PHYTOTOXIC EFFECTS ON WHEAT GERMINATION AND SEEDLINGS VIGOR WITH DIFFERENT CONCENTRATIONS OF AQUEOUS EXTRACTS OF MESQUITE ROOT STEM AND LEAF

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ABSTRACT

An experiment was performed to evaluate the phytotoxic effects of mesquite (Prosopis juliflora (Sw.) DC. by using its aqueous solutions. Extracts of all main parts of mesquite including leaf, stem and root were prepared in different concentrations to see their efficacy as phytotoxic components on wheat. The trial was conducted under laboratory conditions at the Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan. Different concentrations (10, 20, 30 and 40%) were compared with control (tap water treatment). The use of aqueous extract in multiple concentrations showed significant effects over tap water treatment in almost all the parameters, however, germination and seedling vigour of wheat were gradually suppressed as the concentration of extract increased. It was concluded that 40% concentration of leaf aqueous solution was found most effective, which is evident that mesquite must be uprooted prior to the cultivation of any economically important crop.

Keywords: Aqueous extract, germination, phytotoxicity, *Prosopis juliflora*, seedling vigor, *Triticum aestivum.*

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the staple food crop of Pakistan. It adds 12.5% to the contribution of crops in agriculture and 2.7% to gross domestic products (GDP) of Pakistan (Aslam *et al*., 2013). It is annually cultivated on an area of 8.66 million ha with total production of 24.21 million tons in the country. Contribution of irrigated in total wheat production is 95% while the remaining 5% is covered by the rain-fed areas (Aslam *et al*., 2013). Government has assigned high priority to wheat over the last few decades with an intention to achieve self-sufficiency in staple food crops despite the rapidly increasing population of the country. However, there exists a big difference between the actual (2.5-3 t ha^{-1}) and potential yield (6-8 t ha^{-1}) of existing wheat varieties, which needs to be bridged up by proper agronomy and extension services (Aslam *et al*., 2013). This seems quite a challenging task especially when soil health is on continuously decline and farmers are not aware of or cannot afford modern production technology.

Weed-crops compete with each other in the presence of biotic and abiotic factors that are responsible for yield deterioration (Qureshi and Bhatti, 2001; Ullah *et al*., 2013). Weeds are responsible to reduce 25-30% crop yield (Willis, 2004). Moreover, several weeds contain phytotoxic compounds which deteriorate wheat quality (Hussain *et al*., 2007). Such weeds have phytotoxic activities by which they release the allelopathic chemicals and toxicity. These chemicals play an important role to stop the growth and development of different crops (Alam and Islam, 2002; Taiwo and Makinde, 2005) and create toxin in stem, roots, flowers, leaves and rhizomes (Zeng *et al*., 2008) which mix with soil through decomposition and cause root exudation, leaching, volatilization (Fujii *et al*., 2004). Through these chemicals, a complex interaction occurs among plants and the environment (Bais *et al*., 2003).

Mesquite (*Prosopis juliflora (Sw.) DC.*, generally known as Kabuli kikar, is a well adopted shrub to harsh environmental conditions of arid zones. It is a large shrub native to semi-arid areas of the West Indies, Mexico, Central America and northern South America (Columbia, Venezeuela, Ecuadore and Peru) and has been naturalized in Pakistan since 1950s (Alcazar and Soriano, 2008). The ground vegetation under its canopy indicates that it has some allelopathic potential which is caused either by fallen leaves (through decomposition of leaves) or plant leachates or root exudates (Siddiqui *et al*., 2009). Consequently, the release of allelochemicals (organic substances) into the soil inhibits seed germination and establishment of agricultural crops and vegetation. Currently, *P. juliflora* poses a threat to indigenous biodiversity where ever it is established in Ethiopia in general and in the Middle Awash area in particular because of its weedy and invasive nature. In the Middle Awash, about 30,000 ha of grassland, rangelands, water points and croplands are estimated to be occupied by *P. juliflora* (Mehari, 2008). The invasion by *P. juliflora* reduces grass availability and stocking density by livestock. It impacts the plant biodiversity by creating a physical barrier on seedlings of other plant species, preventing sunlight to reach to the under canopy vegetation, lowering the water table and by releasing various chemicals that may have negative effect on the native plant species. Since the allelopaths obstruct plant growth at a certain concentration, therefore, their proper screening tests should be conducted to ensure their effects on weed flora and on economic crops (Tanveer, 2008). The present study was set up in view of the aforementioned facts under the agro-ecology of Dera Ismail Khan.

