Pak. J. Weed Sci. Res. 19(1): 15-29, 2013

COMPARATIVE ALLELOPATHIC POTENTIAL OF *Fumaria indica* L. AND *Polygonum plebejum* L. AGAINST FIELD CROPS

Raza Ullah[1], Asif Tanveer[*], Abdul Khaliq and Sajid Hussain

ABSTRACT

The comparative allelopathic potential of *Fumaria indica* L. and *Polygonum plebejum* L. leaf, stem, root, fruit and whole plant aqueous extracts was evaluated on germination and seedling growth of *Triticum aestivum* L., *Cicer arietinum* L., *Lens culinaris* Medic. and *Brasica napus* L. in laboratory condition. Germination and seedling growth of *T. aestivum, C. arietinum*, *L. culinaris* was significantly reduced by the leaf extract of *F. indica* and *P. plebejum*. But germination and seedling growth of *Brasica napus* was completely inhibited by the leaf extract of *F. indica*. The degree of sensitvity of different crops in respect of germination was canola > chickpea > lentil > wheat. The degree of germination inhibition of different *F. indica* and *P. plebejum* plant parts can be classified in order of leaf extract > root extract > fruit extract > stem and whole plant extract in wheat; leaf extract > root extract and stem extract > fruit extract and whole plant extract in chickpea; leaf extract > root extract > stem extract > fruit and whole plant extract in lentil and leaf extract > root extract and stem extract > fruit extract and whole plant extract in canola. Inhibitorier effect was observed with *F. indica* than *P. plebejum*. It was due to more phenolics in *F. indica* leaves (13091.12 mg kg^{-1}) as compared to those of *P. plebejum* (8131.49 mg kg^{-1}). Chromatographic analysis reveled presence of six phytotoxins, viz., ferulic acid, *m*-coumaric, syringic acid, caffeic acid, gallic acid and 4-Hydroxy-3-Methoxybenzoic acid in aqueous leaf (1:10) fraction of *F. indica*. Ferulic acid, syringic acid, caffeic acid and vanillic acid were recorded in aqueous leaf extract of *P. plebejum.*

Key words: Allelopathy, *Brasica napus, Cicer arietinum*, *Fumaria indica,* germination, *Lens culinaris, Polygonum plebejum*, seedling growth, *Triticum aestivum.*

INTRODUCTION

Weeds compete with the crops for different environmental resources and either inhibit or stimulate the crop growth by releasing substances (allelochemicals) into the growing environment (Alam and Islam, 2002). Inhibitory or stimulatory effect of weeds on growth of crops depends upon the concentration of allelochemicals, which inhibit the growth of some crops at certain concentrations, may stimulate the

[1]Department of Agronomy, University of Agriculture, Faisalabad-38040.
*Corresponding author's email: drasiftanveeruaf@hotmail.com

growth of same or different crops at lower concentrations (Narwal, 2004). The chemicals involved in allelopathic interactions are present in virtually all plant parts including leaves, stems, fruits, roots, rhizomes, buds and seeds (Alam *et al*., 2001; Weston and Duke, 2003; Qin *et al.,* 2006; Rudrappa *et al*., 2007).

Different weed species differ widely in their ability to produce allelopathic effects (Hamayun *et al*., 2005). Different parts of same weed also differ in their ability to produce allelopathic effects on germination and growth of crop plants. Some parts are more inhibitory than others (Ferguson and Rathinasabapathi, 2003; Tanveer *et al*., 2008). A number of studies have shown that allelochemicals release into the soil from residues of weeds, thus affecting the growth of crop plants (Qasem and Foy, 2001; Kobayashi, 2004; Kong *et al*., 2006; Kumar *et al*., 2009). Furthermore, many allelopathic plants incorporated in soil are known to inhibit the growth of other plants (Rajashekhara *et al.,* 2007).

Fumaria indica L. (Fumitory) and *Polygonum plebejum* L. (Knotweed) are common weeds in Pakistan. *Fumaria* is a genus of 50 species of annual plants, native to Europe, Africa and Asia, most diverse in the Mediterranean region, and introduced to North and South America and Australia. *Polygonum* is a genus of 300 species and is disseminated all over the world. It has been identified in Afghanistan, Pakistan, India, Bangladesh, Nepal, Tropical East Africa, Madagascar, Bhutan extending to Australia through Indonesia and Malaysia.

Fumaria indica contains the alkaloids fuyuziphine and alpha-hydrastine (Pandey *et al.,* 2008). These weeds emerge in November and invade winter crops and vegetables, such as wheat, lentil, chickpea and canola. Weeds allelopathy against wheat, canola, lentil and chickpea crops have been reported in the text (Shukla *et al.,* 2003; Mishra *et al.,* 2004; Kadioglue *et al.,* 2005) but no study has yet been conducted on allelopathy of *P. plebejum* and *F. indica* on wheat, lentil, chickpea and canola crops. Therefore, the present study has been planned with the objectives (a) to explore the allelopathic effects of whole plant and different plant parts i.e. stem, leaves, fruits and roots of *F. indica* and *P. plebejum* on seed germination and seedling growth of wheat, lentil, chickpea and canola. (b)to compare the allelopathic potential of *F. indica* and *P. plebejum* against aforesaid field crops.

MATERIALS AND METHEDS

Laboratory experiments were conducted during 2011-12 to investigate the comparative allelopathic potential of *Fumaria indica* L. and *Polygonum plebejum* L. against field crops. The study comprised two weed species viz., *F. indica* and *P. plebejum* with diferent (stem, leaf, root, fruit and whole plant) extracts on four test crops namely wheat, chickpea, lentil and canola.

