

A NEW GENERIC RECORD OF ASTERACEAE (*SOLIVA ANTHEMIFOLIA* (JUSS.) SWEET & *SOLIVA PTEROSPERMA* (JUSS.): ADDITION TO THE ALIEN INVASIVE FLORA OF PAKISTAN

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Abstract

The genus *Soliva* of family Asteraceae is first time reported for the flora of Pakistan. *Soliva anthemifolia* (Juss.) Sweet and *Soliva pterosperma* (Juss.) Less have been reported first time growing as problematic weeds in the turf and natural areas of different regions in the Province Punjab, Pakistan. Both species are widely distributed and reported as major invasive weeds of turf as well as recreational parks. Recently, *Soliva anthemifolia* is also reported as emerging problematic weed in fodder crops and *S. pterosperma* has become a noxious invasive species of turf. A detailed description with illustrations, geographic distribution, phenology, invasive potential, economic importance and management approaches of both species are described.

Key words: *Soliva anthemifolia*, *Soliva pterosperma*, Invasive species, Turf weeds.

Introduction

Anthemideae is one of the largest groups in Family Asteraceae comprising almost 1,741 plant species (Bremer, 1993). The genus *Soliva* Ruiz et Pavon was reported first time from Chile in 1794 and consists of almost nine species (Ray, 1987). *Soliva* spp are annual, low growing species, native to South America but now become naturalized in many parts of the world especially in temperate areas. These species are generally present in parks, lawns and playing grounds (Webb, 1986). The genus *Soliva* in India and China is represented by one and two species, respectively. However in Pakistan, genus *Soliva* is not reported previously. Hence, it's a new generic record for the flora of Pakistan. This paper reports *Soliva anthemifolia* and *S. pterosperma* first time from different areas of the Punjab, Pakistan.

Soliva anthemifolia commonly known as Button bur weed, is a low growing annual herb, native to South America but geographically distributed to many regions of the world. It is reported from some islands of Japan (Kato, 2007), Nepal (Johsi & Gretzmacher, 1999), Texas (Nesom, 2009), Australia (c *et al.*, 1979), Taiwan (Boufford & Peng, 1993), New Zealand (Webb, 1987), China (Yuefeng *et al.*, 2002) and India (Bhattacharyya, 1963; Prakash *et al.*, 2009). In China, this plant was first time reported from Hong Kong in 1912. Later it was spread to many parts of China particularly in southern parts of the country (Zhenghao *et al.*, 2011). This stoloniferous herb is also well distributed in many parts of the India where the first report of its occurrence was published in 1963 from Northern districts of Uttar Pradesh (Bhattacharyya, 1963). After that, its distribution was extended to New Delhi (Dakshini *et al.*, 1973), Haryana (Kumar, 2001), Rajasthan (Singh & Shetty, 1987), Himachal Pradesh (Prakash *et al.*, 2009) and Jammu & Kashmir (Bhellum, 2013) showing its aggressiveness and invasiveness. It is very likely that this plant moved from India to Pakistan.

Soliva anthemifolia is recognized as one of the invasive alien species in China (Liu *et al.*, 2006; Qingwen *et al.*, 2010) and become a major weed of lawns in some cities of Guangxi (Yuefeng *et al.*, 2002). Recently its invasion and spread into the protected areas has been reported from Nanjishan Nature Reserve of Poyang Lake and Shengjin Lake National Nature Reserve of Anhui Province in China (Cheng *et al.*, 2009; Jie, 2015). It is also listed in the invasive alien species of Japan (Mito & Uesugi, 2004)) and classified as a noxious weed in Taiwan (Wu *et al.*, 2004b).

Crop fields and their production rate are also affected by the presence of this weed in some countries. For example, it is a very common weed of wheat fields in India (Gupta *et al.*, 2008) and Nepal (Dangol, 2013; Ranjit & Suwanketnikom, 2003). Some of the rice fields in China and Nepal are also manifested with this species (Johsi & Gretzmacher, 1999; Zhang *et al.*, 2014). In addition, *Soliva anthemifolia* is spreading very fast and invading the wetlands of Terai region in Nepal which may result in replacement of native wetland species in recent years (Siwakoti, 2006). Sulfosulfuron is also used for the suppression of both broadleaf and narrow leaf weeds in wheat fields of Nepal (Ranjit & Suwanketnikom, 2003). Different herbicides lactofen, cyhalofop-butyl, ethoxy-sulfuron and tribenuron are used for the effective control of *S. anthemifolia* in China (Yuefeng *et al.*, 2002).

