Pak. J. Weed Sci. Res., 19(2): 179-189, 2013

Tagetes minuta L., A USEFUL UNDERUTILIZED PLANT OF FAMILY ASTERACEAE: A REVIEW

Sehrish Sadia[1*], Shahida Khalid[2], Rahmatullah Qureshi[1] and Ali Ahsan Bajwa[3]

ABSTRACT

Plants are widely used in the medicine industry of modern era, and are the sources of raw material and essential ingredients for medicines. These plant extracts and active constituents are used to make different formulations. Tagetes minuta, an annual ornamental plant, has been identified as potential medicinal plant as it contains allelochemicals and essential oils that have multi-dimensional uses and applications such as weedicides, germicides, nematocides, insecticides, fungicides etc. Moreover, different medicines also have the fractions of these compounds. This plant is also used for beautification and landscaping i.e. as an ornamental one. However, sometimes it appears to be a weed in lawns, parks and crop fields. In such case, it should be managed by mechanical, cultural and by chemical control methods. A comprehensive research is needed to explore more qualities and uses of this beneficial plant in future. Tagetes minuta L., a widely distributed plant in northern Pakistan, has immense and diverse utilities. The objective of the paper is to target this plant for exploitation and change its status from weed to underutilized minor crop.

Key words: Allelochemicals, essential oils, medicinal plants, *Tagetes minuta*.

INTRODUCTION

Tagetes minuta is a very important member of Genus *Tagetes* belonging to Asteraceae family. It has tiny involucres, toxic flowers and a particular odor. Being a weed, it is able to adapt almost every temperate area (Neher, 1968). Phylogenetic study with the help of one morphological and three molecular data sets tells that there are 40 genera and 26000 angiospermic species included in the order Asterales. Out of which 23000 species are included in a single family Asteraceae.

[1]PMAS- Arid Agriculture University, Rawalpindi, Pakistan
[2]Weed Management Programme, Dept. of Plant & Environment Protection, NARC, Islamabad Pakistan
[3]Dept. of Agronomy, University of Agriculture, Faisalabad, Pakistan
[*]Corresponding author's email: sehrish.sadia.chakwal@gmail.com

There is a sister group relation between Calyceraceae and Asteraceae in both morphological and molecular data (Lundberg and Bremer, 2003; Takhtajan, 1997; Bremer, 1994; Cronquist, 1981). Whereas phylogenetic studies within the Tageteae, based on nuclear ribosomal ITS and chloroplast ndhF gene sequences, show that Tageteae probably originated in Mexico and then independently introduced to South America. Approximately 216 new world species are included in Tageteae. In the light of these phylogenetic studies *Tagetes* is paraphyletic due to nesting of *Vilobia* and *Adenopappus* within genus (Lookerman *et al.*, 2003).

Synonyms of *T. minuta* L. is *T. glandulifera* Schrank. The specific epithet of *T. minuta* is from the Latin word *minutes* meaning small and refers to the small size of the capitula and "glandulifera" from *glandula* and *fere* and shows glands on undersurface of leaves and on bracts of involucrum (Hulina, 2008). As far as history of invasion of *T. minuta* is concerned, it is appeared to be an escape from cultivation. In Azad Kashmir, Pakistan, it is vernacularly known as Gainda and its flowering period is from June to August (Qureshi *et al.*, 2007). It is a weed of spring and it disappears at the start of winter after completion of its life cycle (Chamorro *et al.*, 2008).

Description

It is an annual plant with 50-150 cm height. It has glabrous, erect and branched stem with opposite branches (Fig. 1). Its leaves are opposite and pinnately parted but the upper leaves are alternate. Length and width of *Tagetes* leaves is 4 to 8 cm and 3 to 4.5 cm, respectively. Margins of leaves are acute and serrate. It has corymbiform dense inflorescence at the end of branches. Phyllaries forming a cylindric tube is naked at base and 7 to 10 mm long. It has 3 florets that are ligulate, dark brown or lemon-colored and 2.5 to 3 mm long. Tubular florets are orange and 3 mm long. Achenes are 5 to 6.5 mm (excluding pappus) long and 0.5 mm wide. Color of achene is dark-brown and is covered with appressed hairs (Naqinzhad and Mehrvarz, 2007).

