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ALLELOPATHIC EFFECTS OF HERBACEOUS AND WOODY PLANT SPECIES ON SEED GERMINATION AND SEEDLING GROWTH OF WHEAT

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ABSTRACT

A laboratory experiment conducted at the Agricultural Research Institute, Dera Ismail Khan during 2011 investigated the allelopathic effects of water extracts from the leaves of Eucalyptus camaldulensis, Acacia nilotica, Helianthus annuus and Parthenium hysterophorus on 20 different wheat varieties. Results revealed significant effects of the aqueous extracts from leaves upon the seed germination of all the investigated wheat varieties. The maximum number of days to germination (13.7 and 13.3) was recorded for the untreated control treatments and H. annuus followed by E. camaldulensis, P. hysterophorus and A. nilotica extracts. Among wheat varieties, the maximum days to germination (13.9) were recorded for Meraj-2006 while the minimum days to germination (11.4) were noted for Khirman variety. Aqueous extracts reduced all growth parameters (shoot length, root length, fresh and dry weight of shoot, fresh and dry weight of root). The variable performance among the wheat varieties found during the experiment indicates that some varieties had tolerance against the allelochemicals. In general, Hashim-8 variety was more resistant while Moomal-2002 and Saleem-2000 were both susceptible. Based on this investigation, it can be suggested that the tested plant species may hinder both seed germination and seedling growth of wheat varieties; however, some wheat varieties may show resistance to the allelochemicals that may be released by the test plant species.

Keywords: Allelopathy, extracts, growth, seed germination, wheat.

INTRODUCTION

The grains of wheat are an essential ingredient of human diet worldwide. It contributes 14.4% to the value added in agriculture and

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3.1% to the GDP. Area and production target of wheat for the year 2009-10 in Pakistan had been set at 9.045 million ha and 25 million tons, respectively but decreased about 0.04% than the last year due to both the irrigation water shortage and lower rainfall. The prospects for wheat harvest improved somewhat with healthy fertilizer off take and reasonable rainfall in pre harvesting period (Anonymous, 2010).

Although there are many factors of low wheat production in Pakistan but weed-crop competition remains the major yield-deteriorating factor. In weed management, the main aim is to shift the weed crop competition in favour of the crop and against the weeds. Among weed management tools, chemical weed control is the most improved and time saving technique. This method involves the use of chemical commonly known as herbicides or weedicides to kill the weeds. But due to hazardous effects of synthetic weedicides like contamination of water, soil, plants and air, there is a shift of trends towards the organic farming in recent years. This involves the use of organic compounds (farmyard manure, compost manure) for nutritional management and biotic agents, which release phyto-toxic substance, for weed management. The later phenomenon is termed as allelopathy. It involves the release of chemicals into the ecosystem, which have their beneficial or harmful effect on the crop. It is important that all allelochemicals once released are short lived in environment and therefore don't disastrously upset the balance as the chemical would.

The main points concerning allelopathy is that its effect depends upon a chemical compound being added to the environment by allelopathic agents. It has adverse effects on the crop plants and resulting in the reduction and delaying of germination, mortality of seedlings, reduced absorption of water and nutrients, increased susceptibility of pathogens and parasitic effect, reduction in growth and yield, reduction of soil fertility and productivity problem.

Since allelochemicals inhibit the growth of plants at a certain concentration (Tanveer, 2008). Therefore, their proper screening tests are to be conducted to ensure that these allelochemicals effect the weed flora and not on the economic crop. The present study was aiming at evaluating the effect of different plant and tree leaf extracts on seed germination and early seedling growth of wheat.

MATERIALS AND METHODS

Laboratory based experiment was conducted at the Agricultural Research Institute, Dera Ismail Khan, during 2011. Allelopathic effect of different water extracts of plant and tree species was evaluated on twenty wheat varieties collected from various agricultural research institutes across the country. Leaves of plant and tree species were cut

in to small pieces and then boiled in fresh water with ratio of 2:10 (w/v) and the extracts were filtered through a muslin cloth and squeezed by pressing with hand. The seeds were placed in aluminum plates, measuring about 70.85 cm^2, which were arranged in a completely randomized design (CRD) with factorial arrangement.

Factor-A consisted of wheat varieties viz. Dera-98, Pirsabak-2008, Saleem-2000, Fakhr-e-Sarhad, Bhakkar-2002, Sindh-81, Sarsabz, Kiran-95, Sassuai, Mehran-98, Abadgar-93, Moomal-2002, SKD-1, Meraj-2006, Seher-6, Khirman, Zam-04, Hashim-8, GA-2002 and Chakwal-97. While water extracts of plant and tree species including eucalyptus (*Eucalyptus camaldulensis*), acacia (*Acacia nilotica)*, sunflower (*Helianthus annuus)* and congress grass (*Parthenium hysterophorus* L.) were assigned to sub-plots. A check (tap water) was also included for comparison. Each treatment was repeated three times. Seeds were treated with fungicide (Topsin-M) @ 1g L^{-1}) before sowing to avoid the fungal attack.

The data on days to seed germination, shoot length (mm), root length (mm), fresh shoot weight (g), dry shoot weight (g), fresh root weight (g) and dry root weight (g) were recorded 14 and 21 days after sowing and were analyzed statistically using analysis of variance techniques (Steel *et al*., 1997) and then LSD test was used to compare the treatment means with the help of MSTATC software program (MSTATC, 1991).

RESULTS AND DISCUSSION

Days to germination of wheat seedlings

The data taken on days after germination revealed that aqueous extracts of eucalyptus, acacia, sunflower and congress grass significantly inhibited wheat seed germination (Table-1). Higher number of days to germination (13.68) was recorded in tap water (control) that differed significantly from all other extracts except sunflower (13.25). It was followed by eucalyptus and congress grass with 12.85 and 12.17 days to germination, respectively. Among varieties, significantly the maximum number of days to germination (13.93) was recorded in Meraj-2006, Sindh-81 (13.60), Sassuai (13.53), Seher-6 (13.47) and Saleem-2000 (13.40) while the minimum days to germination (11.40) was taken by Khirman. The results showed that Meraj-2006 was most resistant to allelochemicals present in aqueous extracts whereas Khirman was prone to those chemicals. The interactive effect of varieties and aqueous extracts was non-significant statistically.

The results presented implied that allelochemicals present in aqueous extracts of leaves had inhibitory effect on germination of wheat seeds. Inhibition of seed germination of crop plants is generally

due to disturbance in the enzymatic activities responsible for germination and growth. Wheat varieties were also influenced by different aqueous extracts. However, some varieties showed tolerance to the adverse effect of allelochemicals contained in those extracts while most varieties were sensitive toward extracts application. These results are in agreement with Patel *et al*. (2002), Nadal *et al*. (2005), Khan *et al*. (2007) and Kumar and Siangshai (2009) who reported reduction in wheat seed germination after extracts application. Likewise, Alam and Islam (2002) reported that plants produce chemicals which interfere with other plants and effect seed germination and seedling growth of crops. Kamal and Bano (2008) studied the effect of sunflower on germination of wheat varieties (Margalla-99 and Chakwal-97) and reported that leaf extract significantly inhibited the rate of germination and growth of seedling.

