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Performance of local populations of *Medicago truncatula, M. laciniata* and *M. minima* collected in the Algerian steppe areas

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Abstract. As part of the development of local species to be used in pastures and in crop-livestock systems in Algeria, twelve populations of *Medicago truncatula, M. laciniata* and *M.* minima were evaluated for their forage and grain yield during 2016/2017 cropping season. The study focused on dry matter yield and pod and seed production. A randomized block design with three replications was used. The results obtained show that the populations of the three species tested differ significantly for all measured variables. The study identified populations with high dry matter and seed yields. The Principal Component Analysis clearly discriminated the populations of *M. minima, M. laciniata* and *M. truncatula*. We noted that early populations of *M. truncatula* had the highest of pods and seeds yield.

Key words. *Medicago truncatula* – *M. laciniata*– *M. minima* – Seed yield – Forage yield.

Performance de populations locales de* Medicago truncatula, M. laciniata *et* M. minima *collectées dans les zones steppiques Algériennes

Résumé. *Dans le cadre du développement des espèces locales à exploiter en pâturages et dans les systèmes de culture-élevage en Algérie, douze populations de* Medicago truncatula, M. laciniata *et M*. minima *ont été évaluées pour leur rendement fourrager et leur rendement en graine au cours de la compagne agricole 2016/2017. L'étude a porté sur la lez rendement en matière sèche et la production en gousses et en graines. Le dispositif expérimental utilisé est un bloc complètement randomisé avec trois répétitions. Les résultats obtenus montrent que les populations des trois espèces testées diffèrent significativement pour l'ensemble des variables mesurées. L'étude a identifié des populations présentant un bon rendement en matière sèche et en graines. L'analyse en composantes principales a clairement différencié les populations de* M. minima, M. laciniata *et* M. truncatula*. Nous avons également noté que les premières populations avaient le rendement le plus élevé en gousses et en graines. Nous avons noté que les populations précoces de M. truncatula ont enregistré les meilleurs rendements en gousses et en graines.*

Mots-clés. Medicago truncatula – M. laciniata – M. minima – *Rendement en grains – Rendement fourrager.*

I – Introduction

Among crops reliable to promote pastoral zones that produce forage and restore destroyed pasture land especially in arid and semi-arid areas, the genus *Medicago* L. (Fabaceae) constitutes an important genetic resource (Haddioui *et al*., 2012). Annual species are found in all bioclimatic zones from wet area to the Sahara. Some have a wide spectrum of distribution; others have limited distribution area (Abdelkefi and Marrakchi, 2000).

Medics are excellent candidates for pastures and cover crops in sustainable agriculture systems, such as pastures and cover crops (Dorry, 2010). Their high levels of hard seededness makes them well adapted to ley farming systems and to persistence in regions of unreliable rainfall (Nichols *et al*., 2007).

With others annual legumes, medics are mainly the base of agropastoral systems. They show a high potential for seed and forage production, and self regeneration ability (Porqueddu and Gonzalez, 2006).

The objective of the present work is to evaluate forage yield and seed production of twelve local populations of *Medicago truncatula*, *M.laciniata* and *M. minima*.

II – Materials and methods

Twelve local populations of *Medicago truncatula, M. laciniata* and *M. minima* collected in different sites of Djelfa area by the National Institute of Agronomic Research of Algeria (INRAA) in 2008 were used (Table 1). The trial was conducted during the 2016/2017 cropping season at the experimental farm of the Research station of Baraki, Algiers (INRAA). Populations were sown on 22 December 2016 at a density of 100 scarified seeds/ row of 1 m long spaced by 1.5 m. A randomized block design with 3 replications was used. At flowering period, the rows were mown and aerial biomass (AB, g) and dry matter yield (DMY, g) were measured. Dry matter was determined after drying a sample in a forced air oven at 65°C during 48 hours. Total number of pods (TNP), pod weight (PW, g), total number of seeds (TNS) and seed weight (SW, g) were measured after harvest.

The collected data were subjected to an analysis of variance (ANOVA) using the GenStat software edition 12 and the measured traits means were compared between populations with Least Significant Difference (LSD) test at 5% probability level. Principal components analysis (PCA) was performed to establish the importance of different traits in explaining multivariate polymorphisms, using Statistica 6.0 software. Relationships among measured traits were tested using Pearson correlation coefficients.

