PROGRESS REPORTS

OF

DEPARTMENTAL SPECIAL PROGRAMS (UGC-CAS, SAP-DRS, DST-FIST)

SHOWING

NAME OF THE TEACHERS INVOLVED

DEPARTMENT OF BOTANY

(UGC-CAS, DST-FIST)

जयनारायण व्यास विश्वविद्यालय, जोधपुर
Jai Narain Vyas University, Jodhpur

DEPARTMENT OF BOTANY
CENTER OF ADVANCED STUDY

Progress Report (IV-year) Under CAS Program

Thrust Areas:

Bio-resources of Plants and Microbes of Desert Areas

Taxonomy, Ecology and Molecular aspects of Desert Plants

Prof. S. Sundaramoorthy – Coordinator
Prof. Pawan Kumar Kasera – Dy. Coordinator

Research in Progress

The Department Council discussed the research endeavours for achieving the targets in CAS program to a satisfactory level. Accordingly, five sub teams have been formed so as to cover all aspects of Departmental research activities that fall within the ambit of the thrust areas. The teams formed and their main areas of research are as under:

A. Bio resources of Desert Plants

i. Prof. P.K. Kasera, In-Charge
ii. Dr. H.R. Dagla
iii. Dr. Vinod Kataria
iv. Dr. Suman Parihar
v. Dr. Ashok Patel
vi. Dr. Rachana Dinesh Nee Modi
vii. Dr. Sumitra Kumari Choudhary

B. Microbes of Desert Areas

i. Prof. H.S. Gehlot, In-Charge
ii. Dr. Praveen Gehlot
iii. Dr. Sharad Bissa
iv. Dr. NishaTak
v. Dr. Kamana Sharma
vi. Mr. AlkeshTak

C. Taxonomy

i. Dr. G.S. Deora, In-Charge
ii. Ms. Seema Sen

D. Ecology of Plants

i. Prof. S. Sundramoorthy, In-Charge
ii. Dr. Santosh K. Mehar

E. Molecular aspects of Desert Plants

i. Dr. Gyan Singh Shekhawat, In-Charge
ii. Dr. Shweta Jha
iii. Dr. Kheta Ram
iv. Ms. Meena

F. Non-Thrust Areas:

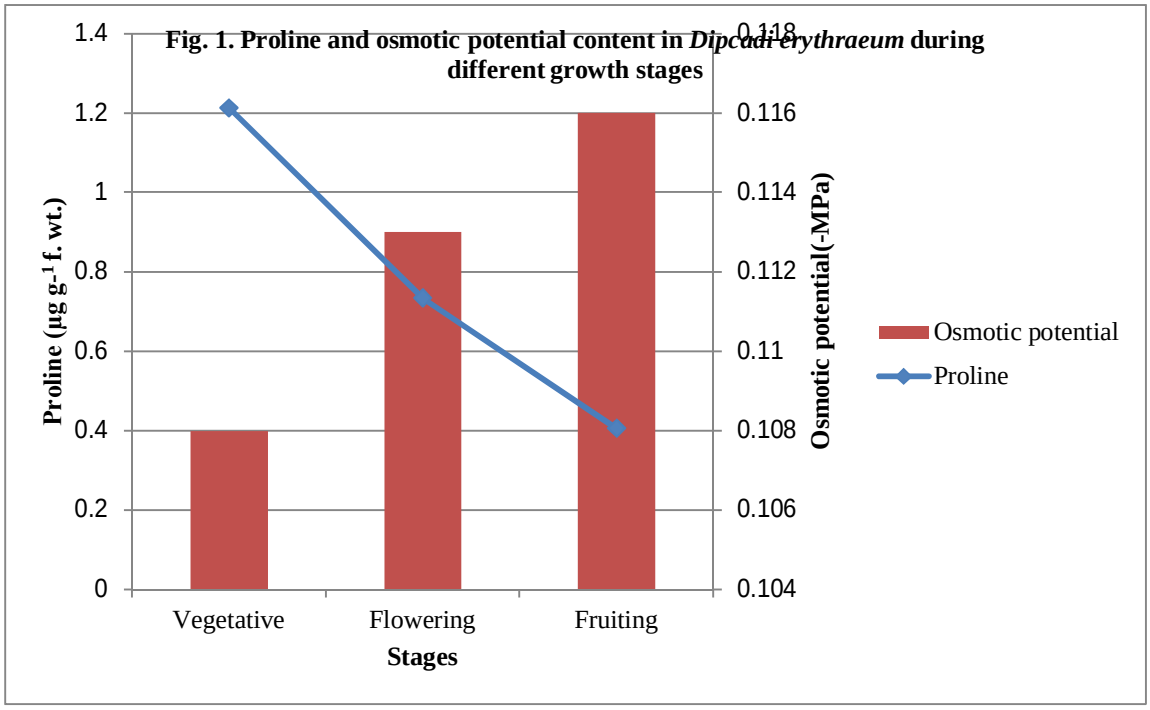
Stress Physiology

i. Dr. Bhana Ram Gadi, In-Charge
ii. Mr. Ramesh

The area-wise research progress achieved is briefly reported:

A. Thrust area: Bio resources of Desert Plants:

Group-I: Prof. Pawan K. Kasera [Plant Ecology Laboratory]
Primary and secondary metabolic products in selected medicinal plants



It is evident from Fig. 1 that in *D. erythraeum* proline and osmotic potential were maximum during vegetative stage and decreased simultaneously with an advancement of growth stages (flowering and fruiting).

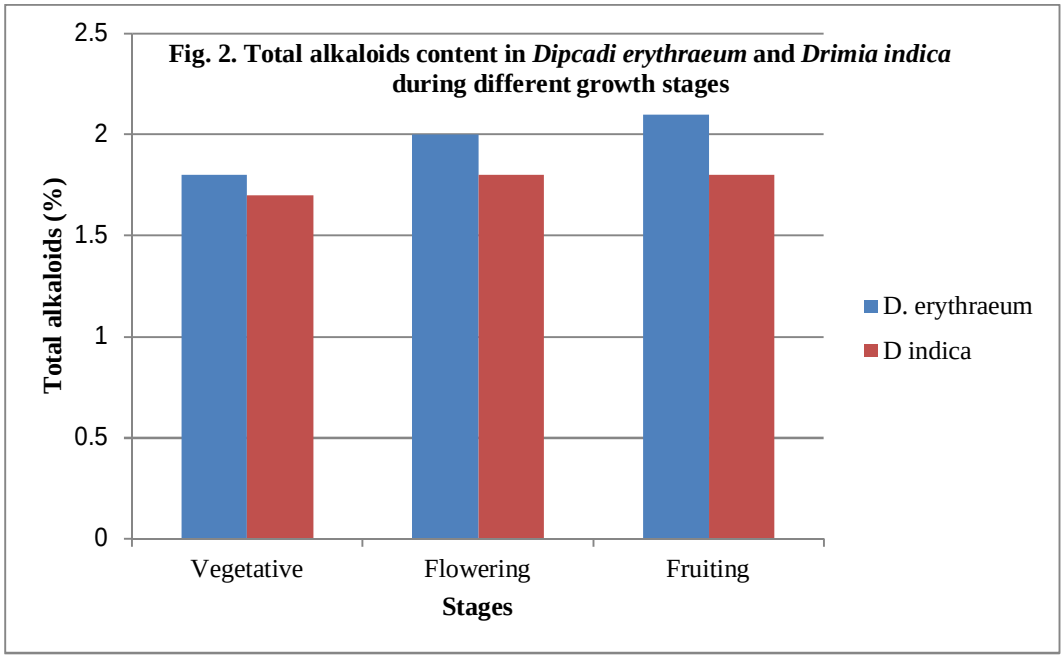


Fig. 2 shows that total alkaloids values ranged from 1.8 to 2.1 and 1.7 to 1.8% in *D. erythraeum* and *D. indica*, respectively. The values remain almost same during all growth stages. Bulbs of *D. erythraeum* accumulated higher amount as compared to *D. indica*.

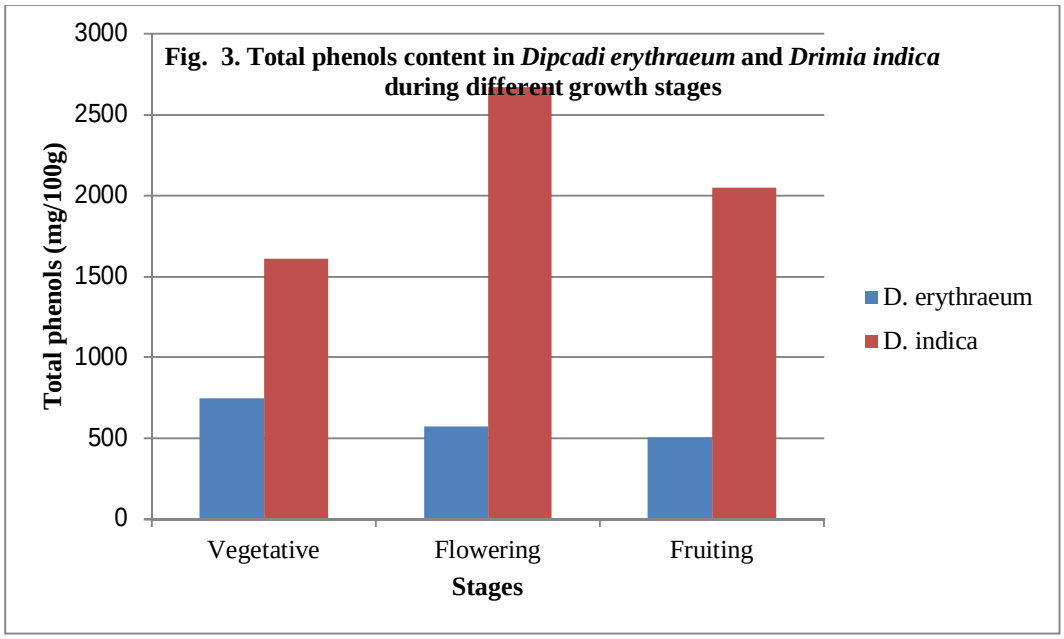
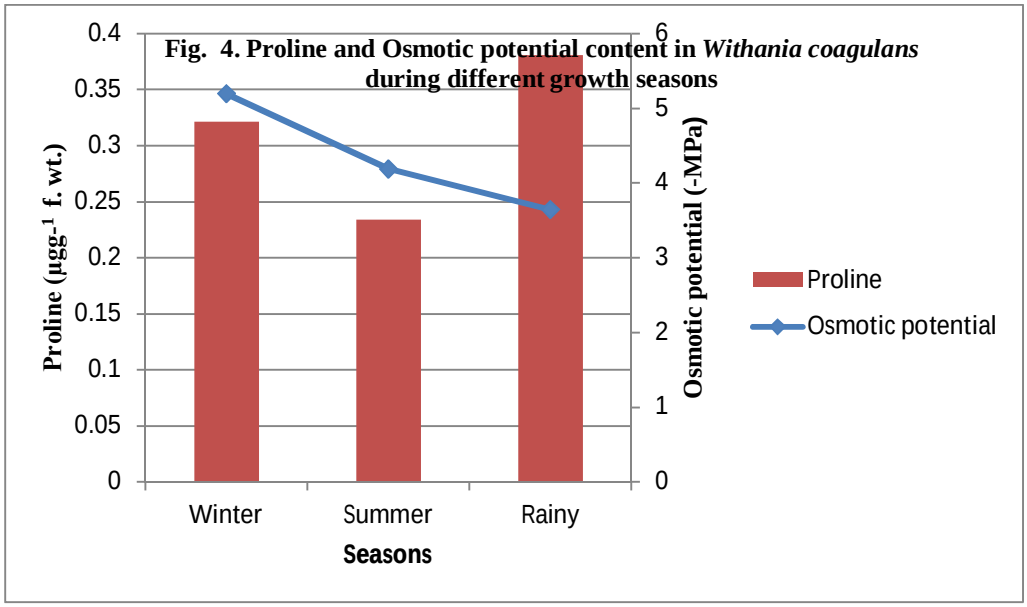
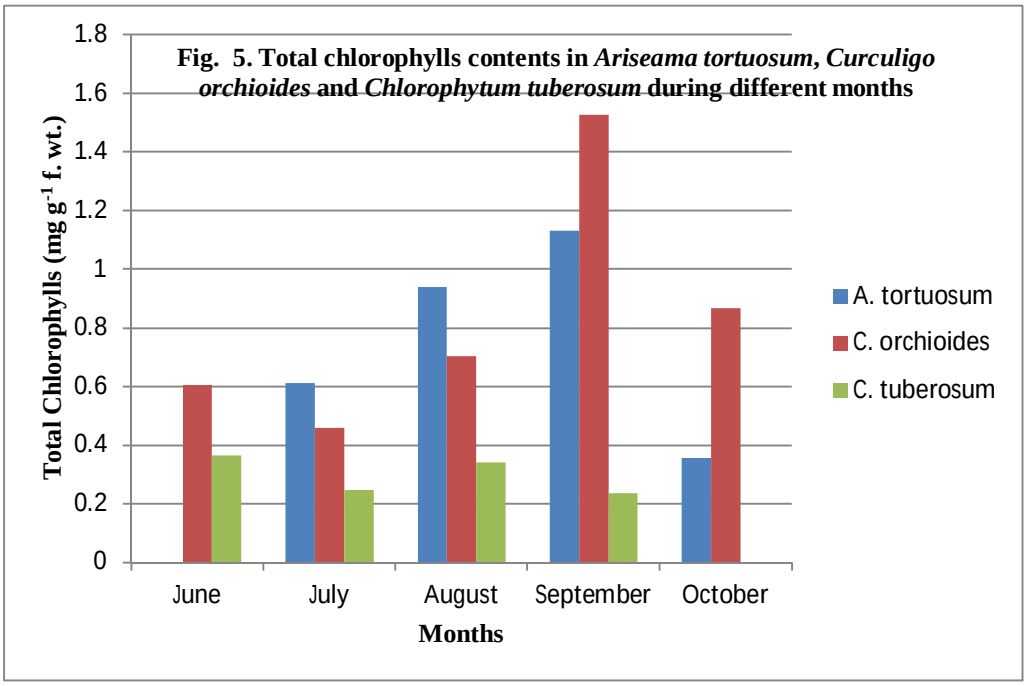


