

Diversity of rhizospheric fungi associated with *Dipsacus inermis* Wall. growing in Kashmir Himalaya

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The microbiome in the rhizosphere of a plant plays a crucial role in the survival and growth of plants by offering tolerance and resistance to abiotic stress and greatly boosting the synthesis of bioactive compounds. *Dipsacus inermis* Wall., growing in Kashmir Himalaya, is very valuable medicinally since, it contains several bioactive chemicals. The relationship between fungus and medicinal plants that occur in this region of Himalaya have not received much focus. So the current study was carried out to characterize the diversity of rhizospheric fungi, for understanding the structure and dynamics of rhizospheric soil fungi of *Dipsacus inermis* for preserving soil ecosystem and enhancing sustainable agriculture. We identified twenty fungal species belonging to nine genera from the rhizospheric soil samples collected from various locations in the Kashmir Valley. *Aspergillus* was the most dominant genus, followed by *Trichoderma*.

Keywords : *Dipsacus inermis*, *Penicillium verrucosum*, rhizospheric soil

INTRODUCTION

Prokaryotes and fungi are among the various microorganisms that colonize plants in the phyllosphere (above ground) and rhizosphere (below ground). These microorganisms display varying ecological relations with their host organisms, ranging from commensal, beneficial symbiosis and other pathogenic relations (Hardoim *et al.* 2015; Jia *et al.* 2016; Brader *et al.* 2017). Uniquely fungi were reported in a variety of plants and their different compartments such as rhizosphere, leaf, bulbs, flower, fruit, and seed (Copeland *et al.* 2015; Hamonts *et al.* 2018; Ahmad *et al.* 2021; Nisa *et al.* 2023; Mushtaq *et al.* 2024; Sultan *et al.* 2024).

Previous studies on plant microbiomes have shown benefits for general fitness of plants (Rodriguez *et al.* 2009; Uroz *et al.* 2019), growth promoting effects (Naik *et al.* 2019) and the improvement of plant resistance against diseases

(Ansary *et al.* 2018; Vurukonda *et al.* 2018). Numerous research examined the microbiome of different medicinal plants (MPs), including *Salvia miltiorrhiza* (Chen *et al.* 2018; Huang *et al.* 2018), *Matricaria chamomilla*, *Calendula officinalis* and *Origanum vulgare* (Pontonio *et al.* 2018; Castronovo *et al.* 2020).

A large number of distinct secondary metabolites and several endophytes that produce pharmacologically active compounds are characteristics of MPs. (Köberl *et al.* 2013; Rahman *et al.* 2017; Gupta *et al.* 2020; Teimoori-Boghsani *et al.* 2020). Evidence has thus mounted that the plant microbiome influences MPs' production of secondary metabolites in addition to its possible effects on pathogen resistance and overall fitness (Köberl *et al.* 2013; Schmidt *et al.* 2014; Jia *et al.* 2016; Huang *et al.* 2018; Pacifico *et al.* 2019). The microbial species are recognized highly beneficial to plant health. They directly or indirectly affect growth, metabolism and other attributes of medicinal plants. So, the present study was designed to elucidate differences in microbial communities within different habitats of rhizospheric fungi of *Dipsacus inermis* Wall.

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growing in Kashmir Himalaya. *D. inermis* also called as Himalayan Teasel belongs to family Dipsacaceae, is an edible herb which is mainly used in traditional Ayurvedic system of medicine against various disorders related to inflammation. It is an erect tall perennial herb, stem robust angled with reflexed hairs. Flowers cream white crowded in terminal heads. We extended the investigations in understanding the structure and dynamics of fungi inhabiting the rhizosphere of *D. inermis* for preserving soil ecosystem and enhancing medicinal value of these plants.

MATERIALS AND METHODS

The current study was carried out to characterize the diversity of rhizospheric fungi, for understanding the structure and dynamics of fungi inhabiting the rhizosphere of *D. inermis* for preserving soil ecosystem and enhancing sustainable agriculture. We identified twenty fungal species belonging to nine genera from the rhizospheric soil samples collected from various locations in the Kashmir Valley.

Soil sampling

Samples of soil from the rhizospheric zone of *Dipsacus inermis* were collected from several locations of Gurez, Sonmarg and Doodhpathri of Kashmir valley (Fig. 1). A soil auger was used to take samples from each site up to a depth of 0-14 to 15-30 cm near the base of plant. Each location had its soil excavated to a depth of 0 to 30 cm. The soil was then collected by gently shaking the roots, and a sterile brush was used to gather samples of the rhizosphere soil to ensure that the soil was root free. Soil samples were collected and brought to Plant Pathology and Mycology Laboratory, Department of Botany, University of Kashmir in sterilized polythene bags. For additional analysis, soil samples held in sterile polythene bags were refrigerated at $4 \pm 1^\circ\text{C}$.

