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PLANT PRODUCTION

Effect of Mesquite (*Prosopis juliflora*) Pericarps Aqueous Extracts on Seed Germination and Plumule and Radicle Elongation of Bermudagrass (*Cynodon dactylon*)

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Abstract. Mesquite (*Prosopis juliflora*) pericarps aqueous extracts, prepared by the extraction of 10, 20, 40, 60 and 80 g dry pericarp in a liter of distilled water, were tested for their allelopathic effects on seed germination and plumule and radicle elongation of bermudagrass (*Cynodon dactylon*) cv Common Bermuda. Compared with the distilled water control, all extracts, with the exception of the least concentrated, reduced seed germination percentage, the seed germination rate, as judged by the corrected germination rate index (CGRI) and the time to 50% of the final germination (GT_{50}), and plumule and radicle length, considerably. This reduction increased with the increase of extract concentration throughout the incubation period. In the two most concentrated extracts, both plumules and radicles elongated during the first day of incubation only, then growth ceased. Using polyethylene glycol 2000 (PEG) solutions, with the same osmotic potential and pH as the extracts, resulted in significantly higher values of the aforementioned parameters than most of their corresponding extracts. Hence, it could be concluded that the mesquite pericarp contains water-soluble allelochemicals which could inhibit the seed germination and reduce the rate of germination, and the plumule and radicle growth, of bermudagrass 'Common Bermuda'.

Introduction

The phytotoxic effects of a plant species on another, a phenomenon commonly known as allelopathy[1], have been reported with several angiosperms[2]. Unfortunately, these effects could be inflicted on a crop plant, either by a weed [3-5] or by another crop plant[6,p.8;7]. Among the later is the failure of the turf grass, bermudagrass, *Cynodon dactylon* (L.) Pers. to grow under sycamore, *Platanus occidentalis* L., trees [8], jeopardizing the co-existence of these two species. Lately, Al-Humaid and Warrag (1997) [9] showed that the seed germination and plumule and radicle growth of bermudagrass cv Common Bermuda were significantly retarded by leaf aqueous extract of mesquite, *Prosopis juliflora* (Swartz) D.C. Evidently, this was due to the allelopathic effects of mesquite, a well adapted shrub to harsh environmental conditions of many arid zones [10,p.137;11, p.92;12]. As yet, whether pericarps, which are occasionally incorporated in the soil intended to be sown with bermudagrass, could have a similar effect, has not been clarified.. Such information should be beneficial when planning for sowing bermudagrass beneath or near mesquite trees and should help enrich the rather limited research into the allelopathic potentials of crop germplasm [13]. Hence, this study was conducted to investigate the allelopathic potentials of mesquite pericarp on seed germination and plumule and radicle growth of bermudagrass 'Common Bermuda'.

Materials and Methods

Fully ripe pods were picked from three mesquite trees, grown at the College of Agriculture and Veterinary Medicine, King Saud University, Research Center at Burieda, Saudi Arabia. Each tree was considered as a replicate. The pods were quickly washed with distilled water and oven dried at 45 °C for 72 h. They were then broken into one - seeded portions and stored at room temperature after the removal of the seeds. A sample of 10, 20, 40, 60 and 80 g pericarp was soaked in a liter of distilled water at 27°C for 24 h. Then, these were filtered through a 1.0 mm wire mesh and then through Whatman No. 1 filter paper. The filtered extracts and a distilled water control were stored in a refrigerator at 2-4°C. Prior to use, the osmotic potential and the pH of the distilled water control and the extracts were determined with a freezing point depression osmometer (μ Osmette, Model 5004, Precision System Inc.) and an Orion Digital, Ionalyzer (Model 501), respectively.

Six ml of the distilled water control and of each of the extracts of the pericarp of one tree were dispensed in a 9.5 cm glass Petri dish lined with Whatman No. 1 filter paper. This step was repeated twice using the remaining two sets of the extracts. The dishes were then placed in polyethylene bags, to prevent evaporative water loss, and arranged in a completely randomized design inside an oven maintained at 27°C. An hour later, as the temperature of the dishes reached 27°C, 100 seeds of bermudagrass 'Common Bermuda' were uniformly spaced in each Petri dish. The seeds were examined daily under a dissecting microscope, fitted with a micrometer. Germinated seeds were counted and discarded daily, until no further germination was observed for five successive days. A seed was considered germinated when the radicle protruded beyond the seed coat by ≥ 0.2 mm.

