INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
11–146/AWB/2011/13–5–823–826
http://www.fspublishers.org

Full Length Article

The Effect of Exotic *Acacia saligna* Tree on Plant Biodiversity of Northern Jordan

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ABSTRACT

Exotic species can cause a major threat to ecosystems, because of its effect on reducing natural biodiversity. The aim of this paper is to study the effects of the exotic *Acacia saligna* on native plant biodiversity of northern part of Jordan. Within each studied area we estimated plant species cover in six replicates of a 0.5 m^2 quadrate distributed randomly inside and outside the canopy of *A. saligna*. From these plant cover we estimated the total number of species, Shannon's diversity index, Simpson's diversity index and Margalef's diversity index of the associated annual and perennial species. The overall results showed that the effect of *A. saligna* on plant diversity depends largely on the proximity to the tree canopy. Namely, it has been found that native plant species diversity such as Shannon's diversity index, Simpson's diversity index are reduced under canopy (1.88, 0.8831) compared to the outside canopy of the trees (2.21, 0.876), respectively (One-way ANOVA; F = 14.99, 12.46; *P*-values<0.001). Moreover, observed and cumulative species richness of native plant biodiversity of Jordan is significantly affected by the presence of this exotic tree. It can be concluded that competition and intrinsic characteristics of tree i.e., nutrient uptake efficiency, are among the possible mechanisms responsible for the impact of *A. saligna* trees on native plants of Jordan.

Key Words: *Acacia saligna*; Invasion; Biodiversity; Species richness; Jordan

INTRODUCTION

Human can be a major threat to natural ecosystems; for example by acting as a vector for the introduction of invasive exotic species, which have significant effects on native ecosystems (Levine *et al*., 2008). Once introduced into new ecosystems, exotic species can interfere with native species (Dukes & Moony, 1999), reduce biodiversity of natural communities (Vitousek & Walker, 1989; Brown & Gurevitch, 2004). They alter the ecosystem structure and function (Ehrenfeld, 2004; Gratton & Denno, 2005). Thus, ecological assessment of the effects of biological invasion is of a fundamental importance in conservation and maintaining native biodiversity.

Several studies have provided evidence on the effect of exotic plant on altering the community composition and on reducing the diversity of native plants (Levine *et al*., 2008). These studies hypothesized diverse processes or mechanisms that generate consequential impacts of plant invasion. Among these processes are; competition (Wyckoff & Webb, 1996; Kwiatkowska *et al*., 1997; Lavergne *et al*., 1999; Martin, 1999), allelopathy (Gentle & Duggin, 1997), and alteration of native ecosystem characteristics (Vivrette & Muller, 1977; El-Ghareeb, 1991).

Acacia saligna is a native shrub or small tree of the southwest of Western Australia, which considered as invasive exotic species in many parts of the world's native ecosystems (Holmes & Cowling, 1997). Recently, *A. saligna* has been introduced to Jordan presumably for fodder and sand conservation and has successfully grown in many parts of the country. However, the impacts of this exotic tree on plant communities of Jordan are unknown. The goal of the present study is to assess the ecological effects of *A. saligna* on native biodiversity of Jordanian natural communities.

This study was based on field observations of plant species cover and diversity in response to *A. saligna*. The results of this work could serve as a basis to understand mechanisms underlying the success of this tree in invading natural plant ecosystems of Jordan.

MATERIALS AND METHODS

The study area and species: Field work was conducted from March to May 2009 during the flowering period of most native plant species of Jordan (Al-Esawi, 1999). A total of 24 stands of *Acacia saligna* trees were randomly studied in several localities in northern part of Jordan (Bani

To cite this paper: Odat, N., W. Al Khateeb, R. Muhaidat, M. Al U'datt and L. Irshiad, 2011. The effect of exotic *Acacia saligna* tree on plant biodiversity of Northern Jordan. *Int. J. Agric. Biol.,* 13: 823–826

Kenana, Al Yarmouk, Al Nu'aema, Jerash). The climate in these localities is fundemntally Mediterranean with cool, wet winters and warm dry summers. The soil of the studied locations is Terra Rossa and the vegetation includes mainly tall grasses (*Hordeum spontaneum*, *Avena sterilis*) and legumes (*Vicia* sp., *Ononis* sp., *Trifolium* sp., *Medicago* sp.).

Methodology and experimental design: Different experimental designs are currently employed to estimate the effects of invasive trees such as *A. saligna* on native plant diversity (Pysek & Pysek, 1995; Holmes & Cowling, 1997). To study the effects of this tree on native plant diversity, we used the approach developed by Jäger *et al*. (2007) with minor modification. Briefly, three replicates of a 0.5 m^2 quadrates were visually placed under and near the tree i.e., along the distance from the tree trunk to approximately one meter from the edge of the tree crown (hereafter called inner segment). Additionally, three more quadrates were placed outside the tree crown (called outer segment). Accordingly, average plant species cover was estimated in both inner and outer segments for all studied stands of *A. saligna*.

