Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Plant Sciences 6 (8): 1217-1222, 2007
ISSN 1682-3974
© 2007 Asian Network for Scientific Information

Nitrogen Fertilizing Systems and Harvest Frequency Effects on Forage, Pod and Seed Yields of Annual Medic (*Medicago scutellata* var. Robinson)

Amir Hossein Agha Ahmadi and Mohammad Reza Chaichi
Department of Crop Production and Plant Breeding, College of Agronomy and Animal Sciences,
University of Tehran, Iran

Abstract: The study was conducted to determine the effects of nitrogen fertilizing systems and harvest frequency on dry forage, pod and seed yields of snail medic; *Medicago scutellata* var. Robinson. *Rhizobium meliloti* inoculation and four levels of chemical nitrogen fertilizer (0, 25, 75 and 125 kg N ha^{-1}) were allocated to the main plots while four levels of harvest frequencies such as weekly, 2 and 3 weekly intervals and control with only one harvest at 50% flowering were assigned to subplots. According to the results of this experiment, harvest frequency and nitrogen fertilizing systems had significant effects on forage, pod and seed yields of *M. scutellata* as these traits increased with increment in harvest frequency and availability of nitrogen. Interaction between harvest frequency and nitrogen fertilizer systems was significant for forage and seed yields; hence treatment of 75 kg N ha^{-1} with 3 week harvest interval produced acceptable forage and seed yields in *M. scutellata*, which eliminated the necessity of *Rhizobium* inoculation and reduced the cost and environmental contamination compared to 125 kg N ha^{-1}.

Key words: Annual medic, *Medicago scutellata*, *Rhizobium meliloti* inoculation, nitrogen fertilizer, harvest frequency

INTRODUCTION

Improvement of annual medic (*Medicago scutellata*) cropping could result in significant production of dry forage. It would be possible to produce 5.7 ton dry forage ha^{-1} by annual medics at one harvest during 60 or 70 days after sowing (Bauchan, 1999). *M. scutellata* growths more rapidly than alfalfa and has suitable adaptation to moderate climatic conditions. Seed production, soil seed bank, hard-seediness, natural regeneration and plant establishment are the key subjects that should be investigated for a successful ley-farming agricultural system (Barnard, 1977).

Plant phenologic stage is an important factor to determine the intensity of defoliation (Young *et al.*, 1994). Time and frequency of harvest also must be regarded in forage harvesting (Turner *et al.*, 2006). Many researchers have studied the effects of harvest system on annual medics by grazing, but separating and determining the effects of harvest intensity and frequency from each other is a difficult task in this method. So, with mechanical harvest it would be possible to separate these two effects from each other (Lawson *et al.*, 1988). Soil nitrogen status has a significant influence on forage yield of annual medics especially in ley-farming system. Annual medics that grow in pastoral soils usually produce more forage and nitrogen content than medics which grow in soils under cultivation of cereals (Alston and Graham, 1982).

Zhu *et al.* (1998) investigated the effects of inoculation and nitrogen on herbage properties of annual medic species and showed that nitrogen fertilizer could increase the herbage dry matter of spring-seeded *M. scutellata* only when inoculum was applied. They concluded that nitrogen deficiency limits the forage production in *M. scutellata*. In a study Farahani *et al.* (2004) and her colleagues examined the effects of *Rhizobium* strains and mineral nitrate on growth of four species of annual medics and revealed that under mineral nitrate treatment, *M. littolaris* and *M. polymorpha* produced the highest shoot dry mater yield. Altinok *et al.* (1997) reported that the ability of annual medics to regenerate after harvesting or grazing at different phenologic stages is a favorable characteristic in medic pasture management. Chaichi *et al.* (1996) reported that harvest or grazing frequency reduces the forage yield in *M. truncatula*. He also suggested that if frequency of harvest is properly managed for plants to have adequate time for regeneration and if they do not encounter environmental limitations such as water stress during growth, the biological yield will increase. Defoliation at

Corresponding Author: A.H. Agha Ahmadi, Department of Crop Production and Plant Breeding, College of Agronomy and Animal Sciences, University of Tehran, Iran

early flowering in annual medics enhances more branching and increases dry matter yield (Lowe and Bowdler, 1988). Annual forage legumes tolerate herbage removal with little negative effect on seed yield (Muir *et al.*, 2005). Medium grazing can be continued to early flowering without significant decrease in seed yield (Tow and Alkailah, 1981). Conlan *et al.* (1994) assessed the impact of grazing intensity and grazing frequency on the growth and seed production of *M. murex* and found that under favorable spring conditions, murex medic can be grazed heavily until late in the season without adversely affecting seed yield.

