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Effect of Planting Density on Productivity of Six Species of Annual Medics

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ABSTRACT

This study was conducted on six species of annual medic, which can survive in different climates, produce sufficient forage, and improve fertility of the soil effectively. Four levels of density were 800, 1000, 1200 and 1400 plants m^{-2} (factor A: species, factor B: density). The results showed a significant difference in weight of dried forage among the diverse species in one level of density. There was also significant difference among diverse density in the weight of dried forage. Among the species, *Medicago litoralis* was the most forage-producing (1528 kg ha^{-1}), while *M. rigidula* the least productive (950.8 kg ha^{-1}). Data revealed that dry forage production was the greatest (1476 kg ha^{-1}) at planting density of 1400 plants m^{-2}, compared to 800 plants m^{-2} (producing 1095 kg dry forage). It is suggested that a density of 1400 plants ha^{-1} may be used for high productivity and improving fertility in dry lands with all species except *M. truncatula*.

Key Words: Annual medics; Density; Productivity

INTRODUCTION

One of the most important factors, which influence high productivity and the improvement on dry lands and rangelands is the cultivation density and seeding of annual medics. The lack of nutrients, erosion and the decrease of fertility in dry lands soil and rangelands impose a great loss upon economy. Annual medics not only compensate the above-mentioned losses but also control un-wanted weeds. It signifies a progressive pace towards sustainable agriculture (Bauchan, 2000; Groose, 2001; Shrestha *et al*., 2001). The vital issue in development of cultivation program of annual medics is climate conditions, soil and cultivation density. So as an alternative cultivation system of cereals and annual medics (ley-farming system) is largely used in the south of Australia (Puckridge *et al*., 1983).

The annual medics cultivation can improve about 10-12 million hectares (Mha) of rain-feeds in Iran. It can also produce considerable amount of dried forage. This species can be also used in combining cultivation in 7 Mha of fallow lands in the country (Torknezhad, 1998). Annual medics are capable of producing a great amount of forage. Diversity in growth of annual medics and their rapid growth make a suitable vegetation cover, which helps the preservation of soil. The amount of 5.7 tons of DM (dry matter) per hectares can be harvested in one-time harvest in span time of 60-70 days after the cultivation (Bauchan, 2000). Studies show that over 60% of western regions of Iran have suitable temperature, geographical conditions, soil, and rainfall over 300 mm. The cultivation of annual medics in rain-feeds for producing livestock forage causes high productivity of wheat, the decrease of erosion, the increase of soil mineral material and optimum use of suitable rainfall (Francis, 1988; Torknezhad, 1998). Mediterranean countries, such as Algeria, Tunisia and Libya and other countries such as Syria and Iraq have made a great effort to cultivate annual medics for 20 years.

Modarres and Bagheri (2006) studied the effect of different cultivation densities on five annual medic species including: *M. polymorpha, M. scutellata, M. minima, M. litorallis and M. truncatula* in order to compare the productivity of dried forage. He observed that *M. polymorpha* had the maximum productivity (with mean of 2675.4 kg ha^{-1}) in high density, while M. minima had the minimum productivity (with mean of 504.6 kg ha^{-1}) in low density. The maximum productivity of dried forage also obtained from the distance on row of 20 cm. The maximum productivity of dried forage belongs to *M. truncatule* with mean of 780.07 kg ha^{-1}. The study on *M. truncatula* and *M. polymorpha* reveals that the maximum amount of produced seeds obtained from *M. trancatula* in the 100 plants density m-2 (711 kg ha^{-1}) and from *M. polymorpha* in the density of 250 plants m^{-2} (820 kg ha^{-1}).

Rahmati and *et al*. (2005) did a series of experiments in order to study the amount of production of dried forage in the different cultivation density of *Medicago scutellata* in Lorestan. He showed no significant difference between the amount of different seeds due to dried forage. Shakeel ahmad *et al*. (2005) studied on the effects of increasing plant density and irrigation regimes on yield attributes. Plant density and increasing application of irrigation significantly increased both grain yield and its components. Plant density

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with 14 irrigations produced the maximum grain yield. Azizi and *et al*. (2006) demonstrated that *Medicago trancatula* produced more seeds and also enriched the soil bank better than *M. rigidula, M. scutellata*. The present study was conducted for optimizing the best density in the different species of annual medics regarding their characteristics and benefits. Researches of Muhammad Amjad *et al*. (density of 111000, 55500 or 37000 plants ha^{-1} on seed production) in 2001, Mohd al-rifaee *et al*. (five plant populations such as 12.5, 25, 50, 100 & 150 plants m^{-2} on local faba bean yield & yield components) in 2004, Aftab Wajid *et al*. (different plant densities 200, 300 & 400 plants m^{-2} on Growth, Light Interception & Yield of Wheat under Semi Arid Conditions) in 2004, Sabagh Nekonam *et al.* (at three plant densities such as 80, 120 & 160) plants m^{-2} on Yield, Yield Components of Blond Psyllium (*Plantago ovata Forsk*.)) in 2007 and Anjum *et al*. (with 5, 10, 15 and 20 plants m^{-2} on Growth and Yield Response of *Gossypium hirsutum*) demonstrated that there is significant difference to yield, production and growth in different density.