Isolation of fungi

Dilution plate method (Waksman, 1944) was followed for isolation of rhizospheric fungi associated with *Dipsacus inermis*. Using this technique, 1 g of soil was extracted from the *D. inermis* composite soil samples. In test tubes that

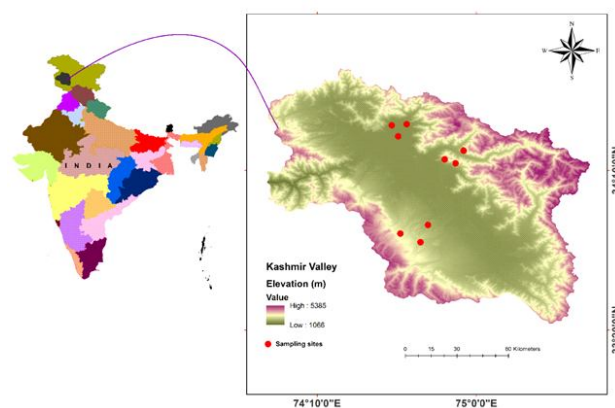


Fig. 1. : Map of the study area showing sampling sites.

have been sterilized, one gram of soil sample was repeatedly diluted up to a dilution of 10^{-6} . Inoculation was done in laminar air flow chamber; 10 ml of medium was added to each Petri plate. One ml of the soil suspension was added to the medium and mixed thoroughly. Following ten to fifteen minutes of solidification in the laminar air flow chamber, these Petri plates were subsequently incubated in BOD at $25 \pm 2^\circ\text{C}$ for 5-6 days. After that, the number of fungal colonies was counted and the growth of the fungi on these Petri plates was recorded.

Identification of fungi

The identification of rhizosphere mycoflora was done using microscopic characteristics and colony characteristics. Some macro-morphological aspects that were assessed included the colony's growth that includes colony length and width, as well as lack of aerial mycelium. To identify the specimen, it was examined under a microscope. Monographs and pertinent literature were used for identification (Watanabe, 2002).

Raising and maintenance of pure culture of fungi

The pure cultures of fungi isolated from the Petri plates were maintained on Richard synthetic agar medium.

Periodicity of Occurrence

The term periodicity of occurrence refers to the number of times a fungus appears in the total number of sampling events. According to the

classification by (Saravanakumar and Kaviyarasan, 2010), fungi are categorized based on their frequency of occurrence as follows:

Common -observed in 10-15 samplings;

Frequent -observed in 7-9 samplings;

Moderate-observed in 4-6 samplings;

Rare- observed in 1-3 samplings.

Relative frequency and Abundance of rhizospheric soil fungi associated with *Dipsacus inermis*

The Relative frequency and Relative abundance of soil fungi isolated from different sites were determined using a formula described by McLean and Ivimey Cook (1957).

The frequency and Relative abundance of soil fungi isolated from different sites were determined

$$\text{Frequency} = \frac{\text{No of plates containing a particular fungus}}{\text{Total no. of plates poured}} \times 100$$

$$\text{Relative abundance} = \frac{\text{Total no. colonies of a fungus}}{\text{Total no. of colonies of all fungi}} \times 100$$

RESULTS

Fungal Diversity from rhizospheric soil of *Dipsacus inermis* Wall.

During the present investigation, 20 species of microfungi belonging to 9 genera were isolated from rhizosphere of *D. inermis* at three different sites of Kashmir valley. The isolated fungi were: *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *A. versicolor*, *A. terreus*, *Alternaria alternata*, *A. tanuissima*, *Pencillium expansum*, *P. verrucosum*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *F. solani*, *Mucor mucedo*, *M. racemosus*, *Nigrospora sphaerica*, *Trichoderma viride*, *T. harzianum*, *T. longibrachiatum*, *Talaromyces flavus* and *T. purpureogenus*. Cultural and microscopic characteristics of these isolated fungi are given in Table 1 and Fig. 1&2. *Aspergillus* was the most dominant genus, followed by *Trichoderma*.

Periodicity of occurrence

During the present study six species viz., *Aspergillus niger*, *A. flavus*, *Pencillium expansum*, *Mucor mucedo*, *Rhizopus stolonifer* and *Trichoderma harzianum* showed common occurrence. Eight species viz., *Aspergillus fumigatus*, *Alternaria alternata*, *Fusarium oxysporum*, *F. solani*, *Mucor racemosus*, *Trichoderma viride*, *Trichoderma longibrachiatum* and *Talaromyces purpureogenus* showed frequent occurrence species viz., *Aspergillus versicolor*, *A. terreus*, *Pencillium verrucosum* and *Talaromyces flavus* showed moderate occurrence. The rest of the three species *Alternaria tanuissima* and *Nigrospora sphaerica* showed rare occurrences in all selected study sites.