The objective of this experiment was to determine the effects of simulation of grazing by harvest management (harvesting interval) and application of different nitrogen fertilizing systems on forage, pod and seed yields of *M. scutellata* var. Robinson and determine whether inoculation can provide enough nitrogen to obtain suitable forage and seed yields in snail medic, camper to nitrogen fertilizer.

MATERIALS AND METHODS

Location: The experiment was conducted at the Agricultural Research farm, University of Tehran, Karaj during 2005 and 2006. The site is located at 35°25′ N latitude, 71°25′ E longitude with an altitude of 1321 m above sea level. Karaj is located about 30 km west of Tehran and has a semi-arid climate (275 mm annual precipitation). The soil of experimental site was clay loam with montmorillionite clay type, low in nitrogen (0.04-0.05%), low in organic matter (0.9-1%) and alkaline in reaction with pH of 7.8 and EC = 0.44 dS m^{-1}.

Experimental design and statistical analysis: The experiment was carried out in Randomized Complete Block with Split-Plot Design in three replications, combined over two years. Main plots included of *Rhizobium meliloti* inoculation and four levels of chemical nitrogen fertilizer (0, 25, 75 and 125 kg N ha^{-1}) while, four levels of harvest frequencies (weekly-interval, Two-week interval, three-week interval and control with only one harvest at 50% flowering) were assigned to the subplots. Data were statistically analyzed by using MSTATC statistical program and Duncan test was employed to classify mean values of different treatments when F-values were significant. Graphs were generated by using EXCEL software.

Sowing and cultivation: Seed of *Medicago scutellata* (var Robinson) was sown after scarification in subplots of 3×5 m dimensions in April 14, 2005 and March 18, 2006. Unfavorable climatic condition delayed the sowing date in the first year for 26 days. The soil temperatures at sowing time in the first and second years were 13 and 8°C, respectively. Climatic conditions data during experimental period in each year is shown in Table 1. Each sub-plot consisted of 6 rows of annual medic sown on both sides of each ridge at a density of 128 plant m^{-2}. In the inoculated treatment, seeds were soaked in dilute sugar solution and then inoculated with bacteria powder of *Rhizobium meliloti* at 2 g kg^{-1} seed ratio. Seeds were immediately sown after drying in shadow. Ammonium nitrate fertilizer containing 46% of nitrogen was applied as a nitrogen treatment. Each nitrogen treatment was applied in three stages including: sowing time, plant establishment (5 to 6 trifoliate leaves) and early flowering. In each stage, one thirds (33%) of each nitrogen fertilizer treatment was applied. All treatments were irrigated at weekly-interval. The plots were hand weeded in different vegetative stages and Malation pesticide was once applied against Aphids in April 2006.

Table 1: Climatic conditions during experimental period in 2005 and 2006 growing seasons

Year	Mean temperature (°C)	Mean relative humidity (%)	Precipitation (mm)
First year (2005) (April 14 to July 18)	22.4	41	68
Second year (2006) (March 18 to July 4)	18.9	42	57

Measurements: The first harvest in each plot started after plant establishment in about 40 days after sowing by using a 1×1 m quadrate with 5 cm in height. Harvest treatments continued until 50% flowering in each plot. The sites of harvest samples were constant in all experimental plots all through the sampling period. Samples were dried by oven at 72°C for 48 h and then weighed. The number of harvests in each harvest frequency treatment was one for control at 50% flowering, 6 for weekly interval, 3 for two weekly intervals and 2 for three weekly intervals.

Forage of these harvests in each treatment was accumulated to calculate the total forage yield at the end of the growing period.

RESULTS

Dry forage yield: The statistical analysis of two year's data indicated that year, nitrogen fertilizing treatment and harvest frequency had significant effects on dry forage yield. Interaction of nitrogen fertilizing systems with harvest frequency was also significant ($p<0.01$) (Table 2).