Plants of fully mature weed species were collected during winter season 2010-11 from the Agronomic Research Area, University of Agriculture, Faisalabad, (31.25° N latitude, 73.09° E longitude, 184 m above sea level). The plants were kept for drying under shade till complete drying was ensured. After drying, plant parts i.e. roots, stems, leaves and fruits were separated and small pieces were made with the help of a scissor. These pieces were put in oven for 24 hours at 70°C.

The dried pieces of plant parts and whole dried plants were put in distilled water separately in the ratio of 1:20 (w/v) at room temperature for 24 hours. The extract of whole plant and different parts of plant were obtained by filtering water through sieve and then through Minisart non-pyrogenic 0.45 µm filters. The extracts were collected in separate bottles and tagged. The extract obtained after filtering was used for study.

The experiment was carried out by following complete randomized design (CRD) with factorial arrangement with four replications. The twenty seeds of each test crop were placed evenly between two layers of Whatman # 42 filter paper in sterilized Petri dishes of 9 cm diameter separately for each crop. At start of experiment 5 ml of each extract was applied in every Petri dish, separately according to nature of treatment. The aqueous leaf extract of both the weed species was used for phenolic determination as it showed more inhibitory effect.

The peaks were detected by UV detector. Standards of suspected phytotoxins (Aldrich, St Louis, USA) were run similarly for identification and quantification. Standards of phenolics were prepared in different concentrations. Furoic, coumaric, syringic and caffeic acids were identified by their retention time with authentic standards.

Observations on germination (%), mean germination time (days), seedling vigour index were calculated by equations/formulas viz., Official Seed Analysis (1990), Ellis and Roberts (1981) and Abdul-baki and Anderson (1973), respectively. Shoot and root length of all the seedlings from each replication were measured with measuring tape and dried separately at 70°C till constant weight. The completely dried samples were weighed and dry weight of different plant parts was expressed in mg per plant.

Data were recorded up to fourteen days and then analyzed statistically by using the Fisher's Analysis of Variance procedure and least significant difference (LSD) at 5% probability was used to compare the treatment's means (Steel *et al.,* 1997).

Table 1. HPLC conditions for determination of phytotoxins in aqueous *F. indica* and *P. plebejum* leaf extracts

Parameter	Characteristic
Column dimensions	25 cm length ×4.6 mm diameter, particle size of 5 µm
Diatomite	Supleco wax 10
Attenuation	0.01ppm
Rate of recorder	10 mm min^{-1}
Detector	SPD-10A vp-detector
Detection	UV,280 nm
Flow rate	0.25 ml min^{-1}
Volume injection sample	50 µl
Type of Column	Shim-pack CLC-Octadecyl Silicate (ODS) (C-18)
Mobile phase	Isocrartic;100% methanol
Temperature	25 °C

RESULTS AND DISCUSSION

Seed germination

The interactive effect of weed species (*F. indica* and *P. plebejum*) and their plant part extracts on seed germination of different test crops (wheat, chickpea, lentil and canola) is presented in Fig.1. Aqueous extracts from different plant parts of both the weed species significantly reduced seed germination of all test crops compared with distilled water (Control). The minimum germination value of wheat (70.50%), chickpea (55.25%) and lentil (64.75%) was observed in leaf extract of *F. indica* followed by *P. plebejum* (Fig. 1a, 1b and 1c). But in canola crop seed germination was completely inhibited by leaf extract of *F. indica* (Fig. 1d).

The differential inhibitory effect of weed species could be attributed to different phenolics identified. The observations are in confirmaty with the findings of Oudhia (2001) who reported that leaf extract of *Parthenium hysterophorus* had an inhibitory effect on seed germination of wheat. Similarly, Maharjan *et al*. (2007) has also found leaf extract of parthenium the inhibitoriest to the seed germination of wheat and other crops.

Mean germination time

The water extract of plant organs (stem, leaf, root, fruit and whole plant) of *F. indica* and *P. plebejum* significantly increased the mean germination time of wheat, chickpea, lentil and canola as compared to control (Distilled water) treatment (Fig. 2). Maximum mean germination time was recorded in wheat, chickpea and lentil with leaf aqueous extract of *F. indica* followed by *P. plebejum* (Fig.

2a, 2b and 2c). These results are supported by the findings of Tanveer *et al.* (2008) who reported that the leaf extract of *Xanthium strumarium* caused maximum delay in germination of wheat, barley, maiz, rice, cotton and sunflower.

Shoot germination

The comparative allelopathic potential of *F. indica* and *P. plebejum* and their plant part extracts on shoot length of wheat, chickpea, lentil and canola is given in Fig.3. Minimum shoot length (12.49, 7.87 and 7.30 cm in wheat, chickpea and lentil seedling, respectively) was recorded with leaf extract of *F. indica* which was followed by that of leaf extract (13.47, 9.77 and 7.80 cm in wheat, chickpea and lentil seedling, respectively) of *P. plebejum* compared with control (Fig. 3a, 3b and 3c). The statistically lowest shoot length (1.61 cm) was recorded in canola seedling subjected to leaf extract of *P. plebejum* compared with control (Fig. 3d). These results are in line with those of Shajie and Saffari (2007) who reported the allelopathic influence of cocklebur (*Xanthium strumarium* L.) water extract of leaves on seedlings growth of corn, canola, sesame, lentil and chickpea. Similarly, Mohammadi *et al.* (2003) reported that plumule growth was influenced more severely than radical growth. Maharjan *et al*. (2007) found significant allelopathic inhibition of shoot growth of wheat and other crop species with parthenium plant extract.