Reproduction of *T. minuta* is done by seeds. Seed production of one *Tagetes* plant is very high (more than 29,000 seeds plant^{-1}). It is ruderal and segetal weed. Habitat of *Tagetes minuta* includes roadsides, waste ground, orchards, vineyards and gardens. It has drought tolerance and poor soils are also places of its survival (Hulina, 2008).

On the undersurface of leaves of *T. minuta* a number of small, multicellular and punctate glands are present. When these glands are punctured liquorice like aroma is produced. These glands are also present on involucres bracts and the stem. Oil of *T. minuta* can be

extracted with hexane is a raw material for perfume production and an established product of flavor. The oil is a rich source of limonene, ocimene, dihydrotagetone, tagetone, and tagetenone (Shahzadi *et al*., 2010).

A

B

Fig. 1A. *Tagetes minuta* in its natural habitat; 1B. Herbarium specimen

Worldwide Distribution

Tagetes minuta is native to the temperate grasslands and mountain regions of southern South America but naturalized in Europe, Africa, Asia, Australia, New Zealand, and United States including Hawaii, Cape Verde, Madeira and Madagascar (Naqinzhad and Mehrvarz, 2007). It also grows in Ethiopia, Kenya, and other areas of East Africa, northern India and waste places of Spain. This plant is growing on a broad range of environments starting from extreme temperate to tropical regions of the world. The height of the plant is 50 to 150 cm with a highly branched stem at the top. In tropics, it is grown for essential oil production (Shahzadi *et al.*, 2010). Its worldwide cultivation is done due to its pharmacological and agrochemical properties (Hulina, 2008).

Distribution in Pakistan

Tagetes minuta L. can survive in a wide range of climatic conditions starting from 3000 to 11000 ft height from sea level in the north and Northwestern parts of Pakistan (Shahzadi *et al.*, 2010). In Pakistan, *T. minuta* prefers cooler climates and is common in Swat and Hazara districts of Khyber Pakhtunkhwa (Marwat *et al.*, 2010). It is also present in Abbottabad (Abbasi *et al.*, 2010) District Bagh, Azad Kashmir (Qureshi *et al.*, 2007), Murree Hills, Margala Hills, Salt Range and Rawalpindi district (Abbasi *et al.*, 2010) (Fig. 2.).

