CELL BIOLOGY & DEVELOPMENT
Volume 1, Number 2, December 2017
Pages: 51-54

E-ISSN: 2580-4499
DOI: 10.13057/cellbioldev/v010203

Allelopathic effects of mesquite (*Prosopis juliflora*) aqueous extracts on seeds germination and seedlings growth of alfalfa, sesame and sorghum

HUDA HAROUN MOHAMMED OMER, IBRAHIM SAEED MOHAMMED♥
College of Agricultural Studies, Sudan University of Science and Technology. Shambat, Khartum, Sudan
Tel.: +249-9-12422515. ♥email: ibrahsaeed@yahoo.com, ibrahsaeed@sustech.edu

Manuscript received: 30 July 2017. Revision accepted: 18 December 2017.

Abstract. *Omer HHM, Mohammed IS. 2017. Allelopathic effects mesquite (Prosopis juliflora) aqueous extracts on seeds germination and seedling growth of alfalfa, sesame and sorghum. Cell Biol Dev 1: 51-54.* Mesquite plant [*Prosopis juliflora* (Swartz) DC] is an invasive tree or shrub native to South America. Unfortunately, the plant threatens biodiversity and agriculture due to deliberate distribution within Sudan. Furthermore, this plant has an allopathic potential that may be caused by falling leaves, fruits, root exudates, or plant leachates. These allelochemicals may inhibit the germination and growth of agricultural crops. This study was conducted in the Laboratory of Plant Pathology, College of Agricultural Studies, Sudan University of Science and Technology, Khartoum, in January-February 2016. The aim of this study was to elucidate the potential of allopathic effects of aqueous extract of different parts of mesquite plant, i.e., leaves, fruits, bark, and roots, on germination and early seedlings growth of alfalfa, sesame, and sorghum. The results indicated that the aqueous extracts of different parts of the mesquite plant significantly ($P \leq 0.05$) inhibited the seeds' germination and reduced the early growth of the seedlings. These suggest that the inhibitory substance (s) were widely distributed in mesquite plants but to varying extents. Moreover, fruits and leaves extracts were more pronounced and consistent than bark and roots. That could be attributed to the mesquite fruits and leaves aqueous extracts containing more water-soluble allelochemicals than roots and bark. They gave 0.0% germination in alfalfa and sesame and 47.6-86.7% in sorghum, respectively, compared to control. At the same time, the length of hypocotyl and radical was reduced to 0.0 cm and up to 2.7 cm depending on the efficacy of extract and the response of the test crop. Thus, it is recommended to study the nature of inhibitors to determine whether allelopathic is the cause of the extraordinary success of mesquite on the flat plains of agricultural land in Sudan.

Keywords: Allelopathic, aqueous extracts, mesquite, *Prosopis juliflora*

INTRODUCTION

Common mesquite *Prosopis juliflora* (Swartz) DC of the family Leguminosae is an invasive, evergreen, and multi-purpose leguminous tree or shrub (Babiker 2006). The plant, native to semi-arid areas of the West Indies, Mexico, Central America, and northern South America, was introduced to Sudan in 1917's (Brown and Massey 1929; Pasiecznik 2001; Felker et al. 2003). The plant is known to be well adapted to harsh environmental conditions of many arid zones. At its center of origin, the shrub has played an important social role. In addition to its role in combating desertification and supply of high-value mechanical wood products, firewood and charcoal mesquite provides shelters, animal feed, and food for humans in areas where protein intake is very low and under adverse conditions of drought and famines (Ibrahim 1989). Unfortunately, in Sudan, where mesquite was introduced in 1917 from South Africa and Egypt (Brown and Massey 1929), and due to underutilization of the plant, mismanagement, and its deliberate distribution within the country, the plant became a threat to agriculture and biodiversity **(**Babiker 2006).

The ground vegetation under the plant's canopy indicates that it has some allelopathic potential which might have been caused either by falling leaves, plant leachates, or root exudates. Consequently, releasing allelochemicals into the soil inhibits seed germination and the establishment of agricultural crops and vegetation (Rice 1974). The mesquite plant is an invasive species which widespread in many countries. Shankhla et al. (1965) reported the inhibitory effect of *Prosopis juliflora* aqueous extracts on the growth of some plants. Many researchers reported similar results (Noor et al. 1995; Warrag 1995; Al-Humaid and Warrag 1997; Nakano et al. 2001).