Shoot length (mm) of wheat seedlings 14 days after germination

The results revealed that aqueous extracts of leaves of eucalyptus, acacia, sunflower, congress grass significantly decreased the length of shoots (Table-2). The highest shoot length (19.28mm) was recorded in control and eucalyptus and sunflower treatments with shoot length of 19.25 and 18.80mm, respectively. However, all these treatments were at par statistically. The lowest shoot length (17.22mm) was recorded in plants treated with acacia that was statistically similar to congress grass with shoot length of 17.52mm. Among wheat varieties, significantly the highest shoot length (21.77mm) was recorded in Hashim-8 and Chakwal-97 (20.57mm). The lowest shoot length (15.15mm) was found in Saleem-2000. These results indicated that Hashim-8 was most resistant to allelochemicals present in aqueous extracts while Saleem-2000 was susceptible to those chemicals.

The cumulative effect of varieties and extracts was also significant. The maximum shoot length (26.17mm) was recorded in wheat variety Hashim-8 treated with sunflower extract, Mehran-89 of control treatment and Sassuai variety treated with eucalyptus extract possessed shoot length of 26.00mm. The minimum shoot length (13.00 mm) was recorded in Saleem-2000 treated with aqueous extract of congress grass leaves.

Shoot length (mm) of wheat seedlings 21 days after germination

The data showed minimum shoot length (20.03mm) of wheat varieties treated with eucalyptus extract (Table-3). However, it was statistically similar to acacia (21.06mm) and congress grass (20.77mm) extracts. Maximum shoot length (23.44mm) was recorded in control that did not differ significantly from that of sunflower leaves

extracts. Among wheat varieties, the maximum shoot length (27.70mm) was noted in Sassuai and Kiran-95 with 24.53mm each, Chakwal-97 (24.43mm) and Hashim-8 (24.17mm). All these varieties were, however, statistically similar to each other. Variety Sehar-6 had the minimum shoot length (15.07mm) which was non-significantly different from Bhakkar-2002 and Moomal-2002 with shoot length of 18.00mm each. The results indicated that Seher-6 was most susceptible to allelochemicals of different plant extracts while Sassuai was found resistant. The interaction of varieties and extracts was also significant. The maximum shoot length (31.33mm) was recorded in Sassuai treated with acacia extract while minimum shoot length (8.00mm) was found in Sehar-6 of eucalyptus treatment.

The results presented in Tables-2 and Table-3 showed that allelopathic effect of aqueous extracts had inhibitory effect on early growth of wheat. Shoot length of wheat varieties was adversely affected by different leaf extracts. The variation of shoot length among wheat varieties was probably due to their genetic make-up.

Root length (mm) of wheat seedlings 14 days after germination

The data recorded on root length 14 days after germination are presented in Table-4. The results indicated that use of aqueous extracts significantly inhibited root length. The highest root length (9.88 mm) was measured in control that differed significantly from all other extracts. It was followed by eucalyptus, sunflower, congress grass and acacia extracts with root length of 7.242, 6.675, 5.997 and 5.383 mm, respectively. The acacia extract had adverse effect on root length of wheat varieties followed by congress grass. While eucalyptus extract was least effective in reducing root length. As far as different wheat varieties are concerned, the highest root length (9.067mm) was recorded in Mehran-89 and Fakhr-e-Sarhad (8.433 mm). The variety Saleem-2000 showed its susceptibility to allelochemicals and resulted in shortest root length (5.021mm). It was noted that allelochemicals released from leaves of different plant and tree species had variable effect on root length.

The interactive effect of varieties and extracts was also significant. The maximum root length (16.00mm) was noticed in Fakhr-e-Sarhad in tap water and minimum (3.00mm) in Saleem-2000 treated with aqueous extract of acacia leaves.

Root length (mm) of wheat seedlings 21 days after germination

The data showed that different aqueous extracts significantly reduced root length of wheat varieties 21 days after germination (Table-5). The minimum root length of 8.167mm was recorded in sunflower extract showing its adverse effects on root development. Ghafar *et al*. (2000) also showed that sunflower water extracts at concentration of 25, 50, 75 and 100% inhibited wheat seedling in term

of root and shoot lengths. The maximum root length of 10.810mm was recorded in control that was statistically similar to eucalyptus but differed significantly from acacia, sunflower and congress grass. Significant variation was found in root length of different wheat varieties. The maximum root length of 19.970mm was recorded in Sassuai, Hashim-8 (10.800 mm) and Chakwal-97 (10.43mm). However, all these varieties were statistically at par with each other. The data also indicated that Seher-6 was prone to allelopathetic effect of extracts followed by Sindh-81 with root lengths of 5.467 and 6.268mm, respectively.

The cumulative effect of varieties and extracts was also significant. The maximum root length of 15.50mm was recorded in Sassuai of control treatment and Hashim-8 and Khirman treated with tap water with 15.00mm root length each. The minimum root length of 3.00mm was recorded in Seher-6 of control treatment.

Data regarding root length of different wheat varieties demonstrated that aqueous extracts significantly reduced root length (Tables 4-5). The difference among wheat varieties in response to allelochemicals might be due to their genetic variability. The negative effect of extracts on seedling growth might be due to phytotoxic decomposing products, released from leaves, stem, root, fruits and seeds. Alam and Islam (2002) reported that plants produce chemicals which interfere with other plants and effect seed germination and seedling growth. Alagesaboopthi (2010) reported reduction in root length of pearl millet and cowpea while Kumar and Siangshai (2009) recorded reduction in radicle length of rice, rape and mustard and soybean due to leaf and bark aqueous extracts of *Aporoso octandras, Anthocephmallus chinensis* and *Albizzia procera*.

Fresh shoot weight (g) of wheat seedlings 14 days after germination

Fresh shoot weight of wheat varieties was significantly affected by different aqueous extracts (Table-6). The maximum reduction in shoot weight was recorded in acacia extract (1.342g), congress grass (1.367g), sunflower (1.373g) and eucalyptus (1.374g) extracts. Overall, the fresh shoot weight (1.515g) in control treatment was significantly higher than all other treatments. Wheat varieties also differed significantly in fresh shoot weight. The maximum fresh shoot weight of 1.449g was noted in Sassuai, Meraj-2006 (1.444g), Kiran-95 (1.425g), Hashim-8 (1.421g), Sarsabz (1.420g) and Mehran-89 (1.431g). However, all these varieties were statistically at par with each other. The minimum fresh shoot weight of 1.315g was found in Moomal-2002 possibly due to its susceptibility against allelochemicals.

