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ALLELOPATHIC EFFECT OF *PARTHENIUM HYSTEROPHORUS* EXTRACT ON SEED GERMINATION AND SEEDLING GROWTH OF SELECTED PLANTS

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Abstract

The present study was performed to investigate the allelopathic effect of *Parthenium hysterophorus* aqueous extract on seed germination and seedling growth of selected eight plants *viz. Allium sativum* L. (Garlic), *Brassica campestris* L. (Mustard), *Coriandrum sativum* L. (Coriander), *Cucumis sativus* L. (Cucumber), *Eruca sativa* Mill. (Taramira), *Solanum lycopersicum* L. (Tomato), *Trifolium pratense* L. (Clover), and *Triticum aestivum* L. (Wheat). Leaf aqueous extracts of *P. hysterophorus* at 0%, 25%, 50%, 75% and 100% were applied to examine their effects under pot culture. The experiment was laid down in a completely randomized design using two replicates. The result revealed that the aqueous leaf extract of *P. hysterophorus* significantly reduced the germination and suppresses the growth parameters of tested species. The highest inhibitory effects of leaf extracts were observed in *T. repens*, *E. sativa* and *A. sativum* (except 25%), while a maximum deleterious effects were recorded at higher concentration. The seed germination of *B. campestris, C. sativus*, *C. sativum,* and *S. lycopersicum* was less inhibited at 50% and 75%, while an this concentration, a stimulatory effect was recorded in *T. aestivum.* It was concluded that *P. hysterophorus* aqueous leaf extract had allelopathic effects on seed germination and seedling growth of the tested crops.

Key words: Allelopathic effect, Growth parameter, Inhibited, Leaf extract, *Parthenium hysterophorus, Triticum aestivum*.

Introduction

Parthenium hysterophorus L. is a annual herbaceous alien invasive weed and considered now as major threats to native species and ecosystems worldwide (Kathiresanm, 2004; Singh, 2005). Invasive species are matter of concern because of their fast spreading capability, change soil properties are the major factors that affect plant community structure and diversity (Zavaleta, 2000; Hejda & Pysek, 2006). Regarding to the effects of invasive species, there are few reports that the invasive species effect on species composition, soil properties and diversity (Chacon *et al.*, 2008). The effects on species composition and soil properties study are significant because both can influence each other.

P. hysterophorus (locally known as Altamisa, carrot grass, bitter weed, congress grass or *Gajar Ghans*) belong to the family Asteraceae. This weed can grow up to 30-150 cm tall and produce up to 10,000 to 26,000 seeds (Nguyen *et al*., 2010). It is native to tropical and sub-tropical Americas, was unintentionally introduced into many countries, mainly Asia, Africa, Europe, Americas and Australia and United Arab Emirates (Mahmoud *et al*., 2015). Probably through in Pakistan, it was reported in the 1980s in Gujrat district (Rao, 1956), and then rapidly spread throughout the Province of Punjab, Islamabad Capital Territory (ICT) and Khyber Pukhtunkhwa Province (Khan *et al*., 2014). Presently *Parthenium* weed are found in abandoned agricultural land, tank bunds, waste lands, along roadsides, natural areas (Chitwan National Park and the World Natural Heritage site) (Hassan & Amin, 2009; Khan *et al*., 2014). The most common effects of the allelochemicals on the plant are reduction in percent germination and rate of germination, reduction in root or/ and stem length injuring of the root tips, lack of chlorophyll, boost seminal root, decline dry matter accumulation, increased sterility in crop (Bhadoria, 2011). *P. hysterophorus* can also affect crop production, animal husbandry as well as human health and ecosystems in its area of infestation (Nadeem *et al*., 2005; Shabbir & Bajwa, 2006). Effect of *parthenium* extracts on seed germination and seedling growth inhibition of many crops have been reported in Wheat (*Triticum aestivum* L.) (Naeem *et al*., 2012), *Cicer arietinum*, *Glycine max* (Rana *et al*., 2021), *Abelmoschus esculentus* L. (Akbar *et al*., 2021), *Brassica campestris* (Hassan *et al*., 2018), and maize (Rashid *et al*., 2008). Utilization of allelopathic properties of allelopathic plant species offers promising opportunities for sustainable weed management (Lorenzo *et al*., 2013).

To observe and investigate the effect of *P. hysterophorus* leaf extract on seed germination and seedling growth, we selected eight plants *viz. Allium sativum* L. (Garlic), *Brassica campestris* L. (Mustard), *Coriandrum sativum* L. (Coriander), *Cucumis sativus* L. (Cucumber), *Eruca sativa* Mill. (Taramira), *Solanum lycopersicum* L. (Tomato), *Trifolium pratense* L. (Clover), and *Triticum aestivum* L. (Wheat). Keeping in view the importance of the allelopathic potential of *P. hysterophorus*, pot experiment was conducted with the following objectives: 1) to investigate the allelopathic effect of *Parthenium* aqueous leaf extract on seed germination among tested crops ii) to quantify the allelopathic effect of *Parthenium* extract on the growth and development of crops.

Material and Methods

Experimental site and plant materials: Pot experiments were conducted to investigate the effect of *Parthenium hysterophorus* (L.) on seed germination and seedling growth of selected eight plants, at the laboratory of Biotechnology Department, University of Malakand, Lower Dir (Khyber PakhtunKhwa) Pakistan in 2017-2018.

The tested eight crop plants *viz. Allium sativum* L. (Garlic), *Brassica campestris* L. (Mustard), *Coriandrum sativum* L. (Coriander), *Cucumis sativus* L. (Cucumber), *Eruca sativa* Mill. (Taramira), *Solanum lycopersicum* L. (Tomato), *Trifolium pratense* L. (Clover), and *Triticum aestivum* L. (Wheat), were purchased locally from Chakdara, Pakistan. The healthy seeds were surface sterilized with sodium hypochlorite (5%) for 2-3 min, and then washed several times with sterile distilled water for 2-3 min.

Preparation of *Parthenium hysterophorus* aqueous extract: The plants grown naturally around the university campus in Ramora, Lower Dir (Khyber PakhtunKhwa, Pakistan), were collected in December 2017. The plant material was brought into the laboratory and then washed and dried in shade for about one month. The dried leaves were separated from stems and ground well in mechanical grinder. Twenty, 50, 75 and 100 g of ground plant materials were weighted and soaked in 100 ml of distilled water separately and mixed well by rotator shaker. After 24 h of soaking at room temperature (21-22°C), extracts were collected by sieving through sterilized cotton or muslin cloth. The stock solution was stored at 4°C until further use.