MATERIALS AND METHODS

Phytotoxic effect of mesquite was assessed under laboratory conditions at Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan in a completely

randomized design (factorial) with 4 replications for 28 days. Freshly vegetative growing tissues of the mesquite were collected from experimental site and were separated into leaf, stem and root, crushed and grinded. Tap water was used as control treatment. The ground plant material of mesquite was soaked in distilled water in different ratios (treatments) with the following details:

Treatments	Deatil of Treatments
T_0	Tap water
T_1	100 g leaf L^{-1} of water for 72 h (P. *juliflora*)
T_2	200 g leaf L^{-1} of water for 72 h (P. *juliflora*)
T_3	300 g leaf L^{-1} of water for 72 h (P. *juliflora*)
T_4	400 g leaf L^{-1} of water for 72 h (P. *juliflora*)
T_5	100 g stem L^{-1} of water for 72 h (P. *juliflora*)
T_6	200 g stem L^{-1} of water for 72 h (P. *juliflora*)
T_7	300 g stem L^{-1} of water for 72 h (P. *juliflora*)
T_8	400 g stem L^{-1} of water for 72 h (P. *juliflora*)
T_9	100 g root L^{-1} of water for 72 h (P. *juliflora*)
T_{10}	200 g root L^{-1} of water for 72 h (P. *juliflora*)
T_{11}	300 g root L^{-1} of water for 72 h (P. *juliflora*)
T_{12}	400 g root L^{-1} of water for 72 h (P. *juliflora*)

The aqueous extract was collected in bottles and tagged by filtering through 10 and 60 mesh sieves. Thirteen trays, filled with sand, silt and clay (1:1:1) were taken for sowing 100 seeds (tray^{-1}). An approved wheat variety 'Gomal-8' was used for carrying out the experiment. All treatments were applied 5 and 10 days after sowing. Water was applied on daily/alternate day basis to keep the soil moist or on its field capacity. Data on different physiological parameters were collected by using the following procedure.

Speed of germination (%)

The number of normal seedlings recorded in the first count represents the population of first germinating seeds and thus functions as a vigor measurement. The following formula was used to calculate the speed of germination.

$$SG = \frac{\text{No. of normal seedlings}}{\text{Day of 1st count}} + \ldots\ldots + \frac{\text{No. of normal seedlings}}{\text{day of final count}}$$

Mean germination time (days)

Mean germination time was calculated by using the following formula:

$$M.G.T = \frac{\sum(GXT)}{F}$$

Where T = the day on which germination count was made

G = the number of seeds germinated on the day of the count

F = final number of seeds which germinated in each replicate

Germination rate (days)

Germination rate was determined by calculating the germination percentage at 14, 21 and 28 days after sowing.

Germination (%)

Germination percentage is an estimate of the viability of a population of seeds. It was calculated by using the following formula:

GP = (Seed germination/ total seeds) x 100

Germination energy (%)

The percent seeds, by number, in a given sample which germinate within a given period under optimum or stated conditions were determined at 7 and 14 days after sowing (DAS).

Shoot length (cm)

Root and shoot length of 10 randomly selected wheat seedlings in each tray was measured at 14, 21 and 28 DAS and recorded.

Root length (cm)

Root length of 10 randomly selected wheat seedlings in each tray was measured at 14, 21 and 28 DAS and recorded.

Fresh shoot weight (g)

Fresh shoot weight of 10 randomly selected wheat seedlings in each tray was recorded 14, 21 and 28 at DAS with the help of electronic balance.

Fresh root weight (g)

Fresh root weight of 10 randomly selected wheat seedlings in each tray was recorded 14, 21 and 28 at DAS with the help of electronic balance.

Dry shoot weight (g)

Dry shoot weight of 10 randomly selected wheat seedlings in each tray was recorded at 14, 21 and 28 DAS with the help of electronic balance.

Dry root weight (g)

Dry root weight of 10 randomly selected wheat seedlings in each tray was recorded at 14, 21 and 28 DAS with the help of electronic balance.

Root: shoot ratio

The root: shoot ratio is measured to assess the overall budgeting of photosynthate into different organs. For measuring root: shoot ratio, 10 plants were removed from the soil, the loose soil was washed off and plants were sun dried and weighed on electronic balance. The root was then separated from the shoot, weighed separately and recorded. The ratio was computed by using the following formula:

Root: shoot ratio = (Dry weight for root/dry weight for shoot) x 100

Chlorophyll contents (µg cm^{-2})

Chlorophyll contents were recorded in 10 randomly selected at wheat seedlings at 14, 21 and 28 DAS. The SPAD meter was used for measuring chlorophyll contents.

