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PHYTOTOXICITY OF DIFFERENT AQUEOUS EXTRACT CONCENTRATIONS OF MESQUITE (*PROSOPIS JULIFLORA*) ON GERMINATION AND SEEDLING GROWTH OF WHEAT

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ABSTRACT

The research trial was conducted under laboratory conditions at Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan in order to study phytotoxic effects of mesquite (*Prosopis juliflora*) aqueous extract taken from its leaves, stem and root on germination and seedling growth of wheat. There were five treatments *viz*. 100g, 200g, 300g, and 400g aqueous leaves, stem and root extract of mesquite including tap water as control. It was evident from the results that by using different concentrations of aqueous extract of mesquite, seed germination and seedling growth of wheat were inhibited. The maximum reduction in germination and seedling growth was noted by applying higher concentration (400g) of aqueous extracts of mesquite. Hence, it is concluded that seed germination and seedling growth of wheat is inhibited due to presence of water soluble allelochemicals in aqueous leaves, stem and root extracts of mesquite at 400 g for 72 hours. These allelochemicals have negative effects on growth and development of wheat. It is, therefore, recommended not to cultivate wheat crop near the mesquite.

Keywords: Phytotoxicity, *Prosopis juliflora*, extract, germination, seedling vigor, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the leading food grain of Pakistan, which contributes 10.3% value added in agriculture and 2.2% to GDP. It is annually cultivated on an area of 9.03 million hectares with total production of 25.9 million tons in the country (Anonymous, 2015).

The yield of wheat is low in Pakistan due to number of abiotic and biotic factors (Qureshi and Bhatti, 2001; Ullah *et al*., 2013). Weeds are the most serious but less noticeable yield-deteriorating factor that also poses allelopathic effects against crops (Khan *et al*., 2004) due to presence of organic compounds, which release phytotoxic substance. These phytotoxic substances release chemicals into the ecosystem (Tanveer, 2008) in the form of secondary metabolites which may leach out from various parts of plants to the surrounding rhizosphere either as exudates or rain-residues which impact on germination and growth processes of other plants (Sajjad *et al*., 2007; Iqbal *et al*., 2010). In allelopathy, plant growth is negatively affected due to competition of the two organisms when using the same resources (Burhan and Shaukat, 2000). It has been reported that the plants which release phytotoxic substances, can have both positive and negative effects with the interaction of weeds and crops (Rebaz *et al.*, 2001; Shaukat *et al*., 2002). Mehar (2011) reported that allelopathic plants have certain compounds effecting the environment is totally different from competition. Competition is to remove and reduce all available resources of neighboring plants.

Phytotoxic plants discharge toxic chemicals or secondary plant metabolites, which affect seed germination, cell division, cell elongation, membrane permeability and ion uptake of the nearby plants (Dongre *et al*., 2007). Oweyegha-Afunaduula, (2008) has reported that interaction of trees with crop plants may have positive or negative effects on both crops and forest plants. Therefore, before introducing to an agro-forestry system it is necessary to check the phytotoxic compatibility of plants with the trees. Mesquite plant is considered to be both

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invasive and phytotoxic, because it can delay the growth of some nearby plants species by discharging allelochemicals in the environment (Mehar, 2011).

Mesquite (*Prosopis juliflora*) is generally known as Kabuli kikar, a well adopted shrub to harsh environment conditions of arid zones. It is large inhabitant shrub of the Northern South America, West Indies, Central America and Mexico. It was introduced in Pakistan in 1950s. It has been noted that the fallen leaves, leachates or root exudates of mesquite release phytotoxic substances which affect all ground vegetation under its canopy (Siddiqui *et al*., 2009). Therefore, discharging of toxic chemicals into the soil delayed seed germination and establishment of field crops and vegetation. Due to its weedy nature, mesquite is a threat to indigenous biodiversity in Ethiopia and in the Middle Awash. The reported area under mesquite invasion is about 30,000 hectare in the Middle Awash (Mehari, 2008), however in Pakistan its area under cultivation is still under study.

