Effects Of Bituminaria Bituminosa (L.) Stirton On The Growth Of Atriplex Nummularia Lindl.

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Abstract: In Morocco, forests are under severe pressure because of the intense needs of the population for land used for food crops and wood for domestic or industrial use. To this over-exploitation is added climatic and edaphic aridifications which accentuate the phenomenon of erosion, the degradation and the decrease of soil fertility. Consequently, alternative strategies based on the use of appropriate plants are needed to restore and / or to rehabilitate degraded lands and to improve crop production.
In many countries, Bituminaria bituminosa is used; this shrub has attracted considerable attention related to its important role in nitrogen fertilization, soil protection against erosion and significant productivity improvement (Yates et al.,2009).
Also, the purpose of this study is to evaluate the impact of Bituminaria-rhizobia symbiosis on associated plants such Atriplex nummularia.
So, a trial was conducted under-greenhouse at the Faculty of Sciences of Meknes (Morocco); there were pots with plants of Bituminaria bituminosa and Atriplex nummularia grown alone (monoculture) and others with the association of the two species.
At the flowering stage of the plants, the growth as well as the nodulation parameters including respectively height and dry biomass and number and dry biomass of nodules was evaluated.
The results obtained revealed that Atriplex nummularia benefited from its association with Bituminaria bituminosa as its biomass was high in comparison to its monoculture. Besides that, the growth and the nodulation parameters of B.bituminosa were improved in mixed culture.

Keywords: Bituminosa bituminosa, Atriplex nummularia, Rhizobial symbiosis, Association

1. INTRODUCTION

In Morocco, the rangelands cover around 53 million hectares, which represent 74% of the national territory; 9 million hectares are forest rangelands, grouped in ten large ecological groups distinguished from one another by their characteristics climatic, edaphic and floristic (MARA, 1992; Mahyou et al.,2010).
These rangelands constitute the primary source of animal feed; they contribute an average of 36% of annual fodder production (MADRPM, 2007) which is approximately 3.4 billion fodder units (UF).Moreover, in Morocco, the most practiced farming method is the extensive type, and it is carried out on collective rangelands or in forests. Forest areas contribute to the

national fodder balance of 17% (Bendahmane, 2001) and support 10 million heads (45% of the national herd)(FAO, 2011).

However, these ecosystems are exposed to real threats mainly due to zoo-anthropic factors and climatic hazards. Indeed, the scale of demographic growth in forest and peri-forest areas, the sedentarization of pastoralists, overgrazing, supplemented by the recurrence of drought periods has led to major dysfunctions in forest areas, to the point that regeneration of natural silvopastoral formations is compromised (Hoffman & Todd, 2000; Solomon et al., 2007; Schultz & Prasad, 2009; Al-Karablieh, 2010).

In this way, studies on the dynamics of natural vegetation in Morocco revealed a clear reduction in the extent of natural rangelands, a change in their floristic composition and a decrease in their productivity (De Waroux and Lambin (2012); Bechchari et al ., 2014; Mahyou et al.,2016).

Faced to this alarming situation, many pastoral development actions have been initiated to restore and / or rehabilitate degraded rangelands; these include defenses, assisted regeneration operations, planting fodder shrubs in addition to so-called Water and Soil Conservation (CES) techniques (Hachmi et al.,2018).

In this respect, the leguminous Bituminaria bituminosa (L.) Stirton is a shrub with high forage potential which could be used to rehabilitate and / or improve rangelands; therefore, this work has been undertaken with the aim of seeing what effects could have its installation on the other components of the ecosystem, in particular the soil and the neighboring plants, in relation to its ability to fix atmospheric nitrogen in symbiosis with Rhizobiums. Therefore, a trial was carried out in pots, where the Atriplex nummularia Lindl, a non-legume shrub, was sown alone and in association with B. bituminosa.

2. MATERIAL AND METHODS

2.1 Experimental device

After pre-germination, seedlings of Bituminaria bituminosa (B.b) and Atriplex nummularia (A.n) at the 3 to 6 leaf stage were transplanted into pots of 10 liters capacity arranged in a completely random block with three repetitions; each of the two species was cultivated alone, at the rate of four plants per pot, respectively (4 B.b) and (4 A.n), in addition to mixed culture (2 B.b and 2 A.n). Also, the B.b plants were carefully inoculated by a rhizobial culture at 10^9 cfu. ml^{-1}.

