CPQ Microbiology (2019) 3:4
Review Article

Effects of *Prosopis juliflora* on Soil Microbial and Other Pathogenic Activities: A Review Paper

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Received: 23 July 2019

Published: 16 August 2019

Keywords: *Colonization; Extracts; Microbial; Mycorrhization; Native Plants; P.juliflora; Rhizosphere; Soil; Species*

Abstract

This paper was aims to assess the effects of *Prosopis juliflora* (Sw.) DC (*P.juliflora*) on the abundance, composition, and activity of soil microbial and pathogenic communities, and their effects soil communities of beneficiary plant species. *P.juliflora* is effective in increasing the total mycorrhizal colonization of roots and reducing heavy metals such as Cadmium (Cd) levels in plants. Results depicted that intensity of mycorrhization of *P.juliflora* was significantly higher than that of native Acacia species. On the other hand, in study results in all sites in Saudi Arabia revealed that Cmic of *P.juliflora* was greater in the rhizosphere of *P.juliflora* than in the rhizosphere of *Acacia ehrenbergiana* and *Acacia tortilis*. Extracts from parts of *P.juliflora* are used in disinfecting, and also potentials in various bio-functions against different bacterial pathogens. These extracts are more active in green leaves than dry leaves. The diverse soil microbial associations, antagonistic and biopharmaceutical functions of the extracts of *P.juliflora* might change the negative perceptions of communities using it and impacts on native plant species.

Introduction

P.juliflora belongs to the family Fabaceae (Leguminosae), subfamily Mimosoideae and genus Prosopis. It is a well-adopted shrub to harsh environmental conditions of many arid zones [1]. *P.juliflora* is originated from South America, the Caribbean, and Central America [2]. The species is distributed in the lowlands of Americas, Africa and Asia [3].

The ecology or habitats of *P.juliflora* are grasslands, shrubland, and dry forests. This is a salt and drought tolerant tree/shrub species. Moreover, it is nitrogen-fixing, has deep-reaching roots and tolerates dry as well as waterlogged soils [4]. *P.juliflora* is found in areas where water and poor soil fertility are the principal agents limiting plant growth and can survive and even flourish on some of the poorest land, unsuitable for any other tree species [3]. However, the impact of plant invasions on ecosystems, habitats and native species is severe and often irreversible [5].

P.juliflora is one of the most economically and ecologically important tree species in arid and semi-arid zones of the world. It is an important species because of its high nitrogen-fixing potential in very dry areas and drought seasons [6]. Moreover, *P.juliflora* is effective in increasing the total mycorrhizal colonization of roots and reducing heavy metals such as Cadmium (Cd) levels in plants. This is affected by Coir pith that is a by-product of the coir industry and *P.juliflora* charcoal prepared by burning *P.juliflora* plant wood [7].

The most probable number analysis showed that density of rhizobia organisms which were able to nodulate *P.juliflora* was greater than for Acacia species. Arbuscular mycorrhizal fungi colonization in the roots of native species was also affected by *P.juliflora* [5].

P.juliflora is among nurse plants acting as facilitation and involved in the organization of plant communities and maintenance of biodiversity, particularly in harsh environments. Nurse plants increase plant diversity and productivity in these ecosystems, but our knowledge on the mechanisms through which such facilitation operates is still expanding. Despite of the growing evidence of soil microbiota impacts on plant fitness and plant community dynamics, facilitation of nurse plants in terms of microbial associations were less understood [8].

Globally, several types of research were conducted regarding the effects of *P.juliflora* on native species, composition, and diversity [9,10], its effects on soil properties [11,12], allelophystic effects on associated plants [13], impacts on socioeconomic activities [2,14,15], but its role in terms of plant facilitation has been little explored. Thus, this paper tried to assess the effects of *P.juliflora* on the abundance, composition, and activity of soil microbial and pathogenic communities, and their effect of these soil communities on beneficiary plant species.

Materials and Methods

To compile this paper, 27 selected papers such as books, research papers, manuals, reports, and proceedings were reviewed. Main findings of research papers and textbook facts are tried to verify and reviewed to achieve the objectives of the paper.

