

Effects of Sowing Methods on the Quality and Quantity Traits of Three Annual *Medicago* Species

H. SADEGHI^{1**}, G. A. GHANBARIAN^{1*} and A. R. BAYAT^{2*}

¹Department of Natural Resources and Environmental Engineering, College of Agriculture,
Shiraz University, Shiraz, I. R. Iran.

²Animal Production Research, MTT, Finland

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ABSTRACT- Annual *Medicago* species (*Medicago* spp.) are native to the Mediterranean region and widely used in fields and pastures in Iran. There are several methods of sowing annual *Medicago* species, each with different effects on the performance. However, there is currently no sufficient information about the appropriate methods for sowing *Medicago* species. In order to evaluate methods of sowing (broadcast planting and row planting) on qualitative and quantitative traits of three annual *Medicago* species (*M. rigidula*, *M. polymorpha* and *M. scutellata*), a 2-yr field study was conducted in Shiraz, Iran during the growing season 2010-2011. This study was carried out as a split plot experiment based on a randomized complete block (RCB) design with three replications. The results showed that there were no significant differences for most traits between the two years. *Medicago* planted in the row method had more root dry weight, ash, extract ether, natural detergent fiber (NDF) and nitrogen free extract (NFE). It was also demonstrated that shoot to root weight ratio, water content, organic matter, metabolic energy (ME) and digestibility (DE) were higher in *Medicago* plants that were planted by the broadcast method. All quantitative traits and ash of *M. polymorpha* were greater than those of the other two species. *M. scutellata* had higher percentage of organic matter, extract ether and crude fiber; *M. rigidula* also had a higher content of calcium, phosphorous, crude protein, NDF, NFE, ME and DE. Higher forage production was observed in *M. polymorpha* planted by the row method in both years, but this was especially evident in 2011. Overall, these results indicated that the row method was a more suitable method for planting *M. polymorpha*. Furthermore, broadcast planting was identified as a better method for planting *M. scutellata* and *M. rigidula*.

Keywords: Broadcast Planting, Crude Protein, Digestibility, *Medicago* species, Row Planting

* Associate Professor, Assistant Professor and Researcher, respectively.

** Corresponding Author

INTRODUCTION

Medicago species belong to the leguminous family that are native to semiarid areas of the Mediterranean region and have long been used in pastures in the region (17). *Medicago* is now widely distributed throughout the world, mostly in areas with mild, rainy winters and alkaline soils (9). In Michigan, annual *Medicago* and berseem clover provide an extra source of emergency forage when *Medicago* is killed over winter (18). *Medicago* in Western Montana provides the same benefits associated with perennial legumes in annual cropping systems. These benefits are that of being a low effort input system applied as green manure (24).

Annual *Medicago* is found in almost all regions of Iran. More than 556,000 ha of *Medicago* species are grown as continuous cropping in Iran. This suggests that these plants are appropriate for Iranian pastures.

Medicago has several annual species, such as *M. rigidula*, *M. polymorpha* and *M. scutellata*, which can produce high numbers of seeds. It establishes relatively easily but its early growth in autumn is rapid and erect, making it susceptible to overgrazing (20). This species can enhance water permeation into the soil and consequently can improve soil structure and protect soil surface (9). Although most *Medicago* species are specific to tropical areas, *M. rigidula* is native to cold and temperate zones (5). *M. rigidula* is a species that is found at high latitude and elevation in Eurasia. *M. polymorpha* has very low forage production compared with other cultivars, resulting in low protein and seed production (9).

Low *Medicago* performance in Iran can be due to an inappropriate sowing method or use of inappropriate species. Proper sowing methods control plant competition and facilitate soil moisture storage; they are able to partially offset unreliable rainfall (8). A wide variety of methods are used for sowing in pastures, ranging from allowing cattle to spread the seed through dung when they graze; using airplane, fertilizer spreaders and drum seeders for broadcasting seeds into the existing pasture, with or without prior soil disturbance to employing specialized and precise seed drills on fully cultivated seedbeds (8). *Medicago* is usually sown in large areas by broadcasting method. Broadcasting not only requires a higher seed rate but it also results in lower plant population whereas row planting is recommended because of its uniform seed distribution (21). Row planting usually results in higher germination, better emergence, uniform stand, better establishment and consequently higher productivity (7).

