Journal Crop and Weed, 11(2):47-54(2015)

Botanical description, eco-physiology and control of *Trianthema portulacastrum* Linn.

G. GADDEYYA AND P. K. RATNA KUMAR

Centre of Advanced Study (UGC-SAP-CAS-I), Department of Botany
College of Science &Technology, Andhra University

Received : 24.07.2015, Revised : 07.10.2015, Accepted : 18.11.2015

ABSTRACT

Trianthemae portulacastrum L. (Family: Aizoaceae), commonly known as horse purslane is a troublesome weed in Indian agriculture. It is known as Hand Qooqi in Arabic, Dewasapt in Persian and Horse purslane in English. A field study was conducted at crop fields of Visakhapatnam district in Andhra Pradesh to screening of agents to control weed population by means of eco-friendly approach i.e., biological control. During field study severe infection on horse purslane was examined and the foliar disease symptoms represented as round to irregular maroon spots with dark borders. The pathogen allied with the infection of horse purslane was isolated from infected parts of the weed and the isolate was confirmed as Gibbago trianthemae Simmons. The disease severity of the isolate was examined by means of invitro study and the results revealed the pathogenicity of the isolate. The findings of research suggested that the isolate, G. trianthemae is highly virulent to host weed and recommended for further studies as an effective biological control agent.

Keywords: Biological control, *Gibbago trianthemae*, *Trianthemae portulacastrum* L.

A weed is a plant growing where it is not desired (Klingman and Noordhoff, 1961). Weeds are very common, dominant and wide spread in the crop fields. Weed interference is one of the most important factors to decrease the yields of all crops. Weeds are the oldest problem in agriculture since about 10000 B.C. and have represented one of the main limiting factors in profitable crop production (Avery, 1997). They are the most complex and serious problems in natural resource management. Weeds cause significant losses each year in agriculture, forestry, and aquaculture, also affect the health, causing allergies and other health hazards (Handerson and Anderson, 1996). Apart from quantitative losses caused by weeds due to competition for water, light, space and nutrients, they also cause qualitative indirect damage due to unitary seed reduction, contamination of seeds, slowing of tillage and harvesting practices (Anderson, 1983; Asthon and Monaco, 1991).

In India, many alien species such as *Parthenium hysterophorus* L. *Lantana camera* L. and *Phalaris minor* Retz. have significant negative impacts on the ecosystems, economic systems and human health because of their high reproductive capacity, diverse dispersal mechanisms and colonization ability in new habitats, capacity to out-compete native species (Bhowmik, 2014). Profuse growth of several weeds with high invasive capacity coupled with poor fertility status often becomes limiting factor in crop cultivation. Aggressive growth of the broadleaved weeds with high invasion potential becomes an important constraint in crop cultivation during *Rabi* season. Therefore, proper weed management is essential to make the cropping economical (Rahaman and Mukherjee, 2008).

Trianthema portulacastrum L. (Family: Aizoaceae) is one of the serious weeds of Indian agriculture. It is known as Hand Qooqi in Arabic, Dewasapt in Persian and Horse purslane in English. It is an annual herb which spreads on the ground in circle and not more than 4-6 ft in length, commonly found in moist soil and near the river and pound. The plant is found in tropical and subtropical countries of the world, and almost throughout India as a weed in cultivated and wastelands (Ghani, 1929; Kirtikar and Basu, 2003). *T. portulacastrum* is an annual indigenous plant of South Africa. It is widely distributed in South East and West Asia, Africa and Tropical America and extensively distributed in India, Srilanka, Baluchistan and it is one of the serious weeds of maize, sugarcane, cotton and summer vegetables in Pakistan (Kirtikar and Basu, 2003; Nayyar *et al*., 2001). In India and neighbouring countries, it is among the most common weeds during summer season in the major field crops such as pulses, cotton, sugarcane, direct-seeded rice and maize. Its infestation in cotton, maize and direct-seeded rice especially in rainy season is a matter of great concern and could reduce crop yields by 32-60% (Baylan and Malik, 1989). Two biotypes of *T. portulacastrum* occur in India. Typical description refers to red biotypes that form larger plant and reddish stems with long internodes and green bracts and pods and white sepals. The red type is more abundant, but the green one appears earlier in the season. It comprises about 17 species and is closely related to *Sesuvium* and *Cypselea*. These three genera are thought to link the Aizoaceac to the Portulacaceae.