Results

In arid and semi-arid systems results show that nurse plants promote the development of differentiated soil microbial communities characterized by a higher microbial abundance and activity, the dominance of competitive bacteria and larger mycorrhizal networks, compared to coexisting non-nurses [8]. Microbial associated plants enhance and facilitate the growth of other plants (target species). Plant-plant facilitation is thus a process by which one plant species has a positive effect on the germination, survival growth or fitness of other species [16-18]. In this paper, *P.juliflora* can be taken as nurse plants for other native species.

According to McIntire and Fajardo [18], biotic drivers in this case plants create and maintain biological diversity within trophic levels have focused primarily on negative interactions (i.e. competition), leaving marginal room for positive interactions (i.e. facilitation). However, understandings of plant ecology have an aboveground bias that neglects soil micro-organisms in plant species interaction environment [17].

Significance of Microbial Mechanisms of Plant-Plant Interactions

Communication among organisms is one of the best gifts of nature that played a key role in the evolution and involvedness of life on Earth [19]. For instance, one symbiont might be a better competitor for soil resources and might more efficiently deliver these remunerations to a single host species. This would be consistent with the competitive dominance of the host species. On the other hand, plant-plant interactions could be stabilized by negative feedback generated by highly disproportionate fitness relations between the plant and symbionts. Such unequal fitness relations resulting in negative feedback have been observed in interactions between co-occurring plants and arbuscular mycorrhizal fungi [20].

Effects of *P.Juliflora* Invasion Microbial Colonization

Results depicted that intensity of mycorrhization of *P.juliflora* was significantly higher than that of native Acacia species (Fig 1). Moreover, the intensity of mycorrhization of A. ehrenbergiana and A. tortilis decrease significantly from 20 and 17% (for plant growing on bulk soil) to 13.7 and 11.1%, respectively, for plant growing on soil collected from under *P. juliflora* tree canopies [5].

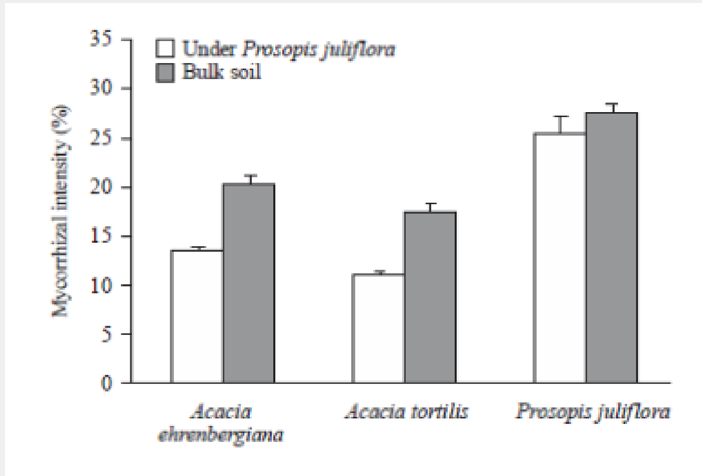

Figure 1: *The mycorrhizal intensity in P.juliflora, Acacia ehrenbergiana and A. tortilis roots in bulk soil and soil collected from under P.juliflora) in Saudi Arabia (Source: [5]).*

On the other hand, microbial biomass also differed significantly between soils from under *P.juliflora* and native Acacia species (Fig 2). In all sites, Cmic was greater in the rhizosphere of *P.juliflora* than in the rhizosphere of *A. ehrenbergiana* and *A. tortilis* ([5]).

