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DETERMINATION OF SEEDING RATE IN THE BLUE MELILOT (*Melilotus caeruleus* (L.) Desr.) FOR FORAGE YIELD AND SOME QUALITY FEATURES UNDER SUBTROPICAL CONDITIONS

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ABSTRACT

The aim of this research was to determine to blue melilot yield and quality properties sown at different rates of 5, 10, 15, 20, 25, 30, 35 [1] and 40 on November 4, 2015, on November 7, 2016 and on October 30, 2017. Investigated properties showed significantly differences. The lowest number of branches per plant (1.47), main stem diameter (3.20 mm) and leaflet width (1.44 cm) values were measured from blue melilot genotype 'BG-4' with 40 kg ha^{-1} seeding rate. The maximum main stem diameter (4.96-5.04 mm) and leaflet length (4.50-4.88 cm) were found from 5 to 15 kg ha^{-1} seeding rates. Highest plant height (84.48 cm), number of branches per plant (4.27), leaf length (7.12 cm), main stem diameter (4.41 mm), leaf/stem ratio (0.82), leaflet length (4.38 cm) and width (2.22 cm) were observed for BG-3 blue melilot genotype compared to other genotypes. Increasing seed rates resulted with an increase in crude protein, fresh fodder and dry matter yields. However, increasing seed rates caused decrease in crude fiber, neutral detergent fiber, acid detergent fiber and acid detergent lignin contents. The K, Ca, P and Mg contents of blue melilot genotypes ranging from 2.40-2.55 %, 1.48-1.56 %, 0.60-0.68 % and 0.40-0.45 %, respectively. According to results, blue melilot can be sown at a seeding rate of 30 kg ha^{-1} similar regions.

Keywords: Dry matter yield, fresh fodder yield, *Melilotus caeruleus* (L.) Desr., morphological characters, quality traits

INTRODUCTION

On the world, a wide array of animal production system based on the judicious use of forage legumes, sown in monoculture or forage legume/grass or other species mixtures, is practiced grassland farming. The superior nutritive values of forage legumes over forage grasses at similar stages of digestibility, either fresh or conserved, has been demonstrated in many studies. For example, better dairy-cow performance, in terms of higher yields of milk, milk protein and lactose, was achieved from red clover (*Trifolium pratense* L.) silage than from perennial ryegrass (*Lolium perenne* L.) silage compared at similar digestibility levels (Thomas et al., 1985; Frame et al., 1998). For this reason, forage legumes [alfalfa (*Medicago* sativa L.), clovers (*Trifolium* sp.), peas (*Pisum* sp.), vetches (*Vicia* sp.), melilots (*Melilotus* sp.) and etc.] play a very important role in the livestock.

Melilots are clasified in the tribe *Trifolieae* of the sub family *Faboideae*, family *Fabaceae*. It contains approximately 20 species and about 2/3 of the melilot species are biennial, the remainders are annuals (Tekeli and Ates, 2011). The genus show considerable variations in botanical and agricultural characters. Some melilots are an important source of nutrients for livestock and these 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. Intakes of melilots are usually greater than that of grasses of equal digestibility. However, high concentrations of a secondary plant compound, coumarin, is a major limiting factor of the use of melilots in the world (Ates, 2015).

The origin of blue melilot (*M. caeruleus* (L.) Desr.) is the Caucasus on the border between Asia and Europe, the mountains of central, eastern and south eastern Europe. It is an annual, winter annual legume normally growing 20 to 120 cm tall and can survive at -5 °C (Ates, 2011). 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, soil improvement, food for bees (*Apis sp*.), aromatic, medical and culinary plants (Ates, 2016). For medical and culinary, it is collected from nature in the Balkan countries.

Seeding rate optimization is important to achieve efficient fresh fodder or dry matter production for forage crops. As plant populations increase within a field, the biomass yield per plant decreases but the increased number of plants may be enough to offset the biomass yield decrease per plant. However, at seeding rates greater than the optimum, the biomass yield increase from adding plants may be insufficient to offset the biomass yield loss per plant. The point at which biomass yield gained from adding plants is offset by biomass yield lost from per plant reduction is the agronomic optimum-sowing rate (Van Roekel and Coulter, 2011; Lindsey et al., 2015; Lindsey et al., 2018).