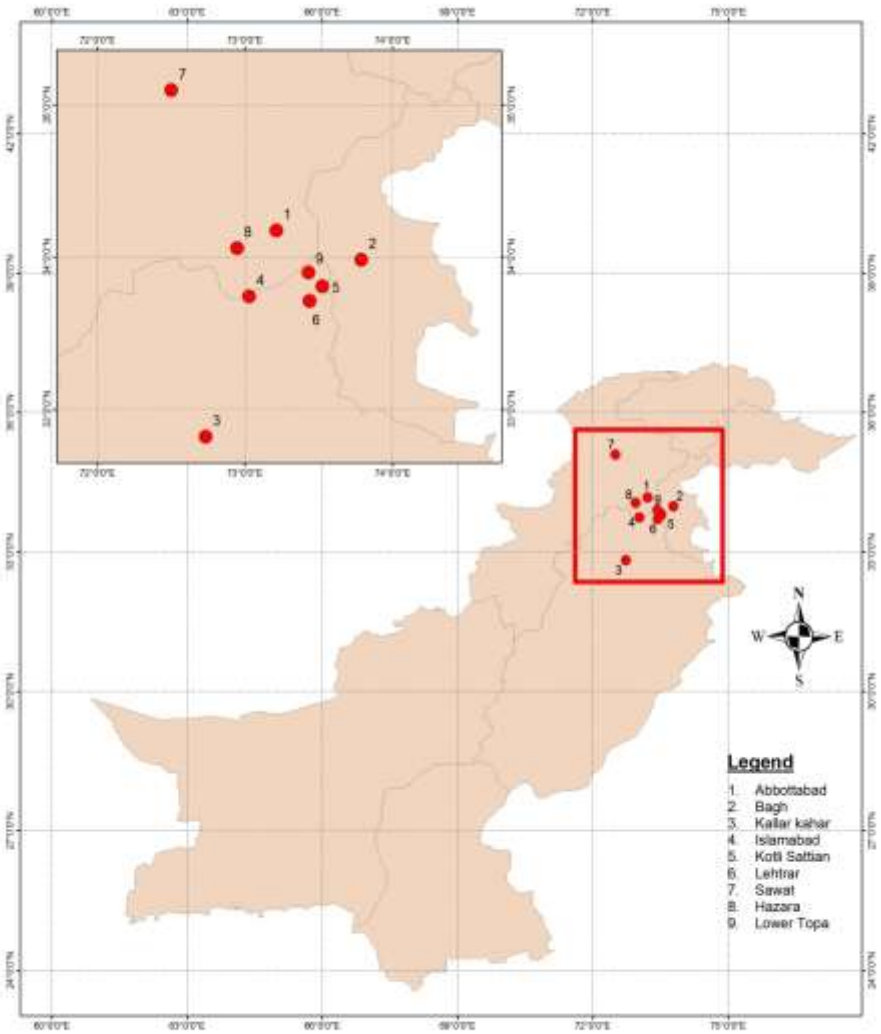

Fig. 2. Distribution of *Tagetes minuta* in Pakistan.

Phytochemical analysis and essential oils

Phytochemical analysis of aerial parts of this plant showed the presence of terpenoides, saponines, tannins, flavonoides and alkaloids

(Hadjiakhoondi *et al.*, 2005). The main constituents of *T. minuta* oil include limonene and (Z) - ocimene (monoterpenes); dihydrotagetone (E)-and (Z) - tagetone (E) - and (Z) - tagetenone (also known as (E) - and (Z) - ocimenone) (Shahzadi *et al*., 2010).

Essential oil composition is different in different parts of the plant but is same with respect to plant material origin. Essential oils from bloomed plant leaves and flowers contain β-ocimene and tagetenone whereas non-bloomed plant leaves and flowers mainly have dihydrotagetone (Chamorro *et al.*, 2008).

Gas chromatography GC-Olfactometry using aroma extract dilution analysis (AEDA) showed the presence of 43 odorant zones. Highest flavor dilution (*FD*) values were observed for ethyl 2-methylpropanoate, (*E*)-ocimenone, ethyl 3-methylbutanoate, two tentatively identified thiols, and two unknown compounds. Whereas vocabulary-intensity-duration of elementary odors by sniffing (VIDEO-Sniff) showed the presence of 42 odorant zones and 37 compounds. Both of the methods concluded that ethyl 2-methylpropanoate and ethyl 2- and 3-methylbutanoate are the main odorants in essential oil of *Tagetes minuta* (Breme *et al.*, 2009).

Fungitoxic activity of *Tagetes minuta*

Performance of *T. minuta* in controlling *Fusarium oxysporum* (soil borne fungi) through inhibiting its conidia germination is very good (Obongoyai *et al.*, 2010). On the other hand, when steam distilled shoot extracts of *T. minuta* along with entomopathogenic fungi were evaluated for the control of *Tetanops myopaeformis* (picture-winged fly), it was concluded that *T. minuta* caused developmental arrest and mortality depending upon dose without interfering with the action of fungi (Dunkel *et al.*, 2010). Amounts of 700 and 800 ppm of the *Tagetes* oil inhibit 67% of growth of *Ascosphaera apis* (fungus that produces chalkbrood). A ratio selection of this oil could be used in field conditions with a better safety margin (Eguaras *et al.*, 2005).

Allelopathic Potential of *Tagetes minuta*

A chemical characterization of volatile components of *Tagetes minuta* showed that a total of 27 compounds are present that constitute 92 % of essential oil of aerial parts (Meshkatalsadat *et al.*, 2010). Potential utilization of dried powder of *T. minuta* as a natural herbicide for managing rice weeds was investigated. It was observed that leaf powder of *T. minuta* applied to soil of rice field significantly reduced emergence and growth of weeds (*Echinochloa crus-galli* and *Cyperus rotundus*) in pot experiment under greenhouse and in rice field plots (Batish *et al.*, 2007). Essential oils of *T. minuta* and *Schinus areira* were investigated as allelopathic agents. Both of oil treatments presented an enhancement in malondialdehyde values from 24 to 48 hrs, while the main components of the essential oils, α pinene,

ocimenone and limonene, presented an increase from 24 to 96 hrs indicating exhausted lipid peroxidation. The *T. minuta* oil had an oxidant effect and a strong inhibitory action on root of *Zea mays* than *S. areira* oil (Scrivanti *et al.*, 2003). Allelopathy of *T. minuta* aqueous extracts on seed germination and root hair growth was also studied. The seeds of test species (*Lotus corniceatus* var. japonicus and *Lectuca sativa*) were inoculated in Petri dishes containing 0, 10, 50 and 100 % *T. minuta* aqueous extracts. At 5^{th} day, it was observed that seed germination of *L. corniculatus* var. japonicas was significantly inhibited, however *L. sativa* was not inhibited (Kil *et al.*, 2002).