Data analysis and diversity statistics: Prior to the analysis, the values for individual plant species cover were log-transformed to meet the assumptions of ANOVA for normality and homogeneity of variances. From these plant cover data, we calculated Shannon's, Simpson's and Margalef's diversity indices as measures for community diversity, using the software PRIMER (Clarke & Gorley, 2007). In addition, we used the software EstimateS (Colwell, 2006) to determine species richness by computing 'estimated number of species' from the mean estimated species accumulation curves based on the observed number of species in area. This way of estimating species richness is recommended to produce a better estimate of species richness extrapolated to a larger sample area (Ugland *et al*., 2003). One-way analysis of variance (ANOVA) was conducted to compare species cover and diversity parameters between inner and outer segments of studied trees canopy with post hoc tests of Tukey HSD at $P < 0.05$ using SPSS Version 14.0 for Windows.

To discover whether invasion by *A. saligna* influences native plant community composition and structure we analyze total native plant cover of individuals species in the two segments (inside & outside) by employing an ordination statistical method using a principle component analysis (PCA; Clarke & Gorley, 2007). The two principal components resulted from this method were projected and presented in scatter plot (Jäger *et al*., 2007; Yu *et al*., 2011).

RESULTS AND DISCUSSION

Analysis of species diversity revealed that both the estimated and the observed numbers of plant species of studied communities in Jordan were significantly affected by the presence of *A. saligna* (Fig. 1). The species accumulation curves and observed number of species showed a clear reduction of the estimated number of species from the outer to inner portions of studied acacia trees (Fig. 1a & b). These results are consistent with these of the one-way analysis of variance ANOVA carried out on the different diversity parameters (Table I). Moreover, various diversity indices has shown that the proximity to *A. saligna* trunk causes a decrease in community diversity (Fig. 2).

The sub-area factor (i.e., inner & outer segments) was significant for all comparisons of total number of species, Shannon's, Simpson's and Margalef's diversity indices with Post hoc tests indicated that mean observed numbers of species for the inner and outer segments of studied trees was significantly different. Additionally, there were significant differences in average plant species cover with distance from the *A. saligna* tree (data are not shown). The results of this study provided evidence supporting the main objective of the study (see Introduction section). The results clearly showed that the number of plant species and their cover decreased significantly with proximity to *A. saligna* trees suggesting that invasion by *A. saligna* is associated with great impact on the diversity of Jordanian plant communities. Additionally, the results mentioned above were supported by ordination method of PCA, which revealed that native plant community composition varied as the distance from the tree trunk increases suggesting that plant species composition varied between inner and outer segment as a result of invasive *A. saligna*. The first and the second PCA ordination axis explained about 76% of total variance of the species community between inner and outer segments.

Our results are in agreement with previous findings conducted in different ecosystems worldwide showing that exotic plant species can significantly alter community structure and reduces local plant diversity (El-Ghareeb, 1991; Musil, 1993; Pysek & Pysek, 1995; Martin, 1999). However, similiar to many other observational studies **(**Belote *et al.,* 2008; Levine *et al*., 2008), our study was limited because it did not provide direct evidence for the processes underlying consequential impacts of invasive *A. saligna* on plant community structure in Jordan.

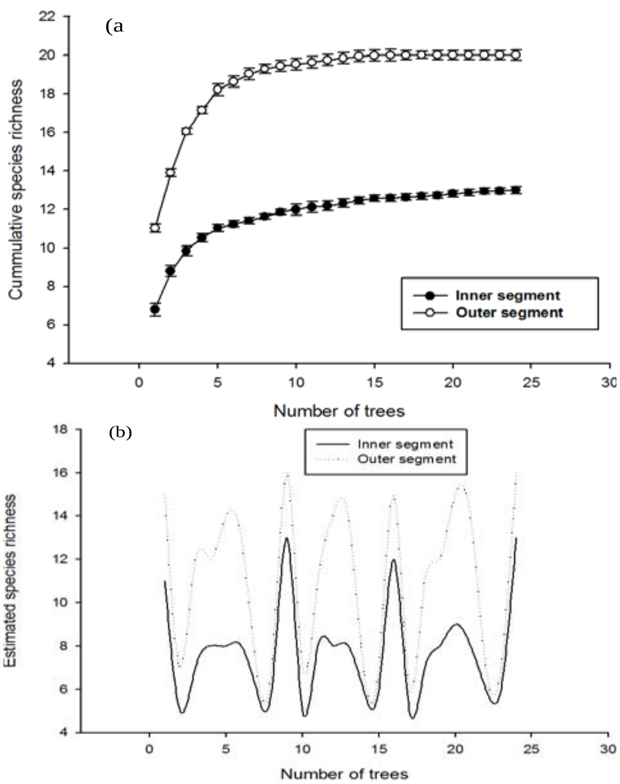
Here however, a number of mechanisms by which *A. saligna* may extert an effect on plant diversity in Jordan can be proposed. *A. saligna* is known to alter soil characteristics and thus quality in a way that suits its own benefits (Richardson *et al*., 1997). Additionally, it has been shown that Acacia species are superior over other native plants partly because it produces a large amount of litterfall due to its large biomass as well as being excellent nitrogen fixers as compared to other native plants **(**Holmes & Cowling, 1997; Yelenik *et al.*, 2004; Hellmann *et al*., 2011). Moreover, with their large canopy and high transpiration rates, *Acacia* species also reduce water content and field capacity of soil, where they grow (Musil, 1993).