Dry forage yield was 3775 kg ha^{-1} in 2005 which was 18% less than 2006 (4621 kg ha^{-1}). This could be

Table 2: Mean squares of year, nitrogen fertilizing systems and harvest frequency effects on dry forage, pod and seed yields of *M. scutellata* (kg ha^{-1})

SOV	df	Dry forage	Pod	Seed
Year	1	241051.459**	22715.010**	603.905**
Year×Replication	4	15580.188**	8206.183**	19.357*
Nitrogen fertilizing systems	4	58531.318**	31984.060**	243.570**
Year×Nitrogen fertilizing systems	4	2451.179^{ns}	778.904^{ns}	4.626^{ns}
Error	16	2034.923	1619.652	6.386
Harvest frequency	3	189886.585**	56721.430**	181.497**
Year×Harvest frequency	3	508.386^{ns}	4686.897*	8.816^{ns}
Nitrogen fertilizing systems×Harvest frequency	12	3553.590**	1351.340^{ns}	2.285*
Year×Nitrogen fertilizing systems×Harvest frequency	12	506.004^{ns}	706.682^{ns}	0.940^{ns}
Error	60	877.613	1441.358	8.120
CV		7.100	3.840	7.430

**, *: Indicate significance of effects at 0.01and 0.05 probability levels and NS stands for no significant effect, respectively

Table 3: Mean values of dry forage, pod and seed yields (kg ha^{-1}) as affected by N fertilizing systems and harvest frequency (averaged over two years)

	Seed yield (kg ha^{-1})	Pod yield (kg ha^{-1})	Total dry forage yield (kg ha^{-1})
Fertilizing systems			
Control (No inoculation and fertilizer)	349.7^{c}	948.8^{d}	3644^{c}
Inoculation	356.5^{c}	963.4^{cd}	3663^{c}
25 kg nitrogen ha^{-1}	378.5^{b}	982.5^{c}	4301^{b}
75 kg nitrogen ha^{-1}	410.3^{a}	1011.0^{b}	4595^{a}
125 kg nitrogen ha^{-1}	421.5^{a}	1040.0^{a}	4664^{a}
Harvest frequency			
Control	353.4^{c}	937.1^{d}	3102^{d}
Three-week interval	403.4^{a}	1000.0^{b}	4695^{b}
Two-week interval	413.5^{a}	1041.0^{a}	4854^{a}
Weekly-interval	372.8^{b}	977.3^{c}	4043^{c}

*: Means of the same category followed by different letter(s) are significantly different at 0.05% level of probability using Duncan test

corresponded to 27 days delay in sowing time in the first year because of the bad climatic conditions and consequently shorter growing season in 2005.

Dry forage yield increased by increment in soil N content either by inoculation or chemical N fertilizer.

Harvest frequency had positive effect on dry forage yield while it increased by increment in harvest frequency. Plants under two-week interval and control (one harvest at 50% flowering) produced the highest (4854 kg ha^{-1}) and lowest (3102 kg ha^{-1}) dry forage yield, respectively (Table 3).

Chemical N treatment of 125 kg nitrogen ha^{-1} with two-week harvest interval produce maximum dry forage yield (5548 kg ha^{-1}) while control (with one harvest at 50% flowering) had the minimum yield among all N fertilizing and harvest frequency systems (Fig. 1). On the other hand, there was no significant difference between 125 and 75 kg nitrogen ha^{-1} at two-week harvest interval in respect to dry forage production (Fig. 1). Inoculation had no significant effect on dry forage yield through all harvest treatments (Fig. 1).

Plants under harvest treatment of weekly-interval produce higher dry forage yield than control (with one harvest at 50% flowering). However, total dry forage produce in this treatment was significantly less than two and three-week harvest intervals (Fig. 1).

Pod yield: Pod yield across all harvest frequency treatments in second year (2006) was significantly higher than the first year (2005) (Fig. 2). This result could be corresponded to longer growth season and better climatic conditions (Table 1) during second year which provided a suitable vegetative and regenerative growth season for *M. scutellata*.