Mesquite not only decreases grass availability for the livestock but also restricts many physiological and biochemical processes of the crop plants due to release of phytotoxic compounds. (Getachew *et al*., 2012). Since the allelopaths restrict plant growth at a certain concentration, therefore, their proper screening tests should be conducted to ensure their effects on economic crop (Tanveer, 2008). The present research was therefore designed to investigate the phytotoxic potential of different concentrations of aqueous leaves, stem and root extract of mesquite on germination and early seedling growth of wheat.

MATERIALS AND METHODS

Phytotoxic effect of mesquite (*Prosopis juliflora*) was assessed under laboratory conditions at Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa (KPK), Pakistan, in a completely randomized design with 4 replications for 28 days. Fresh Vegetative growing tissues of the weed species were collected from fields nearby the experimental site. For the weed specie, plants were separated into three leaves, stem and root parts, crushed and grinded. Tap water was used as control treatment. The ground plant material of mesquite was soaked in distilled water in different ratios, *viz-a-viz*, T_1 = 100g leaves/ liter of water for 72 h, T_2 = 200g leaves/liter of water for 72 h, T_3 = 300g leaves/liter of water for 72 hours for 72 hours, T_4 = 400g leaves/liter of water for 72 h, T_5 = 100g stem/liter of water for 72 h, T_6 = 200g stem/liter of water for 72 h, T_7 = 300g stem/liter of water for 72 h, T_8 = 400g stem/liter of water for 72 h, T_9 = 100g roots/liter of water for 72 h, T_{10} = 200g roots/liter of water for 72 h, T_{11} = 300g roots/liter of water for 72 h and T_{12} = 400g roots/liter of water for 72 h of *P.juliflora*. The aqueous extract was collected in bottles and tagged by filtering through 10 and 60 mesh sieves. Thirteen trays, replicated 4 times, filled with sand, silt and clay (1:1:1) were taken for sowing 100 wheat seeds in each tray viz. Tray-1: T_0: Tap water (check) and Tray-2 to 13: Treatments T_1–T_{12} (*P.juliflora*). All treatments were applied 5 and 10 days after sowing (DAS). Water was applied on daily/alternate basis to keep the soil moist/field capacity. The parameters recorded during the course of experimentation were speed of germination, mean germination time, germination rate, germination (%), germination energy (%), root and shoot length (cm), fresh and dry root weight (g), fresh and dry shoot weight (g), root: shoot ratio and chlorophyll content (μ g cm^{-2}).

Data for the individual parameters were subjected to statistical analysis by using analysis of variance technique (Steel *et al*., 1997). The difference among the treatment means was computed by using least significant difference (LSD) test at 1% probability level using MSTATC computer software (MSTATC, 1991).

RESULTS

Speed of germination, mean germination time, germination rate

The results showed that aqueous extract from leaves, stems and root of mesquite negatively affected the speed of germination, mean germination time and germination rate (Table -- 1). All the treatments showed significant reduction at 1 percent level of probability in the speed of germination, germination rate and also delay in mean germination time as compared to control (Tap water). The maximum speed of germination and germination rate was noted in control where no extract was used. Among different concentrations applied, aqueous leaves extract (400g) showed maximum reduction in speed of germination and germination rate (7.81 and 57.25) respectively, by taking more mean germination time (13.73). Similar trend was also noted with increasing concentration of aqueous stems and root extract which significantly reduced the speed of germination and germination rate and by delaying mean germination time.

Germination percentage and germination energy

Germination percentage and germination energy (recorded 7 and 14 DAS) was significantly_reduced at 1 per cent level of probability with the increasing concentration of aqueous leaf, stem and root extract of mesquite when compared with control (Table - 2). Significantly lowest germination percentage was recorded (2.25 and 59.50%) with the higher concentration (400g) of aqueous leaf extract over control (Tap water) which showed higher germination percentage (13.50 and 100.0%) 7 and 14 DAS respectively. Similarly, the higher concentration (400g) of aqueous stems and roots extract recorded the minimum germination percentage (4.50, 69.50% and 4.50, 71.75%) on both 7 and 14 DAS respectively. Similar trend was also noted for germination energy. In control, maximum germination energy was recorded (13.50 and 100.00%) 7 and 14 DAS respectively, whereas minimum germination energy (2.09 and 59.51%, 4.51 and 69.51% and 4.51and 71.74%) was recorded 7 and 14 DAS with higher concentration (400g) of aqueous extract of leaves, stems and roots of mesquite, respectively.