Table 1. List of populations of *Medicago truncatula, M. laciniata* and *M. minima* populations and their original collection sites

Species	Geographical Origin	Altitude (m)
Medicago minima	Ain Oussera **(MmAO)**	758
	Mliliha **(MmMli)**	806
	Charef **(MmCh)**	960
	Oued Touil **(MmOT)**	718
Medicago laciniata	Bouiret Lahdab **(MlBL)**	830
	Messaad **(MlMes)**	950
	Mliliha **(MlMli)**	806
	Oued Touil **(MmOT)**	718
Medicago truncatula	Charef **(MtCh)**	960
	Mliliha **(MtMli)**	806
	Ain Oussera **(MtAO)**	758
	Oued Touil **(MtOT)**	718

III – Results and discussion

Means and range of variation of the measured traits are given in Table 2. The variance analysis showed significant to highly significant differences between populations. The flowering date varied from 86 to 98 days after emergence. The *M. truncatula* populations from Oued Touil and Ain Oussera were the earliest ones with 86 calendar days, while the *M. minima* population from Charef region was the latest (98 days). Populations of *M. truncatula* were earlier than those of *M. laciniata* and *M. minima*. In Sicilian *M. polymorpha* populations, the flowering time ranged from 110 to 128 days (Graziano *et al.,* 2010). According to Del Pozo and Aronson (2000), annual legumes show both ecotypic differentiation and a high degree of plasticity in flowering time. For forage production, the most productive population was Oued Touil for *M. truncatula* with 1997 g for aerial biomass and 340 g

for dry matter yield. While population of *M. minima* from Mliliha had the lowest biomass and dry matter (768 g and 120.3 g, respectively). Graziano *et al.* (2010) reported large differences among Sicilian populations for DM yield at spring cut (231-655 g/m² with an average of 443 g/m²). According to Porqueddu and Gonzalez (2006), forage yields depend upon the specific growing conditions, but especially rainfall during the growing season. The tested populations of the three species differed significantly for pod and seed production. The highest pod and seed yields were recorded by the two populations of *M. truncatula* from Charef and Ain Oussera (477.7 g and 119.8 g respectively). While, the highest pod and seed numbers were obtained by the population of *M. minima* from Charef (with respectively 14867 and 74928 seeds) as reported by Chebouti *et al.* (2015).

Table 2. Mean and values of the measured traits in *M. minima, M. laciniata* and *M. truncatula* populations

Populations/traits	FT (days)	AB (g)	DMY (g)	TNP	PW (g)	TNS	SW (g)
MlBL	95^{b}	1199^{bcd}	302^{abc}	5100^{ef}	78.2^{f}	31200^{ef}	64^{efg}
MlMes	95^{b}	1407^{abc}	292^{abc}	3500^{f}	79.2^{f}	17500^{g}	45.5^{g}
MlMli	88^{c}	1418^{abc}	300^{abc}	8457^{cd}	196.9^{e}	49391^{cd}	84^{cd}
MlOT	88^{c}	787^{d}	164^{de}	10443^{bc}	223.4^{de}	57215^{bc}	107.7^{ab}
MmAO	95^{b}	1322^{abc}	322^{ab}	6885^{de}	307.1^{c}	39964^{de}	67.8^{def}
MmCh	98^{a}	1012^{abc}	183^{cde}	14867^{a}	237.5^{de}	74928^{a}	95.1^{bc}
MmMli	96^{b}	768^{d}	120^{e}	11206^{b}	258.5^{cde}	60959^{b}	82.5^{cde}
MmOT	88^{c}	1077^{abc}	220^{bcde}	10296^{bc}	282.9^{cd}	51510^{bc}	59.2^{fg}
MtAO	86^{d}	1305^{bcd}	243^{abcd}	8861^{cd}	407.2^{b}	40759^{de}	119.8^{a}
MtCh	88^{c}	1495^{ab}	302^{abc}	7663^{d}	477.7^{a}	33412^{ef}	90.9^{bc}
MtMli	88^{c}	877^{cd}	168^{de}	4221^{f}	256.8^{cde}	23404^{fg}	65.8^{def}
MtOT	86^{d}	1997^{a}	340^{a}	4667^{f}	279.3^{cd}	28315^{f}	79.8^{cde}
Lsd	1.466	600.9	120.3	1992.0	64.6	10255.1	19.4
Sign.	***	*	**	***	***	***	***

Lsd: Least significant difference, FT: Flowering time, AB: aerial biomass per line, Pod formation time, DMY: Dry matter yield per line, TNP: Total number of pods per line, PW: Pods weight per line, TNS: Total number of seeds, SW: Seed weight per line.

Correlation coefficients are given in Table 3. Populations with high biomass had high dry matter yield (r = 0.885***). Dry matter yield was negatively correlated with total number of pods (r = –0.579*) and with total number of seeds (r = –0.578*). Total number of pods and seeds were closely related and vary in similar ways (r = 0.973***). Populations that recorded high seed yield had the highest pods and seeds number. Cocks (1988) indicted that seed yield was closely related to number of pods in all ecotypes of annual *Medicago* sp. In many legumes, pod number is one of the most effective factor on seed yield is pod number and commonly there is a linear function between pod number and seed yield (Bagheri *et al*., 2010). Nevertheless, no relationships were observed between flowering time and the rest of the traits.