The aim of this research was to determine the seeding rate of blue melilot for forage yield and some quality features under subtropical conditions.

MATERIALS AND METHODS

Location of Experiment

This research was conducted during 2015-2018 in Malkara-Tekirdag (40.0 °N, 26.0 °E), western Turkey, located at about 243 m altitude above sea level, with a typical subtropical climate. The soil of the experimental area was low in organic matter (1.06 %), moderate in phosphorus content (58.7 kg ha^{-1}), but rich in potassium content (549.0 kg ha^{-1}). The total rainfall of experimental area was 689 mm. This location has approximately similar overall temperature (12.7 °C) during vegetation period.

Experimental design and field applications

Two hopefuls blue melilot genotypes 'BG-3' and 'BG-4', were evaluated with mass selection, were planted in two-factor factorial Randomized Complete Block Design with four replications. Each parcel was sown 10 rows, with a spacing of 25 cm and 5 m in length (Demiroglu et al., 2008). The seeds were sown at rates of 5, 10, 15, 20, 25, 30, 35 and 40 kg ha^{-1} on November 4, 2015, on November 7, 2016 and on October 30, 2017 with a hand seeder. Before sowing, seed viability was tested so that the seed density in the parcels (plants/m^2) could be achieved. At each year, N and P (50 kg ha^{-1}) was incorporated into the soil at the time of land preparation. The experimental area was not irrigated after they were sown and harvested.

Measurements and chemical analyses

The plant height (cm), number of branches per plant, main stem diameter (mm), leaf length (cm), leaflet length (cm) and width (cm) were determined on twenty-five plants, which were randomly chosen from all plots at full-bloom stage (Ates, 2016). The main stem diameter was measured between the second and third node (Tekeli and Ates, 2003). The leaf length, leaflet length and width were measured on the leaf at the third node of the plants (Tekeli et al., 2003). Measurements of width and length of leaflet were concluded on the middle leaflet. Samples were hand separated into leaf (including leaf sheath and inflorescence) and stem components to calculate leaf/stem ratio (Ates and Seren, 2020). The fresh fodder yield (t ha^{-1}) was determined in 2.5 m^2 at the full bloom (first year: May 23, second year: June 3, third year: May 30) at 2 cm height form ground level and later it was calculated per hectare. One cut was made in each year. Approximately 1 kg herbage samples were dried at 55 °C for 48 h and stored for one day at room temperature for calculating dry matter (DM) yield (t ha^{-1}) (Ates and Tekeli, 2007). All dried fodder samples were ground to small (1 mm) pieces and used for the analyses (Atis et al., 2019; Atis and Acikalin, 2020). The crude protein (CP) and crude fiber (CF) contents were determined by the micro-Kjeldahl and Weende methods (AOAC, 2019). Crude protein (CP) content (%) was then calculated by multiplying the N content by 6.25. Plant fiber analysis was performed according to the methods of Van Soest et al. (1991), without sodium sulfite or amylase and data were not corrected for residual ash. Samples were extracted individually in Berzelius beakers on a reflux rack and filtered through coarse porosity Gooch crucibles for neutral detergent fiber (NDF, %), acid detergent fiber (ADF, %) and acid detergent lignin (ADL, %). The samples were wet-fired with nitric-perchloric acid, and phosphorus (P) content (%) was determined spectrophotometrically, potassium (K), calcium (Ca) and magnesium (Mg) contents (%) were found using an atomic absorption spectrophotometer (ICP–OES, Inductively Coupled Plazma-Optical Emission Spectrometer) (Isaac and Johnson, 1998). All samples were analyzed in triplicate.

Statistical analysis

The results were analyzed using the MSTAT-C statistical computer package. Same program was used for the comparison test described by Steel and Torrie (1980) (Least Significant Difference, LSD) of the means over the three years.

