*Bulgarian Journal of Agricultural Science, 17 (No 5) 2011, 642-648*
*Agricultural Academy*

# EFFECTS OF FERTILIZATION ON FORAGE YIELD AND QUALITY OF CRESTED WHEATGRASS (*AGROPYRON CRISTATUM* L. GAERTN.)

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## Abstract

ALBAYRAK, Sebahattin and Mevlut TURK, 2011. Effects of fertilization on forage yield and quality of crested wheatgrass (*Agropyron cristatum* L. Gaertn.). *Bulg. J. Agric. Sci.,* 17: 642-648

This study aimed to determine the effects of six nitrogen rates (0, 40, 80, 120, 160 and 200 kg $ha^{-1}$) on forage yield and quality of crested wheatgrass (*Agropyron cristatum* L. Gaertn.). Dry matter (DM) yield, N, P, K, Ca, Mg, (K/Ca+Mg), NDF, ADF, TDN, DDM, DMI, RFV and $NE_1$ were determined. Nitrogen rates significantly affected most of the components determined in crested wheatgrass. Nitrogen applications increased DM yield, N, P and K contents but decreased Ca, Mg, tetany ratio, NDF and ADF. TDN, DDM, DMI, RFV and $NE_1$ increased by increasing N fertilization. The results showed that crested wheatgrass at the 160 kg $ha^{-1}$ nitrogen treatment achieved a higher forage yield and quality than other nitrogen doses.

*Key words:* crested wheatgrass, forage, dry matter, neutral detergent fiber, relative feed value

## Introduction

Crested wheatgrass (*Agropyron cristatum* L. Gaertn.), a forage plant of the *Poacea* family, is commonly used to improve the artificial and natural pastures in arid and semi-arid areas of Turkey (Acikgoz, 2001). This grass produces palatable and nutritious spring forage and withstands heavy spring grazing (Haferkamp et al., 1987). Plant nutrients are the most important, and readily manageable, variables for producing a profitable crop. Nitrogen, because of its high demand in the plant and variability within the soil, is the most intensively managed plant nutrient in crop production (Lingorski, 2000; Lingorski, 2002). Grasses need nitrogen more than many plant groups need it. Organic matter and nitrogen deficiency could be removed by fertilization in agricultural areas including dry farming in Turkey (Serin et al., 1999; Koc et al., 2004). McGinnies (1968) and Power (1985) reported that increasing N fertilization increased dry matter yield in crested wheatgrass.

The nutrient contents of the forage have an important role in animal feeding. The factors influencing the nutritive value of forage are many, and the degree to which they are interrelated may vary considerably from one area to another. These factors may include, alone or in combination, plant type, climate, season, weather, soil type and fertility, soil moisture, leaf to stem ratio, and physiological and morphological characteristics, and may change depending on whether the plants are annuals perennials, grasses or legumes (Turk et al., 2009).

The objective of this research was to determine

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the effects of different rates of nitrogen fertilizers on yield and nutritional value of crested wheatgrass.

## Materials and Methods

The research was performed at Isparta (37°45′N, 30° 33′E, altitude 1035 m) located in the Mediterranean region of Turkey, for 4 years between 2006 and 2009. The major soil characteristics, based on the method described by Rowell (1996) were as follows: the soil texture was clay-loam (clay: 31.2%, silt: 45.1%, sand: 23.7%); organic matter was 1.1% by the Walkley-Black method; total salt was 0.3%; lime was 7%; sulphur was 12 mg $kg^{-1}$; extractable P by 0.5N $NaHCO_3$ extraction was 3.3 mg $kg^{-1}$; exchangeable K by 1N $NH_4OAc$ was 119 mg $kg^{-1}$; pH was 7.1 in soil saturation extract. Soil type was a calcareous fulvisol. The climatic data are given Table 1 for the experimental area.