Relative frequency and Relative abundance of mycoflora isolated from rhizosphere of *Dipsacus inermis* Wall from different sites of Kashmir Valley

The present study, revealed a significant variation in the relative frequency and relative abundance (Table 2 and Fig. 4&5) of rhizospheric soil fungi associated with *Dipsacus inermis*, an important medicinal plant of Kashmir Valley growing in different areas of Kashmir valley such as Gurez, Sonmarg and Doodhpathri. At Gurez, the relative frequency (Fig. 3) of fungi were *Aspergillus niger* (72.22%), *A. flavus* (83.33%), *A. fumigatus* (44.44%), *A. versicolor* (33.33%), *A. terreus* (41.66%), *Alternaria alternata* (58.33%), *A. tanuissima* (21.11%), *Pencillium expansum* (74.44%), *P. verrucosum* (38.33%), *Rhizopus stolonifera* (81.66%), *Fusarium oxysporum* (58.33%), *F. solani* (46.66%), *Mucor mucedo* (73.33%), *M. racemosus* (55.55%), *Nigrospora sphaerica* (14.44%), *Trichoderma viride* (41.66%), *T. harzianum* (83.33%), *T. longibrachiatum* (48.88%), *Talaromyces flavus* (25.00%) and *Talaromyces purpureogenus* (53.33%), respectively. Similarly, at Sonmarg, the frequency of fungi were *Aspergillus niger* (83.33%), *A. flavus* (71.66%), *A. fumigatus* (50.00%), *A. versicolor* (33.33%), *A. terreus* (33.33%), *Alternaria alternate* (62.22%), *A. tanuissima* (8.33%), *Pencillium expansum* (63.33%), *P. verrucosum* (46.66%), *Rhizopus stolonifera* (82.22%), *Fusarium*

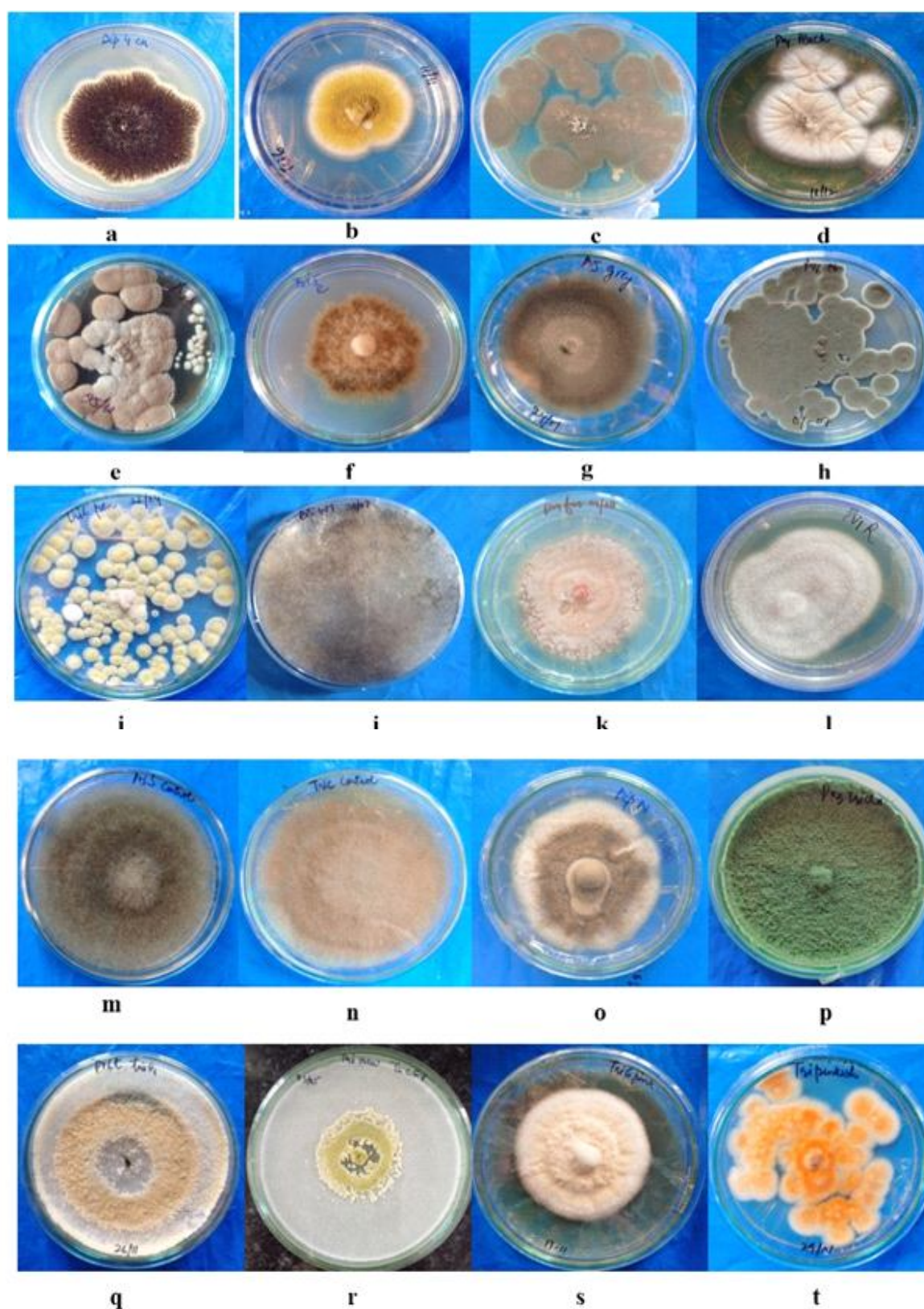


Fig 1: Cultural characteristics of rhizospheric fungi isolated from *Dipsacus inermis*.