RESULTS AND DISCUSSION

Morphological characters

A significant seeding rate, genotype and genotype x seeding rate interaction were found statistically significant for morphological characters measured in research. Three years averages of plant height, number of branches per plant, main stem diameter, leaf length, leaf/stem ratio, leaflet length and width showed (Table 1) that the highest plant height, leaflet length and leaf/stem ratio were obtained from blue melilot genotype 'BG-3' with 30, 35 and 40 kg ha^{-1} seeding rates, whereas the blue melilot genotypes showed decreasing trend in number of branches per plant, main stem diameter, leaflet length and width with increasing seeding rate.

Table 1. The means of some morphological characters of blue melilot genotypes (G) at different seeding rates (Sr)

Morphological Characters	Genotypes	Seeding rates (kg ha^{-1}) 5	10	15	20	25	30	35	40	Mean ¥
Plant height (cm)	BG-3	71.81f	72.05f	70.74f	76.77e	85.49c	100.49a	99.43a	99.08a	84.48a
	BG-4	68.92g	68.51g	67.74h	69.60g	77.74d	95.61b	94.72b	94.17b	79.63b
	Mean†	70.37d	70.28d	69.24d	73.19c	81.62b	98.05a	97.08a	96.63a	82.06
	LSD	G: 3.222*			Sr: 1.421*		G x Sr: 1.537*			
No. of branches per plant	BG-3	6.12a	6.27a	5.99a	5.47b	3.50c	2.46e	2.25e	2.09f	4.27a
	BG-4	3.41c	3.64c	3.33d	3.06d	3.17d	2.08f	1.83f	1.47g	2.75b
	Mean	4.77a	4.96a	4.66b	4.27b	3.34c	2.27c	2.04d	1.78d	3.51
	LSD	G: 0.933*			Sr: 1.197*		G x Sr: 0.291*			
Main stem diameter (mm)	BG-3	5.18a	5.17a	5.10a	4.53b	4.10b	3.80c	3.67c	3.74c	4.41a
	BG-4	4.90a	4.75a	4.90a	4.14b	3.61c	3.44c	3.42c	3.20d	4.05b
	Mean	5.04a	4.96a	5.00a	4.34b	3.86b	3.62c	3.55c	3.47c	4.23
	LSD	G: 0.348**			Sr: 0.640**		G x Sr: 0.437**			
Leaf length (cm)	BG-3	5.79d	5.99d	6.23d	6.47c	7.66b	8.28a	8.34a	8.17a	7.12a
	BG-4	4.70f	4.80e	5.31e	5.90d	6.30d	7.04c	7.10b	7.32b	6.06b
	Mean	5.25d	5.40d	5.77c	6.19c	6.98b	7.66a	7.72a	7.75a	6.59
	LSD	G: 0.987**			Sr: 0.767**		G x Sr: 0.606**			
Leaflet length (cm)	BG-3	5.25a	5.07a	4.78a	4.45b	4.09b	3.88b	3.78c	3.77c	4.38a
	BG-4	4.50b	4.61a	4.22b	3.80c	3.81c	3.64c	3.70c	3.70c	4.00b
	Mean	4.88a	4.84a	4.50a	4.13b	3.95b	3.76b	3.74c	3.74c	4.19
	LSD	G: 0.361**			Sr: 0.382**		G x Sr: 0.644**			
Leaflet width (cm)	BG-3	2.63a	2.48a	2.48a	2.17c	2.23c	1.98d	1.87d	1.90d	2.22a
	BG-4	2.34b	2.40b	2.22c	1.90d	1.75e	1.61e	1.60e	1.44f	1.91b
	Mean	2.49a	2.44a	2.35b	2.04c	1.99d	1.80e	1.74e	1.67e	2.07
	LSD	G: 0.266**			Sr: 0.139**		G x Sr: 0.160**			
Leaf/stem ratio	BG-3	0.79b	0.69c	0.74c	0.77b	0.85b	0.94a	0.89a	0.92a	0.82a
	BG-4	0.67c	0.57d	0.68c	0.67c	0.79b	0.85b	0.80b	0.81b	0.73b
	Mean	0.73c	0.63d	0.71c	0.72c	0.82b	0.90a	0.85a	0.87a	0.78
	LSD	G: 0.087**			Sr: 0.052**		G x Sr: 0.081**			