Pot experiment and treatments: The experiment was laid down in a Completely Randomized Design (CRD) with factorial arrangement and two replications and kept under growth chamber (Temperature: 27 ± 3°C; Relative humidity: 50 ± 5% and photoperiod: 12-h light/12-h dark). The aqueous leaves extract at different concentrations (0, 25, 50, 75 and 100%) each applied once on eight tested crop plants. The concentration of control (0%) was used for comparison. Ten seeds except garlic (which were 4) were planted in plastic pots (90 mm in diameter, DC 10p Model) filled with soils, and latter thinned to five plants per pot. The seeds were soaked in their respective concentration for 24 hours before sowing and later, and then were watered with the respective concentration (10 ml). The experiment was terminated 35 days after planting and the experiment was repeated once.

Measurement of morphological parameters: During the period of germination, the germinated (number of seedlings with visible shoot and root growth) were examined daily after planting. The rate of germination was calculated by the methodology used by Maguire (1962). After germination, the shoot length per plants (cm), number of leaves per plant, the fresh and dry biomass per plant were recorded daily using a graduated scale and an electronic balance. In addition, water content was also calculated by subtracting the dry biomass from fresh biomass of each plant.

Statistical analysis

Thirty five days after planting, data on germinated and nongerminated seeds (number of seedling with visible shoot and neither shoot), shoot length (cm), leaves (number), fresh and dry biomass (g) and water contents (g) were recorded. The averages obtained from the experiments were subjected to ANOVA using PAST software (Hammer *et al*., 2001). Least Significance Difference was tested for all the means at $p<0.01$.

Results

Effect of *P. hysterophorus* aqueous leaf extract on *Brassica campestris*: The result revealed that seed germination of *B. campestris* germination was found to be decreased with the increasing concentration of *P. hysterophorus* extract. Furthermore, there was a slightly stimulatory effect of *Parthenium* extract at 25% on seed germination, while at higher concentration, less inhibitory effect was recorded.

Statistical analysis revealed that *Parthenium* extracts significantly decreased the growth parameters of *B. campestris.* Shoot length of *B. campestris* was gradually decreased with increased concentration of *P. hysterophorus* extract. After control treatment, maximum shoot length of 6.25 cm was found at 25%, while increasing the concentration of *parthenium* extracts beyond the minimum dose, shoot length was decreased significantly. A maximum leaf number of 74 were recorded at 25%, while minimum was observed at higher concentration. Both fresh and dry biomass were decreased with increasing concentration of *P. hysterophorus* extract. The lowest fresh biomass value of 2 g and dry biomass value of 0.4 g were recorded at higher concentration (100%). The highest water content value of 5.8 g was recorded at 0% and lowest value of 1.6 were recorded at higher concentration 100%. The effect of Parthenium extracts on seed germination and growth parameters are illustrated in (Fig. 1).

Effect of *P. hysterophorus* aqueous leaf extract on *Coriandrum sativum:* Seed germination of *C. sativum* was found to be decreased with increased concentration of all the five aqueous extracts when compared to control. In addition, there was a slightly stimulatory effect of *Parthenium* extract at 25 % on seed germination, while at higher concentration, less inhibitory effect was recorded.

Statistical analysis revealed that *Parthenium* extracts decreased the growth parameters of *C. sativum.* Shoot length was gradually decreased with the increased of *P. hysterophorus* extract concentration. After control treatment, maximum shoot length of 7 cm was found at 25%, while minimum shoot length of 5. 25 cm was recorded at 100%. The highest leaves value of 40 was observed in control (0%), while the number of leaves was seriously inhibited at higher concentration. Both fresh and dry biomass were decreased as concentration of *P. hysterophorus* extract increased. The minimum fresh biomass value of 0.5 g and dry biomass value of 0.7 g were recorded at 100%, while maximum fresh biomass value of 1.8 g and dry biomass value of 0.28 g were recored at 0% and 25%. The extract concentration gradually decreased water content of *C. Sativum* as the concentration of extract increased. The highest water content value of 1.58 g was recorded at 0%, and 25%, while lowest water content value of 0.46 was recorded at 100% (Fig. 2).