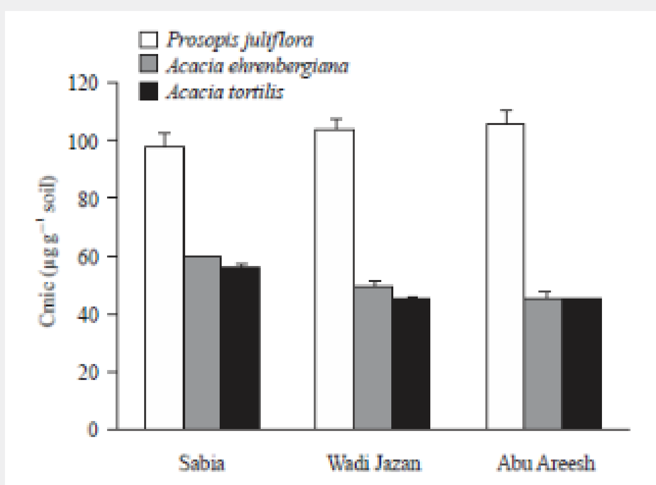

Figure 2: *TRhizosphere soil microbial biomass carbon (Cmic) of P.juliflora, A. ehrenbergiana and A. tortilis collected from three sites in Jazan regions of Saudi Arabia. (Sabia, Wadi Jazan and Abu Areesh) ([5])*

Mahdi *et al.* [21] reported that *P.juliflora* negatively affects the arbuscular mycorrhizal fungi colonization of Sorghum bicolor roots. It was found that *P.juliflora* stimulated the soil microbial biomass carbon, soil metabolic quotient, and soil enzymes activities. For instance, the intensity of mycorrhization in S. bicolor was significantly lowered by 24.6% (plants growing on bulk soil) to 17.1% in plants growing on soil collected from under *P.juliflora* tree canopies (Fig 3).

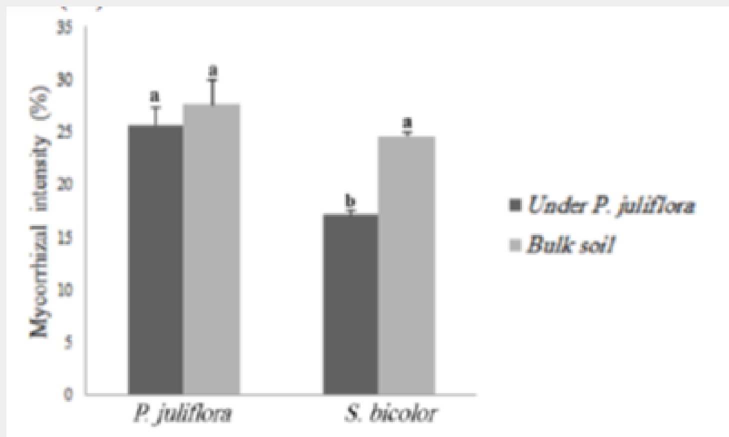

Figure 3: *The mycorrhizal intensity in P.juliflora and S. bicolor roots in bulk soil and soil collected from under P.juliflora in Jazan region of Saudi Arabia (Source: [21]).*

Antagonistic and Biopharmaceutical Effects of *P.juliflora*

It was indicated that *P.juliflora* had adverse effects on the growth of associated plants namely grass species in an ecosystem (e.g., Cenchrus ciliaris, Panicum antidotale and Panicum maximum). These outcomes suggest that *P.juliflora* foliage contains allelochemicals that had an inhibitory effect on plant growth [22]. Furthermore, results showed that different aqueous extracts of *P.juliflora* significantly affected the germination of native Acacia species. Plant growth of these species was also affected by the litter of the invasive plant.

Results on other aspects revealed that green leaves extract of *P.juliflora* has a higher zone of inhibition compared with dry leaves with a diameter ranged between 10 and 22 against all tested bacteria and with more inhibition to Gram positives than Gram-negatives (Saadoun *et al.,* 2014). Moreover, Odhiambo *et al.* [23] reported that ethanolic extract of root and leaves of *P.juliflora* possessed saponins, tannins, and alkaloids; phytochemicals whose antimicrobial properties were well documented and therefore could be attributed to antibacterial activity exhibited by these extracts. Results from this study strongly validated the use of *P.juliflora* in the management of bacterial infections.