The experiments were evaluated in a randomized complete block design with three replications. Sowing was done by hand on 27 March in 2006. Seeding rates were 25 kg $ha^{-1}$. Plot sizes were 2.1 x 5 m = 10.5 $m^2$. Crested wheatgrass (cv. Fairway) fertilized at the rates of 0, 40, 80, 120, 160 and 200 kg N $ha^{-1}$ $year^{-1}$. Calcium ammonium nitrate 26% was used as fertilizer. Herbage was not harvested during the growing season of 2006 due to the establishment year. All plots had been harvested only once every year (50% flowering stage of crested wheatgrass). Samples taken from each plot were dried at room temperature then dried in an oven at 65°C till they reached constant weight. After cooling and weighing, the samples were ground for mineral contents analyses. Nitrogen content was calculated by the Kjeldahl method (Kacar and Inal, 2008); K, Ca and Mg contents of samples were determined using an atomic spectrophotometer after digesting the samples with $HClO_4$:$HNO_3$ (1:4); P content was determined by vanadomolybdophosphoric yellow colour method (Kacar and Inal, 2008). Tetany ratios (K: (Ca + Mg)) were calculated on a milliequivalent basis (Cherney and Marten, 1982). The ANKOM Fibre Analyser was used for NDF and ADF analysis. ANKOM F57 filter bags were used for ADF and NDF analysis in this study. Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy for lactation ($NE_l$) were estimated according to the following equations adapted from

**Table 1**

**Some climatic values of study area**

| Precipitation, L m² | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
| 2006 | 53.7 | 27.7 | 105.5 | 38.9 | 43.8 | 25.7 | 3.5 | 21 | 72.3 | 140.7 | 79.8 | 0 | 612.6 |
| 2007 | 90.2 | 42.5 | 25.8 | 25.6 | 18.6 | 25.4 | 11.4 | 10.2 | 3.1 | 30.2 | 91.1 | 84.5 | 429.1 |
| 2008 | 10 | 15 | 34.2 | 51.1 | 13.3 | 4.4 | 2.6 | 35.7 | 20.4 | 31.2 | 60.7 | 5 | 293.6 |
| 2009 | 124.7 | 70.3 | 55.2 | 40.4 | 66.6 | 26.8 | 18 | 0.2 | 26.2 | 18.1 | 51.6 | 168.6 | 666.7 |
| 1975-2008 | 64.2 | 54.9 | 52.9 | 58.8 | 46 | 27.8 | 12.8 | 12.9 | 15.4 | 38 | 51.5 | 70.9 | 506.1 |
| Temperature, °C | | | | | | | | | | | | | |
| Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
| 2006 | 0 | 2.6 | 6.7 | 11.7 | 15.7 | 21.2 | 24 | 25.5 | 18.9 | 13.3 | 6 | 2.1 | 12.31 |
| 2007 | 1.1 | 2.9 | 7 | 9.4 | 17.4 | 22.5 | 25.1 | 24.5 | 19.3 | 14.5 | 7.6 | 2.6 | 12.83 |
| 2008 | -0.1 | 1.4 | 8.9 | 12.1 | 15.4 | 21.7 | 24.5 | 25.3 | 19.4 | 12.8 | 9 | 3.7 | 12.84 |
| 2009 | 3.4 | 4 | 5.5 | 11 | 15 | 20.9 | 23.6 | 23.1 | 18 | 15.1 | 7.5 | 5.7 | 12.73 |
| 1975-2009 | 1.8 | 2.6 | 5.9 | 10.6 | 15.5 | 20.1 | 23.5 | 22.9 | 18.3 | 12.8 | 7 | 3.1 | 12.01 |

Horrocks and Vallentine (1999):

$TDN = (-1.291 \times ADF) + 101.35$,

$DMI = (120/\%NDF$, dry matter basis),

$DDM = 88.9 - (0.779 \times \%ADF$, dry matter basis),

$RFV = \%DDM \times \%DMI \times 0.775$,

**Table 2**

**Dry matter yield, N, P, K, Ca, Mg and tetany ratio of crested wheatgrass. Figures followed by same letter do not differ significantly (P<0.05)**