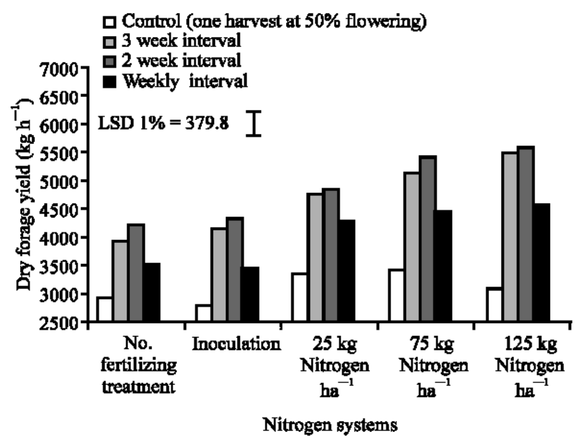

Fig. 1: Effect of N fertilizing systems and harvest frequency on dry forage yield of *M. scutellata*. Data are averaged over years (2005 and 2006)

Application of N fertilizing systems increase the pod yield, compared to control (no inoculation and fertilizer). Chemical N fertilizer treatment of 125 kg nitrogen ha^{-1} increases the pod yield by about 9% (Table 3).

Plants treated with any harvest frequency treatment produced higher pod yield than control (with one harvest at 50% flowering). Two-week interval and control produce the maximum (1041 kg ha^{-1}) and minimum (937.1 kg ha^{-1}) pod yields, respectively (Table 3).

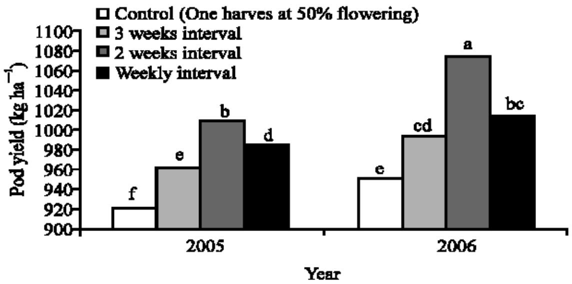

Fig. 2: Effect of harvest frequency and year on pod yield of *M. scutellata*

Pod yield increased with decrement in frequency of harvest up to 2 week interval and then decreased in weekly-interval (Fig. 2).

Seed yield: Mean seed yield in 2005 was about 12% less than 2006. The same reasons (delay in sowing, longer growth season and better climatic conditions) that previously were explained for dry forage and pod yields could cause this reduction.

Chemical N fertilizer of 125 kg ha^{-1} increased seed yield by about 20%, as it increased from 349.7 kg ha^{-1} in control (no inoculation and fertilizer) to 421.5 kg ha^{-1} in this treatment. Inoculation treatment produced 356.5 kg seed ha^{-1} that was not significantly different from control. There was also no significant difference between 125 and 75 kg nitrogen ha^{-1} treatments.

Plants under 2 week and Three-week harvest interval produced significantly more seed than control (with one harvest at 50% flowering) (Table 3). The minimum seed yield was obtained when no inoculation or chemical fertilizer and harvest (control) treatment was applied. Chemical N fertilizing treatments increase the seed yield compared to control (no inoculation and fertilizer) and inoculation, however, this increment was only significant for 125 and 75 kg nitrogen ha^{-1} treatments. Similar to dry forage yield results, there was no significant difference between 125 and 75 kg nitrogen ha^{-1} treatments across all harvest frequencies.

DISCUSSION

Dry forage yield: Nitrogen fertilizer treatment increased the dry forage yield compared to control and 125 kg nitrogen ha^{-1} produced the highest (4664 kg ha^{-1}) yield, among other N fertilizing systems (Table 3). This is in support of findings by Alston and Graham (1982) who suggested that medics that grow in pasteurised soils usually produce more dry weight and nitrogen content than those that grow in soils under cereals cultivation.

Total dry forage produce in weekly-interval harvest treatment was significantly less than two and three-week harvest intervals (Fig. 1). Frequent and continuous harvesting and lack of enough time between harvests for plants to regenerate properly, could be the reason of reduction in dry forage yield in this treatment (Chaichi *et al*., 1996).

There was no significant difference between 125 and 75 kg nitrogen ha^{-1} (Fig. 1). Due to these results it seems that chemical fertilizer treatment of 75 kg nitrogen ha^{-1} with three-week harvest interval treatment is more favorable because of its lower costs and environmental contamination. Inoculation increases the dry forage yield but this increment was not significant through all harvest treatments (Fig. 1). In fact, symbiotic N_2 fixation by *Rhizobium* inoculation could not supply enough nitrogen for *M. scutellata*, probably because of its high requirement for nitrogen and therefore nitrogen deficiency limited the growth of *M. scutellata*, camper to chemical fertilizer treatments(Zhu *et al*., 1998). This was previously shown in *M. littolaris* and *M. polymorpha* by Farahani *et al*. (2004).