Figure 1: Experimental device

The plants were harvested after a growing period spread from March to June; the fresh and dry biomass accumulated by all shoots and roots parts were determined after drying in an oven at 60◦C for 72h; also, the nodulation parameters of B.b, namely the number and the dry weight of the nodules were evaluated.

2.2 Statistical analysis

All the cumulative data were subjected to a single factor analysis of variance (ANOVA) in order to investigate the effect of the Culture (mixed or pure) on the development of biomass; SPSS software,version 17, at 5% significance level was used.

2.3 Efficiency in using the rhizobial symbiosis

The efficiency of the rhizobial symbiosis was estimated by the slope of the regression model of the aerial biomass on the nodular biomass via the equation of the regression line: $y = a x + b$; b corresponds to the biomass production without nodules and makes it possible to deduce the expected efficiency.

3. RESULTS

3.1. Aerial and root biomass of Atriplex nummularia

The figure 2 represents the aerial biomass accumulated by A.n according to the type of culture; it let to show a net difference between mixed and pure culture; the analysis of variance was significant at $p < 0.05$. The dry weight has been improved by 150% in the mixed situation.

Root biomass varied similarly as the above ground part (figure 3); the dry root weight 12.65g and 2.5g for A.n in mixed and pure culture respectively which reveals a 5-fold improvement rate.

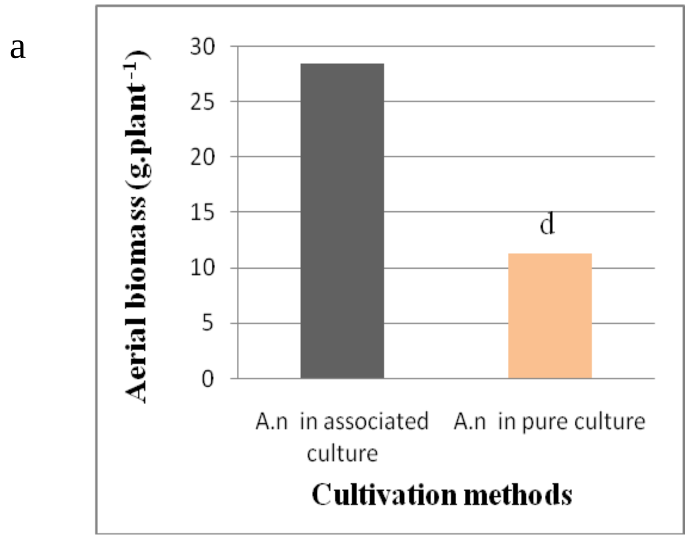


Figure 2: Aerial biomass accumulated by A.n according to the two cultivation methods

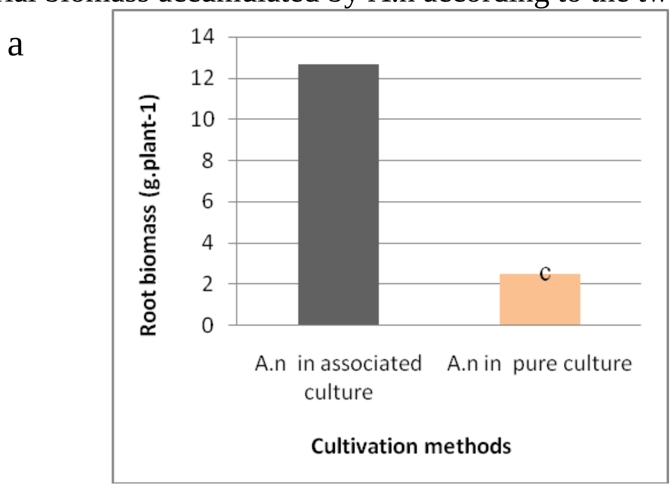


Figure 3: A.n. root biomass according to the two cultivation methods.