Table I: ANOVA Summary statistics of the effects of *Acacia saligna* on total number of species, Shannon's diversity index, Simpson's diversity index and Margalef's diversity index. Data is based on means of three replicates of studied quadrates (see material and methods)

Parameters	Inner segment	Outer segment	MS	*P*-value
Total Species number	7.79 (0.48)	11.08 (0.73)	130.02	< 0.01
Shannon's index	1.88 (0.05)	2.22 (0.07)	1.37	< 0.001
Simpson's index	0.83 (0.01)	0.88 (0.01)	0.03	< 0.001
Margalef's index	1.18 (0.10)	1.61 (0.01)	2.18	< 0.001

Data based on results of one-way ANOVA and Tukey HSD tests (n = 24, d.f.=1, values appear in table represent means with standard errors shown between brackets)

Fig. 1: Species richness based on estimated number of species extracted from expected species accumulation curves (a) and observed number of species (b) for inner and outer segment



CONCLUSION

These results of this study provided us with evidence that the exotic tree of *A. saligna* reduces plant biodiversity of Jordan. Reduction of plant diversity by exotic tree is driven by a variety of mechanisms and there is an urgent need for controlled experimental designs coupled with field manipulations in order to discover the actual mechanism of impact. Such experiments are crucial from ecological and conservation points of view and we are considering carrying out such experiments.

Fig. 2: Effects of position from canopies of *Acacia saligna* on different diversity indices of Shannon's diversity index, Simpson's diversity index and Margalef's diversity index of the associated annual and perennial species native plants of Jordan

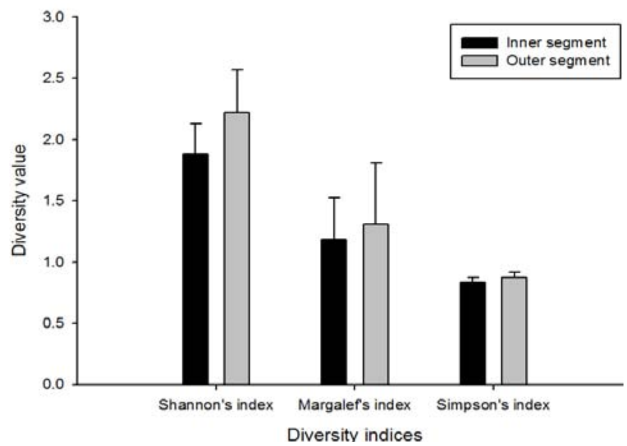
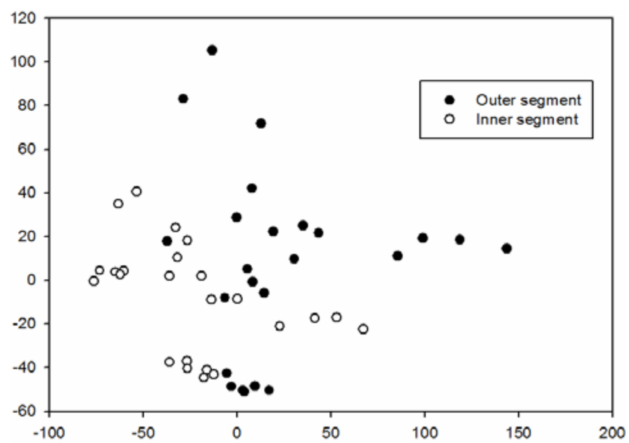


Fig. 3: Scatter plot of component scores of the first two principal components analysis (PCA) on the total native plant cover of individual species (filled circle = inner segment and closed circle = outer segment)



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(Received 26 February 2011; Accepted 07 May 2011)