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Effect of Different Fertilizing Systems on Seed Yield and Phosphorus Uptake in Annual Medics under Dryland Farming Conditions

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Abstract

The effect of different fertilizing systems on the seed yield and phosphorus uptake in annual medic (*Medicago scutellata* cv. 'Robinson') was examined at two locations under dry farming conditions in Kermanshah province, Iran, in 2009. Experiments were conducted based on a randomized complete block design with three replications; the treatments consisted of control (no fertilizer), chemical fertilizer, biological fertilizer and different combinations of chemical and biological fertilizing systems. The results showed that application of different fertilizing systems had a highly significant effect ($P<0.001$) on the number of pods per plant. The highest values were obtained in the treatment using the urea chemical fertilizer + phosphorus-solubilizing bacteria + mycorrhiza. The highest soil seed bank was recorded in the nitrogen-fixing bacteria + phosphorus-solubilizing bacteria treatment; it increased the number of seeds by approximately 50 percent compared to the control (only 134 pod containing seeds). The highest pod yield was obtained after applying nitrogen-fixing bacteria + mycorrhiza (445 kg/ha), the lowest yield in the control treatment (266 kg/ha). In general, under the conditions of this experiment, the seed yield of annual medic var. 'Robinson' receiving nitrogen-fixing + phosphorus-solubilizing bacteria out-yielded other fertilizing treatments. This indicates a synergistic interaction between these groups of bacteria that increases seed yield, the soil seed bank as well as the seed phosphorus uptake of this plant species under dry farming conditions.

Keywords: annual medics, mycorrhiza, nitrogen-fixing bacteria, solubilizing bacteria

Introduction

In rotation with other agricultural crops, annual medics have a better water use efficiency; this feature makes them a suitable crop in rotation with wheat in dry climatic conditions (Weston, 1996). Establishing a wheat-annual medic rotation system, however, depends on a sufficiently high rate of seed production by annual medics. Experiments show that the success or failure of such a system is strongly related to seed production potential (Donald, 1967; Olsen and Sommers, 1990).

The term "soil seed bank" is applied to a set of seeds that remains intact and alive in the soil for various reasons such as seed hardiness or lack of suitable conditions for germination. A soil seed bank changes according to the growth conditions of different areas and the intensity and duration of grazing (Christiansen and Cocks, 1994). If the seed reserve in soil is below a threshold number of seed-containing pods per square meter, then the natural regeneration of annual medic will not be successful (Kassaim, 1979). This criterion, however, varies with different medic species and varieties. Examples include *Medicago rigidula* (about 600 pods/m^2) and *Medicago scutellata* (250 pods/m^2; Francis, 1988).

Soil quality depends not only on its physical and chemical characteristics, but is also closely related to its biological activities (Ebhin Masto *et al.*, 2006). Biological fertilizers, for example, are composed of different kinds of symbiotic microorganisms. Through biological processes they can change prime nutrients from an unavailable form to an available form, extend the root system and improve seed germination (Chen, 2006; Rajendran and Devaraj, 2004; Vessey, 2003).

Mycorrhizae improve the host plant's ability to absorb immobile nutrients, especially phosphorus and several other macronutrients. Mycorrhizae therefore improve the physical quality of the soil by extending the fungal mycelium, improve its chemical quality by promoting nutrient absorption, and improve its biological quality via the soil's nutritional network (Cardoso and Kuyper, 2006). A range of experiments has showed a synergetic interaction between mycorrhizae and rhizobia: their simultaneous inoculation with the plant increases plant phosphorus uptake and improves growth (Piccini and Azcon, 1987).

Mycorrhiza fungi moderate the adverse effects of drought. The symbiosis of the mycorrhiza with most crop roots under drought conditions improves crop productivity by absorbing more immobile nutrients such as phosphorus, zinc and copper. Moreover, crop drought tolerance is increased by improved water absorption and better leaf water potential, increased root length and depth, and developing terminal hyphae (Al-Karaki *et al.*, 2003; Vamerali *et al.*, 2003). Mycorrhizae improve the interaction between water and the host plant by increasing the soil's hydraulic conductivity, increasing the perspiration ratio, and decreasing stomata resistance by changing the crop's hormonal balance. These changes improve the phosphorus uptake by mycorrhizal-inoculated crops under drought conditions (Elwan, 2001). Under humid conditions, the hydraulic conductivity of root systems was higher in mycorrhizal-inoculated crops versus non-mycorrhizal crops. This was due to the increased root length of the former (Zahra and Loynachan, 2003). Nadian *et al.* (1998) reported that the dry matter of mycorrhizal-inoculated berseem clover was significantly higher than the control. Applying *Rhizobium* sp. bacteria along with the mycorrhiza fungi increased clover growth: both the shoot dry matter and the leaf area index increased by a factor of five. Newman and George (2004) found no significant differences in the phosphorus content of mycorrhizal and non-mycorrhizal crops.