In Pakistan, the species was first found growing in the lawns of Jinnah Garden, Lahore growing sparsely near shady and moisture places of public lawns during the winter season. Later on, it was also collected from the districts of Pattoki, Kasur and Sahiwal in the Punjab Province. *Soliva anthemifolia* is a winter annual plant species which develops clustered of heads near the base of plant, usually half embedded in the ground. In summer season, plant is dried and died due to water scarcity and high temperature. Numerous hairy achenes are produced in a single head which dispersed in summer after maturity.

The second species of *Soliva* reported here is lawn burweed, *Soliva pterosperma*. It is also a winter annual prostrate herb native to North-east Argentina, Uruguay and Southern Brazil (Healy, 1953) and introduced in many parts of the world. The species is characterized by its spiny winged achenes which are very small and produced in the heads. The size of plant is very small as it hides between the ground grasses cover and is not removed by grass trimming equipment. *Soliva pterosperma* was described from California, USA first time by Crampton (1954) and also reported as adventive species of New Zealand (Healy, 1953) and Taiwan in 1982. Later it become naturalized and recognized as a noxious weed in lawns and parks of Taiwan (Boufford & Peng, 1993; Wu *et al.*, 2004a). Lawn burweed is listed in the flora of China and in the checklist of western weeds (Hussey *et al.*, 2007). It was also reported from the Azore island in Portugal (Hansen, 1987). It is known as a serious weed in Mississippi, Louisiana and South Carolina of the USA (Webster *et al.*, 2001) and become a major problem of golf grounds and playing fields in Florida (Lawson *et al.*, 2002). Most recently, this herb was discovered from Iran in 2007 near the coastal line of Astara (Naqinezhad *et al.*, 2007). In Southern Australia, *S. pterosperma* is recognized as a common weed of turf grounds (James *et al.*, 1981). *Soliva sessilis* Ruiz & Pav. is considered as synonym of *S. pterosperma* in literature, although both are different in achene morphology, hence it becomes difficult to envisage its worldwide distribution precisely.

Different management approaches are used to get rid of this weed. For example, application of mixture of Mecoprop, 2,4-D and dicamba resulted in 95% suppression of *S. pterosperma* in the lawns and golf grounds of Florida (Lawson *et al.*, 2002). In USA, application of 0.5 lb/acre of isoxaben was very effective in controlling the lawn burweed at pre-emergence level in the turf grounds (Grant *et al.*, 1990). Other chemicals like picloram, ioxynil, dicamba and bromoxynil are also used for the control of *Soliva* spp in New Zealand (Matthews, 1972).

In Lahore, *S. pterosperma* was found abundantly during winter season in parks and gardens. Its peak growth season is from December to March in Lahore. The lawns and sports grounds are found to be highly infested with this weed in the recent few years. The plant species dies back in summer leaving behind its brown mature heads with its sharp and spiny achenes which can

puncture the human skin and cause irritation and discomfort to the people using these infested turf areas (Johnson, 1980).

Materials and Methods

Specimens of *S. anthemifolia* and *S. pterosperma* were collected from different areas of Lahore, Pattoki, Kasur and Sialkot during different field surveys in 2015-16 (Table 1). Once collected, necessary measurements and photographs of plants specimens were taken at each site in the field. Later, plant specimens of both plant species were brought back to the Ecology and Environmental Management Research Laboratory where morphological characters (both vegetative and reproductive) were recorded for each species. For accurate identification and study of the minute details (corolla, style, stamens, achenes, trichomes etc.), specimens were studied under the stereomicroscope. The specimens of both species were preserved and submitted to the MS Zahoor Herbarium, Department of Botany, University of the Punjab, Lahore.