The interaction of extracts and wheat varieties was also found significant. The maximum fresh shoot weight (1.730g) was recorded in

Sarsabz, Sassuai (1.680g), Mehran-89 (1.660g) and Meraj-2006 (1.640g) treated with tap water (control). The minimum fresh shoot weight of 0.973g was recorded in Moomal-2002 treated with acacia leaf extract.

Fresh shoot weight (g) of wheat seedlings 21 days after germination

The data showed significant reduction in fresh shoot weight of wheat varieties 21 days after germination by using different aqueous extracts (Table-7). The maximum reduction was noticed in congress grass extract with fresh shoot weight of 1.422g, acacia and sunflower extracts with fresh shoot weight of 1.424 and 1.440g, respectively. However, all these were statistically at par but significantly different from eucalyptus extract. The maximum fresh shoot weight of 1.569g was recorded in control. Wheat varieties also showed significant differences in fresh shoot weight. The maximum fresh shoot weight (1.524g) was recorded in Mehran-89 and Sassuai (1.508g).The findings indicated that Mehran-89 and Sassuai had resistance against allelochemicals present in leaf extracts of different plants whereas Sarsabz was prone to these chemicals which produced the lowest fresh shoot weight of 1.415g.

The cumulative effect of varieties and leaf extracts was also found significant. The maximum fresh shoot weight of 1.720g was recorded in Meraj-2006, Sassuai and Mehran-89 of control treatments had fresh shoot weight of 1.710 and 1.700g, respectively. All these varieties were however statistically at par with each other. The minimum fresh shoot weight (1.307g) was found in Moomal-2002 treated with acacia extract.

Data recorded at different growth intervals illustrated reduction in fresh shoot weight of wheat by the application of leaf extracts of eucalyptus, acacia, congress grass and sunflower. Wheat varieties also showed variation in fresh shoot weight indicating that some varieties had tolerance to adverse effects of allelochemicals while others were sensitive to extracts application. Similar results were obtained by Yang *et al*. (2002) after treatment of rice plant with allelopathetic phenolics on fresh weight. Patel *et al.* (2002) observed reduction in dry weight, germination, seedling growth and yield due to eucalyptus trees whereas Marwat *et al*. (2008) reported that congress grass (*Parthenium hysterophorus* L.) is an invasive weed threatening the biodiversity and human health in several areas of Pakistan. They further showed that congress grass significantly reduced germination percentage, seedling length and seedling weight of wheat. Alagesaboopthi (2010) reported reduction in fresh weight of pearl millet and cowpea due to extracts application.

Dry shoot weight (g) of wheat seedlings 14 days after germination

The data showed non-significant effects of aqueous extracts on dry shoot weight (Table-8). Similarly, the dry shoot weight did not differ significantly in different wheat varieties. Among varieties tested, the highest dry shoot weight (1.268g) was, however, recorded in Hashim-8 and Sindh-81 (1.262g), followed by Bhakkar-2002 (1.261g), Sarsabz (1.261g) and Meraj-2006 (1.260g). The lowest dry shoot weight (1.241g) was recorded in Zam-04.

The interaction of varieties and treatments was significant statistically. The maximum dry root weight of 1.310g was recorded in Sarsabz treated with eucalyptus extract and Hashim-8 (1.297g) treated with congress grass extract. The minimum dry root weight of 1.220g was recorded in Pirsabak-2008 treated with congress grass leaf extract.

Dry shoot weight (g) of wheat seedlings 21 days after germination

The data regarding dry shoot weight taken 21 days after germination of wheat varieties are presented in Table-9, which revealed significantly the maximum dry shoot weight (1.275g) in control that was statistically similar to sunflower (1.270g), acacia (1.264g) and congress grass (2.66g) treatments but differed significantly from eucalyptus (1.252g) extract. Dry shoot weight also differed significantly among wheat varieties. The maximum dry shoot weight (1.287g) was recorded in Mehran-89 and Sassuai (1.281g), followed by Hashim-8 (1.272g), Fakhr-e-Sarhad (1.269g), Chakwal-97, GA-2002 (1.267g each), Zam-04, Abadgar-93, Kiran-95 and SKD-1 with 1.265g each, respectively. The lowest dry shoot weight of 1.247g was obtained in Moomal-2002, indicating its susceptibility towards extracts application while Mehran-89 and Sassuai were found resistant to those chemicals. The interactive effect of varieties and aqueous extracts was found non-significant statistically.

Fresh root weight (g) of wheat seedlings 14 days after germination

Significant variations were found in fresh root weight of wheat varieties as affected by aqueous extracts of different plants (Table-10). The maximum fresh root weight (1.647g) was recorded in control treatment that did not differ significantly from sunflower and eucalyptus leaf extracts. However, the maximum reduction in fresh root weight was recorded in congress grass extract (1.514g) and acacia (1.538g) and both were statistically similar. These results indicate that aqueous extract of congress grass reduced fresh root weight remarkably while eucalyptus extract was less effective. Wheat varieties also differed significantly in fresh root weight. The maximum

fresh root weight (1.720g) was recorded in Mehran-89, Bhakkar-2002 (1.647g), Sarsabz (1.643g) and Meraj-2006 (1.639g) which were statistically at par with each other. The lowest fresh root weight (1.498g) was recorded in Moomal-2002. The results implied that among tested wheat varieties, Mehran-89 was resistant to allelochemicals while Moomal-2002 was found susceptible.

The interactive effect of varieties and treatments was also significant statistically. The maximum fresh root weight (1.830g) was recorded in SKD-1 of control treatment and Chakwal-97 treated with sunflower extract with fresh root weight of 1.810g. The minimum fresh root weight of 1.333g was obtained in Kiran-95 treated with congress grass leaf extract.

Fresh root weight (g) of wheat seedlings 21 days after germination

The maximum fresh root weight of 1.753g was found in control that was significantly similar to sunflower (1.724g) and eucalyptus (1.704g) extracts (Table-11). The minimum fresh root weight (1.612g) was obtained in varieties grown in congress grass extract which was statistically at par to acacia extract (1.623g). The maximum reduction in fresh root weight in congress grass and acacia extracts indicated their negative effect to curtail fresh root weight. The data further indicated the maximum fresh root weight (1.845g) in Hashim-8, followed by Zam-04 (1.791g). Variety SKD-1 had the lowest fresh root weight of 1.550g. The results revealed that Hashim-8 was resistant to allelochemicals released from leaves of different plant and tree species while SKD-1 was found susceptible to those chemicals. The interactive effect of varieties and leaf extracts was found non-significant statistically.

Dry root weight (g) of wheat seedlings 14 days after germination

The data revealed that dry root weight of wheat varieties was significantly affected by aqueous extracts (Table-12). The maximum dry root weight (1.315g) was recorded in control that was significantly different from sunflower (1.296g), eucalyptus (1.293g) and acacia (1.283g) extracts. The minimum dry root weight (1.278g) recorded in congress grass extract indicated that congress grass extract had most adverse effect on dry root weight as compare to acacia, eucalyptus and sunflower extracts. Significant difference in dry root weight was observed in different wheat varieties. The highest and statistically similar dry root weight (1.318g) was recorded in Zam-04, Mehran-89 (1.317g) and Sassuai (1.310g). The lowest dry root weight (1.267g) was recorded in Saleem-2000 and Kiran-95, which showed their susceptibility to those allelochemicals.