Root length

There was significant difference between aqueous extracts of *F. indica* and *P. plebejum* in influencing root length of wheat, chickpea, lentil and canola seedlings as presented in Fig. 4. The statistically minimum root length (1.12 cm) was observed in canola with leaf extract of *P. plebejum* compared with control (Fig. 4d). But in other test crops minimum root length (7.06, 4.14 and 0.31 cm in wheat, chickpea and lentil respectively) was observed with leaf extract of *F. indica* which was followed by that of leaf extract (7.75, 5.74 and 0.47 cm in wheat, chickpea and lentil, respectively) of *P. plebejum* compared with control (Fig. 4a, 4b and 4c). These findings are supported by Shahrokhi *et al*. (2011) who reported that aqueous leaf extract of pigweed (*Amaranthus retroflexus*) had the greatest inhibitory effect on root length of wheat seedlings. Similarly Shajie and Saffari (2009) reported that the *D. stramonium* water extract of above ground parts significantly affected the radical growth of canola.

Total dry weight

The interactive effects of *F. indica* and *P. plebejum* and their plant parts extracts on total dry weight of wheat, chickpea, lentil and canola seedlings are presented in Fig.5. The lowest total dry weight (17.37, 30.35 and 3.00 mg in wheat, chickpea and lentil, respectively) was recorded in seedlings subjected to leaf extract of *F. indica* followed by that of leaf extract (18.43, 35.71 and 3.23 mg in wheat, chickpea and lentil, respectively) of *P. plebejum* compared with control (Fig. 5a, 5b and 5c). Lowest value of total dry weight (1.49 mg) in canola was recorded with leaf extract of *P. plebejum* compared with control (Fig. 5d).The presence of more (6) phenolics in *F. indica* than *P. plebejum* (4) might had caused more reduction in total dry weight of seedlings. The results are in accordance with those of Tanveer *et al.* (2010) who reported that the aqueous leaf extract of *E. helioscopia* caused significant inhibitory effect on dry weight of wheat, chickpea, and lentil. Aziz *et al.* (2008) also reported that the aqueous extracts prepared from root, stem, leaves and fruit of *Gallium aparine* reduced the biomass of wheat seedlings by 16.5 to 38.0%.

Seedling vigor index

The comparative allelopathic potential of *F. indica* and *P. plebejum* and their plant parts extracts on seedling vigour index of wheat, chickpea, lentil and canola seedlings are presented in Fig.6. The minimum seedling vigour index (4.97.4, 228.8 and 18.94 in wheat, chickpea and lentil seedlings, respectively) was recorded with leaf extract of *F. indica* which was followed by that of leaf extract (577.5, 415.7 and 33.57 in wheat, chickpea and lentil seedlings, respectively) of *P. plebejum* compared with control (Fig. 6a, 6b and 6c).

The statistically lowest (41.50) seedling vigour index was recorded in canola seedlings subjected to leaf extract of *P. plebejum* compared with control (Fig. 6d). The observations are in confirmaty with the findings of Tanveer *et al.* (2010) and Shanee *et al.* (2011) who reported that leaf extract of *E. helioscopia* had great inhibitory effect on seedling vigour index of wheat, chickpea and lentil. Similarly, Channappagoudar *et al*. (2005) stated that leaf extract of *Commelina benghalensis* and *Cyperus rotundus* had great inhibitory effect on seedling vigour index of sorghum, wheat, green gram, soyabean, sunflower and groundnut.

CONCLUSION

From the present study it can be concluded that phenolic compounds in the aqueous extracts of *F. indica* and *P. plebejum* may cause allelopathic effects on wheat, chickpea, lentil and canola growth including impaired seed germination and retarded seedling growth. Therefore, *F. indica* and *P. plebejum* should be removed from fields at early stages to save crops from harmful effects of these weeds.