Allelopathy is the ability of plants to inhibit or stimulate the growth of other plants in the environment by exuding chemicals. Hans Molisch first introduced the concept of allelopathy to describe both the beneficial and the detrimental chemical interactions of plants and microorganisms (Molisch 1937; Narwal and Jain 1994). Since then, the term 'allelopathy' has undergone several changes. First, it has been defined as any direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that it releases into the environment (Rice 1979).

The present study aimed to elucidate the Allelopathic potential of different parts aqueous extract of *P. juliflora* plant in respect of their *in vitro* effect on germination and growth of some field crops with the following objectives: (i) To investigate the effect of the aqueous extracts of different parts of mesquite plant on germination of seeds of some field crops, and (ii) To study the inhibitory effect of different mesquite plant parts extracts on early growth of seedlings hypocotyl and radical length.

MATERIAL AND METHODS

Experimental site

The research was conducted in the Laboratory of Plant Pathology, Department of Plant Protection, College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Khartoum, in January-February 2016.

Collection of mesquite plant and crop seeds samples

Different parts of the mesquite plant, i.e., fruits, leaves, barks, and roots, were collected from trees growing on the campus of the College of Agricultural Studies, Shambat. The parts collected were cleaned from dust and strange material by hand, washed with distilled water, surface sterilized with 1% sodium hypo chloride, thoroughly washed in sterilized water and dried under shade at ambient temperature (25-30c), ground and powdered separately to obtain fine powder for extraction and kept till use.

The central grain market obtained healthy, uniform grains of sorghum, sesame, and alfalfa. Before germination, the grains were surface sterilized with 1% sodium hypochlorite for 20 minutes, then rinsed with distilled water several times to remove excess of the chemical.

Preparation of aqueous extract of different plant parts

Aqueous extracts of each plant part were prepared as Okigbo (2006) recommended. The obtained fine powder from different parts of mesquite was weighted (500 gm), added to it 1000 ml sterilized distilled water, and then placed in a shaker for 24 hrs. The extracts were filtered using Whatman No. 1 filter paper, and the filtrate was kept in the refrigerator to serve as stock solutions.

Bioassay

The seed samples were alfalfa, sesame, and sorghum germinated by being platted on filter papers (dia. 9.0 cm), placed in 9.0 cm sterilized plastic Petri-dishes, and then moistened with the respective test extract (four test extracts). Twenty-five seeds were plated from each sample. A total of four seed samples per crop, with three replications, were used. Treatments were arranged in a CRD (completely randomized design) with three replications and kept in the dark place for seed germination. Distilled water was used as a control. Five mL of the respective test extract was added to each petri-dish every other day until the end of the experiment after four days.

Measurement and statistical analysis

The seeds of each crop were examined for germination and early growth of seedlings upon the emergence of radical and hypocotyls after four days. Seeds were considered germinated upon radical emergence. Germination is measured based on the number of germinated seeds in each treatment and expressed as the percentage of the total number of treated seeds. Seedlings were then retrieved, and radicle and hypocotyl lengths were measured using a millimeter ruler and recorded. The seeds' germination percentages and seedlings' growth were employed as measures for allelopathic activity.

The data were analyzed by ANOVA (analysis of variance) using MStat software. Means were separated for significance using Duncan's Multiple Range Test (DMRT) ($P \leq 0.05$).

RESULTS AND DISCUSSION

Effect of mesquite plant aqueous extracts on the germination percentages

The results of the effect of aqueous extracts from different parts of *P. juliflora* on the final germination percentages of seeds of various test crops after four days from sawing are presented in Table 1 and Figure 1. Generally, the results showed that aqueous extracts of different parts of mesquite screened invariably and significantly inhibited the seeds germination of the test crops compared to control (100%). The inhibitory effect resulted in germination percentages ranging from 0.0% to 93.3%.

Among different parts of mesquite extracts, that of fruits and leaves reduced significantly (0.05) and consistently germinated all seeds of test crops. They gave 0.0% germination in alfalfa and sesame fruits extracts and 46.7% and 70.7% in sorghum; respectively; followed in descending order by bark extract, which gave 46.7%, 86.7%, and 64.0% and roots extract 80.0%, 93.3% and 86.7% germination in seeds of alfalfa, sesame, and sorghum; respectively. The roots extract exhibited the lowest inhibitory effect on the germination of seeds of all crops. Moreover, the suppressing effect of fruit extract was more pronounced on seeds of all crops than on other parts of mesquite. However, among crops, the germination of sorghum seeds was the least affected by the different extracts.