(a) *Aspergillus niger*; (b) *Aspergillus flavus* (c) *Aspergillus fumigatus* (d) *Aspergillus versicolor* (e) *Aspergillus terreus* (f) *Alternaria alternata* (g) *Alternaria tenuissima* (h) *Penicillium expansum* (i) *Penicillium verrucosum* (j) *Rhizopus stolonifera* (k) *Fusarium oxysporum* (l) *Fusarium solani* (m) *Mucor mucedo* (n) *Mucor racemosus* (o) *Nigrospora sphaerica* (p) *Trichoderma viride* (q) *Trichoderma harzianum* (r) *Trichoderma longibrachiatum* (s) *Talaromyces flavus* (t) *Talaromyces purpureogenus*.

oxysporum (44.44%), *F. solani* (41.66%), *Mucor mucedo* (86.66%), *M. racemosus* (42.22%), *Nigrospora sphaerica* (11.11%), *Trichoderma viride* (33.33%), *T. harzianum* (72.22%), *T. longibrachiatum* (22.22%), *Talaromyces flavus* (33.33%) and *T. purpureogenus* (66.66%) respectively. Likewise, at Doodhpathri, the frequency of fungi were *Aspergillus niger* (75.00%), *A. flavus* (62.22%), *A. fumigatus* (33.33%), *A. versicolor* (22.22%), *A. terreus* (33.33%), *Alternaria alternata* (50.00%), *A. tanuissima* (16.66%), *Pencillium expansum* (75.00%), *P. verrucosum* (16.66%), *Rhizopus stolonifer* (73.33%), *Fusarium oxysporum* (50.00%), *F. solani* (55.55%), *Mucor mucedo* (78.88%), *M. racemosus* (66.66%), *Nigrospora sphaerica* (8.33%), *Trichoderma viride* (50.00%), *T. harzianum* (81.66%), *T. longibrachiatum* (41.66%), *Talaromyces flavus* (33.33%) and *T. purpureogenus* (50.00%) respectively.

A significant variation was seen in the relative abundance (Fig. 4) of rhizospheric soil fungi associated with *Dipsacus inermis*, an important medicinal plant of Kashmir Valley growing in different areas of Kashmir valley such as Gurez, Sonmarg, Doodhpathri. At Gurez, the relative abundance of fungi were *Aspergillus niger* (7.88 %), *A. flavus* (7.62%), *A. fumigatus* (5.08%), *A. versicolor* (5.93%), *A. terreus* (4.08%), *Alternaria alternata* (6.77%), *A. tanuissima* (1.93%), *Pencillium expansum* (7.22%), *P. verrucosum* (3.10%), *Rhizopus stolonifera* (6.52%), *Fusarium oxysporum* (5.98%), *F. solani* (3.98%), *Mucor mucedo* (5.08%), *M. racemosus* (4.32%), *Nigrosporasphaerica* (2.77%), *Trichoderma viride* (5.34%), *T. harzianum* (7.11%), *T. longibrachiatum* (3.75%), *Talaromyces flavus* (2.55%) and *T. purpureogenus* (2.99%) respectively. Likewise, at Sonmarg, the relative abundance of fungi were- *Aspergillus niger* (7.99 %), *A. flavus* (7.72%), *A. fumigatus* (3.55%), *A. versicolor* (3.88%), *A. terreus* (2.52%), *Alternaria alternata* (3.99%), *A. tanuissima* (2.78%), *Pencillium expansum* (6.95%), *P. verrucosum* (3.87%), *Rhizopus stolonifera* (8.17%), *Fusarium oxysporum* (5.69%), *F. solani* (3.55%), *Mucor mucedo* (6.98%), *M. racemosus* (5.77%), *Nigrosporasphaerica* (1.86%), *Trichoderma viride* (5.70%), *T. harzianum* (7.71%), *T. longibrachiatum* (4.78%), *Talaromyces flavus* (3.09%) and *T.*

purpureogenus (3.45%) respectively. Likewise, at Doodhpathri, the abundance of fungi were *Aspergillus niger* (8.74%), *A. flavus* (7.14%), *A. fumigatus* (4.51%), *A. versicolor* (3.77%), *A. terreus* (3.54%), *Alternaria alternata* (5.03%), *A. tanuissima* (1.91%), *Pencillium expansum* (6.28%), *P. verrucosum* (4.66%), *Rhizopus stolonifera* (7.04%), *Fusarium oxysporum* (50.03%), *F. solani* (4.11%), *Mucor mucedo* (4.44%), *M. racemosus* (4.52%), *Nigrosporasphaerica* (2.66%), *Trichoderma viride* (6.54%), *T. harzianum* (8.28%), *T. longibrachiatum* (5.66%), *Talaromyces flavus* (4.03%) and *T. purpureogenus* (2.11%) respectively.

