Determination of forage yield and its components in blue melilot 
(Melilotus caerulea (L.) Desr.) grown in the western region of Turkey

E. Ates
Department of Field Crops, Faculty of Agricultural, University of Namik Kemal, Tekirdag, Turkey
Email: ertan_ates@hotmail.com

The aim of this research was to determine the forage yield and its components in blue melilot (Melilotus caerulea (L.) Desr.) grown in the western region of Turkey. Blue melilot seeds were collected during two years (2005-2006) at mature stage from grasslands (43.0 °N, 26 °E) of the Belovets village in Razgrad, the north-east of Bulgaria. This study was conducted during the 2006-2009 growing season (October-July) on xeralf soil with pH 6.8-7.1 at Field Crops Department experimental area (41.0 °N, 27.5 °E) in Agricultural Faculty of Namik Kemal University (Tekirdag), Turkey. The experimental design was a randomized complete block with four replicates. The plant height (cm), main stem diameter (mm), number of leaves per main stem, leaf length (cm), leaflet length (cm) and width (cm), green fodder yield (t ha⁻¹), dry matter yield (t ha⁻¹), crude protein (%) and fiber (%) were determined at the three growing stages such as ¼ bloom, ½ bloom and full-bloom. It is concluded that green fodder yield (9.79-9.97 t ha⁻¹) and dry matter yield (2.49-2.62 t ha⁻¹) in the ½ bloom and full-bloom stages were determined to be higher than in the rest of the stage. Quality is high if the crop is cut in the ¼ bloom stage. According to yield and other components, the blue melilot can be sown and cutting at ¼ bloom, ½ bloom and full-bloom stages in the western of Turkey as well as in subtropical conditions.

Key words: blue melilot, dry matter, green fodder, growth stage, Melilotus caerulea (L.) Desr.

Melilots (Melilotus L.) are classified in the tribe Trifolieae of the sub family Faboideae, family Fabaceae. Melilotus L. contains approximately 20 species (Tekeli and Ates 2011) and about 2/3 of the melilot species are biennial, the remainders are annuals. The genus show considerable variations in botanical and agricultural characters. Many melilots are an important source of nutrients for livestock and they are grown throughout the world because of these high yield, forage quality, and wide climatic and soil adaptation. Melilots are a reliable and economical protein source for the ruminant and non-ruminant animals because they are independent of soil nitrogen. Besides, melilots are an excellent source of minerals. Intakes of melilots are usually greater than that of grasses of equal digestibility. But, high concentrations of a secondary plant compound, coumarin, is a major limiting factor in the use of melilots in the world.

The origin of blue melilot (M. caerulea (L.) Desr.) is the Caucasus on the border between Asia and Europe, the mountains of central, eastern and south eastern Europe (Anon 2010a). It is an annual, winter annual legume normally growing 20 to 100 cm tall and can survive at -5 °C. Blue melilot is adapted to a wide range of soil types, but it is best suited on low-lying areas, with well-drained, chernozem, vertisol and airy textured soils of pH from 6 to 8. It has been successfully grown in areas that receive between 450 and 1200 mm annual rainfall. It is used as forage, pasture, silage, soil improvement, food for bees (Apis sp.), aromatic, medical and culinary plants. Nevertheless; in Georgia, the dried seeds of blue melilot are widely utilized as a spice, usually sold as a playe greyish-brown powder consisting of pods and seeds. There are some soft cheeses flavoured with garlic (Allium sativum L.) or pepper (Piper ssp.), but other spices are seen only rarely. Blue melilot is not commonly used to flavour other types of cheese, besides bread spreads based on cottage cheese. It is, generally, not much used for foods prepared in home kitchens, although it is occasionally called for in Swiss potato foods, where it indeed makes good appearance (Anon 2010a).

Macro factors that affect the yield and quality of forage legumes and grasses during growth and development include: a) ecological factors, b) growth stage, c) cutting time, e) disease damage, f) insect damage, g) weeds ratio, i) soil traits and j) other management applications. Forages differing in morphological characteristics, growth stage at harvest were evaluated for their effects on variables assumed to be related to the characteristics of forage (Ates et al. 2010). The objective of this work was to determine the forage yield and its components in blue melilot grown in the western of Turkey.

Materials and Methods

Blue melilot seeds were collected during two years (2005-2006) at mature stage from grasslands (43.0 °N, 26 °E) of the Belovets village in Razgrad, the north-east of Bulgaria. This study was conducted during the 2006-2009 growing season (October-July) on xeralf soil with pH 6.8-7.1 at Field Crops Department experimental area (41.0 °N, 27.5 °E) in Agricultural Faculty of Namik Kemal University (Tekirdag), Turkey, located at about 5 m altitude above sea level and with a total precipitation of 482 mm on average and an annual overall temperature of 10.5 °C. The soil where the study was
conducted was low in organic matter (0.89-0.91 %), moderate in phosphorus content (60.3-61.7 kg ha⁻¹), but rich in potassium (522.3-532.7 ha⁻¹). The soil test recommendation showed that it did not require fertilization and lime.