The data 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 5% probability level using MSTATC computer softwere (MSTATC, 1991).

RESULTS

Speed of germination (%)

Speed of germination was significantly reduced with a corresponding increase in aqueous extract concentrations obtained from leaves, stem and roots of mesquite (Table-1). Compared to the untreated plants, maximum reduction in speed of germination (8.07%) was noted where the highest concentration (400 g L^{-1}) of leaf extract was applied. A similar trend was seen among the plants which were treated with stem and root extracts. The highest concentration of stem and root extracts (400 g L^{-1}) caused a maximum reduction in speed of germination (8.58 and 8.61%), respectively. It was noted that the inhibitory effect of mesquite delayed the speed of germination and there exists a proportionate relationship between the quantity of allelochemicals and germination speed.

Mean germination time (days)

Significant reduction in mean germination time was recorded due to the application of aqueous extracts of leaf, stem and root (Table 1). Maximum concentration (400g) of extracts obtained from mesquite increased the mean germination time. Mean germination time was increased to 13.40 days with the highest amount of leaf extract as compared to control. A similar trend was noted with the application of higher stem and root extract concentrations.

Germination rate (days)

Data presented in Table 1 elucidated that germination rate of wheat was negatively affected by mesquite extracts. It continued to decrease as the concentration of extracts was increased. It was found that the rate of germination (59.00, 65.25 and 68.75 days) was decreased as compared to control and other treatments, when 400 g L^{-1} of leaf, stem and root extracts was applied, respectively. The study revealed that the mesquite plant had an inhibitory effect on the germination rate of wheat, which was possibly due to the presence of toxic chemicals.

Germination (%)

Application of different concentrations of mesquite extracts showed significant decrease in germination percentage (Table 2). For maximum leaf extract (400 g L^{-1}), the germinating seedlings of wheat were reduced to 2.50 and 64.25% as compared to control where germination was 15.98 and 100.00% after the first week and second week of sowing. Results for stem and root extracts followed the same trend where germination percentage continued to decrease as the concentration of aqueous extracts increased resulting in minimum seed germination at the highest level of concentration.

Germination energy (%)

Allelopathic effect of mesquite extracts caused dwindling in germination energy (Table-2). Maximum leaf extract showed 2.83 and 61.45% germination energy at 7 and 14 days after sowing (DAS) respectively. Stem and root extracts also showed diminution in germination energy with increase in concentrations of aqueous extracts. In this regard 400g stem extract had 4.08 and 69.95% germination energy at 7 and 14 DAS as compared to the untreated control. Root extract also caused a similar influence on the studied parameter wherein the use of highest concentration resulted in minimum germination energy.

Shoot length (cm)

Shoot length was recorded at three intervals as shown in Table-3. It was significantly influenced by mesquite plant extracts. The highest level of leaf, stem and root extracts was found most lethal for the growing seedlings. Compared to control, short statured shoots were observed with the increasing concentration of aqueous extracts. Data recorded for 400g leaf extract showed 10.50, 17.09 and 20.13 cm shoot length. Stem and root extracts also caused a visible decrease in the shoot length at 14, 21 and 28 DAS.

Root length (cm)

The data revealed that root length was significantly influenced by extracts of mesquite (Table-3). Minimum root length was noted with a maximum concentration of mesquite obtained from leaf, stem and root. Root length of 2.67, 3.80 and 5.00 cm at 14, 21 and 28 DAS, respectively was recorded with the highest level of leaf extract. A similar effect was also noticed with the application of maximum extracts concentrations obtained from stem and root of mesquite.

Fresh shoot weight (g)

Data on fresh shoot weight are presented in Table-4. A significant decrease was noticed in fresh shoot weight with increasing concentration of selections. Fresh shoot weight (1.27, 1.74 and 2.11g) was noted at 14, 21 and 28 DAS, respectively. Maximum stem and root extracts (400g) also reduced fresh shoot weight of wheat as compared to control.

Fresh root weight (g)

It is revealed from the data given in Table-4 that maximum concentration (400g) caused highest reduction in fresh root weight (0.62, 0.70 and 0.89 g) at 14, 21 and 28 DAS, respectively. Extracts obtained from stem and root showed corresponding decrease in the said parameter due to increase in the concentrations of allelochemicals, the reduction being the maximum at the highest level of concentration.