| Nitrogen fertilization, kg ha$^{-1}$ | DMY, kg ha$^{-1}$ | N, g kg$^{-1}$ | P, g kg$^{-1}$ | K, g kg$^{-1}$ | Ca, g kg$^{-1}$ | Mg, g kg$^{-1}$ | K/Ca+Mg ratio |
|---|---|---|---|---|---|---|---|
| 2007 | | | | | | | |
| 0 | 2617 c | 12.8 e | 3.2 c | 12.1 e | 5.60 a | 4.60 a | 1.19 e |
| 40 | 3384 b | 14.7 d | 3.6 bc | 15.4 d | 4.90 b | 4.20 b | 1.69 d |
| 80 | 3982 a | 16.0 c | 3.9 ab | 16.6 c | 4.63 bc | 3.90 c | 1.95 c |
| 120 | 4133 a | 17.2 b | 4.0 ab | 18.9 b | 4.37 cd | 3.80 cd | 2.32 b |
| 160 | 4300 a | 17.8 ab | 4.2 ab | 19.7 a | 4.17 d | 3.80 cd | 2.47 a |
| 200 | 4332 a | 18.2 a | 4.3 a | 19.9 a | 4.03 d | 3.67 d | 2.59 a |
| LSD 0.05 | 375 | 0.7 | 0.63 | 0.62 | 0.37 | 0.22 | 0.12 |
| 2008 | | | | | | | |
| 0 | 3050 f | 12.6 e | 2.9 c | 11.2 e | 4.5 a | 4.2 a | 1.29 e |
| 40 | 4067 e | 14.4 d | 3.2 bc | 15.3 d | 4.1 b | 4.1 a | 1.86 d |
| 80 | 4867 d | 15.7 c | 3.5 ab | 16.4 c | 3.8 c | 3.8 ab | 2.15 c |
| 120 | 5300 c | 16.6 b | 3.7 ab | 17.2 b | 3.6 d | 3.6 b | 2.40 b |
| 160 | 6932 a | 17.5 a | 3.9 a | 18.4 a | 3.4 de | 3.5 b | 2.67 a |
| 200 | 6533 b | 17.4 ab | 3.8 a | 18.5 a | 3.2 e | 3.4 b | 2.81 a |
| LSD 0.05 | 377 | 0.82 | 0.52 | 0.56 | 0.25 | 0.43 | 0.17 |
| 2009 | | | | | | | |
| 0 | 2933 e | 12.4 e | 2.5 d | 10.2 e | 3.6 a | 4.0 a | 1.34 e |
| 40 | 3883 d | 14.1 d | 2.9 c | 13.9 d | 3.4 a | 3.9 ab | 1.91 d |
| 80 | 4433 c | 14.9 c | 3.1 bc | 15.2 c | 3.1 b | 3.9 ab | 2.17 c |
| 120 | 4900 b | 15.6 b | 3.4 ab | 16.7 b | 2.8 c | 3.5 bc | 2.64 b |
| 160 | 5400 a | 16.8 a | 3.6 a | 17.5 a | 2.6 d | 3.4 c | 2.89 a |
| 200 | 5067 ab | 16.6 a | 3.5 a | 17.3 a | 2.4 e | 3.3 c | 3.06 a |
| LSD 0.05 | 337 | 0.57 | 0.38 | 0.52 | 0.21 | 0.43 | 0.22 |
| Average of 3 years | | | | | | | |
| 0 | 2867 f | 12.6 e | 2.87 d | 11.17 e | 4.57 a | 4.27 a | 1.27 f |
| 40 | 3778 e | 14.4 d | 3.23 c | 14.87 d | 4.13 b | 4.07 b | 1.82 e |
| 80 | 4428 d | 15.5 c | 3.50 bc | 16.07 c | 3.85 c | 3.87 c | 2.09 d |
| 120 | 4778 c | 16.5 b | 3.70 ab | 17.59 b | 3.59 d | 3.63 d | 2.45 c |
| 160 | 5544 a | 17.4 a | 3.89 a | 18.53 a | 3.39 e | 3.59 d | 2.68 b |
| 200 | 5311 b | 17.4 a | 3.87 a | 18.57 a | 3.20 f | 3.46 d | 2.82 a |
| LSD 0.05 | 192 | 0.37 | 0.28 | 0.3 | 0.15 | 0.2 | 0.09 |

$NE_1 = (1.044 – (0.0119 x \%ADF) x 2.205$

Data were analyzed using the standard analysis of variance (ANOVA) technique and means were separated using the comparisons based upon the least significant difference (LSD) using the SAS statistical analysis package (SAS, Institute, Inc., Cary, NC, 1998). Regression analysis was conducted using the PROC REG statement in SAS.