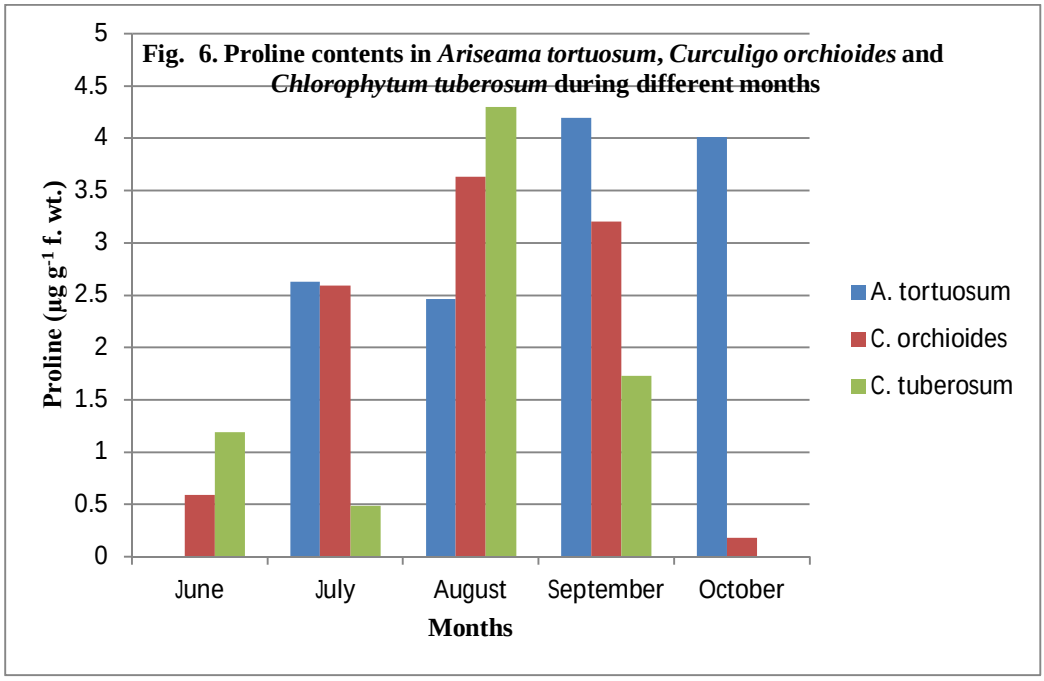
Fig. 3 reveals that total phenols were maximum during vegetative in *D. erythraeum* whereas during flowering in *D. indica*. The values were higher in *D. indica* bulbs as compared to *D. erythraeum*.



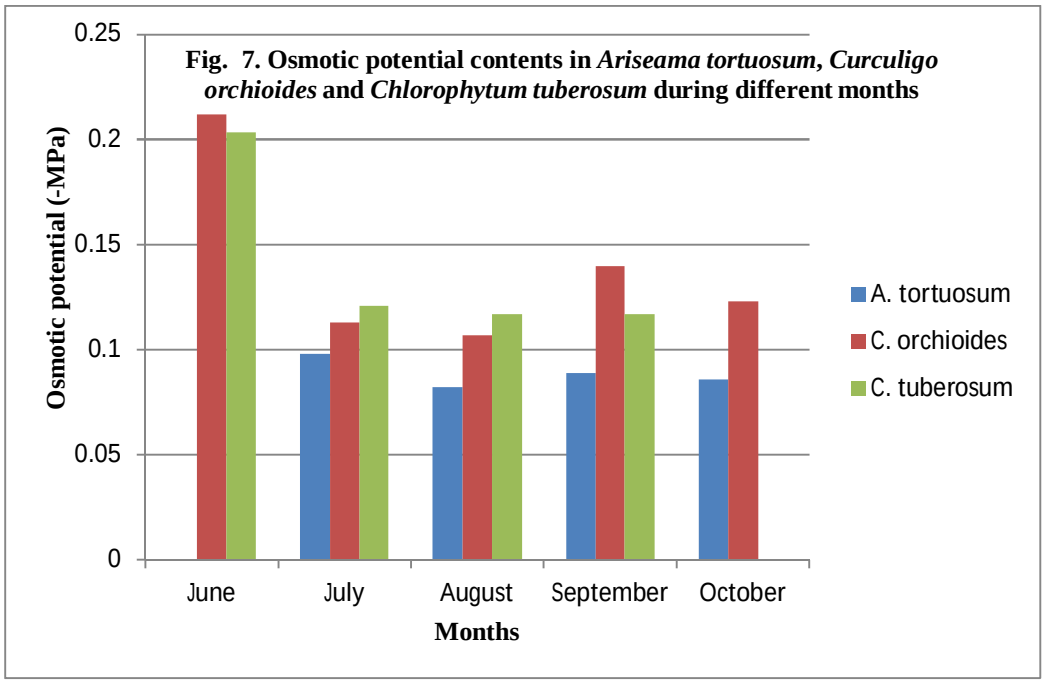
The data presented in Fig. 4 reveals that in *W. coagulans* the values of osmotic potential and proline were maximum during rainy season and both indicates negative correlations with each other



The maximum values of total chlorophylls were observed during September in *A. tortuosum* and *C. orchioides* where as in *C. tuberosum* during June (Fig. 5).



Data presented in Fig. 6 shows that in *C. orchioides* and *C. tuberosum*, the highest values of proline content were observed during August whereas in *A. tortuosum* during September.



C. orchioides and *C. tuberosum* exhibited maximum values of osmotic potential during June where as in *A. tortuosum* during July (Fig. 7).

Group-II: Prof. H.R. Dagla [Plant Biotechnology and Molecular Biology (PBMB) Laboratory]

Effect of NaCl on growth and development of *in vitro* cultured shoots of *Haloxylon recurvum* and *H. Salicornicum*

Cotyledonary node of *in vitro* germinated seedlings were used as explants for analysis of growth and development on different concentrations of NaCl.Seedlings were cultured on hormone free MS culture medium for one week. Cotyledonary node of *in vitro* germinated seedlings were excised and inoculated on MS culture medium containing BAP (4µM BAP and 1µM NAA for *H. recurvum* and 8 µM BAP for *H. salicornicum*) and different concentration of NaCl, for four weeks.On the basis of number of nodes, axillary shoots and length of shoots and leaves, 100mM NaCl was found to be suitable for growth and development of *in vitro* cultured shoots of *Haloxylon recurvum* and *H. Salicornicum.*

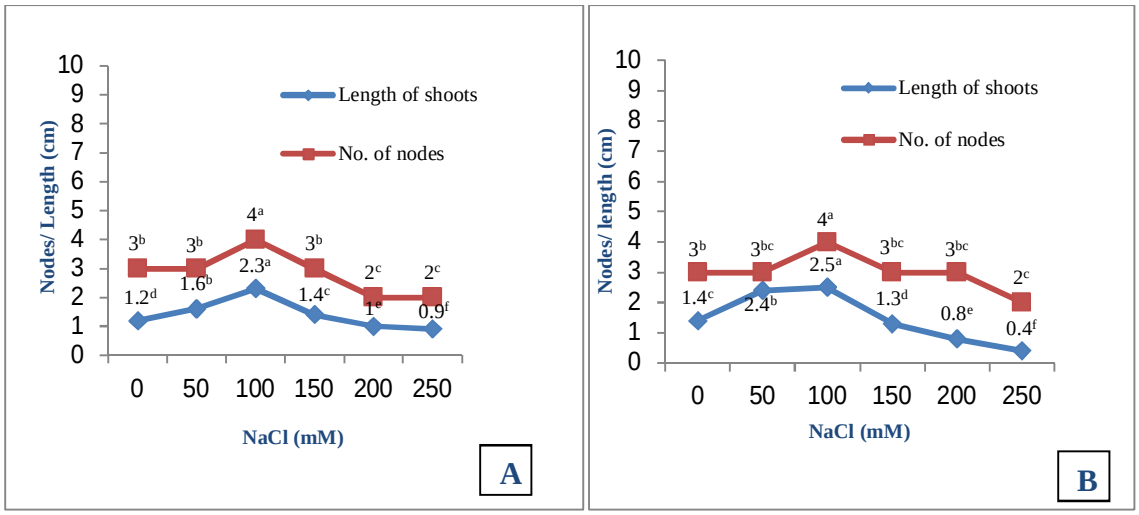


Fig. Effect of NaCl on shoot length and node number of *in vitro* cultured shoots: (A) *Haloxylon recurvum* and (B) *H. Salicornicum*

Group-III: Dr. Vinod Kataria, Dr. Suman Parihar, Dr. Ashok Kumar Patel, Dr. Sumitra Choudhary and Dr. Rachana Dinesh nee Modi (Biotechnology Unit)

(i) Dr. Vinod Kataria:

In Vitro Studies, Micromorphological Studies, Molecular Analysis and Transcriptome analysis of some Plants of Stressed Ecosystem

The following protocols were developed for conservation and multiplication of some multipurpose trees of arid environments.

1. ***Bauhinia racemosa***

Bauhinia racemosa Lam. is a medicinal tree in family of Caesalpiniaceae, A micropropagation system for *Bauhinia racemosa* Lam. was developed involving axillary shoot proliferation and ex vitro rooting using nodal explants obtained from mature tree. MS medium with 3.0 mg l-1 BA (6benzyladenine) was optimum for shoot bud induction. For shoot multiplication, mother explants were transferred repeatedly on medium containing low concentration of BA (0.75 mg l-1). In vitro regenerated shoots were rooted under ex vitro conditions treated with 400 mg l-1 IBA (indole-3-butyric acid) for 7 min on sterile soilrite. After successful hardening in greenhouse, ex vitro rooted plants were transferred to the field conditions with &85% of survival rate. Micromorphological changes were observed on leaf surface i.e. development of vein density and trichomes and stomatal appearance, when plants were subjected to environmental conditions.

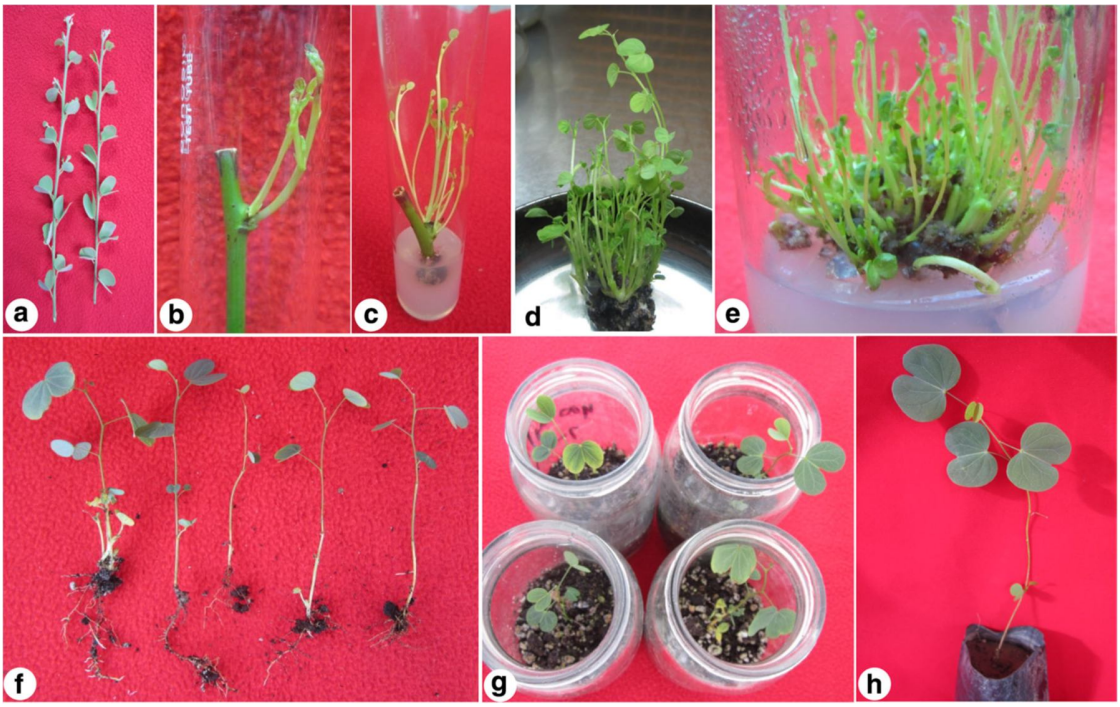


Fig. 1 a Young branches with axillary nodes. b Induction of axillary shoots on MS + 3 mg l -1 of BA. c Repeated transfer of mother explants on MS ? 0.75 mg l-1 of BA. d, e Shoot multiplication and subculturing on MS medium supplemented with BA (0.25 mg l-1), Kin (0.25 mg l-1), NAA (0.1 mg l-1) and TDZ (0.004 mg l-1). f Ex vitro rooting in shoots pulse treated with IBA (400 mg l-1) for 7 min. g Acclimatization of ex vitro rooted plantlets under greenhouse conditions. h Transfer of a successfully hardened plant into polybag

2. *Prosopis cineraria*

Prosopis cineraria (L.) Druce, which belongs to the family Fabaceae, is an important tree of the arid and semiarid regions.This study reports the identification and characterization of microsatellite markers in *P. cineraria* by cross species amplification of 18 microsatellite markers developed in *P. chilensis, P. alba, and P. flexuosa.*

We identified and characterized 10 microsatellite markers in *P. cineraria*by cross species amplification. Total 18 Simple Sequence Repeat (SSR) primer pairs developed in *P. chilensis, P. alba,* and *P. flexuosa*were used to amplify SSR loci in *P. cineraria*. Out of eighteen SSR markers tested, ten (55.5%) amplified recognizable amplicons. The number of alleles detected at each locus ranged from one to four, a total of 24 with an average of 2.4 alleles. Observed heterozygosity (*Ho*) and expected heterozygosity (*He*) values varied from 0.14 to 0.85 and 0.21

to 0.56 with an average of 0.47 and 0.37, respectively. The polymorphic information content (PIC) values ranged from 0.49 to 0.78 with an average of 0.66. Of the nine polymorphic markers, seven were highly informative and polymorphic (PIC >0.5). These microsatellite markers are characterized for the first time in *P. cineraria*. All microsatellite markers identified in this study may be useful in comparative genomics and population genetics studies of *P. cineraria*.