An experiment was carried out for bioassays of seed extracts of *Tagetes minuta* which is naturally growing in north of Pakistan. By using solvent extraction method, the essential oils from the seeds were extracted and crude fractions were prepared for biological activities such as malaricidal, phytotoxic and insecticidal. Ether and n-hexane fractions of *T. minuta* were applied on *Plasmodium flaciparum* 3D7, *Lemna minor* and three common fungal grain pests. Antimalarial activity was found significantly better for n-hexane fraction than ether fraction. Both fractions showed little or no pytotoxic activity and insecticidal activity was observed from both of fractions (Shahzadi *et al.*, 2010).

The dominant terpenes in the essential oils of the leaves and reproductive structures of *T. minuta* L. (Asteraceae) were studied throughout its life cycle in a natural population. The anatomy of the secretory cavities was described in order to correlate the changes in terpene content with structural changes. Finally, the phytotoxic effect of ocimenones on germination was also evaluated. Monoterpenes increased in both green leaves and reproductive structures throughout the plant's life cycle, whereas the opposite occurred in senescent leaves. Spathulenol was the main component in senescing leaves. The highest content of ocimenones, the bioactive components of the essential oil, was found in the reproductive structures. Bioassays showed that both pure ocimenones and fruit material from *T. minuta* delayed and inhibited the germination of cohabitant species. A relationship between allelopathy, biosynthesis, catabolism and terpene release is proposed for the chemical ecological effect of *T. minuta* (Lopez *et al.*, 2009).

DNA Analysis of *Tagetes minuta*

High concentrations of flavonoids, essential oils, polysaccharides and polyphenols present in *Tagetes minuta* interfere with DNA and cause no PCR products. Sun-dried, shade-dried and fresh-leaf tissues, as well as seeds were used for DNA analysis. Good quality DNA was obtained from seeds and fresh-leaf tissues with a

modified cetyltriethylammonium bromide buffer protocol, with no contaminants and colored pigments. Good quality DNA from fresh leaf tissues was obtained without using liquid nitrogen. DNA was also obtained from the sun- and shade-dried tissues in a relative high amount but low in quality as compared to obtained from seeds. PCR using arbitrary RAPD primers was used to amplify the extracted DNA. High molecular weight DNA was extracted from other plant materials containing essential oils and secondary metabolites with the same method (Shahzadi *et al.*, 2010).

Uses

Tagetes minuta leaves paste is typically used for wound healing, has anti-inflammatory, bronchodilatory (Abbasi *et al.*, 2010), hypotensive, spasmolytic, antifungal (Shahzadi *et al.*, 2010), germicidal (Abbasi *et al.*, 2010), carminative, anti-abortion (Hadjiakhundi *et al.*, 2005), vermifuge (Neher, 1968) and microbicidal characteristics (Abbasi *et al.*, 2010). Entire plant is used as a condiment, diaphoretic, diuretic, purgative, stomach strengthener, hysteria remedy, menstrual stimulant and for flavoring to milk and cheese (Neher, 1968). Flowers of *T. minuta* are used for epileptic fits and fevers (Qureshi *et al.*, 2007). Its flowers are also used as mild laxative, insect repellent, for gastirites, indigestion (Neher, 1968). Leaves are used for kidney trouble, piles, muscular pain and their juice is used for ophthalmia, earache (Qureshi *et al.*, 2007), hemorrhoids and as a snuff (Neher, 1968). Leaves are also used locally to repel safari ants and mosquitoes and to kill mosquitoes larvae. Oil obtained from leaves is more toxic to mosquitoes larvae than DDT (Macedo *et al.*, 1997). Its flowers are used for ornamental purposes (Hamayun *et al.*, 2006). *Tagetes* roots have fungicidal and nematocidal characteristics (Batish *et al.*, 2007; Osman *et al.*, 2008). The oil obtained from seeds, leaves and flowers of *Tagetes minuta* strongly repels the blowflies and is also useful for blowfly dressing (Jacobson, 1983). Its oil is also used for perfume production, treatment of smallpox, earache and colds and to reduce fevers (Shahzadi *et al.*, 2010). Volatile *Tagetes* oil is highly suppressing against Plants, animals and humans pathogens and micro-organisms. It is also used as flavoring agent in food industry and in perfumes (Mohamed *et al.*, 1999).