## Results

The results of variance analysis showed that the effects nitrogen rates were significant except NDF concentrations in 2008 and 2009 years (Tables 2 and 3). Years were shown separately, because differences of years were significant all parameters of crested wheatgrass. Linear, quadratic and cubic effects were shown for nitrogen treatments in Table 4. For all three years, there was significant effect of nitrogen fertilizer applications on dry matter yield ($P < 0.01$) (Table 2). Generally, the highest yield was obtained by the N160 treatment except the first year. The lowest yield was observed in the controls. Concentration of N, P and K and K/Ca+Mg ratio increased linearly ($P<0.01$) by increasing N fertilization rates. However, concentrations of Ca, Mg, NDF and ADF decreased linearly ($P<0.01$) by increasing N fertilization rates. Generally, increasing N fertilization rates resulted in an increase in TDN, DDM, DMI, RFV and $NE_1$ values (Tables 2, 3 and 4).

## Discussion

The effects of fertilizer applications on dry matter production were significant. Over the mean of the three years, dry matter yield ranged from 3778 to 5544 kg ha$^{-1}$ in the plots treated with N (Table 2). Dry matter production in the control plot was 2867 kg ha$^{-1}$, and nitrogen application increased the dry matter production of the plots by about 93% in the present study. Increases in N fertilizer resulted in a linear increase (DMY = 3174.3 + 127.7N [N is kg ha$^{-1}$]) in dry matter yield. However, in average of three years, 160 kg ha$^{-1}$ N treatment is same statistical group with 200 kg ha$^{-1}$ N treatment for DMY (Table 4).

Lauriault et al. (2002) reported that N is the most important fertilizer nutrient required for growing grasses. Increase in DMY due to N application is well documented by many authors (Power, 1986; Hall et al., 2003; Scarbrough et al., 2004). Nitrogen content of forage is one of the most important criteria for forage quality evaluation (Holechek et al., 1989; Vogel et al., 1993). Increasing N fertilization rates resulted in an increase in N concentration of crested wheatgrass (Table 2). Nitrogen treatments (160 and 200 kg ha$^{-1}$) had the highest N contents (17.4 g kg$^{-1}$) followed by the 120 kg ha$^{-1}$ nitrogen dose (16.5 g kg$^{-1}$). These results are in agreement with those reported by Jacobsen et al. (1996) and McCaughey and Simons (1998).

Nitrogen treatments significantly increased P and K concentration while they decreased Ca and Mg content. Kidambi et al. (1989) reported that both Ca and Mg had negative association with K in grasses. Tetany (K+Ca+Mg) is associated with Mg deficiency in the blood. There is an antagonistic relationship between K and Mg. The decreased production or mortality in livestock given feeds which are rich in K is due to the fact that Mg is blocked. The threshold for risk of tetany increases at K: (Ca + Mg) ratio of 2.2 or higher (Elkins et al., 1977). Tetany values changed from 1.19 to 2.59 with increasing N rates. This change resulted from the increase in the K content and decrease of the Ca and Mg contents with nitrogen fertilization.

Other important quality characteristics for forages are the concentrations of NDF and ADF (Haferkamp et al., 1987; Karn et al., 2006). In present study, increasing nitrogen treatments decrease NDF and concentrations. Control plot had higher NDF and ADF concentrations than nitrogen doses. Nitrogen fertilization treatments had higher TDN than control plots. Increasing nitrogen fertilization increased TDN. The TDN

**Table 3**
**NDF, ADF, TTD, DDM, DMI, RFV and NE1 contents of crested wheatgrass. Figures followed by same letter do not differ significantly (P<0.05)**