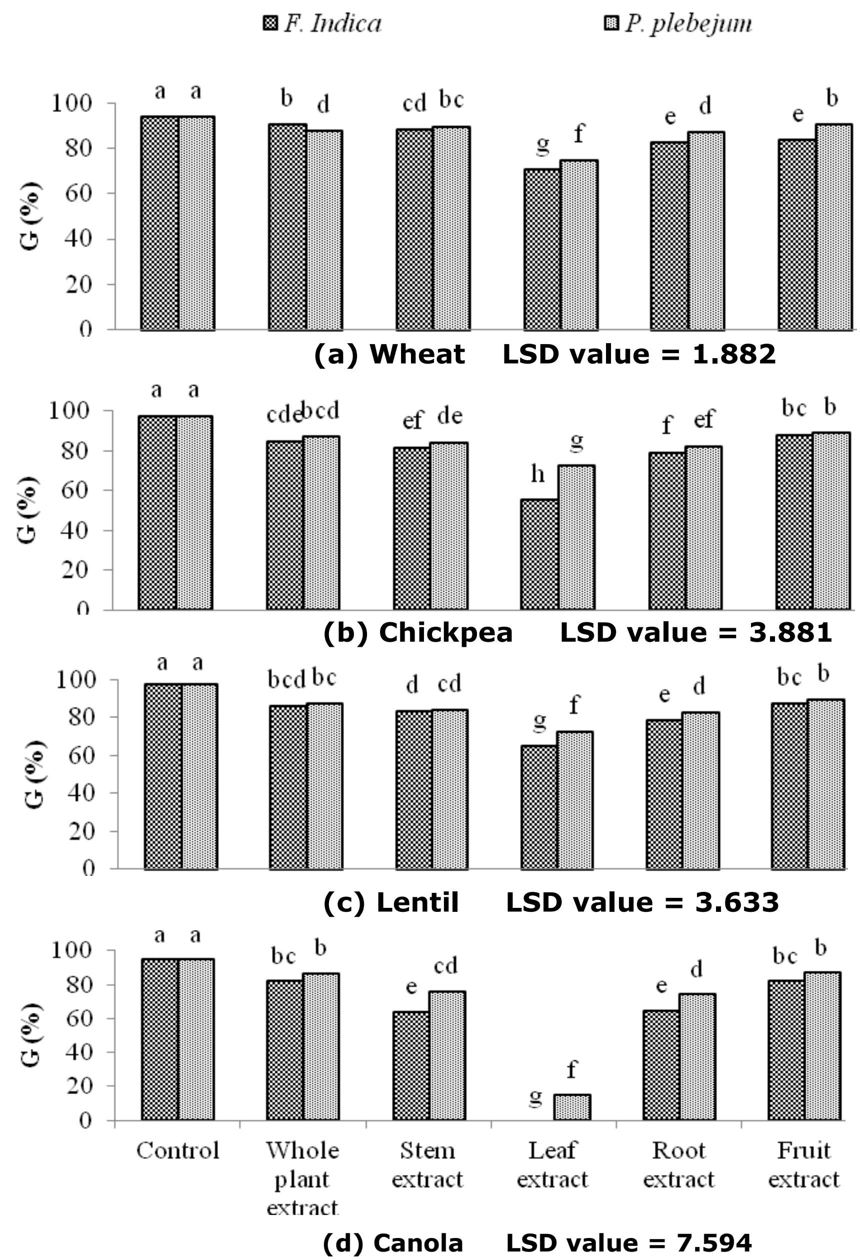

Figure 1. Comparative allelopathic potential of *Fumaria indica* and *Polygonum plebejum* on seed germination of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

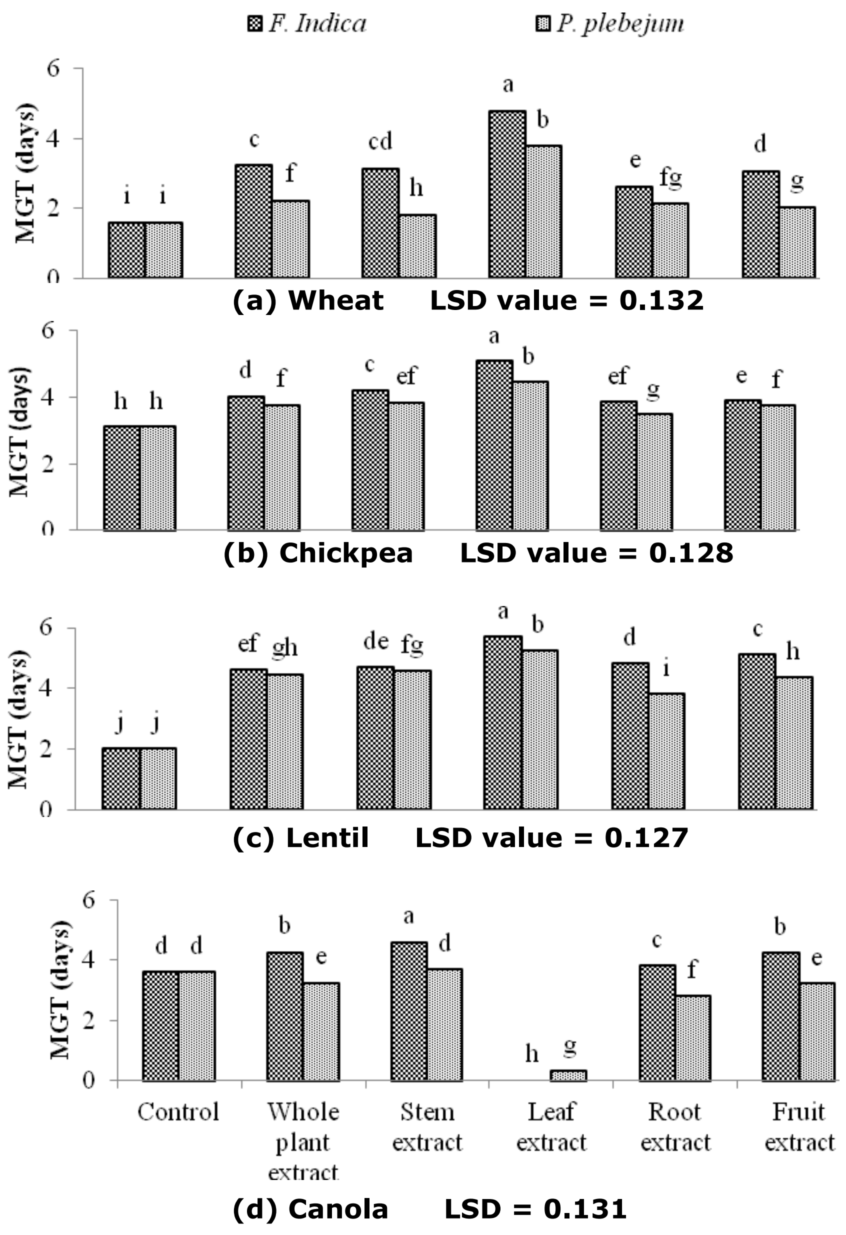

Figure 2. Comparative allelopathic potential of *F. indica* and *P. plebejum* on mean germination time (MGT) of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