In another experiment, some seeds of the same cultivar were put in five Petri dishes onto two layers of Whatman No.1 filter paper moistened with distilled water. These dishes were put in an oven kept at 27°C. A day later, five just germinated seeds were transferred to each of a set of Petri dishes prepared as described in the previous experiment. These were then placed in plastic bags and arranged in a completely randomized design inside an oven kept at 27°C. Using the dissecting microscope, the plumule and the radicles lengths were measured daily for five days. The average lengths were then calculated for each dish.

Based on the results of the above experiments, polyethylene glycol 2000 (PEG) solutions with the same osmotic potential as the extracts were prepared. The pH of these solutions were adjusted with dilute hydrochloric acid to the same levels of the extracts. Using the extracts and the PEG solutions, two experiments were conducted to determine the seed germination, and the lengths of plumule and radicle, in the same manner as described above. For all parameters, split plot design was used, with the osmotic potential and pH levels as main treatments and the solutions as subtreatments.

Seed germination percentage and number of days to reach 50% of the final germination(GT_{50}) were determined. The germination rate index (GRI) was calculated as the summation of the daily germination percentage divided by the total number of days of germination [14]. The corrected germination rate index (CGRI) was calculated by dividing GRI by the final germination percentage and then multiplying by 100 [15;16].

The seed germination percentages and the GT_{50} values were arcsin and square root $(x + 0.5)^{1/2}$ transformed, respectively. Then, these in addition to the rest of the data were subjected to analysis of variance. Mean separation was performed using Duncan's multiple range test (DMRT) [17, pp.8-308].

Results

As shown in Table 1, the pH of all pericarp aqueous extracts were lower than that of the distilled water control. The acidity of the extracts increased, whereas their osmotic potential decreased, with the increase of concentration, expressed as weight of dry pericarp soaked in a litre of distilled water (Table 1).

Table 1. The osmotic potential and the pH of mesquite pericarp aqueous extract

Growth medium	Osmotic potential (-mPa)	pH
Distilled water	0.00	6.53
Extract concentration (gl^{-1}):		
10	0.038* ±0.002	6.20±0.03
20	0.052±0.001	5.74±0.02
40	0.113±0.002	4.98±0.03
60	0.169±0.003	4.77±0.04
80	0.204±0.002	4.68±0.08

* Average of three samples ± standard error of the mean.

With the exception of the least concentrated, all the extracts exhibited significantly lower final germination percentages than the distilled water control (Table 2). Progressively less percentage of seeds germinated with the increase of extract concentration. In the most concentrated extract it was less than 50% of that in the distilled water control and the least concentrated extract. The corrected germination rate index (CGRI) also decreased with the increase of extract concentration (Table 2). The change was gradual, and the difference in the CGRI values between an extract and the next concentrated one was less than 10 day^{-1}. However, there were statistically significant differences at the 5% level between the control and, among most of the extracts. Compared with the distilled water control, the two least concentrated extracts resulted in almost the same time to reach 50% of the final germination (GT_{50}), whereas the other extracts resulted in significantly higher GT_{50} values (Table 2). The two most concentrated extracts exhibited the same GT_{50} value, which was slightly higher than that exhibited by the next concentrated extract. The seed testa in the distilled water control and the least concentrated extract were brownish, then they became increasingly darker in color with the increase of extract concentration.

Table 2. Effect of distilled water and mesquite pericarp aqueous extracts on the final seed germination percentage (%), corrected germination rate index (CGRI) (day^{-1}) and time to reach 50% of the final germination (GT_{50}) (day) of bermudagrass

Germination parameter	Distilled water	Extract concentration				
		10	20	40	60	80
Germination (%)	69.33 A*	67.33 A	42.67 B	37.33 C	33.67 CD	29.67 D
CGRI (day^{-1})	67.65 A	64.16 A	56.68 B	49.53 C	48.44 C	40.23 D
GT_{50} (day)	3.02A	3.00 A	3.33 A	4.00 B	4.33 B	4.33 B

* Means in the same row followed by the same letter were not significantly different at the 5% level, using DMRT.