3.2. Aerial and root biomass of Bituminaria bituminosa

The results relating to the aerial biomass of B.b are presented in Figure 4;the analysis of variance revealed a significant difference at p <0.05, between the two modalities of culture. The accumulation of biomass by B.bin mixed culture was 1.88-foldenhanced in comparison with B.b biomass in pure culture.

Also, there was a clear improvement (about 119.3 %) of the roots dry weight in the mixed culture (37.83 g), compared to that accumulated in pure culture (17.25g).

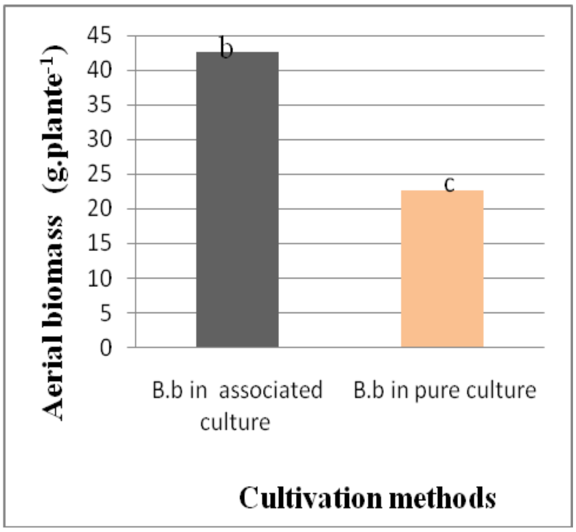


Figure 4: B.b aerial biomass according to the two culture methods

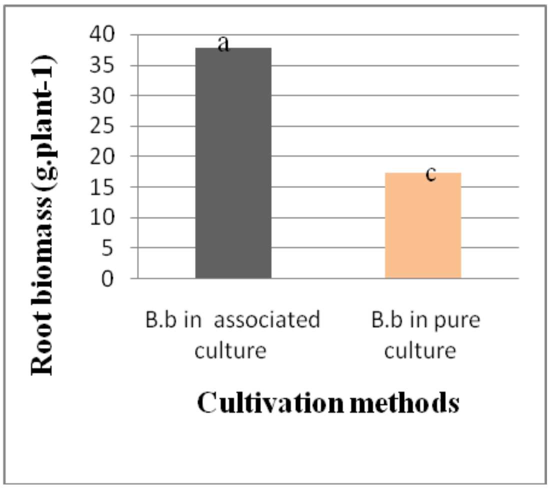


Figure 5: Root biomass of B.b according to the two cultivation methods

3.3. Nodulation parameters

3.3.1 Number of B.b nodules

According to Figure 6-1, the number of nodules estimated for B.bin associated culture was significantly higher (454 nodules / plant) than that formed in pure culture (291.33 nodules / plant).

3.4.2 Nodular biomass of B.b

The results obtained for the nodular biomass show that B.bin combination has a nodular biomass (1.92 g / plant), statistically different (at p <0.05) in comparison to that recorded in pure culture (1.25g / plant) (Figure 6-2).