Soomaro et al. (21) reported that plant vigor and grain yield of wheat increased under sowing by the drilling method. Ahmad et al. (1) showed that sowing methods had significant effects on head diameter, thousand grain weight, grain yield and oil yield. Maximum levels of these traits were obtained from ridge -sown crops, while the furrow method resulted in the lowest values for these variables.

The most common method in Iranian pastures is broadcast planting, however it seems that this method lacks efficiency. So, this study was conducted to evaluate the effect of sowing methods such as broadcast planting and row planting on qualitative and quantitative traits of annual *Medicago* species *Medicago rigidula*, *Medicago polymorpha* and *Medicago scutellata*.

MATERIALS AND METHODS

To evaluate the effects of sowing methods on qualitative and quantitative traits of three annual *Medicago* species a 2-yr field study was conducted in Fars Province of Iran during the growing seasons of 2010 and 2011. The site for the experiment was located at the Research Farm of College of Agriculture, Shiraz University (29°43' N and 52°35' W). This study was carried out as a split plot experiment based on a randomized complete block (RCB) design with three replications. The treatments had two factors: sowing methods and species. Sowing methods were broadcast planting (BP) and row planting (RP) and species being tested were three annual *Medicago* species: *Medicago rigidula*, and *Medicago polymorpha* and *Medicago scutellata*. Descriptions of soil characteristics and wheatear properties are given in Tables 1 and 2, respectively.

Table 1. Soil properties (0-30 cm) of the experimental site at Badjgah, Shiraz, Iran before plant sowing.

Year	pH [†]	Soil Texture	Sand	Silt	Clay	OC	Total N	P	K	EC
			Percentage (%)						mg kg ⁻¹	
2010	7.1	Silty loam	17.50	61.20	21.30	0.83	0.09	15.5	470	0.54
2011	7.8	Silty loam	17.30	61.50	22.20	1.23	0.23	16.7	483	0.61

†- pH, Soil Acidity; OC, Organic Carbon; N, Nitrogen; P, Phosphorous; K, Potassium; EC, Electrical Conductivity.

Table 2. Weather characteristics of the experimental site at Badjgah, Shiraz, Iran during the study period.

Month	Temperature (°C)		Relative Humidity (%)		Precipitation (mm)	
	2010	2011	2010	2011	2010	2011
May	19.59	18.8	42.37	54.59	0	14
June	21.99	23.48	36.91	40.1	0	0
July	25.5	26.82	35.91	37.58	0	0
August	25.66	23.5	41.38	44.36	0	10
September	19.89	20.76	38.00	45.79	0	0

In each of the three replicates, sowing methods were assigned to the three main plots. Each main plot was divided into three sub-plots and each sub-plot was randomly assigned to one of the three species - *M. rigidula*, *M. polymorpha* and *M. scutellata*. In

two years, the viable scarified seeds were sown on 25th May and the plants were harvested at the flowering stage in late September. In RP, row spacing and plant space on rows were 75 cm and 20 cm, respectively, with a sowing depth of 3 cm. Also in BP, the seeds were dispersed on the soil surface by hand and then covered with soil by a rake. Weed control was done by hand during the growing season and plots were irrigated with a garden hose every 10 days. Chemical fertilizer was applied by hand at a ratios of 30 kg N/ha (as urea for starter) and 80 kg P/ha (as superphosphate) prior to sowing.

Total fresh weight and shoot fresh weight (TFW and SFW respectively), shoot dry weight, root dry weight (SDW and RDW respectively), dry matter (DM), shoot to root weight ratio (S/R) and water content (WC *f*) were measured as quantitative traits. Ten plants were selected randomly from each plot and all above ground and below - ground parts of the plants were harvested for measuring quantitative and qualitative traits. Samples were dried at 70°C for 24 hours. Water content, can then be defined as follows:

$$WC_f = \frac{SFW - SDW}{SFW}$$

where WC_f is water content based on fresh weight, SFW and SDW are shoot fresh and shoot dry weight.