Effect of aqueous extracts of mesquite plant on the growth of hypocotyl and radical of alfalfa

The effect of aqueous extracts from different parts of *P. juliflora* on the growth of hypocotyl and radical of test crops four days after sawing is presented in Tables 2, 3, and 4. The data revealed that the extracts of different parts of the mesquite plant screened exhibited considerable differences in their inhibitory effect on the early growth of the test crops' hypocotyl and radicle of seedlings compared to control. The inhibitory effect ranged from 0.0% cm to 2.7 cm in length.

Among different parts of mesquite extracts, fruits and leaves expressed similar consistency in reducing significantly ($P \leq 0.05$) the growth of hypocotyl and radical of seedlings of the test crops compared to control. The length of the hypocotyl and radical was reduced to 0.0% cm in alfalfa, and sesame ranged from 0.10% cm for radical to 1.033 cm in hypocotyls of sorghum. The reduction effect given by bark and roots extracts on both

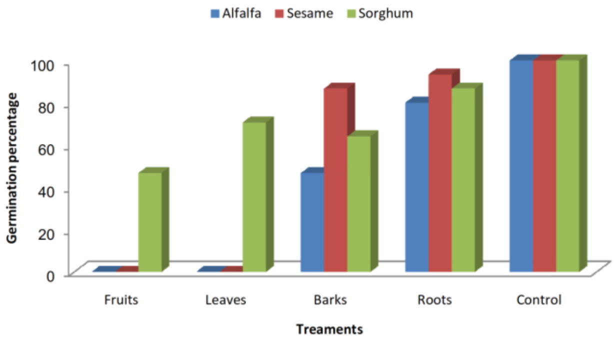

Figure 1. Effect of aqueous extracts from different parts of *mesquite plant* on the germination of seeds of various crops

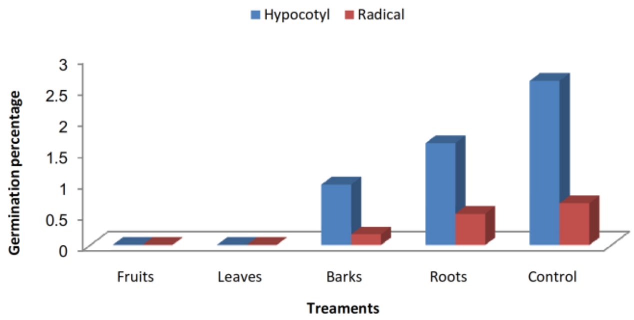

Figure 2. Effect of aqueous extracts from different parts of mesquite plant on the mean seedlings hypocotyl and radicle length (cm) of alfalfa

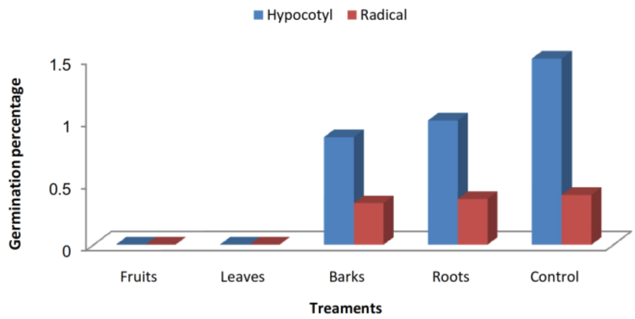

Figure 3. Effect of aqueous extracts of different mesquite plant parts on the mean seedlings hypocotyl and roots radical length (cm) of sesame.

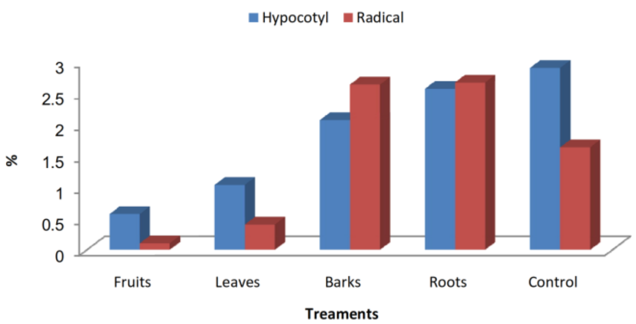

Figure 4. The effect of aqueous extracts of different mesquite plant parts on the mean seedlings' hypocotyl and radical length (cm) of sorghum crop

growth parameters was less in all seedlings of the test crops. Furthermore, the root extract exhibited the lowest inhibitory effect on the growth of hypocotyl and radicle of test crops. Moreover, the suppressing effect of fruit extract was more pronounced on the seedlings' growth of all crops. However, among crops, the growth of the sorghum seedlings was the least affected by the different extracts.