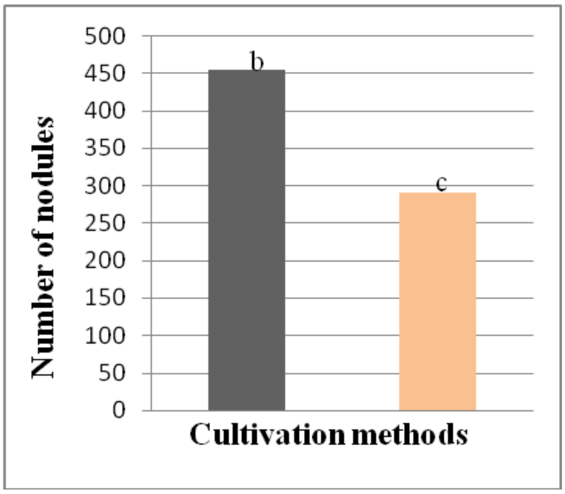


Figure 6:6-1: Number of nodules of B.b according to the two culture methods

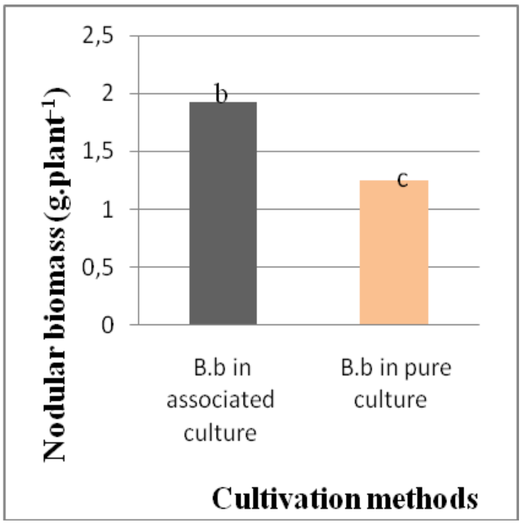
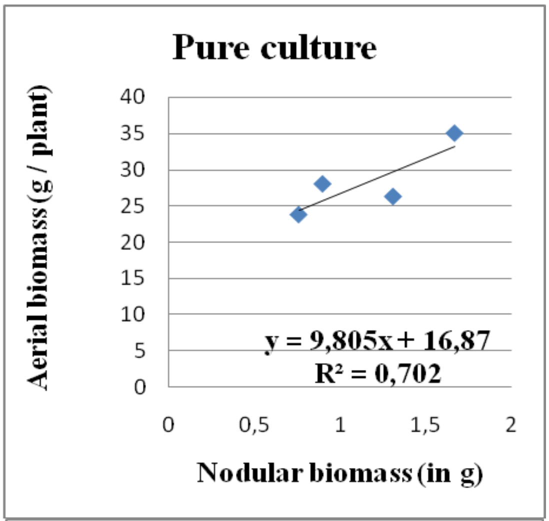


Figure 6: 6-2 Nodular biomass of B.b according to the two culture methods

3.4 Effectiveness of the use of rhizobial symbiosis

The effectiveness of the use of rhizobial symbiosis has been defined by Bargaz et al.,(2012) as the linear regression slope between the nodular and the shoot dry weights. Also, graphical representations of correlation between nodular biomass and B.b dry aerial biomass were made; the aim was to emphasize the effect of Nitrogen fixation on B.b growth, according to the two cultivation methods (monoculture and mixed culture).

So, the regression curves illustrated in figure 7 show positive correlations between nodulation and aerial growth in the two types of culture (pure and associated).The correlation is high between the two parameters in mixed culture (R = 0.961) while in pure culture, the value of the correlation coefficient is lower (R = 0.702).



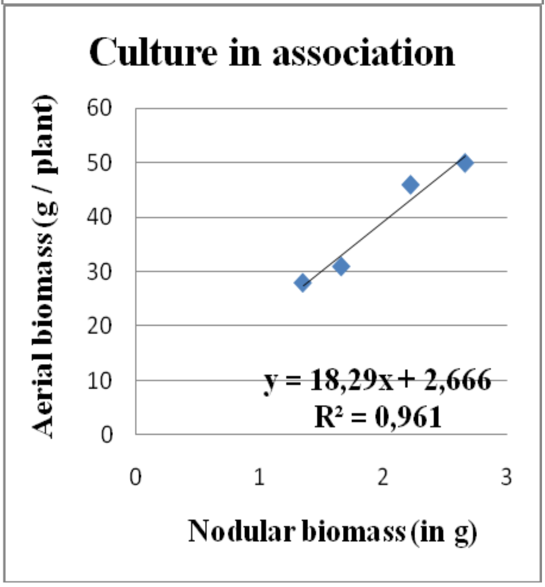


Figure 7: Correlation between the nodular biomass and the aerial biomass of B.bin the two types of culture

So, the regression curves illustrated in figure 7 show positive correlations between nodulation and aerial growth in the two types of culture (pure and associated).The correlation is high between the two parameters in mixed culture (R = 0.961) while in pure culture, the value of the correlation coefficient is lower (R = 0.702).
Although reflecting a negative effect of one species on the other, the phenomena of interspecific competition can induce a yield gain when the associated species are complementing and use resources more efficiently than their corresponding mono-specific cultures (Willey, 1979).This happens notably when the components of the association don't have the same requirements and therefore are not in strong competition for the same resources (in time, space or chemical form), which results in interactions less interspecies competitive than intraspecies.
Thus, the results obtained in the present work show that both the aboveground and the root biomass of A.n in association with B.b are superior to the biomass accumulated in pure culture; This is in accordance with several studies which report that the combination of legumes and cereals compared to monoculture results in an efficient use of environmental resources for plant growth due to the complementarity and / or interspecific synergy, which

results in the attenuation of competition between associated species (Corre-Hellou and Crozat, 2005).