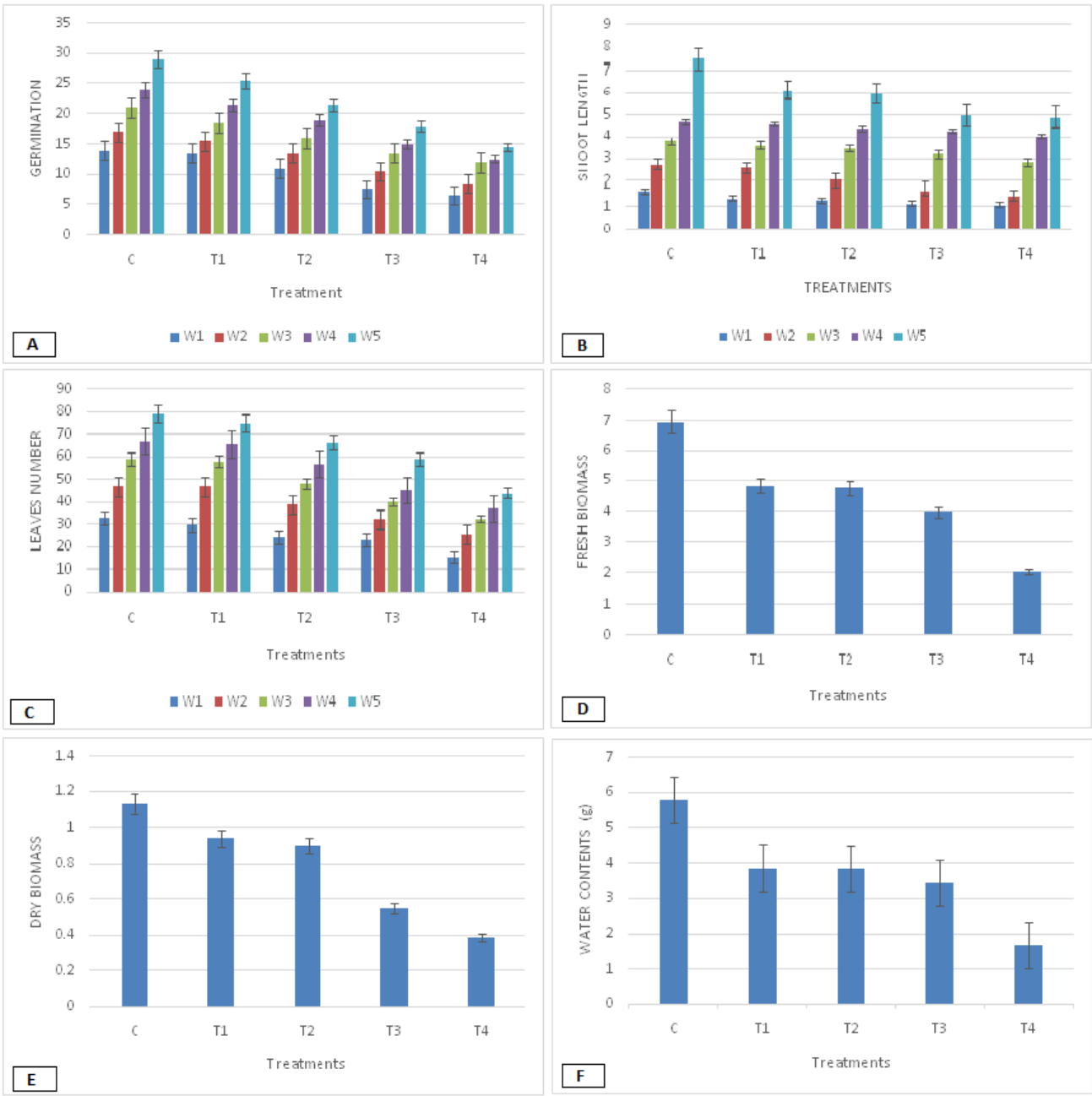

Fig. 1. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *B. campestris*. A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Effect of *P. hysterophorus* aqueous leaf extract on *Cucumis sativus*: The result revealed that *C. sativus* germination was significantly decreased with increasing concentration of *P. hysterophorus* extract. Furthermore, there was stimulatory effect of *Parthenium* extract at 25%, and 50% on seed germination, while at higher concentration, less inhibitory effect was recorded.

Statistical analysis revealed that *Parthenium* extracts significantly decreased the growth parameters of *C. sativus*. Shoot length of *C. Sativus* was gradually decreased as *P. hysterophorus* extract concentration was increased. After control, the highest shoot length of 3.6 cm was found at 25%, while minimum shoot length of 2.45 cm was recorded at 100 %. The maximum value of leaves (23 leaves) was observed at control, while inhibitory effect was recorded at higher concentration. Both fresh and dry biomass were decreased as concentration of *P. hysterophorus* extract increased. The maximum fresh biomass value of 18 g and dry biomass value of 1.3 g were recorded at control (0%), while at higher concentration the fresh and dry biomass were significantly decreased. The extract concentration gradually decreased water content when the extract concentration was increased. The highest water content value of 17 g was recorded at control 0%, and 25%, while lowest water content value of 0.6 was recorded at 100% (Fig. 3).

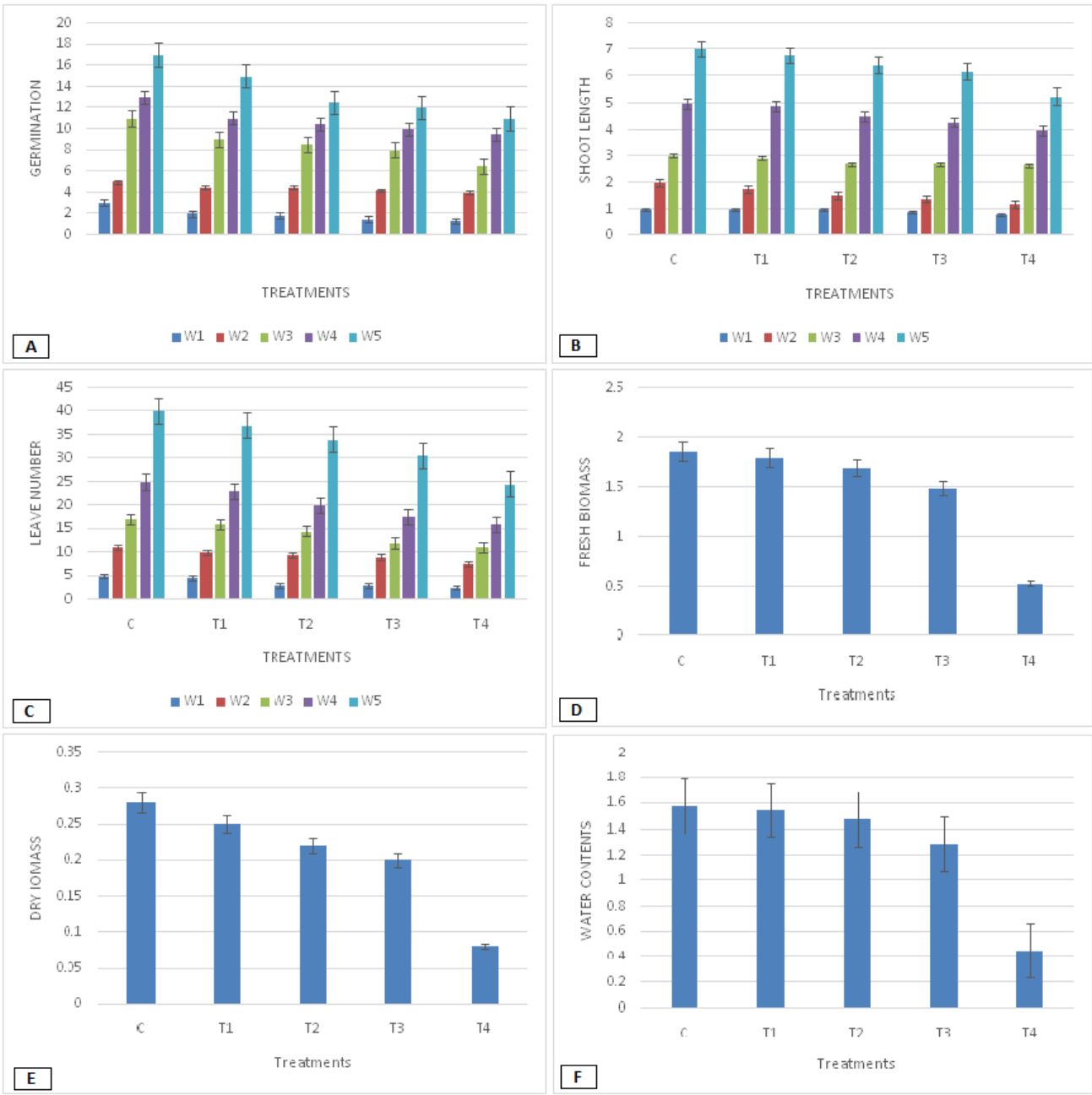

Fig. 2. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *C. sativum.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Effect of *P. hysterophorus* aqueous leaf extract on *Solanum lycopersicum*: The result revealed that *S. lycopersicum* germination was decreased with increasing concentration of *P. hysterophorus* extract. In addition, there was stimulatory effect of *Parthenium* extract at 25%, 50% and 75% on seed germination, while at higher concentration, less inhibitory effect was recorded.