Components of *P.juliflora* such as flavonoids, tannins, alkaloids, quinones, or phenolic compounds demonstrate potentials in various bio-functions, such as analgesic, anthelmintic, antibiotic, antiemetic, microbial antioxidant, antimalarial, antiprotozoal, antipustule, and antiulcer activities. Its components also used in the enhancement of H^+, K^+, ATPases; oral disinfection; and probiotic and nutritional effects; as well as in other biopharmaceutical applications, such as binding abilities for tablet production [24]. On the other hand, *P.juliflora* contains 24-methylencycloartan-3-one, which can safely be used to treat diabetes mellitus instead of using insulin [25]. This compound is contained in the oil of *P.juliflora* pods. Additionally, it has a good hypoglycemic effect in the screening assay of alloxan inducing fasted diabetic rabbits. The compound 24-methylencycloartan-3-one shows no cytotoxicity to red mammalian blood cells [26,27].

Conclusion

In several research findings, it was found that abundances and composition of both Rhizobium and mycorrhizal soil micro-organisms are greater in bulk soils under *P.juliflora* than under other native species. These indicated that more bacterial biomass under the soils of *P.juliflora* is far greater under soils of *P.juliflora* than other species, for instance, Acacia species. On the other hand, extracts from parts of *P.juliflora* are used in disinfecting, and also potentials in various bio-functions against different bacterial pathogens. These extracts are more active in green leaves than dry leaves. However, several research reports indicated that the negative effects of *P.juliflora* were outwaited that of positive ones. To reverse these problems, more researches will be carried out to promote and reduce negative integration of *P.juliflora* with associated native plants.

Conflicts of Interests

The article should be free from any such conflicts between authors or with others in any aspect.

Bibliography

1. El-Shabasy, A. (2017). Study on allelopathic effect of *P.juliflora* on the mineral content of Acacia ehrenbergiana in the Farasan Islands, KSA. *Journal of Medicinal Plants Studies, 5*(1), 130-134.

2. Haji, J. & Mohammed, A. (2013). The economic impact of *P.juliflora* on agropastoral households of Dire Dawa Administration, Ethiopia. *African Journal of Agricultural Research, 8*(9), 768-779.

3. Pasiecznik, N. M., Felker, P., Harris, P. J. C., Harsh, L. N., Cruz, G., Tewari, J. C., Cadoret, K. & Maldonado, L. J. (2001). *The P.juliflorajuliflora - P.julifloraplallida Complex: A Monograph*, HDRA, Coventry. (p. 172).

4. Weber, E. (2003). *Invasive Plant Species of the World. A Reference Guide to Environmental Weeds.* CABI Publishing, Wallingford, UK. (p. 344).

5. Mosbah, M., Taieb, T. & Habib, K. (2017). Invasive Character of *P.juliflora* Facilitated by its Allelopathy and a Wide Mutualistic Interaction with Soil Microorganisms. *J. Biol. Sci., 18*(3), 115-123.

6. Dave, P. N. & Bhandari J. (2013). *P.juliflora*: A review. *International Journal of Chemical Studies, 1*(3), 181-196.

7. Senthilkumar, P., Prabha, D., Subpiramaniyan, S. & Venkatasamy C. S. (2015). Remediation of cadmium contaminated vertisol mediated by *P.juliflora* charcoal and coir pith. *Eurasian Journal of Soil Science, 4,* 44-53.

8. Rodriguez-Echeverria, S., Lozano, Y. M. & Bardgett, R. D. (2016). Mechanisms and Consequences of facilitation in Plant Communities Influence of Soil Microbiota in Nurse Plant Systems. *Functional Ecology, 30,* 30-40.

9. Kumar, S. & Mathur, M. (2014). Impact of invasion by *P. juliflora* on plant communities in arid grazing lands. *Tropical Ecology, 55*(1), 33-46.

10. Shiferaw, W., Demissew, S. & Bekele, T. (2018). Invasive alien plant species in Ethiopia: ecological impacts on biodiversity a review paper. *Int J Mol Biol., 3*(4), 171-178.

11. Tiedemann, A. R. & Klemmedson, J. O. (1973). Effect of Mesquite on Physical and Chemical Properties of the Soil. *Journal of Range Management, 26*(l), Arizona, USA.

12. Mesene, M. & Kabtamu, T. (2017). Soil Quality Variation between *P.juliflora* Dominated Land and Adjacent Land Use Types: The Case of Dupti Sub-Watershed, Afar Regional State, Ethiopia. *Journal of Resources Development and Management, 30,* 85-97.