A significant variation in the relative frequency and relative abundance of soil fungi associated with *Dipsacus inermis* at all the study sites. The most frequently isolated fungi were *Aspergillus flavus* and *Trichoderma harzianum* with an isolation frequency (IF) of 83.33%, followed by *Rhizopus stolonifera* (IF, 81.66%), and least frequently isolated fungus was *Nigrospora-sphaerica* (IF, 14.44%) at Gurez. Likewise *Aspergillus flavus* showed highest relative abundance (7.88%) where as *Alternaria tanuissima* (1.93%) showed least relative abundance. Most frequently isolated fungus at Sonmarg was *Mucor mucedo* (IF, 86.66%) followed by *Aspergillus niger* (IF, 83.33%) and least frequently isolated one was *Alternaria tanuissima* (IF, 8.33%). Likewise *Aspergillus flavus* showed highest relative abundance (7.99%) where as *Nigrospora sphaerica* (1.86%) showed least relative abundance. Most frequently isolated fungus at Doodhpathri was *Trichoderma harzianum* (IF, 81.66%) followed by *Mucor mucedo* (IF, 78.88%) and least frequently isolated one was *Nigrosporasphaerica* (IF, 8.33%). Likewise *Aspergillus niger* showed highest relative abundance (8.74%) whereas *Alternaria tanuissima* (1.91%) showed least relative abundance.

DISCUSSION

Our results indicate that twenty fungal species belonging to nine genera of fungi constitute the rhizospheric fungal diversity of *Dipsacus inermis* Wall. growing in Kashmir Himalaya. During the

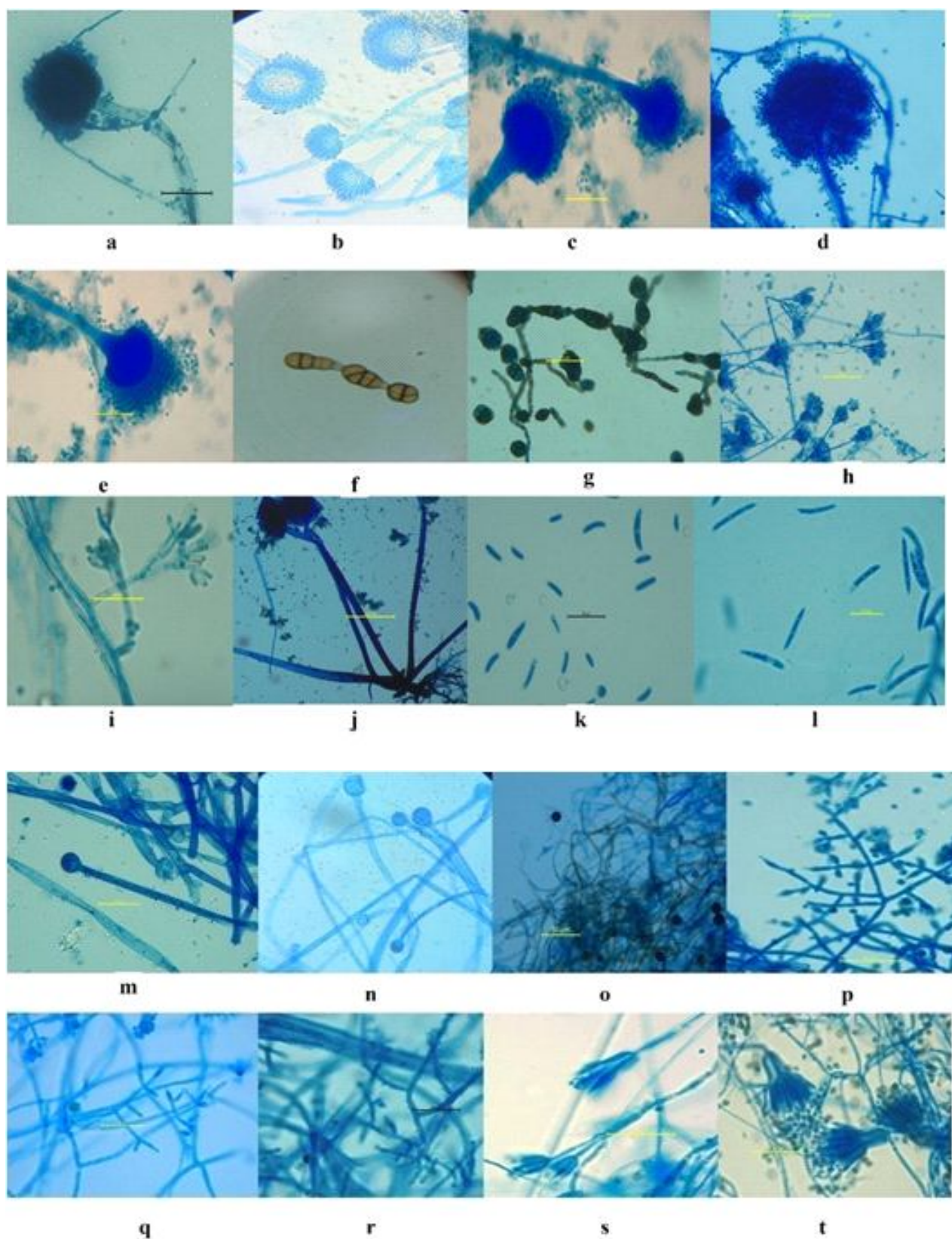


Fig 3: Microscopic characteristics of rhizospheric fungi isolated from *Dipsacus inermis*.