The interaction of varieties and treatments showed significantly the maximum dry root weight of 1.450g in Zam-04 of control treatment. Similarly, the minimum dry root weight of 1.230g was found in Kiran-95 in the same tap water treatment.

Dry root weight (g) of wheat seedlings 21 days after germination:

The data indicated maximum dry root weight (1.329g) in control that differed significantly from all other extracts (Table-13). It was followed by sunflower (1.312g) and eucalyptus (1.302g) extracts treatments. The minimum dry root weight of 1.289g was recorded in acacia treatment. Einhelling (1995) stated that chemicals released from leaf, stem and bark are potential inhibitors of dry root weight. Significant variations were found in dry root weight of different wheat varieties. The maximum dry root weight (1.337g) was recorded in Mehran-89 and Hashim-8 (1.333g), followed by Meraj-2006 (1.325g), Zam-04 (1.319g) and Pirsabak-2008 (1.318g). Dera-98 and Abadgar-93 had similar dry root weight of 1.313g each. The minimum dry root weight (1.271g) was obtained in Seher-6 indicating that it was susceptible to allelochemicals of leaf extracts of different plant and tree species.

The interactive effect of varieties and leaf extracts was also found significant statistically. The maximum dry root weight (1.440g) was recorded in Mehran-89 and Kiran-95 (1.420g) and minimum (1.230g) in Seher-6 of control treatment. Such a variation among wheat varieties might be attributed to their genetic diversity.

Table-1. Allelopathic effects of different plant and tree leaf extracts on days to germination of wheat seeds

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	12.000^{NS}	10.000	12.333	12.000	13.333	11.93bcd
Pirsabak-2008	12.333	10.000	12.333	12.667	14.333	12.33a-d
Saleem-2000	13.667	13.000	13.667	13.667	13.000	13.40ab
Fakhr-e-Sarhad	11.000	13.000	12.000	12.333	11.000	11.87bcd
Bhakkar-2002	15.000	10.000	11.000	12.333	14.333	12.53a-d
Sindh-81	15.667	13.000	13.667	12.000	13.667	13.60ab
Sarsabz	12.000	10.000	13.667	12.667	15.000	12.67a-d
Kiran-95	12.333	12.000	13.333	12.000	14.667	12.87a-d
Sassuai	13.000	10.000	15.000	14.000	15.667	13.53ab
Mehran-89	12.000	13.000	16.000	12.667	12.333	13.20abc
Abadgar-93	11.000	10.000	14.333	11.333	14.333	12.20a-d
Moomal-2002	13.000	10.000	13.000	12.333	14.667	12.60a-d
SKD-1	14.333	11.000	13.000	13.333	14.000	13.13a-d
Meraj-2006	14.667	13.000	13.667	13.333	15.000	13.93a
Seher-6	14.333	13.000	15.000	12.000	13.000	13.47ab
Khirman	12.000	10.000	12.000	12.000	11.000	11.40d
Zam-04	13.333	10.000	13.000	10.000	15.000	12.27a-d

Hashim-8	11.000	10.000	13.667	11.000	13.667	11.87bcd
GA-2002	11.000	11.000	12.000	11.667	12.000	11.53cd
Chakwal–97	13.333	10.000	12.333	10.000	13.667	11.87bcd
Mean	12.85bc	11.10d	13.25ab	12.17c	13.68a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05. $LSD_{0.05}$ for extracts = 0.727, $LSD_{0.05}$ for varieties = 1.456, NS = Non-significant

Table-2. Allelopathic effects of different plant and tree leaf extracts on shoot length (mm) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	17.50d-r	17.67d-r	20.34a-p	16.50g-r	17.67d-r	17.93b-f
Pirsabak-2008	17.33d-r	14.33o-r	15.84i-r	15.00l-r	17.67d-r	16.03fg
Saleem-2000	14.83l–r	14.50m-r	15.44k-r	13.00qr	18.00d-r	15.15g
Fakhr-e-Sarhad	17.50d-r	15.50k-r	19.50b-q	18.33d-r	17.83d-r	17.73c-g
Bhakkar-2002	14.67m-r	19.67b-q	19.17c-r	17.67d-r	19.00c-r	18.03b-f
Sindh-81	18.33d-r	17.33d-r	13.67pqr	19.00c-r	16.00h-r	16.87efg
Sarsabz	16.67f–r	21.00a-o	23.00a-g	16.50g-r	19.50b-q	19.33a-e
Kiran-95	22.00a-k	16.50g-r	18.00d-r	19.00c-r	25.00abc	20.10abc
Sassuai	26.00ab	16.33g-r	21.20a-m	15.67j-r	17.67d-r	19.37a-e
Mehran-89	22.00a-k	17.00e-r	17.50d-r	18.17d-r	26.00ab	20.13abc
Abadgar-93	22.33a-j	18.67c-r	14.32o-r	23.50a-e	19.33c-q	19.63a-d
Moomal-2002	18.50c-r	16.00h-r	17.00e-r	12.50r	17.67d-r	16.33fg
SKD-1	17.33d-r	18.50c-r	14.74m-r	24.00a-d	16.67f-r	18.25b-f
Meraj-2006	19.67b-q	18.00d-r	19.44c-q	19.00c-r	20.00a-p	19.22a-e
Seher-6	17.33d-r	15.00l-r	14.44n-r	15.83i-r	16.33g-r	15.79fg
Khirman	23.33a-f	16.00h-r	21.50a-l	18.00d-r	20.50a-o	19.87abc
Zam-04	20.00a-p	17.67d-r	17.25e-r	13.17qr	16.67f-r	16.95d-g
Hashim-8	22.33a-j	19.00c-r	26.17a	21.00a-o	20.33a-p	21.77a
GA-2002	17.33d-r	18.33d-r	22.50a-i	15.33k-r	22.67a-h	19.23a-e
Chakwal-97	20.00a-p	17.33d-r	25.00abc	19.33c-q	21.17a-n	20.57ab
Mean	19.25a	17.22b	18.80a	17.52b	19.28a	

Means followed by different letters in a column are statistically significant at α = 0.05

$LSD_{0.05}$ for extracts = 1.151, $LSD_{0.05}$ for varieties = 2.302, $LSD_{0.05}$ for interaction = 5.148