Dry shoot weight (g)

Data showed significant differenceS due to application of extracts obtained from leaf, stem and root of mesquite (Table-5). Increasing the concentration of extracts to the maximum level (400g) curtailed the dry shoot weight of wheat plants (0.10, 0.13 and 0.15g) at 14, 21 and 28 DAS. Such decrease was also noticed with the application of stem and root extracts at 14, 21 and 28 DAS.

Dry root weight (g)

The dry root weight of wheat was lower when treated with maximum concentration of all three plant parts (Table-5). It was 0.06, 0.07 and 0.09g, and 0.06, 0.08 and 0.09g, and 0.06, 0.08 and 0.09g, respectively at 14, 21 and 28 DAS recorded for leaf, stem and root extracts, respectively.

Root: shoot ratio

Data for root:shoot weight of wheat are presented in Table-6. Among various extract concentrations, 400g of leaf, stem and root extract caused a maximum reduction in root: shoot ratio as compared to control. Root:shoot ratio of 57.27, 58.87 and 58.28 at 14, 21 and 28 DAS was recorded for leaf extract. Similar results were found in the stem and root extracts at 14, 21 and 28 DAS.

Chlorophyll contents (µg cm^{-2})

Data showed that maximum concentration of leaf, stem and root (400g) decreased the chlorophyll contents considerably in Table-6. Chlorophyll contents were 22.67, 26.60 and 20.25 µg cm^{-2} at 14, 21 and 28 DAS, respectively. Stem and root extracts also showed similar reduction in the chlorophyll contents (Table-6).

DISCUSSION

Some plant species or their residues delay growth of other plants (Al-Zahrani and Al-Robai, 2007). In this study, the aqueous extract of leaves, stem and roos of mesquite has reduced germination and seedling growth of wheat. The maximum reduction in germination was at the highest concentration of aqueous extract of leaves, stems and root of mesquite. Similarly, the highest concentration (400 g L^{-1}) of all three parts significantly reduced the speed of germination and germination rate and also delayed the mean germination time as compared to control. This was due to some phytotoxic compound in mesquite including tannins flavonoides, wax, alkaloids and phenolic acids which negatively affected the seed germination and radical length of wheat (Pragnesh and Bhandari, 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 were 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 the presence of plant growth inhibitory alkaloids which were extracted from the mesquite leaves (Nakano *et al*., 2004). Phytochemical analysis 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 the root has spinning, 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 parameters 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 seedling growth of several crops and weed species (Khan *et al*., 2004). Their inhibitory effect on seed germination, root length and other growth parameters are well established (Rafique *et al*., 2003; Hassan *et al.*, 2008). The mesquite extract is reported to cause maximum reduction in root length of wheat (Siddiqui *et al*., 2009). Similarly, aqueous extract application of mesquite significantly reduced the germination and seedling growth of a varying number of crop plants (Khan *et al.*, 2005; Hassan *et al.*, 2998).

CONCLUSIONS

It is imperative to study the phtytotoxicity of mesquite on field crops like wheat. On the basis of our data, it is concluded that phytotoxic properties of this forest weed have adverse effects on germination and growth of wheat. Hence, the presence of mesquite in fields may disturb the stand establishment of wheat crop. It was also found that aqueous extracts of this weed contain many phytotoxic substances which may negatively affect the growth and yield of different crops, therefore, wheat should not be planted close to the mesquite. It can, however, be used as bio-herbicide to control weeds in wheat crop. Thus, further studies are suggested to examine the efficacy of mesquite extracts as a source of commercial herbicide (s).

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 (days)	Germination rate (days)
T_0 = Tap water	10.779 a	9.61 j	85.25 a
T_1 = 100g leaves	9.893 b	10.72 i	83.00 a
T_2 = 200g leaves	9.794 b	10.91 hi	77.75 b
T_3 = 300g leaves	8.235 f	13.09 a	61.75 fg
T_4 = 400g leaves	8.070 f	13.40 a	59.00 g
T_5 = 100g stem	9.608 bc	11.13 gh	76.50 b
T_6 = 200g stem	9.329 c	11.57 ef	70.75 cd
T_7 = 300g stem	8.924 d	12.01 cd	68.75 d
T_8 = 400g stem	8.585 e	12.49 b	65.25 e
T_9 = 100g roots	9.429 c	11.45 fg	69.00 d
T_{10} = 200g roots	8.969 d	12.14 cd	63.00 ef
T_{11} = 300g roots	8.925 d	11.88 de	72.50 c
T_{12} = 400g roots	8.616 e	12.34 bc	68.75 d
$LSD_{0.05}$	0.3013	0.3536	3.3993