(a) *Aspergillus niger*; (b) *Aspergillus flavus* (c) *Aspergillus fumigatus* (d) *Aspergillus versicolor* (e) *Aspergillus terreus* (f) *Alternaria alternata* (g) *Alternaria tenuissima* (h) *Penicillium expansum* (i) *Penicillium verrucosum* (j) *Rhizopus stolonifera* (k) *Fusarium oxysporum* (l) *Fusarium solani* (m) *Mucor mucedo* (n) *Mucor racemosus* (o) *Nigrospora sphaerica* (p) *Trichoderma viride* (q) *Trichoderma harzianum* (r) *Trichoderma longibrachiatum* (s) *Talaromyces flavus* (t) *Talaromyces purpureogenus*.

Table 1: Cultural and microscopic characteristics of the isolated fungi from rhizosphere of *Dipsacus inermis* Wall.

Fungi	Cultural Characteristics	Microscopic Characteristics		
		Hyphae	Sporangiophores/ Conidiophores	Conidia
<i>Aspergillus nigervan</i> Tieghem	Granular colonies, white, become black after conidia production. Reverse colony dull yellow with deep sulcus/fissures	Branched, hyaline and septate	Conidiophores are smooth, hyaline, smooth walled and bear a globose head at the terminus measuring 32-75µm	Globose with rough surface, brown to black in color, measuring 3.5-5µm.
<i>Aspergillus flavus</i> Link	Smooth yellowish green colonies with granular texture. Reverse colony creamy yellow having radial fissures. Very fast growth.	Branched, hyaline and septate	Conidiophores are hyaline and thick walled with a terminal globose head measuring 25-35× 5-25 µm with flat apex.	Globose to sub-globose, yellow to greenish color measuring 3.9- 4.5 µm.
<i>Aspergillus fumigatus</i> Fresen .	Colonies are bluish green in colour with suede like texture. Reverse colony is tan to pale yellow. Very fast growth.	Branched, hyaline, globose and septate	Conidiophores are smooth walled with conical terminal vesicles which support a row of phialides	Pale green, echinulate conidia produced in chains from phialides basipetally, measuring 2.6-3.2 µm.
<i>Aspergillus versicolor</i> (Vuill.) Tirab.	Initially, colonies are usually velvety green and white, but as they mature, they change to orange, yellow or green or sometimes with hints of pink or red.	Branched, hyaline and septate	Conidiophores are hyaline, thick walled with a terminal globose head measuring 25-35× 5-25 µm with flat apex. Conidial heads are biseriate and loosely radiate.	Conidia are spherical 2.5-3.5µm in diameter.
<i>Aspergillus terreus</i> Thom	Brownish colonies which become darker with time. Reverse colony is yellow	Branched, hyaline and septate	Hyaline and smooth walled conidiophores. Conidial heads are compact, columnar and biseriate	Globose, smooth walled light yellow to hyaline around 2-2.5 µm. Aleuiocidia are produced directly on hyphae measuring around 7µm.
<i>Alternaria alternata</i> (Fr.) Keissler	Olive green colonies which turn fluffy brown in older cultures	Irregularly branched, thick walled, brown and septate	Conidiophores are olive green and brown in colour	Ovate, obpyriform to pear shape with small tapering beak. Conidia develop in chains, are brown with horizontal and vertical septa varying from 13-46.5× 5.5-12µm.
<i>Alternaria tenuissima</i> (Kunze) Wiltshire	Initially white colonies which turn olive green with white margins on maturity, woolly in texture. Reverse colony is brown in colour.	Branched, septate and black	Linear, light brown and sparsely branched conidiophores measuring 22.2-39.7×3.2-5µm	Ovate, obpyriform, obclavate to club shape with short tapering beak. Pale to dark brown conidia developing in chains with 0-2 vertical septa and 1-5 horizontal septa measuring 12.2-45.7×4.9-12.5µm
<i>Penicillium expansum</i> Link	Initially white colonies which later turn dull green to green with whitish margins. Reverse yellow brown in colour with curvy margins and radial fissures	Branched and septate	Simple, septate, branched and terminate in triverticillate penicilli. Conidiophores terminate by cluster of flask shaped phialides which bear chains of conidia	Ellipsoid, smooth, greenish in color measuring 4.2-4.5×3.3-3.5µm.
<i>Penicillium verrucosum</i> Dierckx	Greenish colonies with white margins with reverse colony yellowish to brown in colour.	Branched, colourless and septate	Branched, rough-walled with flask shaped phialides	Smooth walled, globose to sub globose measuring 2.5-3.2 µm.
<i>Rhizopus stolonifer</i> (Ehrenb.) Vuill.	Whitish growth in cultures which eventually turns black	Branched, filamentous with coenocytic hyphae. The branched hyphae include stolons, pigmented rhizoids and unbranched sporangiophores	Sporangiophores bear single spherical sporangium containing numerous sporangiospores. Sporangia are black in color	Sporangiospores are present rather than conidia measuring 100-270 µm in diameter.

