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Does Weeds-derived Smoke Improve Plant Growth of Wheat

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Abstract: Main cause of crops yield reduction in the world is the presence of weeds. Plant-derived smoke solution is well known for its promotry effect on plant growth. In the present study smoke solution derived from six different weeds *Asphodelus tenuifolius* (Cav.), *Avena sativa* (L.), *Galium tricornutum* (Dandy). *Parthenium hysterophurs* (L.), *Phalaris minor* (Retz.) and *Scandix pecten-veneris* (L.) were applied to find their effect on wheat seed germination, seedling vigor and seedling mass. It was observed that all the weeds-derived smoke solution significantly increased seed germination at 12, 24 and 36h at higher dilutions (1:1000, 1:3000, 1:5000 and 1:10000). Seedling length of wheat was also increased by *Asphodelus*, *Avena*, *Galium*, *Parthenium* and *Phalaris* at 1:1000, 1:3000 and 1:10000 dilutions. Similar effects were observed on seedling mass of wheat and increased at different dilutions by all weeds smoke solutions. Concentrated smoke solutions significantly inhibited plant growth of wheat. It might be concluded that effect of smoke solution is concentration dependent and it increases with the increase of smoke dilutions. It is also concluded that smoke solution application is environment friendly.

Key words: Smoke solutions, Plant growth, Seed germination, Seedling vigor, Weeds

Introduction

Weeds are undesirable plants which compete with main crops in the growth media for nutrients, moisture, space, light and hamper the healthy growth and ultimately reducing the growth and yield both qualitatively and quantitatively. It is because they exhibit allelopathic effect by releasing water- soluble allelochemicals from leaves, stems, roots, rhizomes, flowers, fruits and seeds (Batish et al., 2007). Therefore, suppression of weeds is important to minimize production losses to the major crops (Norris, 1982). It is also reported that some of the weeds specious

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stimulated seed germination and also the production of crops (Acciaresi and Asenjo, 2003).

In Pakistan, weeds pose a serious problem in crop production. Because of lack of education and financial resources, the smaller farmers cannot afford to remove them from their fields. Weeds growing among crop plants adversely affect yield and quality, resulting in high economic losses (Alam, 1991). Losses caused by weeds are well documented and reported that the weeds caused more loss to agriculture than all pests, put together (Roberts and Chancellor, 1980).

Stimulation of germination from the soil seed bank by the passage of fire is a well-known phenomenon and a number of different cues associated with fire itself, or with a post fire environment, have been identified as stimulant for germination (Paul et al., 2007). In the early 1990's, smoke was identified as an important germination tool than heat in post fire environments (De Lange and Boucher, 1990; Brown, 1993; Baldwin and Morse, 1994). It has been long established that plant-derived smoke promotes seed germination of a broad range of weed species (Daws et al., 2007), wild species (Keely and Fotheringham, 1998) and crop species (Van Staden et al., 2006).

Wheat (*Triticum aestivum* L.) is very important economic crop of Pakistan but it is seriously effecting by different type of weeds due to which per hector yield is much reduced.

It is common observation that weeds have negative effect on plant growth and yield but in this study smoke solution of six different weeds i.e Annual asphodel (*Asphodelus tenuifolius* Cav.), Oat (*Avena sativa* L.), rough fruit corn bedstraw *(Galium tricornutum* Dandy. Whitetop Weed (*Parthenium hysterophurs* L.), Canarygrass (*Phalaris minor* Retz.) and Shepherd's Needle (*Scandix pecten-veneris* L.) were applied on wheat seeds to study their effects on seed germination, seedling length and seedling mass.

Materials and Methods

Six different weeds (*Asphodelus tenuifolius* (Cav), *Avena sativa* L., *Galium tricornutum* Dandy. *Parthenium hysterophurs* L, *Phalaris minor* Retz. and *Scandix pecten-veneris* L.) were collected from wheat fields of district Karak.