Email: mycology.au@gmail.com

Keeping the above concepts in mind, the biological and ecological aspects of *T. portulacastrum* were studied in agricultural fields, where the abundant growth of the weed is established. We hope that this study will encourage farmers, agronomists and researchers for the effective management of horse purslane in view of the conservation of natural resources and biodiversity.

MATERIALS AND METHODS

Field study and sample collection

The field observations on infestation of horse purslane were conducted in different agricultural crops classifieds as food crops, pulses, vegetable crops, oil crops and commercial crops at Vishakhapatnam district during 2012-2013. The weed infestation was studied using random sampling method in all agricultural fields and some valuable information about the weed infestation was gathered from local farmers. Field trips were conducted depending on climatic conditions to study the weed infestation in agriculture fields as well as to determine the loss of production due to weeds. Each field trip includes 5-10 days covering a particular area, during various seasons. Fields were surveyed at three to five weeks after planting of different crops. All the weeds encountered in the field sites of the crop fields were carefully identified and collected for further studies.

Taxonomic identification of the weed

The taxonomic features of the weed were critically studied using relevant literature such as *Flora of British India* (Hooker, 1872-1897), *Flora of Presidency of Madras* (Gamble and Fischer, 1915-1935), *The grasses of Burma, Ceylone, India and Pakistan* (Bor, 1960), *Flora of Andhra Pradesh* (Pullaiah and Chennaiah, 1997), and District Floras of Srikakulam (Rao and Sriramulu, 1986), Visakhapatnam (Rao and Kumari, 2002) and Vizianagaram (Venkaiah, 2004).

Family: Aizoaceae

Annual or perennial herbs; Leaves simple, often fleshy, opposite, alternate or falsely whorled; stipules scarious or 0; Flowers regular, hermaphrodite or rarely polygamous, in cymes or fascicles, rarely solitary. Calyx of 4-5, sepals free or rarely adnate to the ovary, usually persistent; Petals usually 0, when present small. Stamens perigynous or hypogynous, definite or indefinite, sometimes with staminodes; filaments free or connate; anthers oblong. Ovary free, 2-5 celled, syncarpous or rarely apocarpous; ovules many in each carpel, axile or solitary basal. styles as many as the the carpels. Fruit usually capsular, dehiscing loculicidally or circumscissly, some times of indehiscent cocci. Seeds many or 1 in each carpel, usually reniform, compressed; testa membranous or crustaceous, often pitted or crustaceous, often pitted or tuberculate; albumen mealy, surrounded by the curved or annular embryo.

Fruit-syncarpous;
Calyx tube elongate; stamens inserted on the calyx tube;
Capsule circumsciss;
Petals 0;
Ovary and capsule 1-2 celled.....*Trianthema*
Leaves obovate;
Flowers solitary, sessile, sheathed by the base of the petiole;
Style 1; stamens 10 to 15;
Capsule top mitriform, enclosing at least 1 seed, the lower part 3-5 seeded; Seeds with concentric muriculate lines.....*T. portulacastrum*

Protocol for management and eco-physiology study of *T. portulacastrum*

Inoculation of greenhouse plants (in vitro)

Healthy seeds and seedlings of horse purslane (*T. portulacastrum* L.) were collected from agricultural fields during the field study. The collected seeds were dried and maintained in healthy condition without any contamination. For further studies, the test plants were grown by sowing the seeds in 25x15 cm diameter plastic bags containing sterilized, black soil. The plotted plants or seedlings of the weed were maintained in a greenhouse with a 12 h light/dark photoperiod. Proper care was taken to avoid pre-infection of test plants by other contaminants before inoculation of pathogen spores. For epidemic studies, test plants were maintained in replicates for each experiment.The healthy greenish plants of horse purslane were used for the assay of the infection process. Inoculations were made by hand sprayer after sunset (between 6 - 7 PM) to avoid drying of the spores. The plants with young leaves (at 6-8 leaf stage) were inoculated with an optimal conidial suspension ($5x10^4$ spores ml^{-1} + 0.02% Tween 20) of *Gibbago trianthemae* Simmons. The spore treated plants were enclosed with sterile polythene bags for 48 h to maintain 100% humidity for feasibility of the spore germination on leaf surfaces. Control plants were treated in the same manner except that they were sprayed with sterile water + 0.02% + Tween 20. The adjuvant Tween-20 was applied as a wetting agent. After inoculation experiment, leaves were collected from both test plants (spore treated) and control plants (water treated) at 10 days of intervals to examine pathogenicity of the isolate applied.