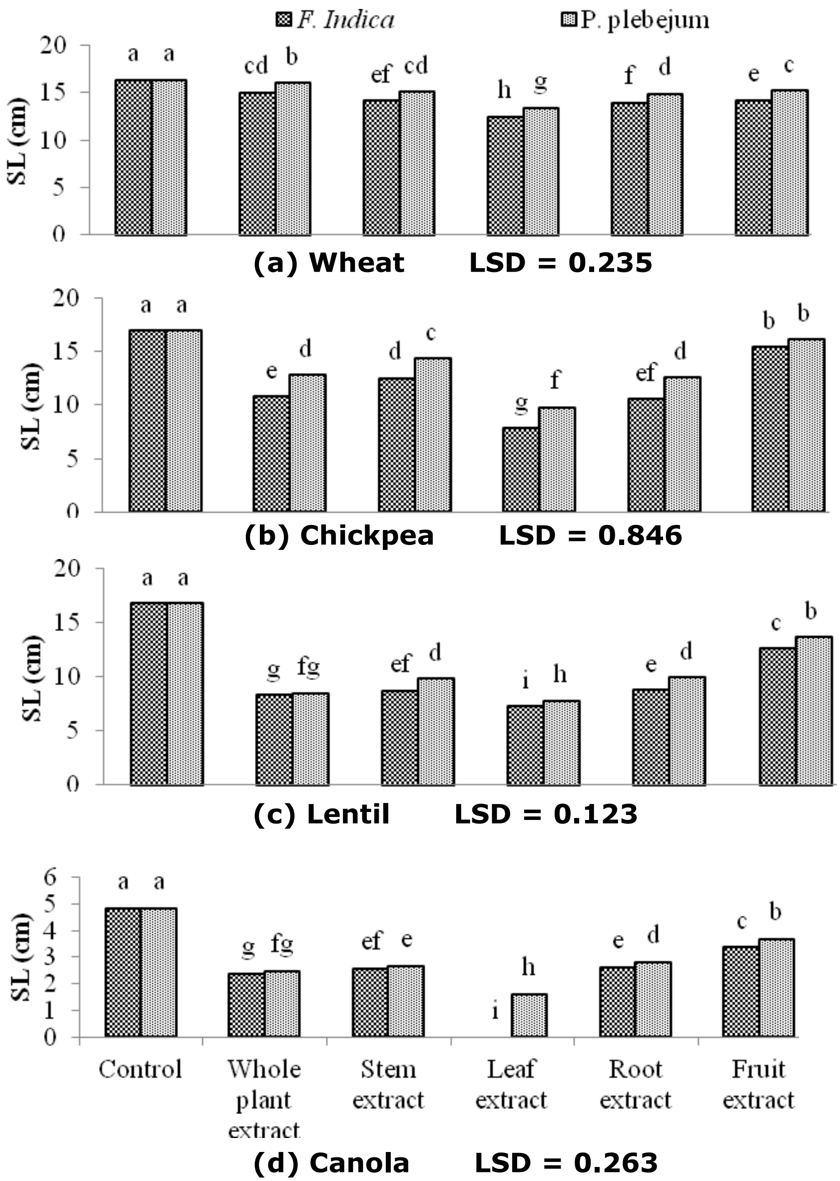

Figure 3. Comparative allelopathic potential of *Fumaria indica* and *Polygonum plebejum* on shoot length (SL) (cm) of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