Means followed by different letter(s) in a column are statistically significant at 5% 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	14.75 a	100.00 a	15.98 a	100.00 a
T_1 = 100g leaves	11.50 b	94.50 b	11.58 b	94.70 b
T_2 = 200g leaves	11.25 bc	89.00 c	11.33 c	89.20 c
T_3 = 300g leaves	2.50 f	64.25 h	3.33 l	64.45 l
T_4 = 400g leaves	2.25 f	61.25 h	2.83 m	61.45 m
T_5 = 100g stem	10.00 bc	86.50 c	10.08 e	86.70 d
T_6 = 200g stem	9.75 bc	80.50 d	9.83 f	80.70 e
T_7 = 300g stem	6.25 de	75.00 e	6.33 h	76.20 h
T_8 = 400g stem	4.50 ef	69.75 g	4.08 j	69.95 k
T_9 = 100g roots	11.00 bc	80.00 d	10.58 d	79.70 f
T_{10} = 200g roots	8.75 cd	71.75 fg	8.83 g	71.95 j
T_{11} = 300g roots	5.75 e	78.25 d	4.83 i	78.45 g
T_{12} = 400g roots	4.50 ef	73.25 ef	3.58 k	73.45 i
$LSD_{0.05}$	2.707	3.0805	0.2059	0.0541

Means followed by different letter(s) in a column are statistically significant at 5% 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	19.58 a	26.43 a	30.19 a	4.20 a	6.20 a	7.05 a
T_1 = 100g leaves	13.39 d	20.34 c	23.06 c	3.17d ef	4.50 bc	5.65 c
T_2 = 200g leaves	12.64 e	19.20 d	22.26 d	3.02 efg	4.32 cd	5.42 de
T_3 = 300g leaves	11.44 f	18.40 e	21.09 e	2.92 fg	4.17 de	5.20 fg
T_4 = 400g leaves	10.50 g	17.09 f	20.13 f	2.67 g	3.80 f	5.00 h
T_5 = 100g stem	14.47 b	21.33 b	24.18 b	3.82 b	4.45 bc	5.62 c
T_6 = 200g stem	13.43 d	20.32 c	23.28 c	3.37 cd	4.35 cd	5.42 de
T_7 = 300g stem	12.34 e	19.44 d	22.32 d	3.22 def	4.20 d	5.27 ef
T_8 = 400g stem	11.31 f	18.39 e	21.33 e	2.97 efg	3.97 ef	5.10 gh
T_9 = 100g roots	14.04 c	21.34 b	24.20 b	3.57 bc	4.60 b	5.85 b
T_{10} = 200g roots	13.42 d	20.27 c	23.21 c	3.32 cde	4.42 bc	5.52 cd
T_{11} = 300g roots	12.53 e	19.30 d	22.22 d	3.10 def	4.17 de	5.42 de
T_{12} = 400g roots	11.32 f	18.38 e	21.42 e	2.95 fg	3.95 f	5.25 fg
$LSD_{0.05}$	0.6679	0.4068	0.3703	0.4434	0.3614	0.211

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	1.75 a	2.87 a	3.05 a	0.80 a	0.97 a	1.13 a
T_1 = 100g leaves	1.37 b	1.84 bcd	2.21 de	0.65 bc	0.74 bc	0.92 bcd
T_2 = 200g leaves	1.34 bcd	1.81 cde	2.18 de	0.64 bc	0.72 bcd	0.91 def
T_3 = 300g leaves	1.29 cde	1.79 de	2.15 de	0.63 bc	0.72 cd	0.89 def
T_4 = 400g leaves	1.27 e	1.74 e	2.11 e	0.62 c	0.70 d	0.86 f
T_5 = 100g stem	1.39 b	1.88 bc	2.40 b	0.66 bc	0.75 b	0.96 b
T_6 = 200g stem	1.38 b	1.87 bc	2.37 b	0.65 bc	0.72 bcd	0.91 cde
T_7 = 300g stem	1.35 bc	1.85 bcd	2.32 bc	0.72 ab	0.72 bcd	0.90 def
T_8 = 400g stem	1.29 cde	1.81 cde	2.24 cd	0.63 bc	0.70 d	0.89 def
T_9 = 100g roots	1.39 b	1.89 b	2.39 b	0.68 bc	0.74 bc	0.96 bc
T_{10} = 200g roots	1.35 bc	1.83 bcd	2.37 b	0.63 bc	0.73 bcd	0.93 bcd
T_{11} = 300g roots	1.30 cde	1.81 cde	2.35 b	0.64 bc	0.71 d	0.89 def
T_{12} = 400g roots	1.28 de	1.78 de	2.31 bc	0.63 bc	0.70 d	0.87 ef
$LSD_{0.05}$	0.0658	0.0755	0.103	0.099	0.0345	0.0474