Design of the experiments

For *in vitro* experiments, both the control plants and test plants were maintained in five replicates. Each replicate contains 10 bags/pots (two plants per one pot). A total of 200 plants (100 control plants and 100 test plants) maintained for each experiment. An average of 60 leaves examined in each replicate for the assessment of disease severity of the test pathogen. The disease severity of *G.trianthemae* Simmons was examined on weed plants, growing in the greenhouse by applying spore inocula. The control group of horse purslane weed was treated with distilled water + 0.02 % Tween-20. The disease severity was examined at 10 days of interval and the leaf spot disease was evaluated using Standard Area Diagram of infected leaves. The quantitative data on disease severity (DS) was calculated using the analysis of variance.

Disease severity

Disease severity is the area of the sampling unit (leaf) showing symptoms of disease. It can be expressed as a percentage or proportion (Nutter *et al.,* 1991). Disease severity is expressed as disease index (DI) or percent disease index (PDI).

The Percent Disease Index is expressed by the following the formula (Chaube and Singh, 1991):

$$\text{Percent Disease Index} = \frac{\text{Sum of all ratings}}{\text{No. of leaves observed} \times \text{Highest rating}} \times 100$$

Where, the sum of all numerical ratings was $(0 \times N_0) + (1 \times N_1) + (2 \times N_2) + (3 \times N_3) + (4 \times N_4) + (5 \times N_5)$, and N_0 is the number of leaves with the score 0, N_1 is the number of leaves with the score 1,… N_5 is the number of leaves with the score 5.

For the estimation of leaf area diseased, the whole leaf surface area was considered as 100 and thereby the infected area was determined by eye estimation for percent of disease index (PDI), *i.e.* severity. Disease intensity and severity was rated by visual observation and the infected leaves were scored using a 0- to 5-scale rating system (Ray and Hill, 2012). Using this rating system, a disease index (DI) was calculated (Chaube and Singh, 1991) per observations made at an interval of 10 d after treatment (DAT). For the assessment of disease severity, individual leaf ratings were taken into an account until the death of the weed.

Statistical analysis

The data were analyzed by mean, standard deviation and an analysis of variance (ANOVA) using the Microsoft Office Excel (Data Analysis Tool Pack-2007). The significance of the data was compared at the 0.05 level of significance.

RESULTS AND DISCUSSION

T. portulacastrum L. was identified as one of the serious weed at agricultural fields of Visakhapatnam district. Taxonomical and eco-physiological properties of the weed plant were observed during field study for the effective management of weed.

Scientific classification (Shivhare *et al.,* 2012)

Kingdom: Plantae
Sub Kingdom:Tracheobionta
Division:Spermatophyta
Sub Division:Magnoliophyta
Class:Magnoliopsida
Sub class:Caryophyllidae
Order:Caryophyllales
Family:Aizoaceae
Genus:*Trianthema* Linnaeus
Species:*Trianthema portulacastrum* L.

Botanical description of T. portulacastrum

Diffuse prostrate branched herbs, glabrous or papillose, thickened and flattened at the nodes. Leaves petioled, opposite, unequal, one of the lower pair much smaller than the other, entire, subfleshy. leaf blade obovate- orbicular, or oblong, 1.5-3.5 × 1-3 cm, subsucculent, purpulish on margins, base cuneate, margin entire, apex obtuse, apiculate, the petioles of each pair connected at the base by stipuliform membranous. Flowers small, white or bright pink, axillary, solitary in pouch or between forks of branches; bracts membranous as are the 2 bractioles. Calyx-tube short or long; lobes 5, coloured within, mucronate on the back near the tip. Petals 0. stamens 5, 10, or 15, inserted near the top of the calyx-tube. Ovary free, sessile, usually truncate at apex, 1-2 celled; ovules 1 or more in each cell, from a basal placenta; styles 1 or 2, papillose. Fruit a capsule, capsules circumscissile, glabrous, partly concealed in the petiolar hood; the upper part carrying away 1-2 seeds, the lower 2- many seeded. Seeds 2 or more, reniform, rough, with concentric muricate lines; embryo annular (Fig. 1).

Microscopic description (Anatomy)

Mature root shows anamolous secondary growth; cork 5 to 8 layered; secondary cortex narrow zone consisting of round to polygonal, tangentially elongated, thinwalled, parenchymatous cells, a few cells containing groups of prismatic crystals of calcium oxalate; below secondary cortex five concentric bands

of vascular tissue; vessels of varying sizes occurring along with xylem fibres and phloem; phloem composed of thin walled cells having intercellular spaces, a few cells containing prismatic crystals of calcium oxalate; a few rows of polygonal, thin walled, parenchymatous cells occur in rings; medullary rays prominent in middle of the cortical region and in the second or third vascular bundle ring; centre mostly occupied by a single vascular bundle strand with two isolated groups of phloem.