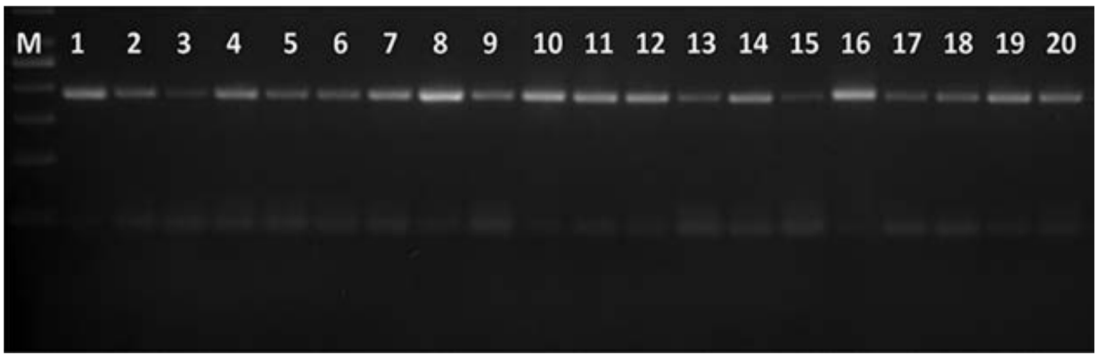


Figure 1. A gel image showing amplification patterns in 20 *P. cineraria* samples using SSR primer Mo07. M ¼ 50 bp DNA, 1 to 20 - *P. cineraria* samples.

3. ***Farsetia macrantha* Blatt. & Hallb.:**

An erect, perennial medicinal undershrub, commonly known as motio-hiran chobbo belongs to the family Brassicaceae. *F.macrantha* is an endemic plant species and categorized as rare and threatened species. The whole plant is used as rheumatism and as a cooling medicine. The *in vitro* propagation of this plant is via Cotyledonary nodes segments excised from 2-3 weeks old aseptically grown seedlings served as explant and cultured on MS basal media containing 3% sucrose and additives(50.0 mg l−1 of ascorbic acid, and 25.0 mg l−1 each of citric acid L-arginine and adenine sulfate). The multiplication of shoots has been done on 0.5 mg/l of BAP + 0.25 mg/l of Kin and subculture within 14-15 days. About 70% of the shoots of *F. macrantha* rooted in vitro on half strength MS salts + 2.0 mg/l of IBA.

4. ***Dipterygium glaucum* Decne.:**

D. Glaucum locally known as “Phel” belongs to the family Capparaceae is medicinally an important shrub and also a source of volatile alkaloids, flavinoides, cumarins and cyanides. The whole plant is used to cure respiratory diseases, skin redness and irritation, wounds, unhealthy

patchy skin, chronic fever. It has multiple medicinal uses like antispasmodic, analeptic, antileishmanial, insecticidal, antibacterial and antifungal. Ecologically it is also an important plant plays a role as a soil binder. The nodal explant and leaves of Dipterygium glaucum were inoculated on MS medium supplemented with 2,4-D (0.2-2 mg/l) and NAA (0.2-2 mg/l) for callus induction. For differentiation of shoot, proliferated callus was transferred to MS medium fortified with 0.25 mg/l of BAP and 0.1 mg/l of Kin and NAA. Further work for plant regeneration is in progress.

Tylophora indica : (a) Bud break (b) Shoot multiplication

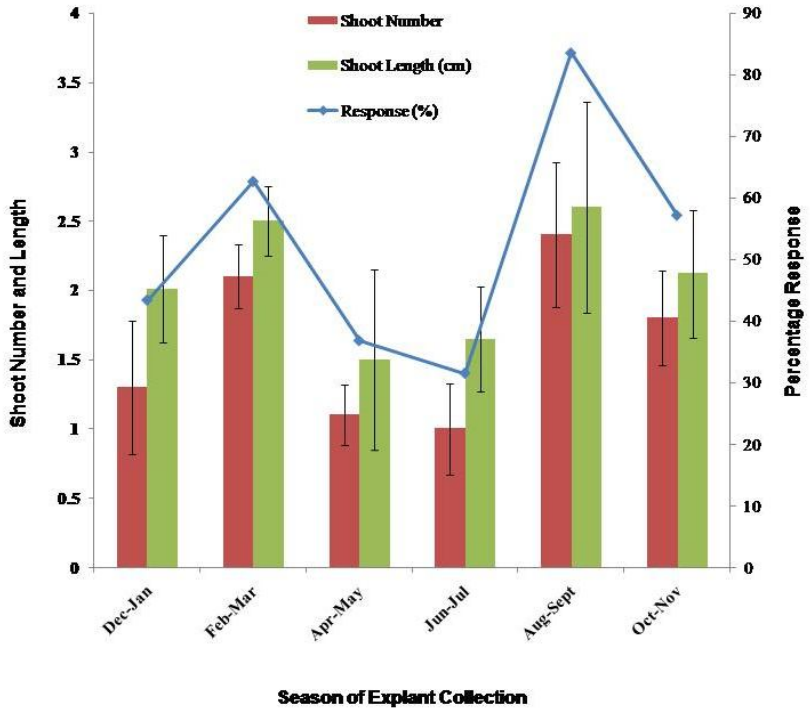
Farsetia macrantha : (a) Plant in habitat (b) seedling as

(ii) Dr. Suman Parihar

Micropropagation of *Ceropegia bulbosa*

Ceropegia bulbosa (Roxb.) commonly known as khedula, belongs to family Apocynaceae, is a medicinally important plant of Thar Desert of Rajasthan. Murashige and Skoog (1962) medium supplemented with 6-benzyladenine (BA) (2.0 mgl^{-1}) was found optimum for axillary shoot bud induction with 83.4 % response. The nodal shoot segments collected during rainy

season (August-September) was found to be the best for initiation of culture. Further shoots were multiplied through repetitive (3-4 times) transfer of the original explant and by subculture of the *in vitro* generated shoots. Maximum number of shoots 5.7±0.78 with shoot length of 3.6±0.82 cm was achieved on MS medium augmented with combination of cytokinins i.e. BA 0.25 mgl^{-1} + KN 0.25 mgl^{-1} + IAA 0.1 mgl^{-1} and additives (50.0 mgl^{-1} ascorbic acid, 25 mgl^{-1} each of citric acid, arginine and adenine sulphate).*In vitro* produced shoots were harvested and washed with water to remove adhered agar to avoid bacterial and fungal contamination. The basal part of these shoots was pulsed with different concentrations of IBA for 3-4 minutes and subsequently transfers to bottles containing soilrite and placed near pad section of the green house. The maximum frequency (73.5 %) of root induction with 3.1±0.56roots with root length of 2.3±0.44 cm. was recorded when the shoots were treated with 250 mgl^{-1} of IBA for 3 minutes.The rooted shoots were successfully hardened in the green house condition (RH 75-80% with 26-28˚C temperature) and about 80 % shoots were transferred to the garden.



(iii) Dr. Ashok Patel

Transverse thin cell layer induced micropropagation of *Caralluma edulis* (Edgew.) Benth. & Hook. f., a rare and nutraceutically important plant of extreme arid regions

Caralluma edulis (Edgew.) Benth. & Hook. f., (family Asclepiadaceae) is an edible plant of the extreme arid regions of the Thar Desert. It is locally known as **"Pimpa"** and habitat/region in which it grows is said as **Pimpthali**.This plant is a rich source of anti-oxidants and attracted interest of several nutraceutical and cosmetic industries. *C. edulis* has been historically used as emergency food and appetite suppressor during the times of scarcity in arid regions for centuries. Anthropogenic activities on established sand dunes, habitat destruction and harvesting/grazing of complete plant prior to its reproductive maturity restrict the propagation by sexual means. Poor reproduction and seed set have put adverse pressure on native populations of this endemic and slow multiplying plant of Indian Thar desert. Therefore, an alternative method is necessary to meet the growing pharmaceutical needs and its sustainable utilization. Plant tissue culture includes transverse thin cell layer (tTCL) technique that provides an opportunity to produce large number of plants in a short period of time by using a minimum of stating plant material and hence has a minimal impact on its native populations.

For transverse thin cell layer culture, the nodal as well as internodal portions of shoot segment were transversely sliced in to pieces of about 1–4 mm (thickness), and these slices were used as tTCL explants for shoot regeneration. Of the concentrations of cytokinins studied, MS medium containing BAP (1.0 mg l^{-1}) proved the best in terms of percentage response (93.0 %) and number of shoot buds (4.2 ± 0.78) from tTCL nodal explants. For further multiplication of shoots, explants along-with the induced shoots were transferred to the medium containing different combinations of PGRs. Among the all combinations tested, MS medium having a combination of BAP and Kin (0.25 mg l^{-1} each) + IAA (0.1 mg l^{-1}) was found the best and produced the higher number of shoots (23.6 ± 1.34 per tTCL explant) of an average length (6.09 ± 0.67 cm). In comparison to inverted orientation, significantly higher ($P< 0.05$) number of shoots per tTCL explant was observed in upright oriented tTCL nodal explants. The internodal thin cell layer explants were also tried for shoot differentiation using different concentrations and combinations of PGRs. On all the combinations of PGRs tried, only callus was induced from tTCL explants and the callus further failed to differentiate shoots. The tTCL raised shoots

were rooted ex vitro on pulse treatments with freshly prepared IBA and NOA (50 and 100 mg l^{-1}) for 4 min. The rooted plantlets were acclimatized and hardened successfully in the green house.

(iv) Dr. Sumitra Choudhary

Assessment of genetic stability of wild female plant of Momordica dioica regenerates

In vitro genetic stability of wild female plant of *Momordica dioica*regenerates (developed from *in vitro* maintained shoot cultures) was assessed by two DNA-based fingerprinting techniques i.e. RAPD and ISSR. Of 10 RAPD and 12 ISSR primers screened 5 primers from each produce 2-4 scorable/reproducible bands. A total of 15 and 16 amplicon/fragments were generated with an average 3 and 3.2 band per RAPD and ISSR primer respectively. Among all the amplicons no polymorphism was observed; confirm the reliability of microprpagation method for wild female plant of *Momordica dioica*as shoot cultures maintains the genetic integrity even after prolonged period more than three years under *in vitro* conditions without any somaclonal variations. Cultures were maintained on agar gelled [0.8% (w/v) bacteriological grade, Qualigens Fine Chemicals, Mumbai, India] MS medium having sucrose 3% (w/v), additives (50 mg L^{-1} ascorbic acid, 25 mg L^{-1} each of adenine sulphate, citric acid and L-arginine (HiMedia®, Mumbai, India)) and PGRs (BAP (0.5 mg L^{-1}), IAA (0.1 mg L^{-1})) The probable reason for this attribute may be the regeneration of plants through organized (pre-existing meristems), which is supposed to maintain strict genotypic and phenotypic stability under tissue culture conditions). In addition, maintenance of shoot cultures on lower levels of PGRs (cytokinin and auxin).

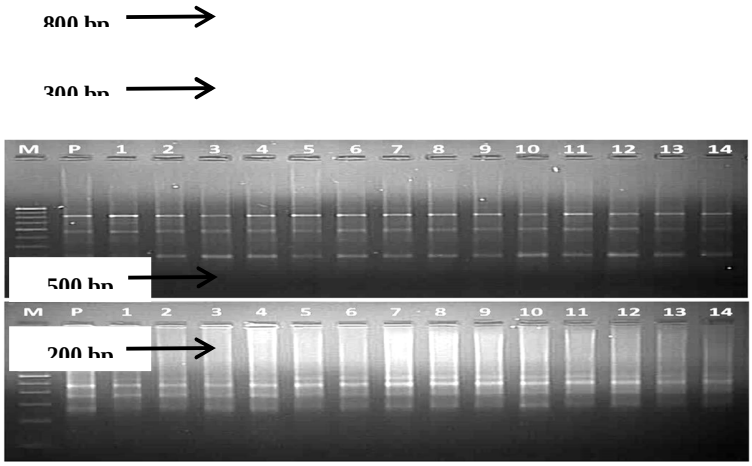


Figure 1: Shoot multiplication by subculturing of in vitro raised shoot-clumps on MS + BAP (0.5 mg L^{-1}) + IAA (0.1 mg L^{-1}) and additives; Figure 2: Ex vitro rooted shoot in Soilrite® on pulse treatment with IBA (250 mg L^{-1}) for 5 min; Figure 3: Validation of genetic homogeneity in micropropagated plants of wild female *M. dioica;* DNA amplification pattern obtained with RAPD primer OPG-06; DNA amplification pattern obtained with ISSR primer UBC-821; Lane M: 100 bp ladder, Lane P: Mother plant, Lanes 1-14: Micropropagated plants.

(v) Dr. Rachna Dinesh nee Modi

Molecular characterization of germplasm and also in vitro studies of selected plants of arid and semi arid region of Rajasthan i.e. Date palm and Pomegranate.

(i) In vitro propagation and ex vitro rooting of *Punica granatum*

A micropropagation protocol for plant regeneration of a selected genotype of *Punica granatum* cv. Jalore seedlesshas been developed using rapid axillary bud proliferation followed by ex vitro rooting. The nodal segments obtained from a field grown mature plant were used as explants. The highest bud breaking response (82.8%) was recorded on Murashige and Skoog (MS; 1962) medium containing BAP (3.0 mg l^{-1}). The shoots were further multiplied by subculturing of in vitro raised shoots on MS medium containing cytokinins (BAP or Kin) in combination with an auxin (IAA). Amongst the combinations tested, MS medium containing BAP (0.5 mg l^{-1})and IAA (0.1 mg l^{-1}) was found the best and produced the maximum number of shoots (14.2 ± 1.03 per culture vessel) with an average length (5.50 ± 0.54 cm), after 5 weeks of culture. The regenerated shoots were rooted under vitro as well as ex vitro conditions. About 72.9% shoots were rooted in vitro on half-strength MS medium containing IBA (2.0 mg l^{-1}) and activated charcoal (200 mg l^{-1}). In comparison to in vitro, a higher percentage (85.2%) of shoots was rooted ex vitro and formed a maximum number (5.2 ± 0.78) of roots per shoot on treating the shoot base with IBA (300 mg l^{-1}) for 5 min. The incorporation of ex vitro rooting technique in a micropropagation protocol is more emphasized due to its cost-effectiveness, less labour intensiveness and it also saves time. The rooted plantlets by both the methods were acclimatized successfully in the green house and transferred to the nursery. The discussed micropropagation protocol could be employed for the large scale propagation of this seedless genotype of the *Punica granatum*, an economically important horticultural fruit plant.