Results

Soliva anthemifolia (Juss.) Sweet

Description: annual forb, stemless initially, prostrate stems up to 15 cm long, stoloniferous, adventitiously rooting beneath head. Leaves in rosette, alternate, 5-15 cm long and 1-2.5 cm wide, leaflets 2 or 3-pinnatisect sparsely hairy on both surfaces, dense hairs near base, petiole 2-4 cm long, leaf sheathing base present. Flower heads present at base of stem, mostly clustered in centre (1-10 heads), 7-11 mm in diameter, sessile, fruiting head somewhat larger, globular, 8-13 mm in diameter and 3-4 mm in height. Disk florets 7-8 flowers, tubular, 1.5-2 mm long, bisexual but functionally male, sterile, 3-lobed yellowish corolla, style capitate at apex, 3 stamens; ray florets small, numerous, pistillate, fertile, villous near style, green, without corolla, curved forked style. Involucres bracts, green, in 2 -3 rows, 10-15 bracts in each row, 2-3 mm long, hairy. Achenes narrow, 3 mm long and 1mm wide, dark brown centre with light brown lateral corky wings, wrinkled margins, white long hairs at apex, 2 mm long, spine soft with 2-3 mm length (Figs. 1a-1d).

Table 1. Collection of plant specimens from different regions of the Punjab, Pakistan.

Plant species	Plant status	Location	Coordinates	Habitat
<i>Soliva anthemifolia</i>	Invasive	University of the Punjab, Quaid-e-Azam Campus, Lahore	31°29'45.45"N 74°17'39.87"E 690 ft	Turf grounds
		Bagh-Jinnah, Lahore	31°33'13.52"N 74°19'49.42"E 703 ft	Recreational area, lawns and playing grounds
		Jhok Reserve Forest, Lahore	31°26'27.67"N 74° 8'6.86"E 656 ft	Reserved forest
		Government postgraduate College ,Sahiwal Ladies Park, Faisal Colony, Pattoki and fields in Kasur	30°40'37.44"N 73° 5'35.27"E 542 ft 31° 1'8.65"N 73°50'56.51"E 640 ft	Lawns, playing grounds Recreational Park and Berseem fodder crops
<i>Soliva pterosperma</i>	Invasive	University of the Punjab, Quaid-e-Azam & Allama Iqbal Campus Lahore	31°29'45.45"N 74°17'39.87"E 690 ft	Turf grounds, playing grounds
		Bagh-Jinnah, Lahore	31°33'13.52"N 74°19'49.42"E 703 ft	Recreational area, lawns and playing grounds
		Govt. College of Science, Wahdat Road, Lahore	31°30'31.21"N 74°17'44.59"E 689 ft	Turf grounds
		Ladies Park, Faisal Colony, Pattoki	31° 1'8.65"N 73°50'56.51"E 640 ft	Recreational Park



Fig. 1. *Soliva anthemifolia* habit (a) plant showing its dissected leaves and central head having disk and ray florets along with bracts (b) clustered capitula showing numerous achenes spine (c) mature achenes showing their villous apex and soft spine (d).

Common name: Button burweed, Dwarf jojo, Button onehunga weed

Flowering period: Winter to spring (November to April in Pakistan)

Native region: South America

Habitat: Lawns, moist places, along watercourse, crop field, disturbed sites, wetland areas. It is seen that the plant usually grows in association with *Cynodon dactylon* L., *Soliva pterosperma* (Juss.) Less, *Lepidium didymus* L., *Oxalis corniculata* L., *Gnaphalium indicum* L., *Mazus pumulis* (Burm. f.) Steenis.

Synonyms: *Gymnostyles anthemifolia*, *Gymnostyles mutisii*, *Soliva mutisii*

Similarity with other species: *Soliva anthemifolia* is often confused with *Lepidium didymus* L. due to similarity in their leaves and rosette form but it is differentiated from *L. didymus* due to its inflorescence. The inflorescence of *L. didymus* is in the form of dense

raceme but *S. anthemifolia* bears inflorescence in the form of capitulum. Another closely related and similar species is *Soliva stolonifera* (Brot.) R.Br. ex G.Don but it differs from *S. anthemifolia* in its achene morphology. Achinal wings of *S. stolonifera* are pointed laterally near apex.