| Nitrogen fertilization, kg ha$^{-1}$ | NDF, g kg$^{-1}$ | ADF, g kg$^{-1}$ | TDN, g kg$^{-1}$ | DDM, g kg$^{-1}$ | DMI, g kg$^{-1}$ of body weight | RFV, % | $NE_{1,}$ Mcal kg$^{-1}$ |
|---|---|---|---|---|---|---|---|
| 2007 | | | | | | | |
| 0 | 606 a | 347 a | 565 c | 619 c | 19.8 d | 95.2 d | 1.39 c |
| 40 | 583 b | 324 b | 595 b | 636 b | 20.59 c | 101.7 c | 1.45 b |
| 80 | 577 bc | 313 bc | 609 ab | 645 ab | 20.80 bc | 104.0 bc | 1.48 ab |
| 120 | 565 cd | 307 bc | 617 ab | 650 ab | 21.26 ab | 107.1 ab | 1.50 ab |
| 160 | 562 cd | 302 c | 624 a | 654 ab | 21.39 a | 108.4 a | 1.51 a |
| 200 | 554 d | 299 c | 628 a | 656 a | 21.67 a | 110.2 a | 1.52 a |
| LSD 0.05 | 16.27 | 19.93 | 25.7 | 15.5 | 0.57 | 4.36 | 0.06 |
| 2008 | | | | | | | |
| 0 | 628 | 366 a | 541 c | 604 c | 19.2 | 89.8 | 1.34 c |
| 40 | 609 | 342 ab | 572 bc | 623 bc | 19.7 | 95.3 | 1.40 bc |
| 80 | 596 | 326 bc | 593 ab | 635 ab | 20.1 | 99.1 | 1.45 ab |
| 120 | 580 | 318 bc | 603 ab | 641 ab | 20.7 | 102.7 | 1.47 ab |
| 160 | 578 | 306 c | 619 a | 651 a | 20.8 | 104.7 | 1.50 a |
| 200 | 581 | 317 bc | 604 ab | 642 ab | 20.7 | 102.9 | 1.47 ab |
| LSD 0.05 | 47.4 | 35.7 | 46.1 | 27.8 | 1.54 | 10.8 | 0.1 |
| 2009 | | | | | | | |
| 0 | 644 | 378 a | 526 d | 595 d | 18.6 | 85.8 c | 1.31 d |
| 40 | 616 | 355 b | 555 c | 612 c | 19.5 | 92.7 bc | 1.37 c |
| 80 | 602 | 339 bc | 576 bc | 625 bc | 19.9 | 96.6 ab | 1.41 bc |
| 120 | 596 | 327 cd | 591 ab | 634 ab | 20.1 | 99.1 ab | 1.44 ab |
| 160 | 587 | 312 d | 611 a | 646 a | 20.5 | 102.3 a | 1.48 a |
| 200 | 592 | 324 cd | 595 ab | 637 ab | 20.3 | 100.1 ab | 1.45 ab |
| LSD 0.05 | 45.8 | 16.3 | 21 | 12.7 | 1.47 | 7.39 | 0.04 |
| Average of 3 years | | | | | | | |
| 0 | 626 a | 364 a | 544 d | 606 d | 19.2 c | 90.3 d | 1.35 d |
| 40 | 603 b | 340 b | 574 c | 624 c | 19.9 b | 96.6 c | 1.41 c |
| 80 | 592 bc | 326 c | 593 b | 635 b | 20.3 ab | 99.9 bc | 1.45 b |
| 120 | 581 c | 317 cd | 604 ab | 642 ab | 20.7 a | 103.0 ab | 1.47 ab |
| 160 | 576 c | 307 d | 618 a | 650 a | 20.9 a | 105.2 a | 1.50 a |
| 200 | 576 c | 313 cd | 609 ab | 645 ab | 20.9 a | 104.4 a | 1.48 ab |
| LSD 0.05 | 20.8 | 13.5 | 17.4 | 10.5 | 0.67 | 4.23 | 0.04 |

refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage. As ADF increases there is a decline in TDN which means that animals are not able to

**Table 4**
**Probability levels and coefficients of determination of crested wheatgrass yield and quality parameters**

| Quality variables | Linear | Quadratic | Cubic | Linear | Quadratic | Cubic |
|---|---|---|---|---|---|---|
| DMY | ** | * | ns | 0.59 | 0.64 | 0.64 |
| N | ** | ** | ns | 0.84 | 0.9 | 0.9 |
| P | ** | * | ns | 0.45 | 0.49 | 0.49 |
| K | ** | ** | ns | 0.78 | 0.89 | 0.89 |
| Ca | ** | ns | ns | 0.29 | 0.3 | 0.3 |
| Mg | ** | ns | ns | 0.56 | 0.58 | 0.58 |
| K/Ca+Mg | ** | ** | ns | 0.88 | 0.91 | 0.91 |
| NDF | ** | * | ns | 0.33 | 0.38 | 0.38 |
| ADF | ** | ** | ns | 0.45 | 0.52 | 0.52 |
| TDN | ** | ** | ns | 0.45 | 0.52 | 0.52 |
| DDM | ** | ** | ns | 0.45 | 0.52 | 0.52 |
| DMI | * | ns | ns | 0.33 | 0.37 | 0.37 |
| RFV | ** | * | ns | 0.42 | 0.47 | 0.47 |
| $NE_1$ | ** | ** | ns | 0.45 | 0.52 | 0.52 |

utilize the nutrients that are present in the forage (Lithourgidis et al., 2006). The lowest values for TDN increased wheatgrass are attributed to the high amount of ADF (Table 3).