Seedlings

Enormous seeding capacity or very little dormancy allows the mature seed to germinate immediately thus, producing multiple generations in the same season. Cotyledons elliptic, have epigeal germination. Seeds of *T. portulacastrum* germinate between 20- 45°C, with an optimum at 35°C. More than 50% of fresh seeds germinate within 4–8 days of incubation. When stored under field conditions, germination increases during 7–8 months. The plant is propagated by seeds and stem cuttings very easily. Seedlings are erect but soon become prostrate. Cotyledons are linear and green.

Phenology

Flowering -June to October; fruiting -July to December. The production of flowers and seeds of *T. portulacastrum* starts 20 - 30 days after germination of the seeds.

Eco-physiology of T. portulacastrum

The field crops *viz.*, food crops, pulses, vegetable crops, oil crops and commercial crops in various agricultural regions of Vishakhapatnam district were heavily infested with horse purslane weed. The weed plant *T. portulacastrum* was popularly known as Ambatimadu/ Atikamamidi/ Galijeru in Andhra Pradesh and Telangana states. The weed infestation in crop fields was studied by random sampling method. The weed infestation was affected by the irrigation or water resources, agricultural practises and climatic conditions. The weed species inhabited at different crop fields were examined during pre -monsoon and post-monsoon seasons. During the field study horse purslane was heavily competing with agricultural crops such as paddy, jowar, maize, sugarcane, groundnut, brinjal, tomato and okra (Table 1). The maximum weed infestation was recognised in the vegetable crops such as okra, tomato, capsicum and ridge gourd. The sources like high irrigation and nutrients and soil factors were the main factors to the abundant growth of horse purslane.

Weed control by means of indigenous fungus

Diagnostic features of the isolate

The cultures inoculated with diseased spots of horse purslane on potato dextrose agar yield the pathogenic fungi *G. trianthemae* within three days of the experiment. After approximately 5 to 7 days of incubation, dark gray velvety mold growth was observed on culture plates. The observations under a light microscope by staining of mycelial fragments confirmed that conidiophores of the isolated fungus were stemphylioid in general appearance, simple, pale straw colored with 1- 4 transeptate and very slightly swollen at apex. Conidiophores solitary or 2-4, loosely fasciculate, erect, rarely distantly branched, simple with a single apical conidiogenous locus. *G. trianthemae* often proliferating by means of a secondary conidiophore that arises immediately bellow the apical cell of the existing conidiophores. Conidia initially solitary, smooth, broadly ellipsoid to broadly sub ovate-ellipsoid, beakless, pigmented (pale yellow brown) becoming transversely and longitudinally septate (1- 4 complete or partial transverse septa); apical cells swelling slightly and producing secondary conidia similar to initial ones. On the basis of these morphological and cultural characteristics the isolated pathogen was identified as *G. trianthemae* Simmons (Fig. 2) a phaeodictyoconidial fungus.

Disease intensity on green house plants

The leaf spot disease was initiated as round to oval straw colored spots with maroon margins at the initial stage on plants treated with $5x10^4$ spore/ml spore suspension of *G. trianthemae* Simmons. The typical symptoms were examined on test plants at 3 days after treatment (DAT) by means of Disease Rating Scale (Table 2). No symptoms were observed on control plants treated with sterile distilled water. After 24 hours of incubation of test plants, small pinpoint maroon colored spots examined on the surfaces of the leaves. These minute lesions on the leaves were the result of the penetration of the germ tube or infectious structures in host tissue. A significant infection rate (69.12 ± 2.94) was observed at 20 days after treatment (DAT) and the epidemic was increased timely with an increase of incubation period and various percentages of infection *viz.*, 80.20 ± 3.17, 89.26 ± 3.23 and 94.56 ± 2.82 on 30, 40 and 50 DAT respectively ($p<0.05$) was recorded on test plants (Table 3). The environmental conditions like 100% moisture, temperature, nutrients and incubation period enhances the rate of infection on host and in addition the susceptibility of the host plant and the virulence of the pathogen significantly increased the

rate of infection. The increase of incubation time offers the favorable conditions for spore germination and the development infection structures and mycelial development. The *Gibbago* (pathogen) - *Trianthema* (host) pathosystem revealed the virulence of the pathogen as a mycoherbicide to the host which causes severe endemic on leaves, petioles, stem and other propagules of the weed plant.