Joint inoculation of *Azotobacter* and *Rhizobium* increases faba bean yield as well as mineral elements (Rodelas, 1999). Piccini and Azcon (1987) examined the effect of phosphate-solubilizing bacteria and mycorrhizal fungi on alfalfa and reported that applying phosphate-solubilizing bacteria increased the absorption of potassium and phosphorus nutrients as well as the biological yield of alfalfa.

There is a need to manage plant nutrition to increase and stabilize the yield in dry farming systems. At the same time, there is a need to conserve the environment. No research, however, has been done on the effect of biological fertilizers on the growth, yield, and conservation of the soil seed bank of annual medic. The present experiment was therefore designed to study the effect of different fertilizing systems on the pod and seed yield as well as on the phosphorus uptake in annual medic (*Medicago scutellata* var. 'Robinson').

Material and methods

This experiment was conducted in two locations during the 2009 growing season: 1. Sararood Dryland Farming Research Station (longitude 47°20′ latitude 34°20′; elevation 1351 m above sea level), and 2. Mahidasht Soil Fertility Research Station (longitude 46°50′ latitude 24°16′; elevation 1380 m above sea level). Selected physical and chemical characteristics of soil and climatic information of two experimental sites are shown in Tab. 1 and 2.

The experimental sites in both locations were kept as fallow in the preceding year. The experiment was conducted in the form of a randomized complete block design with three replications. Soil samples were collected prior to the experiment. The experimental treatments consisted of control (without fertilizer), chemical, biological and integrated fertilizing systems as follows:

T_0: Control (no fertilizer application)

T_1: Chemical fertilizer (135 kg/ha urea fertilizer + 185 kg/ha triple superphosphate fertilizer)*

T_2: Urea chemical fertilizer + phosphorous-solubilizing bacteria

T_3: Urea chemical fertilizer + mycorrhiza

T_4: Urea chemical fertilizer + phosphorous solubilizing bacteria + mycorrhiza

T_5: Nitrogen-fixing bacteria + triple superphosphate fertilizer

T_6: Nitrogen-fixing bacteria + phosphorous-solubilizing bacteria

T_7: Nitrogen-fixing bacteria + mycorrhiza

T_8: Nitrogen-fixing bacteria + phosphorous-solubilizing bacteria + mycorrhiza

*Chemical fertilizers triple superphosphate and urea were applied according to a soil test to fulfill the requirements of the crop in each site.

Tab. 1. Selected physical and chemical characteristics of soil (0-30 cm depth) in two experimental sites

Characteristic	Experimental stations	
	Sararood	Mahidasht
pH	7.68	7.93
Dissolved solids (EC.103)	30.0	55.0
Organic carbon (%)	0.31	0.62
$CaCO_3$ (%)	30	28
Olsen phosphorus (mg kg^{-1})	8.00	9.40
Available potassium (mg kg^{-1})	530	430
DTPA extractable Zn (mg kg^{-1})	0.38	1.56
DTPA extractable Cu (mg kg^{-1})	0.70	1.40
DTPA extractable Fe (mg kg^{-1})	2.00	4.76
DTPA extractable Mn (mg kg^{-1})	2.42	3.78
Soil texture	Loamy silt	Loamy clay

Land preparation took place before sowing annual medic in early March. All experimental plots consisted of 6 planting rows that were 5 m long and 25 cm apart . The annual medic var. 'Robinson' was planted at a rate of 20 kg of seed/ha. Before sowing, based on soil analysis and according to fertilizer recommendations for annual medic, half of the urea fertilizer and all of the phosphorus fertilizer (in treatments containing phosphorus chemical fertilizer) were applied to the soil. Nitrogen and phosphorus chemi-

Tab. 2. Climatic information for the two experimental sites during the annual medic growing season

Month	Average precipitation (mm)		Average temperature (°C)	
	Sararood	Mahidasht	Sararood	Mahidasht
Feb.	18.3	21.2	7.3	6.4
Mar.	36.1	71.8	9.4	8.0
Apr.	15.2	12.4	16.2	14
May	0.2	0.9	22.7	19.7
Jun.	0	0	26.5	24.0

cal fertilizers were applied to the soil in bands. The remainder of the nitrogen fertilizer was applied to each plot when the plants reached the four-leaf stage, respectively.