Preparation of weeds-smoke solution

Smoke solutions of Asphodelus, Avena, Galium, Parthenium, Phalaris, and Scandix were prepared by burning 333g of plant material in burner by heater whose smoke bubble through 1 liter of distilled water with slight modification (Tieu et al., 2001). After making, the stock smoke solutions each weed was further diluted to 1:100, 1:500, 1:1000, 1:2000, 1:3000, 1:5000 and 1:10000 times.

Seed source

The whole research work was conducted on Wheat seeds (*Triticum aestivum* L. Var. KT 2000) obtained from Barani Agriculture Research Station, Kohat.

Pre-soaking of seeds

Seeds were pre-soaked in control, concentrated smoke solution and different dilutions of the weeds smoke solution i.e 1:100, 1:500, 1:1000, 1:3000, 1:5000, 1:10000 for nine (9) hours (Ahmad et al., 1998).

Germination experiments in petri plates

To find out effect of weeds-derived smoke solutions on seed germination and seedling vigor, seeds were germinated in 9cm Petri plates lined with two layers of filter paper (Whatman No.41) moistened with 2-3 ml of respective dilutions according to the requirement. Three replicates with 10 seeds in each replica were used in each experiment.

All the experiments were conducted at temperature of 25±3^{o} C for 10 days. The data for germination were taken after each 12h. After 10 days, the root, shoot length and fresh weight of the seedling were taken. The dry weights of seedling were taken after keeping them in oven for 24 h at 80-85^{o} C. The whole data was analyzed by One Way Analysis of Variance (ANOVA) at 5% of significance.

Results and Discussion

Effect of weeds-derived smoke solution on seed germination

It was observed that all the weeds-derived smoke solution significantly increased seed germination of wheat after 12h. It was found that 1:100, 1:500, 1:3000, 1:5000 and 1:10000 dilutions of *Asphodelus, Avena, Galium* and *Phalaris* significantly improved seed germination of wheat (Fig 1 A, B, C and E) respectively. 1:500 dilution of *Parthenium* (Fig. 1D) and 1:100, 1:3000, 1:5000s and 1:10000 dilutions of *Scandix* significantly increased seed germination of wheat after 12h (Fig. 1 F). These results are supported by (Drewes et al., 1995) who reported that high concentrations of smoke extracts are inhibitory to germination while lower concentration (1:1000 dilution) significantly increased seed germination compared to control. All the above results cleared that weeds-derived smoke solution increased seed germination of wheat. These results are also in accordance to the studies of Van Staden et al. (2000) who observed that smoke solution widely increased different plant seeds germination.

Same results were observed after 24h of the experiment. All dilutions of *Asphodelus, Avena, Parthenium* and *Phalaris* (Fig. 1 A, B, D and E) respectively, 1:500, 1:1000, 1:3000 and 1:5000 dilutions of *Galium* (Fig.1 C) significantly increased germination of wheat. Smoke is now widely recognized as a germination cue for fire-dependent as well as non fire-dependent plant species (Light et al., 2005). 1:500 and 1:3000 dilutions of (Fig. 1 E) and 1:500 and 1:1000, 1:3000, 1:5000 and 1:10000 dilutions of *Scandix* significantly increased seed germination of wheat after 24h (Fig. 1 F). It is also reported that seed imbibitions (1 and 2 h prior to smoke treatment) speed up the process of germination. It may due to the removal of germination inhibitors like ABA and phenolics during the transferal of imbibed seeds to new Petri dishes for smoke treatments (Hilhorst and Karssen, 1992; Bewley, 1997). Our results are supported by the report that many species from these fire-prone environments germinate in response to smoke treatments and several weed species, many from; non-fire prone regions, respond to various smoke treatments (Adkins and Peters, 2001).