Pod yield: According to Thorn and Revell (1987), pod and seed production in annual medics is higher under low intensities and short periods of grazing. This shows that to reach suitable pod yield, it is necessary for plants to have proper vegetative development before flowering that enables them to prepare adequate nutrients before the flowering phase. These conditions are probably present in 2 week harvest interval treatment (with 3 harvests) and causes more pod yield production in this treatment, compared to other harvest treatments. On the other hand, weekly harvest interval has the effects similar to intensive harvest on vegetative and regenerative points that reduce branches, nudes, flowers and pod in plants (Carlson, 1966). Results of regression analysis also showed significant relationship (r = 0.92) between pod and dry forage yield.

Seed yield: There was no significant difference between 125 and 75 kg nitrogen ha^{-1} treatments across all harvest frequencies. Consequently, treatment of 75 kg nitrogen ha^{-1} with three-week harvest interval could be more favorable treatment, because its seed yield was not significantly lower than treatment of 125 kg nitrogen ha^{-1} with 2 week harvest interval and also imposes lower cost because of its requirement to less number of harvests and amount of fertilizer application. High correlation (r = 0.86) between dry forage and seed yields implicate the fact that effect of N fertilizer systems on seed yield is similar to its effect on dry forage yield.

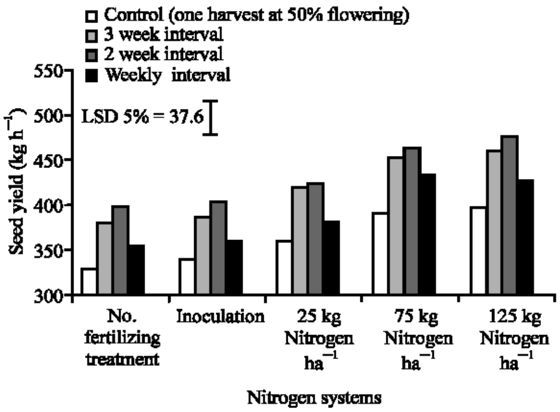

Fig. 3: Effect of N fertilizing systems and harvest frequency on seed yield of *M. scutellata*. Data are averaged over years (2005 and 2006)

Two week harvest interval with three harvests before 50% flowering stage, had a similar effect to medium grazing intensity on seed yield (Carter, 1978). Tow and Alkailah (1981) reported that medium grazing can be continuous until early flowering without significant decrease in seed yield; control treatment was only once harvested at 50% flowering when plants were producing pods, therefore a large amount of plant shoots including flowers and pods were eliminated by harvest. This could be the cause of the significant reduction of seed yield in this treatment.

Reduction in seed yield of annual medic under weekly harvest interval was previously reported in *M. truncatula* where seed yield significantly decreased under intensive harvesting treatment (Muyekho, 1993).

The results of this experiment revealed that chemical N fertilizer treatment of 75 kg nitrogen ha^{-1} produces acceptable forage and seed yields in *M. scutellata* and eliminates the necessity for *Rhizobium* inoculation and reduces the cost and environmental contamination of excessive fertilizer application compared to 125 kg nitrogen ha^{-1}. Medics under biological nitrogen fertilizer (*Rhizobium* inoculation) treatment produced less dry forage and seed yields than chemical nitrogen fertilizing treatments. Application of 75 kg nitrogen ha^{-1} along with three-week harvest interval can be recommended for suitable production of forage and seed yields (Fig. 3).

CONCLUSION

This study has provided important evidence that proper harvesting or grazing management of medic along with suitable application of N fertilizer is critical issues to achieve favorable vegetative and regenerative properties of *M. Scutellata* Var. Robinson. Further research, however, is needed to determine how much cutting or grazing intensity (height of harvesting or grazing) this medic will tolerate and still produce sufficient forage and seed yield, or which *Rhizobium* strains with what ratios are most suitable for efficient inoculation.

REFERENCES

Alston, A.M. and R.D. Graham, 1982. The influence of soil nitrogen status and previous crop on nitrogen fixation (acetylene reduction) in Barrel Medic, *Medicago truncatula* Gaertn. Aust. J. Soil Res., 20(1): 51-59.