However, qualitative traits such as organic matter (OM), crude protein (CP), extract ether (EE), crude fiber, natural detergent fiber (NDF), ash, nitrogen free extract, calcium (Ca), phosphorous (P), digestibility (DE) and metabolic energy (ME) were determined as follows:

The dried samples were analyzed for quality by an NIR Systems 5000 scanning monochromator (NIR Systems Inc., Silver Spring, MD, USA) applying the Near Infrared Reflectance Spectroscopy (NIRS) methodology (2, 13, 19, 16).

Collected data were subjected to combined analysis of variance (ANOVA) and then significant differences between treatment means were compared by the LSD test (least significant difference) at $P \leq 0.05$ and $P \leq 0.01$ probability levels using SAS (v. 9.1) Software.

RESULTS AND DISCUSSION

Quantity traits

The effect of sowing method on the total and shoot fresh weight was not significant, and there was no significant difference between the two years. Cultivar and its interaction with sowing method had a significant effect on total and shoot fresh weight at 5% probability level (Table 3). *M. polymorpha* and *M. rigidula* had higher and lower total fresh weight (TFW), in two sowing methods for both years, respectively (Table 4). All three species grown under the row planting method had higher TFW than those grown under the broadcast planting method in both years. Shoot fresh weight (SFW) was the highest in *M. polymorpha* under all conditions, but the lowest was observed in *M. scutellata* under row planting in both years. Compared with row planting, broadcast planting led to better growth in the SFW of the species in both years. The sowing

methods had similar effects on the fresh weight of all species in both years (Table 3). In relation to shoot and root dry weight; there were no significant effects, except for the effect of cultivar on shoot dry weight and the effect of sowing method on root dry weight. There was no significant difference between the two years (Table 3).

Table 3. Analysis of variance for sowing method, cultivar and their interaction effects on *Medicago* species qualitative and quantitative characteristics.

Source	Degree of Freedom	Mean Square							
		TFW [†] (g)	SFW (g)	SDW (g)	RDW (g)	S/R (g)	WCf (%)	OM (%)	Ash (%)
Year	1	700.04ns [‡]	207.69ns	34.65ns	0.18ns	0.01ns	0.01ns	54.93**	2.37ns
Sowing M. (S)	1	16300.05ns	326.58ns	42.55ns	72.53*	2279.68**	0.21**	52.15**	52.12**
Cultivar (C)	2	300028.39*	270633.07*	58388.14**	50.08ns	1279.29*	0.02ns	154.81**	154.77**
S × C	2	8434.60*	1545.74*	464.80ns	38.40ns	1809.79**	0.03ns	83.70ns	13.70ns
Coefficient Variance (CV)		19.12	22.13	21.10	18.15	22.13	21.95	12.06	5.82

Source	Mean Square								ME (Mcal/kg)	DE (Mcal/kg)
	Ca(%)	P (%)	CP (%)	EE (%)	CF (%)	NDF (%)	NFE (%)			
Year	0.02ns	0.01ns	2.44**	0.05ns	4.30ns	14.58ns	9.07ns	39954.01ns	56465.64**	
Sowing M. (S)	0.04ns	0.01ns	0.04ns	0.52**	55.10**	296.90**	23.49**	71937.49**	77578.03**	
Cultivar (C)	3.14**	0.21**	38.44**	2.62**	582.06**	571.65*	170.50**	25965.57**	23304.94**	
S × C	0.83ns	0.12*	0.84ns	0.65**	32.41*	2799.01**	103.32ns	9637.19ns	205277.73ns	
CV		7.26	11.25	10.32	6.59	6.55	8.54	13.08	7.04	11.96

[†]- TFW, Total fresh weight; SFW, Shoot fresh weight; SDW, Shoot dry weight; RDW, Root dry weight; S/R, Shoot to root dry weight ratio; WCf, Water content based on fresh weight. OM, Organic matter; Ca, Calcium; P, Phosphorous; CP, Crude protein; EE, Extract ether; CF, Crude fiber; NDF, Natural detergent fiber; NFE, Nitrogen free extract; ME, Metabolic energy; DE, Digestibility.

[‡]- ns, * and ** are non-significant, significant at the 5% and 1% probability levels, respectively

Root dry weight of plants that were grown under the row planting method was significantly greater than those grown under the broadcast planting method (Table 4). Unlike the broadcast planting method, the row planting caused *M. scutellata* to have higher root dry weight.