Shoot and root length

Data pertaining to shoot and root length are presented in Table - 3, which indicated that aqueous leaf, stems and root extracts significantly at 1 percent level of probability inhibited shoot and root length as compared to tap water. Maximum shoot length (18.70, 25.61 and 29.35cm) was recorded in control 14, 21 and 28 DAS. Among different concentrations, the maximum concentration (400g) of aqueous extract of all three parts of mesquite produced minimum shoot length of wheat 14, 21 and 28 DAS. Similarly, maximum root length was measured in control (3.75, 5.50 and 6.20cm) 14, 21 and 28 DAS respectively. The root length was subsequently reduced with increase in extract concentration. The highest concentration (400g) of aqueous leaf, stem and root extracts produced minimum root length compared to untreated plot.

Fresh shoot and root biomass

Fresh shoot and root biomass was reduced by increasing concentration of aqueous leaf, stem and root extracts as compared to control (Table - 4). Maximum shoot weight was noted in control (1.32, 2.37 and 2.60g) 14, 21 and 28 DAS, respectively. The highest concentration (400g) of aqueous leaf extract considerably reduced the shoot weight (0.84, 1.24 and 1.66g) 14, 21 and 28 DAS, respectively. Similar reduction in fresh shoot weight was also noted with the application of higher concentration (400g) of aqueous stem and root extract. Similarly, all three aqueous leaves, stem and roots extracts of plant significantly reduced fresh root biomass as compared with tap water (0.61,0.68 and 0.79g) 14, 21 and 28 DAS, respectively.

Dry shoot and root weight

Data given in Table - 5 revealed significant reduction in dry shoot and root weight by applying different concentration of aqueous extract of leave, stem and root than control (Tap water). The minimum dry shoot weight (0.079, 0.110 and 0.137g) was noted by applying maximum concentration (400g) of aqueous leaves extract over control, which had maximum dry shoot weight (0.106, 0.145 and 0.176g) 14, 21 and 28 DAS respectively. Similarly, aqueous stem and root extracts also reduced dry shoot weight as compared to untreated control. Similar results were noted in case of dry root weight in which the increasing concentrations of aqueous leave, stem and root extracts of mesquite correspondingly decreased dry root weight as compared to control that had maximum dry root weight (0.073, 0.087 and 0.11g) 14, 21 and 28 DAS, respectively.

Root: Shoot ratio, Chlorophyll Content

Applications of aqueous leave, stem and root extract of mesquite significantly at 1 percent level of probability reduced the root: shoot ratio and chlorophyll content as shown in Table - 6. By increasing concentration of aqueous extract of all three plant parts correspondingly decreased the root: shoot ratio as well as chlorophyll content compared with control. The maximum root: shoot ratio was noted in control (39.67, 40.17 and 41.0) 14, 21 and 28 DAS, respectively. Application of highest concentration (400g) of all three plant parts (leaves, stem and root) correspondingly reduced the root: shoot ratio. Similarly, the control treatment showed maximum chlorophyll content (27.05, 33.48 and 26.23) while it decreased considerably by increasing the concentration of aqueous extract. Minimum chlorophyll content (21.79, 25.74 and 19.47) was recorded 14, 21 and 28 DAS, respectively, by applying the highest concentration (400g) of aqueous leave extract of mesquite.

Table – 1: Phytotoxic effect of mesquite (*Prosopis juliflora*) on speed of germination, mean germination time and germination rate of wheat

