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Effect of Leaf Aqueous Extract of *Prosopis juliflora* (Swartz) DC and *Acacia raddiana* (Brenan) on Early Growth of *Sorghum sudanese* (Piper Stapf)

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Abstract: *Prosopis juliflora (Swartz) DC was introduced to Sudan in 1917 and then naturalized to invade both natural and managed habitats, especially watercourses and irrigated lands. In most of the infested sites it forms impenetrable thickets that smothered native vegetation; the case provokes contradictive allegations on its ecological significance. The objective of this study was to contribute in elucidating the dispute on its allelopathic behavior. Aqueous was extracted by distilled water from the leaves of both P. juliflora and Acacia raddiana (Brenan) to investigate its impact on the early growth of Sorghum sudanense (Piper) Stapf. Transparent plastic cups of 3.0 cm midiameter and 10.5 cm height, filled with clay soil, were used to raise the seedlings of the test crop. The cups were placed in glass house in split plot design set out in three replicates. The two main plots were allocated for the source of the aqueous. Each main plot was divided into six subplots to stand for aqueous ratios at 0%, 1%, 2%, 3%, 4% and 5% of volume of dry matter to water. Each subplot contained five cups and each cup contained one seedling of S. sudanense thinned out after one week from sowing to single out homogenous stock all over the subplots. The seedlings irrigated with distilled water without diluting the aqueous concentration. Shoot height, length of leaves shoot zone and number of leaves was taken weekly. The results revealed insignificant effect of the aqueous of both tree species at any ratio of concentration on the early growth of S. sudanense. Therefore, it could be concluded that P. juliflora had no allelopathic effect on the early growth of S. sudanense and behaved in this context like A. raddiana.*

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I. Introduction

Prosopis juliflora (Swartz) DC is an evergreen alien exotic tree species in many arid and semiarid regions of Africa. It was introduced to Sudan in 1917 and then propagated for sand dunes fixation in the early 1950s[1]. Thereafter, it has been spreading and invading wide area of irrigated agricultural and natural range lands. Its vigorous competent growth provoked continuous dispute; whether it is a threat to agriculture and pasture or a useful adapted dry land tree that could be managed to enrich the pasture and halt the degradation of the dry lands. The opponents are worried much to the claim that it has allelopathic impact on the vegetation and ecosystem. Their apprehension is encouraged by the fact that the leaves, roots, flowers and pods of *P. juliflora* contain potential allelopathic compounds such as L-tryptophan, Syringin, laricriesinol, L-tryptophan and 3-oxo-juliprosine[2,3,4]. Many studies concluded that aqueous extract from the leaves of *P. juliflora* inhibited the seed germination and reduced the seedlings growth of *Triticum aestivum*[5, 6]. Also fruit and seed extract delayed and reduced germination growth of root, shoot and seedling of *Zea mays*, *T. aestivum* and *Albizia lebbeck*[7]. In study carried out[8], lengths of both radicle and plumule of *Cynodon dactylon* were significantly retarded by leaf aqueous extracts of *P. juliflora*. Plant growth inhibitory like alkaloids and 3-oxo-juliprosine isolated from the extract of *P. juliflora* leaves, had strong inhibitory effect on the growth of *Lepidium sativum* L. seedlings[3]. The leaf aqueous extract of the species was argued to have negative impact on the germination and early growth of woody species such as *Acacia nilotica*, *Acacia tortilis* (Forssk.) Hayne, *Bauhinia racemosa, Cassia occidentalis, Cenchrus ciliaris* L, *Drypetes sepiaria, Enteropogon rupestris* (J. A. Schmidt) A. Chev., *Flueggea leucopyrus, Salvadora persica* and *Ziziphus mauritiana*[9,10,11]. However, most of these trees are native to Sudan. Other scientists[12] disclosed opposing results when found that leaf aqueous extracts of *P. juliflora* stimulated the germination and height growth of the *T. aestivum* and *Avena fatua*. Observations of the effect of different aqueous extract concentrations of *P. juliflora* on the growth of *Oryza sativa* seedlings and the results indicated that most of the treatments had led to comparable or better growth of seedlings than did the control treatment[13]. Some scientists[14] compared the allelopathic effect of leaf leachate of *P. juliflora* and *P. cineraria* in north-west

India region. They found that the leaf leachate had neutral to negative effects on root growth of three common crop species whereas that of *P. cineraria* had positive effects.