Furthermore, the association affects positively B.bas the aerial and underground biomass accumulation is more important in comparison to the monoculture; in a similar way, Finlayson (2012) has shown that the production of Bituminaria bituminosa C.H. Stirt var. Albomarginata was improved about 58% in mixed crops in Australian dry lands.

The ability of legumes to use atmospheric nitrogen through the symbiotic fixation with rhizobia, has a positive effect on non-legumes grown in association with them; first, soil nitrogen is mainly exploited by the non-legume species; also, the associated species indirectly benefits from the transfer of biologically fixed nitrogen via exudation and / or excretion or after senescence of the nodules and nitrogen turnover.

Several authors reported that grasses can benefit from nitrogen from neighboring legumes (Pirhofer-Walzl et al.,2012). Oberson et al.(2013) showed that in a grass-clover association, approximately 50% of the nitrogen in grass came from clover; that nitrogen transfer could be explained by the release by the legume roots of compounds relatively labile and rich in nitrogen (Fustec et al.,2010). Also, according to Fustec et al.,(2010), during its cycle, an annual legume can "rhizodepose" up to 15% of its total nitrogen; these rhizodeposits consist of $NH4^{+}$ (Brophy and Reichel, 1989), $NO3^{-}$ (Wacquant et al.,2005), exudates such as organic acids, sugars, proteins, amino acids (Paynel et al.,2001), and mucilage (Nguyen, 2003).

Moreover, a significant increase in the number and biomass of B.b nodules in association with A.n was observed, which is in agreement with the results reported by Li et al.,(2004) where there was an increase in chickpeas and cowpeas in association with corn developed a more nodules in association than in monocultures.

Also, in mixed culture, the progressive absorption of nitrates by the non-legume creates a deficit in soil that stimulates more and more nitrogen fixation by the associated legume (Naudin and al.,2010, Latati et al.,2013), whereas, several scientific works reported that in soils with high nitrogen contents, the symbiotic nitrogen fixation is low or even absent.

In the same way, Li et al.,(2009) showed an increase in the atmospheric nitrogen fixation by fababean cultivated in association with durum wheat.

Also, the positive correlation between the nodular and the aerial biomass of B.b certifies that the efficiency of the rhizobial symbiosis use was better in association than in monoculture.

Thus, it seems that the association Atriplex - Bituminous clover is favorable for the two shrubs in comparison with their respective monocultures.The mutual benefit reflects a reduction in interspecific competition in comparison to intraspecific one. Atriplex benefits from the presence of the legume, in particular via exploitation of soil resources and indirect profit from the fixation of atmospheric nitrogen; for the legume, its ability to fix nitrogen is stimulated by the presence of the non-legume which affects the nitrogenous pool of the soil.

4. CONCLUSION

The results obtained in the present work show that Atriplex nummularia benefited from its association with Bituminaria bituminosa and the aerial biomass as well as the roots dry weight were improved in comparison to the respective pure culture. Also, the association induced an increase in the nodulation of Bituminaria bituminosa and in the efficiency of use of the rhizobial symbiosis.

In view of our main objective which consists of the rehabilitation of sylvo-pastoral land by installing bituminous clover, the value of this species as a multi-purpose shrub is confirmed; indeed, Bituminaria bituminosa possess a good forage value and has the ability to improve soil fertility and the growth of associated plants. Therefore, all components of the ecosystem, soil and biocenosis are improved.

In addition, this association can constitute a model to be used in agroforestry, in “Alley-cropping”, for a better management of the silvopastoral space, a profitability and diversification of production on the same surface unit.

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