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# FORAGE POTENTIAL OF SOME GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS

**Yaşar Özyiğit*, Mehmet Bilgen**

Akdeniz University, Faculty of Agriculture, Department of Field Crops, Antalya/Türkiye.
*E-mail: ozyigit@akdeniz.edu.tr

## ABSTRACT

**This study was carried out to determine haulm forage capacity of some groundnut genotypes in Antalya/Türkiye climatic conditions for two years (2006 and 2007). Five groundnut cultivars (Gazipaşa, Çom, Florispan, NC-7, Batem-5025) and one groundnut line (PI-355276) were studied. The trial was laid out in randomized complete block design with three replicates. According to results of the study there were statistically significant differences ($p<0.05$) in green fodder yield (GFY, kg. ha$^{-1}$), dry fodder yield (GFY, kg. ha$^{-1}$), dry matter ratio (DMR, %), leaf/stem ratio (L/SR), dry pod yield (DPY, kg. ha$^{-1}$) and haulm crude protein ratio (CPR, %) among the groundnut genotypes. Leaf dry matter ratio (%) and stem dry matter ratio (%) were also determined in this study. The highest green fodder yield (38760 kg. ha$^{-1}$) and dry pod yield (3150 kg. ha$^{-1}$) were obtained from PI-355276 line. The PI-355276 line also had the highest dry haulm yield, of 9320 kg. ha$^{-1}$. The highest crude protein ratio was obtained in Batem-5025 and Gazipaşa with 12.28% and 12.19%, respectively. According to correlation analysis, there were significant relationships between forage matter (GFY and DFY) and dry pods yields of genotypes. Results of this study showed that PI-355276 line produced the highest forage and pod yields, and therefore it is suitable in Mediterranean conditions.**

**Keywords**: groundnut, haulm, forage, crude protein.

## INTRODUCTION

World population has increased rapidly in recent years and it has reached today about 7 billion (Anonymous, 2011a). Depending on population growth rate, the nutritional needs of people have increased, so more production is needed. For this reason, the remaining parts of the agriculture products have to be used for different purposes, to provide more benefits per unit area. The residues of plants grown for different purposes (oil, grain, etc.) are often used as animal feed (Onwuka et al., 1997; Ngwa and Tawah, 2002; Syamsu, 2008).

The stovers from cereals have low nitrogen and high fibre contents and poor digestibility, and therefore have low nutritive value, while the stover from legumes are of high nutritional quality (Singh et al., 2004). Especially, leaves of legume crops can provide good quality forage material in farms. Crop residues of groundnut (*Arachis hypogaea* L.) provide important feed resources for livestock production (Pande et al., 2003; Bdliya, 2007).

Groundnut (*Arachis hypogaea* L.), also known as peanut, is an annual legume and it is important in human nutrition, due to its high protein and energy content. In addition to the seed, peanut plants produce high-protein forage that has long been used as ruminant feed (Garduno-Lugo and Olvera-Novoa, 2008). It is cultivated in 109 countries, in tropical, sub-tropical, and warm temperate regions of the world (Upadhyaya et al., 2006). Currently, the major groundnut-producing countries are China, India, Indonesia, Myanmar, and Vietnam in Asia; Nigeria, Sudan, Democratic Republic of Congo, Chad, Mozambique, Zimbabwe, Burkina Faso, Uganda, and Mali in Africa; the U.S.; and Argentina, Brazil, and Mexico in Central and South America (Liao and Holbrook, 2007). Annual groundnuts production (with shell) of the world is around 35.5 million tonnes from the 23.5 million ha of production area.

In Turkey, annual groundnut production is 90.000 tonnes and production area is 25.5 thousand ha (FAO, 2009). It is grown primarily for high quality edible oil and easily digestible protein in its seeds (Upadhyaya et

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al., 2006). Also different parts of the groundnut can be utilized for different purposes, such as, groundnuts leaves, which provide good-quality roughage after the crops was harvested.