However, the dispute on the allelopathic effect of *P. juliflora* is still going on, but is the accusation has to do with it in particular or also pertain to other trees. When looking to *Acacia raddiana* (Brenan), the tree species of wide natural distribution in the ecosystem of *P. juliflora* in the dry land of Sudan and very valuable for the environment, pastures and agriculture, we can find the same trend of argument. Study in north Africa on allelopathic and autotoxicity effects of aqueous extracts from under the canopy soil and from leaf, fruit, shoot and root of *A. raddiana* showed that they were significantly reduced germination and seedling growth of *Hordeum vulgare*, *T. sativum* L. and *T. aestivum* L.[15]. However, the same major author found with other scientists opposed results when studied the effect of *A. raddiana* on *H. vulgare* L., *T. sativum* L. and *T. aestivum* L. in south Tunisia. The results showed that there were positive effects as far as the yield in dry and wet seasons was measured[16]. In general, quantitative analysis of aqueous leaf extract of *A. raddiana* showed that it contained phenolic compounds and flavonoids that could be potential as allelochemicals agents[17]. Certainly not only the species *A. raddiana* in the genus *Acacia* was accused; the species *Acacia auriculiformis* was suggested to have allelopathic effects on the germination and roots growth of some field crops[18].

Experiences in Sudan witness the same argument, against or with *P. juliflora*, but none of the two opinions supported by research findings. Hence, this study was carried out to investigate the impact of leaf aqueous extract of *P. juliflora* on the early growth of *Sorghum sudanense* (Piper) Stapf in comparison with *A. raddiana*.

II. Materials and Methods

Fresh leaves of *P. juliflora* and *A. raddiana* were collected, washed with distilled water, dried, chopped and thoroughly mixed. The chopped materials soaked in the distilled water at 1:4 ratio of dry mater to water. The mixture stirred after every eight hours for 24 hours to maintain the oxygen level and to avoid the anaerobic conditions, then filtered through Whitman filter paper and the resultant brownish extract stored in conical flasks placed in dark room. When required, it was taken from the aqueous of each species amounts of 25, 50, 75, 100 and 125 ml and diluted into 500 ml of distilled water to prepare concentrations of 5%, 10%, 15%, 20% and 25%. This viz with ratios of 1%, 2%, 3%, 4% and 5% of dry matter to water respectively.

The experiment conducted in glass house at Nishishiba Compass of the Gezira University in Sudan. The temperature kept inside the glass house during the day at 35°C and the relative humidity above 50%. Transparent plastic cups of 3.0 cm midiameter and 10.5 cm height were used as containers to raise the seedlings of the test crop, *S. sudanense*. Each cup filled with fine clay soil of 297 cm^3 in volume and thereafter arranged in the glass house in split plot laid out in three blocks. The main plot allotted for the two species, *P. juliflora* and *A. raddiana* as sources of the aqueous. Each main plot was divided into six subplots to stand for the five aqueous ratios and the control (0%) which was distilled water. The seedlings of *S. sudanense* originated from seeds sown in the transparent plastic cups and thinned at the emergence of the first leaf, one week after sowing, to result in one plant per cup. Then immediately they irrigated with the aqueous to saturated status. Thereafter, the aqueous extracts was kept to be added weekly to the pots to avoid degradation of potential allelochemicals. The seedlings kept to be irrigated without diluting the concentration of the aqueous by adding daily amount of distilled water to each cup equivalent to the amount evaporated. The amount of the evaporated water calculated according to daily records of evaporation in the glass house and the area of the opened top end of the cup. A total of five seedlings, they were homogenous in the growth before application of the treatments, were taken as an observational unit for each ratio. Observations on shoot height, length of leaves shoot zone and number of leaves were taken weekly. The data were analyzed using MSTAT computer software.

III. Results

Table (1) illustrated that at the initial, after two weeks from application of the treatments, there was negative effect of the two sources of the aqueous on the growth of the shoot height of the seedlings of *S. sudanense*. The aqueous extracted from the leaves of *A. raddiana* was significantly ($P = 0.04$) suppressed the growth of the shoot compared to that extracted from the leaves of *P. juliflora*. The negative effect of both sources significantly increased as the ratio of the aqueous increased ($P = 0.00$). However, the significant effect was eliminated when the seedlings developed to more than two weeks in age. It could be also noted that after growing for three weeks the shoot started to slow in growth.

Both, aqueous source (species) and ratio didn't show significant differentiation in the length of the leaves shoot zone throughout the measured stage of growth (Table 2). Nevertheless, there was tendency at two weeks of growth to restrain the elongation by the aqueous of *A. raddiana* as the ratio increased to more than 3%. When the seedlings developed to more than that age the tendency of suppression was diminished and reversed to increased growth. It was noticed that the length of leaves shoot zone of the seedlings irrigated by distilled water

(control) was constant all through the period of growth while it was developed in those irrigated with either of the aqueous.