(ii) **Propagation of female Date Palm (*Phoenix dactylifera*) through somatic embryogenesis**

Date-Palm (*Phoenix . dactylifera* L.) is an important horticultural plant of arid/semi-arid regions. A protocol has been developed for *in vitro* regeneration of selected mature female plants of Date-Palm suited for climatic conditions of Rajasthan. The axillary shoot buds (measuring 0.5-2.0 cm) were used as explants for culture initiation. After 5-6 months the cultured buds produced creamy white, slow growing callus on MMS medium augmented with 10.0 mgl^{-1} of 2,4-D and additives.. The cultures were transferred to MMS medium containing 3.0 mgl^{-1} of 2,4-D, 0.5 mgl^{-1} each of iP and kinetin, 4.0% sucrose, 1.0% glucose and 2.0%

maltose and additives for the proliferation of callus. The granular embryogenic cell cultures differentiated on hormone-free full strength of MMS salts containing 4.0% sucrose, 1.0% glucose and 2.0% maltose and additives. The *in vitro* raised plantlets were hardened in the green house and then transferred to soil in polybags.

B. Microbes of Desert Areas

1. **In-Charge of Thrust area**: **Prof. Hukam S. Gehlot**

Group-I
A. Characterization of Native rhizobia associated with wild legumes of Thar Desert (Dr. H.S.Gehlot)
B. Genomics of native rhizobia and their symbiotaxonomy (Dr. Nisha Tak)
C. Characterization of symbiotic genes and structure of nodules (Mr. Alkesh Tak)
Group-II
D. Biodiversity and molecular characterization of wild mushroom from diverse regions of Indian Thar Desert (Investigator: Dr. Praveen Gehlot)
Group-III
E. Antimicrobial potential of some desert plants (Dr. Sharad Bissa)

Group-I (BNF and Microbial Genomics Lab.) and its objectives

1. Characterization of Native rhizobia associated with wild legumes of Thar Desert
2. Genomics of native rhizobia and their Symbiotaxonomy.
3. Characterization of symbiotic genes and structure of nodules

Summary of Group-I (BNF and Microbial Genomics Lab.) work: After molecular identification of root nodule microsymbionts associated with native legumes of Indian Thar Desert, the novelty of RNB strains was defined using multi locus sequence analysis of 3-4 housekeeping including protein-coding genes. Since our laboratory is working on number of native legumes belonging to all the three subfamilies and we have ongoing projects from DST and UGC, the UGC-SAP-II-CAS program additionally helped us to achieve the long-term objectives and specifically strengthen our microbial storage facilities to accommodate large number of isolated and well characterized microsymbionts from all over the country. In this report we are presenting Symbiotaxonomy/host range, robust phylogenetic trees based on number of housekeeping genes as well as symbiotic genes from number of microsymbionts isolated from several native legumes worked out under other projects as well as partial support from UGC-SAP-CAS-I program. UGC-SAP-CAS-I program has been duly acknowledged in the papers published in high impact factor SCI journals in addition to other funding agencies.

Comparative Concatenated Housekeeping Gene(s) Analysis: Concatenated phylogenetic tree constructed using ***glnII-atpD-recA-dnaK*** gene sequences of various Thar Desert-*Ensifer* revealed that tree (species of *Mimosa* and *Vachellia*) rhizobial strains formed a separate clade and distinct lineages close to *E. saheli* and *E. kostiensis*. The maximum percentage sequence similarity of these *Ensifer* strains with various type strains based on individual and concatenated sequences of housekeeping gene is given in Table 1. The *Tephrosia-Ensifer* strains formed four MLSA phylogenetic types. *Ensifer* sp. TV1 and *Ensifer* sp. TL4 formed a discrete lineage close to *E. psoraleae* and *E. adhaerens* respectively. Interestingly the mimosoid-*Ensifer* sp. PC2 clustered along with other papilionoid-*Ensifer* strains in a novel clade. Probably the alkalinity and aridity of the Thar Desert are acting as driving force for diversification of *Ensifer* strains nodulating native legumes of this region.

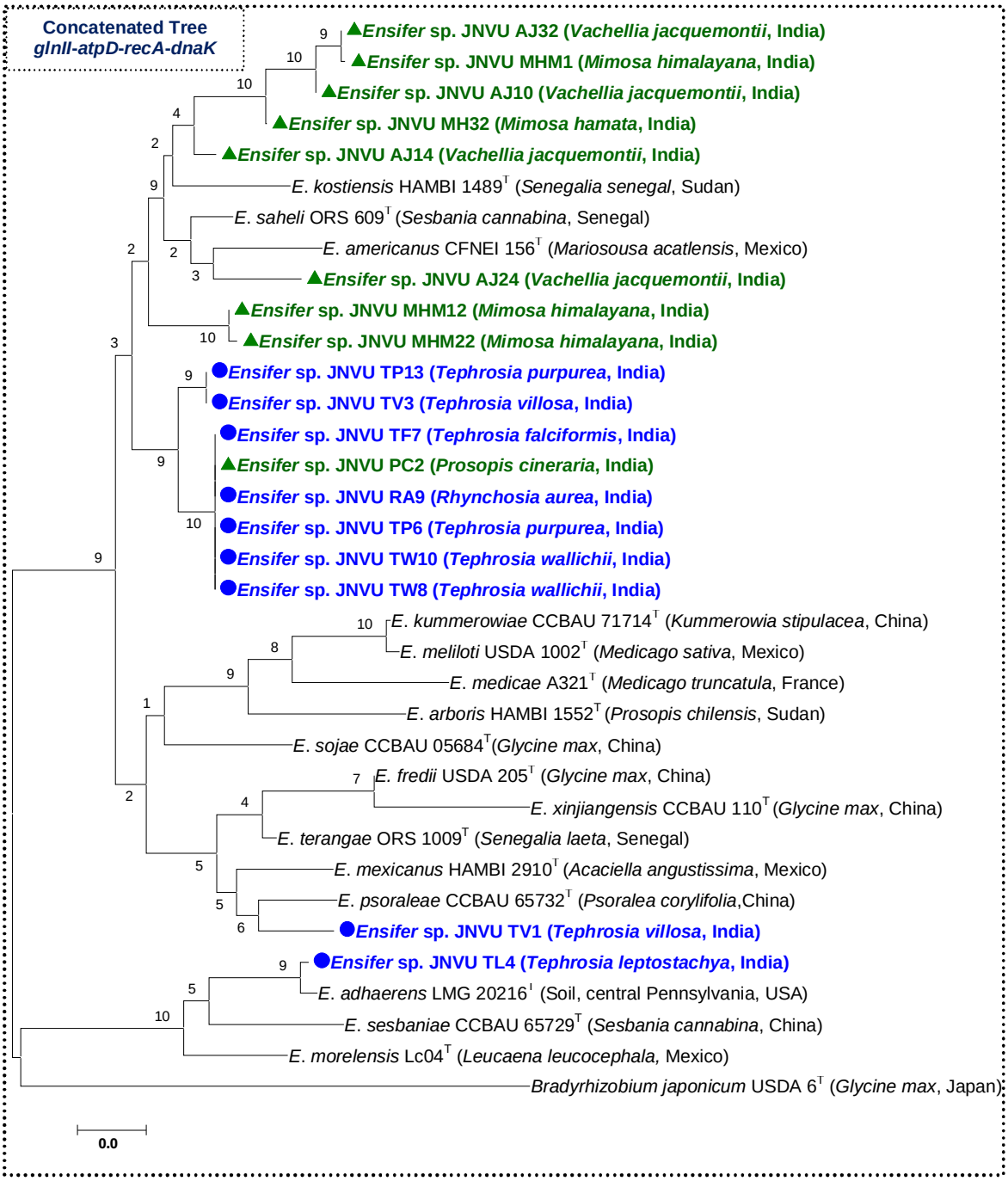


Fig. 2 Comparative phylogenetic analysis based on symbiotic gene (nodA) of selective Thar-Desert-Ensifer strains isolated from various native and invasive legume hosts growing in Western Rajasthan.

Table 1:The maximum percentage sequence similarity of selective Thar Desert-*Ensifer* strains with closest type strains based on housekeeping and symbiotic genes.**

Gene / Strain name	*rrs*	*recA*	*atpD*	*glnII*	*dnaK*	Concatenated *glnII, atpD, recA* and *dnaK*	Concatenated *rrs, glnII, atpD, recA* and *dnaK*	*nodA*	*nifH*
TF7 TP6 TW10 TW8	*E. saheli* and *E. kostiensis* (99.7)	*E. saheli* (96.0)	*E. saheli* (96.4)	*E. saheli* (95.5)	*E. saheli* (93.7)	*E. saheli* (96.0)	*E. saheli* (98.0)	*E. fredii* and *E. xinjiangensis*(92.6)	*E. xinjiangensis* and *E. sojae* (97.3)
TV3 TP13	*E. kostiensis* (99.7)and *E. saheli* (99.6)	*E. saheli* (96.0)	*E. saheli* (95.8)	*E. saheli* (95.3)	*E. saheli* (92.2)	*E. saheli* (95.6)	*E. saheli* (97.8)	*E. fredii* and *E. xinjiangensis* (91.8)	*E. xinjiangensis* and *E. sojae*(97.0)
TV1	*E. terangae* (99.7)	*E. psoraleae* (99.0)	*E. psoraleae* (96.7)	*E. garamanticus* (95.6)	*E. terangae* (93.2)	*E. psoraleae* (95.8)	*E. terangae*(97.7)	*E. fredii* and *E. xinjiangensis*(93.0)	*E. xinjiangensis* and *E. sojae* (96.6)
TL4	*E. adhaerens* (100)	*E. adhaerens* (98.2)	*E. adhaerens* (99.4)	*E. adhaerens* (99.1)	-----	*E. adhaerens* (99.2)	*E. adhaerens* (99.7)	*E. fredii* and *E. xinjiangensis*(90.1)	*E. xinjiangensis* and *E. sojae* (98.5)
AJ10	*E. saheli* (99.6)	*E. saheli* (98.1)	*E. saheli*(95.01)	*E. saheli* (96.1)	*E. saheli* (92.9)	*E. saheli* (95.6)	*E. saheli* (97.7)	*E. arboris* (95.0)	*E. kostiensis* (98.4)
AJ14	*E. saheli*(100)	*E. kostiensis* (96.4)	*E. saheli* (97.1)	*E. saheli* (97.0)	*E. saheli* (94.3)	*E. saheli* (97.0)	*E. saheli* (98.5)	*E. arboris* (95.0)	*E. kostiensis*(98.4)
AJ23	*E. saheli*(100)	*E. saheli* (97.9)	*E. saheli* (95.0)	*E. saheli* (96.6)	*E. saheli* (93. 4)	*E. saheli* (95.9)	*E. saheli* (98.0)	*E. arboris*) (92.0)	*E. kostiensis*(97.2)
AJ24	*E. mexicanus* (99.7) and *E. terangae* (99.7)	*E. saheli* (95.1)	*E. saheli* (94.4)	*E. saheli* (97.2)	*E. fredii*(95.1)	*E. saheli* (96.0)	*E. saheli* (97.7)	*E. kostiensis* (93.6)	*E. terangae*(94.3)
AJ18 AJ31 AJ32	*E. saheli*(99.8)	*E. saheli* (97.9)	*E. saheli* (95.0)	*E. saheli* (95.2)	*E. saheli* (92.4)	*E. saheli* (95.1)	*E. saheli* (97.6)	*E. arboris* (95.2)	*E. kostiensis* (98.4)

Abbreviations: TF, *Tephrosia falciformis*; TL, *Tephrosia leptostachya*; TP, *Tephrosia purpurea*; TV, *Tephrosia villosa*; TW, *Tephrosia wallichii*; AJ, *Vachellia*(*Acacia*) *jacquemontii*

Multi locus sequence analysis (MLSA) data as published in Tak et al., 2016 (Systematic and Applied Microbiology) and Sankhla et al., 2017 (Plant and Soil)

Symbiotic *nodA* gene phylogenetic analysis:Symbiotic (*nodA*) gene phylogeny of various Thar-Desert *Ensifer* strains isolated fromdifferent shrub/herbaceous (Papilionoideae) legumes revealed that these *Ensifer* strains have novel nodulation genes forming a separate clade distant from the clade of type strain *E. fredii* (Asiatic origin). Interestingly the *nodA* gene of mimosoid *Prosopis cineraria-Ensifer* also clustered in this clade. However on the basis of core genes these all strains showed genetic similarity with Old World *Ensifer* strains such as *E. saheli*, *E. kostiensis* and *E. terangae*.This incongruence is due to horizontal transfer of the *sym* genes. *Ensifer* strains nodulatingspecies of *Mimosa* and *Vachellia* in the Thar Desert possess different *nodA* genes that are closer to *E. arboris* (Old World).Other tree rhizobia (*Senegalia senegal-Ensifer*) AS50 had *nodA* genes divergent from other tree rhizobia. Similarly*Vachellia nilotica-Ensifer* (AN11) and *Prosopis juliflora-Ensifer* (PJ11) *nodA* genes were divergent and showed close similarity with *nodA* gene of New World *Ensifer americanus* CFNEI 156^{T} strain.