For each of the first five days after germination, both plumules and radicles were significantly longer in the distilled water control than in all extracts (Table 3). Within the extracts, they decreased in length with the increase of extract concentration, throughout the incubation period. While the plumules continued to increase substantially in length every day in the distilled water control and the two least concentrated extracts, the radicles behaved similarly in the earlier growth medium only (Table 3). In the three most concentrated extracts, both plumules and radicles elongated during the first day after germination, then they ceased to grow. The radicles in the distilled water control and the least concentrated extract were whitish, whereas their tips became increasingly brownish in color with the increase of extract concentration. In the three most concentrated extracts, the radicles were very soft and could be easily smashed.

Compared with the extracts of the same osmotic potentials and pH, polyethylene glycol 2000 (PEG) solutions resulted in significantly higher seed germination percentage and CGRI, with the exception of the effect of the least concentrated PEG on the former parameter (Table 4). Although both seed germination percentage and CGRI decreased with the increase of PEG concentration, the differences were minor, in comparison with those in the extracts. Five days from germination, plumules in the two least concentrated PEG solutions were almost equal in length to those in the corresponding extracts, whereas in the rest of PEG solutions they were significantly shorter. On the other hand, the radicles were significantly longer in all PEG solutions than in any extract (Table 4).

Table 3. Time course of the plumule and the radicle lengths of bermudagrass under different concentrations of mesquite pericarp aqueous extract

Day of incubation	Distilled water	Extract concentration 10	20	40	60	80
			Plumule length (mm)			
1	1.5 A*	1.1 B	0.8 B	0.7 CD	0.5 CD	0.4 D
2	1.8 A	1.7 A	1.1 B	0.8 BC	0.5 C	0.4 C
3	3.7 A	2.4 B	1.8 C	0.8 D	0.5 D	0.4 D
4	4.6 A	3.8 B	3.0 C	0.8 D	0.5 D	0.4 D
5	5.1 A	5.0 A	4.1 B	0.8 C	0.5 C	0.4 C
			Radicle length (mm)			
1	2.5 A	1.0 B	0.6 BC	0.5 C	0.4 C	0.3 C
2	7.8 A	3.5 B	1.1 C	0.6 C	0.6 C	0.5 C
3	11.6 A	3.8 B	1.3 C	0.6 CD	0.6 CD	0.5 D
4	15.6 A	4.0 B	1.3 C	0.6 C	0.6 C	0.5 C
5	20.3 A	4.1 B	1.3 C	0.6 C	0.6 C	0.5 C

* Means in the same row followed by the same letter were not significantly different at the 5% level, using DMRT.

In fact, the shortest radicle in the PEG solutions was more than twice as long as the longest radicle in the extracts. The interactions were statistically significant for all these parameters. The colors of the seed testa and the radicles in the PEG solutions and the extracts were as described for the distilled water control and the extracts of the previous experiments, respectively.

Table 4. Effect of mesquite pericarp aqueous extracts and polyethylene glycol (PEG) solutions on seed germination and plumule and radicle length 5 days after germination of bermudagrass

Osmotic potential (-mPa)	0.038	0.052	0.113	0.169	0.204
pH	6.20	5.74	4.98	4.77	4.68
			Seed germination (%)		
Pericarp extract	66.67 A*	45.33 B	39.67 B	36.33 B	26.67 B
PEG solution	67.33 A	64.00 A	63.67 A	61.67 A	58.333 A
			CGRI (day^{-1})		
Pericarp extract	62.15 B	58.53 B	50.24 B	42.25 B	35.9 B
PEG solution	75.04 A	73.78 A	70.65 A	68.13 A	65.09 A
			Plumule length (mm)		
Pericarp extract	4.29 A	4.64 A	1.13 B	0.61 B	0.58 B
PEG solution	5.26 A	4.80 A	4.53 A	4.50 A	4.27 A
			Radicle length (mm)		
Pericarp extract	4.57 B	1.64 B	0.86 B	0.71 B	0.64 B
PEG solution	13.80 A	13.62 A	12.94 A	12.18 A	12.65 A

* Means in the same column followed by the same letter were not significantly different at the 5% level, using DMRT.