The number of leaves produced by the seedlings of *S. sudanense* was given in table (3). The source of aqueous (species) had no impact on the leaves production, but the ratio revealed a positive significant (p = 0.002) effect when increased to 4% and more. That effect induced by the aqueous was persisted at the stage of growth measured. Whether that effect pertained to elongation of the shoot or leaves shoot zone, the correlation was given in figures (1) and (2). It was clear from both figures that it was associated with shoot elongation. However, taking collectively the effect of the leaves aqueous of the two species on all the parameters measured, it was found that they had similar mode of impact and boosted the growth of the test crop rather than suppressed it (Fig. 3).

Table 1: Shoot height (cm) of seedlings of *Sorghum sudanense* (Piper) Stapf measured at weekly intervals from application of irrigation with aqueous extracted from leaves of *Prosopis juliflora* (Swartz) DC and *Acacia raddiana* (Brenan) on basis of volume of dry mater to distilled water

Aqueous ratio	Interval of measurement after application of irrigation with aqueous								
	One week			Two weeks			Three weeks		
	Pj	*Ar*	Mean	*Pj*	*Ar*	Mean	*Pj*	*Ar*	Mean
0%	21.8	20.4	21.1	23.5	22.2	22.9	23.7	21.9	22.8
1%	21.3	19.5	20.4	22.8	22.6	22.7	22.9	22.3	22.6
2%	19.9	17.3	18.6	22.5	23.4	23.0	22.3	25.0	23.7
3%	19.2	17.0	18.1	21.8	23.1	22.4	25.0	24.1	24.6
4%	18.9	12.6	15.8	23.4	23.4	24.4	24.5	25.8	25.1
5%	18.8	12.3	15.6	23.2	21.4	22.3	25.1	24.3	24.8
Mean	20.0	16.5		22.9	22.7		23.9	23.9	
SE	± 0.49		± 0.76	± 0. 61		± 0.96	± 0.55		± 0.99
CV	10.21%			10.14%			10.21%		

Pj = Prosopis juliflora; *Ar = Acacia raddiana; n* for species = 18 and for aqueous ratio = 6

Table 2: Length of leaves shoot zone (cm) of seedlings of *Sorghum sudanense* (Piper) Stapf measured at weekly intervals from application of irrigation with aqueous extracted from leaves of *Prosopis juliflora* (Swartz) DC and *Acacia raddiana* (Brenan) on basis of volume of dry mater to distilled water

Aqueous ratio	Interval of measurement after application of irrigation with aqueous								
	One week			Two weeks			Three weeks		
	Pj	*Ar*	Mean	*Pj*	*Ar*	Mean	*Pj*	*Ar*	Mean
0%	6.1	5.8	6.0	6.4	5.5	6.0	6.2	5.7	6.0
1%	5.9	5.8	5.8	5.8	6.1	6.0	6.0	6.2	6.1
2%	5.6	6.1	5.8	5.7	7.0	6.3	6.1	7.0	6.6
3%	5.6	5.6	5.6	5.7	6.6	6.2	5.7	6.7	6.2
4%	6.2	4.8	5.5	6.8	6.5	6.6	5.6	7.0	6.8
5%	5.9	4.8	5.3	5.8	6.1	6.0	6.2	6.3	6.2
Mean	5.9	5.5		6.0	6.3		6.1	6.5	
SE	± 0.22		± 0.29	± 0. 29		± 0.30	± 0.12		± 0.28
CV	12.57%			11.97%			10.74%		

Pj = Prosopis juliflora; *Ar = Acacia raddiana* ; *n* for species = 18 and for aqueous ratio = 6

Table 3: Number of leaves of seedlings of *Sorghum sudanense* (Piper) Stapf counted at weekly intervals from application of irrigation with aqueous extracted from leaves of *Prosopis juliflora* (Swartz) DC and *Acacia raddiana* (Brenan) on basis of volume of dry mater to distilled water