Means followed by different letter(s) in a column are statistically significant at 5% 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	0.12 a	0.16 a	0.19 a	0.08 a	0.10 a	0.12 a
T_1 = 100g leaves	0.10 b	0.14 bc	0.16 b	0.06 bcd	0.08 bc	0.10 b
T_2 = 200g leaves	0.10 bc	0.13 cd	0.16 cd	0.06 cde	0.08 bc	0.09 bcd
T_3 = 300g leaves	0.10 cd	0.13 de	0.16 de	0.06 de	0.08bc	0.09 cde
T_4 = 400g leaves	0.10 d	0.13 e	0.15 e	0.06 e	0.07c	0.09 f
T_5 = 100g stem	0.10 b	0.14 b	0.16 b	0.06 bc	0.08 b	0.10 bc
T_6 = 200g stem	0.10 bc	0.13 bc	0.16 bc	0.06 bcd	0.08 bc	0.09 bcd
T_7 = 300g stem	0.10 bc	0.13 cd	0.16 cd	0.06 de	0.08 bc	0.09 cde
T_8 = 400g stem	0.10 cd	0.13 de	0.16 e	0.06 de	0.08 bc	0.09 f
T_9 = 100g roots	0.10 b	0.14 b	0.16 b	0.06 b	0.08 bc	0.10 bc
T_{10} = 200g roots	0.10 bc	0.13 bc	0.16 bc	0.06 bcd	0.08 bc	0.09 bcd
T_{11} = 300g roots	0.10 bc	0.13 cd	0.16 de	0.06 de	0.08 bc	0.09 def
T_{12} = 400g roots	0.10 b	0.13 de	0.16 de	0.06 de	0.08 bc	0.09 ef
$LSD_{0.05}$	3.39	3.274	2.765	2.821	4.835	3.241

Means followed by different letter(s) in a column are statistically significant at 5% level of probability.

Table-6. Phytotoxic effect of mesquite (*Prosopis juliflora*) on root:shoot ratio and chlorophyll content (µ g cm^{-2}) of wheat.

Treatments	Root shoot ratio			Chlorophyll content		
	14 DAS	21 DAS	28 DAS	14 DAS	21 DAS	28 DAS
T_0 = Tap water	66.04 a	62.39 a	65.13 a	27.92 a	34.34 a	27.01 a
T_1 = 100g leaves	59.18 b	59.14 b	60.71 b	25.02 def	28.66 bc	23.08 cd
T_2 = 200g leaves	59.26 b	59.50 b	61.09 b	24.21 g	28.42 bc	22.16 ef
T_3 = 300g leaves	59.45 b	59.63 b	60.62 b	23.59 h	27.40 de	21.04 g
T_4 = 400g leaves	57.27 b	58.87 b	58.28 d	22.67 i	26.60 f	20.25 h
T_5 = 100g stem	60.49 b	59.25 b	60.24 bc	25.25 cd	29.05 b	23.38 b
T_6 = 200g stem	59.19 b	58.86 b	59.75 cd	25.19 de	28.23 c	22.36 e
T_7 = 300g stem	59.43 b	58.99 b	59.88 cd	24.84 ef	28.15 c	21.67 fg
T_8 = 400g stem	58.33 b	59.26 b	58.65 cd	24.65 f	27.18 ef	21.19 g
T_9 = 100g roots	60.37 b	58.53 b	60.23 cd	25.73 b	28.95 b	23.63 b
T_{10} = 200g roots	59.66 b	58.86 b	59.62 cd	25.62 bc	28.74 bc	23.22 bc
T_{11} = 300g roots	59.09 b	58.99 b	59.80 cd	25.21 cde	28.38 bc	22.70 de
T_{12} = 400g roots	58.80 b	59.95 b	59.49 cd	24.90 def	28.07 cd	22.55 de
$LSD_{0.05}$	3.5017	3.6909	1.9608	0.4079	0.698	0.6679

Means followed by different letter(s) in a column are statistically significant at 5% level of probability.

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