13. Getachew, S., Demissew, S. & Woldemariam, T. (2012). Allelopathic Effects of the Invasive *P.juliflora* (Sw.) DC on Selected Native Plant Species in Middle Awash, Southern Afar Rift of Ethiopia. *Management of Biological Invasions, 3*(2), 105-114.

14. Abebe, Y. T. (2012). Ecological and Economic Dimensions of the Paradoxical Invasive Species- *P.juliflora* and Policy Challenges in Ethiopia. *Journal of Economics and Sustainable Development, 3*(8), ISSN 2222-2855.

15. Tilahun, M., Birner, R. & Ilukor, J. (2017). Household-level preferences for mitigation of *P.juliflora* invasion in the Afar region of Ethiopia: a contingent valuation. *Journal of Environmental Planning and Management, 60*(2), 282-308.

16. Ren, H., Yang, L. & Liu, N. (2008). Nurse plant theory and its application in ecological restoration in lower subtropics of China. *Progress in Natural Science, 18*(2), 137-142.

17. Bever, J. D., Dickie, I. A., Facelli, E., Facelli, J. M., Klironomos, J., Moora, M., *et al.* (2010). Rooting Theories of Plant Community Ecology in Microbial Interactions. *Trends Ecol Evol., 25*(8), 468-478.

18. McIntire, E. J. B. & Fajardo, A. (2013). Facilitation as a ubiquitous driver of biodiversity: Tansley review. *New Phytologist, 201*(2), 403-416.

19. Ma, Y., Oliveira, R. S., Freitas, H. & Zhang, C. (2016). Biochemical and molecular mechanisms of plant-microbe-metal interactions: relevance for phytoremediation. *Front Plant Sci., 7,* 918.

20. Bever, J. D. (2002). Negative feedback within a mutualism: Host-specific growth of mycorrhizal fungi reduces plant benefit. *Proceedings of the Royal Society of London, B., 269*(1509), 2595-2601.

21. Mahdhi, M., Tounekti, T. & Khemira, H. (2019). Effects of *P.juliflora* on germination, plant growth of Sorghum bicolor, mycorrhiza and soil microbial properties. *Allelopathy Journal, 46*(2), 265-276.

22. Qayyum, A., Rafiq, M. K., Zahara, K., Bibi, Y., Sher. A., Rafiq, M. T., Aziz, R. & Manaf, A. (2017). Allelopathic effects of invasive *P.juliflora* on grass species of Potohar Plateau, Pakistan. *Planta Daninha, 36,* 018182503.

23. Odhiambo, R. S., Patrick, K. G., Helen, K. L., Gathu, N. C., Kimani, N. F., Waithaka, W. R. & Kipyegon, C. (2015). Antibacterial activity of ethanolic extracts of *Prosopis juliflora* against gram-negative bacteria. *European Journal of Experimental Biology, 5*(11), 43-46.

24. Henciya, S., Seturaman, P., Rathinam, A. J., Tsai, Y., Nikam, R., Wu, Y., Dahms, H. & Rong, F. C. (2017). Biopharmaceutical potentials of *P.juliflora* (Mimosaceae, Leguminosae). *Journal of Food and Drug Analysis, 25*(1), 187-196.

25. Alsaadi, J. H. H. & Al-Maliki, A. D. M. (2015). Hypoglycemic effect of 24- methylencycloartan-3-one isolated from *P.juliflora* pods in alloxan-induced diabetic rabbits. *World J Exp Biosci., 3*(1), 6-13.

26. Rajvanshi, S. & Garg, V. (2015). King of the desert (Prosopis): a source of potential medicinal values in Arid Zones of India: a review. *Int. J Res Eng Appl Sci., 5*(8), 185.

27. Saadoun, I., Challah, L. M. A., Aldhuhouri, F. M., Hamoudi A. A. & Joubori, B. A. (2014). Antagonistic Effect of the Exotic Plant " *P.juliflora*" Extract on Different Bacterial Pathogens. *Int. J. Curr. Microbiol. App. Sci., 3*(7), 865-873.