After calculating the number of seeds per treatment, the seeds were placed into a polyethylene bag (30 mg of each inoculation substance for 100 g of seed) along with 4% Arabic gum solution. The seed and the adhesive substance were then gently shaken for 30 s. One gram of inoculation substance was added to the adhesive seeds and shaken for 45 s, ensuring that the inoculation substance was uniformly distributed among the seeds.

At the end of experimental period, soil samples were randomly taken from 0 to 5 cm depth in each plot in both experimental locations using an auger to measure the soil seed bank. The soil samples were taken to the laboratory and, after segregating the seeds from the soil, passed through sieve numbers 8 and 10; this removed all impurities. The samples were again passed through sieve numbers 8 and 10, which were stacked, to separate the particles. The soil was washed through the sieves repeatedly until the water became clear. In order to verify that no seeds were left among the gravel and sand in the container, the contents were placed in 25% saline water and the seeds floating on the surface of the salt water were collected. The soil seed bank population was determined after gathering the seeds from the salt water surface. Pod phosphorus content was measured spectrophotometrically using the method of Olsen and Sommers (1990).

The data were analyzed using the SAS software package. An analysis of variance was performed for each trait using the GLM procedure to test the significance of differences among locations, treatments and location by treatment interactions. Comparisons of all means were done at the 5 percent probability level based on a least significant difference (LSD) method.

Results and discussion

Pod number per plant

Applying different fertilizing systems had a highly significant effect ($P<0.001$) on the number of pods per plant (Tab. 3). The highest values were obtained in the treatment using the urea chemical fertilizer + phosphorus-solubilizing bacteria + mycorrhiza (T_4), followed by that using nitrogen-fixing bacteria + mycorrhiza (T_7) and nitrogen-fixing bacteria + phosphorus-solubilizing bacteria + mycorrhiza (T_8). Significantly fewer pods were recorded in the control treatment (T_0) compared to other treatments. Overall, applying the T_4 fertilizing system increased the amount of pods in the plant by 28.2% compared to the control (Tab. 4). This points to a synergistic effect between chemical fertilizer and the application of phosphorus- solubilizing bacteria and mycorrhiza on pod development in annual medic. Studies on sugar beet and barley growth and development show a similar positive effect of chemical fertilizer application along with inoculation with phosphorus-solubilizing and nitrogen-fixing bacteria (Ferrettin *et al.*, 2004).

The interaction effects indicated significant differences between traits in the two experimental sites. The highest number of pods per plant was recorded in T_7 in Sararood and T_8 in Mahidasht (significantly higher than in the other treatments). The treatments including integrated fungi and bacteria components had synergistic effects on the number of pods per plant in annual medic.

The better climatic conditions at the Mahidasht site (more and better distribution of rainfall, moderate temperature; Tab. 2) caused a better response in the number of pods per plant to most fertilizer treatments compared to the Sararood site; exception: T_7 treatment).

Soil seed bank

The, soil seed bank was significantly influenced by the experimental sites and different fertilizing treatments (Tab. 3 and 4). The highest soil seed bank was recorded in the nitrogen-fixing bacteria + phosphorus solubilizing bacteria (T_6) treatment, which increased the number of seeds by approximately 50% compared to the control (only 134 pods containing seeds; Tab. 4). Applying a combination of nitrogen-fixing bacteria + phosphorus-solubilizing bacteria intensified the effect of the fertilizer, improved crop growth and ultimately increased the soil seed bank. Comparing the two experimental sites also showed that the soil

Tab. 3. The Anova of annual medic agronomic characteristics as affected by different fertilizing systems under dry farming conditions (experimental sites: Sararood and Mahidasht Experimental Stations)

SOV	Df	Pods per plant	Soil seed bank	100-seed weight	Pod yield	P-concentration	P-uptake
		Pr > F					
Location (L)	1	<0.0001	<0.0001	<0.0001	<0.0001	0.0013	<0.0001
Treatment (T)	8	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
L*T	8	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001

Tab. 4. The effect of different fertilizing systems on seed characters at the two experimental research stations