MATERIALS AND METHODS

In order to study the effect of different densities on biomass of various species of annual medics experiment was performed in March and April in 2006 on six species of annual medics, which can survive in cold and moderate regions. The selected species were: *Medicago orbiculari, M. polymorph, M. radiata, M. littoralis M. rigidula and M. truncatula.* The experimental design was a 6×4×4 factorial employing Randomized Complete Block (RCB) with four replications within 76 days. Four levels of density were 800, 1000, 1200 and 1400 plants m-2 (factor A = species, B = density). In order to achieve the above-mentioned densities, the amount of seeds at the level of pot considered as 16, 20, 24 and 28, respectively. The experiment included 96 samples. The maintenance operations were done to meet the necessities of the experiment. The factors such as height, number of nodules and dried weight of air organs were also measured. Before sowing, the seeds were sterilized by Atelic Alcohol 98% and Hgcl solution 0.2% and pots were sterilized by atelic alcohol 98%. Results were statistically analyzed for variance using the SPSS software. Duncan's multiple range test was applied to compare the means at P=0.05, wherever needed.

RESULTS AND DISCUSSION

The results showed a difference in the dried weight of forage among various species, within a planting density. Various densities also indicated significant difference in the dry weight of forage. Species differed significantly for plant height, but non-significantly for the number of nodules, although their interactive effect was evident (Table I). Among the species, *M. littoralis* produced the maximum (1528 kg ha^{-1}) and *M. rigidula* the minimum (950.8 kg ha^{-1}) yield of forage. For planting densities, maximum dry forage yield (1476 kg ha^{-1}) was obtained from density of 1400 plants m^{-2}, while 800 plants m^{-2} yielded only 1095 kg dry forage.

Table I. The analysis of variance measured characteristic under the influence of different treatments and densities

Characteristic Treatments		Means: Dry matter (kg ha^{-1})	Means: Height (cm)	Means: Nodules
factor=A	V_1: *M. orbicularis*	1139.94	24.97	9.38
	V_2: *M. polymorpha*	1026	23.41	11.25
	V_3: *M. radiata*	950.75	21.78	11.44
	V_4: *M. littoralis*	1527.88	29.34	12
	V_5: *M. rigidula*	1420.19	21.78	11.44
	V_6: *M. truncatula*	1500.81	31.91	12.19
factor=B	$D_{1=800 \text{ plants per}}\ m^2$	1094.88	25.65	11.54
	$D_{2=1000\text{plants per}}\ m^2$	1139.38	25.54	11.29
	$D_{3=1200 \text{ plants per}}\ m^2$	1333.63	25.83	11.38
	$D_{4=1400 \text{ plants per}}\ m^2$	1475.83	25.1	10.92
Interaction A×B	V_1D_1	956	25.75	9.75
	V_1D_2	1009.25	23	9
	V_1D_3	1077.75	26.5	9.75
	V_1D_4	1516.75	24.63	9
	V_2D_1	777.25	21.75	11
	V_2D_2	1004.75	25.25	11.5
	V_2D_3	1023	23.5	11.25
	V_2D_4	1299	23.13	11.25
	V_3D_1	814.25	22.25	11.75
	V_3D_2	1012	23.63	11
	V_3D_3	775.75	20	11.25
	V_3D_4	1201	21.25	11.75
	V_4D_1	1340	30.5	12
	V_4D_2	1273.25	26.63	11.75
	V_4D_3	1724.25	29.88	12.25
	V_4D_4	1774	30.38	12
	V_5D_1	1366.25	22.88	12.25
	V_5D_2	1244.25	22.5	12.5
	V_5D_3	1519	22.5	11.25
	V_5D_4	1551.25	19.25	9.75
	V_6D_1	1315.5	30.75	12.5
	V_6D_2	1292.75	32.25	12
	V_6D_3	1882	32.63	12.5
	V_6D_4	1513	32	11.75
Means of Treatments		1260.93	25.53	11.28
Factor A		**	**	**
Factor B		**	ns	*
Factors A×B		ns	ns	*

*: significant at 5% **: significant at 1% probability level and ns: non significant

M. truncatula indicated maximum height (31.91cm), while *M. radiata* the minimum (21.78cm). *M. truncatula* has the greatest number of nodules (12.19), while *M. orbicularies* the smallest (9.38). Nodule number was 11.54 in the density of 800 plants per m2 and in the density of 1400 plants m^{-2} was (Table II). The interacting effect of density and species regarding nodules indicated a significant difference. It also classified into 6 groups. *M. truncatula* had the maximum nodules in the density treatment of 1200 plants m^{-2}, while *M. orbicularis* had the minimum number of nodules at a planting density 1000 plants m^{-2} (Table III).