In present study, increasing nitrogen treatments resulted in an increase in DDM and DMI values. The NDF is used to predict DMI and is negatively correlated with DMI, which means that when NDF is high the quality and the DMI are low (Horrocks and Vallentine, 1999). A similar trend was observed for the RFV and the NE. The RFV was much higher in fertilized crested wheatgrass than in crested wheatgrass control plot (Table 3). The RFV is an index that is used to predict the intake and energy value of the forages and it is derived from the DDM and DMI. Forage with an RFV value >151 is considered prime (Horrocks and Vallentine, 1999). The RFV of crested wheatgrass in the present study was recorded as good hay quality at the 120, 160 and 200 kg ha$^{-1}$ nitrogen treatments, but was fair for the control plot, and 40 and 80 kg ha$^{-1}$ nitrogen treatments, according to Linn and Martin (1999). Nitrogen fertilization treatments affected NE in crested wheatgrass. Increasing nitrogen treatments increased in $NE_1$ value (Table 3).

## Conclusion

The results of this study clearly indicate dry matter yield was higher in 160 and 200 kg ha$^{-1}$ nitrogen treatments compared with 40, 80, 120 kg ha$^{-1}$ nitrogen treatments and control plots. The highest N was obtained from 160 kg ha$^{-1}$ N rates. The highest P content was obtained from 160 and 200 kg ha$^{-1}$ N rates, while the highest K content was obtained from the control plot. As N rate increased from 0 to 200 kg ha$^{-1}$, ADF, NDF, TDN, DDM and DMI decreased. The highest RFV and $NE_1$ were obtained from 120-200 kg ha$^{-1}$ nitrogen treatments. At the end of the 4-year research conducted in Mediterranean conditions of Turkey, 160 kg ha$^{-1}$ nitrogen fertilizer is recommended for high herbage quality in crested wheatgrass.

## References


**Acikgoz, E.,** 2001. Yem Bitkileri. Uludag Universitesi Guclendirme Vakfı Yayin No: 182. Vipas AS Yayin No: 58. 584pp. (Tr).

**Cherney, J. H. and G. C. Marten,** 1982. Small grain crop forage potential: I. Biological and chemical determinants of quality and yield. *Crop Science*, **22:** 227-231.

**Elkins, C. B., R. L. Haaland and C. S. Honeland,** 1977. Tetany potential of forage species as affected by soil oxygen. Proceedings of the XIII International Grassland Congress, 18-21 May. Pp. 1505-1507.

**Hall, M. H., D. B. Beegle, R. S. Bowersox and R. C. Stout,** 2003. Optimum nitrogen fertilization of cool-season grasses in the northeast USA. *Agronomy Journal,* **95:** 1023-1027.

**Haferkamp, M. R., R. F. Miller and F. A. Sneva,** 1987. Mefluidide effects on forage quality of crested wheatgrass. *Agronomy Journal,* **79**: 637-641.

**Holechek, J. L., R. E. Estell, C. B. Kuykendall, R. Valdez, M. Cardenas and C. N. Hernandez,** 1989. Seeded wheatgrass yield and nutritive quality on New Mexico big sagebrush range. *Journal of Range Management,* **42:** 118-122.

**Horrocks, R. D. and J. F. Vallentine,** 1999. Harvested Forages. *Academic Press*, London, UK.

**Jacobsen, J. S., S. H. Lorbeer, H. A. R. Houlton and G. R. Carlson,** Nitrogen fertilization of dry land grasses in the Northern Great Plains. *Journal of Range Management,* **49:** 340-345.