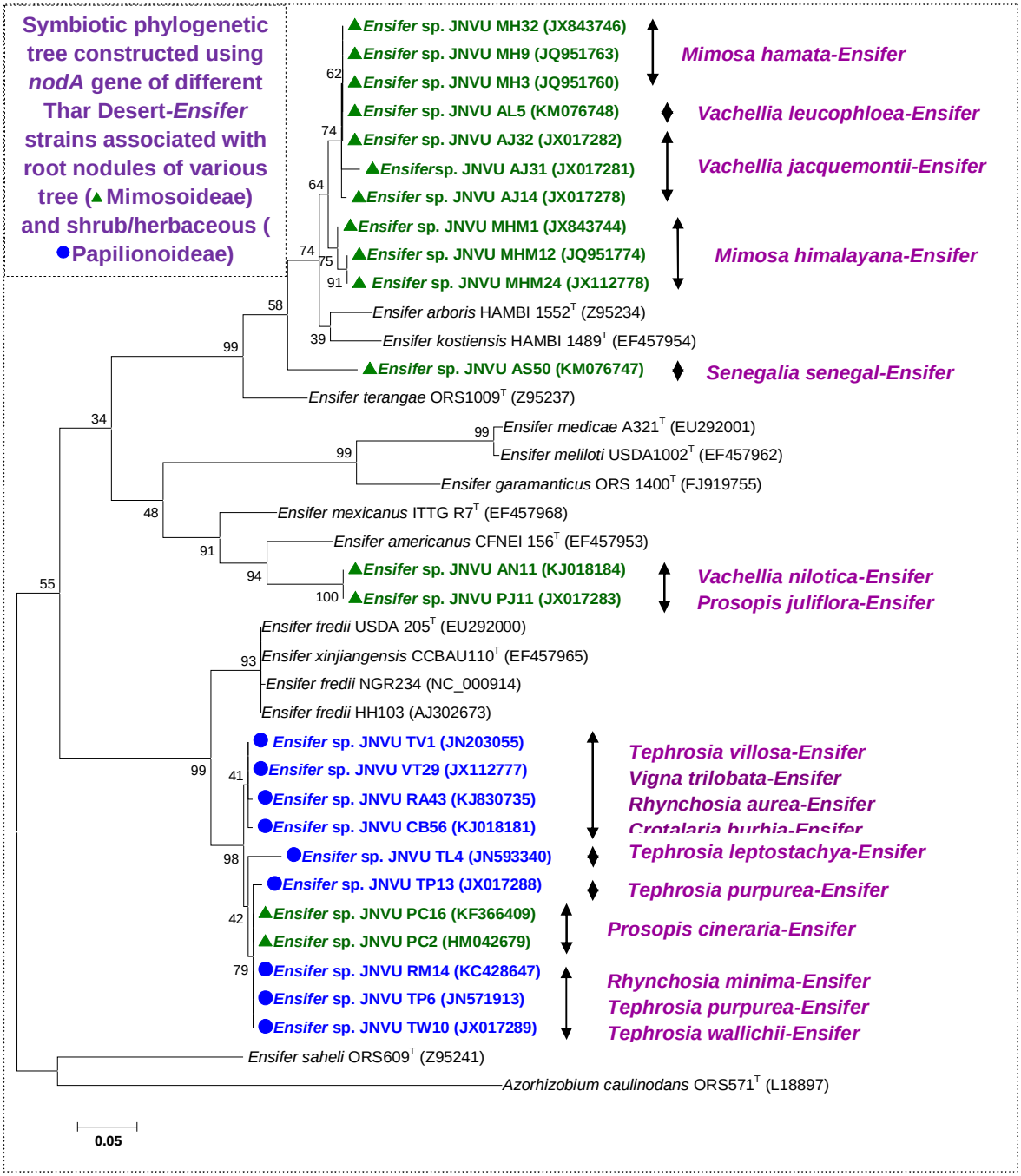


Fig. 2 Comparative phylogenetic analysis based on symbiotic gene (*nodA*) of selective Thar-Desert-*Ensifer* strains isolated from various native and invasive legume hosts growing in Western Rajasthan.

Table 2: Authentication and Cross inoculation tests of novel Thar Desert-*Ensifer* strains on different wild and crop legume species.***

Host plant species	Sub-family	Wild/ crop	PAPILIONOIDEAE *TEPHROSIA-ENSIFER*							MIMOSOIDEAE TREE-*ENSIFER*						
			TF 7	TP 6	TW 10	TP 13	TP 18	TV 1	TL 4	PC 2	AJ 32	AJ 18	AJ 24	AL 5	MH 40	MH M2
Tephrosia falciformis	P	Wild	+	+	+	+	NT	+	NT	NT	NT	NT	NT	NT	NT	NT
Tephrosia leptostachya	P	Wild	+	+	+	NT	NT	+	+	NT	NT	NT	NT	NT	NT	NT
Tephrosia purpurea	P	Wild	+	+	+	+	+	+	+	+	NT	NT	NT	NT	NT	NT
Tephrosia villosa.	P	Wild	+	+	+	+	NT	+	NT	NT	NT	NT	NT	NT	NT	NT
Tephrosia wallichii	P	Wild	+	+	+	+	+	+	+	+	NT	NT	NT	NT	NT	NT
Prosopis cineraria	M	Wild	+	+	+	+	NT	+	NT	+	+	+	-	NT	+	-
Prosopis juliflora	M	Wild	NT	+	+	NT	NT	NT	NT	+	NT	NT	NT	NT	+	+
Vachellia gummifera	M	Wild	NT	+	+	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Senegalia senegal	M	Wild	NT	-	-	NT	NT	NT	NT	NT	NT	NT	NT	+	+	+
Mimosa hamata	M	Wild	-	-	-	-	-	-	-	+	+	+	-	NT	+	+
Mimosa himalayana	M	Wild	-	-	-	-	-	-	-	NT	+	+	-	NT	NT	+
Vachellia jacquemontii	M	Wild	NT	NT	NT	NT	NT	NT	NT	NT	+	+	+	NT	+	+

Vachellia nilotica	M	Wild	NT	NT	NT	NT	NT	NT	NT	NT	+	+	-	+	+	+
Vachellia tortilis	M	Wild	NT	+	+	NT	NT	NT	NT	+	NT	NT	NT	NT	NT	NT
Vachellia leucophloea	M	Wild	NT	+	+	NT	NT	NT	NT	+	NT	NT	NT	+	NT	NT
Leucaena leucocephala	M	Wild	NT	+	+	NT	NT	+	NT	+	NT	NT	NT	NT	-	NT
Chamaecrista pumila	C	Wild	NT	+	+	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Vigna unguiculata	P	Crop	NT	+	+	NT	+	NT	NT	+	NT	NT	NT	NT	NT	NT
Vigna radiata	P	Crop	+	+	+	+	+	+	+	+	NT	NT	NT	-	-	-
Vigna aconitifolia	P	Crop	+	+	+	+	+	+	NT	+	NT	NT	NT	NT	NT	NT
Vigna trilobata	P	Crop	NT	NT	NT	NT	NT	NT	NT	NT	-	-	-	NT	NT	NT
Macroptilium atropurpureum	P	Crop	+	+	+	+	NT	+	NT	+	-	-	-	NT	NT	NT
Cyamopsis tetragonoloba	P	Crop	+	+	+	+	+	+	NT	+	NT	NT	NT	NT	NT	NT
Phaseolus vulgaris	P	Crop	-	-	-	-	NT	-	+	-	NT	NT	NT	NT	NT	NT
Arachis hypogaea	P	Crop	NT	-	-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Glycine max	P	Crop	NT	-	-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Abbreviations:P, Papilionoideae; C, Caesalpinioideae; M, Mimosoideae +, nodulation observed and positive expression of GFP; -, no nodulation; NT, not tested TF, *Tephrosia falciformis*; TL, *Tephrosia leptostachya*; TP, *Tephrosia purpurea*; TV, *Tephrosia villosa*; TW, *Tephrosia wallichii*; AJ, *Vachellia jacquemontii*; AL, *Vachellia leucophloea*;PC, *Prosopis cineraria*; MHM, *Mimosa himalayana*; MH, *Mimosa hamata.* ***Nodulation data published in Gehlot et al. 2016 (BMC-Standards in Genomic Sciences); Tak et al., 2016 (Systematic and Applied Microbiology); Le Quere et al., 2017 (BMC-Genomics); Sankhla et al., 2017 (Plant and Soil); Choudhary et al., 2016 (Indian Forester) and few unpublished data.**

Symbiotaxonomy/Host-range analysis: The nodulation tests (Table 2) performed on various leguminous species demonstrated the specificity of Tree-*Ensifer* strains and broad host range of *Tephrosia-Ensifer* strains. The inoculated plants comparatively had vigorous growth, higher biomass and more height as compared to un-inoculated N-control. Mostly no nodules were found on the plant roots of N- and N+ controls. *Ensifer* strains isolated from root nodules of perennial *Tephrosia* species could nodulate the wild tree legumes *P. cineraria*, *P. juliflora*, *V. gummifera*, *V. tortilisV. leucophloea* and *L. leucocephala* belonging to the sub-family Mimosoideae, indicating a wide host range, but these strains failed to nodulate *S. senegalM. hamata* or *M. himalayana*.The *Tephrosia-Ensifer* strains nodulated *Chamaecrista pumila* ofsub-family Caesalpinioideae. Interestingly these strains effectively nodulated various crop legumes such as *Vigna* sp.,*M. atropurpureum* and *C. tetragonoloba*. The genetically different *Tephrosia-Ensifer* strains having similar monophyletic symbiotic genes had common host range. The broad host range of *Tephrosia-Ensifer* strains is remarkable and these strains could be used as potential inoculums in improving the productivity of agricultural crops grown in arid regions of Rajasthan.

Some tree rhizobial strains are host-specific, whereas others have a wide host range. Our knowledge about symbiotic affinities among Thar Desert tree rhizobia is limited. The cross-inoculation studies of various Thar tree-rhizobia indicated that the *E. saheli*-like group of *Ensifer* strains isolated from *V. jacquemontii* (AJ10, AJ14, AJ23, AJ31 and AJ32) had a wide host range and were capable of nodulating other mimosoid legumes, such as *V. nilotica, M. hamata, M. himalayana* and *P. cineraria*. While single strain AJ24, was very specific and nodulated only *V. jacquemontii*. The leguminous trees *Prosopis* have been reported to be infected by both fast and slow growing rhizobia. The legume *Prosopis cineraria,* state tree of Rajasthan is nodulated by highly effective novel strain *Ensifer* sp. PC2 which in addition to cross-nodulating various papilionoid and mimosoid legumes is also able to nodulate the *Acacia saligna* (Western Australian golden wattle), a promiscuous legume tree mainly nodulated by species of *Bradyrhizobium* in Australia.Other native tree rhizobias, *Ensifer* sp. MH40 and MHM2 showed effective nodulation on cross-inoculation in wild tree legume *P. juliflora, S. senegal, V. nilotica* and *V. jacquemontii* belonging to sub-family Mimosoideae but failed to nodulate *Leucaena leucocephala* (exotic tree) of same sub-family and crop legume *Vigna*

radiata.Similarlythe *Vachellia* (*Acacia*) *leucophloea* RNB (*Ensifer* sp. AL5) effectively cross nodulated *S. senegal* and *V. nilotica* but failed to nodulate the *V. radiata*. The cross-inoculation results are signifying wide host range of these Thar *Ensifer* strains and more studies are needed to explore their nodulating efficiency in different tribes of three sub-families of Leguminosae.

Group-II

1. **Title of Research Project:** Biodiversity and molecular characterization of wild mushroom from diverse regions of Indian Thar Desert
2. **Investigator: Dr. Praveen Gehlot**
3. **Summary of work:**

In continue to research progress (III year i.e. 2015-2016), Ethno-mycology surveys were conducted to collect information about neutraceutical and pharmaceutical values oflocal gastroid mushroom *Phellorinia herculeana Berk. (P. iniquinans)* and *Podaxis pistillaris* (Linn.) Fr.. Study revealed that *P. herculeana and P. pistillaris* areedible and medicinal significance mushroom but nocomprehensive literatures were available. Therefore, review work done on both xeric mushrooms occurred in very short period in Indian Thar Desert. In review, distribution, taxonomy, morphology, nutritive value, bioactive components, cultivation, economic importance with traditional pharmacological significances were documented.

During the ethno-mycological survey, It has been observed that *P. herculeana* mushroom is known to its delicacy and deliciousness as its medicinal value. It is hunted and eaten by rural folk, since centuries for its nutritional as well therapeutic worth. It is sold in the market as a fresh as in dried form by local ethnic persons of Thar Desert.

Despite of high Nutraceutical and Pharmaceutical properties, *P. herculeana* is defying attempts of its domestication. Mycologists have been making sustained efforts since long for cultivation but couldn't domesticate it till date. Many researchers have made sustained efforts to cultivate it under controlled environmental conditions but the optimum conditions that are favorable for sporophore (Basidiocarp) development have not been clearly determined and till date no one achieved success in domesticating *Phellorinia* under controlled conditions. This call for continued studies on the basic biology and life cycle of *Phellorinia* with comprehensive study of ecological factors especially soil characteristics and weather prerequisites of natural growing sites. However, soil characteristics of natural growing sites of *Phellorinia* have been

studied in previous year (year 2014-2015) but information regarding precise weather prerequisites like air temperature, relative humidity and total rainfall in this region were need to work out for fructification in *Phellorinia* under natural growing sites of Jodhpur district of Rajasthan.

During the study of meteorological data of the year, 2015, it was found that specimens of *Phellorinia* were observed and collected in the vicinity of the site during 26th to 36th meteorological weeks (M.wk). Therefore, only *i.e.* 23th to 39th week were taken into consideration and correlated with the initiation and development of the fruiting bodies of *Phellorinia*. A graphical representation of the maximum and minimum air temperatures during this period is depicted in fig-1. The data exhibited wide variation, the maximum temperature varied from 29.1 to 41.2^{o}C and the minimum from 24 to 30.3^{o}C during the period. The maximum and minimum relative humidity varied considerably from 44.7 to 90% and 20.7 to 76%, respectively (fig-2).The first rainfall was received during the 23th M. wk and subsequent rainfall in 24th to 34th M. wk was recorded. There was no rainfall from 35th to 38th M. wk. The minimum rainfall of 0.5 mm was received in 25th M. wk and the maximum of 13.5mm was recorded in 30thM.wk (fig.3). The sporophore observed during 26th to 36th M. wk i.e. 22 June to 6 September, 2015. During these 11 weeks, the maximum temperature varied from 29.1 to 38.9^{o}C and minimum temperature from 24.9- 28.8^{o}C. The maximum relative humidity varied 61-90% and the minimum from 31-76 %.