Table II. The classification of means of dried forage weight, the height of plant, and the number of nodules

Dry matter (kg ha^{-1})			height (cm)			Number of nodules in clone		
Factor A	**mean**	**Means comparison**	**Factor A**	**mean**	**Means comparison**	**Factor A**	**mean**	**Means comparison**
M. littoralis	1528	a	*M. truncatula*	31.91	a	*M. truncatula*	12.19	a
M. truncatula	1501	a	*M. littoralis*	29.34	b	*M. littoralis*	12	ab
M. rigidula	1420	a	*M. orbicularis*	24.97	c	*M. rigidula*	11.44	bc
M. orbicularis	1140	b	*M. polymorpha*	23.41	cd	*M. radiata*	11.44	bc
M. polymorpha	1026	bc	*M. rigidula*	21.78	d	*M. polymorpha*	11.25	c
M. radiata	950.8	c	*M. radiata*	21.78	d	*M. orbicularis*	9.38	d
Factor B	mean	Means comparison	Factor B	mean	Means comparison	Factor B	mean	Means comparison
D_4(1400 plants)	1476	a	-	-	-	D_1(800 plants)	11.54	a
D_3(1200 plants)	1334	a	-	-	-	D_3(1200 plants)	11.38	ab
D_2(1000 plants)	1139	b	-	-	-	D_2(1000 plants)	11.29	ab
D_1(800 plants)	1095	b	-	-	-	D_4(1400 plants)	10.92	b

Table III. The classification of means of the number of nodules in six species of annual medics under influence of different densities (the interaction effect of species in density)

Treatments	Means	Means Comparison	Treatments	Means	Means Comparison
M. truncatula×$_{1200\ plants}$	12.5	a	*M. polymorpha*×$_{1000\ plants}$	11.5	abc
M. truncatula×$_{800\ plants}$	12.5	a	*M. polymorpha*×$_{1200\ plants}$	11.25	bc
M. rigidula×$_{1000\ plants}$	12.5	a	*M. polymorpha*×$_{1400\ plants}$	11.25	bc
M. rigidula×$_{800\ plants}$	12.25	ab	*M. rigidula*×$_{1200\ plants}$	11.25	bc
M. littoralis×$_{1200\ plants}$	12.25	ab	*M. radiata*×$_{1200\ plants}$	11.25	bc
M. littoralis×$_{800\ plants}$	12	abc	*M. radiata*×$_{1000\ plants}$	11	c
M. littoralis×$_{1400\ plants}$	12	abc	*M. polymorpha*×$_{800\ plants}$	11	c
M. truncatula×$_{1000\ plants}$	12	abc	*M. orbicularis*×$_{800\ plants}$	9.75	d
M. littoralis×$_{1000\ plants}$	11.75	abc	*M. rigidula*×$_{1400\ plants}$	9.75	d
M. radiata×$_{1400\ plants}$	11.75	abc	*M. orbicularis*×$_{1200\ plants}$	9.75	d
M. radiata×$_{800\ plants}$	11.75	abc	*M. orbicularis*×$_{1400\ plants}$	9	d
M. truncatula×$_{1400\ plants}$	11.75	abc	*M. orbicularis*×$_{1000\ plants}$	9	d

The means mentioned in each column having no words in common illustrate significant difference to each other at the level of 99%

The density of 1400 plants per m^2 in different species produced 10%, 29% and 39% more yield than the densities of 800, 1000 and 1200, respectively. So the density of 1400 plants was optimal for all species, with the exception of *M. truncatula*. Silsbury and Fukai (1978) carried out a series of experiments to determine the suitable density of annual medics. They suggested 1000-2000 plants m^{-2} as perfect density. This result is quite in agreement with the present study. Catterton (1989) also took the idea that the density lower than 500 plants m^{-2} was not sufficient for annual medics to enrich the soil with nitrogen for the followed by cereal crop.

The suitable density usually selected according to the amount of seeds. In order to have a suitable cover for annual medics, an amount of 200 kg seeds ha^{-1} is required. So the considerable proportion of hard seeds in annual medics demands high density of seed cultivation in order to obtain the maximum biological productivity. The result of present study illustrates the high production of forage in *M. littoralis,* which is quit in disagreement with the results obtained by Modarres and *et al.* (2005), who found that *M. polymorpha* is the best for forage production. This may be due to the climate conditions and region. The results showed that *M. truncatula* has the maximum plant height and productivity. In his study, Azizi (2006) also demonstrated that *M. truncatula* could produce a large amount of seeds and enrich soil bank more comparing to the rest of the species.

CONCLUSION

The selection of species and cultivation density can improve the dry lands and influence directly the plant height and the number of nodules. *M. littoralis* in planting density of 1400 plants m^{-2} may have positive effects on annual medics productivity in dry lands.

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