Table-3. Allelopathic effects of different plant and tree leaf extracts on shoot length (mm) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	23.00a-m	17.33e-n	22.67a-m	18.17d-n	22.00a-m	20.63bcd
Pirsabak-2008	20.50b-n	25.67a-g	26.00a-f	15.83h-o	23.00a-m	22.20bc
Saleem-2000	25.00a-i	24.33a-k	15.00j-o	17.25e-n	19.00d-n	20.12cd
Fakhr-e-Sarhad	19.67c-n	24.67a-j	22.33a-m	22.67a-m	25.00a-i	22.87bc
Bhakkar-2002	11.34no	13.67mno	20.33b-n	20.33b-n	22.67a-m	18.00de
Sindh-81	16.35f-o	18.33d-n	15.33I-o	23.00a-m	25.00a-i	19.60cd
Sarsabz	14.00l-o	23.00a-m	17.33e-n	21.33b-m	22.33a-m	19.60cd
Kiran-95	25.67a-g	24.33a-k	25.00a-i	21.33b-m	26.33a-e	24.53ab
Sassuai	24.50a-j	31.33a	29.00abc	27.33a-d	26.33a-e	27.70a
Mehran-89	20.67b-n	21.67a-m	24.00a-k	22.00a-m	24.00a-k	22.47bc
Abadgar-93	21.50b-m	23.67a-l	23.33a-m	19.67c-n	23.67a-l	22.37bc
Moomal-2002	14.67k-o	14.00l-o	22.00a-m	18.33d-n	21.00b-m	18.00de
SKD-1	22.00a-m	17.33e-n	24.67a-j	17.83d-n	25.33a-h	21.43bcd
Meraj-2006	19.50c–n	22.67a-m	27.00a-e	20.33b-n	23.33a-m	22.57bc
Seher-6	8.000o	16.00g-o	20.33b-n	13.67mno	19.50c-n	15.07e
Khirman	22.00a-m	18.00d-n	22.33a-m	23.33a-m	22.00a-m	21.53bcd
Zam-04	22.34a-m	17.67d-n	26.33a-e	23.67a-l	25.83a-f	23.17bc
Hashim-8	24.50a-j	18.67d-n	27.00a-e	23.67a-l	27.00a-e	24.17ab
GA-2002	22.67a-m	25.00a-i	22.00a-m	19.33c-n	26.67a-e	23.13bc
Chakwal-97	22.67a-m	23.83a-k	30.00ab	24.67a-j	21.00b-m	24.43ab
Mean	20.03b	21.06b	23.10a	20.77b	23.44a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 1.679, $LSD_{0.05}$ for varieties = 3.358, $LSD_{0.05}$ for interaction =7.510

Table-4. Allelopathic effects of leaf extracts on root length (mm) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	10.17b-k	5.333l-r	6.667g-r	6.000i-r	8.670c-p	7.367a-d
Pirsabak-2008	8.333d-p	5.000m-r	5.333l-r	5.000m-r	10.50b-i	6.833b-e
Saleem-2000	4.333o-r	3.000r	4.833n-r	4.500o-r	8.440d-p	5.021e
Fakhr-e-Sarhad	7.833d-q	6.000i-r	4.667n-r	7.667d-r	16.00a	8.433ab
Bhakkar-2002	4.000pqr	5.667k-r	5.667k-r	6.500h-r	9.340b-n	6.235cde
Sindh-81	7.000e-r	4.667n-r	7.667d-r	8.000d-q	5.000m-r	6.467cde
Sarsabz	6.000i–r	5.333l-r	7.000e-r	7.750d-q	11.50b-e	7.517a-d
Kiran-95	5.667k-r	5.000m-r	5.167l-r	5.000m-r	7.840d-q	5.735de
Sassuai	9.333b-n	5.167l-r	7.000e-r	5.000m-r	10.34b-j	7.368a-d
Mehran-89	11.33b-f	6.000i-r	10.33b-j	6.000i-r	11.67bcd	9.067a
Abadgar-93	6.667g-r	5.667k-r	6.000i-r	8.000d-q	8.000d-q	6.867b-e
Moomal-2002	7.000e-r	6.000i-r	6.333h-r	4.500o-r	10.67b-h	6.901b-e
SKD-1	5.667k-r	5.000m-r	4.500o-r	5.333l-r	9.000c-o	5.900de
Meraj-2006	6.667g-r	7.000e-r	7.000e-r	6.000i-r	13.50ab	8.033abc
Seher-6	6.000i-r	5.000m-r	6.833f-r	5.833j-r	9.670b-m	6.667b-e
Khirman	9.333b-n	5.667k-r	7.333d-r	5.500k-r	7.500d-r	7.067bcd

Zam-04	9.000c-o	5.000m-r	5.667k-r	3.500qr	13.00abc	7.233a-d
Hashim-8	6.667g-r	7.000e-r	8.000d-q	7.250d-r	9.000c-o	7.583a-d
GA-2002	5.500k-r	5.000m-r	6.333h-r	7.000e-r	9.750b-l	6.717b-e
Chakwal-97	8.333d-p	5.167l-r	11.17b-g	5.600k-r	8.220d-p	7.697a-d
Mean	7.242b	5.383d	6.675bc	5.997cd	9.880a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.802, $LSD_{0.05}$ for varieties = 1.605, $LSD_{0.05}$ for interaction = 3.588

Table-5. Allelopathic effects of leaf extracts on root length (mm) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	10.33a-o	7.667d-p	6.000j-p	6.833f-p	11.25a-l	8.417a-e
Pirsabak-2008	10.67a-n	11.33a–l	13.17a-g	6.667g-p	9.000a-p	10.17abc
Saleem-2000	6.000j-p	6.500g-p	5.500l-p	6.750g-p	10.50a-o	7.050def
Fakhr-e-Sarhad	13.50a-f	10.00a-o	7.667d-p	8.667b-p	13.00a-h	10.57abc
Bhakkar-2002	8.833b-p	4.333m-p	6.500g-p	9.000a-p	6.670g-p	7.067def
Sindh-81	9.667a-p	4.000nop	3.833op	7.500d-p	6.340h-p	6.268ef
Sarsabz	10.67a-n	8.833b-p	6.667g-p	11.00a-m	8.000c-p	9.033a-d
Kiran-95	10.33a-o	7.000e-p	5.667k-p	6.167i-p	14.00a-d	8.633a-e
Sassuai	9.000a-p	10.33a-o	10.33a-o	9.667a-p	15.50a	10.97a
Mehran-89	10.67a-n	7.500d-p	8.667b-p	8.167c-p	10.50a-o	9.100a-d
Abadgar-93	7.667d-p	7.667d-p	7.667d-p	6.333h-p	11.00a-m	8.400a-e
Moomal-2002	10.67a-n	4.000nop	8.333b-p	9.667a-p	6.670g-p	7.867c-f
SKD-1	9.333a-m	6.000j–p	7.333d-p	7.000e-p	11.00a-m	8.133b-e
Meraj-2006	8.500b-p	9.000a-p	11.33a-l	5.667k-p	8.340b-p	8.568a-e
Seher-6	4.333m-p	7.000e-p	8.333b-p	4.667l-p	3.000p	5.467f
Khirman	8.000c-p	4.000nop	9.000a-p	13.67a-e	15.00ab	9.933abc
Zam-04	12.50a-j	8.333b-p	9.667a-p	9.667a-p	12.84a-i	10.60abc
Hashim-8	12.67a-j	7.333d-p	10.00a-o	9.000a-p	15.00ab	10.80ab
GA-2002	10.33a-o	9.000a-p	9.000a-p	8.333b-p	14.50abc	10.23abc
Chakwal-97	11.17a-l	6.000j–p	8.667b-p	12.33a-k	14.00a-d	10.43abc
Mean	9.742a	7.375b	8.167b	8.337b	10.81a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 1.149, $LSD_{0.05}$ for varieties = 2.298, $LSD_{0.05}$ for interaction = 5.139