It was found that 1:500, 1:5000 and 1:10000 dilutions of *Asphodelus*, 1:100, 1:1000, 1:3000 and 1:10000 dilutions of *Avena*, 1:500 dilution of *Galium*, 1:100, 1:500 and 1:3000 dilutions of *Parthenium*, 1:1000, 1:3000 dilutions of *Phalaris* and 1:100, 1:500, 1:1000 and 1:5000 dilutions of *Scandix* increased seed germination of wheat after 36h. Similar results were also observed by Brown and Van Staden (1997) and Tieu et al. (2001) that the ability for smoke to promote germination in a variety of plant species in South Africa, Australia, and North America. Jefferson et al. (2008) have also discovered that smoke also promotes the germination of a variety of tall-grass species in the mid west regions of North America. A positive germination response to smoke has also been extensively demonstrated for many species in Australia (Thomas et al., 2003). It was found that seed germination was inhibited by concentrated state of all weeds derived smoke solution

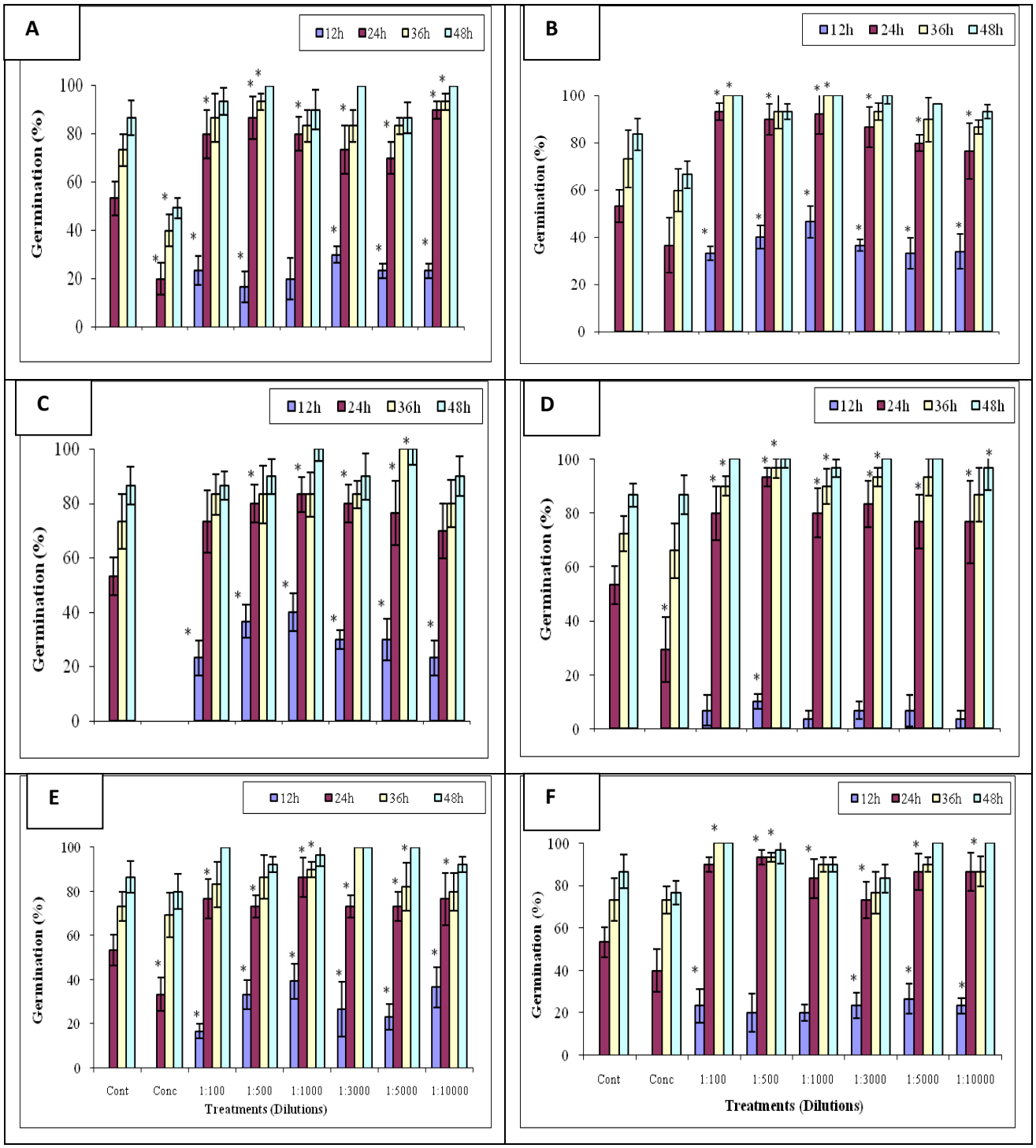

Fig. 1. Effect of *Asphodelus* (A), *Avena* (B), *Galium* (C), *Parthenium* (D), *Phalaris* (E) and *Scandix* (F) smoke dilutions (Conc. and different dilutions) on seed germination of wheat after 12, 24 and 36h. Seeds were incubated in the dark at room temperature for 10 days. Each data point shows mean of three replicates with 10 seeds in each replica. Vertical error bar (I) indicates standard deviation. Asterisk (*) represents significant difference of treatment with control. Legends represents time interval (h).

and these results are according to (Light et al., 2010) who recently reported a butenolide related compound named 3, 4, 5-trimethylfuran-2 (5H)-one, in having inhibitory effect on seed germination.

Seedling length (shoot and root) of wheat

After germination, effects of weeds-derived smoke solution were also observed on seedling length of wheat. It was found that 1:100, 1:1000, 1:5000 and 1:10000 dilutions of *Asphodelus* (Fig. 2 A), 1:500, 1:3000 and 1:10000 dilutions of *Avena* (Fig. 2 B), 1:3000, 1:5000 and 1:10000 dilutions of *Galium* (Fig. 2 C), 1:10000 dilution of *Parthenium* (Fig. 2 D), 1:5000 and 1:10000 dilutions of *Phalaris* (Fig. 2 E) and 1:100, 1:1000 and 1:10000 dilutions of *Scandix* significantly increased shoot