<i>Fusarium oxysporum</i> Schlecht.	Initially white colonies which later turn pink with fluffy, profuse, woolly and cottony texture.	Branched, hyaline and septate	Simple and cylindrical, hyaline conidiophores bearing both micro and macro conidia	Macroconidia are sickle shaped, hyaline with pointed apical cell and pedicellate basal cell bearing 2-5 septa measuring 14.5-46×9-5µm. Microconidia are small, straight or round, aseptate or uniseptate measuring 4.5-14.8×2.8-5µm.
<i>Fusarium solani</i> (Mart) Sacc	Whitish colonies with dense mycelial growth in concentric rings. Reverse colony is creamy white with smooth margins	Branched, hyaline and septate	Short cylindrical hyaline conidiophores possessing both micro and macro conidia which were described by Parey <i>et al</i> (2013)	Macroconidia are sickle shaped measuring 15-30×2.5-5µm. Microconidia are ovoid aseptate or uniseptate measuring 9-15×2-5µm.
<i>Mucor mucedo</i> L.	Fluffy	Branched, aseptate or sparsely septate hyphae, lacking rhizoids		
<i>Mucor racemosus</i> Bull.	Fluffy to cottony colonies that turn grey or brown on development of spores. Reverse colony is whitish.	Branched, aseptate or pauciseptate, ribbon like lacking rhizoids	Smooth-walled, brownish, subglobose without rhizoids	Sporangia are globose and flattened. Sporangiospores are brown, ellipsoid and smooth-walled measuring 4.5-7.6×5–6.2µm.
<i>Nigrospora sphaerica</i> (Sacc.) Mason	White woolly colonies which turn grayish with age upon sporulation of the conidia. Reverse colony is black	Hyaline and septate	Simple, hyaline stalked conidiophores producing single conidia at the apex.	Oblate to sphaeroid, black, unicellular measuring 11-14×20-22µm.
<i>Trichoderma viride</i> Rifai	Colonies are yellowish green, fluffy with reverse colony colour brownish green	Septate and hyaline.	Highly branched conidiophores, containing spore masses at verticillate phialides at apical position.	Conidia single celled, phialosporous, globose, subglobose or ovate and hyaline, 2.2µm - 3 µm × 2.7µm– 4.7µm in diameter.
<i>Trichoderma harzianum</i> Kleifeld.	Yellowish green colonies, fluffy with 1-2 concentric rings. Reverse colour of the colony pale yellow	Septate and hyaline.	Conidiophores branched containing spore masses on verticillate phialides at apical position.	Conidia single celled, ovate, hyaline, 2.3µm - 2.6µm × 2.1µm– 2.4µm.
<i>Trichoderma longibrachiatum</i> Kleifeld.	White to grayish colonies which later turn dark green, cottony with 1-3 concentric rings. Pale yellow reverse colony.	Septate and hyaline	Conidiophores are branched, erect with spore masses on verticillate phialides at apical position	Hyaline, single-celled, globose to sub-globose, sometimes ovate measuring 1.9-3.1×2.5–4.9µm.
<i>Talaromyces flavus</i> (Klocker) Stolk & Samson	White to yellow colonies, floccose. Grey orange reverse colony.	Branched, septate and hyaline	Conidiophores are smooth walled, unbranched and septate which terminate in globose vesicles measuring 14.5-21.2×1.7-2.1µm	Smooth and ellipsoid measuring 1.2-2×1.4-2.4µm.
<i>Talaromyces purpureogenus</i> (Stoll) Samson	Whitish orange colony which later develops a green layer of conidia. Reverse colony is yellow to orange.	Branched and septate	Bi-verticillate conidiophores measuring 145-225×2.2-3.4µm	Conidia smooth, ellipsoid measuring 3.1-3.7×2.1-2.4µm.

present study 20 fungal species were isolated and identified based on cultural and microscopic characteristics. The association of these rhizospheric fungi may have good impact on the growth and metabolism of plant and may serve as baseline study for cultivation and conservation of many important medicinal plants as have been reported in similar studies (Chen *et al.* 2021; Adedayo *et al.* 2023). Our findings align with the results of Thombre *et al.* (2016) who reported *Aspergillus terricola*, *Penicillium* spp., *Aspergillus*

niger, as the most common and abundant fungi among isolated fungal species from rhizosphere of *Santalum album*. In the current study, *Aspergillus* species were found to be not only dominant but also common and integral components of the soils examined. Our studies are also in accordance with Wahid *et al.* (2000); Tamilarasi *et al.* (2008) and Sundar *et al.* (2011) who reported association of rhizospheric fungi on some other medicinal plants and isolated numerous species of rhizospheric soil fungi