The pathogenicity of *G. trianthemae* evaluated on different life stages *viz.*, growth stage-1 (3-5 foliage), growth stage-2 (6-10 foliage), growth stage-3 (11-14 foliage) and growth stage-4 (15-20 foliage) of target weed (*T. portulacastrum* L.). Statistical analysis of the data on the inoculated plants, revealed that percent infection was highly significant ($p<0.05$) at various growth stages of the weed (Table 4). The highest percent disease index (PDI) was observed at growth stage-1 (95.5 ± 1.1) of the weed followed by growth Stage-2 (87.04 ± 2.0) growth stage-3 (78.9 ± 3.2) and growth stage- 4 (77.08 ± 2.4). The highest rate of infection (95.5%) and the severe damage were examined on susceptible plants after 40 days of spore inoculation. The early stage of the weed plant with 3-6 foliage, favors the germination and penetration of the conidia of *G. trianthemae*, the infective propagules of the pathogen. The destructive damage of leaves and stems was examined on the susceptible stage of the weed and causes 100% mortality of the weed within a short period.

Leaf spot disease

G. trianthemae Simmons causes leaf spot disease on horse purslane weed at favorable conditions and controls the huge number of weed population *in vitro* and *in vivo*. Symptoms on leaves initiated as small pinpoint lesions at the early stage of infection. At maturity of the disease, the lesions occurred on leaves and stems and examined as round to oval straw colored

Table 1: The frequency (%) of horse purslane in different crop fields of study area

Scientific name	Common name	F	FC	Weed status
Oryza sativa L.	Paddy/Rice	16.33	A	Occasional
Sorghum bicolor (L.) Moench	Jowar/Great millet	60.54	D	Common
Pennisetum glaucum (L.) R.Br.	Bajra/Pearl millet	70.00	D	Common
Zea mays L.	Maize/Corn	73.33	D	Common
Eleusina coracana Gaertner	Ragi/Finger millet	68.55	D	Common
Cajanus cajan (L.) Millsp.	Red gram/Pigeon pea	68.00	D	Common
Vigna mungo (L.) Hepper	Black gram	70.22	D	Common
Vigna radiata (L.) Wilczek	Green gram/Mung bean	36.55	C	Occasional
Macrotyloma uniflorum (Lam.) Verdc.	Horsegram	47.88	C	Occasional
Solanum melongena L.	Brinja/Egg plant	85.55	E	Common
Abelmoschus esculentus (L.) Moench	Okra/Ladies finger	78.66	D	Common
Lycopersicon esculentum Miller.	Tomato	82.25	E	Common
Capsicum annuum L.	Pepper/Capsicum	73.32	D	Common
Luffa acutangula(L.) Roxb.	Ridge gourd	74.55	D	Common
Arachis hypogaea L.	Ground nut/Pea nut	67.00	D	Common
Sesamum indicum L.	Sesamum /Gingelly	74.00	D	Occasional
Helianthus annuus L.	Sunflower	68.22	D	Common
Ricinus communis L.	Castor	10.00	A	Rare
Saccharum officinarum L.	Sugarcane	12.84	A	Rare
Gossypium arboreum L.	Cotton	68.00	D	Common
Nicotiana tabacum	Tobacco	21.55	B	Occasional
Corchorus olitorius L.	Jute	65.00	C	Common

Note: F= Total no. of quadrates in which the species occur X 100/ Total no. of quadrates studies Frequency Class (FC): A=1-20; B=21-40; C=41-60; D=61-80; E=81-100

Table 2: Disease rating scale used for the assessment of leaf spot on horse purslane

Disease rating scale	Disease description
0	No symptoms
1	1 to 10% of the leaf area covered by spots
2	11 to 25% of the leaf area covered by spots
3	26 to 50% of the leaf area covered by spots
4	51 to 75% of the leaf area covered by spots
5	≥ 75% of the leaf area covered by spots