length of wheat (Fig. 2 F). Modi (2004) also proved that smoke solution have promoting effect on maize kernels as compare to control. Different plant species like *Albuca pachylamys*, *Merwilla natalensis* and *Tlbaghia vilacea* showed good seedling vigor in response to smoke solution treatment. Thus, smoke treatments have the potential to improve not only the percentage germination but also the seedling vigour of commercially breed maize seeds (Sparg et al., 2006). Smoke and KAR1 treatments have the potential to improve not only the germination percentage but also the seedling vigour of many species. Regarding maize, this effect is more pronounced as smoke and KAR1 treatment results in a massive increase in post-germination growth and seedling vigour (Soos et al., 2009; Van Staden et al., 2006).

Root length of wheat was significantly increased by weeds-derived smoke solution at different dilutions as compare to control. It was found that 1:10000, 1:3000, 1:5000 and 1:10000 dilutions of *Asphodelus* (Fig. 2 A), 1:3000, 1:5000 and 1:10000 dilutions of *Avena* (Fig. 2 B) increased root length of wheat. These results are similar to the report that the use of smoke or aqueous extract of plant has positive and enhancing effect on seed germination as well as seedling vigor of different plants species (Sprag et al., 2005). 1:1000, 1:3000 and 1:5000 dilutions of *Galium* (Fig. 2 C), 1:500, 1:5000 and 1:10000 dilutions of *Parthenium* (Fig. 2 D) 1:3000, 1:5000 and 1:10000 dilutions of *Phalaris* (Fig. 2 E) and 1:100, 1:500, 1:1000 and 1:10000 dilutions of *Scandix* derived smoke solution significantly increased root length of wheat (Fig. 2 F). These findings are similar to the results of Baxter and Van Staden (1997) and Brown (1993) who proved that root and shoot length of *Themeda triandra* and *Erica* species grew vigorously when treated with plant-derived smoke solution. Sparg et al. (2005) also stated that although smoke treatment may not necessarily have an effect at the germination stage, it may play a role at the post germination stage and suggested that in previous studies where many species have not responded to smoke treatments, these species may show some response at their post-germination stages, i.e. improved seedling vigour.