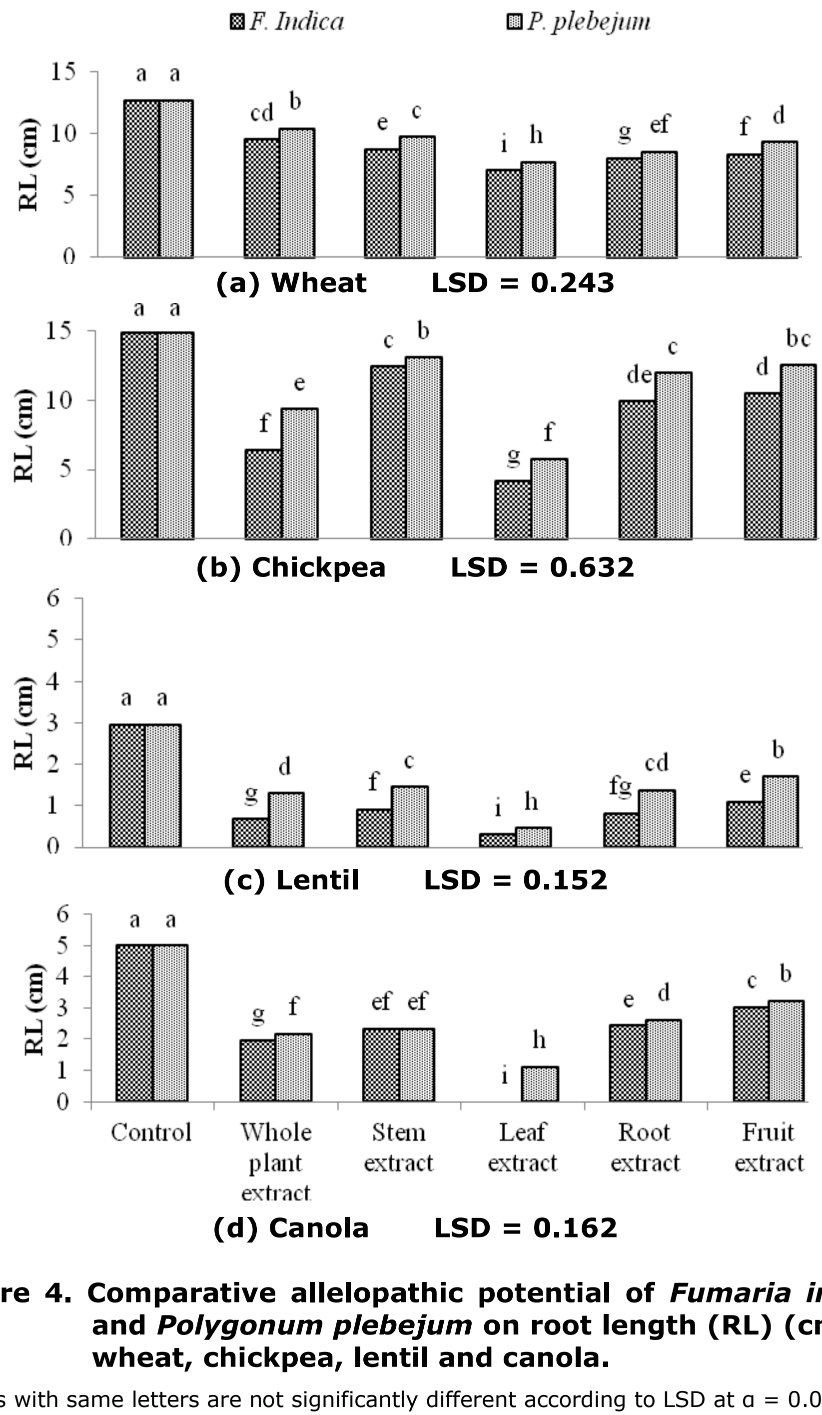

Figure 4. Comparative allelopathic potential of *Fumaria indica* and *Polygonum plebejum* on root length (RL) (cm) of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

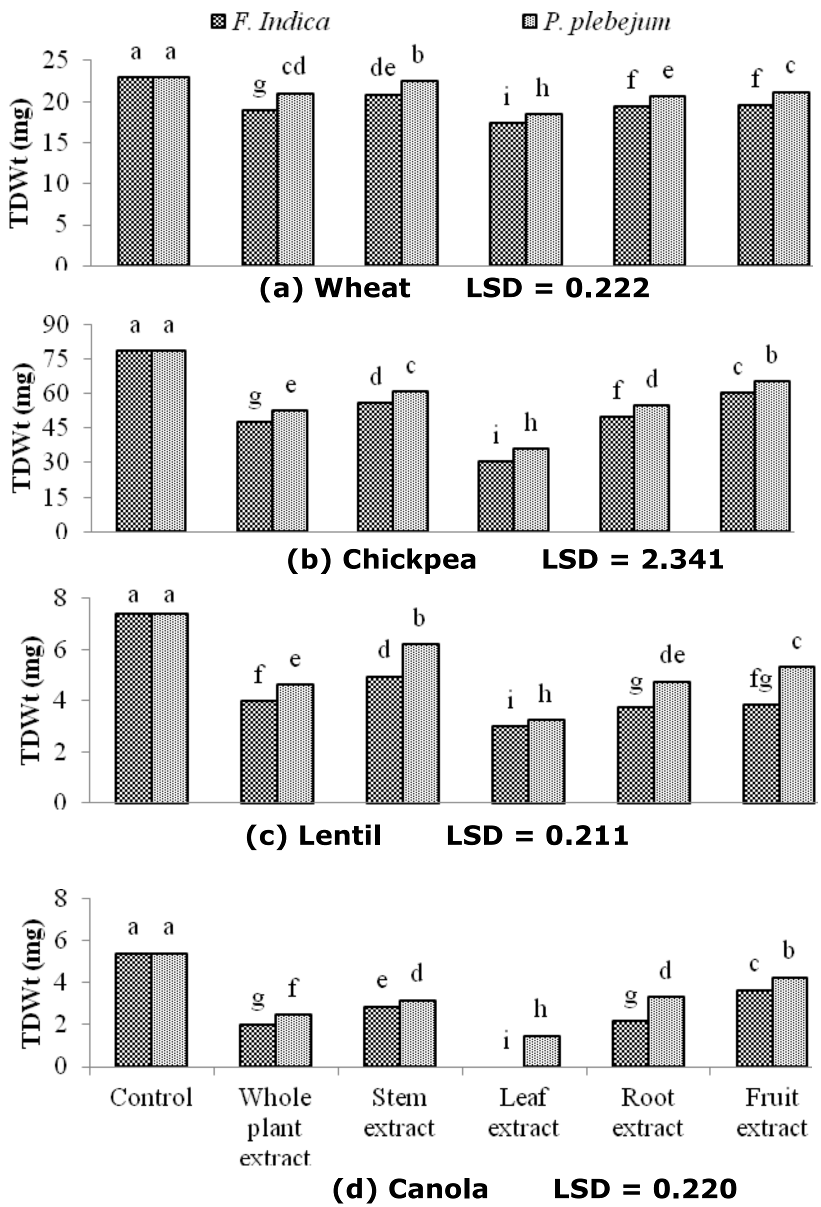

Figure 5. Comparative allelopathic potential of *F. indica* and *P. plebejum* on total dry weight (TDWt) of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