Discussion

The presence of biochemical inhibitors associated with some weeds, shrubs, or tree parts is widespread in the plant kingdom (Hedge and Miller 1990). Many trees are reported to have phytotoxins (Akram et al. 1990; May and Ash 1990; Chou and Lee 1991; Ferguson 1991); Kil and Yun (1992). For example, Chou and Yang (1982) showed that leachates of the bamboo, *Phyllostachys edulis* (Carr.), contain significant amounts of allelopathic compounds that can suppress the growth of undergrowth weeds. However, the water-soluble allelopathic substances released by the woody plants that participate in such interactions have been identified as phenolic compounds, flavonoids, and alkaloids distributed in woody species (Chou 1989; Harborne 1989). However, the ecological significance of phytotoxins in old field succession and other natural communities has attracted the attention of many workers (Mizutani 1989; May and Ash 1990; Choesin and Boerner 1991).

This study investigated the effect of aqueous extracts from different parts of P. juliflora on the final germination percentages of seeds and the early growth of seedlings of various test crops. The data revealed that extracts of different parts of the mesquite plant screened significantly inhibited the seeds germination of the test crops compared to control, with considerable differences among crops.

Moreover, the effect of fruit and leaf extracts was found to be more pronounced than that of bark and root. This highly significant inhibitory effect of fruits and leaves extracts could be attributed to the fact that the mesquite fruits and leaves aqueous extracts contain water-soluble allelochemicals than that of roots and bark; hence, the inhibitory effect was more. These results confirm that of Sazada et al. (2009), who reported similar results on wheat seeds, and Chellamuthu et al. (1977), who reported that the *P. juliflora* significantly reduced the germination percentage of gram and sorghum.

In this regard, Chou (1989) reported that the allelopathic metabolites leached out from woody plants often suppress the growth of undergrowth species sharing the same habitat. The results obtained in this study are also in line with Akram et al. (1990) and Kil and Yun (1992). They reported that the allelopathic effects generally produce germination inhibition and seedlings' early growth. Moreover, Macias et al. (1992) reported that although allelochemicals' specific mode of action was not investigated, many other studies demonstrated inhibition occurring through limiting cell division, respiration, photosynthesis, or disrupting membrane regulation. Accordingly, the presence of allelochemical activity in some parts of mesquite explains the possibility of the role of allelopathy in the phenomenal success of *P. juliflora* as an invader. These results also suggested that the inhibitory substance (s) were widely distributed in mesquite plants but to varying extents.

The data also demonstrated that the extracts of different parts of the mesquite plant screened inhibited the early growth of seedlings as measured by hypocotyl and radical length with considerable differences among crops. However, the inhibitory effect of root extract on growth parameters was found to be the least. That could be attributed to active allelochemicals' continuous release and leaching during crop growth. However, this mere presence of a suppressing effect does not prove that allelopathy does occur under natural conditions. Similar results were reported by Mehar et al. (1995). They demonstrated that mesquite root extract has the least effect on germination and early seedlings growth of various cultivars of *Zea mays* and *Triticum aesitvum.*

To conclude, this present study proved that the different parts of mesquite plant extracts invariably significantly reduced seed germination and early growth of all test seeds crops seedlings, indicating the presence of Allelopathic potential in *P. juliflora.* Furthermore, there are considerable differences in the inhibitory effect of the mesquite parts screened. Likewise, the seeds crops tested responded differently to the suppressing effect of mesquite parts extracts.

REFERENCE

Akram M, Ahmed N, Hussain F, Aslam KM. 1990. Allelopathic potential of four species of Ficus. Pak J Sci Industr Res 33: 52-54.

Al-Humaid AI, Warrag MOA. 1997. Allelopathic effects of mesquite (*Prosopis juliflora*) foliage on seed germination and seedling growth of bermuda grass (*Cynodon dactylon)*. J Arid Environ 38: 237-243.

Babiker AG. 2006. Mesquite (*Prosopis* spp.) in Sudan: history, distribution and control. In: Labrada R. (ed.) Problems Posed by the Introduction of *Prosopis* spp. in Selected Countries. Plant Production. Plant Production and Protection Division, Food and Agriculture Organization of the United Nations, Rome.

Brown AF, Massey RE. 1929. Flora of the Sudan. Thomas Murby and Co., London.

Chellamuthu V, Balasusbramanian TN, Rajarajan A, Palaniappan SN. 1977. Allelopathic influence of *Prosopis juliflora* on field crops. Allelopathy J 4 (2): 291-302.

Choesin DN, Boerner REJ. 1991. Allylisothiocyanate release and the allelopathic potential of *Brassica napus* (Brassicaceae). Amer J Bot 78: 1083-1090.

