultivars had acceptable values, and 25 April could be preferred as the sowing time. Keeping in mind that the cowpea is a warm climate plant, it can be recommended for fodder production in the ecological conditions of Erzurum.

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