The fructification in *Phellorinia* occurred during 26 to 36 M.wk and it indicates that the prevalent air temperature, relative humidity and persistent rains during the period must have favored the sexual life cycle of the *Phellorinia* from either over wintered spores or dormant mycelium presented in soil as inoculums. The over wintering spores and dormant mycelium lying in the soil in the vicinity of the observation sites might have received a triggering shock due to sufficient rains in preceding week 23- 25th M. wk resulting in absorption of water and change in their osmotic pressure. Sufficient rainfall in prior to *Phellorinia* appearance under natural conditions appear to be the limiting factors and prerequisite for initiation of sexual cycle in*Phellorinia*. Although the air temperatures were favorable during the entire period of observations but sporophore does not appear to be limited factor for *Phellorinia* fructification.

The data from 1 to25 M.wk and 37 to 52 M.wk exhibited favorable air temperatures and relative humidity but *Phellorinia* but the sexual cycle didn't trigger. It might explain so as to why *Phellorinia* grow only in 26 to 36 M.wk due to availability of sufficient water in soil. Despite rainfall in 9th, 10th, 11th, 14th and 15th, M. wk, *Phellorinia* failed to produce sporophore due to unfavorable temperature. Fruiting bodies of *Phellorinia* could not be collected after 36M.wk, despite all favorable condition available in 39th M. wk. because majority of the overwintering spores and active mycelium completed life cycles in the form of basidiocarps and produced next generation spores which require sufficient dormant period (over wintering period). Nevertheless, active mycelium also converted into dormant stage. **Thus**, Present studies give sufficient clues for further controlled experimentation by maintaining air temperature near to 29.1-41.2^{o}C, relative humidity between 44 to 90% and sufficient availability of water in substrates to conduct domestication trials under controlled conditions.

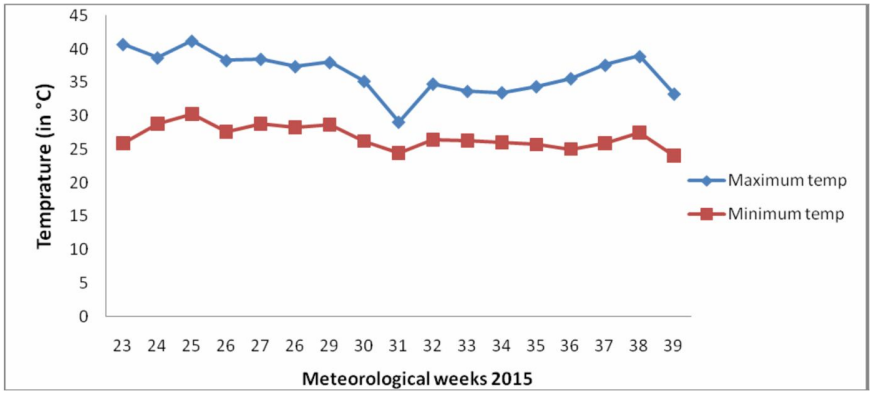


Fig.1: Air temperature variation during mushroom fructification

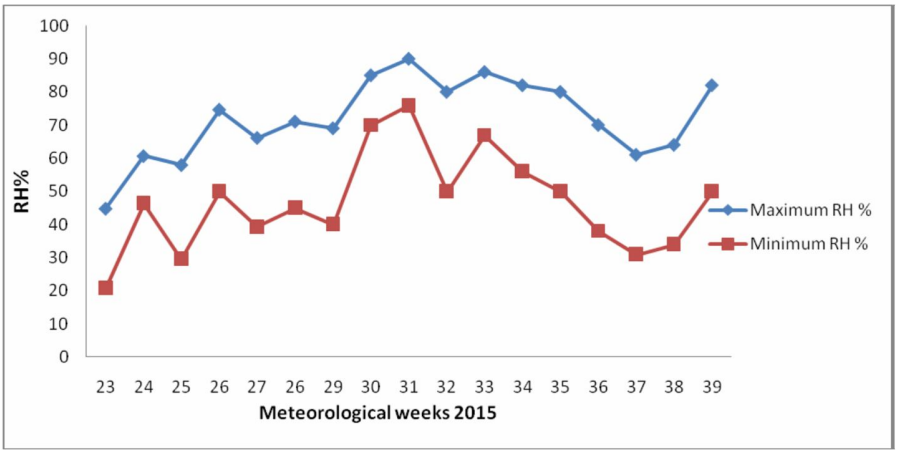


Fig. 2: RH (%) variation during mushroom fructification

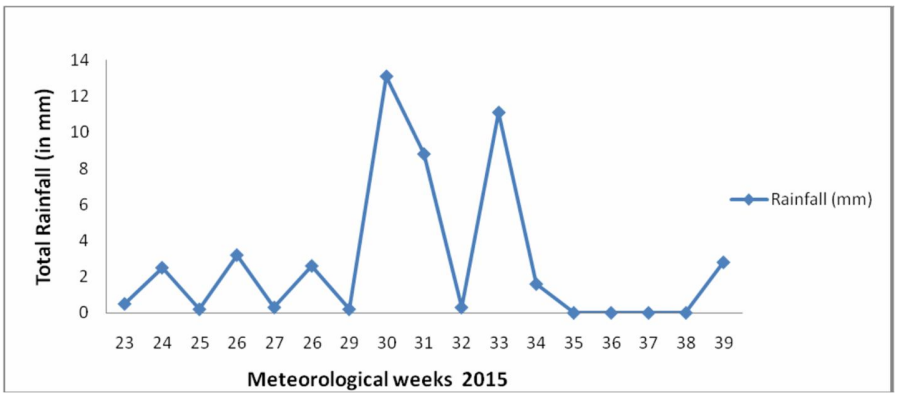


Fig. 3: Total rainfall during mushroom fructification

Group-III

1. Title of Research Project: Antimicrobial Activities of Some Medicinal Plants of Thar desert

Investigator: Dr. Sharad Bissa

Summary of work:

The traditional use of medicinal plants in health care practices among rural communities of villages in desert area provides the basis for novel natural drug discovery development. In the present study 5 desert medicinal plants: *Convolvulus microphyllous*, *Evolvulus alsinoides*, *Moringa oleifera*, *Mollugo cerviana* and *Pedalium murex* were screened for their antibacterial potential against different human pathogenic bacteria viz. *E. coli*, *Salmonella typhi*, *Enterobacter aerogenes* and *Klebsiella pneumoniae*, procured from IMTECH, Chandigarh. Different plant parts i.e. root, leaves, stem, fruits and seeds were examined using water, Ethanol, Chloroform and Petroleum ether as solvents.The antibacterial activity was determined by using

disc diffusion method. Minimum Inhibitory Concentration (MIC) assay were determined for the effective extracts. Ciprofloxacin was used as positive control whereas DMSO and water as negative controls. All the plants exhibited antibacterial but extracts of *Moringa oleifera* showed highest bactericidal action.

Moringa species are well documented plant herbs due to their extraordinary nutritional and medicinal properties. *Moringa oleifera* Lam. are the most widely cultivated species of the monogenic family, the Moringaceae. They have long been known in folk medicine as having value in treating a wide variety of ailments. *Moringa oleifera* is a highly valued plant, distributed in many countries of the tropics and subtropics and it has an impressive range of medicinal uses with high nutritional value. They are known to be anti-helminthic, antibiotic, detoxifiers, immune builders and have been used to treat malaria. The whole *Moringa oleifera* plant is used in the treatment of psychosis, eye diseases, fever and as an aphrodisiac. In the present investigation antibacterial potential of leaves, roots, bark and seeds of *Moringa oleifera* Lam. were tested against some human pathogenic bacteria. All the plants parts exhibited significant antibacterial activity and highest activity was observed in petroleum ether extract of leaves against *E.coli* and petroleum ether extract of seeds against *E. aerogenes*. Phytochemical screening was also done which confirmed the presence of Alkaloids, Flavanoids, Tannin, steroids, glycosides and Saponins in leaves and root extracts.

The findings revealed that the medicinal plants of desert area are a major source of herbal drugs and the survey can be used as baseline information for further scientific investigation to develop new plant based commercial drugs.

Table. 1. Antibacterial activity of dried plant part extracts of *Moringa oleifera*

Plant Part	**Plant Extracts**	**Zone of Inhibition (mm)**			
		E. coli	***S. typhi***	***K. pneumoniae***	***E. aerogenes***
Root	Aqueous	5	-	-	7
	Ethanol	8	4	-	10
	Chloroform	11	7	7	6

	Pet. Ether	12	9	9	9
Leaves	Aqueous	11	-	-	-
	Ethanol	10	-	7	9
	Chloroform	14	8	9	9
	Pet. Ether	**18**	8	9	12
Bark	Aqueous	7	5	5	-
	Ethanol	12	5	5	-
	Chloroform	12	10	8	12
	Pet. Ether	14	11	11	14
Seeds	Aqueous	8	-	-	6
	Ethanol	13	6	7	11
	Chloroform	6	6	5	11
	Pet. Ether	15	10	10	**18**

Table 2. Phytochemical Analysis of plant part extracts of *Moringa oleifera*

Phytochemical Component	**Root**	**Leaves**	**Bark**	**Seeds**
Alkaloids	+	+	+	+
Glycosides	+	+	+	-
Saponins	-	+	+	+
Flavonoids	+	+	+	+
Tannins	+	+	+	-
Steroids	+	+	+	+

C. Taxonomy

Title of project: Plant diversity of Thar Desert: Collection, Taxonomic characterization and Digitization.

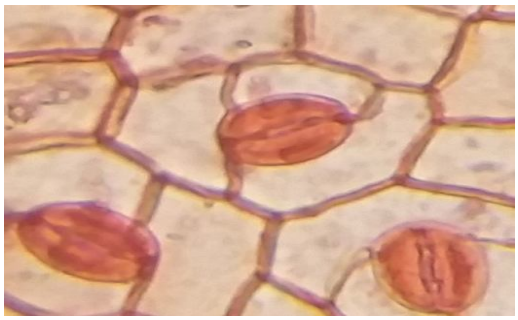
Investigators: Dr. G.S. Deora

Mrs. Seema Sen

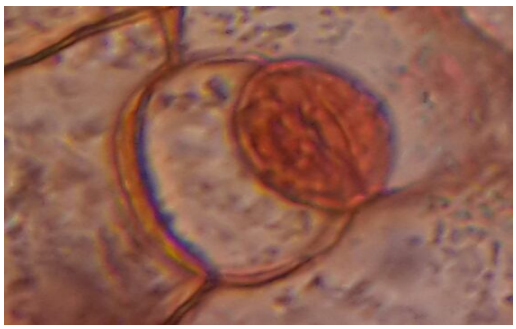
I In continuation of earlier work done, listing, proper arrangement, photography, preparation of soft copy and systematic arrangement of total 102 plants species belonging to 19 families was done for digitization of departmental herbarium.

II Micromorphological studies:

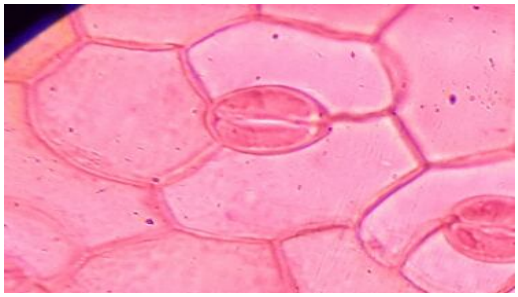
Micromorphological characters of taxon species are important tools for species level identification and classification along with morphological characterization. Micromorphological study of leaf peal of different species of *Tephrosia* and *Abutilon* were studied to correlate and identify the species .On the basis of stomatal and trichomes type the species can be easily identified and classified.



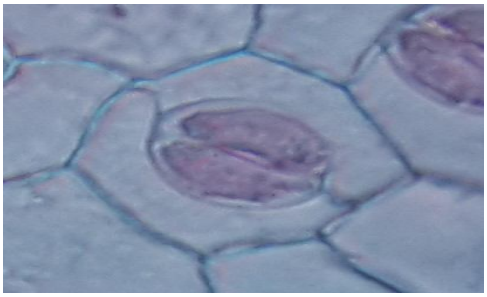
T. purpurea: **Animocytic stomata**



T. uniflora: Hemiparacytic stomata

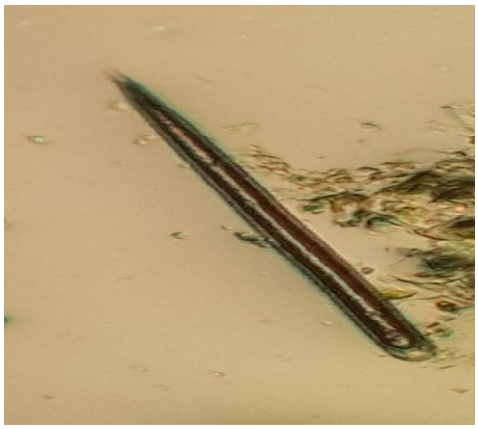


***T. villosa*: Isocytric stomata**

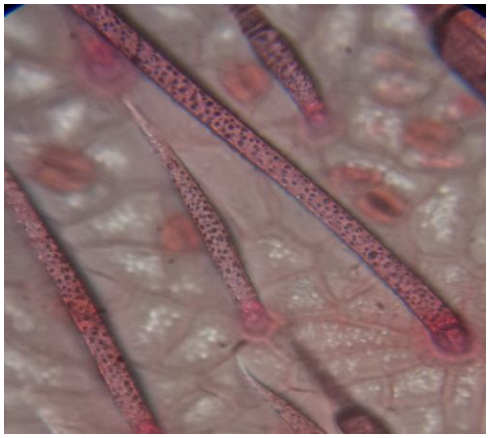


T. wallichi: **Paracytic stomata**

Micromorphological characters of *Abutilon* Spp

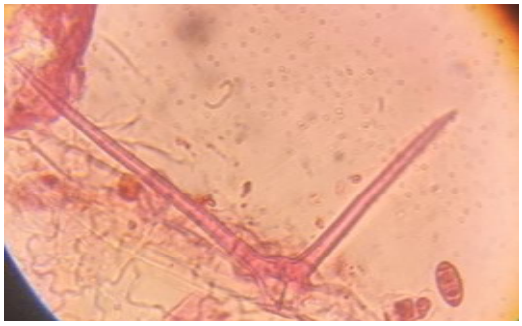


***T. purpurea*: Single tapering trichome**

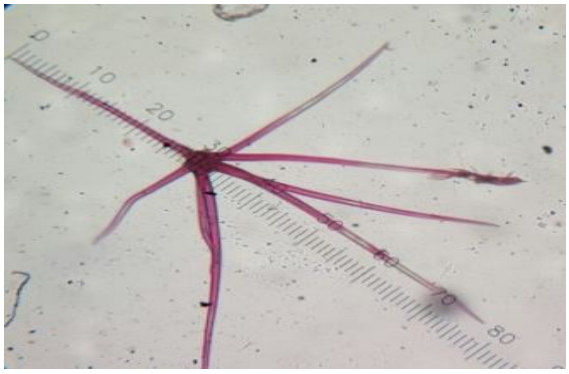


***T. unilora:* Trichmes with warty wall**

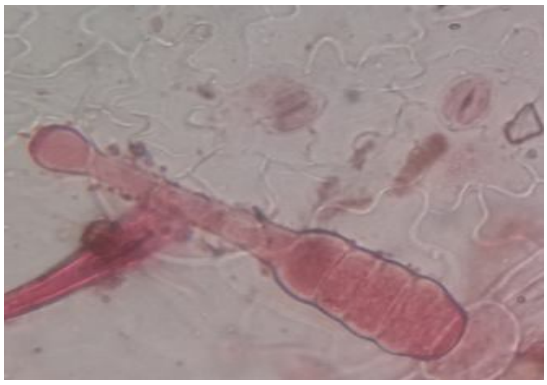
***A. indicum:* Simple unicellular trichome**



***A. pannosum*: Forked trichome**



***A. ramosum*: Stellate trichome**



***A. ramosum*: Glandular trichome**

III Collection, identification, taxonomical study of other vascular plants such as

Pteridophytes.