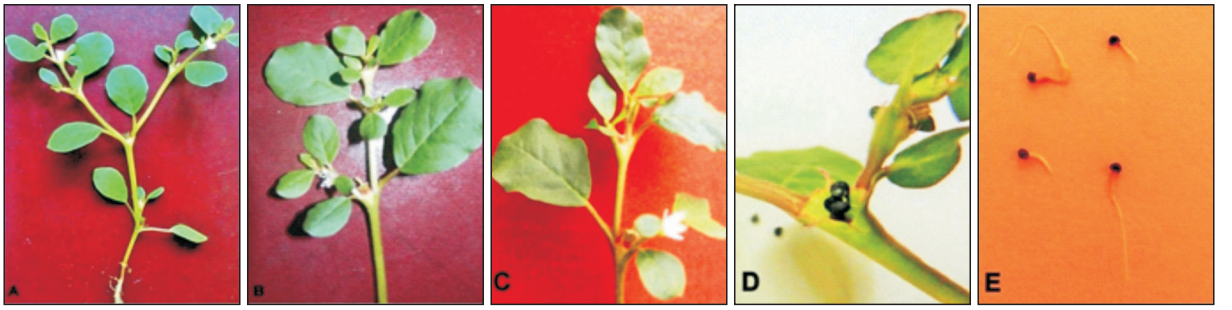

Fig. 1: Morphological characteristics of *T. portulacastrum* (A) whole plant (B) twig (C) flowering (D) seeds (E) germinated seeds

Fig. 2: Biological control of horse purslane by means of fungal pathogen (A) Leaf spot disease (B) Gibbago trianthemae, the causal agent of leaf spot

spots with dark maroon borders (Fig. 2). Spots expanded with the passage of time and became sunken and cause the loss of tissue. As the disease progressed, affected leaves became chlorotic and dried up causing severe defoliation and withering of stems.

Table3: Disease intensity of *G.trianthemae* on greenhouse plants at different days of incubation

Concentration of inoculum	Days after treatment(DAT)	PDI (Mean± SE)
5×10^4 ml^{-1} + 0.02 (Tween-20)	20	69.12 ± 2.94 [a]
30	80.20 ± 3.17	
40	89.26 ± 3.23	
50	94.56 ± 2.82	

Note: a = Mean value (n=5) ± Standard Error; significant at the probability level of p<0.05

Table 4: Disease intensity of *G. trianthemae* on horse purslane at different growth stages

Concentration of inoculum	Growth stage of the weed	PDI (Mean± SE)
5×10^4 ml^{-1} + 0.02 (Tween-20)	Stage 1	95.5 ± 1.1 [a]
Stage 2	87.04 ± 2.0	
Stage 3	78.9 ± 3.2	
Stage 4	77.08 ± 2.4	

Biological control of T. portulacastrum (horse purslane): the future prospect

Despite continuous research and extension efforts made in weed science, weeds continue to cause considerable losses to farming. As per the available estimates, weeds cause up to one–third of the total losses in yield, besides impairing produce quality and various kinds of health and environmental hazards (DWSR, 2014). In India, horse purslane has been reported in the states of Uttar Pradesh, Punjab, Haryana, Rajasthan and Delhi and considered as a number one problematic terrestrial weed by virtue of its infestation in various agricultural and vegetable crops such as mustard, maize, pigeon pea, mung bean, potato, onion, cotton, soybean, pearl millet and sugarcane, especially during the rainy seasons (Balyan and Bhan, 1986; Simmons, 1986).

Horse purslane (*T. portulacastrum* L.) is an introduced terrestrial weed in India but it has become a noxious weed due to competition for yields in various agricultural and vegetable crops such as mustard, maize, pigeon pea, soybean, potato and onion crops in Northern India. Up to 60-70% infestation of this weed has been reported in pigeon pea and soybean fields and 80-90% in maize and brassica fields (Aneja *et al.,* 2000). Balyan and Malik (1989) reported that horse purslane is a strong competitor, reducing the yield of mung bean by 50 to 60% when left untreated. Significant losses in maize, soybean and peanut yield are also attributed to this weed (Grichar 1993, 2008; Hazra *et al.,* 2011; Saeed *et al.,* 2010). Allelopathic growth inhibition of crop plants from horse purslane infestation has also been reported (Sethi and Mohnot 1988). Umarani and Selvaraj (1995) reported on the negative allelopathic effects of extracts of horse purslane on seed germination, seedling vigour, and productivity in soybeans. High seed production and

short dormancy allow the mature horse purslane seed to germinate rapidly, thereby producing multiple generations in a single season. Consider all these negative aspects of horse purslane, the effective control methods have needed individually or by the integration of two or more control methods.

Exploitation of microorganisms especially plant pathogenic fungi is now emerging as an effective and eco-friendly alternative to conventional methods of weed control (Aneja, 2009; Aneja and Kaushal, 1998; Charudattan, 1991). Biological control of weeds has advantages over mechanical and chemical methods of weed control, as unlike chemical weedicides, these can be specific to the weed and do not lead to residue problems and accumulation of toxic pollutants in the soil or underground water (Hasan, 1980). The herbicidal potential of *G. trianthemae* Simmons, a foliar fungal pathogen of horse purslane has been reported as a promising biological control agent to its host weed (Mitchell, 1988; Aneja and Kaushal, 1998; Kumar and Gaddeyya, 2014). The present study revealed the host specificity, virulence and mycoherbicidal potential of *G. trianthemae* Simmons against horse purslane.