The principal component analysis identified two principal components, which together accounted for 76.21% of the total variation (Figure 1). The component 1explained 47.47% of the variation and was positively influenced by aerial biomass and dry matter yield and negatively by totals numbers of pods and seeds. The second component explained 28.74% of the variation, it is positively correlated with flowering time and negatively with pod and seed weight (Figure 1). In fact, populations from Ain Oueesra and Oued Touil of *M. minima* and *M. truncatula*, respectively, from the positive side of the PC1, are characterized by high biomass and high dry matter yield. They oppose on the negative side of PC1, populations of *M. minima* from Mliliha, Charef and Oued Toui Regions and that of *M. laciniata* from Oued Touil, which have the highest pod and seed numbers. Populations of *M. truncatula* from Ain Oussera and Charef, plotted on the negative side of PC2, were the earliest ones and have high pod and seed yields. They opposed populations of *M. laciniata* from Messaad and of *M. truncatula* from Mliliha which have the lowest pod and seed yields.

Table 3. Relationships among measured traits in *M. truncatula, M. laciniata* and *M. minima* populations

	FT	AB	MDY	TNP	PW	TNS	SW
FT	1.00						
AB	-0.328	1.00					
MDY	-0.163	**0.885*** **	1.00				
TNP	0.237	-0.492	**-0.579***	1.00			
PW	-0.479	0.156	-0.005	0.251	1.00		
TNS	0.285	-0.510	**-0.578***	**0.973*** **	0.116	1.00	
SW	-0.340	-0.107	-0.269	**0.585***	**0.576***	**0.601***	1.00

Significant levels, *< 0.05, **< 0.01 and ***< 0.001.

FT: Flowering time, AB: aerial biomass per line, Pod formation time, DMY: Dry matter yield per line, TNP: Total number of pods per line, PW: Pods weight per line, TNS: Total number of seeds, SW: Seed weight per line.

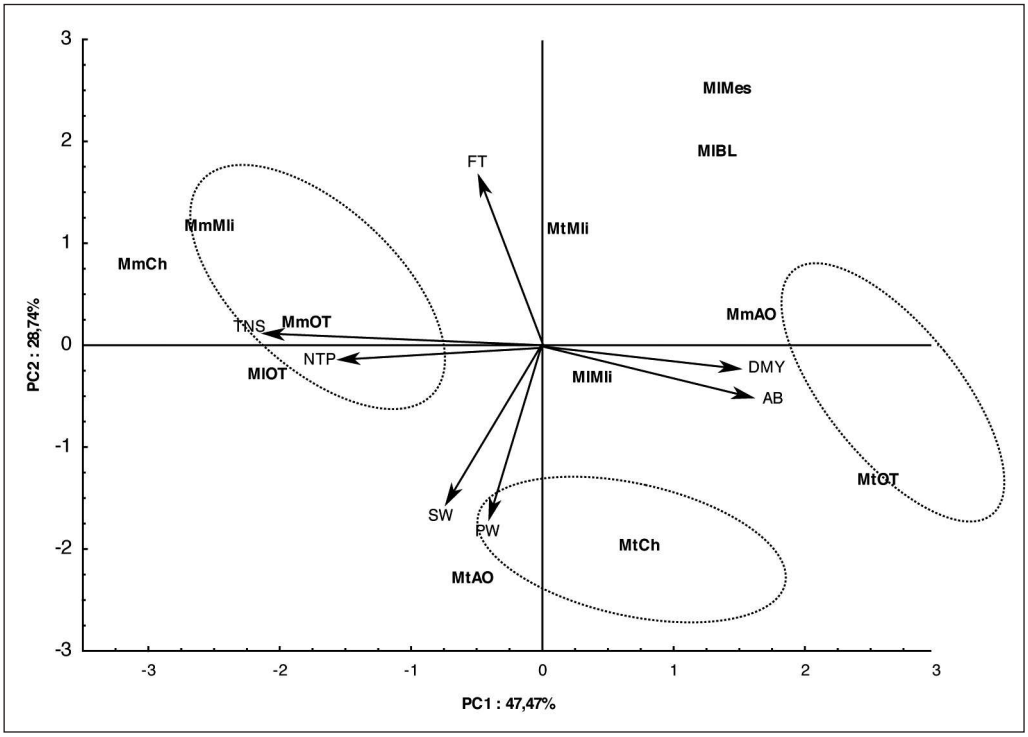

Fig. 1. The Biplot of Principal Component Analysis (PCA) performed on traits and populations of *M. truncatula, M. laciniata* and *M. minima.*

IV – Conclusions

In conclusion, we noted a large differentiation between local populations of *M. minima, M. laciniata* and *M. truncatula* for the most of agronomic traits. From these results, several populations of *M. truncatula* and *M. minima* were selected with regard to their high pods and seeds production and high dry matter yield. They will be exploited in pastures in order to improve forage production in Algeria.

From the PCA, populations from Oued Touil and Ain Oussera of *M. truncatula* and *M. minima*, respectively selected for their performance on dry matter and seed yield as well as their aerial bio-

mass. Also, the *M. minima* populations from Charef, Mliliha and Oued Touil regions as well as the *M. laciniata* population from Oued Touil were selected for their high pod and seed numbers and the *M. truncatula* populations from Ain Oussera and Charef regions as the most performant populations for their seeds yields.

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