Groundnut haulms constitute approximately 45% of the total plant biomass and provide excellent forage for livestock in many regions. Haulms are rich in protein and more palatable than many other fodders (Liao and Holbrook, 2007). Groundnut haulm is a nutritious feed for livestock and it contains protein (8-15%), lipids (1-3%), minerals (9-17%), and carbohydrates (38-45%) at levels higher than cereal fodder. The digestibility of nutrients in groundnut haulm for animals is around 53% and that of crude protein is 88%. Haulms release an energy up to 2.337 cal $kg^{-1}$ of dry matter (Singh and Diwakar, 1993). Groundnut haulm provides the most easily available roughage alternative to maize stover, although it is more limited in supply, because the amount grown locally is much smaller than that of maize. Groundnut haulm has a similar energy value to maize stover but is higher in protein (Addy and Thomas, 1977).

There is limited research on the forage utilization of groundnut haulm by ruminant livestock. The current study was therefore carried out to determine yield characteristics and protein level of groundnut haulm in several genotypes.

## MATERIALS AND METHODS

This study was carried out in 2006 and 2007 years in Antalya-Turkey (Latitude 36°15'N longitude 31°30'E and altitude 20 m above the sea level). The soil properties of experiment area are: alkaline, loamy, strong limy and having sufficient organic matter. Monthly precipitation, mean temperature and humidity data of Antalya in 2006 and 2007 are summarized in Table 1.

The plant material consisted of five groundnut cultivars (Batem-5025, Gazipaşa, Çom, Florispan and NC-7) and one groundnut line (PI-355276). The cultivars and the line were provided from Bati Akdeniz Agriculture Research Institute (BATEM) in Antalya/Turkey.

*Table 1.* Temperature, humidity and precipitation data of Antalya in 2006 and 2007 years

| Days | Temperature (°C ) | | Humidity (%) | | Precipitation ($l.m^{-2}$) | |
|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| May | 21.0 | 21.7 | 64.2 | 69.4 | 12.3 | 5.2 |
| June | 25.9 | 27.2 | 57.9 | 55.7 | 21.9 | 1.4 |
| July | 28.8 | 29.7 | 55.6 | 54.2 | 0.3 | 0.2 |
| August | 28.8 | 29.0 | 66.9 | 68.1 | 3.4 | 1.0 |
| September | 24.9 | 26.3 | 60.8 | 52.0 | 29.9 | 0.0 |
| October | 19.6 | 22.8 | 68.5 | 55.2 | 494.7 | 16.6 |

The experiment was conducted as a randomised complete block design with three replicates. Plot size was 15 $m^2$ (3 x 5 m) with a 1.5 m buffer between plots and replications. Seeds were sown by hand in lines which were made with hand marker. Row spacing and intra-row spacing were 75 cm and 20 cm, respectively. At the time of sowing, Ammonium nitrate was used as the source of 50 kg $ha^{-1}$ nitrogen and Di-ammonium phosphate (DAP) was used as the source of 80 kg $ha^{-1}$ phosphorus. First irrigation was made with sprinkler irrigation systems and basin irrigation was used when plants reached sufficient length. Two weeding controls were done by the use of hand hoe.

Harvest was done with hand at the pod maturity phase, when vine began to turn yellow and leaf shedding started (Anonymous, 2011b). Peanut pods were removed from the plants and fresh materials (without pods) were weighed in the field and determined fresh fodder yield ($kg.ha^{-1}$). 500 g of above ground materials (leaf + stem) were dried in an oven at 80°C for 48 h (Dzomeku et al., 2009) to determine dry matter ratio (%) and dry fodder yield ($kg.ha^{-1}$). Pods dried in sun for a week were weighed to determine pod yield ($kg.ha^{-1}$).