Treatment	Pods per plant (no)			Soil seed bank (no/m^2)			100-seed weight (g)		
	Location		Mean	Location		Mean	Location		Mean
	L_1	L_2		L_1	L_2		L_1	L_2	
T_0	7.80	8.70	8.25^{b}	130	137	134^{d}	15.5	24.2	19.8^{ab}
T_1	8.43	10.8	9.63^{bcd}	198	250	224^{bc}	15.3	19.6	17.4^{bc}
T_2	7.60	10.6	9.12^{cd}	195	227	211^{bc}	13.3	20.0	16.6^{cd}
T_3	8.43	9.83	9.13^{cd}	185	205	195^{c}	13.4	18.5	15.9^{cde}
T_4	10.2	12.7	11.5^{a}	176	315	245^{ab}	14.4	14.4	14.4^{def}
T_5	8.63	9.00	8.81^{d}	209	255	232^{abc}	9.9	15.6	12.7^{f}
T_6	8.50	12.3	10.4^{abc}	280	258	269^{a}	10.0	16.4	13.2^{ef}
T_7	12.4	8.70	10.5^{ab}	185	279	232^{abc}	25.4	16.1	20.7^{a}
T_8	8.40	12.9	10.6^{ab}	157	311	234^{ab}	14.0	16.9	15.4^{cdef}
Mean	8.94^{b}	10.6^{a}		191^{b}	248^{a}		14.6^{b}	17.9^{a}	
$LSD_{local*treat}$ (5%)	1.95			53.2			4.09		

T_0: Control (no fertilizer application); T_1: Chemical fertilizer (135 kg/ha urea fertilizer + 185 kg/ha triple superphosphate fertilizer); T_2: Urea chemical fertilizer + phosphorus-solubilizing bacteria; T_3: urea chemical fertilizer + mycorrhiza; T_4: urea chemical fertilizer + phosphorus-solubilizing bacteria + mycorrhiza; T_5: Nitrogen -fixing bacteria + triple superphosphate fertilizer; T_6: Nitrogen-fixing bacteria + phosphorus-solubilizing bacteria; T_7: nitrogen-fixing bacteria + mycorrhiza; T_8: Nitrogen-fixing bacteria + phosphorus-solubilizing bacteria + mycorrhiza

seed bank was significantly influenced by the experimental locations (Tab. 3). Annual medic in Mahidasht had a larger soil seed bank than Sararood (Tab. 4). The treatment using nitrogen-fixing bacteria + phosphorus-solubilizing bacteria (T_6) produced the richest soil seed bank (269 pods/m^2). Because of more in rainfall (Tab. 2), the soil seed banks contained more pods at Mahidasht than at Sararood. The fertilizing systems in annual medic must be adjusted such that the plant can produce a sufficient amount of seed to create a rich soil seed bank to ensure its natural regeneration. The critical limit for a successful re-establishment of annual medic in a ley farming system for *Medicago scutellata* is an average of 250 pods/m^2. This critical limit, however, varies with different species and types of annual medic. For *Medicago rigidula* and *Medicago scutellata*, for example, approximately 600 and 250 pods/m^2, respectively, are sufficient (Francis, 1988). In this experiment the treatment using nitrogen-fixing bacteria + phosphorus-solubilizing bacteria (T_6) enabled sufficient seed production and a rich soil seed bank for successful natural regeneration; it stood out among the other fertilizing treatments in this respect. Applying a combination of different fertilizing systems containing bacteria and mycorrhiza had a positive effect on annual medic growth and seed production in our experiment. These results are supported by Wasule *et al.* (2002), who observed the synergistic effect of applying the nitrogen-fixing symbiotic bacteria *Brady rhizobium* and the phosphate-solubilizing bacteria *Pseudomonas putida* on soybean.

The interaction effect of fertilizing treatments and experimental sites indicated that the T_4 treatment produced the highest number of pods in the soil seed bank in Mahidashte, whereas the T_6 treatment created the richest soil seed bank in Sararood. The better soil seed reserves in Mahidash versus Sararood under all different fertility treatments can be explained by the more favorable climatic conditions in the former site (greater mean annual precipitation).