Management of Tagetes as weed

It is present in maize fields. Being a weed it is competitive for maize crop therefore it should be managed. Best method of its management is composting of the FYM. Along with this method crop rotation is also effective. In non crops and maize field, non selective herbicides and maize herbicides can be used in case of severe damaging effect of *Tagetes minuta* (Marwat *et al.*, 2010).

CONCLUSION

As the crops are integral part of economy of Pakistan so this plant could be used as a bio-herbicide for weed control in our major crops. Similarly, ethnobotanical investigations of this plant render an immense importance to this plant. And these investigations are the benchmark of further medicinal testing of this plant. By managing its negative sides we can get benefit from its positive effects and ultimately this can serve for the whole mankind.

REFERENCES CITED

Abbasi, A. M., M. A. Khan, M. Ahmad, R. Qureshi, M. Arshad, S. Jahan, M. Zafar and S. Sultana. 2010. Ethnobotanical study of wound healing herbs among the tribal communities in Northern Himalaya Ranges District Abbottabad, Pakistan. Pak. J. Bot. 42(6): 3747- 3753.

Batish, D.R., K. Aroraa, H.P. Singhb and R.K. Kohlia. 2007. Potential utilization of dried powder of *Tagetes minuta* as a natural herbicide for managing rice weeds. Crop Protec. 26: 566-571.

Bremer, K. 1994. Asteraceae cladistics and classification. Timber, Portland, Oreg. Cladistics 10: 295- 304.

Breme, K., P. Tournayre, X. Fernandez, U. J. Meierhenrich, H. Brevards, D. Joulains and J. L. Berdague. 2009. Identification of Odor Impact Compounds of *Tagetes minuta* L. Essential Oil: Comparison of Two GC-Olfactometry Methods. J. Agric. Food Chem. 57(18): 8572–8580.

Chamorro, E. R., G. Ballerini, A. F. Sequeira, G. A. Velasco and M. S. Zalazar. 2008. Chemical composition of essential oil from *Tagetes minuta* L. leaves and flowers. J. Argentine Chemical Soc. 96(1-2): 80- 86.

Cronquist, A. 1981. An integrated system of classification of flowering plants. Columbia University Press, New York.

Dunkel, F.V., S.T. Jaronski, C.W. Sedlak, S.U. Meiler and K.D. Veo. 2010. Effects of steam distilled shoot extract of *Tagetes minuta* (Asterales: Asteraceae) and Entomopathogenic fungi on larval Tetanops myopaeformis. J. Essent. Oil Res. 13: 122.

Eguaras, M. J., S. Fuselli, L. Gende, R. Fritz, S. R. Ruffinengo, G. Clemente, A. Gonzalez, P. N. Bailac and M. I. Ponzi. 2005. An in vitro evaluation of *Tagetes minuta* essential oil for the control of the honeybee pathogens *Paenibacillus* larvae and *Ascosphaera apis* and the parasitic mite Varroa destructor. J. Essent. Oil Res. 17(3): 336- 340.

Hadjiakhoondi, A., H. Vatandoost, M. Khanavi, M. R. Abaee and M. Karami. 2005. Biochemical Investigation of Different Extracts

and Larvicidal Activity of *Tagetes minuta* L. on *Anopheles stephensi* larvae. Iranian J. Pharmaceut. Sci. 1(2): 81- 84.

Hamayun, M., F. Hussain, S. Afzal and N. Ahmad. 2006. Allelopathic effect of *Cyperus rotundus* and *Echinochloa crus-galli* on seed germination, and plumule and radical growth in maize (*Zea mays* L.). Pak. J. Weed Sci. Res. 11(1-2): 81-84.

Hulina, N. 2008. Wild marigold- *Tagetes minuta* L. New Weed on the Island of Hvar, and New Contribution to the Knowledge of its Distribution in Dalmatia (Croatia) Agriculture Conspectus Scientificus. 73: 23-26.