Leaves and stems were separated to determine leaf/stem ratio in five plants from each plots and they were dried separately at 80°C for 48 h. Total nitrogen was analysed according to the Kjeldahl method in dried samples and crude protein content (%) was calculated by multiplying total N by 6.25 (Blümmel et al., 2005a). Data were analysed with the SAS statistical program and Duncan Multiple Range Test (DMRT) was used for comparison of means.

## RESULT AND DISCUSSIONS

Results of the variance analysis indicated that there were significant differences among genotypes for green fodder yield, dry fodder yield, dry matter ratio, dry pod yield and haulm crude protein ratio at $p<0.01$ and for leaf/stem ratio at $p<0.05$ level of probability (Table 2).

*Table 2.* Analysis of variance different characteristics

| | | Green fodder yield | | Dry fodder yield | | Dry matter ratio | | Leaf/stem ratio | |
|---|---|---|---|---|---|---|---|---|---|
| Source | DF | Mean Square | F Value | Mean Square | F Value | Mean Square | F Value | Mean Square | F Value |
| Blocks | 2 | 899007.75 | 8.18 | 49225.5 | 13.52 | 5.29 | 1.47 | 0.0001 | 0.00 |
| Cultivar | 5 | 2256879.33 | 20.53** | 76322.5 | 20.97** | 21.56 | 6.00** | 0.0922 | 3.54* |
| Bloc.*Cult. | 10 | 715739.28 | 6.51** | 29999.9 | 8.24** | 4.08 | 1.14 | 0.0340 | 1.31 |
| Year | 1 | 5377.78 | 0.05 | 13417.3 | 3.69 | 19.15 | 5.33* | 0.0667 | 2.56 |
| Cult.*Year | 5 | 171642.18 | 1.56 | 9949.8 | 2.73 | 1.20 | 0.34 | 0.0942 | 3.62 |
| | | Leaf dry matter ratio (%) | | Stem dry matter ratio (%) | | Dry pod yield (kg.da$^{-1}$) | | Haulm crude protein ratio (%) | |
| Source | DF | Mean Square | F Value | Mean Square | F Value | Mean Square | F Value | Mean Square | F Value |
| Blocks | 2 | 5.129 | 2.00 | 8.595 | 1.75 | 712.44 | 03.29 | 2.263 | 1.27 |
| Cultivar | 5 | 6.599 | 2.58 | 11.297 | 2.29 | 20063.84 | 92.58** | 11.548 | 6.50** |
| Bloc.*Cult. | 10 | 2.892 | 1.13 | 8.939 | 1.82 | 3362.17 | 15.51** | 0.976 | 0.55 |
| Year | 1 | 3.648 | 1.42 | 0.288 | 0.06 | 2240.44 | 10.34** | 8.477 | 4.77* |
| Cult.*Year | 5 | 4.755 | 1.86 | 9.408 | 1.91 | 1905.77 | 8.79** | 4.722 | 2.66 |

* Effects are significant at 0.05 level of probability,
** Effects are significant at 0.01 level of probability

However, significant differences were not observed (at $p>0.05$) for years and for cultivars*years interaction (except for dry pod yield).

Duncan groups of the results are shown in Table 3. According to results, green fodder yield ranged from 24060 to 38760 kg.ha$^{-1}$. The highest green fodder yield was obtained from PI-355276 line with 38760 kg.ha$^{-1}$. Also PI-355276 line produced a high dry fodder yield of 9320 kg.ha$^{-1}$. Çalışkan et al. (2000) reported the number of branches of several varieties, and PI-355276 line had high plant height and number of primary and secondary branches. The same results were observed in our field observations. This situation may explain the high haulm yield of PI-355276.

In contrast to the results of haulms yield, lowest dry matter ratio was determined in PI-355276. While other cultivars produced results close to each other, the highest dry matter ratio was obtained from Florispan with 29.63%. Florispan cultivar has an erect habitus and this trait provides that leaves intercept much more sunlight in comparison to oblate and semi-oblate cultivars. Rate of the crop dry matter is a result of accumulated daily carbon gains from photosynthesis (Shuting et al., 1993). Cechin and Fumis (2004) reported that higher rates of photosynthesis were accompanied by an increase in dry matter. As well known, in plant production, the value of dry matter refers to the accumulation of photosynthetic and especially structural savings. Therefore it symbolizes a healthier and more stable character than fresh forage yield which contains water (Geren et al., 2002).