Altinok, S., A. Erac and R.C. Martin, 1997. The effects of cutting at different phenological stages to shoot and root development and forage yield of annual medics. Turk. J. Agric. For., 21: 371-378.

Bauchan, G.R., 1999. Use of annual medics in sustainable agriculture systems. Lucerne and medics for the XXI century. Proceedings XIII EUCARPIA *Medicago* sp. Group Meeting, Perugia, Italy, 13-16 September. Perugia: Universita di Perugia, 2000, pp: 146-153.

Barnard, C., 1977. Register of Australia herbage plant cultivars. J. Aust. Inst. Agric. Sci., 43: 1-2.

Carlson, G., 1966. Growth of clover leaves after complete or partial defoliation. Crop Sci., 6: 419-422.

Carter, E.D., 1978. Stocking Rate and the Ecosystem: Some Interrelationships of Pasture Availability. Grazing Behavior and Productivity of Merino Sheep on Sown Annual Pasture in South Australia. Proceeding IV World Conference on Animal Production. Buenos Aires. Argentina, Luis, S. Verde and F. Angel (Eds.). (1980). August, pp: 482-490.

Chaichi, M.R., E.D. Carter and P.G. Tow, 1996. Summer grazing management of medic pasture to ensure adequate dry residues and seed reserves. Proceedings of the 8th Australian Agronomy Conference. Toowoomba, queensland, Australia. Australian Society of Agronomy Inc., pp: 128-131.

Conlan, D.J., B.S. Dear and N.E. Coombes, 1994. Effect of grazing intensity and number of grazings on herbage production and seed yields of *Trifolium subterraneum*, *Medicago murex* and *Ornithopus compressus*. Aust. J. Exp. Agric., 34(2): 181-188.

Farahani, S.M., R.T. Afshari, H.H. Sharifabadi and M.R. Chaichi, 2004. Effects of *Rhizobium* strains on growth and nitrogen fixation of annual medics. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 Sep-1 Oct.

Lawson, A.R., P.W.G. Sale and K.B. Kelly, 1988. Effect of defoliation frequency on an irrigated perennial pasture in northern Victoria. 1. Seasonal production and sward composition. Aust. J. Agric. Res., 48(6): 811-818.

Lowe, K.F. and T.M. Bowdler, 1988. Effects of height and frequency of defoliation on the productivity of irrigated oats (*Avena strigosa* cv. Saia) and perennial ryegrass (*Lolium perenne* cv. Kangaroo Valley), grown alone or with barrel medic (*Medicago truncatula* cv. Jemalong). Aust. J. Exp. Agric., 28(1): 57-67.

Muir, J.P., W.R. Ocumpaugh and T.J. Butler, 2005. Trade-offs in forage and seed parameters of annual medicago and *trifolium* species in north-central Texas as affected by harvest intensity. Agron. J., 97: 118-124.

Muyekho, F.J.N., 1993. Environmental and agronomic factors affecting seed production in annual medics. Ph.D Thesis, The University of Adelaide.

Thorn, C.W. and C.K. Revell, 1987. The effect of grazing on the seed production of a range of annual medic species. Proceeding 4th Australia Agronomy Conference Melbourne. August, pp: 170.

Tow, P.G. and Al. Alkailah, 1981. Factors affecting seed production in Jemalong barrel medic Aust. Seed Sci. Newslett., 7: 74-89.

Turner, L.R., D.J. Donaghy, P.A. Lane and R.P. Rawnsley, 2006. Effect of defoliation management, based on leaf stage, on perennial ryegrass (*Lolium perenne* L.), prairie grass (*Bromus willdenowii* Kunth) and cocksfoot (*Dactylis glomerata* L.) under dryland conditions. 1. Regeneration, tillering and water-soluble carbohydrate concentration. Grass Forage Sci., 61(2): 164-174.

Young, R.R., K.J. Morthorpe, H.I. Nicol and P.H. Croft, 1994. Effects of sowing time and grazing on the dry matter yield, phonology, seed yield and hardseed levels of annual pasture legumes in Western New South Wales. Aust. J. Exp. Agric., 34(2): 189-204.

Zhu, Y., C.C. Sheaffer, C.P. Vance, P.H. Graham, M.P. Russelle and C.M. Montealegre, 1998. Inoculation and nitrogen affect herbage and symbiotic properties of annual *Medicago* species. Agron. J., 90: 781-786.