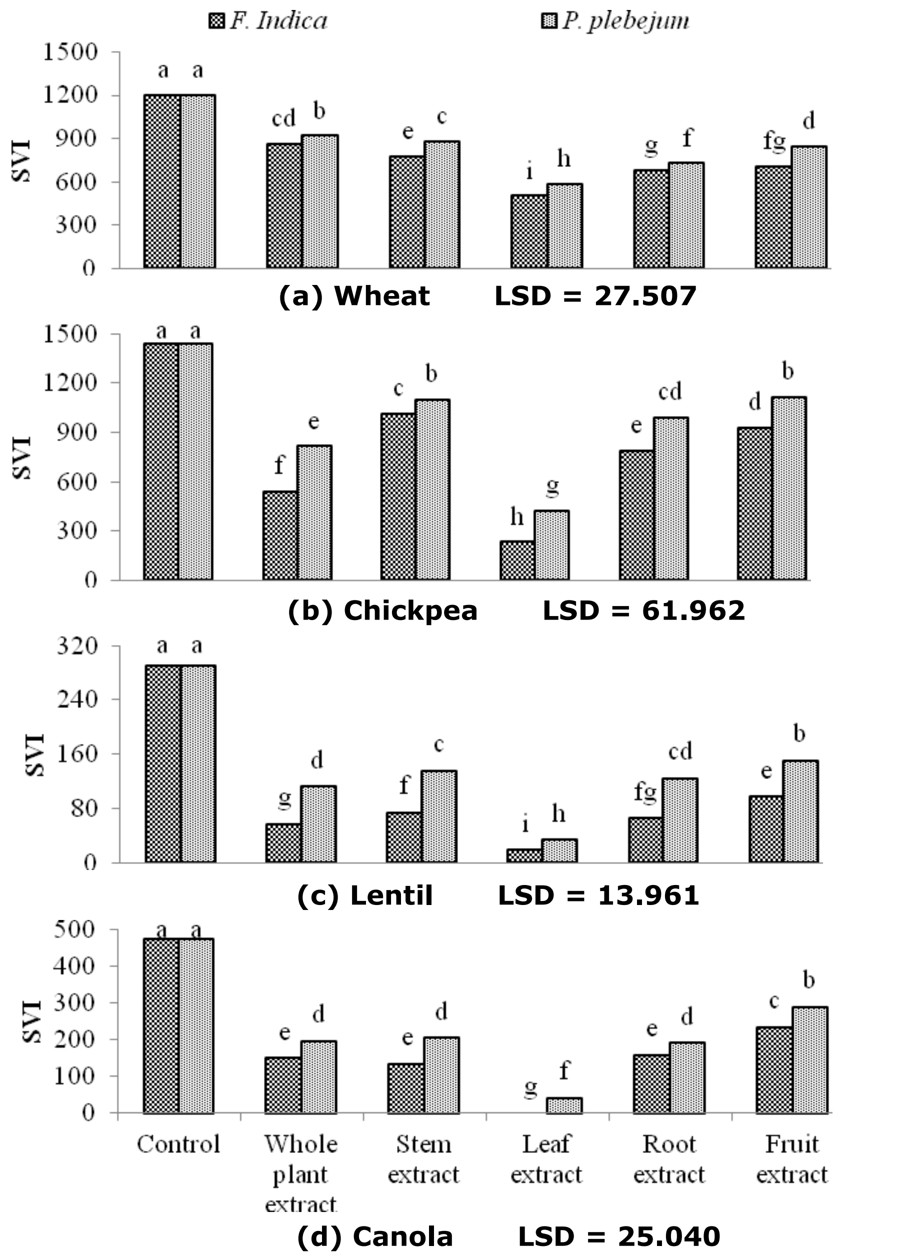

Figure 6. Comparative allelopathic potential of *F. indica* and *P. plebejum* on seedling vigour index (SVI) of wheat, chickpea, lentil and canola.

Values with same letters are not significantly different according to LSD at α = 0.05

REFERENCES CITED

Abdul-Baki, A.A. and J.D. Anderson. 1973. Vigour determination in soybean by multiple criteria. Crop Sci. 13: 630-637.

Alam, S.M. and E. Islam. 2002. Effects of aqueous extract of leaf, stem and root of nettleleaf goosefoot and NaCl on germination and seedling growth of rice. Pak. J. Seed Technol. 1: 47-52.

Alam, S.M., S.A. Ala, A.R. Azim, M.A. Khan and R. Ansari. 2001. Allelopathy and its role in agriculture. J. Biol. Sci. 1(5): 308-315.

Association of Official Seed Analysts (AOSA). 1990. Rules for testing seeds. J. Seed Technol. 12 : 1-112.

Aziz, A., A. Tanveer, A. Ali, M.Yasin, B.H. Babar and M.A. Nadeem. 2008. Allelopathic effect of cleavers (*Galium aparine*) on germination and early growth of wheat (*Triticum aestivum*). Allelopath. J. 22(1): 25-34.

Channappagoudar, B.B., B.R. Jalager and N.R. Biradar. 2005. Allelopathic effect of aqueous extracts of weed species on germination and seedling growth of some crops. Karnataka J. Agri. 18: 916-920.

Ellis, R.A. and E.H. Roberts. 1981. The quantification of ageing and survival in orthodox seeds. Seed Sci. Tech. 9: 373-409.

Ferguson, J.J. and B. Rathinasabapathi. 2003. Allelopathy: How plants suppress other plants. Hort. Sci. Deptt., Co-op Ext. Ser., Instt. of Food and Agricultural Sci., University of Florida, Gainesville, 3(2): 6-11.

Hamayun, M., F. Hussain, S. Afzal and N. Ahmad. 2005. Allelopathic effects of *Cyperus rotunds* and *Echinochloa crus-galli* on seed grermination and plumule and radical growth in maize (*Zea mays* L.). Pak. J. Weed Sci. Res. 11: 81-84.