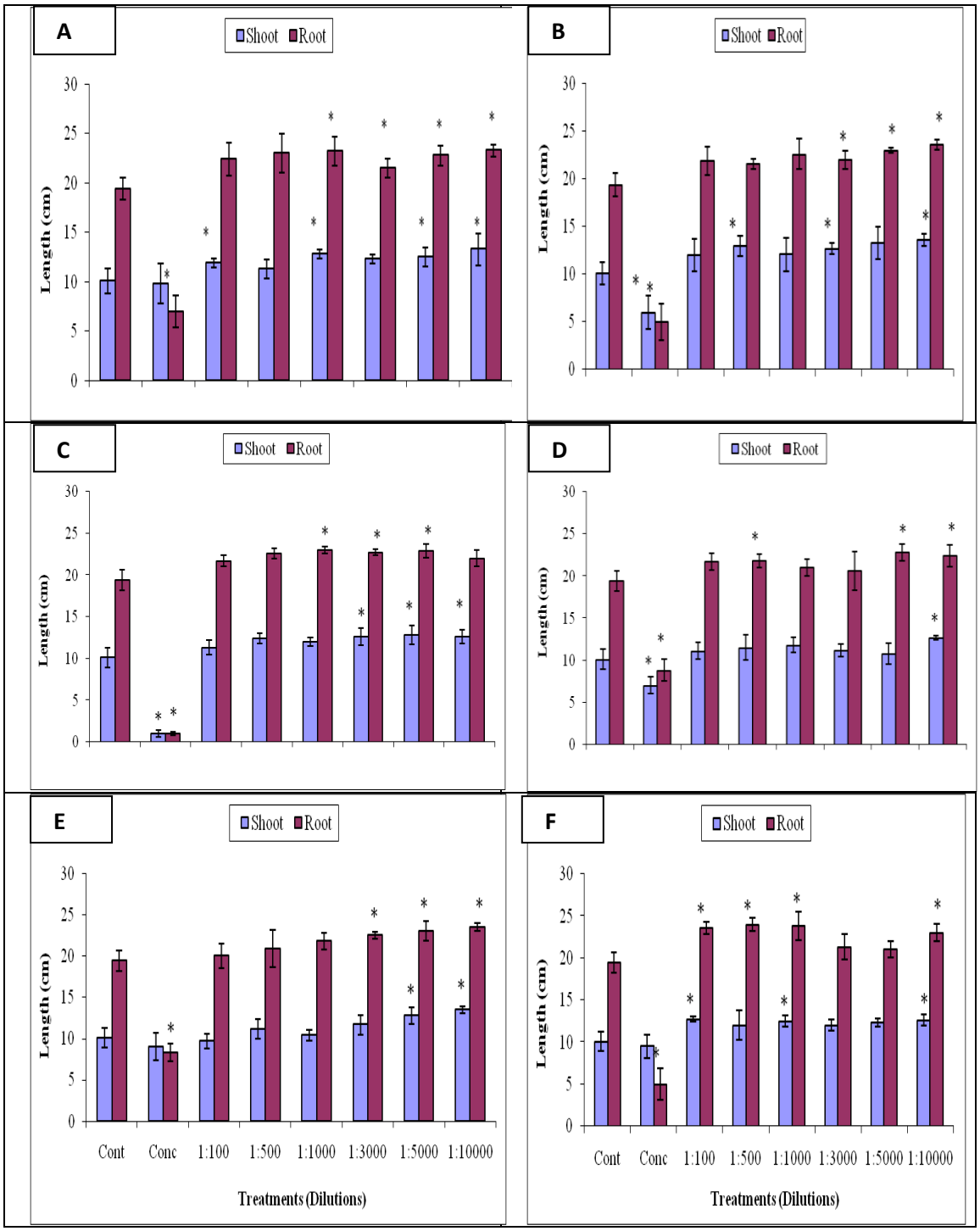

Fig. 2. Effect of different smoke *Asphodelus* (A), *Avena* (B), *Galium* (C), *Parthenium* (D), *Phalaris* (E) and *Scandix* (F) dilutions (Conc. and different dilutions) on shoot and root length of wheat after 10 days. Vertical error bar (I) indicates standard deviation. Asterisk (*) represents significant difference of treatment with control. Legends represent shoot and root.