Discussion

Apparently, the detrimental effects of the mesquite pericarps aqueous extracts on seed germination and plumule and radicle elongation of bermudagrass were very substantial. Beside the failure of a significant proportion of the seeds to germinate, the germination rate was remarkably reduced, as evaluated by the CGRI and GT_{50}. These two indices have been widely used to compare the relative rate of germination[16;18] and to evaluate this parameter in meaningful biological units[19], respectively. Such seeds would be more vulnerable to attack by microorganisms. Moreover, a high percentage of the seedlings would be as useless as the ungerminated seeds. This is due to the failure of the plumules and radicles to elongate beyond a fraction of a millimeter, five days after germination. Most likely, such plumule and radicles would not be able to survive.

These detrimental effects could have been induced by the osmotic potential, the pH and/or by the allelopathic effects, of these extracts [2;20-23]. However, the levels of the osmotic potential[20] and the pH of the two least concentrated extracts were not low enough to be responsible for the effects brought about by these two extracts. This was clearly indicated by the significantly higher seed germination percentage, seed germination rate, as evaluated by the CGRI, and plumule and radicle growth rate, exhibited by the polyethylene glycol 2000 (PEG) solutions, in comparison with most of their corresponding extracts and by the significant interactions (Table 4). Thus, it could be deduced that the mesquite pericarp extracts contained water soluble allelochemicals that could cause inhibition of seed germination and reduction of seed germination, and plumule and radicle growth, rate of bermudagrass. Most probably, these allelochemicals were also responsible for the darker and brownish appearance of the seed testa and the radicle tips, respectively. These symptoms have been reported with some other plant species exposed to phytotoxins [4; 23-25].

Having many popular characteristics, such as drought [10,p.137] and salt [12] tolerance, mesquite has been intensively grown in public parks of Suadi Arabia. Large quantities of pods are produced every year, covering wide areas under and around the shrubs. Thus, when intended to be sown with bermudagrass, such areas should be kept free of mesquite pods during seed germination and seedling growth.

References

[1] Rice, E.L. "Allelopathy an Update". *Bot. Review,* 45 (1979), 15-109.

[2] Evenari, M. "Germination Inhibitors". *Bot. Review,* 15 (1949), 153-194.

[3] Bhowmick, P.C. and Doll, J.D. "Allelopathic Effects of Annual Weed Residues on Gowth and Nutrient Uptake of Corn and Soybean". *Agron. J.,* 74 (1984), 601-606.

[4] Weston, L.A. and Putnam, A.R. "Inhibition of Growth, Nodulation, and Nitrogen Fixation of Legumes by Quackgrass (*Agropyron repens*)". *Crop Sci.*, 25, (1985), 561-565.

[5] Mason-Sedun, W., Jessop, R.S., and Lovett, J.V. "Differential Phytotoxicity Among Species and Cultivars of the Genus Brassica to Wheat. 1- Laboratory and Field Screening of Species". *Plant and Soil*, 93 (1986), 3-16.

[6] Rice, E.L. *Allelopathy*. 2nd. ed. London: Academic Press, 1984.

[7] Walker, D.W. and Jenkins, D.D. "Influence of Sweet Potato Residue on Growth of Sweet Potato Vine Cuttings and Cowpea Plants". *HortSci.*, 21 (1986), 536-429.

[8] Al-Naib, F.A. and Rice, E.L. "Allelopathic Effects of *Platanus occidentalis*". *Bull. of Torrey Bot. Club*, 98 (1971), 75-82.

[9] Al-Humaid, A.I. and Warrag, M.O.W. "Allelopathic Effects of Mesquite (*Prosopis juliflora*) Foliage on Seed Germination and Plumule and Radicle Growth of Bermudagrass (*Cynodon dactylon*)". *J. Arid Environ.* (In Press).

[10] Evans, J. *Plantation Forestry in the Tropics*. Oxford: Clarendon Press, 1982.

[11] Douglas, J.S. and Hart, R.A.J. *Forest Farming*. London: Intermediate Technology Publications, 1984.

[12] Goyal, S.P., Bohra, H.C., Ghosh, P.K. and Parakash, I. "Role of *Prosopis cineraria* in the Diet of Two Indian Desert Antelopes". *J. Arid Environ.*, 14 (1988), 285-290.