The experiment was designed as a randomized complete block with four replicates. Each plot (25 m² per plot) consisted of 20 rows 25 cm apart (Anon 2010b) and 5 m in length. The seeds were sown at a rate of 10 kg ha⁻¹ (Tekeli and Ates 2011) on October 29, 2006, on October 30, 2007 and on October 26, 2008 with a hand-seeder. The green fodder yield (t ha⁻¹) was determined in 2 m² at the three growing stages such as ¼ bloom (first year: May 14, second year: May 20, third year: May 17), ½ bloom (first year: May 20, second year: May 25, third year: May 24) and full-bloom (first year: May 26, second year: June 1, third year: May 29) at 3 cm height form ground level and later it was calculated per hectare. One cut was made in each year. Approximately 500 g herbage samples were dried at 55 °C for 48 h and stored for one day at room temperature (Ates and Tekeli 2007). Then, the dry matter (DM) yield (t ha⁻¹) was calculated. The plots were not irrigated and fertilized after they were sown and harvested.

The plant height (cm), main stem diameter (mm), number of leaves per main stem, leaf length (cm), leaflet length (cm) and width (cm) were determined on twenty plants, which were randomly chosen from all plots at three growth stages. The main stem diameter was measured between the second and third node. The leaf length, leaflet length and width were measured on the leaf at the third node of the plants. Measurements of width and length of leaflet were concluded on the middle leaflet (Ates 2011). Samples were hand-separated into leaf (including leaf sheath and inflorescence) and stem components. The components were weighed, and the leaf dry weight was divided by the stem dry weight to calculate leaf/stem ratio.

All dried fodder samples were ground to small (<2mm) pieces and used for the analyses. The crude protein (CP) and crude fiber (CF) contents were determined by the micro-Kjeldahl and Weende methods (AOAC 2007). All samples were analyzed in triplicate. The results were analyzed using the TARIST statistical computer package. There were no significant differences between years and interactions (P>0.05 and 0.01). Therefore, this program was used for the comparison test (Fisher's Least Significant Difference, LSD) of the means from the three years.

Results and Discussion

The growth stages affected plant height, number of leaves per main stem, green fodder yield, DM yield, CP and CF ratios significantly (P<0.01) (table 1). Nevertheless, the growth stages had not significant effects on main stem diameter, leaf length, leaf/stem ratio, leaflet length and width (P > 0.05) (table 1).

The plant height, main stem length, number of branches per plant, main stem diameter, number of leaves per plant, leaf length and leaf weight are important characters used to determine green fodder yield and dry matter yield (Ates and Servet 2004); besides, leaf length, leaf weight, leaf/stem ratio, protein, fiber and mineral contents are important traits for forage quality. There were no significant differences between the growth stages for the main stem diameter (4.92 mm to 5.05 mm), leaf length (7.42 cm to 8.49 cm), leaf/stem ratio (0.70 to 0.85), leaflet length (3.65 cm to 3.78 cm) and width (1.81 cm to 1.89 cm) (P > 0.05). Generally, blue melilot is a superior feed for livestock, in the form of both good quality hay and silage. Other nutritional benefits are its mineral, carotene, and vitamin E content. Because it is a leafy plant, losses of dry leaves may be large at harvest. Ates and Servet (2004) measured a main stem diameter of 8.01-8.60 mm and a leaflet width of 3.43-3.51 cm for Persian clover (Trifolium resupinatum L.). Badrzadeh and Ghaforzadeh-namazi (2009) investigated some morphological traits and chromosome numbers in blue melilot and obtained similar values for leaflet length (2-5 cm) and leaflet width (1-2cm). Anon (2011a) reported measurements of leaf length between 1.27 cm and 5.08 cm in white melilot (M. alba Medik.).

Full-bloom stage showed the highest plant height (100.43 cm) and number of leaves per main stem (23.80) (P<0.01). The lowest green fodder (8.71 t ha⁻¹) and DM (2.21 t ha⁻¹) yields were determined for ¼ bloom stage (P<0.01). Hay yields up to 7-8 t ha⁻¹ are achievable in white melilot (Frame 2002). In Alaska, USA, yellow melilot (M. officinalis (L.) Pall.) yielded 7.70-9.03 t ha⁻¹ on neutral soil at one site, but 3.25-3.97 t ha⁻¹ on acid soil at another cooler site (Sparrow et al. 1993). Total forage and digested forage yield of yellow melilot (cv. Madrid) harvested by growth stages at Fargo, North Dakota were studied by Meyer (2005), who reported that forage yields at mid-bud, 10% bloom and late-bloom stages ranging from 7.18 t ha⁻¹, 7.43 t ha⁻¹ and 5.20 t ha⁻¹, respectively. Basaran et al. (2006), Tekeli and Ates (2011), Anon (2011a) and Anon (2011b) obtained measurements of plant height between 25-182.9 cm in melilot species. Anon (2010b) stated that blue melilot grew to a height of 100 cm, whereas Badrzadeh and Ghaforzadeh-namazi (2009) found this value to be only 25-60 cm. The results were similar to those reported by these researchers.
Table 1. The green fodder and dry matter (DM) yields, crude protein (CP), crude fiber (CF), and some morphological characters of blue melilot at different growth stages.