*Table 3*. Data of forage characteristics and Duncan groups in groundnut genotypes (mean of two years)

| Cultivars or line | Green fodder yield (kg.ha$^{-1}$) | Dry fodder yield (kg.ha$^{-1}$) | Dry matter ratio (%) | Leaf/stem ratio | Leaf dry matter ratio (%) | Stem dry matter ratio (%) | Dry pod yield (kg.ha$^{-1}$) | Haulm crude protein ratio (%) |
|---|---|---|---|---|---|---|---|---|
| Batem-5025 | 24500 C | 6980 B | 28.49 A | 1.16 C | 27.10 A | 28.81 AB | 2370 B | 12.28 A |
| NC-7 | 24150 C | 6890 B | 28.71 A | 1.22 BC | 27.13 A | 29.07 A | 2130 C | 9.89 BC |
| Florispan | 24060 C | 7090 B | 29.63 A | 1.31 ABC | 26.15 AB | 29.64 A | 1360 D | 8.75 C |
| Gazipaşa | 32920 B | 8980 A | 27.82 A | 1.43 AB | 27.01 A | 29.41 A | 2340 B | 12.19 A |
| Çom | 32220 B | 8740 A | 27.33 A | 1.49 A | 26.00 AB | 28.19 AB | 2510 B | 10.04 BC |
| PI-355276 | 38760 A | 9320 A | 24.17 B | 1.28 BC | 24.42 B | 25.90 B | 3150 A | 10.79 AB |
| LSD | 417.13 | 758.95 | 2.3836 | 0.203 | 2.0131 | 2.7911 | 185.19 | 1.6768 |

Mean differences with different letters within the same column are statistically significant ($P<0.05$)

Leaf/stem ratio of forage crops is an important factor affecting diet selection, quality, and intake of forages (Smart et al., 2001), because leaves have usually higher nutrient quality (for example crude protein) than stems (Bakoglu et al., 1999). In this study, there were significant differences among cultivars in leaf/stem ratio. While values ranged from 1.16 to 1.49, highest leaf/stem ratio was observed in the Çom cultivar with 1.49. According to our results, all cultivars and the line had leaf/stem ratio higher than 1. This shows that leaf quantity of groundnut is higher than stems quantity. Neucere and Godshall (1979) reported that fresh leaves of groundnut contained 42.2% carbohydrate, 25.4% ash, 18.0% protein, 8.8% fat, 4.6% moisture, and 0.8% fibre. Leaves were less variable in the parameters of nutritive value than stems in groundnut (Reed, 1991). Also the same scientist reported that, groundnut leaves had a high content of N and a moderate amount of NDF and high *in vitro* dry matter digestibility.

Values of leaf dry and stem dry matter ratios varied from 24.42% to 27.13% for leaf dry matter and from 25.90% to 29.64% for stem dry matter, but differences among cultivars were not significant. Leaf dry matter content (LDMC) is widely used as an indicator of plant resource use in plant functional trait databases (Vaieretti et al., 2007).

In an unarguable and undisputed manner, pods are the most important organ of groundnut, because pods are used to produce many products (oil, cake, flour, animal feed). Also groundnut seeds are a rich source of protein, minerals (Ca, Mg, P, and K), and vitamins (E, K, and B1) (Savage and Keenan, 1994). Pod yield did significantly vary among groundnut cultivars in this study. While the highest pod yield was obtained from PI-355276 line (3150 kg.ha$^{-1}$), the cultivars Gazipaşa, Çom and Batem-5025 had similar pod yields. Çalışkan et al. (2000) reported that pod yields of PI-355276, NC-7 and Çom were 3001, 3032 and 2312 kg.ha$^{-1}$ respectively in Hatay district. Their results are similar to our results, especially for PI-355276 and Çom. Lowest pod yield was determined in Florispan with 1360 kg.ha$^{-1}$. This may be explainable by the fact that Florispan is an oil cultivar with a kernel that is smaller than other cultivars (Canavar and Kaynak, 2010).