**Kacar, B. and A. Inal,** 2008. Bitki Analizleri. *Nobel Yayınları* . Ankara, 892pp. (in Turkish).

**Karn, J. F., J. D. Berdahl and A. B. Frank,** 2006. Nutritive quality of four perennial grasses as affected by species, cultivar, maturity, and plant tissue. *Agronomy Journal,* **98:** 1400-1409.

**Kidambi, S. P., A. G. Matches and T. C. Gricgs,** 1989. Variability for Ca, Mg, K, Cu, Zn, and K/(Ca +Mg) ratio among 3 wheat grasses and sainfoin on the southern high plains. *Journal of Range Management,* **42:** 316-322.

**Koç, A., A. Gokkus, M. Tan, B. Comakli and Y. Serin,** 2004. Performance of tall fescue and lucerne-tall fescue mixtures in highlands of Turkey. *New Zealand J. of Agric. Research,* **47:** 61-65.

**Lauriault, M. L., R. E. Kirksey and G. B. Donart,** 2002. Irrigation and nitrogen effects on tall wheatgrass yield in the southern high plains**.** *Agronomy Journal,* **94:** 792-797.

**Lingorski, V.,** 2000. Effect of leaf fertilizer Lactofol O on some bioproductive indices of cocksfoot (*Dactylis glomerata* L.) monoculture. *Bulg. J. Agric. Sci*., **6:** 651-654.

**Lingorski, V.,** 2002. Yields and botanical composition of smooth bromegrass (*Bromus inermis* Leyss.) after leaf fertilization. *Bulg. J. Agric. Sci.*, **8:** 377–380.

**Linn, J. G. and N. P. Martin,** 1999. Forage quality tests and interpretations. Univ. of Minnesota Ext. Ser. Publ. FO-02637, Univ. of Minnesota, St. Paul.

**Lithourgidis, A. S., I. B. Vasilakoglou, K. V. Dhima, C. A. Dordas and M. D. Yiakoulaki,** 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. *Field Crops Research,* **99:** 106-113.

**McCaughey, W. P. and R. G. Simons,** 1998. Harvest management and N-fertilization effects on protein yield, protein content and nitrogen use efficiency of smooth bromegrass, crested wheatgrass and meadow bromegrass. *Canadian Journal of Plant Science,* **78:** 281-287.

**McGinnies, J. W.,** 1968. Effects of nitrogen fertilizer on an old stand of crested wheatgrass. *Agronomy Journal,* **60:** 560-562.

**Power, J. F.,** 1986. Nitrogen cycling in seven cool-season perennial grass species. *Agronomy Journal,* **78:** 681-687.

**Power, J. F.,** 1985. Nitrogen and water-use efficiency of several cool-season grasses receiving ammonium nitrate for 9 years. *Agronomy Journal,* **77***:* 189-192.

**Rowell, D. R.,** 1996. Soil science: methods and applications. Harlow, Longman.

**SAS Institute**, 1998. INC SAS/STAT users guide release 7.0. Cary, NC, USA.

**Scarbrough, D. A., W. K. Coblentz, K. P. Coffey, K. F. Harrison, T. F. Smith, D. S. Hubbell, J. B. Humphry III, Z. B. Johnson and J. E. Turner,** 2004. Effects of nitrogen fertilization rate, stockpiling initiation date, and harvest date on canopy height and dry matter yield of autumnstockpiled bermudagrass. *Agronomy Journal,* **96:** 538-546.

**Serin, Y., M. Tan, A. Koc and A. Gokkus,** 1999. The effect of n applied at different seasons and doses on seed yield and some yield components of smooth bromegrass (*Bromus inermis* Leyss.) and relationships among the characteristics. *Turkish J. of Agric. and Forestry,* **23:** 257-264.

**Turk, M., S. Albayrak and O. Yuksel,** 2009. Effects of fertilisation and harvesting stages on forage yield and quality of hairy vetch. *New Zealand J. of Agric. Research,* **52:** 269-275.

**Vogel, K. P., B. C. Gabrielsen, J. K. Ward, B. E. Anderson, H. F. Mayland and R. A. Masters,** 1993. Forage quality, mineral constituents, and performance of beef yearlings grazing two crested wheatgrasses. *Agronomy Journal,* **85:** 584-590.


*Received May, 11, 2010; accepted for printing June, 9, 2011.*