The effect of sowing method, cultivar and their interaction on S/R were significant at 5% and 1% probability levels, respectively. There was no significant

difference between the two years (Table 3). On average, compared with row planting, using broadcast planting caused greater S/R in all species (Table 4). In both years, *M. scutellata* had better S/R when using the broadcast planting method than the row planting one. Only the effect of sowing method on water content was significant at 1% probability level. There was no significant difference between the two years (Table 3).

Quality traits

Organic matter was significantly affected by sowing method, cultivars and their interaction at 1% probability level (Table 3). *Medicago* plants sown by broadcast method had higher organic matter than those sown by row planting method (86.6 vs. 84.2). Organic matter of *M. rigidula* and *M. scutellata* was greater than that of *M. polymorpha* by about 3% and 9%, respectively (Table 4). Although this trend was similar in both sowing methods, in broadcasting planting method differences were more distinct. So, the highest organic matter content was achieved in *M. scutellata* that was planted by broadcast method in 2011, and its lowest was observed in *M. polymorpha* planted by row method in 2010 (Table 5). Ash was non-significant between the two years (Table 3; on average 17.5% and 17.9% in 2010 and 2011 respectively) and was significantly greater when using the row planting method by 14.6% (Table 4). The amount of ash was significantly different among the *Medicago* species. *M. polymorpha*, compared with *M. rigidula* and *M. scutellata*, had higher ash at 10.4 and 50.7%. In two years, *M. polymorpha* and *M. rigidula* had greater ash percentages under the row method than under the broadcast planting method.

Table 4. The main effect of sowing methods on some quality and quantity characteristics of three annual *Medicago* species (*Medicago* spp).

Treatment	SDW [†] (g)	RDW (g)	WC ^f (%)	OM (%)	Ash (%)	Ca (%)	CP (%)	NFE (%)	ME (Mcal/kg)	DE (Mcal/kg)
Sowing M.										
RP	47.69a [‡]	4.18a	0.43b	84.24b	18.91a	1.77a	18.01a	35.52a	2259.17b	2692.43b
BP	45.51a	1.35b	0.59a	86.65a	16.50b	1.70a	18.08a	33.90b	2348.57a	2785.28a
Species										
<i>M. polymorpha</i>	127.13a	4.17a	0.54a	82.47c	20.68a	1.79b	18.98a	35.74b	2259.17c	2697.59c
<i>M. rigidula</i>	4.92b	0.42a	0.50a	84.43b	18.72b	2.22a	19.18a	37.85a	2352.01a	2785.28a
<i>M. scutellata</i>	7.75b	3.70a	0.49a	89.43a	13.72c	1.20c	15.98b	30.53c	2300.43b	2733.70b

†- SDW, Shoot dry weight; RDW, Root dry weight; WC^f, Water content based on fresh weight; OM, Organic matter; Ca, Calcium; CP, Crude protein; NFE, Nitrogen free extract; ME, Metabolic energy; DE, Digestibility; RP, Row planting; BP, Broadcast planting.

‡- In each column means followed by the same letters are not significantly different (LSD 0.05)

The percentage of calcium and phosphorous was significantly (at 1% PL) different among *Medicago* species, but not significant when comparing the effect of the two sowing methods. The effect of their interaction was significant (at 5% PL) only on

phosphorous percentage (Table 3). *M. rigidula* and *M. scutellata* had, respectively, higher and lower nutrient percentages than the other (Table 4). In both years, *M. rigidula* planted by the broadcast method had the highest calcium and phosphorous percentages. Although there was no significant difference between the two years, in 2011, differences between the treatments were less than those in 2010 (Table 5). Crude protein amount was significantly different between the two years at 1% probability level (Table 3). *M. polymorpha* and *M. rigidula* (without significant difference with each other and had significantly 19 and 20% more crude protein than *M. scutellata*. Despite this difference, the effect of the interaction was not significant. However, using broadcast planting method in 2010 resulted in the lowest amount of crude protein contents in *M. scutellata* and the highest amount in *M. rigidula*, in 2011.