Treatments	Speed of germination	Mean germination time	Germination rate
T_0 = Tap water	10.61 a	9.62 h	87.50 a
T_1 = 100g leaves	9.10 def	11.81 cd	68.50 de
T_2 = 200g leaves	8.61 gh	12.54 b	62.25 fg
T_3 = 300g leaves	8.06 i	13.37 a	59.00 gh
T_4 = 400g leaves	7.81 i	13.73 a	57.25 h
T_5 = 100g stem	9.45 cd	11.28 ef	76.00 bc
T_6 = 200g stem	9.21 de	11.64 de	71.50 cd
T_7 = 300g stem	8.82 fgh	12.12 bc	70.25 d
T_8 = 400g stem	8.53 h	12.57 b	65.00 ef
T_9 = 100g roots	9.93 b	10.76 g	84.00 a
T_{10} = 200g roots	9.60 bc	11.07 fg	78.50 b
T_{11} = 300g roots	8.92 efg	12.15 bc	71.50 cd
T_{12} = 400g roots	8.57 gh	12.45 b	67.25 de
$LSD_{0.01}$	0.376	0.460	4.691

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

Table – 2: Phytotoxic effect of mesquite (*Prosopis juliflora*) on germination percentage and germination energy of wheat

Treatments	Germination (%)		Germination energy (%)	
	7 DAS	**14 DAS**	**7 DAS**	**14 DAS**
T_0 = Tap water	13.50 a	100.0 a	13.50 a	100.00 a
T_1 = 100g leaves	8.00 cd	76.50 c	8.08 e	76.51 g
T_2 = 200g leaves	5.00 def	67.25 e	5.09 g	67.23 k
T_3 = 300g leaves	2.50 f	61.50 f	2.25 i	61.23 l
T_4 = 400g leaves	2.25 f	59.50 f	2.09 i	59.51 m
T_5 = 100g stem	9.00 bc	85.00 b	9.09 d	85.10 d
T_6 = 200g stem	8.00 cd	79.50 c	8.09 e	79.53 e
T_7 = 300g stem	5.75 de	76.00 cd	5.76 f	76.10 h
T_8 = 400g stem	4.50 ef	69.50 e	4.51 h	69.51 j
T_9 = 100g roots	11.50 ab	95.50 a	11.51 c	95.55 b
T_{10} = 200g roots	9.25 bc	87.75 b	9.25 d	87.74 c
T_{11} = 300g roots	5.75 de	77.25 c	11.76 b	77.24 f
T_{12} = 400g roots	4.50 ef	71.75 de	4.51 h	71.74 i
$LSD_{0.01}$	3.008	4.531	0.226	0.065

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

Table – 3: Phytotoxic effect of mesquite (*Prosopis juliflora*) on shoot length and root length of wheat

Treatments	Shoot length(cm)			Root length(cm)		
	14 DAS	21DAS	28 DAS	14 DAS	21 DAS	28 DAS
T_0 = Tap water	18.70 a	25.61 a	29.35 a	3.75 a	5.50 a	6.20 a
T_1 = 100g leaves	12.50 d	19.52 c	22.22 c	2.72 def	3.80 bc	4.80 c
T_2 = 200g leaves	11.75 e	18.38 d	21.42 d	2.57 d-g	3.62 cd	4.57 de
T_3 = 300g leaves	10.55 f	17.58 e	20.25 e	2.47fg	3.47 de	4.35 fg
T_4 = 400g leaves	9.61 g	16.27 f	19.29 f	2.22 g	3.10 f	4.15 h
T_5 = 100g stem	13.58 b	20.51 b	23.34 b	3.37 b	3.75 bc	4.77 c
T_6 = 200g stem	12.54 d	19.50 c	22.44 c	2.92 cd	3.65 cd	4.57 de
T_7 = 300g stem	11.46 e	18.62 d	21.48 d	2.77 c-f	3.50 d	4.42 ef
T_8 = 400g stem	10.42 f	17.57 e	20.49 e	2.52 efg	3.27 ef	4.25 gh
T_9 = 100g roots	13.15 c	20.52 b	23.36 b	3.12 bc	3.90 b	5.00 b
T_{10} = 200g roots	12.53 d	19.45 c	22.37 c	2.87cde	3.72 bc	4.67 cd
T_{11} = 300g roots	11.64 e	18.48 d	21.38 d	2.65 def	3.47 de	4.57 de
T_{12} = 400g roots	10.43 f	17.56 e	20.58 e	2.50 fg	3.25 f	4.40 fg
$LSD_{0.01}$	0.406	0.370	0.443	0.361	0.211	0.170

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

Table – 4: Phytotoxic effect of mesquite (*Prosopis juliflora*) on fresh shoot weight and fresh root weight of wheat