Our findings revealed that *G. trianthemae* is a highly virulent pathogen on horse purslane weed and host specific. Our results revealed that the horse purslane weed was controlled by the fungal pathogen *G. trianthemae* Simmons at the field as well as greenhouse conditions. The fungus *G. trianthemae* causes destructive damage on its host plant at favorable conditions such as the availability of moisture, the susceptible stage of the host plant, suitable climatic conditions and soil environment. Our research enlightening the mycoherbicide properties of *G. trianthemae* Simmons and concluded it is an effective biocontrol agent to the target weed. The quantitative data revealed the biocontrol potential of *G. trianthemae* as a successful mycoherbicide against horse purslane. The extensive work is required to study pathogenicity, adaptability, and dispersal and survival efficiency of the pathogen for the development of a commercial mycoherbicide. Our findings may explore the knowledge of the weed biology and helps to management of this weed for sustainable agriculture.

ACKNOWLEDGEMENTS

Authors are very grateful to the funding agency University Grants Commission, New Delhi for the constant encouragement through UGC-SAP-CAS-I Programme.

REFERENCES

Anderson, W.P. 1983. *Weed Science: Principles*. 2nd ed., West Publishing Co., St. Paul, MN.

Aneja, K. R. 2009. Biotechnology: An alternative novel strategy in agriculture to control weeds resistant to conventional herbicides. In: *Antimicrobial Resistance from Emerging Threats to Reality* (Eds., Lawrence, R., Gulati, A.K. and Abraham, G.), Narosa Publishing House, New Delhi, pp. 160-73.

Aneja, K. R. and Kaushal, S. 1998. Occurrence of *Gibbago trianthemae* on horse purslane in India. *J. Biol. Cont.,* **12 :** 157-59.

Aneja, K. R., Khan, S.A. and Kaushal, S. 2000. Management of Horse purslane (*Trianthema portulacastrum* L.) with *Gibbago trianthemae* Simmons in India. In: *Proc. Xth Int. Symp. Bio. Control of Weeds* (Ed., Spencer, N. R.), 4-14 July 1999, Montana State University, Bozeman, Montana, USA, pp. 27-33.

Asthon, F.M. and Monaco, T.J. 1991. *Weed Science: Principles and Practices*. 3rd ed., John Wiley and Sons, New York.

Avery, D.T. 1997. Saving the planet with pesticides, Biotechnology, European Farm Reform, *Proc. Brighton Crop Prot. Conf. Weeds*., **1** : 3-18.

Balyan, R.S. and Bhan, V.M. 1986. Emergence, growth, and reproduction of horse purslane (*Trianthema portulacastrum* L.) as influenced by environment conditions. *Weed Sci*, **34**:516-19.

Balyan, R.S. and Malik, R.K. 1989. Control of horse purslane and barnyard grass with post-emergence herbicides in mungbean (*Vigna radiata*). *Indian J Weed Sci*, **37**: 695-699.

Bhowmik, P. C. 2014. Invasive weeds and climate change: past, present and future. *J Crop Weed*, **10:**345-49.

Bor, N. L. 1960. *The Grasses of Burma, Ceylon, India and Pakistan*. Peragmon Press, Oxford.

Charudattan, R. 1991. The mycoherbicides approach with plant pathogens. In: *Microbial Control of Weeds* (Ed., TeBeest, D.O.), Chapman and Hall, New York, pp. 24-57.

Chaube, H.S. and Singh, U.S. 1991. *Plant Disease Management: Principles and Practices*. CRC Press, Boca Raton, Florida.

DWSR. 2014. *Vision 2050*. Directorate of Weed Research, Jabalpur, M.P, India.

Gamble, J.S. and Fischer, C.E.C. 1915-35. *Flora of the Presidency of Madras*. London Repr. Ed. 1957, Calcutta, India.

Ghani, N. 1929. *Khazainul Advia. Idara Kitabus Shifa* (YNM), New Delhi. pp. 231.

Grichar, W. J. 1993. Horse purslane (*Trianthema portulacastrum* L.) control in peanut (Arachis hypogaea). *Weed Tech.*, **7:**570–72.