The species, sowing method and their interaction had significant effects on extract ether, but there was no significant difference between the two years (Table 3). *Medicago* planted by row planting had about 13% more extract ether than that planted using the broadcast method. Also *M. scutellata* and *M. polymorpha* had the highest and the lowest records for extract ether, respectively (Table 4). Compared with *M. rigidula*, *M. scutellata* had about 23.6% more extract ether and *M. polymorpha*, about 14.2% less. There were no significant differences between extract ether of the three *Medicago* species planted by row planting; but in the broadcast planting method *M. scutellata* had higher significant extract ether compared to others (Table 5). These trends were similar in both years. The effect of sowing methods (1% PL), cultivars (1% PL) and their interaction (5% PL) on crude fiber was significant (Table 3). *Medicago* species planted by broadcast planting method had more crude fiber than those planted by row planting method (25.13 vs. 22.66). There were significant differences between the three *Medicago* species. *M. scutellata*, compared with *M. rigidula* and *polymorpha*, had remarkably more crude fiber, (Table 4). This trend was similar using both sowing methods in both years (Table 5). Overall, the highest crude fiber was observed in *M. scutellata* that was planted by the broadcast method in 2011.

Natural detergent fiber (NDF) was affected significantly by sowing methods (1% PL), cultivars (5% PL) and their interaction (1% PL), as shown in Table 3. Row planted *Medicago* had more NDF compared to the broadcast method by 13.9%. According to the main effect (Table 4), *M. rigidula* and *polymorpha*, without significant difference with each other, had more NDF compared to *M. scutellata*. In respect to interactions, only *M. polymorpha* had higher NDF using broadcast planting method, whereas NDF of the two other species was higher utilizing row planting method. This was similar in both years. Overall, the highest NDF was recorded in *M. polymorpha* that was planted by the broadcast method in 2011 (Table 5). The effect of sowing method and cultivar was significant on nitrogen free extract (NFE) at 1% PL (Table 3). NFE of *Medicago* by row planting was higher than that by the broadcast planting method by 7.6%. Also, there was a significant difference between *Medicago* species, the highest and lowest NFE levels were observed in *M. rigidula* (37.8%) and *M. scutellata* (30.5%), respectively. Overall, the highest NFE level was recorded in *M. rigidula* planted by row planting method in 2011. There was no significant difference between the years (34 vs. 35%).

Metabolic energy (ME) was affected by sowing method and cultivar at 1% probability level (Table 3). In both years, *Medicago* plants had more ME when the row planting method was employed (Tables 4 and 5). On average (Table 4), compared with

M. scutellata and *M. polymorpha*, *M. rigidula* had higher ME by 3 and 5%, respectively; nevertheless, *M. rigidula*, unlike the other species, had less ME when the broadcast planting method was used (Table 5). These trends were observed in both years. Overall, the highest amount of MD was recorded in *M. rigidula* that was planted by row method in 2011. The effects of all sources of variance, except for interaction (i.e. years, sowing method and cultivar at 1% PL), were significant on digestibility (Table 3). Digestibility of *Medicago* species using row planting was less than that employing broadcast planting method (Table 4). Also, digestibility of *M. rigidula* was higher than that of the other *Medicago* species. Row planting was the best method for *M. rigidula*, but broadcast method was the most successful for *M. polymorpha* and *M. scutellata* (Table 5). Overall, the difference observed between the highest and the lowest levels of digestibility was between *M. rigidula* planted by the row method in 2011 and *M. polymorpha* planted by the row method in 2010, by 16%.

Table 5. The interaction effect of sowing methods on some quality and quantity characteristics of three annual *Medicago* species (*Medicago* spp.).