[13] Putnam, A.R. "Allelopathy: Can it be Managed to Benefit Horticulture?" *HortSci.*, 21 (1986), 411-413.

[14] Maguire, J.D. "Speed of Germination - aid in Selection and Evaluation for Plumule and Radicle Emergence and Vigor". *Crop Sci.*, 2 (1962), 176-177.

[15] Evetts, L.L. and Burnside, O.C. "Germination and Plumule and Radicle Development of Common Milk Weed and Other Species". *Weed Sci.*, 20 (1972), 371-378.

[16] Hsu, F.H., Nelson, C.L. and Matches, A.G. "Temperature Effects on Germination of Perennial Warm - season Forage Grasses". *Crop Sci.*, 25 (1985), 215-220.

[17] Gomez, K.A. and Gomez, A.A. *Statistical Procedures for Agricultural Research*. 2nd. ed. New York: John Wiley, 1984.

[18] Nurdin and Fulbright, T.E. "Germination of 2 Legumes in Leachate from Introduced Grasses". *J. Range Manage.*, 43 (1990), 466-467.

[19] Angus, J.F., Cunningham, R. B., Morcur, M.W. and Mckenzie, D.H. "Phasic" Developmental in Field Crop 1. Thermal Response in the Plumule and Radicle Phase". *Field Crops Res.*, 3 (1981), 365-378.

[20] Bell, D.T. "The Influence of Osmotic Pressure in Tests of Allelopathy". *Trans. Ill. State Academy of Sci.*, 67 (1974), 312-317.

[21] Putnam, A.R. "Allelopathic Chemicals: Nature's Herbicides in Action". *Chemical Engin. News*, 4 (1983), 34-45.

[22] Warrag, M.O.A. "Autotoxicity of Mesquite (*Prosopis juliflora* (Swartz) DC.) Pericarps on Seed Germination and Plumule and Radicle Growth" *J. Arid Environ.*, 27 (1994), 79-84.

[23] Warrag, M.O.A. "Autotoxic Potential of Foliage on Seed Germination and Early Growth of Mesquite (*prosopis juliflora*)". *J. Arid Environ.*, 31 (1995), 415-421.

[24] Yang, H.J. "Autotoxicity of *Asparagus officinalis* L". *J. Amer. Soc. for Hort. Sci.*, 107 (1982), 860-862.

[25] Bialy, Z., Oleszek, W., Lewis, J. and Fenwick, G.R. "Allelopathic Potential of Glucosinolates (Mustard Oil Glycosides) and Their Degradation Products against Wheat". *Plant and Soil*, 129 (1990), 277-281.

التأثير المثبط للمستخلص المائي لقرون شجيرة الغاف على إنبات بذور نجيل البرمودا ونمو الريشة والجذير

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(قدم هذا البحث للنشر في ١٤١٨/٦/٢٥هـ ؛ وقبل للنشر في ١٤١٩/٦/٢٥هـ)

ملخص البحث. أجريت هذه الدراسة للتعرف على تأثير المستخلص المائي لـ ١٠ ، ٢٠ ، ٤٠ ، ٦٠ و٨٠ جراما من قرون شجيرة الغاف لكل لتر من الماء المقطر على إنبات بذور نجيل البرمودا ، الصنف البلدي ، ونمو الريشة والجذير. بالمقارنة مع الماء المقطر. أدت كل المستخلصات ، ماعدا أقلها تركيزًا ، إلى انخفاض واضح في نسبة الإنبات ومعدل الإنبات ، ومعدل نمو الريشة والجذير. ازداد الانخفاض بازدياد تركيز المستخلص. أدى المستخلصان الأعلى تركيزًا إلى استطالة الريشة والجذير خلال اليوم الأول بعد الإنبات ، ثم لم تحدث استطالة بعد ذلك. أدى استخدام محاليل بولي إيثلين جلايكول ٢٠٠٠ المماثلة للمستخلصات في الرقم الهيدروجيني والجهد الأسموزي إلى تأثير أقل معنويًا من تأثير المستخلصات. لذا يمكن استنتاج أن قرون شجيرة الغاف تحتوي على بعض المثبطات الكيمياوية الذائبة في الماء ذات القدرة على منع إنبات البذور وخفض معدل الإنبات واستطالة الريشة والجذير في نجيل البرمودا ، الصنف البلدي.