Treatments	Fresh shoot weight (g)			Fresh root weight (g)		
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS
T_0 = Tap water	1.32 a	2.37 a	2.60 a	0.61 a	0.68 a	0.79 a
T_1 = 100g leaves	0.95 b	1.34 bcd	1.76 de	0.37 b	0.46 bc	0.59 bc
T_2 = 200g leaves	0.92 bcd	1.31 cde	1.73 de	0.36 b	0.44 bcd	0.57 bcd
T_3 = 300g leaves	0.86 cde	1.29 de	1.70 de	0.35 b	0.43 cd	0.55 def
T_4 = 400g leaves	0.84 e	1.24 e	1.66 e	0.33 b	0.41 d	0.53 f
T_5 = 100g stem	0.96 b	1.38 bc	1.95 b	0.38 b	0.47 b	0.60 b
T_6 = 200g stem	0.95 b	1.37 bc	1.92 b	0.37 b	0.44 bcd	0.58 bcd
T_7 = 300g stem	0.92 bc	1.35 bcd	1.87 bc	0.34 b	0.44 bcd	0.56 cde
T_8 = 400g stem	0.87 cde	1.31 cde	1.79 cd	0.34 b	0.42 d	0.55 def
T_9 = 100g roots	0.96 b	1.39 b	1.94 b	0.38 b	0.46 bc	0.59 bc
T_{10} = 200g roots	0.92 bc	1.33 bcd	1.92 b	0.36 b	0.44 bcd	0.58 bcd
T_{11} = 300g roots	0.87 cde	1.31 cde	1.90 b	0.35 b	0.42 d	0.56 def
T_{12} = 400g roots	0.85 de	1.28 de	1.86 bc	0.34 b	0.42 d	0.54 ef
$LSD_{0.01}$	0.065	0.075	0.103	0.053	0.034	0.034

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

Table – 5: Phytotoxic effect of mesquite (*Prosopis juliflora*) on dry shoot weight and dry root weight of wheat

Treatments	Dry shoot weight (g)			Dry root weight (g)		
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS
T_0 = Tap water	0.106 a	0.145 a	0.176 a	0.073 a	0.087 a	0.11 a
T_1 = 100g leaves	0.085 b	0.117 bc	0.143 b	0.052 b	0.071 bc	0.089 b
T_2 = 200g leaves	0.083 bc	0.115 cd	0.140 cd	0.051 b	0.070 bc	0.087 bcd
T_3 = 300g leaves	0.081 cd	0.113 de	0.138 de	0.050 b	0.069 bc	0.085 cde
T_4 = 400g leaves	0.079 d	0.110 e	0.137 e	0.048 b	0.066 c	0.081 f
T_5 = 100g stem	0.085 b	0.119 b	0.144 b	0.053 b	0.072 b	0.088 bc
T_6 = 200g stem	0.084 bc	0.116 bc	0.142 bc	0.051 b	0.070 bc	0.086 bcd
T_7 = 300g stem	0.083 bc	0.114 cd	0.140 cd	0.050 b	0.069 bc	0.085 cde
T_8 = 400g stem	0.081 cd	0.113 de	0.138 de	0.050 b	0.068 bc	0.082 f
T_9 = 100g roots	0.086 b	0.119 b	0.144 b	0.054 b	0.071 bc	0.088 bc
T_{10} = 200g roots	0.084 bc	0.116 bc	0.141 bc	0.052 b	0.070 bc	0.086 bcd
T_{11} = 300g roots	0.083 bc	0.114 cd	0.138 de	0.050 b	0.069 bc	0.084 def
T_{12} = 400g roots	0.085 b	0.113 de	0.136 e	0.050 b	0.069 bc	0.082 ef
$LSD_{0.01}$	3.390	3.274	2.765	2.821	4.835	3.241

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

Table – 6: Phytotoxic effect of mesquite (*Prosopis juliflora*) on root:shoot ratio and chlorophyll content of wheat