100-seed weight

The effect of fertilizing treatments on the weight of 100 seeds was significant ($P<0.05$) (Tab. 3). The heaviest weight was obtained in T_7 (nitrogen-fixing bacteria + mycorrhiza)(20.7 g; Tab. 4). This probably reflects the beneficial effect of integrated fertilizing systems in increasing the available nutrients, improving photosynthesis, better distributing photosynthetic substances to sinks, and improving crop growth. The 100-seed weight and the pod number per plant were highly significantly correlated (Tab. 6). The lower 100-seed weight in treatment T_5 (nitrogen-fixing bacteria + triple superphosphate fertilizer) may be due to the limited availability of nutrients in post-blooming stages; this greatly decreased the plants' ability to produce photosynthesis substances. This may be due to the harmful effects of chemical fertilizer, which offer inappropriate nutrients to provide enough substances within the seeds. Sufficient rainfall at Mahidasht (Tab. 2) enhanced the vegetative growth of annual medic var. 'Robinson', produced adequate photosynthetic substances for seed reserves, promoted the growing period and ultimately led to a higher 100-seed weight (Tab. 4).

Pod yield

Pod yield was significantly influenced by experimental location, fertilizing systems and their interactions (Tab. 3). The highest pod yield was obtained by applying nitrogen-fixing bacteria + mycorrhiza (445 kg/ha). The lowest yield was obtained in the control treatment (266 kg/ha; Tab. 5). The effect of biological fertilizers containing phosphate-solubilizing bacteria on the yield of agricultural crops has been investigated by De Freitas (2000) on wheat and by Ferrettin *et al.* (2004) on barley and sugar beet. The over-

Tab. 5. Affect of different fertilizing systems on pod yield, pod P-content and P-uptake at two experimental research stations

Treatment	Pod yield (kg/ha)			Pod P-content (%)			P-uptake (g/ha)		
	Location		Mean	Location		Mean	Location		Mean
	L_1	L_2		L_1	L_2		L_1	L_2	
T_0	200	332	266^f	0.160	0.160	0.160^f	320	528	424^f
T_1	303	489	395^b	0.260	0.160	0.210^e	787	784	785^{cd}
T_2	260	454	356b^c	0.260	0.310	0.285^{bc}	678	1402	1040^{abc}
T_3	247	377	312^{cd}	0.260	0.310	0.285^{bc}	644	1171	907^{cd}
T_4	250	454	352^{cd}	0.260	0.260	0.263^{cd}	672	1176	924^{bcd}
T_5	213	397	305^{ef}	0.210	0.260	0.235^{de}	445	1034	739^e
T_6	278	423	350^{cd}	0.370	0.310	0.340^a	1038	1310	1174^a
T_7	460	431	445^a	0.306	0.210	0.258^{cd}	1411	906	1159^a
T_8	220	518	368^{bc}	0.370	0.260	0.315^{ab}	806	1341	1073^{ab}
Mean	270^b	430^a		0.273^a	0.248^b		755^b	1072^a	
$LSD_{local*treat}$ (5%)	60.2			0.043			213		

T_0: Control (no fertilizer application); T_1: Chemical fertilizer (135 kg/ha urea fertilizer + 185 kg/ha triple superphosphate fertilizer); T_2: Urea chemical fertilizer + phosphorus-solubilizing bacteria; T_3: urea chemical fertilizer + mycorrhiza; T_4: urea chemical fertilizer + phosphorus-solubilizing bacteria + mycorrhiza; T_5: Nitrogen -fixing bacteria + triple superphosphate fertilizer; T_6: Nitrogen-fixing bacteria + phosphorus-solubilizing bacteria; T_7: nitrogen-fixing bacteria + mycorrhiza; T_8: Nitrogen-fixing bacteria + phosphorus-solubilizing bacteria + mycorrhiza

all conclusion of these experiments is that applying phosphate-solubilizing bacteria on these crops significantly increased the seed yield and its components as well as the total dry matter. Ferrettin *et al.* (2004) demonstrated the positive effects of chemical fertilizers and P-solubilizing bacteria application on sugar beet and barley yields.

Phosphorus content in pods

Phosphorus content in annual medic pods was significantly affected ($P<0.05$) by different fertilizing treatments (Tab. 3). All treatments had a higher phosphorus content in the pods compared to the control. The highest content (0.34%) was found in treatment T_6 (nitrogen-fixing bacteria + phosphorus-solubilizing bacteria; Tab. 5). When chemical fertilizers are applied, most of the P becomes unavailable to the plants due to surface absorption and sedimentation (Ghosh *et al.*, 2004). In both experimental sites, soil Ca content was high (Tab. 1), which tended to convert most of the P added by chemical fertilizer to complex compounds unavailable for plant absorption. The positive effects of P-solubilizing bacteria on shoot dry weight, seed yield and seed N, P, and K content were reported by Rasipour and Aliasgharzadeh (2007).