Kadioglue, I., Y. Yanar and U. Asav. 2005. Allelopathic effects of weed leachates against seed germination of some plants. J. Envi. Bio. 26(2): 169-173.

Kobayashi, K. 2004.Factors affecting phytotoxic activity of allelochemicals in soil. Weed Biology and management, 4 : 1-7.

Kong, C.H., H.B. Li, F. Hu, X.H. Xu and P. wang. 2006. Allelochemicals released by rice roots and residues in soil, 288(1-2): 47-56.

Kumar, V., C.D. Brainerd and R.R. Blender. 2009. Suppression of Powell Amaranth (*Amaranthus powellii*) by Buckwheat Residues: Role of Allelopathy. Weed sci. 57(1): 66-73.

Maharjan, S., B.B. Shrestha and P.K. Jha. 2007. Allelopathic effects of aqueous extract of leaves of *Parthenium hysterophorus* L. on seed germination and seedling growth of some cultivated and wild herbaceous species. Scientific World, 5(5): 33-39.

Mishra, J., S.D. Swain and V.P. Singh. 2004. Studies on germination and allelopathic potential of horse purslane (*Trianthema portulacastrum* L.). Indian J. Plant Physiol. 9: 181-18.

Mohammadi, G., A. Javanshir, K.F. Rahimzadeh, A. Mohammadi and S. Zehtab. 2004. The study of allelopathic effect of some weeds species on germination and seedling growth of chickpea. Desert (biaban), 9(2): 267-278.

Narwal, S.S. 2004. Allelopathy in crop production. Scientific Publishers, Jodhpur, India. Pp. 326-332.

Oudhia, P. 2001. Germination and seedling vigour of wheat as affected by Allelopathy of some obnoxious weeds. Indian Agric. Sci. Dig. 21: 275-276.

Pandey, M.B., A.K. Singh, J.P. Singh, V.P. Singh and V.B. Pandey. 2008. Fuyuziphine, a new alkaloid from *Fumaria indica*. Nat. Prod. Res. 22(6): 533-536.

Qasem, J.R. and C.L. Foy. 2001. Weed Allelopathy, its ecological impacts and future prospects: a review. J. Crop Prod. 4: 43-119.

Qin, B., L.G. Perry, C.D. Broeckling, J.Du, F.R. Stermitz, M.W. Paschke and J.M. Vivanco. 2006. Phytotoxic allelochemicals from roots and root exudates of leafy spurge (*Euphorbia esula* L.). Plant Signaling and Behavior, 1: 323-327.

Rajashekhara, R.B.K., T.N. Shivananda, J. Syamasundara and R. Siddaramappa. 2007. Effects of allelochemicals from selected carbon sources under flooded soil conditions on histological abnormalities induced in rice (*Oryza sativa* L.) roots. Allelopath. J. 20(2): 347-353.

Rudrappa, T., W. J. Quinn, N. R. Stanley-Wall and H.P. Bais. 2007. A degradation product of the salicylic acid pathway triggers oxidative stress resulting in down-regulation of *Bacillus subtilis* biofilm formation on *Arabidopsis thaliana* roots. Planta, 226: 283-297.

Shahrokhi, S., M. Darvishzadeh, M. Mehrpouyan, M. Farboodi and M.Akbarzadeh. 2011. Germination and growth of wheat, *Triticuma estivum*(cv. azar2) in response to Pigweed, *Amaranthus retroflexus* L. organs extracts. I.P.C.B.E.E. 22: 124-128.

Shajie, E. and M. Saffari. 2007. Allelopathic effects of Cocklebur (*Xanthium strumarium* L.) on germination and seedling growth of some crops. Allelopath. J. 19(2) : 501-506.

Shajie, E. and M. Saffari. 2009. Allelopathic effects of aqueous and residue of different parts of *Datura stramonium* on canola growth and germination. Pajouhesh and Sazandegi Agron. 22(1): 62-69.

Shanee, S., A. Tanveer, M.M. Javaid, K.M. Chaudhry, A. Aziz, A. Khaliq, M.N. Chaudhry M.A. Pervez and I.U. Awan. 2011. Phytotoxic effects of *Euphorbia dracunculoides*: a weed of rainfed chickpea-chickpea cropping system. S. J. Agri. Res. 9(2): 580-588.

Shukla, A.K., S. Prasad, S.K. Srivastava, S.P. Singh and R.P. Singh. 2003. Allelopathic effect of thatch grass (*Imperata cylindrica* L.) on various kharif and rabi season crops and weeds. Indian J. Weed Sci. 35: 163-166.

Steel, R.G.D., J.H. Torrie and D. Dickey. 1997. Principles and Procedures of Statistics. Multiple comparison. 3rd Ed. McGraw Hill Book Co., New York, USA. Pp. 178-198.

Tanveer, A., A. Rehman, M.M. Javaid, R.N. Abbas, M. Sibtain, A. Ahmad, M.S. Ibin-I-Zamir, K.M. Chaudhary and A. Aziz. 2010. Allelopathic potential of *Euphorbia helioscopia* L. against wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medic.) Turk. J. Agric. 34: 75-81.

Tanveer, A., M. Tahir, M.A. Nadeem, M. Younis, A. Aziz and M. Yaseen. 2008. Allelopathic effects of *Xanthium strumarium* L. on seed germination and seedling growth of crops. Allelopath. J. 21(2): 317-328.

Weston, L.A. and S.O. Duke. 2003. Weed and Crop allelopathy. Crit. Rev. Plant Sci. 22(3&4): 367-389.