Statistical analysis revealed that *Parthenium* extracts slightly decreased the growth parameters of *S. lycopersicum.* Shoot length of *S. lycopersicum* was gradually decreased with the increased concentration of *P. hysterophorus* extract. The maximum value of shoot length of 5.9 cm and 5.6 cm were found at 0% and 25%, while the minimum value of shoot length of 3.1 cm was recorded at 100%. In addition, the highest number of leaves (51 leaves) was recorded at 0%, while inhibitory effect was observed at higher concentration. Both fresh and dry biomass were decreased as concentration of *P. hysterophorus* extract increased. The maximum fresh biomass value of 3.6 g and dry biomass value of 0. 34 g were recorded at control (0%), while at higher concentration the fresh and dry biomass were significantly decreased. The extract concentration also decreased water content as the extract concentration increased. The highest water content value of 3.4 g was recorded at 0%, while lowest water content value of 1.5 g was recorded at 100% (Fig. 4).

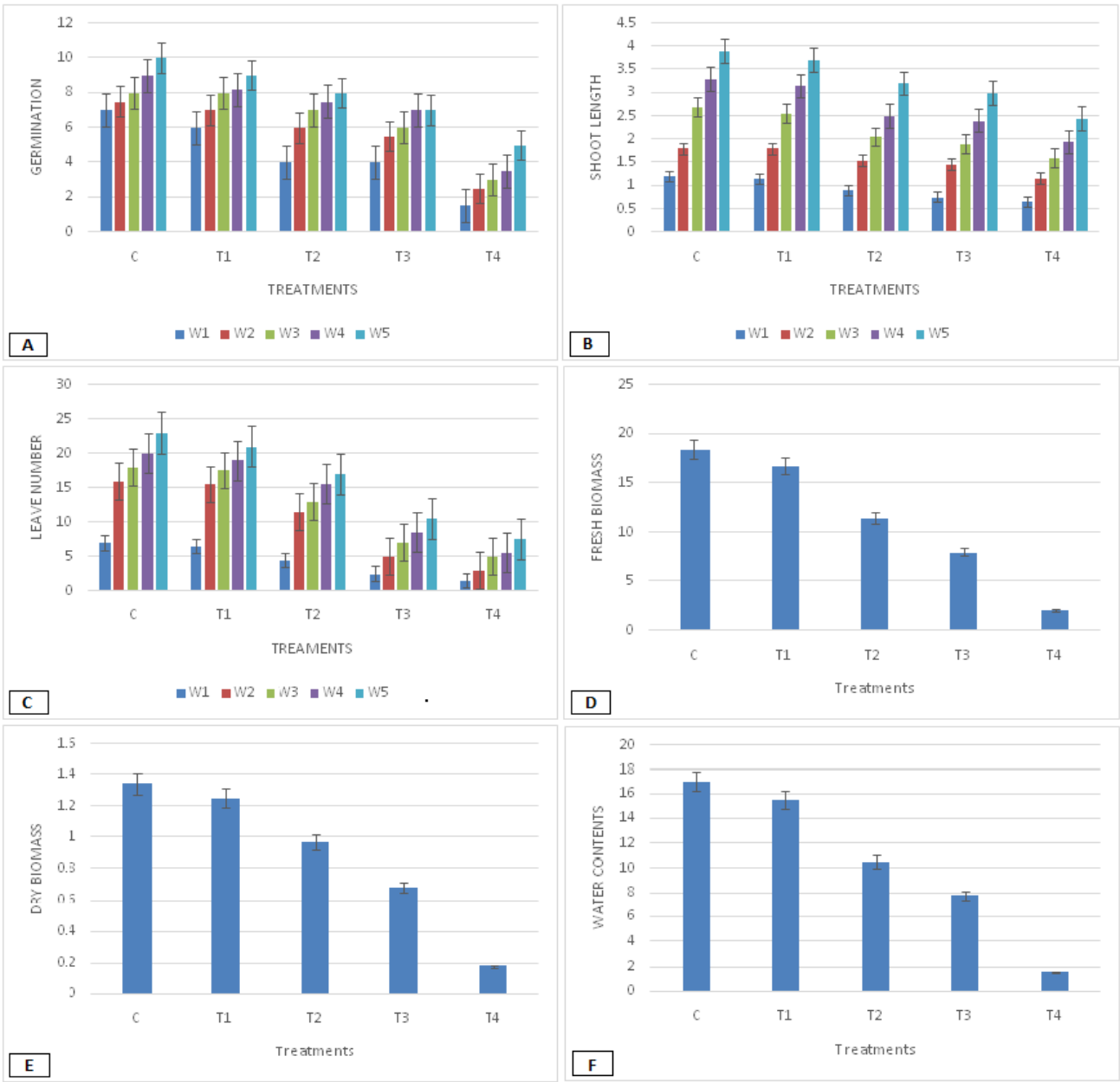

Fig. 3. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *C. sativus.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Effect of *P. hysterophorus* aqueous leaf extract on *Triticum aestivum*: The result revealed the stimulatory effect at all the concentrations of *P. hysterophorus* extract.

Statistical analysis revealed that *Parthenium* extracts did not not affect the growth parameters of *T. aestivum.* The maximum shoot length of 22.9 cm was found at 0%, whereas the minimum value of 16.65 cm was recorded at 100%. The highest number of 75 leaves was recoreded at 0%, while the minimum number of 38 leaves was recorded at 100%. The maximum fresh and dry biomass was observed at 0%, while the minimum fresh and dry biomass was found at 100%. The extract concentration gradually decreased water content of *T. aestivum* as the concentration of extract increased. The highest water content value of 7 g was recorded at 0%, 25% and 50%, while inhibitory effect was recorded at higher concentration (Fig. 5).