Aqueous ratio	Interval of measurement after application of irrigation with aqueous					
	Two weeks			Three weeks		
	Pj	*Ar*	Mean	*Pj*	*Ar*	Mean
0%	4.3	4.3	4.3	4.9	4.5	4.7
1%	4.3	4.7	4.5	4.7	5.1	4.9
2%	4.3	4.9	4.6	5.0	5.1	5.1
3%	4.3	4.5	4.4	4.7	5.2	4.9
4%	5.2	5.1	5.2	5.5	5.6	5.6
5%	4.8	5.3	5.1	5.9	5.8	5.8
Mean	4.6	4.8		5.1	5.2	
SE	± 0.05		± 0.14	± 0. 08		± 0.17
CV	7.49%			7.91%		

Pj = Prosopis juliflora; *Ar = Acacia raddiana; n* for species = 18 and for aqueous ratio = 6

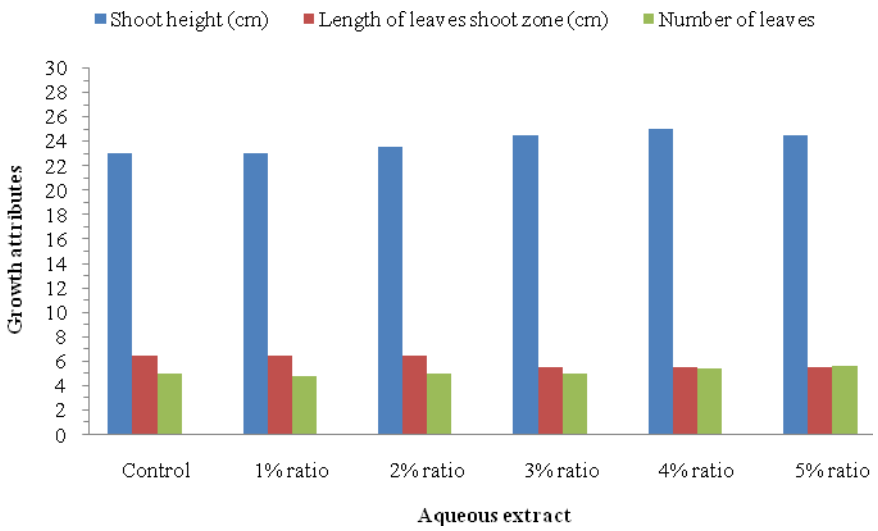

Fig. 1: Growth attributes of the seedlings of *Sorghum sudanense* (Piper) Stapf grown for one month in glass house and irrigated with aqueous extracted by distilled water from the leaves of *Prosopis juliflora* (Swartz) DC. Control was distilled water.

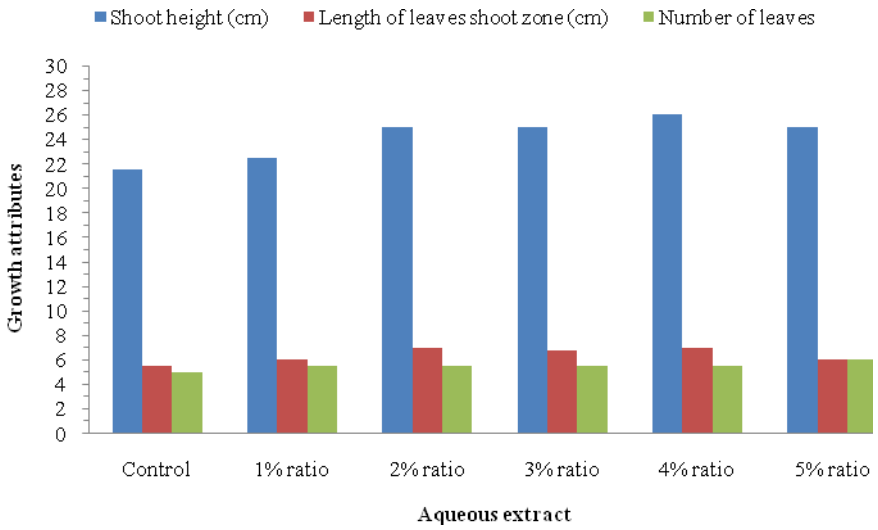

Fig. 2: Growth attributes of the seedlings of *Sorghum sudanense* (Piper) Stapf grown for one month in glass house and irrigated with aqueous extracted with distilled water from the leaves of *Acacia raddiana* (Brenan). Control was distilled water