***Soliva pterosperma* (Juss.) Less.**

Description: Prostrate annual small forb. Procumbent stem, spreads up to 15 cm, well branched (usually 5-6) and ascending, pubescent throughout. Leaves in rosette, emerge radically from each stem, 2-5 cm long and 0.5-1 cm wide, alternate, leaflets tripinnatifid to tripinnate with numerous hairs at both surfaces (Fig. 2a), petiole widen at base, leaf sheath present. Flower heads present in leaf axils, 5-6 mm in diameter, 3 mm in height, solitary, sessile, never clustered (Fig. 2b). Ray and disk florets present; disk florets in center, 6-7 tubular flowers, 1.5-2 mm long, hermaphrodite but sterile, functionally male, 4-

lobed whitish green corolla, style capitate, 4 stamens; ray florets in many series, fertile, up to 25 greenish pistillate flowers, without corolla, forked persistent style become spinose at maturity. Involucral bracts involucre, green, in 2-3 whorls (Fig. 2b), 5-6 bracts in each whorl, unequal in size 2-8 mm long, pilose on abaxial surface, bract margin ciliated. Fruiting head somewhat larger, globular, 5-8 mm in diameter and 3-4 mm in height Fig. 2c) Achenes winged, obovate, pubescent, 3 mm in length, wing lateral and bilobed, upper lobe 4-5mm, lower lobe 2mm wide, style become spiny at maturity, with two other spines on upper lobe of achinal wings (Fig. 2d).

Common name: Jo Jo weed, Bindi weed, Onehunga weed

Flowering period: December to March in Pakistan

Native region: South America

Habitat: Damp places, grounds, parks, sports fields, roadsides, coastal areas. This plant species is usually found growing in association with *Oxalis corniculata* L.,

Malvastrum coromandelianum (L.) Garcke, *Medicago polymorpha* L., *Cotula australis* (Sieber ex Spreng.) Hook. f., *Lepidium didymus* L., *Cynodon dactylon* L. and some other common grasses.

Synonym: *Gymnostyles pterosperma*

Similarity with other species: *Soliva pterosperma* is often confused with *S. sessilis* and *Soliva valdiviana* Phil. The size of plants, leaves shape and spiny tips of achenes all look same but differ in the achene's morphology of three species. Achinal wings of *S. pterosperma* are deeply notched as compare to *S. sessilis* which have entire wings and achenes of *S. valdiviana* are wingless. Due to very close similarities, Thompson (2007) suggested that *S. pterosperma* and *S. sessilis* are the extreme variations of a single species. In field, leaves of *S. pterosperma* also look similar to *Cotula australis* at initial growth stages but *C. australis* does not produce sessile heads like *S. pterosperma* and achenes of both species also look differ (Fig. 3).