Listing, proper arrangement, photography, preparation of soft copy and systematic arrangement of total 13 Pteridophytes and gymnosperms plants species belonging to 11 families were done for digitization of departmental herbarium.

Pteridophytes:

1. *Asplenium nidus* L.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Polypodiopsida/Pteridopsida

Order: Polypodiales

Family: Aspleniaceae

Genus: Asplenium

Species: nidus

Description:

Asplenium nidus is an epiphytic species of fern in the family Asleniaceae, native to tropical southeastern Asia eastern Australia, Hawaii. It is known by the common names **bird's nest fern or simply nests fern.** It forms large fronds visually similar to banana leaves, with the fronds growing to 50-150 centimeters long and 10-20 centimeters in broad. They are slight green, often crinkled, with a black midrib and exhibit circinate vernation. Sores develop in sori on the underside of the fronds. The fronds roll back as they brown and create a massive leaf nest in the branches and trunks of trees.

2. *Athyrium angustum(L.)* Roth

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida

Order: Polypodiales

Family: Athyriaceae

Genus: *Athyrium*

Species: *angustum(filix-femina)*

Description:

Athyrium filix-femina commonly known as lady fern is a large, feathery species of fern, native toughout most of the temperate Northern Hemisphere, where it is often abundant in damp, shady woodland environments and often grown for decoration. It is cespitose (the fronds arising from a central point as a clump rather than along a rhizome). The deciduous fronds are lightly yellow-green 20-90 centimeters broad. Sori appear as dots on the underside of the frond, 1-6per pinnule. They are covered by a prominently whitish to brown reniform inducium. Fronds are much dissected, being 3-pinnate. The stipe may bear long, pale brown, papery scales at the base. The spores are yellow.

3. *Diplazium esculentum* (Retz.) Sw.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Polypodiales

Family: Athyriaceae

Genus: *Diplazium*

Species: *esculentum*

Description:

Diplazium esculentum, the vegetable fern, is an edible fern found throughout the Asia and Oceania. The plant is a large perennial fern with ascending rhizome of about 20 cm high and covered with short rufous scales of about one cm long. The plant is bipinnate with long brounish petioles and the petiole base is black and covered with short scales. The frond can reach 1.5 cm in length and the pinnae is about 8 cm long and 2 cm wide.

4. *Azolla pinnata* R.Br.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Salviniales

Family: Salviniaceae

Genus: *Azolla*

Species: *pinnata*

Description:

Azolla is commonly known as **mosquito fern, duckweed fern, fairy moss, and water fern.** It is aquatic fern. They are extremely reduced in form and specialized, looking nothing like typical other ferns but resembling duckweed or some mosses. *Azolla* are often grown in rice fields, where the plants, after the harvest of rice are plowed down and then with their content of nitrate are an excellent replacement for artificial fertilizers. *A.pinnata,* which is found in an area from Asia to Australia, has a high demand of light and temperature.

5. *Salvinia auriculata* Seg.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Salviniales

Family: Salviniaceae

Genus: *Salvinia*

Species: *auriculata*

Description:

Salvinia is a floating named in honor of Anton Maria Salvini, a 17th century Italian scientists. It is commonly known as water moss. It is heterosporous, producing two types of spores in size. However, leaf development in *Salvinia* is unique. The upper side of the floating leaf, which appears to face the stem axis is morphologically abaxial. It is small floating aquatics with creeping stems, branched, bearing hairs on leaf surface papillose but no roots. Leaves are in trimerous whorls, with two leaves green, sessile or short-petioled, flat, entire and one leaf finely dissected, petiolate, root like and pendent. Submerged leaves bearing sori that are surrounded by basifixed membranous indusia(sporocarp). They bear two types of sporocarp, either megasporangia that are few in number, each with single megaspore or many microsporangia each with64 microspores. Spores are of two kinds in size, both globose, trilete.

6. *Sphaeropteris cooperi* Smith

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Cyatheales

Family: Cyatheaceae

Genus: *Sphaeropteris*

Species: *cooperi*

Description:

Sphaeropteris cooperi is a tree fern that grows upto 40 meter tall with a skinny trunk. Fronds emerge from the trunk covered with stiff white hairs and are generally less arching than other fern of this family. It looks similar to a martini glass. The trunk will be covered with triangular shaped scars caused by old fronds. The fronds look lacey, more intricate than the other native ferns.

7. ***Pteridium esculentum*(G.Frost.) Cockayne**

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Polypodiales

Family: Dennstaedtiaceae

Genus: *Pteridium*

Species: *esculentum*

Description:

Pteridium esculentum is commonly known as **bracken fern, Australian bracken** or simply **bracken** is a species of the bracken genus native to a number of countries in the Southern Hemisphere. First described a *Pteris esculentum* by German botanist George Forster in 1786th it gained its current binomial name in 1908. *P. esculentum* grows from creeping rhizome, which are covered with reddish hair. From them arise single large roughly triangular fronds, which grow to 0.5-2 metres tall. The fronds are stiff with a brown stripe, minor rachises with wing- like lobes between segments, lamina dark green above but paler below, older fronds glabrous above with fine hairs below, broad triangular in outline, 3-4 pinnate; ultimate segments narrow, entire or with a few basal lobes. Sori are continuous between margins. Inducium 2-lipped, outer lip green, inner lip pale brown.

8. ***Dryopteris* filix- mas Adans**

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Pteridopsida (Polypodiopsida)

Order: Polypodiales

Family: Dryopteridaceae

Genus: *Dryopteris*

Species: *filix-mas*

Description:

Dryopteris is commonly called **wood fern, male fern** or **buckler fern**, is a with distribution in Eastern Asia, the Americas, Europe, Africa, India and the Pacific islands. Plant is stout, slowly creeping rootstocks that form a crown, with a vase like ring of fronds. The sori are round, with a peltate inducium. The stipes have prominent scales.

9. *Isoetes butleris* Rchb.

Systematic position

Kingdom: Plantae

Division: Lycopodiopsida

Class: Isoetopsida

Order: Isoetales

Family: Isoetaceae

Genus: *Isoetes*

Species: *butleri*

Description:

Isoetes is commonly known as the **quillworts** is a genus of plants in the class Isoetopsida and order Isoetales. They are lycopods and the only genus in Isoetaceae. *Isoetes* are mostly aquatic or semi aquatic in clear ponds and slow moving sreams, though several grow on wet ground that dries out in the summer. Isoetes leaves are hollow and quill like with a minute ligule at the base of

the upper surface arising from a central corn. Each leaf is narrow 2-20 cm long and 0.5 -3.0 mm wide, with. They can be either ever green, winter deciduous or dry season deciduous. Leaves broaden to a swollen base upto 5 mm wide where they attach in clusters to a bulb like underground rhizome characteristic of most of the quillwort species. This swollen base also contains male and female sporangia, protected by a thin transparent covering (velum), which is used diagnostically to help identifying quillwort species. They are heterosporous containing megaspores and microspores.

10. *Marsilea minuta*. L.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Polypodiopsida/ Pteropsida

Order: Salviniales

Family: Marsileaceae

Genus: *Marsilea*

Species: *minuta*

Description:

Marsilea minuta or dwarf waterclover is a species of aquatic fern in the family Marsileaceae. In the water the plant is creeping and spreading, while on land it can appear cushion like. It is typically perennial but sometimes appears annual. It is a tanagonophyte with the juvenile growing submerged and the adult typically terrestrial. It has a light brown to green rhizome that is 0.4-0.8 mm thick with short tan hairs at the ends and internal roots. The land leaves are on erect teret, 5-13 cm long petioles. The leaflets are 0.8-1.8 cm by 1.3-2.1 cm. mostly glabrous, cuneate or flabellate. The leaves in water are typically not floating, but emergent from the water. Fertile leaves are produced on land withpu to four sporocarps each at peduncles near the base of the petiole. The sporocarp has a superior tooth at the apex of the atslk and an inferior tooth at the base and sporocarp mature above ground.

11. *Polypodium vulgare* L.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Polypodiopsida/ Pteropsida

Order: Polypodiales

Family: Polypodiaceae

Genus: *Polypodium*

Species: *valgare*

Description:

*Polypodium valgare***,** the common **polypody** is a fern of the Polypodiaceae, develops from a horizontal rhizome. The fronds with triangular leaflets measure 10-51 cm. They are divided all the way back to the central stem in 10- 18 pairs of segments or leaflets. The leaflets became much shorter at the end of the frond. The leaflets are generally whole or slightly denticulated and somewhat wider at their base, where they often touch each other. They have an alternating arrangement. Those on one side being slightly offset from those on the other side. The petioles have no scales. The sori are found on the lower side of the fronds and range in colour from bright yellow to orange.They became dark grey at maturity.

12. *Cheilanthes micropteris* Sw.

Systematic position

Kingdom: Plantae

Division: Pteridophyta

Class: Polypodiopsida

Order: Polypodiales

Family: Pteridaceae

Genus: *Cheilanthes*

Species: *micropteris*

Description:

Cheilanthes micropteris is a rock dwelling fern with a cosmopolitan distribution in warm, dry, rocky regions, often growing in small crevices high up to on cliffs. They are small, sturdy and evergreen. The leaves often densely covered in trichomes, spring directly from the rootstocks. They curling up during dry condition and reviving with the coming of moisture. At the ends of veins sporangia or spore bearing structures are protected by leaf margins which curlper them.

13. *Selaginella rupestris* P. Beauv.

Systematic position

Kingdom: Plantae

Division: Pteridophyta/ Lycopodiophyta

Class: Isoetopsida

Order: Selaginellales

Family: Sellaginellaceae

Genus: *Sellaginella*

Species: *rupestris*

Description:

It is creeping or ascendant plant with simple scale like leaves on branching stems from which roots also arise. The stems are aerial, horizontal creeping on the substratum. The vascular steles are plystelic protosteles. Stem sections shows the presence of more than two protosteles. Each stele is made up of diarch and exarch xylem in the center, which are modified endodermal cells with casperian strips on their lateral walls. The stem contains no pith. In *Sellaginella*, each microphyll and sporophyll has a small scale like outgrowth called a ligule at the base of the upper surface. The plants are heterosporous with spores of two different sizes known as megaspores and microspores.

Note: Most of the photos taken from the Departmental herbarium sheets and some others from nature

D. Ecology of Plants

i. Prof. S. Sundramoorthy, In-Charge
ii. Dr. Santosh K. Mehar

I Bioremediation:

Chlorella vulgaris is a unicellular green alga and was collected from Jojari River. Jojari River receives effluents from nearby industrial area known as Boranada. *Chlorococcum humicolo,* is collected from Ayad River near Udaipur. Ayad River carried entire domestic and industrial waste water of Udaipur. Repeated isolation and culture provided the axenic cultures of the algae.

Both the algae were grown diazotrophically in BG-11 medium (Rippka *et al.,* 1979). The axenic culture was multiplied in 250 mL conical flask containing 100 mL BG-11 medium and grown in culture room under continuous light, illuminated with cool fluorescent light (14.4 watt. m^{-2}) at 24±1°C. For routine maintenance, exponentially growing (8-10 day old) algal cells were harvested by centrifugation (4000g, 10 min.), washed thrice with sterile double distilled water before transfer to fresh growth medium.

All the experiments were conducted in triplicate at same culture conditions. The culture contains glass beads (0.5 mm size each; 5 in number in each culture flask) to prevent clumping of cells in growing algal mass, and were shaken gently every day.

Growth pattern were determined in five different media to identify the best one for *Chlorococcum humicolo*and *Chlorella vulgaris*so as to establish nutrient composition that best suit for future experiments with test algae. The five media are: [Bold Basal medium, BG -11 medium, Modified CHU - 10, Kartz & Myer and Hughes medium] were selected based on literature survey. Protein content is determined at different growth stages starting from 1- 28 days. Day one that is the day on which algae is inoculated and after this at regular intervals estimation is done.

All the five media supported the growth of algae in linear fashion in the following order: BG-11 (r^2=0.98) > C-10 (r^2=0.92) > K&M (r^2=0.90) > Hughes (r^2=0.62) > BB (r^2=0.61) for *C.*

vulgaris and K&M (r^2=0.97) > BG-11(r^2=0.95) > C-10 (r^2=0.95) > Hughes (r^2=0.84) > BB (r^2=0.01) for *C. humicolo.*

Protein content was maximum in BG-11, which reveals that BG-11 is most suitable medium for the growth of both the selected algae.