Year	Sowing Method	Species	TFw [‡]	SFW	S/R	P	CF	EE	NDF
2010	RP	<i>M. polymorpha</i>	325.10 a [‡]	275.50a	27.62b	0.45a-c	19.11e	32.22bc	32.838c
		<i>M. rigidula</i>	9.12g	8.07d	14.15c	0.48ab	17.48f	58.05a	39.853ab
		<i>M. scutellata</i>	137.40d	4.63e	4.84d	0.38bc	30.39a-d	48.29ab	27.552d
	BP	<i>M. polymorpha</i>	294.35b	261.43b	36.39ab	0.49ab	21.85c-e	61.20a	37.617a-c
		<i>M. rigidula</i>	12.00f	9.57d	9.87cd	0.53a	20.02e	37.61bc	34.77bc
		<i>M. scutellata</i>	43.50e	33.77c	48.1a	0.27d	32.43ab	22.77c	32.635c
2011	RP	<i>M. polymorpha</i>	339.30a	287.76a	31.15b	0.47a-c	19.67e	33.17bc	33.803c
		<i>M. rigidula</i>	9.61fg	8.43d	17.65c	0.50a	18.00ef	59.75a	41.023a
		<i>M. scutellata</i>	155.03c	4.92e	8.34d	0.39bc	31.29a-c	49.71ab	28.36d
	BP	<i>M. polymorpha</i>	310.12ab	273.39a	39.90ab	0.51a	22.50b-e	63.00a	38.72ab
		<i>M. rigidula</i>	12.90f	10.38d	13.31cd	0.55a	20.61de	38.72bc	35.79bc
		<i>M. scutellata</i>	47.53e	36.91c	51.6a	0.28cd	33.38a	23.44c	33.593c

†- TFW, Total fresh weight; SFW, Shoot fresh weight; SDW, Shoot dry weight; RDW, Root dry weight; S/R, Shoot to root dry weight ratio; WCf, Water content based on fresh weight. OM, Organic matter; Ca, Calcium; P, Phosphorous; CP, Crude protein; EE, Extract ether; CF, Crude fiber; NDF, Natural detergent fiber; NFE, Nitrogen free extract; ME, Metabolic energy; DE, Digestibility.

‡- ns, * and ** are non-significant, significant at the 5% and 1% probability levels, respectively.

DISCUSSION

Although no significant difference was observed among the qualitative traits (except for total fresh weight), most traits (such as, the growth condition, precipitation,

humidity and temperatures) appeared to be higher in 2011 (Table 2).

The sowing method is a major contributing factor to affect crop vigor which ultimately leads to better yield (12). In this study, methods of sowing had a significant effect on root dry weight, shoot to root dry weight ratio (S/R) and water content. Root dry weight was higher in *Medicago* planted by the row method (4.18 g vs. 1.35 g), while the amount of S/R and water content was higher in *Medicago* planted by the broadcast method by 102.5 and 37.2%. Collins and Fowler (7) indicated that broadcasting planting method was considered inferior to other methods (row planting and intercropping). These results confirmed that sowing method was responsible for *Medicago* growth and performance. The sowing method can affect nutrient availability from sun light penetration into the canopy for photosynthesis (6). Persian clover was investigated and the study concluded that traditional planting was the recommended method for more forage production (26).

In terms of quantitative traits, *M. polymorpha*, compared with the other two species, had higher total and shoot fresh and dry weight, and S/R. There were no significant differences between root dry weight and water content; however, *M. polymorpha* had remarkably more growth and canopy size than the other species, especially *M. rigidula*. William et al. (25) showed that *M. scutellata* Mill. cv. Robinson had an ability to produce the higher seeds. In research done by Dorry (9), there were differences between several cultivars of annual medics, which were 1.83, 1.76, 1.69, 1.51, 1.5, 1.43, 1.3 and 1.25 for Robinson, Sava, Herald, *M. minima*, Caliph, Mogul, Orion and Spineless, respectively. Dorry (9) indicated that some cultivars had higher leaf production than others and that this was advantageous to forage production. Forage quality is directly related to growth traits such as fresh and dry weight of shoot as well as S/R. The proportion of leaves in *Medicago* is the main factor to determine quality of the crop both in terms of protein content and digestibility of its cell wall material (9).