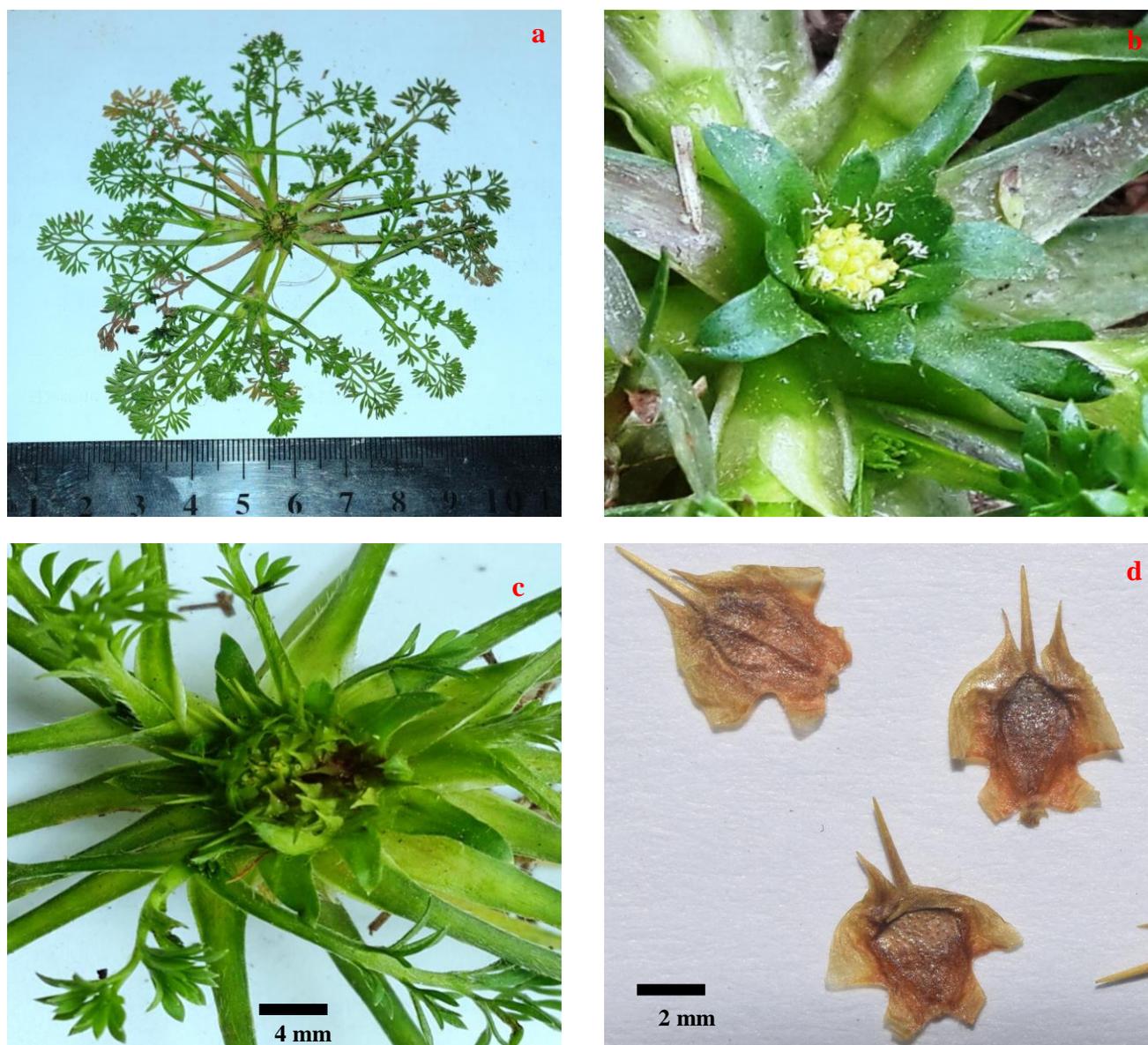


Fig. 2. *Soliva pterosperma* plant showing its branching pattern and dissected leaves (a) flowering head of *S. pterosperma* showing white styles surrounded by its involucre bracts (b) Fruiting head showing spines of achenes (c) closeup of lobed achenes (d).

Table 2. Comparative morphology of *S. pterosperma* and *S. anthemifolia*.

Characteristics	<i>Soliva anthemifolia</i>	<i>Soliva pterosperma</i>
Plant size	15-30 cm	5-15 cm
Leaf size and shape	5-15 cm long and 1-2.5 cm wide, petiole not widen at base, form rosette	2-5 cm long and 0.5-1 cm wide, petiole widens at base, form rosette
Bracts	Small and equal in size (2-3mm), 10-15 bracts in each whorl, margins green, curved outside	Large and unequal in size (2-8 mm), 5-6 bracts in each whorl, margins green, curved outside
Capitulum size	6-13 mm diameter	5-6 mm diameter
Capitulum position	Sessile, head present at the base of plant, often clustered in centre	Sessile, head solitary, present in centre and leaf axils, never clustered at base
Florets	Disk florets; 7-8, with 3-lobbed corolla, capitate style. Ray florets; villous at apex, spine soft at maturity	Disk florets; 5-7, with 4-lobbed corolla, capitate style. Ray florets; not villous at apex, spine hard at maturity
No. of stamens	3 stamens	4 stamens
Achene shape and size	Achene longer than wider, wing entire with corky margins, achene villous at apex	Achene wider than longer, lobed winged seed, hairy body but not villous at apex



Fig. 3. Difference in morphology of achenes of two species, *S. pterosperma* (top) and *S. anthemifolia* (bottom).