*: P<0.05, **: P<0.01, ¥ Genotype means and genotype x seeding rate interactions with different letter fort the same column are significantly different; †Seeding rate means with different letter for the same row are significantly different

The lowest number of branches per plant (1.47), main stem diameter (3.20 mm) and leaflet width (1.44 cm) values were measured from blue melilot genotype 'BG-4' with 40 kg ha^{-1} seeding rate. Besides, maximum main stem diameter (4.96-5.04 mm) and leaflet length (4.50-4.88 cm) were found from 5 to 15 kg ha^{-1} seeding rates. Highest plant height (84.48 cm), number of branches per plant (4.27), leaf length (7.12 cm), main stem diameter (4.41 mm), leaf/stem ratio (0.82), leaflet length (4.38 cm) and width (2.22 cm) were observed for BG-3 blue melilot genotype compared to other genotype. Plant height, branches/plant, leaves/plant, leaf length, stem diameter, leaf/stem ratio, leaflet length and width are usually considered important characters in determining forage yield and quality. These are affected by genotype, environmental conditions and agronomic practices. Duke (1981) described sour clover (*M. indica* (L.) All.) as an annual herb with erect stems up to 50 cm tall, branching, sparingly pilose, leaves trifoliate, stipules often with a small tooth near base; petioles up to 2 cm long, rachis about 5 mm long, 9 mm wide, coarsely toothed; rounded at the apex; racemes many flowered, up to 10 cm long, including peduncle up to 3 cm long; bracts subulate, ca. 0.5 mm long; pedicels ca. 1 mm long, reflexed after flowering; calyx ca 1.5 mm; corolla yellow, ca 2.5 mm long; style 0.9-1.2 mm long; pod 3-4 mm long, 2-3 mm wide, one-seeded, with prominent reticulate veins. McGuire (1983) emphasized that the seeding rate had little influence on leafiness of alfalfa. Mohlenbrock (2002) reported that mean leaflet length varied from 0.8 to 2.54 cm in white melilot (*M. alba* Desr.). Badrzadeh and Ghafarzadeh-namazi (2009) determined a plant height of 25-60 cm, a leaflet length of 2-5 cm and a leaflet width of 1-2 cm for blue melilot. Anonymous (2012) emphasized that both plant height and seed yield increased with seeding rate only under high-yield environmental conditions. It stated that a positive response of plant height to seeding rate might indicate a less stressed environmental condition. Abdel-Rahman and Suwar (2012) found that the plant height of alfalfa was not significantly affected by seeding rates. Dzyubenko and Dzyubenko (2014) reported that blue melilot grew to a height of 30-60 cm, whereas Dolarslan and Gul (2017) determined that this value to be only 75-140 cm for yellow melilot (*M. officinalis* (L.) Desr.). Tucak et al. (2014) reported stem diameter varying between 1.79-2.30 mm in alfalfa. Ates (2015) studied the performance of four blue melilot genotype grown at two locations in the

Thrace region of Turkey, who measured that plant height, main stem diameter, leaves/main stem, leaf length, leaflet length and width at full-bloom stage ranging from 94.68-108.71 cm, 5.63 mm, 23.07-28.79, 8.88-9.00 cm, 4.23-4.47 and 2.17-2.26 cm, respectively. Ates and Seren (2020) determined the forage yield and quality of blue melilot at different growth stages under Edirne ecological conditions, who measured that plant height, leaves/plant, leaf length, leaf/stem ratio, leaflet length and width at ½-bloom stage ranging from 99.05 cm, 120.81, 7.62 cm, 0.88, 4.20 cm and 0.88 cm, respectively, similar to the present findings.

Yield and some quality traits

The genotype x seeding rate interactions for fresh fodder and dry matter yields, CP, CF, NDF, ADF and ADL contents were statistically significant in three years averages (Table 2).