Treatments	Root shoot ratio			Chlorophyll content (μ g cm^{-2})		
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS
T_0 = Tap water	39.67 a	40.17a	41.01 a	27.05 a	33.48 a	26.23 a
T_1 = 100g leaves	37.81 b	37.66 b	38.27 bc	24.14 def	27.81 bc	22.29 bcd
T_2 = 200g leaves	37.91 b	37.84 b	38.45 b	23.34 g	27.56 bc	21.37 ef
T_3 = 300g leaves	38.02 ab	37.91 b	38.25 bc	22.71 h	26.54 de	20.26 g
T_4 = 400g leaves	37.90 b	37.56 b	37.33 d	21.79 i	25.74 f	19.47 h
T_5 = 100g stem	38.49 ab	37.69 b	38.06 bcd	24.38 cd	28.19 b	22.59 b
T_6 = 200g stem	37.86 b	37.53 b	37.85 bcd	24.32 de	27.38 c	21.57 e
T_7 = 300g stem	37.44 b	37.60 b	37.91 bcd	23.96 ef	27.29 c	20.89 fg
T_8 = 400g stem	38.01 ab	37.74 b	37.44 cd	23.77 f	26.32 ef	20.41 g
T_9 = 100g roots	38.43 ab	37.37 b	38.06 bcd	24.85 b	28.10 b	22.85 b
T_{10} = 200g roots	38.09 ab	37.53 b	37.79 bcd	24.74 bc	27.88 bc	22.44 bc
T_{11} = 300g roots	37.68 b	37.59 b	37.88 bcd	24.34 cde	27.52 bc	21.91 cde
T_{12} = 400g roots	36.91 b	37.94 b	37.75 bcd	24.02d ef	27.21 cd	21.77 de
$LSD_{0.01}$	1.683	1.611	0.862	0.407	0.698	0.667

Means followed by different letter(s) in a column are statistically significant at 1% level of probability.

DISCUSSION

Some plant species or their residues selectively delayed growth of other specific plants (Al-Zahrani and Al-Robai, 2007). This sensitivity was observed in field and laboratory experiments with extracts and allelopathic substances. In this study, the aqueous extract of leaves, stems and roots of mesquite has resulted in reduced germination and seedling growth of wheat. The maximum reduction in germination was recorded at the highest concentration of aqueous extract of leaves, stems and root of mesquite. Similarly, the highest concentration (400g) of all the three parts significantly reduced the speed of germination and germination rate and also delayed the mean germination time as compared to control (Tap water). This was due to some phytotoxic compound in mesquite which includes tannins flavonoides, wax, alkaloids and phenolic acids, those negatively affected the seed germination and radical length of wheat (Pragnesh *et al*., 2013). The percent seed germination is reported to decrease with increasing aqueous leaf extract concentration of mesquite (Siddiqui *et al*., 2009). Germination percentage and germination energy was correspondingly reduced in the present study by using different concentration of aqueous leaves, stem and root extracts as compared to control. This was due to presence of plant growth inhibitory alkaloids which were extracted from the mesquite leaves (Nakano *et al*., 2004). Phytochemical analysis of mesquite showed that mesquite contains phenolics, tannins, steroids, flavonoids, alkaloids and terpenoids in leaf extracts. Stem contains, steroids, phenolics, flavonoids and terpenes in minimum concentrations, while root has saponin, alkaloids, phenolics, steroids, flavonoids, tannins and terpenes (Singh, 2012).

In the present study, aqueous extracts of mesquite were also tested for root and shoot length, fresh root and shoot weight and dry root and shoot weight which showed a corresponding reduction in all these parameter as compared to control where no extract was used. Several reports revealed the phytotoxic effects of various plant extracts e.g. *E.camaldulensis*, *P.juliflora* and *A.nilotica* which significantly affected seed germination and seed seedling growth of several crops and weed species (Khan *et al*., 2004). Their inhibitory effect on seed germination, root length and other growth parameters is well established (Rafique *et al*., 2003). The mesquite extract is reported to cause maximum reduction in root length (Siddiqui *et al*., 2009). Similarly, aqueous extract application of mesquite significantly reduced the germination and seedling growth of a number of crop plants (Khan, 2005). An especially maximum degree of inhibition occurred with aqueous extract of leaves at the maximum concentrations in wheat in comparison with aqueous extracts of stem and root.

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