Table-6. Allelopathic effects of leaf extracts on fresh shoot weight (g) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	1.350hi	1.350hi	1.353hi	1.430d-h	1.460c-h	1.389a-d
Pirsabak-2008	1.327hi	1.330hi	1.373f-i	1.250i	1.450d-h	1.346cde
Saleem-2000	1.463c-h	1.347hi	1.393f-i	1.350hi	1.430d-h	1.397a-d
Fakhr-e-Sarhad	1.403e-i	1.393f-i	1.363ghi	1.330hi	1.530b-g	1.404a-d
Bhakkar-2002	1.400f-i	1.400f-i	1.323hi	1.360ghi	1.400f-i	1.377a-e
Sindh-81	1.360ghi	1.367f-i	1.370f-i	1.407e-i	1.570b-e	1.415abc
Sarsabz	1.337hi	1.373f-i	1.350hi	1.310hi	1.730a	1.420ab
Kiran-95	1.387f-i	1.320hi	1.437d-h	1.360ghi	1.620abc	1.425ab

Sassuai	1.350hi	1.440d-h	1.387f-i	1.387f-i	1.680ab	1.449a
Mehran-89	1.347hi	1.377f-i	1.410e-i	1.360ghi	1.660ab	1.431ab
Abadgar-93	1.423d-i	1.300hi	1.337hi	1.430d-h	1.570b-e	1.412abc
Moomal-2002	1.340hi	0.973j	1.363ghi	1.327hi	1.570b-e	1.315e
SKD-1	1.570b-e	1.337hi	1.383f-i	1.340hi	1.580a-d	1.402a-d
Meraj-2006	1.417d-i	1.377f-i	1.397f-i	1.390f–i	1.640ab	1.444a
Seher-6	1.377f-i	1.390f-i	1.373f-i	1.357ghi	1.570b-e	1.413abc
Khirman	1.377f-i	1.363ghi	1.420d-i	1.337hi	1.330hi	1.365b-e
Zam-04	1.330hi	1.317hi	1.343hi	1.367f–i	1.330hi	1.337de
Hashim-8	1.390f-i	1.417d-i	1.337hi	1.540b-f	1.420d-i	1.421ab
GA-2002	1.350hi	1.323hi	1.377f-i	1.350hi	1.390f-i	1.358b-e
Chakwal-97	1.377f-i	1.337hi	1.363ghi	1.350hi	1.380f-i	1.361b-e
Mean	1.374b	1.342b	1.373b	1.367b	1.515a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.030, $LSD_{0.05}$ for varieties = 0.060, $LSD_{0.05}$ for interaction = 0.134

Table-7. Allelopathic effects of leaf extracts on fresh shoot weight (g) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	1.543b-i	1.393h-n	1.403h-n	1.510d-l	1.500d-l	1.470a-e
Pirsabak-2008	1.413h-n	1.393h-n	1.417h-n	1.470e-n	1.540b-j	1.447b-e
Saleem-2000	1.513d-l	1.387i-n	1.463f-n	1.317mn	1.540b-j	1.444b-e
Fakhr-e-Sarhad	1.500d-l	1.483e-m	1.430g-n	1.440g-n	1.600a-g	1.491a-d
Bhakkar-2002	1.533c-k	1.500d-l	1.477e-n	1.453f-n	1.480e-n	1.489a-e
Sindh-81	1.410h-n	1.420h-n	1.410h-n	1.417h-n	1.640a-e	1.459a-e
Sarsabz	1.407h-n	1.373i-n	1.433g-n	1.443g-n	1.420h-n	1.415e
Kiran-95	1.467f-n	1.427g-n	1.447f-n	1.393h-n	1.690abc	1.485a-e
Sassuai	1.460f-n	1.520d-k	1.427g-n	1.423h-n	1.710a	1.508ab
Mehran-89	1.547b-i	1.487e-m	1.430g-n	1.457f-n	1.700ab	1.524a
Abadgar-93	1.503d-l	1.387i-n	1.377i-n	1.457f-n	1.620a-f	1.469a-e
Moomal-2002	1.363k-n	1.307n	1.417h-n	1.343lmn	1.660a-d	1.418de
SKD-1	1.463f-n	1.367j-n	1.433g-n	1.340lmn	1.640a-e	1.449b-e
Meraj-2006	1.473e-n	1.397h-n	1.477e-n	1.390h-n	1.720a	1.491a-d
Seher-6	1.477e-n	1.407h-n	1.483e-m	1.420h-n	1.600a-g	1.477a-e
Khirman	1.437g-n	1.433g-n	1.467f-n	1.390h-n	1.410h-n	1.427cde
Zam-04	1.523d-k	1.420h-n	1.417h-n	1.380i-n	1.460f-n	1.440b-e
Hashim-8	1.493d-l	1.473e-n	1.427g-n	1.563a-h	1.520d-k	1.495abc
GA-2002	1.470e-n	1.463f-n	1.487e-m	1.417h-n	1.460f-n	1.459a-e
Chakwal-97	1.483e-m	1.440g-n	1.483e-m	1.420h-n	1.460f-n	1.457a-e
Mean	1.474b	1.424c	1.440c	1.422c	1.569a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.030, $LSD_{0.05}$ for varieties = 0.060, $LSD_{0.05}$ for interaction = 0.134