Effect of *Parthenium hysterophorus* aqueous leaf extract on *Allium sativum*: The result revealed that seed germination of *A. sativum* was strongly inhibited at all the concentrations of *P. hysterophorus* extract, except 25%. Statistical analysis revealed that *Parthenium* extracts significantly decreased the growth parameters of *A. sativum.* Shoot length was gradually decreased as *P. hysterophorus* extract concentration increased. The maximum shoot length of 17 cm and the highest value of 7 leaves in number were recorded at 0 %, while strong inhibitory effect was observed at higher concentrations. Both fresh and dry biomass was decreased with the increase of *P. hysterophorus* extract concentration. The maximum fresh biomass value of 26 g, and dry biomass value of 16 g were recorded at 0 %, while at higher concentration the fresh and dry biomass was decreased. The extract concentration gradually decreased water content as the extract concentration increased. The

highest water content value of 10 g was recorded at 0 %, while lowest water content value of 6.5 g was recorded at 100 % (Fig. 6).

Effect of *P. hysterophorus* aqueous leaf extract on *Eruca sativa*: The result revealed that germination of *E. sativa* was strongly inhibited at all concentrations of *P. hysterophorus* extract, except 25 %.

Statistical analysis revealed that *Parthenium* extracts were significantly decreased the growth parameters of *E. sativa.* Shoot length was gradually decreased with increasing of *P. hysterophorus* extract concentrations. The maximum shoot length of 3.8 cm and the highest number of leaves value (14 leaves) were recorded at 0 %, while strong inhibitory effect was observed at higher concentrations. Both fresh and dry biomass was decreased as concentration of *P. hysterophorus* extract increased. The maximum fresh biomass value of 0.75 g, and dry biomass value of 0.1 g were recorded at 0 %, while at higher concentration the fresh and dry biomass were decreased. The extract concentration gradually decreased water content as the extract concentration increased. The highest water content value of 0.65 g was recorded at 0 %, while lowest water content value 0.2 g was recorded at 50 % (Fig. 7).

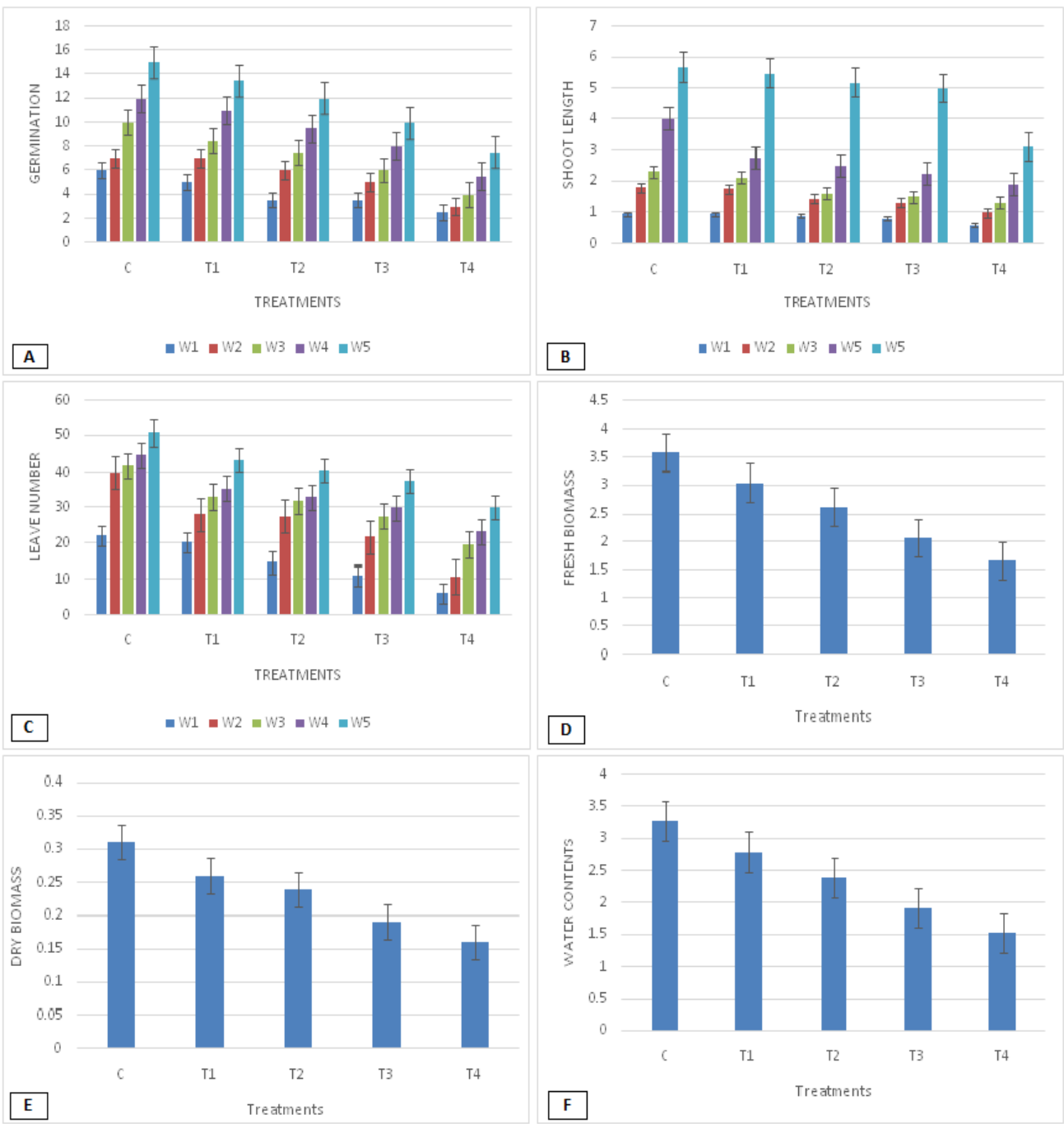

Fig. 4. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *S. lycopersicum.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