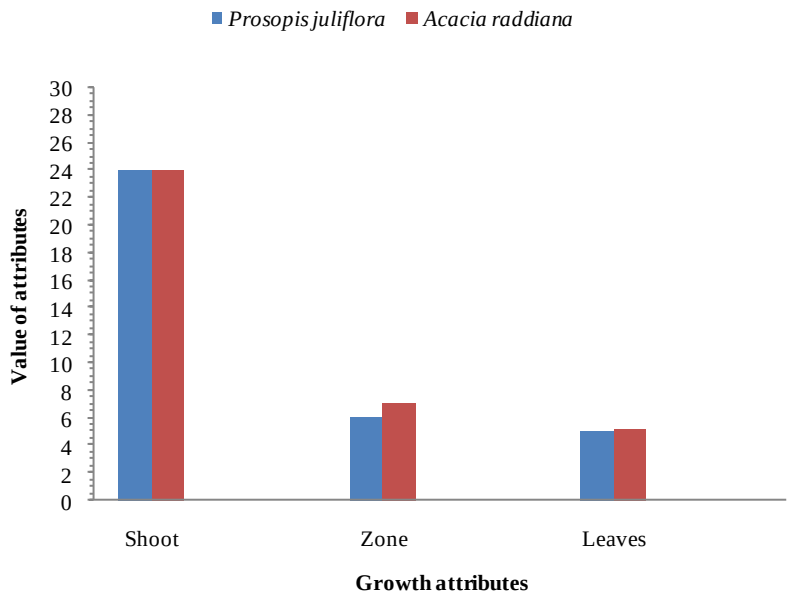

Fig. 3: Shoot length (cm), length of leaves shoot zone (cm) and number of leaves of the seedlings of *Sorghum sudanense* (Piper) Stapf grown for one month in glass house and irrigated with aqueous extracted with distilled water from the leaves of *Prosopis juliflora* (Swartz) DC and *Acacia raddiana* (Brenan)

IV. Discussion

It could be understood from the results that *P. juliflora* was not allelopathically harmful to the plants at the most succulent stage of growth, but it improved the growth as well as *A. raddiana*. This is in agreement with many scientists who reached to conclusion that aqueous from the leaves of *P. juliflora* stimulated the height growth of plants, specially the monocots [14,12,13,19]. In spite of this, the result is also not in conformity with other studies, the most prominent are those concluded that it decreased the growth[8,9,10,5,20,3,6,21,11]. Some arguments could be submitted to explain the situation. It is well known that many interacted or integrated environmental and biological factors prevailing in dry land could have a direct or indirect impact on the process of allelopathy. For example, the activities of microorganisms in dry lands could aggravate the rate of decomposing of the organic matter in due time as it usually accelerate by long prevalence of relatively high temperature, and hence, many excretions that resulted from the plant tissues decomposition would volatilize in short period and not persist in the soil to harm the germination or growth at the succeeded stage. The clay soil itself, due to its physical properties such as dispersion, would not help the percolation of the seepage in general so as to be at the root zone. The other assumption says that impact of allelopathic excretions, if present, needs time longer than the month allowed for the experiment to reflect its symptoms. Somebody may argue that the seedlings of *S. sudanense* grew very steadily at increasing rate for at least three weeks then the growth started to increase at decreasing rate, the case that support the assumption that the allelopathic impact of the aqueous started to reveal after this short lap time. It may be possible this argument, but its logic could be set back if the volume of the soil contained in the cups is considered. It was small enough to support the survival and growth of the seedlings for longer period. Likely seems that the seedlings had exhausted most of the nutrients in the potted soil and then the growth started to slowly increase. Anyhow, the effect of the aqueous of *P. juliflora* resembled that of the comparable species, *A. raddiana*, which was accused by many scientists to have allelopathic effect on the associated plants because of the presence of tannin, wax, flavonoids and phenolic acids in their tissues[17]. However, *Acacia* are planted in the agricultural fields in various arrangements in dry lands without complaining against allelopathic effects.

The increase in the aqueous ratio or concentration didn't prove the logic or assumption that favors the allelopathic effect of *P. juliflora* on the associated plants in dry lands. Instead, the seedling growth was proportionally increased as the aqueous ratio increased. This is also in contradiction with other studies such as that mentioned that the allelopathic chemicals excreted by some plants are natural compounds that have shown far reaching effects on the growth and development of plants even at low concentration[22]. Bringing to mind the argument that says toxic excretions of the plants would not persist longer in the soils of dry lands; this result is acceptable in the sense that more concentration means more organic nutrients that boost the growth.

In conclusion, and as far as the conditions of the experiment are considered, *P. juliflora* had no allelopathic effect on the early growth of the monocot species, *S. sudanense* that belongs to the family boaceace. Moreover, it behaved like *A. raddiana*, the indigenous and widely distributed tree species in the dry region of Sudan where found in association with grasses and field crops without any complaining from the herders or the farmers.

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