Table 2. Fresh fodder yield, dry matter yield (t ha^{-1}), crude protein ratio, cell wall components (in % DM basis) at different seeding rates (Sr) in blue melilot genotypes (G)

		Seeding rates (kg ha^{-1})								
Characters	**Genotypes**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**Mean ¥**
Fresh fodder yield	**BG-3**	9.44b	9.56b	9.61b	9.60b	9.77b	10.74a	10.22a	10.34a	9.91a
	BG-4	8.55c	8.62c	8.67c	8.88c	9.10b	9.66b	9.55b	9.64b	9.08b
	Mean†	9.00c	9.09c	9.14b	9.24b	9.44b	10.20a	9.89a	9.99a	9.50
	LSD			G: 0.754*	Sr: 0.323*		G x Sr: 0.877*			
DM yield	**BG-3**	2.77b	2.79b	2.88b	2.91b	2.95b	3.74a	3.72a	3.70a	3.18a
	BG-4	1.95c	2.05c	2.10c	2.23b	2.35b	2.71b	2.67b	2.69b	2.34b
	Mean	2.36b	2.42b	2.49b	2.57b	2.65b	3.23a	3.20a	3.20a	2.77
	LSD			G: 0.821*	Sr: 0.490*		G x Sr: 0.788*			
CP	**BG-3**	17.50b	17.29b	17.41b	17.45b	17.83b	18.88a	18.68a	18.77a	17.98a
	BG-4	17.00c	17.10c	17.05c	17.12c	17.45b	17.97b	17.85b	17.89b	17.43b
	Mean	17.25c	17.20c	17.23c	17.29b	17.64b	18.43a	18.27a	18.33a	17.71
	LSD			G: 0.422**	Sr: 0.371**		G x Sr: 0.722**			
CF	**BG-3**	25.22b	25.19b	24.45c	23.77c	22.56d	21.22e	21.23e	21.24e	23.11
	BG-4	26.42a	26.33a	25.42b	24.56b	22.13d	21.41e	21.40e	21.42e	23.64
	Mean	25.82a	25.76a	24.94b	24.17b	22.35c	21.32d	21.32d	21.33d	23.38
	LSD			G: NS	Sr: 0.800**		G x Sr: 0.922**			
NDF	**BG-3**	44.65b	44.50b	44.00c	43.87c	43.25d	42.11f	42.13f	42.05f	43.32
	BG-4	45.00a	44.75a	44.51b	43.25d	42.74e	41.33g	41.30g	41.34g	43.03
	Mean	44.83a	44.63a	44.26b	43.56c	43.00c	41.72d	41.72d	41.70d	43.18
	LSD			G: NS	Sr: 0.567**		G x Sr: 0.333**			
ADF	**BG-3**	33.22a	33.15a	32.74b	32.10b	30.57d	28.33e	28.35e	28.31e	30.85
	BG-4	33.45a	33.05a	32.44b	31.75c	30.10d	28.75e	28.70e	28.72e	30.87
	Mean	33.34a	33.10a	32.59b	31.93b	30.34c	28.54d	28.53d	28.52d	30.86
	LSD			G: NS	Sr: 0.691**		G x Sr: 0.655**			
ADL	**BG-3**	4.22a	4.25a	4.10a	3.75b	3.64c	3.44c	3.43c	3.45c	3.79
	BG-4	4.18a	4.20a	4.08a	4.09a	3.98b	3.66c	3.67c	3.65c	3.94
	Mean	4.20a	4.23a	4.09a	3.92b	3.81b	3.55c	3.55c	3.55c	3.86
	LSD			G: NS	Sr: 0.305**		G x Sr: 0.268**			

*: P<0.05, **: P<0.01, NS: Not significant, P>0.05 and 0.01 ¥ Genotype means and genotype x seeding rate interactions with different letter fort the same column are significantly different; †Seeding rate means with different letter for the same row are significantly different