Considering most of the quantitative traits (except for S/R and water content), the best method for planting *M. polymorpha* was row method. This method was also the best for S/R of *M. rigidula*. Soil improvement for nutrient uptake and water use efficiency as a result of row planting was reported (10). For other traits of *M. rigidula*, the row planting method was shown to be better (the amount of traits) than broadcast method. The best *M. scutellata* planting method was broadcast planting, except in terms of total fresh weight and S/R. Overall, maximum of growth (i.e. TFW, SFW, SDW and RDW) was obtained in *M. polymorpha* plants planted by the row method in 2011. However, in 2011, the maximum amounts for S/R and water content were recorded in *M. scutellata* and *M. rigidula*, respectively, when planted by broadcast method. The higher S/R was an indicator of better quality forage due to more aboveground than belowground weight. Also, water content can be a suitable indicator for palatability of forage (8). The highest level for forage production was observed in *M. polymorpha*, compared to the other two species (16). This indicates the potential of *M. polymorpha* for being planted in Iranian pastures, especially if the row planting method is used.

Only organic matter (OM), crude protein (CP) and digestibility (DE) were significantly different comparing the two years, and all evaluations [i.e. OM (84.6 vs. 86.7%), CP (17.7 vs.18.4), DE (2699.2 vs. 2778.47%)] were higher in 2011 than in 2010. Although non-significant, the amounts of other qualitative traits were higher in 2011 than in 2010. As noted above, these differences could be due to greater amounts of

precipitation, relative humidity and better temperature (the optimal temperature for achieving to the better qualitative traits (Table 2).

Except for calcium, phosphorous and CP, the other quality traits were significantly affected by sowing method. The amount of ash, extract ether (EE), natural detergent fiber (NDF) and nitrogen free extract (NFE) was higher in *Medicago* sown by row method. In general, CP and NDF for most annual legumes were greater than 15 g kg⁻¹ and less than 45 g kg⁻¹, respectively (11). They provide a relative nutritive value index of >140 (23). Furthermore, some researchers have indicated that crude protein in *Medicago* ranged from 11 to 24% (9, 18, 3).

Organic matter (OM), crude fiber (CF), digestibility (DE) and metabolic energy (ME) were also different when comparing the outcomes of two sowing methods. OM, CF, DE and ME were greater in plants sown by broadcast method compared to those sown by row planting method by 3, 12, 4 and 4%, respectively. As noted by Dorry (9), DE and CP are factors having the biggest effect of quality of *Medicago*, determined by the proportion of leaves in a plant.

In terms of qualitative traits, there were significant differences between the three *Medicago* species in the study. Amounts of ash were higher in *M. polymorpha* than in the other two species (i.e. *M. rigidula* and *M. scutellata*) by 10.6 and 51.0%, respectively. Also, the highest Ca (2.2%), P (0.52%), CP (19.1%), NDF (48.5%), NFE (37.8%), ME (2352.0 M cal kg⁻¹) as well as DE (2785.1 M cal kg⁻¹) were recorded in *M. rigidula*. Differences in NDF with maturity between annual legumes have been reported Shreshta et al. (18). In addition, *M. scutellata* had higher amount of OM, EE and CF. The average CP content of *Medicago* species, recorded in this study, was comparatively higher than those observed by Williams et al. (25), Panciera and Sparrow (15), and Fraser et al. (11). These high nutritive values and intake characteristics lead to good performance of livestock production.

The interaction effect of sowing methods and species on P, EE, CF and NDF was significant. P content of *M. polymorpha* and *M. rigidula* was higher when sown by broadcast planting method, while it was higher when row planting method was used for *M. scutellata*. In both sowing methods, *M. polymorpha* had more P than the other two species in both years. The more suitable sowing method for EE amount of *M. polymorpha* and *M. rigidula* was row planting, whereas broadcast planting method was more appropriate for *M. scutellata*. In both years, in terms of EE, there were no significant differences between the *Medicago* species sown by row method. As noted by Tabacco et al. (22) improved forage quality can be obtained in several ways such as growing cultivars specifically selected for their quality. Thus the quality of measured traits can be an indicator for the selection of a species that has the best quality forage.

Sowing by the broadcast method caused an increased amount of CF in all three species. CF was higher in *M. scutellata* than in the other two species. The broadcast method of sowing caused an increase in *M. polymorpha* and a decrease in *M. rigidula* and *M. scutellata* in terms of NDF. Furthermore, the amounts of NDF of *M. rigidula* were higher under conditions of row planting but using the broadcast method increased the NDF content of *M. rigidula*. The increase in the NDF contents resulted in decreasing forage quality (22). In order to satisfy nutrient requirements of high performing dairy cows, forage should have NDF of 370 g kg⁻¹ DM or less (4 and 14).