Jacobson, M. 1983. Insecticides, insect repellants, and attractants from arid/semiarid plants. Plants: potential for extracting protein, medicines and other useful chemicals-workshop proceedings (Washington, D.C.: U. S. Congress, office of technology assessment, OTA- BP- F- 23.

Kil, J. H., K. Shim and K. Lee. 2002. Allelopathy of *Tagetes minuta* L. aqueous extracts on seed germination and root hair growth. Korean. J. Ecol. Sci. 1(3): 171-174.

Lookerman, D. J., B. L. Turner and R. K. Jansen. 2003. Phylogenetic relationships within the Tageteae (Asteraceae) based on nuclear ribosomal ITS and chloroplast ndhF gene sequences. Syst. Bot. 28(1): 191- 207.

Lopez, M. L., N. E. Bonazani and J. A. Zygadlo. 2009. Allelopathic potential of *Tagetes minuta* terpens by a chemical, anatomical and phytotoxic approach. Biochem. System. Ecol. 36:882- 890.

Lundberg, J. and K. Bremer. 2003. A phylogenetic study of the order asterales using one morphological and three molecular data sets. Int. J. Plant. Sci. 164(4): 553- 578.

Macedo, M. E., R. A. G. B. Consoli, T. S. M. Grandi, A. M. G. D. Anjos, A. B. D. Oliveira, N. M. Mendes, R. O. Queiroz and C. L. Zani. 1997. Screaning of Asteraceae (Compositae) plant extracts for larvicidal activity against *Aedes fluviatilis* (Diptera: Culicidae). Mem Inst Oswaldo Cruz, Rio de Janeiro, 92(4): 565-570.

Marwat, K.B., M. Hussain and H. Ali. 2010. Weed management: A case study from North West Pakistan. Pak. J. Bot., Special issue (S. I. Ali Fest Schrift) 42: 341- 353.

Meshkatalsadat, M. H., J. S. Ghomi, S. Moharrmipour and M. Nasserui. 2010. Chemical characterization of volatile components of *Tagetes minuta* L. cultivated in South West of Iran by nano scale injection. Digest J. Nanomat. Biostruct. 5(1): 101-106.

Mohamed, M. A. H., P. J. C. Harris and J. Henderson. 1999. An efficient in vitro regeneration protocol for *Tagetes minuta*. Plant Cell, Tissue and Organ Cult. 55: 211- 215.

Naqinzhad, A. and S. S. Mehrvarz. 2007. Some new records for Iran and flora Iranica area collected from Boujagh National Park, N. Iran. Iran. J. Bot. 13(2): 112- 119.

Neher, R. T. 1968. The ethnobotany of *Tagetes*. Eco. Bot. 22: 317-325.

Obongoyai, B. O., S. O. Waga and G. Odhiambo. 2010. Phytotoxic effect of selected crude plant extracts on soil borne fungi of common bean. African Crop Sci. J. 18(1): 15- 22.

Osman, H.A., A.Y. Al- Gindi, H.S. Taha, A.A. Al-Kazzaz, M. M.A. Youssef, H.H. Ameen and A.M. Lashein. 2008. Biological control of root knot nematode *Meloidogyne incognita*: 2- Evaluation of the nematicidal effects of *Tagetes erecta* tissue culture under laboratory and greenhouse conditions. Egypt. J. Phytopathol. 35(1- 2): 33-44.

Qureshi, R. A., M. A. Ghufran, S. A. Gilani, K. Sultana and M. Ashraf. 2007. Ethnobotanical studies of selected plants of Sudhan Gali and Ganga Chotti Hills, District Bagh, Azad Kashmir. Pak. J. Bot. 39(7): 2275- 2283.

Scrivanti, L. R., M. P. Zunino and J.A. Zygadlo. 2003. *Tagetes minuta* L. and *Schinus areira* L. essential oils as allelopathic agents. Biochem. Sys. Ecol. 31: 563-572.

Shahzadi, I., A. Hassan, U. W. Khan and M. M. Shah. 2010. Evaluating biological activities of the seed extracts from *Tagetes minuta* L. found in Nothern Pakistan. J. Med. Plant Res. 4(20): 2108-2112.

Takhtajan, A. 1997 Diversity and classification of flowering plants. Columbia University Press, New York.