Table-8. Allelopathic effect of leaf extracts on dry shoot weight (g) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	1.240j-n	1.253f-l	1.243i-n	1.277cde	1.257e-k	1.254b-g
Pirsabak-2008	1.240j-n	1.250g-m	1.260d-j	1.220o	1.247h-n	1.243hij
Saleem-2000	1.230mno	1.230mno	1.253f-l	1.257e-k	1.263d-i	1.247g-j
Fakhr-e-Sarhad	1.240j-n	1.253f-l	1.240j-n	1.263d-i	1.260d-j	1.251e-h
Bhakkar-2002	1.240j-n	1.273c-f	1.260d-j	1.253f-l	1.280bcd	1.261abc
Sindh-81	1.250g-m	1.260d-j	1.270c-g	1.277cde	1.253f-l	1.262ab
Sarsabz	1.310a	1.283bc	1.240j-n	1.230mno	1.243i-n	1.261abc
Kiran-95	1.260d-j	1.247h-n	1.253f-l	1.243i-n	1.247h-n	1.250f-i
Sassuai	1.260d-j	1.270c-g	1.243i-n	1.267c-h	1.253f-l	1.259b-e
Mehran-89	1.250g-m	1.247h-n	1.260d-j	1.243i-n	1.267c-h	1.253c-g
Abadgar-93	1.250g-m	1.237k-o	1.247h-n	1.243i-n	1.267c-h	1.249g-j
Moomal-2002	1.270c-g	1.227no	1.250g-m	1.233l-o	1.253f-l	1.247g-j
SKD-1	1.230mno	1.243i-n	1.253f-l	1.243i-n	1.240j-n	1.242ij
Meraj-2006	1.280bcd	1.257e-k	1.250g-m	1.253f-l	1.260d-j	1.260a-d
Seher-6	1.260d-j	1.257e-k	1.267c-h	1.250g-m	1.257e-k	1.258b-f
Khirman	1.250g-m	1.243i-n	1.273c-f	1.237k-o	1.243i-n	1.249ghi
Zam-04	1.230mno	1.243i-n	1.240j-n	1.250g-m	1.240j–n	1.241j
Hashim-8	1.270c-g	1.270c-g	1.243i-n	1.297ab	1.260d-j	1.268a
GA-2002	1.250g-m	1.247h-n	1.253f-l	1.257e-k	1.257e-k	1.253d-g
Chakwal-97	1.280bcd	1.247h-n	1.257e-k	1.250g-m	1.263d-i	1.259b-e
Mean	1.254 ^{NS}	1.252	1.253	1.252	1.255	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
NS = Non-significant, $LSD_{0.05}$ for varieties = 0.007, $LSD_{0.05}$ for interaction = 0.016

Table-9. Allelopathic effects of leaf extracts on dry shoot weight (g) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap Water	
Dera-98	1.310 ^{NS}	1.253	1.270	1.277	1.300	1.282 ab
Pirsabak – 2008	1.240	1.250	1.257	1.273	1.260	1.256 bc
Saleem-2000	1.250	1.240	1.263	1.237	1.287	1.255 bc
Fakhr-e-Sarhad	1.240	1.280	1.270	1.263	1.290	1.269 abc
Bhakkar -2002	1.230	1.277	1.267	1.270	1.273	1.263 abc
Sindh-81	1.240	1.267	1.263	1.270	1.260	1.260 abc
Sarsabz	1.273	1.260	1.267	1.273	1.260	1.258 bc
Kiran-95	1.260	1.250	1.280	1.273	1.263	1.265 abc
Sassuai	1.310	1.283	1.273	1.267	1.270	1.281 ab
Mehran-89	1.260	1.313	1.270	1.277	1.317	1.287 a
Abadgar-93	1.260	1.250	1.260	1.270	1.283	1.265 abc
Moomal-2002	1.230	1.230	1.273	1.257	1.247	1.247 c
SKD-1	1.270	1.243	1.273	1.260	1.277	1.265 abc
Meraj-2006	1.230	1.263	1.290	1.253	1.273	1.262 abc
Seher-6	1.230	1.253	1.280	1.263	1.270	1.259 bc
Khirman	1.250	1.270	1.253	1.263	1.267	1.261 abc
Zam-04	1.250	1.273	1.260	1.253	1.283	1.264 abc

Hashim-8	1.270	1.260	1.263	1.293	1.273	1.272 abc
GA-2002	1.230	1.280	1.287	1.267	1.270	1.267 abc
Chakwal-97	1.250	1.277	1.270	1.267	1.270	1.267 abc
Mean	1.252 b	1.264 a	1.270 a	1.266 a	1.275 a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.011, $LSD_{0.05}$ for varieties = 0.022, NS = Non-significant

Table-10. Allelopathic effects of leaf extracts on fresh root weight (g) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	1.533a-n	1.590a-n	1.560a-n	1.587a-n	1.460g-n	1.546bc
Pirsabak-2008	1.730a-g	1.513b-n	1.610a-n	1.650a-l	1.570a-n	1.615abc
Saleem-2000	1.630a-n	1.517b-n	1.560a-n	1.387j-n	1.570a-n	1.533bc
Fakhr-e-Sarhad	1.570a-n	1.597a-n	1.667a-k	1.570a-n	1.650a-l	1.611abc
Bhakkar-2002	1.650a-l	1.660a-l	1.620a-n	1.553a-n	1.750a-g	1.647ab
Sindh-81	1.487e-n	1.403i-n	1.680a-j	1.713a-h	1.630a-n	1.583bc
Sarsabz	1.710a-h	1.597a-n	1.643a-m	1.547a-n	1.720a-h	1.643ab
Kiran-95	1.467f-n	1.470f-n	1.687a-i	1.333n	1.690a-i	1.529bc
Sassuai	1.503c-n	1.547a-n	1.677a-j	1.493d-n	1.780a-e	1.600bc
Mehran-89	1.797abc	1.760a-f	1.760a-f	1.533a-n	1.750a-g	1.720a
Abadgar-93	1.630a-n	1.563a-n	1.533a-n	1.560a-n	1.620a-n	1.581bc
Moomal-2002	1.430h-n	1.493d-n	1.470f-n	1.367lmn	1.730a-g	1.498c
SKD-1	1.597a-n	1.350mn	1.660a-l	1.377k-n	1.830a	1.563bc
Meraj-2006	1.703a-h	1.590a-n	1.583a-n	1.590a-n	1.730a-g	1.639ab
Seher-6	1.697a-i	1.510c-n	1.637a-m	1.470f-n	1.790a-d	1.621abc
Khirman	1.690a-i	1.513b-n	1.550a-n	1.553a-n	1.460g-n	1.553bc
Zam-04	1.623a-n	1.590a-n	1.607a-n	1.400i-n	1.660a-l	1.576bc
Hashim-8	1.673a-k	1.547a-n	1.533a-n	1.657a-l	1.510c-n	1.584bc
GA-2002	1.547a-n	1.593a-n	1.660a-l	1.457g-n	1.490e-n	1.549bc
Chakwal-97	1.657a-l	1.367lmn	1.810ab	1.487e-n	1.550a-n	1.574bc
Mean	1.616a	1.538b	1.625a	1.514b	1.647a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.050, $LSD_{0.05}$ for varieties = 0.101, $LSD_{0.05}$ for interaction = 0.227