Chou CH, Lee YF. 1991. Allelopathic dominance of *Miscanthustrans morrisinensis* in an alpine grassland community in Taiwan. J Chem Ecol 17: 2267-2281.

Chou CH, Yang CM. 1982. Allelopathic research of subtropical vegetation in Taiwan. II. Comparative exclusion of under story by *Phyllostachys edulis* and *Cryptomeria japonica*. J Chem Ecol 8: 1489-1508.

Chou CH. 1989. The role of allelopathy in phytochemical ecology. In: Chou CH, Waller GR. (eds), Phytochemical Ecology: Allelochemicals, Mycotoxins and Insect Pheromones and Allomones. Academia Sinica Monograph Series No. 9, Institute of Botany, Taipei, ROC.

Felker P, Grados N, Cruz G, Prokopiuk D. 2003. Economic assessment of flour from *Prosopis alba* and *P. pallida* pods for human food applications. J Arid Environ 53: 517-528.

Ferguson DE. 1991. Allelopathic potential of western cone flower (*Rudbeckia occidentalis*). Canadian J Bot 69: 2806-2808.

Harborne JB. 1989. Recent advances in chemical ecology. Natural Product Reports 6: 86-109.

Hedge RS, Miller DA. 1990. Allelopathy and autotoxicity in alfalfa: characterization and effects of preceding crops and residue incorporation. Crop Sci 30: 1255-1259.

Ibrahim KM. 1989. *Prosopis* species in the South-western United States, their utilization and research. In: Dutton RW, Powell M, Ridley RJ. (eds.). *Prosopis* Species Aspects of their Value, Research and Development. Proceedings of the *Prosopis* Symposium. University of Durham, UK.

Kil BS, Yun KW. 1992. Allelopathic effects of water extracts of *Artemisia princeps* var.orientalis on selected plant species. J Chem Ecol 18: 39-51.

Macias FA, Galindo JCG, Massanet GM. 1992. Potential allelopathic activity of several sesquiterpene lactone models. Phytochemistry 31: 1969-1977.

May FE, Ash JE. 1990. An assessment of the allelopathic potential of *Eucalyptus*. Austr J Bot 38: 245-254.

Mehar N, Uzma S, Ajma MK. 1995. Allelopathic effects of *Prosopis juliflora* Swartz. J Arid Environ 31: 83-90.

Mizutani J. 1989. Plant allelochemicals and their roles. In: Chou CH, Waller GR. (eds), Phytochemical Ecology: Allelochemicals, Mycotoxins and Insect Pheromones and Allomones. Academia Sinica Monograph Series No. 9, Institute of Botany, Taipei, ROC.

Molisch H. 1937. Der Einflusseiner Pflanze auf die andere-Allelopathie. Gustav Fischer, Jena.

Nakano H, Fujji Y, Suzuki T, Yamada K, Kosemura SS, Yamakura S, Suzuki T, Hassegawa K. 2001. A growth inhibitory substance exuded from freeze-dried mesquite (*Prosopis juliflora* (Sw.) DC.) leaves. Plant Growth Regul 33: 165-168.

Narwal SS, Jain SK. 1994. Hans Molisch (1856-1937): The father of allelopathy. Allelopathy J 1 (1): 1-5.

Noor M, Salam U, Khan AM. 1995. Allelopathic effects of *Prosopis juliuora* Swartz. J Arid Environ 31: 83-90.

Okigbo RN. 2006. Antifungal effects of two tropical plants leaf extracts (*Ocimum gratisimum* and *Afromonum melegatuata* and post harvest yam (*Dioscoreaceae* spp). Afr J Biotech 5: 717-731.

Pasiecznik NM. 2001. The *Prosopis juliflora*-Prosopispallida Copmlex: A Monograph. HDRA, Coventry, UK.

Rice EL. 1974. Allelopathy; Physiological Ecology. Academic Press, New York, NY.

Sazada S, Shilpa B, Shoukat S, Mukesh K. 2009. Allelopathic effect of different concentration of water extract of *Prosopis juliflora* leaf on seed germination and radicle length of wheat (*Triticum aestivum* Var-Lok-1). Amer-Eur Sci Res 4 (2): 81-84.

Shankhla N, Baxi MD, Chatterji UN. 1965. Ecophysiological studies on arid zone plants. I. Phytotoxic effects of aqueous extract of mesquite, *Prosopis juliflora* DC. Curr Sci 21: 612-614.

Warrag MOA. 1995. Autotoxic potential of foliage on seed germination and early growth of mesquite (*Prosopis juliflora*). J Arid Environ 31: 415-421.