Seedling mass (shoot and root fresh and dry) of wheat

Different weeds-derived smoke solutions shown significant effect on fresh and dry weight of wheat root and shoot. 1:5000 dilutions of *Asphodelus* (Fig. 3 A), 1:5000 and 1:10000 dilutions of *Avena* (Fig. 3 B), 1:100 and 1:1000 dilution of *Galium* (Fig. 3 C), 1:100 and 1:1000 dilution of *Parthenium* (Fig. 3 D), 1:10000 dilution of *Phalaris* (Fig. 3 E), 1:1000 and 1:10000 dilutions of *Scandix* (Fig. 3 F) showed promotry effect on fresh mass of wheat root after 10 days. Similar phenomena were observed on dry mass of root (Fig. 3. A, B, C, D, E and F).

It was noted that shoot fresh and dry weight were also significantly affected. 1:1000, 1:3000 and 1:10000 dilution of *Asphodelus* (Fig. 4 A), 1,100, 1:1000 and 1:10000 dilution of *Avena* (Fig. 4 B), 1:10000 dilution of *Galium* (Fig. 4 C), 1,100, 1,3000, 1:5000 and 1:10000 dilution of *Parthenium* (Fig. 4 D), 1:100 and 1:10000 dilution of *Phalaris* (Fig. 4 E) and 1:5000 and 1:10000 dilution of *Scandix* (Fig. 4 F) significantly increased fresh weight of wheat shoot. Blank and Young (1998) found that in some species including *Festuca idahoensis* exposure to smoke increases leaf production and root mass. This study is also supported by (Kulkarni et al., 2006) who investigated that plant derived smoke solutions greatly increase fresh and dry weight of maize. Our results are similar to the report that smoke can considerably increase seedling vigour and dry mass in the MV5405 maize inbred line (Sparg et al., 2006).

It was found that concentrated weeds-derived smoke solutions have inhibitory effect on fresh and dry weight of wheat root and shoot. Modi (2002) investigated that when maize kernels are treated with smoke then it produces more vigorous seedlings (Heavier and Taller). It was found that concentrated smoke solution have inhibitory effect on fresh weight of root and shoot.

Conclusion

As smoke solution shows dual regulation that is both inhibitory in high concentration and promotery in low concentration. Plant showed responses in a different way at seed germination root and shoot growth stages to smoke solution. It is concluded from the present results that wheat seed germination, seedling length and biomass was positively affected by weeds derived smoke solution, furthermore results imply that smoke is a good growth promoter and it can be used as an agent for bio-fertilizers.