Table 2: Relative frequency and Relative abundance of mycoflora isolated from rhizosphere of *Dipsacus inermis* Wall from different sites of Kashmir Valley

Name of fungus	Frequency(%)			Relative abundance (%)		
	Gurez	Sonmarg	Doodhpathri	Gurez	Sonmarg	Doodhpathri
<i>Aspergillus niger</i>	72.22	83.33	75	7.88	7.99	8.74
<i>Aspergillus flavus</i>	83.33	71.66	62.22	7.62	7.72	7.14
<i>Aspergillus fumigatus</i>	44.44	50	33.33	5.08	3.55	4.51
<i>Aspergillus versicolor</i>	33.33	33.33	22.22	5.93	3.88	3.77
<i>Aspergillus terreus</i>	41.66	33.33	33.33	4.08	2.52	3.54
<i>Alternaria alternata</i>	58.33	62.22	50	6.77	3.99	5.03
<i>Alternaria tanuissima</i>	21.11	8.33	16.66	1.93	2.78	1.91
<i>Penicillium expansum</i>	74.44	63.33	75	7.22	6.95	6.28
<i>Pencillium verrucosum</i>	38.33	46.66	16.66	3.1	3.87	4.66
<i>Rhizopus stolonifer</i>	81.66	82.22	73.33	6.52	8.17	7.04
<i>Fusarium oxysporum</i>	58.33	44.44	50	5.98	5.69	5.03
<i>Fusarium solani</i>	46.66	41.66	55.55	3.98	3.55	4.11
<i>Mucor mucedo</i>	73.33	86.66	78.88	5.08	6.98	4.44
<i>Mucor racemosus</i>	55.55	42.22	66.66	4.32	5.77	4.52

<i>Nigrospora sphaerica</i>	14.44	11.11	8.33	2.77	1.86	2.66
<i>Trichoderma viride</i>	41.66	33.33	50	5.34	5.7	6.54
<i>Trichoderma harzianum</i>	83.33	72.22	81.66	7.11	7.71	8.28
<i>Trichoderma longibrachiatum</i>	48.88	22.22	41.66	3.75	4.78	5.66
<i>Talaromyces flavus</i>	25	33.33	33.33	2.55	3.09	4.03
<i>Talaromyces purpureogenus</i>	53.33	66.66	50	2.99	3.45	2.11

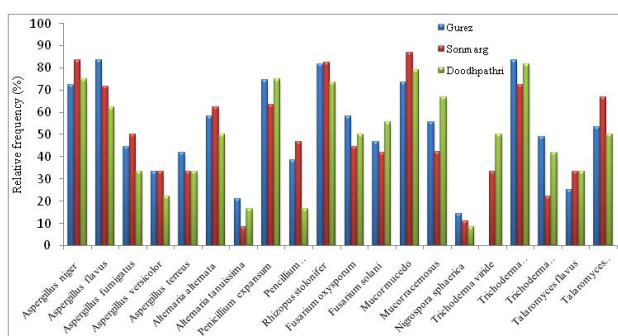


Fig 43: Relative frequency of rhizospheric fungi associated with *Dipsacus inermis* Wall. at different sites of Kashmir Valley

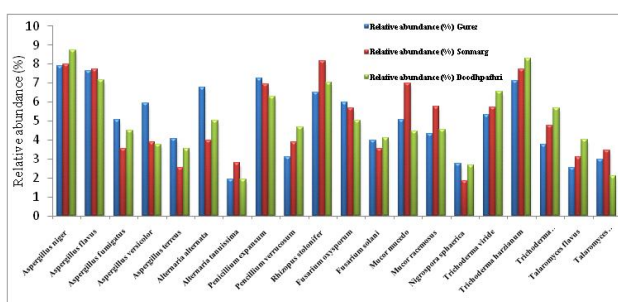


Fig. 5: Relative abundance of rhizospheric fungi associated with *Dipsacus inermis* Wall. at different sites of Kashmir Valley

including *Penicillium*, *Rhizobium*, *Aspergillus* and *Fusarium* which also affect their growth and medicinal properties. Significant variations in the rhizospheric fungus flora of several plants were also noted by Muneer (2005). He documented twelve different fungal species from the rhizosphere of some crops growing in Kashmir.

The main objective of this study was to characterize the rhizospheric soil fungi associated with *Dipsacus inermis*. This is important because the productivity and diversity of aboveground plants can be predicted by the richness of belowground microbial species, which can be used to map out the best places to cultivate *Dipsacus inermis*. This study will also be helpful to search and isolate fungal pathogens and beneficial fungal bioagents for developing ecofriendly management strategies. Therefore, additional research is recommended for better understanding the diversity and function of rhizosphere fungi and their uses in the increased production of medicinal plants by identifying relationship between genetic and functional diversity of fungal species.

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DECLARATION

Conflict of interest. Authors declare no conflict of interest.

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