The results showed that there were significant differences in crude protein ratio among genotypes. While the highest protein ratios were determined in Batem-5025 and Gazipaşa with 12.28% and 12.19% respectively, Florispan had the lowest crude protein ratio with 8.75%. Crude protein content of forage is one of the most important criteria for forage quality evaluation (Aydın et al., 2010). In this study, crude protein ratio of all genotypes was found to be within the limits of the formerly reported studies (Shukla et al., 1985; Sing and Diwakar, 1993; Savodogo et al., 2000).

A correlation analysis was conducted to determine the relationships among the variables. The results of the analysis are shown in Table 4. A highly positive correlation was observed between GFY and DFY (0.96, significant at P<0.01 level), between GFY and DPY (0.72, significant at P<0.01 level), while a negative correlation existed between GFY and DMR (-0.76, significant at P<0.01 level), between GFY and LDMR (-0.51, significant at P<0.01 level). There were negative and significant but weaker correlations between GFY and SDMR (-0.33, significant at P<0.05 level).

*Table 4.* Correlation coefficients between forage characteristics

| | GFY | DFY | DMR | L/SR | LDMR | SDMR | DPY |
|---|---|---|---|---|---|---|---|
| DFY | 0.95935** | | | | | | |
| DMR | -0.76902** | -0.56899** | | | | | |
| L/SR | 0.00841 | 0.04214 | -0.00771 | | | | |
| LDMR | -0.51813** | -0.40973* | 0.60649** | 0.07074 | | | |
| SDMR | -0.33686* | -0.24292 | 0.45900** | -0.27371 | 0.53580** | | |
| DPY | 0.72441** | 0.64178** | -0.66293** | -0.07112 | -0.35473* | -0.42305* | |
| CPR | 0.18563 | 0.18354 | -0.19019 | -0.03667 | -0.15683 | -0.07740 | 0.29160 |

* Correlations are significant at 0.05 level of probability.
** Correlations are significant at 0.01 level of probability.

Forage matter (GFY and DFY) and dry pods yields were significantly correlated. It is therefore suggested that plant breeders could select genotypes with higher seed and forage yield (Omokanye et al., 2001). Blümmel et al. (2005b) determined strongest relationship ($R^2$ = 0.21) between pod and haulm yield in groundnut. In this study, significant relationships were not determined between crude protein and other features. Larbi et al. (1999) reported that there were poor and non-significant relationships between yield (forage and seed) and crude protein. Arslan (2005) determined that haulm fresh and dry weights were negatively correlated with crude protein of groundnut haulm, but the correlation coefficients were not high. Moyer et al. (2003) stated that relationships among forage yield and quality factors are not well understood.

Significant and negative relationship was observed between GFY and DMR, LDMR and SDMR. Amanullah (2000) also found a negative association between percentage dry matter and fresh forage yield in three promising cowpea (*Vigna unguiculata* L.) germplasms.

Although, there are linear relationships between DFY and DMR, a significant and negative correlation was determined in this study. This situation probably originated from the differences in the green fodder yield.

## CONCLUSION

There are limited numbers of annual legume forage crops which can be cultivated in summer time in Mediterranean conditions. So haulm of groundnut plants can be important forage during the dry seasons with regard to forage yield and crude protein.

Results of this study showed that groundnut genotypes produced high forage yield and crude protein. PI-355276 line produced more forage yield (green and dry) and pod yield. Gazipaşa cultivar recorded high values of green forage yield and crude protein ratio.

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