The genus *Tagetes* belongs to family Asteraceae and comprises 56 species, of which 27 are annuals and 29 are perennials (Soule, 1996). Amongst all species, *Tagetes minuta* L. is most widely studied due to its high-grade oil used in food, perfumery, pharmaceutical, nutraceutical and agricultural industries (Chalchat *et al*., 1995; Singh *et al*., 2003). *T. minuta* is native to South America; however, it grows in wild and arable farming systems as a noxious weed (Holm *et al*., 1997). It is a problematic weed of pastures and numerous crops (Hulina, 2008) as it may colonize waste grounds, roadsides, gardens, orchards and vine yards (Bandana *et al*., 2018). The plant was introduced in India for its essential oil (Rao *et al*., 1988) but it has naturalized itself in Himalayan and sub-Himalayan regions up to altitude of 2000 m in waste places, roadsides, rocky hill slopes and cultivated fields of different states viz. Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland and Meghalaya (Maheshwari, 1972).

Essential oil (EO) of *T. minuta* possesses pharmacological, antibacterial, antiviral, antifungal, nematicidal and insecticidal properties (Ali *et al*., 2014; Shirazi *et al*., 2014). Various researchers have reported ocmine, dihydrotagetone, tagetone, tagetene as the major components of its oil as revealed through GC-MS analysis (Meshkalsadat *et al*., 2010; Tiwari *et al*., 2016). Rich phytochemistry of essential oil of *T. minuta* have led farmers to grow it under cultivation specially in drug growing areas of the world (Chalchat *et al*., 1995). Despite many reports of ethnobotanical and pharmacological uses of essential oil of *T. minuta*, very few reports have indicated its possible use in controlling weeds in agroecosystems or wastelands (Singh *et al*., 2003; Lopez *et al*., 2009; Arora *et al*., 2015, 2016). There is no report about the mode of application of EO of *T. minuta* for effective and eco-friendly weed management. With this background, present study was undertaken to explore the effect and efficacy of different methods of oil application on *Phalaris minor* Retz., a common agricultural weed of wheat agroecosystems.

**INTRODUCTION**

The genus *Tagetes* belongs to family Asteraceae and comprises 56 species, of which 27 are annuals and 29 are perennials (Soule, 1996). Amongst all species, *Tagetes minuta* L. is most widely studied due to its high-grade oil used in food, perfumery, pharmaceutical, nutraceutical and agricultural industries (Chalchat *et al*., 1995; Singh *et al*., 2003). *T. minuta* is native to South America; however, it grows in wild and arable farming systems as a noxious weed (Holm *et al*., 1997). It is a problematic weed of pastures and numerous crops (Hulina, 2008) as it may colonize waste grounds, roadsides, gardens, orchards and vine yards (Bandana *et al*., 2018). The plant was introduced in India for its essential oil (Rao *et al*., 1988) but it has naturalized itself in Himalayan and sub-Himalayan regions up to altitude of 2000 m in waste places, roadsides, rocky hill slopes and cultivated fields of different states viz. Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland and Meghalaya (Maheshwari, 1972).

**MATERIALS AND METHODS**

**Plant Material Collection and Oil Extraction**

Aerial parts of *T. minuta* plant were collected at flowering stage from Solan and adjoining places of Himachal Pradesh, India (30°55′0″ North, 77°7′0″ East). Shoots were chopped and subjected to hydro-distillation for 2 h using a Clevenger-type apparatus. Seeds of little seed canary grass (*P. minor*) were collected from the agricultural fields in and around Chandigarh.

**Analysis of Essential Oil and Identification of its Components**

Qualitative data pertaining to identification of relative amount of each constituent in essential oil of *T. minuta* was done by Gas Chromatography-Mass Spectrometry (GC-MS). Detailed procedure has been reported earlier (Arora *et al*., 2015).

**Growth Bioassay**

To test the allelopathic effect of *T. minuta* oil on test weed, growth bioassays were divided into three categories i.e., volatile (VB), solution (SB) and agar-agar (AAB) bioassays. In VB, test seeds (surface sterilized
Fig. 1: Effect of different modes of application of EO of *T. minuta* on growth of *P. minor*. Data are represented as mean values. Vertical bars along each treatment indicate standard deviation of means. Asterisks indicate the statistical significance (**P ≤ 0.01; *P ≤ 0.05) applying Dunnett t-test.

**RESULTS AND DISCUSSION**

27 Compounds were identified in essential oil of *T. minuta* constituting 95% of the oil. The oil was found rich in monoterpenes both hydrocarbon as well as oxygenated types. In another publication detailed composition of *T. minuta* EO has been published (Arora et al., 2015). *cis*-β-Ocimene and dihydrotagetone were the major components of oil. Many reports in past have identified similar compounds in essential oil of *T. minuta* (Meshkalsadat et al., 2010; Ghiavand et al., 2011; Amri et al., 2013; Ali et al., 2014).

Dose response curves (Fig.1) of EO of *T. minuta* on germination and early growth of test plants showed
significant inhibition of *P. minor*. The allelopathic inhibition by EO was statistically significant in all treatments, however, in VB, reduction in germination, root length, shoot length and dry weight was more than SB as well as AAB. At 2 mg/Petri concentration, reduction in root length was 95.6% in *P. minor*. Similarly, reduction in shoot length was 60.2%. Germination and dry weight reduction also followed similar trend.

Thus, present study confirmed allelopathic potential of EO of *T. minuta* which is in accordance with earlier reports related to use of essential oils in weed management (Chaturvedi *et al.*, 2012; Alipour and Saharkhiz, 2016; Benchaaet *et al.*, 2018 etc.). However, the use of *T. minuta* EO in different forms (mode of treatment: VB, SB and AAB) has not been related to its allelopathic potential in any report till date. On the basis of this study, it can be recommended that volatile form of EO of *T. minuta* is best suitable for controlling *P. minor* in agro-ecosystems. Future scope of this study lies in exploring herbicidal potential of foresaid recommendations at field level in correlation with wheat crop that may further confirm the use of EO of *T. minuta* as a bioherbicide.

**ACKNOWLEDGEMENTS**

We would like to thank Department of Botany, Panjab University, Chandigarh for providing suitable facility for undertaking this study. The author would also like to thank DAV College, Jalandhar for providing excellent support.

**REFERENCES**


Shirazi, M., H. Gholami, G. Kavoosi, V. Rowsan and A.