CONCLUSIONS

In the south area of Iran, the quality and quantity of pasture for grazing animals can be increased by improving agronomic aspects that makes them more nutritious and productive. These aspects can involve the sowing methods and species of annual *Medicago*. The choice of sowing method can have a major influence on the processes of germination and seedling survival. The results of our study showed that sowing methods had significant effects on quality and quantity traits of three annual *Medicago* species. Furthermore, the methods appeared to have significant different effects on the species. The results indicated that planting by row method increased quantity traits. That is to say, more forage production was achieved in *Medicago* that was sown by row method. However, broadcast method of planting increased qualitative traits so that better forage quality was achieved in *Medicago* when sown by the broadcast method. *Medicago polymorpha* remarkably produced more forage than the other two species. Overall, the row method was more suitable method for planting *M. polymorpha*; however, broadcast planting method was more appropriate for planting *M. scutellata* and *M. rigidula*

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تأثیر روش های کاشت بر ویژگی های کیفی و کمی سه گونه یونجه یکساله

حسین صادقی^{۱*}، غلامعباس قنبریان^{۱*} و علیرضا بیات^{۲*}

^۱بخش مهندسی منابع طبیعی و محیط زیست، دانشکده کشاورزی دانشگاه شیراز، شیراز، ج.ا. ایران

^۲موسسه تحقیقات تولید دام - فنلاند

چکیده- گونه های یونجه یکساله (*Medicago spp.*)، که بومی مناطق مدیترانه ای هستند، به طور گسترده در مزارع و مراتع ایران کشت می شوند. روش های مختلفی برای کشت یونجه های یکساله وجود دارد؛ و اگرچه روش کشت بر نمود گیاه اثر می گذارد، ولی اطلاعات کمی در مورد روش های کشت یونجه های یکساله وجود دارد. به منظور بررسی تأثیر روش های کاشت (دست پاش و کشت ردیفی) بر ویژگی های کمی و کیفی سه گونه یونجه یکساله (*M. rigidula*, *M. polymorpha* and *M. scutellata*)، پژوهشی مزرعه ای 2 ساله در قالب طرح اسپلیت پلات بر پایه بلوک های کامل تصادفی در 3 تکرار در دانشکده کشاورزی دانشگاه شیراز در سال های زراعی 1389 تا 1390 طراحی و اجرا گردید. بر اساس نتایج تجزیه مرکب داده ها برای بیشتر صفات تفاوت معنی داری در بین دو سال وجود نداشت. نتایج نشان داد که یونجه های کشت شده در روش ردیفی دارای وزن خشک ریشه، مقدار خاکستر، عصاره اتری (EE)، الیاف محلول در شوینده خنثی (NDF) و عصاره خالص (NFE) بیشتری بودند. همچنین مشخص شد که نسبت وزن خشک ساقه به ریشه، محتوای رطوبت، ماده آلی (OM)، انرژی متابولیسی (ME) و انرژی هضم پذیری (DE) در یونجه های کشت شده به صورت دست پاش بیشتر بود. همه ویژگی های کمی و مقدار خاکستر گونه *M. polymorpha* نسبت به دو گونه دیگر بیشتر بود. گونه *M. scutellata* دارای درصد بیشتری OM، EE و الیاف خام بود؛ از سوی دیگر گونه *M. scutellata* نیز دارای مقادیر بیشتری کلسیم، فسفر، پروتئین خام، NDF، NFE، ME و DE بود. بیشترین عملکرد علوفه در گونه *M. polymorpha* که به صورت ردیفی کشت شده بود در هر دو سال، به ویژه در سال دوم، مشاهده شد. به طور کلی نتایج این آزمایش بیان کرد که کشت ردیفی، روش مناسبی برای کشت گونه *M. polymorpha* است، در حالی که کشت دست پاش روش بهتری برای کشت گونه های *M. rigidula* و *M. scutellata* شناسایی شد.

واژه های کلیدی: انرژی هضم پذیری، پروتئین خام، کشت دست پاش، کشت ردیفی، یونجه های یکساله

*به ترتیب دانشیار، استادیار و پژوهشگر

**مکاتبه کننده