Increasing seeding rates resulted an increase in CP, fresh fodder and dry matter yields. However, increasing seeding rates caused decrease in CF, NDF, ADF and ADL contents. The maximum fresh fodder yield (10.22-10.74 t ha^{-1}), DM yield (3.70-3.74 t ha^{-1}) and CP content (18.68-18.88 %) were determined for BG-3 blue melilot genotype at 30, 35 and 40 kg ha^{-1} seeding rates. The contents of CF, NDF ADF and ADL were statistically not significant in terms of blue melilot genotype according to p>0.01 (Table 2), while all other parameters were statistically significant according to p<0.01. Highest CF (26.33-26.42 %) and NDF (44.75-45.00 %) contents were analyzed blue melilot genotype 'BG-4' at 5 and 10 kg ha^{-1} seeding rates. The ADF content (28.31-28.75 %) decreased from 30 to 40 kg ha^{-1} seeding rates at blue melilot genotypes. 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 (irrigation, fertilizer applications, seeding rate and time etc.) (Ates et al., 2010). For example, in Alaska, yellow melilot 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 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. The CP content is one of the most important parameter for forage quality (Kavut, 2019). Generally, forage legumes typically contain higher protein levels (12 % - 26 %) compared with grasses (8 % - 22 %) (Ates, 2011; Tenikecier and Ates, 2018). However, ADL is usually the major limiting digestibility of plant cell walls. In addition to its low digestibility, lignin inhibits the digestion of cell-wall polysaccharides. Furthermore, the undigested lignin-carbohydrate residue acts as ballast in the rumen and reduces forage intake (Van Soest and Jorgensen, 1981). The DM yields for melilots has been reported in a range of 7-8 t ha^{-1} by Frame (2002) or 13.14-13.84 t ha^{-1} by Abbasi et al. (2017) in world-wide studies. Meyer (2005) found that forage yields of yellow melilot 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. Besides, he reported that the forage and hay yields of white and yellow melilots range from approximately 0.91 to 2.72 t ha^{-1} depending on variety and location. Ogle et al. (2008) gives the following nutritional values for melilots: CP 15 %; digestible protein 10.2 % [cattle (*Bos taurus* L.)], 10.8 % [goats (*Capra aegagrus hircus* L.)], 10.5 % [horses (*Equus ferus caballus* L.)], 10.4 % [rabbits (*Oryctolagus cuniculus* L. and *Sylvilagus* sp.)], and 10.6 % [sheep (*Ovis aries* L.)]. Loges (2012) found a DM yield of 4.5 t ha^{-1} for yellow melilot. Elgersma et al. (2013) researched the herbage dry-matter production and forage quality of three legumes and four non-leguminous forbs grown in single-species stands, who determined that DM yield, CP, NDF, ADF, ADL and cellulose contents in yellow melilot ranging from 3.90 t ha^{-1}, 19.8 %, 33.4 %, 27.1 %, 4.5 % and 68 %, respectively. Ates (2015) who worked with five blue melilot genotypes in this region, informed that the dry matter yields of genotypes ranged 2.18 and 3.05 t ha^{-1}. Kavut and Avcioglu (2015) and Turan et al. (2017) reported crude protein contents varying between 16.33-20.16 % in alfalfa. Caddel and Enis (2004) recommended that the 11.21 to 16.86 kg ha^{-1} seeding rates for melilots whereas, Anonymous (2020) reported that the 9 kg ha^{-1} seeding rate for high fresh fodder and dry matter yields of melilots at different soil zones (Brown, Dark Brown, Black and Grey). Maximum CP, fresh fodder and DM yields for BG-3 blue melilot line at 30, 35 and 40 kg ha^{-1} seeding rates determined in this present study was not similar to those researchers.

Macro element contents

An analysis of variance indicated that there were no statistically significant differences in macro elements among blue melilot genotypes, seeding rates and genotypes x seeding rate interaction.