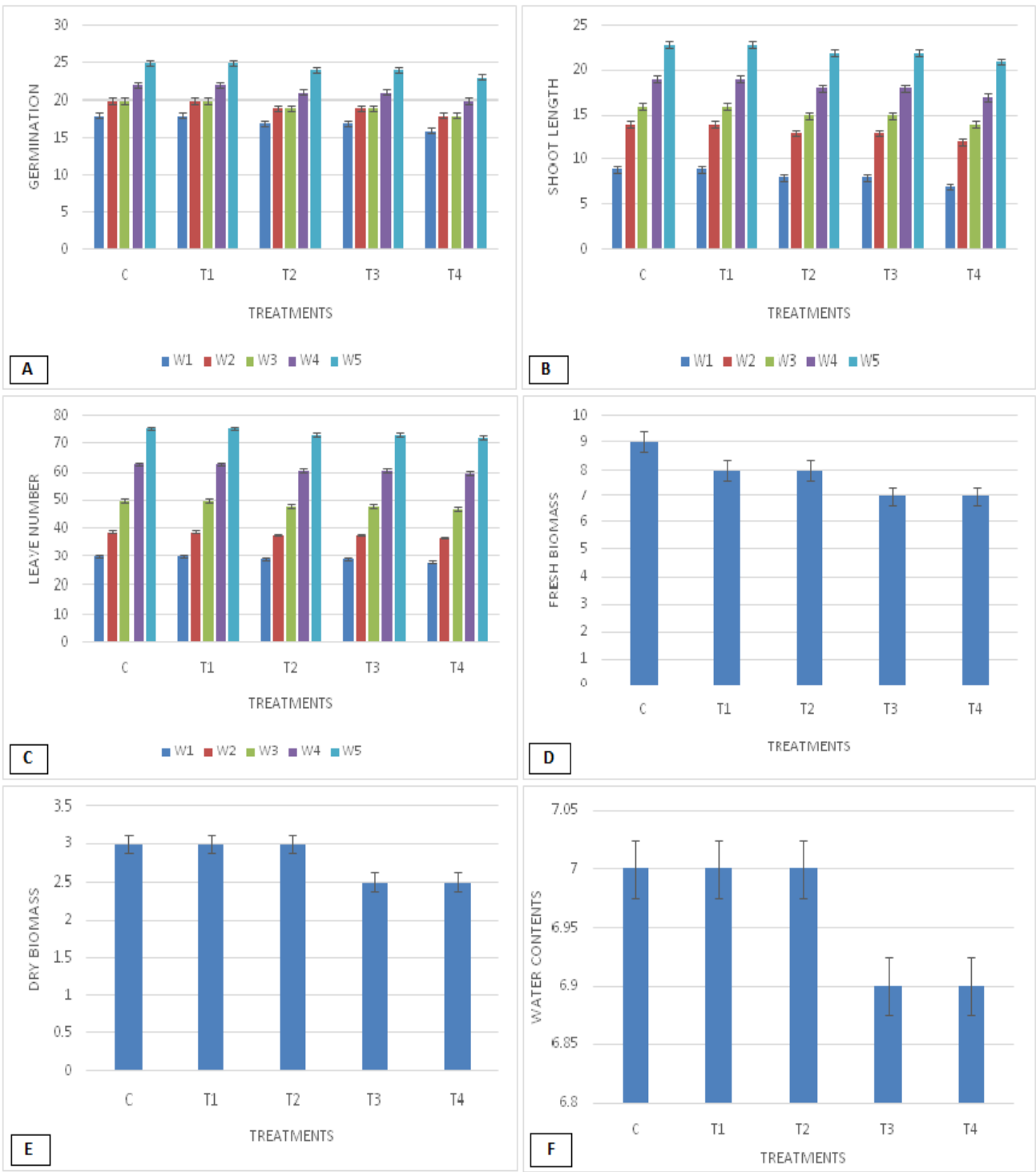

Fig. 5. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *T. aestivum*. A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Effect of *P. hysterophorus* aqueous leaf extract on *Trifolium pratense*: The result revealed that germination of *T. pratense* was strongly inhibited at all concentrations of *P. hysterophorus* extract.

Statistical analysis revealed that *Parthenium* extracts significantly decreased the growth parameters of *T. pratense.* The maximum shoot length of 7.5 cm and the highest value of 8 leaves in number were recorded at 0 %, while strong inhibitory effect at higher concentration was observed. Both fresh and dry biomass was decreased as the concentrations of *P. hysterophorus* extract increased. The maximum fresh biomass value of 0.4 g, and dry biomass value of 0.11 g were recorded at 0 %, while were strongly inhibited at higher concentration. The extract concentration gradually decreased on water content as the extract concentration increased. The highest water content value of 0.34 g was recorded at 0 %, while strongly inhibited with increasing concentrations (Fig. 8).