Table-11. Allelopathic effects of leaf extracts on fresh root weight (g) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	1.573 ^{NS}	1.623	1.750	1.513	1.820	1.656b-e
Pirsabak-2008	1.740	1.617	1.807	1.590	1.730	1.697a-e
Saleem-2000	1.640	1.557	1.507	1.397	1.890	1.598de
Fakhr-e-Sarhad	1.683	1.643	1.840	1.653	1.690	1.702a-e
Bhakkar-2002	1.800	1.787	1.567	1.687	1.690	1.706a-e
Sindh-81	1.613	1.460	1.630	1.600	1.680	1.597de
Sarsabz	1.690	1.660	1.587	1.867	1.580	1.677a-e
Kiran-95	1.600	1.847	1.630	1.550	1.870	1.699a-e
Sassuai	1.777	1.587	1.823	1.640	1.690	1.703a-e
Mehran-89	1.813	1.693	1.990	1.600	1.960	1.703a-e
Abadgar-93	1.840	1.580	1.860	1.523	1.970	1.755a-d
Moomal-2002	1.557	1.550	1.733	1.630	1.560	1.606de
SKD-1	1.690	1.403	1.633	1.393	1.630	1.550e
Meraj-2006	1.650	1.903	1.810	1.607	1.790	1.752a-d
Seher-6	1.617	1.520	1.703	1.503	1.830	1.635cde
Khirman	1.680	1.610	1.680	1.640	1.600	1.642b-e
Zam-04	1.857	1.597	1.893	1.717	1.890	1.791abc
Hashim-8	1.933	1.600	2.080	1.740	1.740	1.845a
GA-2002	1.713	1.557	1.457	1.663	1.770	1.632cde
Chakwal-97	1.617	1.673	1.503	1.720	1.540	1.611de
Mean	1.704 a	1.623 b	1.724 a	1.612 b	1.753 a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.071, $LSD_{0.05}$ for varieties = 0.142, NS = Non-significant

Table-12. Allelopathic effects of leaf extracts on dry root weight (g) of wheat 14 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	1.270g-p	1.310d-m	1.293f-p	1.300e-o	1.250l-p	1.285bcd
Pirsabak-2008	1.307d-n	1.267h-p	1.330c-h	1.327c-i	1.250l-p	1.296abc
Saleem-2000	1.287f-p	1.263i-p	1.267h-p	1.257j-p	1.260j-p	1.267d
Fakhr-e-Sarhad	1.293f-p	1.307d-n	1.290f-p	1.297e-o	1.270g-p	1.291a-d
Bhakkar-2002	1.300e-o	1.313d-l	1.293f-p	1.297e-o	1.280g-p	1.297abc
Sindh-81	1.270g-p	1.260j-p	1.317d-k	1.333b-g	1.300e-o	1.296abc
Sarsabz	1.317d-k	1.293f-p	1.287f-p	1.290f-p	1.320c-j	1.301abc
Kiran-95	1.273g-p	1.273g-p	1.307d-n	1.250l-p	1.230p	1.267d
Sassuai	1.287f-p	1.290f-p	1.313d-l	1.280g-p	1.380bc	1.310ab
Mehran-89	1.330c-h	1.350b-f	1.317d-k	1.267h-p	1.320c-j	1.317a
Abadgar-93	1.297e-o	1.283g-p	1.280g-p	1.277g-p	1.260j-p	1.279cd
Moomal-2002	1.270g-p	1.257j-p	1.267h-p	1.247m-p	1.290f-p	1.266d
SKD-1	1.260j-p	1.243nop	1.297e-o	1.237op	1.390b	1.285bcd
Meraj-2006	1.307d-n	1.317d-k	1.300e-o	1.290f-p	1.290f-p	1.301abc
Seher-6	1.300e-o	1.260j-p	1.283g-p	1.277g-p	1.370bcd	1.29abc
Khirman	1.313d-l	1.273g-p	1.263i-p	1.283g-p	1.290f-p	1.285bcd

Zam-04	1.303e-n	1.283g-p	1.297e-o	1.257j-p	1.450a	1.318a
Hashim-8	1.307d-n	1.287f-p	1.270g-p	1.290f-p	1.360b-e	1.303abc
GA-2002	1.280g-p	1.287f-p	1.320c-j	1.257j-p	1.360b-e	1.301abc
Chakwal-97	1.300e-o	1.253k-p	1.320c-j	1.257j-p	1.380bc	1.302abc
Mean	1.293bc	1.283cd	1.296b	1.278d	1.315a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.011, $LSD_{0.05}$ for varieties = 0.022, $LSD_{0.05}$ for interaction = 0.050

Table-13. Allelopathic effects of leaf extracts on dry root weight (g) of wheat 21 days after germination

Varieties	Extracts					Mean
	Eucalyptus	Acacia	Sunflower	Congress grass	Tap water	
Dera-98	1.283e-k	1.317c-k	1.330c-j	1.297e-k	1.340b-i	1.313a-e
Pirsabak-2008	1.327c-j	1.297e-k	1.357b-f	1.280e-k	1.330c-j	1.318a-d
Saleem-2000	1.300e-k	1.283e-k	1.277e-k	1.257-k	1.370a-e	1.297b-f
Fakhr-e-Sarhad	1.307d-k	1.290e-k	1.313c-k	1.300e-k	1.310c-k	1.304a-f
Bhakkar-2002	1.337b-i	1.307d-k	1.257h-k	1.317c-k	1.270f-k	1.297b-f
Sindh-81	1.277e-k	1.250ijk	1.273f-k	1.287e-k	1.310c-k	1.279def
Sarsabz	1.327c-j	1.310c-k	1.290e-k	1.333b-j	1.300e-k	1.312a-e
Kiran-95	1.290e-k	1.343b-i	1.283e-k	1.273f-k	1.420ab	1.322abc
Sassuai	1.323c-k	1.277e-k	1.310c-k	1.300e-k	1.310c-k	1.304a-f
Mehran-89	1.317c-k	1.297e-k	1.353b-g	1.280e-k	1.440a	1.337a
Abadgar-93	1.293e-k	1.270f-k	1.337b-i	1.263f-k	1.400abc	1.313a-e
Moomal-2002	1.290e-k	1.273f-k	1.337b-i	1.293e-k	1.240jk	1.287c-f
SKD-1	1.290e-k	1.253ijk	1.290e-k	1.260g-k	1.300e-k	1.279ef
Meraj-2006	1.270f-k	1.353b-g	1.357b-f	1.323c-k	1.320c-k	1.325abc
Seher-6	1.287e-k	1.270f-k	1.310c-k	1.260g-k	1.230k	1.271f
Khirman	1.313c-k	1.277e-k	1.290e-k	1.297e-k	1.340b-i	1.303a-f
Zam-04	1.320c-k	1.280e-k	1.350b-h	1.293e-k	1.350b-h	1.319abc
Hashim-8	1.320c-k	1.270f-k	1.393a-d	1.333b-j	1.350b-h	1.333ab
GA-2002	1.300e-k	1.267f-k	1.263f-k	1.297e-k	1.340b-i	1.293c-f
Chakwal-97	1.267f-k	1.290e-k	1.270f-k	1.303d-k	1.300e-k	1.286c-f
Mean	1.302bc	1.289c	1.312b	1.292c	1.329a	

Means followed by different letter(s) in a column are statistically significant at α = 0.05
$LSD_{0.05}$ for extracts = 0.016, $LSD_{0.05}$ for varieties = 0.032, $LSD_{0.05}$ for interaction = 0.072

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