Discussion

Soliva anthemifolia and *Soliva pterosperma* are first time reported from Pakistan. Both species were generally found growing in the public parks, lawns and playing grounds within the turf grasses. The species start germination in winter till spring mostly in turf areas and die in summer when moisture is in limited supply. Both *Soliva* species are non-native, newly introduced into Pakistan and now naturalized or become invasive in Pakistan. The general mode of reproduction of these species is through seeds which are produced in large quantities and deposited in the soil after dispersal. So it is difficult to eradicate them completely through physical treatments (mowing, cutting, hand pulling).

Soliva anthemifolia propagates and reproduce only by its seeds. Many capitula are produced on a single plant and each capitulum contains more than 40 achenes which are very small, dispersed easily at maturity and buried in the soil. Its seeds are spread by movement of air and water and by human activities (Zhenghao *et al.*, 2011). Recently, *Soliva anthemifolia* has been reported as a serious emerging weed of Berseem (*Trifolium alexandrinum* L.) fodder crop in Pattoki and Kasur regions. Through its rosette habit, it suppresses the fodder plants in surroundings and reduces the growth of pasture plants greatly (Mr. Ahmed Personal observation). It is regarded as the invasive plant species of China and in

India and Nepal it has become a crop weed. It is a dominant weed of the wheat crop in Nepal where farmers are using straw mulching for suppression the this weed and restoration of wheat yield in the mid hills of Nepal (Ranjit *et al.*, 2009). As this plant has attained a status of an invasive species and crop weed in the neighbouring countries (India and China) it presents an alarming situations in Pakistan also where efforts are needed to contain the spread of this plant to new areas and localized populations should be eradicated.

Soliva pterosperma is a noxious weed of lawns, parks and playing grounds in many parts of the world and its presence results in serious negative impacts up on biodiversity and human health. It decreases the usefulness of turf grounds and makes the playing surface uneven due to its head and seeds (James *et al.*, 1981). Aesthetic appeal of gardens is also reduced because people are unable to walk bare footed on grounds due to the presence of its prickly seeds which can penetrate in the skin. In turf and public play grounds, the weed becomes most problematic in the spring and early summer seasons when its prickly seeds are matured. Human activities are the major source of its seed dispersal because its achenes have sharp spines which can attach to the shoes, clothes and socks of people to travel long distances. Animals also aid in the movement of its seed.

In some parts of Australia, *Soliva pterosperma* is reported to cause bindii dermatitis which is a skin disease characterized by discrete erythematous papules with puncta produced on the knees, palms, elbows and soles. It is well pronounced in the children involved in outdoor activities. The spine of dried achene pierces deeply into the skin and sometimes breaks off (Commens *et al.*, 1984). The actual allergic chemical responsible for bindii dermatitis is not known but fine hairs on spine are seen under microscopic observations which could be a source of disease as sesquiterpene lactones are found in the fine trichomes of members of Asteraceae family (Rodriguez *et al.*, 1976; Schmidt, 1986).

When the turf gardeners were asked about the invasion history, problems caused and management strategies in place for these two species, most of them were of viewed that these species are relatively new introductions, very problematic and difficult to distinguish from each other. The best control strategy is to remove them through hoeing or wait till the onset of summer season so that these species

complete their life cycle naturally. Due to the rosette habit it is difficult to mow these weeds which often escape the mowing. The comparative morphology of both species is presented in Table 2.

Soliva anthemifolia and *S. pterosperma* are winter annuals, low growing herbs and known as common weeds of turf areas worldwide. The presence of weeds affects the growth of turf grasses because they compete for space, moisture, light and nutrients. The weeds also decrease the aesthetic value of turf grounds due to their coloured flowers and habit and specially the noxious weeds such as *Soliva pterosperma* cause discomfort to the people walking in the grounds. Therefore, the effective management practices of turf grounds are mandatory to make the ground cover even and beautiful. Furthermore, these annual herbs are fast growing, colonize the area rapidly therefore it is necessary to monitor their spread and movement to other areas in Pakistan. If measurements are not taken, then these species could become invasive in other parts of Pakistan and affect the biodiversity, human health and agricultural systems.

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