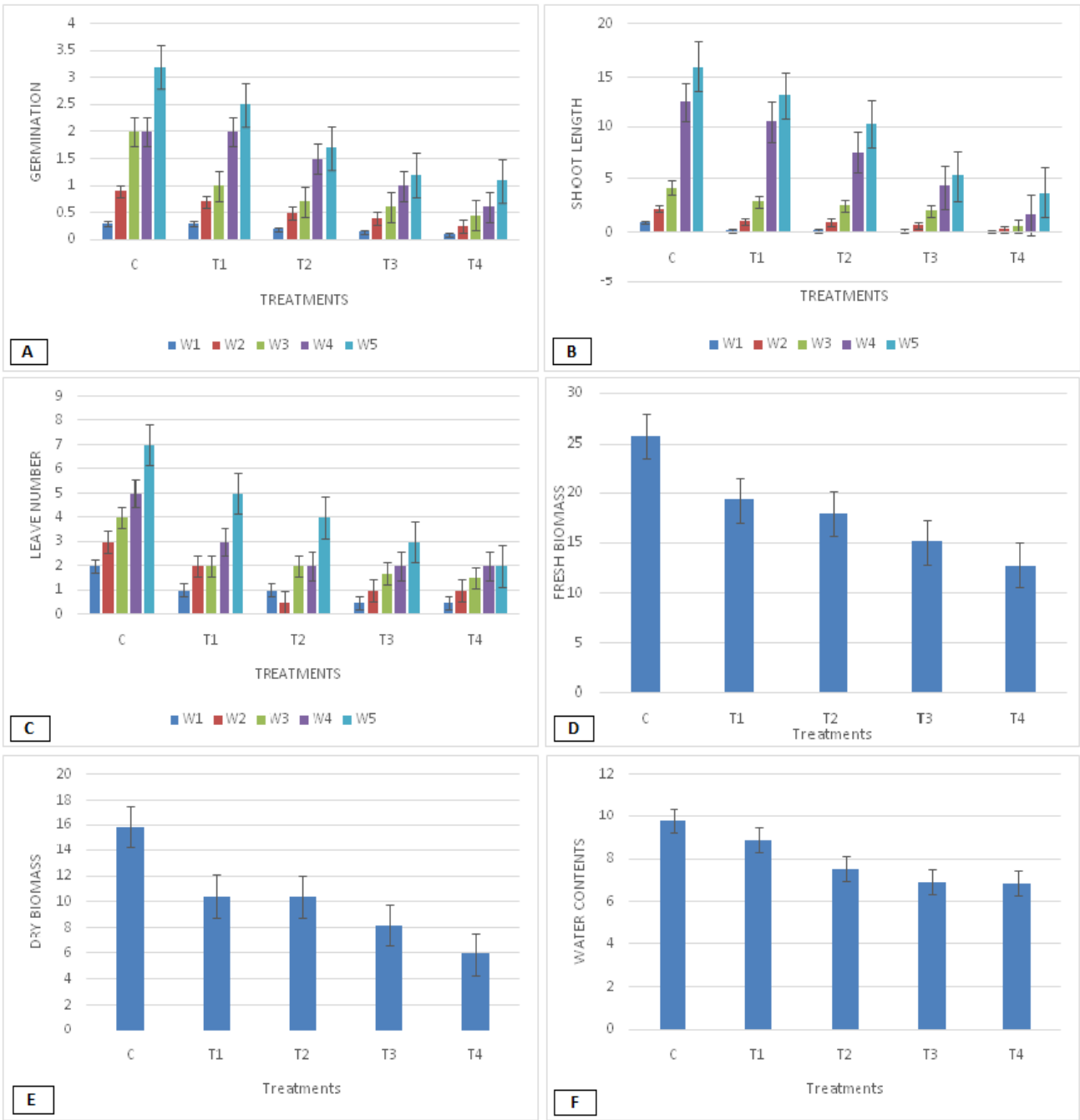

Fig. 6. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *A. sativum.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Discussion

Parthenium hysterophorus has a negative allelopathic effect on the reduction of plant growth, seed germination and reproduction of the other plant community which results in crops reduction. The biochemical study showed that *P. hysterophorus* was highly dangerous for crops as well as the species involved in crop reduction by invading cultivated land as well as non-cultivated land (Vishal *et al*., 2016). *P. hysterophorus* has the ability of rapid spreading which results in the reduction of crop growth rate (Aslam *et al*., 2014; Dafallah *et al*., 2019; Hassan *et al*., 2018; Safdar *et al*., 2014).

In present study, *P. hysterophorus* extract was found to inhibit significantly the seed germination and growth parameters of selected tested plants. *A. sativum, E. sativa* and *T. pratense* were found that showed complete inhibition of seed germination and growth parameters above 25% concentration. Inhibitory effects on selected species were found to be comparatively greater as compared to other tested species. There was slightly inhibitory effects of *P. hysterophorus* extract on the seed germination of *B. campestris*, *C. sativus*, *C. sativum* and *S. lycopersicum*, these plant were less inhibited at higher concentrations of *P. hysterophorus* extract. Similar observations were reported in *P. hysterophorus* extract

concentration on *Brassica* species (Singh *et al*., 2005), wheat (Muhammad & Majeed 2014, Jabeen *et al*., 2013) and *C. sativus* (Hridya and Rajendiran, 2013). Oudhia and Tripathi (2001) reported a significant effect of *Parthenium* extracts on the seed germination and growth of *S. lycopersicum.* Allelochemicals present in the leaf extracts prevented the embryo growth, embryo development and causing of death. Furthermore, these allelochemicals released from *P. hysterophorus* was found to inhibit the growth of vegetables, pasture grasses, cereals, other reported weeds, and even trees (Gnanavel, 2013). It suppress the neighbouring species through the release of allelochemicals from root exudates and decomposing biomass (Gniazowska and Bagatek, 2005; Khaliq *et al*., 2016). Numerous studies reported the negative allelopathic effect of *P. hysterophorus* extract on associated species such as *Eragrostis curvula*, *Echinochloa crusgalli*, *Lactuca sativa* and *Eragrostis tef* (Belz *et al*., 2007), *Ageratina adenophora* and *Artemisia dubia* (Maharjan *et al*., 2007), *Triticum aestivum* (Hassan *et al*., 2018), and canola (Khaliq *et al*., 2016). The present study revealed that wheat had stimulatory effects to *P. hysterophorus* extract at higher concentrations, whereas *A. sativum*, *E. sativa* and *T. pratense* were more sensitive to leaf extracts of *P. hysterophorus*.