The present experiment showed that a significant interaction effect ($P<0.01$) of different fertilizing systems and experimental sites on the phosphorus content in pods (Tab. 5). These results confirm the findings of Mitra *et al.* (1999) and Rodrigez and Rinaldo (1999), who reported positive effects of biological fertilizers containing phosphate-solubilizing bacteria on increasing the nutrient content, especially of phosphorus, in plants.

Pod phosphorus uptake

The amount of phosphorus uptake by pods, calculated by multiplying pod yield and pod phosphorus content (percentage), was significantly influenced by fertilizing treatments (Tab. 3). The highest pod phosphorus uptake was found in treatments using nitrogen-fixing bacteria + phosphorus-solubilizing bacteria (T_6) and nitrogen-fixing bacteria + mycorrhiza (T_7), the lowest uptake in the control treatment (424 g/ha; Tab. 5). Poberejskaya and Egamberdiyeva (2003), applying bacteria along with superphosphate fertilizer to cotton, significantly increased plant dry matter, the absorption of nitrogen, potassium and phosphorus, and also increased the amount of soil-available phosphorus. This result has been supported by

Tab. 6. Simple correlation coefficients between agronomic traits of annual medic as affected by different fertilizing systems under dry farming conditions

Row	Trait	1	2	3	4	5	6	7
1	Pod per plant (no)	1						
2	Soil seed bank (no/m^2)	0.49**	1					
3	100-seed weight (g)	0.30*	-0.29*	1				
4	Pod yield (kg/ha)	0.72**	0.73**	-0.04^{ns}	1			
5	A. g. biomass (kg/ha)	0.46**	0.62**	0.53**	0.62**	1		
6	P-concentration (%)	0.15^{ns}	0.17^{ns}	-0.20^{ns}	-0.01^{ns}	-0.02^{ns}	1	
7	P-absorption (g/ha)	0.69**	0.56**	0.31*	0.45**	0.76**	0.59**	1

Mitra *et al.* (1999) on mung bean. Those authors also concluded that the increments in the availability of absorbable phosphorus in the soil enhance the absorption of other elements such as potassium by the plant. This phenomenon explains why, if the soil is nutrient rich (Tab. 1), that the effect of biological fertilizers on increasing the yield diminishes; conversely, as soil fertility decreases, the effect of biological fertilizers on increasing the yield increases. This may reflect the higher activity of phosphate solubilizing bacteria in poor soils, which is followed by an increase in absorbable phosphorus. The positive effects-root development and enhanced N and P absorption-of co-applying N-fixing bacteria (*Rhizobium* sp.) and mycorrhiza fungi (*G. fasciculatum*) on lentil in the same soil conditions was reported by Zaidi *et al.* (2004).

The present study underlines that, in conditions similar to those in this experiment, the inoculation of annual medic var. 'Robinson' seed with nitrogen-fixing bacteria + phosphorus-solubilizing bacteria increases the pod phosphorus content and soil seed bank. Under dryland farming conditions, the synergetic effect of nitrogen-fixing bacteria and phosphorus-solubilizing bacteria on annual medic (var. 'Robinson') seed system was evident.

The interaction effects of experimental site and fertility treatments showed the highest pod production in the T_4 treatment. The biological fertilizers including T_4 are apparently better adapted to different site climatic and soil conditions and can produce higher yields and yield components. Ehteshami (2007), studying different phosphorus microbial fertilizers on corn production under limited irrigation systems, concluded that corn plants inoculated by *Pseudomonas fluorescens* and *Glomus intraadices* performed better under such systems compared to the control (normal irrigation). These results indicate that biological fertilizers can modify the adverse effects of moisture stress conditions. Our results showed that annual medic (*Medicago scutellata*) inoculated by different microbial fertilizers which requires more time to achieve its potential yield production under a dry farming system.

Considerable forage yields were produced experimentally when annual medic received different fertilizing treatments in spring cultivation. The best treatment should produce not only a reasonable forage yield but also enough pods (in the soil seed bank) to guarantee a successful regeneration in the following growing season. If the main goal is optimal forage production, then the application of the T_8 fertilizing treatment (nitrogen-fixing bacteria + phosphorus-solubilizing bacteria + mycorrhiza) is recommended. If, however, natural regeneration must also be considered, then the T_6 treatment (nitrogen-fixing bacteria + phosphorus-solubilizing bacteria) is highly recommended

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