The K, Ca, P and Mg contents of blue melilot genotypes ranging from 2.40-2.55 %, 1.48-1.56 %, 0.60-0.68 % and 0.40-0.45 %, respectively (Table 3). The micro and macro element contents of the forage have important role in animal feeding. Because, the mineral elements are contained in approximately 1.5-5 % of the animal body and its balances very important to keep animal health. A lack of one mineral element cannot be balanced by the other minerals. Ca and P contents in animal body are closely related to mineral contents of forage. It is very important to keep a proper balance of Ca and P in relation to vitamin D for animals. A desirable ratio of Ca/P is between 2:1 and 1:1 (Tekeli et al., 2003; Tekeli and Ates, 2005; Tenikecier and Ates, 2019). Okuyan et al. (1986) and Celen et al. (2005) reported that the some macro and micro element contents in quality forage crops must be as follow, P 0.16-0.37 %, K 0.3-0.8 %, Ca 0.21-0.52 %, Mg 0.04-0.08 %, Zn (zinc) 35-50 ppm, Mn (manganese) 20-40 ppm. Romero and Marañón (1996) studied the effects of NaCl salinity and plant age on allocation of biomass and mineral elements in corn melilot (*M. segetalis* (Brot.) Ser.), who reported that the immobile Ca accumulated in leaves with age, whereas K was depleted from roots and accumulated in leaves and pods. They found a K relative content of 2.29 %, a Ca relative content of 5.14 % and a P relative content of 0.24 % for corn melilot. NRC (2007) emphasized that the although Ca, K, Mg and all micro minerals contents in the stems are lower, their contents in the leaves and stems of yellow melilot are adequate for sheep. Kostopoulou et al. (2015) reported the content of K, Ca and Mg in the leaves ranged from 14.61 to 23.53 g kg^{-1}, 17.55 to 18.32 g kg^{-1} and 4.50 to 4.96 g kg^{-1} respectively in yellow melilot, similar to the present findings.

Table 3. Macro element contents (in % DM basis) at different seeding rates (Sr) in blue melilot genotypes (G)

Macro Elements	Genotypes	Seeding rates (Sr) (kg ha^{-1}) 5	10	15	20	25	30	35	40	Mean
K	BG-3	2.55	2.52	2.54	2.54	2.50	2.51	2.54	2.50	2.53
	BG-4	2.46	2.44	2.40	2.43	2.42	2.42	2.45	2.40	2.43
	Mean	2.51	2.48	2.47	2.49	2.46	2.47	2.50	2.45	2.48
	LSD				G: NS	Sr: NS	G x Sr: NS			
Ca	BG-3	1.52	1.56	1.53	1.50	1.50	1.51	1.52	1.49	1.52
	BG-4	1.50	1.48	1.53	1.55	1.48	1.49	1.48	1.49	1.50
	Mean	1.51	1.52	1.53	1.53	1.49	1.50	1.50	1.49	1.51
	LSD				G: NS	Sr: NS	G x Sr: NS			
P	BG-3	0.68	0.63	0.66	0.65	0.67	0.65	0.67	0.64	0.66
	BG-4	0.60	0.66	0.62	0.64	0.61	0.62	0.62	0.60	0.62
	Mean	0.64	0.65	0.64	0.645	0.64	0.64	0.65	0.62	0.64
	LSD				G: NS	Sr: NS	G x Sr: NS			
Mg	BG-3	0.43	0.44	0.41	0.45	0.44	0.42	0.43	0.43	0.43
	BG-4	0.45	0.41	0.42	0.40	0.43	0.40	0.42	0.41	0.42
	Mean	0.44	0.43	0.42	0.43	0.44	0.41	0.43	0.42	0.43
	LSD				G: NS	Sr: NS	G x Sr: NS			

NS: Not significant, P>0.05 and 0.01

CONCLUSIONS

Seeding rate is one of the most important factors affecting plant yield and yield components. Decreased yield is evident at seeding rates above or below the optimum rates. The results from the different genotypes and seeding rates applied in blue melilot at subtropical conditions can be summarized as follow:

(a) BG-3 blue melilot genotype had highest plant height, branches/plant, main stem diameter, leaf length, leaflet length, leaflet width, leaf/stem ratio, fresh fodder and dry matter yields.

(b) Increasing seeding rates (30 to 40 kg ha^{-1}) results with an increase in plant height, leaf length, leaf/stem ratio, CP, fresh fodder and dry matter yields. However, the branches/plant, main stem diameter, leaflet length and width, CF, NDF, ADF and ADL contents decreased with the increase of seeding rate.

(c) Mineral contents in blue melilot genotypes did not change depending on seeding rates.

(d) According to results, blue melilot may provide a sufficient amount of macro elements and cell wall components to meet livestock nutritional requirements.

(e) For high forage yield and quality features, seeding rate of 30 kg ha^{-1} can be recommended for blue melilot can be sown under subtropical conditions and similar ecological condition.

(g) When sowing a blue melilot, we should pay attention to the mentioned issues.

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