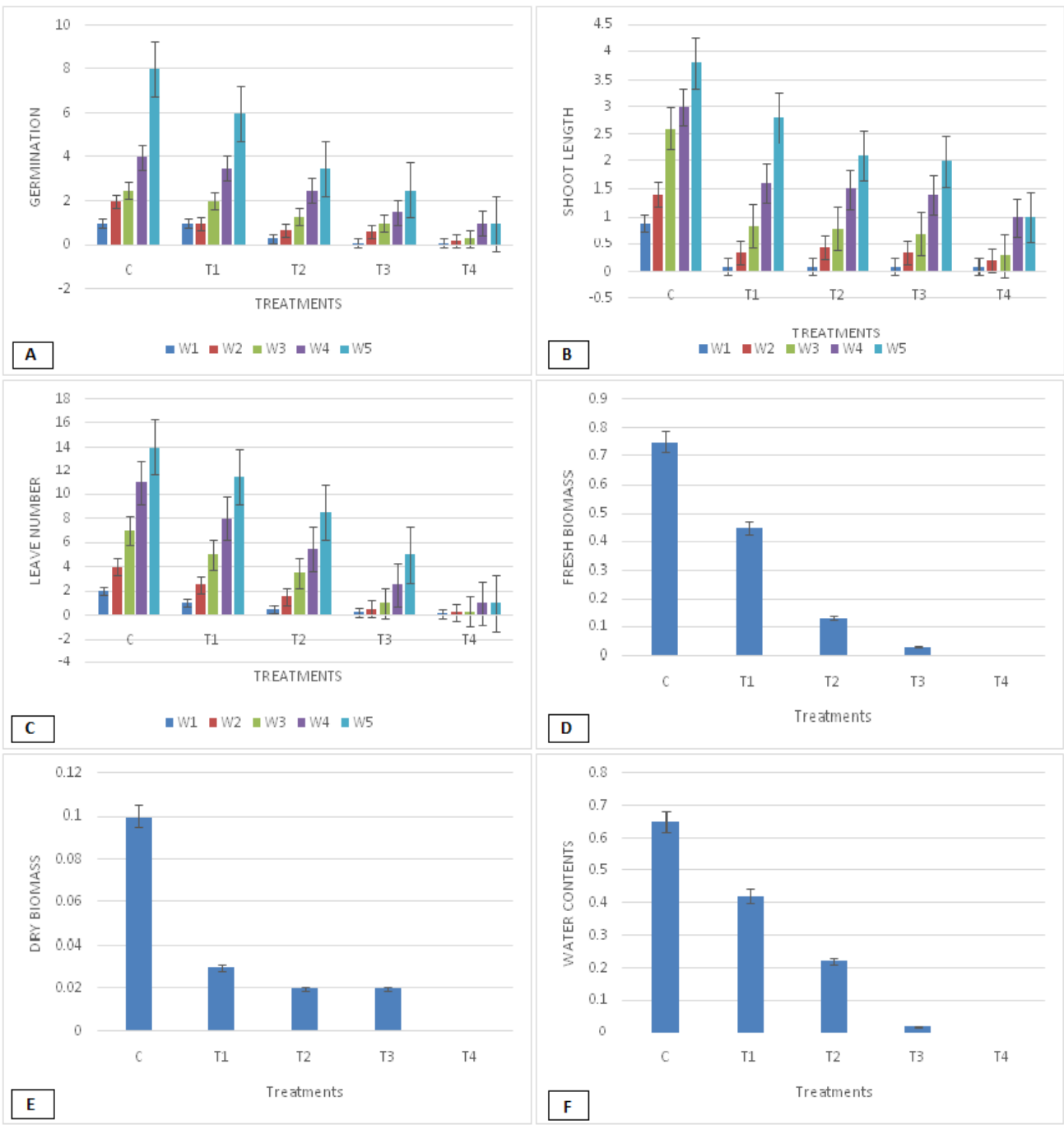

Fig. 7. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *E. sativa.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

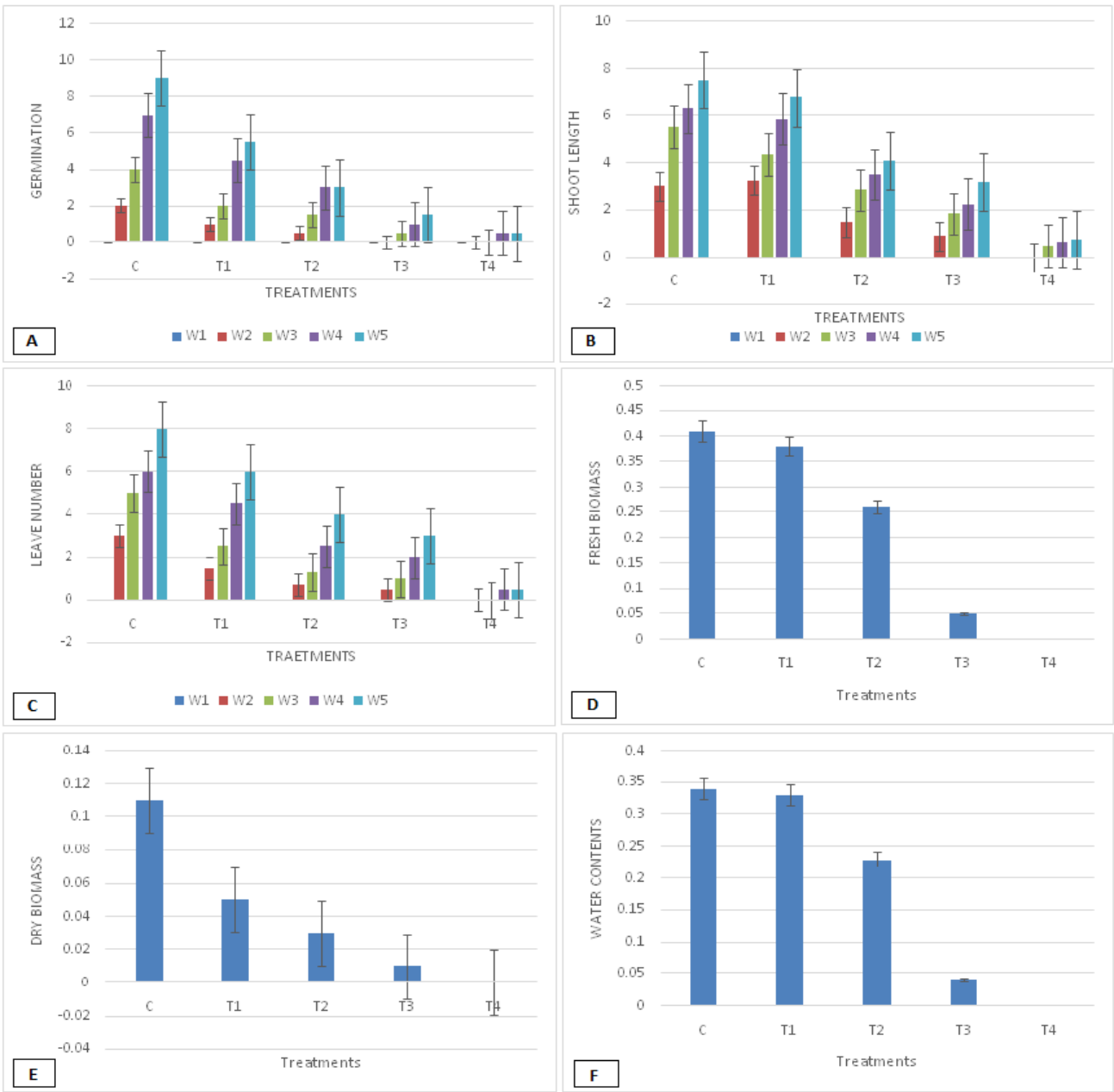

Fig. 8. Effect of different concentrations of *P. hysterophorus* extracts on different parameters of *T. pratense.* A) Germination, B) Shoot Length, C) Leaves number, D) Fresh Biomass, E) Dry Biomass, F) Water contens. W indicates week, C represent control and T indicate treatment: 25%, 50%, 75% and 100%.

Conclusions and Recommendations

In the present investigation, it is concluded that *Parthenium hysterophorus* has strong allopathethic effects on the tested species under pot culture. All the concentrations of aqueous leaf extract strongly inhibited the seed germination and growth parameters of *A. sativum, E. sativa* and *T. pratense*. Wheat was found to be fully resistant to the adverse effects of *P. hysterophorus.* It is recommended that further research is necessary to investigate the allopathic effect of *P. hysterophorus* on the seed germination and growth in various others crop plants. Further investigations are needed to stop the fast spreading of *P. hysterophorus* weed and introducing of plant species which can show half or fully resistance to *P. hysterophorus*. *P. hysterophorus* can only be effectively managed by developing alternative approach involving combination of many options like slightly use of effective herbicides, biological control agents and cultural practices.

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