Grichar, W. J. 2008. Herbicide systems for control of horse purslane (*Trianthema portulacastrum* L.), smellmelon (*Cucumis melo* L.), and Palmer amaranth (*Amaranthus palmeri* S. Wats) in peanut. *Peanut Sci*, **35**:38–42.

Handerson, M. and Anderson, J.G. 1996. *Common Weeds of South Africa.* Memoirs of the Botanical Surveys of South Africa N 37, Department of Agricultural Technical Services, Republic of South Africa.

Hasan, S. 1980. Plant pathogens and biological control of weeds. *Rev. Plant Path,* **59:** 349-56.

Hazra, D., Das, T. K. and Yaduraju. N. T. 2011. Interference and economic threshold of horse purslane (*Trianthema portulacastrum* L.) in soybean cultivation in northern India. *Weed Biol. Manag,* **11:**72–82.

Hooker, JD. 1872-1897- *Flora of British India*. Published under the authority of the secretary of state for India in Council. London, Vol 7. L. Reeve & Co., 5 Henrietta Street, Covent Garden.

Kirtikar, K.R. and Basu, B.D. 2003. *Indian medicinal plants with illustrations*. Oriental Enterprises, Dehradun, 2nd ed. Vol. 5.

Klingman, G. C. and Noordhoff, L. J. 1961. *Weed Control; As a Science.* John Wiley & Sons Inc., New York.

Mitchell, J. K. 1988. *Gibbago trianthemae*, a recently described hyphomycete with bioherbicide potential for the control of horse purslane (*Trianthema portulacastrum* L.). *Pl. Dis*, **72**:354–55.

Nayyar, M.N., Ashiq, M. and Ahmad, I. 2001. *Manual on Punjab Weeds*. Vol. 1, Directorate of Agronomy, Ayub Agricultural Institute, Faisalabad, Pakistan. p: 52.

Nutter Jr, F.W., Teng, P. S. and Shokes, F.M. 1991. Disease assessment terms and concepts. Pl. Dis, **75:** 1187–88.

Pullaiah,T. and Chennaiah, E.1997. *Flora of Andhra Pradesh*. Vol. I. Scientific publishers. Jodhpur, India.

Rahaman, S. and Mukherjee, P.K. 2008. Effect of herbicides on weeds and soil microbes in wheat under *Terai* agro-ecological region of West Bengal. *J Crop Weed*, **4:** 33-37.

Rao, R.S. and Sriramulu, S.H.1986. *The Flora of Srikakulam District*, *Andhra Pradesh, India.* Botanical Survey of India, Meerut.

Rao, S.G.V. and Kumari, G. R. 2002. *Flora of Visakhapatnam District*. Botanical Survey of India, Kolkata.

Ratna Kumar, P. K. and Gaddeyya, G. 2014. Host specificity of *Gibbago trianthemae* Simmons, a Phaeodictyoconidial Hyphomycetes fungus on *Trianthema portulacastrum* L. (Horse purslane). *Int. J. Curr. Microbiol App. Sci*., **3:** 461-70.

Ray, P. and Hill, M.P. 2012. Impact of feeding by Neochetina weevils on pathogenicity of fungi associated with waterhyacinth in South Africa. *J Aquat Pl. Manage*, **50**:79–84.

Saeed, M., Marwat, K. B., Hassan, G. Khan, A. and Khan. I. A. 2010. Interference of horse purslane (*Trianthema portulacastrum* L.) with maize (*Zea mays* L.) at different densities. *Pak. J. Bot*. **42**:173–79.

Sethi, A. and Mohnot, K. 1988. Allelopathic influence of leaf extracts of *Trianthema* portulacastrum on germination and growth of moth bean, *Vigna aconitifollus*. *J. Curr. Biosci.,* **5:** 61–63.

Shivhare, M. K., Singour, P. K., Chaurasiya, P. K. and Pawar, R.S. 2012. *Trianthema portulacastrum* Linn. (Bishkhapra). *Pharmacogn Rev*, **6:**132–40.

Simmons, E.G. 1986. *Gibbago,* a new phaeodictyoconidial genus of hyphomycetes. *Mycotaxon* **27**:107-11.

. Umarani, R. and Selvaraj, J. A. 1995. Studies on the growth and yield of carpet weed (*Trianthema portulacastrum* L.) as influenced by soybean *(Glycine max* (L.) Merrill). *Indian J. Weed Sci*., **27**:209–10.

Venkaiah, M. 2004. *Studies on the Vegetation and Flora of Vizianagram District*. Andhra University Press, Visakhapatnam.