<table>
<thead>
<tr>
<th>Growth Stages</th>
<th>( \frac{1}{4} \text{bloom} )</th>
<th>( \frac{1}{2} \text{bloom} )</th>
<th>Full-bloom</th>
<th>SE±</th>
<th>Sign.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height, cm</td>
<td>63.33( ^a )</td>
<td>76.15( ^b )</td>
<td>100.43( ^a )</td>
<td>1.38E+01</td>
<td>**</td>
</tr>
<tr>
<td>No. of leaves per main stem</td>
<td>16.88( ^a )</td>
<td>19.33( ^b )</td>
<td>23.80( ^a )</td>
<td>3.80E-01</td>
<td>**</td>
</tr>
<tr>
<td>Main stem diameter, mm</td>
<td>4.92</td>
<td>5.05</td>
<td>4.97</td>
<td>4.00E-02</td>
<td>NS</td>
</tr>
<tr>
<td>Leaf length, cm</td>
<td>7.42</td>
<td>8.32</td>
<td>8.49</td>
<td>2.70E-01</td>
<td>NS</td>
</tr>
<tr>
<td>Leaflet length, cm</td>
<td>3.65</td>
<td>3.68</td>
<td>3.78</td>
<td>8.00E-02</td>
<td>NS</td>
</tr>
<tr>
<td>Leaflet width, cm</td>
<td>1.81</td>
<td>1.89</td>
<td>1.85</td>
<td>3.00E-02</td>
<td>NS</td>
</tr>
<tr>
<td>Leaf/stem ratio</td>
<td>0.85</td>
<td>0.77</td>
<td>0.70</td>
<td>2.00E-02</td>
<td>NS</td>
</tr>
<tr>
<td>Green fodder yield, t ha(^{-1} )</td>
<td>8.71( ^b )</td>
<td>9.79( ^a )</td>
<td>9.97( ^a )</td>
<td>1.00E-01</td>
<td>**</td>
</tr>
<tr>
<td>DM, t ha(^{-1} )</td>
<td>2.21( ^b )</td>
<td>2.49( ^a )</td>
<td>2.62( ^a )</td>
<td>1.00E-01</td>
<td>**</td>
</tr>
<tr>
<td>CP, %</td>
<td>19.38( ^a )</td>
<td>17.35( ^b )</td>
<td>17.50( ^a )</td>
<td>7.00E-02</td>
<td>**</td>
</tr>
<tr>
<td>CF, %</td>
<td>18.90( ^a )</td>
<td>19.43( ^b )</td>
<td>21.03( ^a )</td>
<td>1.80E-01</td>
<td>**</td>
</tr>
</tbody>
</table>

**P < 0.01  
NS: P > 0.05

The CF content of the forage was higher at full-bloom stage (21.03 %) compared to other stages (P<0.01) (table 1). The lowest CP contents were determined for \( \frac{1}{2} \) bloom (17.35 %) and full-bloom (17.50 %) stages, which is in agreement with the figure of 18.78 % to 18.83 % reported by Ates and Servet (2004), whereas, Canbolat and Karaman (2009) obtained this value to be only 15.33 % to 15.78% for white and yellow melilots. Blue melilot has a high nutritive value at the vegetative stage of growth, at pre-bloom stage for silage, and at early-bloom stage for hay. Total protein and fiber contents are inversely related to growth stages of the forage crops, nevertheless, protein and fiber contents of forage crops can be quite variable among species and their cultivars. Generally, forage legumes typically contain higher protein levels (12 % - 26 %) compared with grasses (8 % - 22 %). With forages, however, leaves and stems quality begins to decline early in the growth cycle due to deposition and lignification of NDF (neutral detergent fiber) especially in stems (Moore et al. 2007). Onset of blooming signals a continuing decline in forage quality is observed because stems become more fibrous and lignification causes a significant decline in protein content and digestibility in forage legumes with advancing maturity (Moser and Jennings 2007). For example, digestibility of Persian clover leaves is higher than stems due to lower cell wall content and its declines less rapidly with advanced maturity. During the normal ontological process, the ratio of leaves to stems declines as a plant matures. Both the leaf and stem fractions decline in digestibility and protein content with maturation due to primary and secondary cell walls thickening and the deposition of hemicellulose, pectin and lignin (Ates et al. 2010). Obviously cell walls did not evolve to serve as a feed for ruminants. The biological importance of the cell wall is related to a structural function and is of variable and often low digestibility in ruminants. Also, the physical volume occupied by cell walls in the rumen affects feed intake and animal performance (Jung 1997).

It is concluded that green fodder yield (9.79-9.97 t ha\(^{-1} \)) and dry matter yield (2.49-2.62 t ha\(^{-1} \)) in the \( \frac{1}{2} \) bloom and full-bloom stages were determined to be higher than in the rest of the stage. Quality is high if the crop is cut in the \( \frac{1}{4} \) bloom stage. According to yield and other components, the blue melilot can be sown and cut at \( \frac{1}{4} \) bloom, \( \frac{1}{2} \) bloom, and full-bloom stages in the western region of Turkey, and probably in subtropical conditions.

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