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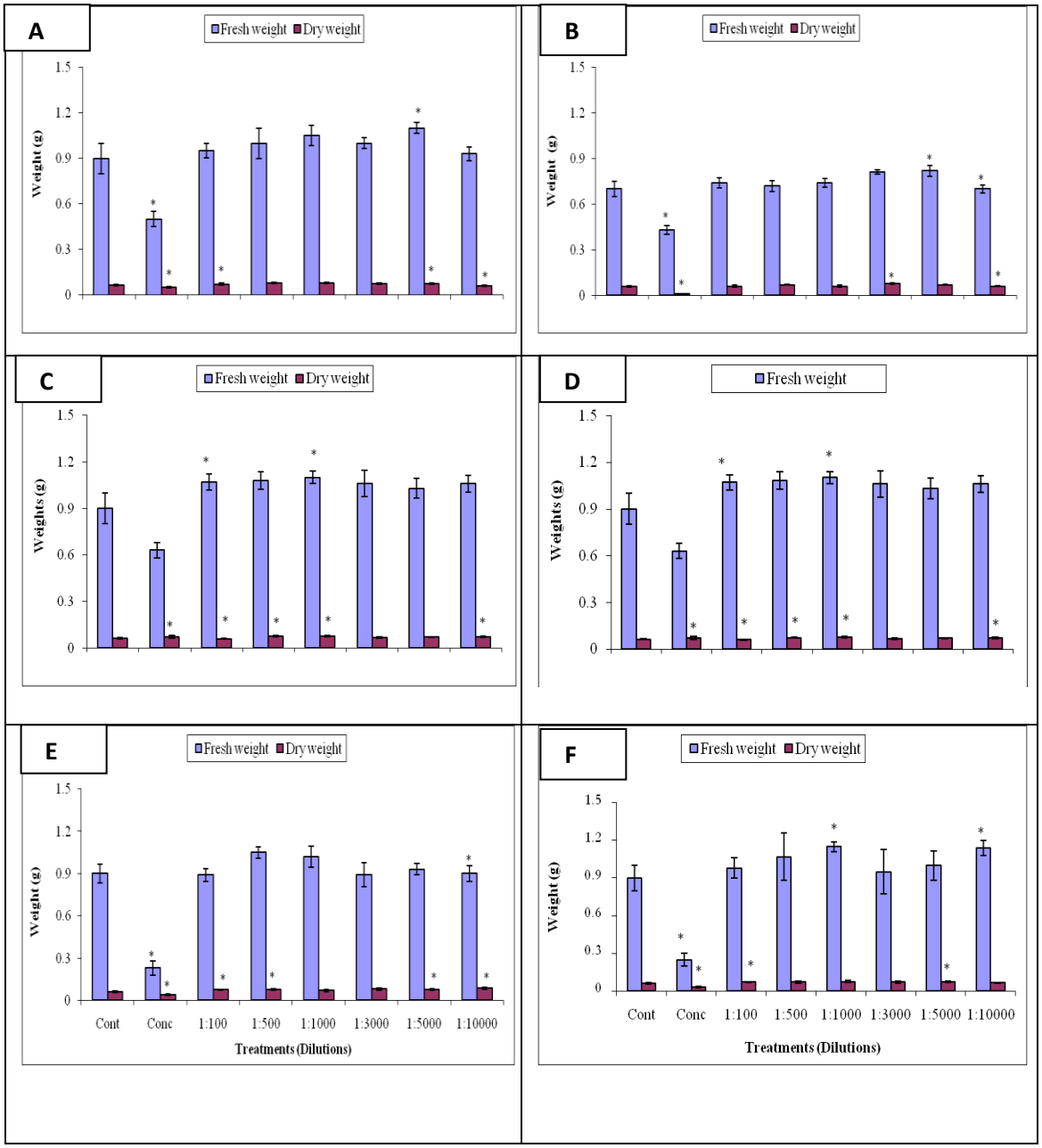

Fig. 3. Effect of different smoke *Asphodelus* (A), *Avena* (B), *Galium* (C), *Parthenium* (D), *Phalaris* (E) and *Scandix* (F) dilutions (Conc. and different dilutions) on root fresh and dry weight of wheat after 10 days. Vertical error bar (I) indicates standard deviation. Asterisk (*) represents significant difference of treatment with control. Legends represent shoot and root.

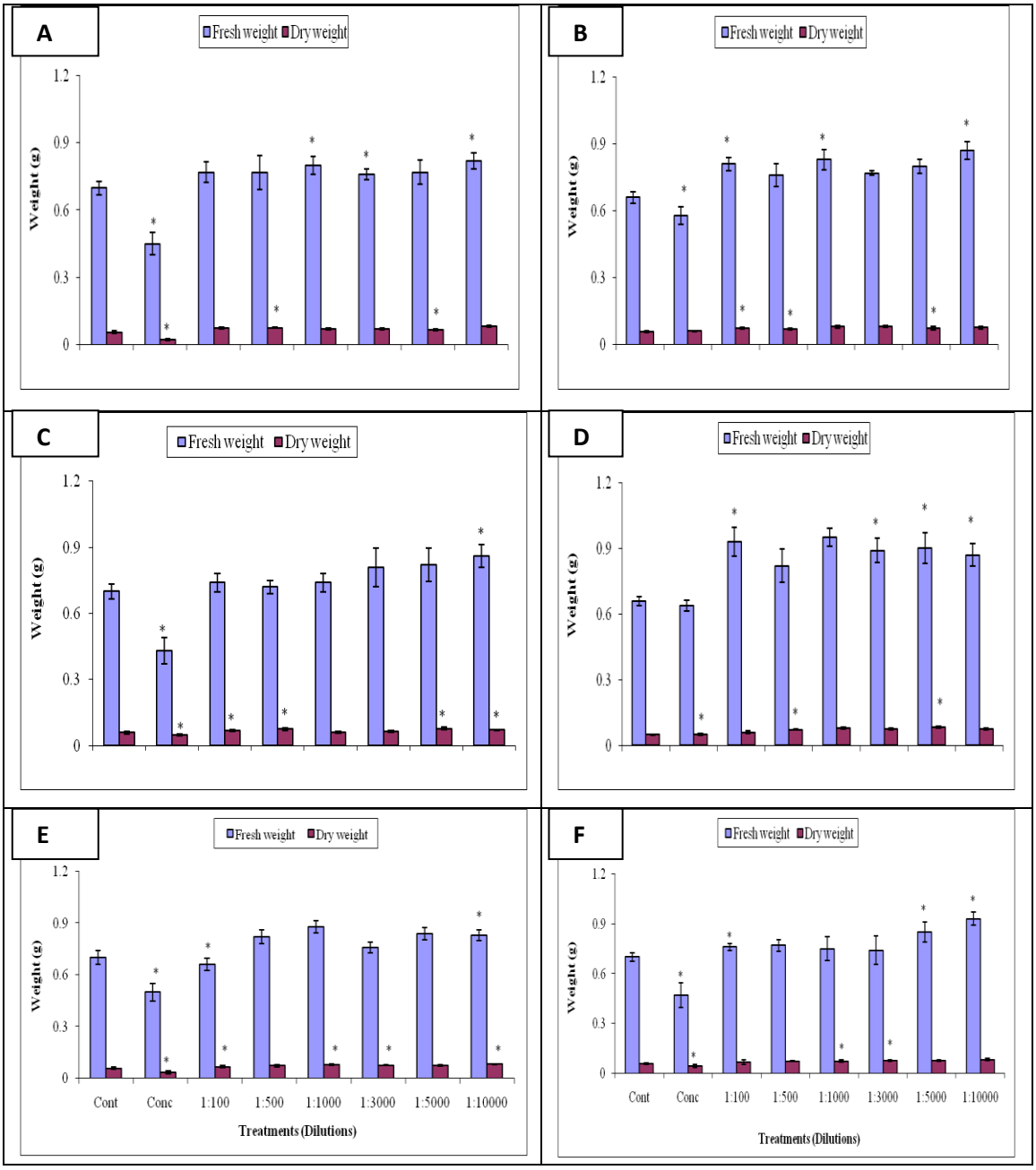

Fig.4. Effect of different smoke *Asphodelus* (A), *Avena* (B), *Galium* (C), *Parthenium* (D), *Phalaris* (E) and *Scandix* (F)-derived smoke dilutions (Conc. and different dilutions) on shoot fresh and dry weight of wheat after 10 days. Vertical error bar (I) indicates standard deviation. Asterisk (*) represents significant difference of treatment with control. Legends represent shoot and root.

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