For short term time series experiment 10 ml of sample was harvested in time series (i.e. after every 15, 45, 75, 105 and 135 minutes) and algal cells were immediately vacuum filtered through Whatman filter paper 42 so that any further uptake of metal by algae from medium could be prevented. Filtrates were then oven dried, digested with double acid [HNO_3: $HClO_4$ mixture (10:1, v/v)] in boiling water bath for 1 hr. After cooling, the samples were diluted to 10 ml with triple glass distilled water and analyzed for metal level by Atomic Absorption Spectrophotometer (Spectrum SP-AA 5000).

Cadmium depletion was observed immediately after treatment starting from 15 minutes. Continuous increase in uptake rate of Cadmium from 15-75 minutes after treatment was found in both the algae. Two peaks for Cd^{+2} uptake was exhibited by *C. vulgaris* and *C. humicolo*. First peak was observed after 75 minutes with uptake rate of (7.941 and 7.65 µg per ml Cd^{+2} uptake min-1) and at 135 minutes a second peak (8.191 and 7.84 µg per ml Cd^{+2} uptake min^{-1}) was observed for *C. vulgaris* and *C. humicolo,* respectively. Elapsed time period was the only factor contributing for the observed variation (F=82.501; P>0.01and F=13.35; P>0.01 for *C. vulgaris* and *C. humicolo* respectively)

Similar to Cd^{+2}, Ni^{+2} depletion was too increased with the time. Initially lowest (1.225 and 0.500 µg per ml Ni^{+2} uptake min^{-1}) uptake was found after 15 minutes of treatment and it increased consciously as the time passed in *C. vulgaris* and *C. humicolo,* respectively. Ni^{+2} depletion was found maximum (3.175 and 2.633 µg per ml Ni^{+2} uptake min^{-1}) after 135 minutes for C. *vulgaris* and *C. humicolo,* respectively. Elapsed time period was the only factor contributing for the observed variation (F=59.28; P > 0.01and F=4.41; P > 0.05 for *C. vulgaris* and *C. humicolo* respectively).

Zn^{+2} depletion was observed immediately after treatment starting from 15 minutes. *C. vulgaris* and *C. humicolo* exhibited continuous increase in uptake rate of Zinc from 15-75

minutes and 15 to 45 minutes after treatment, respectively. First peak was observed after 75 and 45 minutes with uptake rate of 2.80 and 1.8 µg per ml Zn^{+2} uptake min^{-1} from the media for C. *vulgaris* and *C. humicolo,* respectively. Then uptake rate was slightly decreased (2.65 and 1.50 µg per ml Zn^{+2} uptake $min^{-1}$from the media) after 105 and 75minutes for C. *vulgaris* and *C. humicolo,* respectively.Elapsed time period was the only factor contributing for the observed variation ($F=82.501$; $P>0.01$).

Absorption/adsorption kinetics of heavy metal uptake was assessed as long term experiment. After 15th and 30th days of inoculation, 10 ml of algal sample was harvested from homogenous culture and centrifuged (4000 g, 15 minutes) and supernatant media was separated. The algal sample in the sediment were mixed with 10 ml of EDTA (10µM) solution and gently shaken. Samples were once again centrifuged (4000g, 15 minutes). Supernatant EDTA was taken out for measuring the adsorbed ionic concentration. All three parts i.e. media, EDTA and algal pellets from each sample were dried, digested with double acid mixture in boiling water bath for 1 hour. After cooling sample were diluted to 25 mL with triple glass distilled water and analyzed for heavy metal level by atomic absorption spectrometer. Accumulation factor was assessed as the ratio of concentration in the algae in relation to its surroundings.

Metal accumulation was judged on the basis of its concentration in medium, chelating agent (EDTA) and alga. Both the algae were grown in BG-11 medium having different concentrations of metals. Cd^{+2}: (0, 4, 8, 12, 16, 20); Ni^{+2}: (0, 3, 6, 9, 12, 15) and Zn^{+2}: (0, 4, 6, 8, 10, 12) respectively for *C. vulgaris*; Cd^{+2}: (0, 3, 6, 9, 12, 15); Ni^{+2}: (0, 2, 4, 6, 8, 10) and Zn^{+2}: (0, 3, 6, 9, 12, 15) whereas for *C. humicolo*. Concentration in medium, EDTA and algae was determined at two stages of algal growth i.e. 15th and 30th days of growth.

For *C. vulgaris*, Cd^{+2} adsorption was comparatively more than absorption for both the days and concentration in the media (X) and adsorption (Y) and absorption (Y) related parabolically for 15th and 30th days of growth ($Y = -6.8267+6.8874\ X-0.3631\ X^2$; $R^2=0.99$; $Y= -9.2625+8.824\ X -0.0302\ X^2$; $R^2=0.90$ and $Y =0.5917+0.3262\ X+0.1857\ X^2$; $R^2=0.71$; $Y = -9.535+14.521\ X -1.6762\ X^2$; $R^2 =0.71$ for adsorption and absorption, respectively). Adsorption was maximum (41.05 µg ml^{-1}) at 20 mg L^{-1} during 30th day of experiment, indicating increase in adsorption along with passing of time. Absorption was maximum (22.933 µg ml^{-1}) at 8 mg

L^{-1} during 30th day of experiment and it decreased in higher concentrations with passing of days. In case of *C. humicolo*, Cd^{+2} absorption was comparatively more than adsorption. Concentration in the media and adsorption and absorption related significantly and represent a linear and logarithmic relationship for 15th and 30th days of growth (Y= -0.4563+1.373 X; r^2=0.99; Y=-1.0891+1.4223 X; r^2=0.96 and y= 0.617+4.195 log X; r^2= 0.94; y=0.0808+10.52 log X; r^2=0.97 for adsorption and absorption, respectively).

In *C. vulgaris* Ni^{+2} adsorption was comparatively more than absorption for both the days. Concentration in the media and adsorption and absorption related significantly and followed a parabolic path for 15th and 30th days of growth (Y = -5.9283+5.5468 X -0.4732 X^2; R^2=0.93; Y = -3.1375+3.645 X -0.1903 X^2; R^2=0.87 and Y = -4.0417+5.481X-0.681X^2; R^2=0.69; Y = -4.2242+7.319 X-1.0207 X^2; R^2=0.79 for adsorption and absorption respectively). Similarly, in *C. humicolo* absorption was comparatively more than adsorption for Ni^{+2}. Concentration (x) and adsorption (y) or absorption (y) related significantly and followed a parabolic path for 15th and 30th days of growth (Y = 1.0442 +1.201X +0.496X^2; R^2=0.88; Y=1.6442+1.661 X + 0.1588 X^2; R^2=0.92, and Y= -0.655+0.5412X +0.6796 X^2; R^2=0.69; Y=-9.0283+9.3949 X -1.1186 X^2; R^2=0.8785 for adsorption and absorption, respectively).

For Zn^{+2} also adsorption was comparatively more than absorption for both the days in *C. vulgaris*. Concentration in the media and adsorption and absorption related significantly and followed a linear (adsorption) and parabolic (absorption) path for 15th and 30th days of growth ((Y = -5.03+6.8139X-0.6851X^2; R^2=0.96 and Y = -1.9217+5.2407X -0.4893X^2; R^2=0.98 and y= -2.725+4.6762X -0.4833X^2; R^2= 0.83; Y =-1.9592+6.1019X -0.7234X^2; R^2=0.75 for adsorption and absorption, respectively). In *C. humicolo* too adsorption was comparatively more than absorption for both the days. Concentration (x) and adsorption (y) or absorption (y) related significantly and followed a parabolic path for 15th and 30th days of growth (Y= -5.9187+7.201X -.6638r^2; R^2=0.99; Y=-5.2687+6.0237 X -0.5322 X^2; R^2=0.99, and Y= -0.4775+.2833X +0.0326X^2; R^2=0.9523; Y=0.3067-0.3236 X +0.06X^2; R^2=0.97 for adsorption and absorption, respectively).

Maximum (4.2) Accumulation Factor value was found on 30th day at 4 mg L^{-1} metal concentration; with increase in Cd^{+2} concentration in the media for *C. vulgaris*. With increase

in Cd^{+2} concentration in the media AF reduced significantly and at 20 mg L^{-1} minimum (1.05) AF value was recorded. In case of *C. humicolo* maximum AF value 2.57 was found on 30th day at metal 15 mg L^{-1} concentration; with increase in Cd^{2+} concentration in the media AF value increased during the later stage of growth exhibiting the adaptive mechanism of tolerance.

Maximum (2.08) AF value was found on 30th day at 3 mg L^{-1} metal concentration; with increase in Ni^{2+} concentration in the media AF value increased during the later stage of growth in *C. vulgaris*. Similarly, for *C. humicolo* maximum AF value 2.07 was found on 30th day at 2 mg L^{-1} metal concentration; with increase in Ni^{2+} concentration in the media AF value increased during the later stage of growth exhibiting the adaptive mechanism of tolerance.

Maximum (2.66 and 2.70) AF was found on 30th day at 4 and 3 mg L^{-1} concentration of Zn^{2+} for C. vulgaris and *C. humicolo*, respectively. Similar to Cd^{2+} and Ni^{+2}, for Zn^{2+} too both the algae exhibited the adaptive mechanism of tolerance. Maximum AF value 2.70 was found on 30th day at metal 3 mg L^{-1} concentration. Results of present study suggested that both of the algae were not only tolerant species but also found to be a hyper accumulator of the selected metals (Cd^{+2}, Ni^{+2} and Zn^{+2}).

In case of nickel treatment overall expression of proteins was found to be decreased, specifically in the range of mol. weight 18.4-166 kDa for *C. vulgaris* and *C. humicolo*. This decrease in protein expression might be due to toxic effect of heavy metal nickel. Quantitative analysis showed no major difference in overall protein content (*C. humicolo*) and decrease ~0.5 fold in overall protein content (*C. vulgaris*) due to nickel treatment as compared to control.

II **Species Association:**

Three saline inland sites namely Pachpadra (site-I), Didwana (site-II) and Kaparda (site-III) were selected for the detailed phyto-sociological survey (Table 1). At each site nested quadrates were employed for (5m x 5m for woody perennials and 1m x 1m for annual) quantification of temporal vegetation dynamics (Kent and Cooker, 1992).

Sites Characteristics

Soil profile of the selected sites, revealed the basic difference among them where dominant sub-equal proportion of find sand and coarse sand and coarse sand and gravel are the

characteristic features of site 1 and 2, respectively, while site 3 differed from them with dominant coarse sand texture (Table 1).

Table 1. GPS locations and basic soil features of studied sites

Coordinates		Soil texture				
N	E	Clay	Silt	Fine Sand	Coarse sand	Gravel
25°91'51"	72°06'81"	0.8	0.3	54.6	32.6	11.5
26°28'32"	73°44'49"	0.05	0.1	7.2	46.1	46.2
27°23'8"	74°34'56"	0.1		0.3 19.3	75.5	4.6

Species Composition

During the samplings, a total of 47 herbaceous and shrub species were recorded that belongs to 16 families and 41 genera (Figure 1) dominated by Poaceae 12 followed by Cyperaceae and Fabaceae (6). 47, 21 and 15 species were recorded during rainy, winter and summer seasons, respectively at studied sites (Table 2). During the rainy season site wise species richness was ranged from 17 (S3) -27 (S1) and which were dropped to 9 (S2)-15 (S1) and 6 (S2)- 11 (S1) during winter and summer seasons, respectively (Table 3). Among the halophytic grasses and other species, dominance of *Aeluropus lagopoides, Cressa cretica, Salsola baryosma and Suaeda fruticosa* were increased from rain to winter and winter to summer at their respective sites (Table 2). However, *Sporobolus helvolus* was recorded only during rain and winter seasons with IVI 24 (S1 rain)-63 (S1 winter). Seasons wise 17 different grass / sedges species were recorded during the rainy season (*Aeluropus lagopoides, Aristida funiculata, Cenchrus biflorus, Cenchrus setigerus, Chloris virgate, Cyperus arenarius, Cyperus bulbosus, Cyperus iria, Cyperus rotundus, Cyperus compressus, Dactyloctenium aegyptium, Eleusine compressa, Eragostis ciliaris, Eragostis tremula., Melanocenchrus jacquemontii, and Sporobolus helvolus*) which were dropped to 5 during two remaining seasons and *Oligochaeta ramose* was recorded as new species during these two sampling period. *Cressa cretica, Dicoma tomentosa, Salsola baryosma, Suaeda fruticosa,* Senna angustifolia, Crotolaria burhia, Fagonia cretica, Leptadenia pyrotechnica, Tephrosia *purpurea, Tribulus terrestris, Calotropis procera* and *Capparis decidua* were the other important species having various types of provisional, cultural and regulating ecosystem services potentials.

Table 2. IVI of different species recorded during three seasonal events

Rain						Winter				
S. No	Species	S1	S2	S3		S. No	Species	S1	S2	S3
1	*Aeluropus lagopoides*	19	23	36		1	*Aeluropus lagopoides*	78	139	88
2	*Aerva persica*	8	0	0		2	*Aerva persica*	9	0	0
3	*Aristida funiculata*	10	0	0		3	*Blepharis sindica*	0	8	0
4	*Blepharis sindica*	3	0	0		4	*Calotropis procera*	0	27	0
5	*Boerhavia diffusa*	8	0	10		5	*Capparis decidua*	0	0	6
6	*Calotropis procera*	0	4	0		6	*Senna aungustifolia*	10	0	0
7	*Sena aungustifolia*	1	0	0		7	*Convolvulus auricomus*	6	0	0
8	*Cassia fistula*	1	0	0		8	*Cressa cretica*	41	11	28
9	*Cenchrus biflorus*	0	16	0		9	*Crotolaria burhia*	4	5	0
10	*Cenchrus setigerus*	13	0	0		10	*Cyperus iria*	0	16	0
11	*Chloris virgate*	17	37	43		11	*Fagonia cretica*	8	0	10
12	*Convolvulus auricomus*	5	0	0		12	*Heliotropium marifolium*	0	13	0
13	*Corchorus depressus*	0	0	12		13	*Leptadaenia pyrotechnica*	5	10	0
14	*Corchorus tridens*	0	7	0		14	*Oligochaete ramosa*	4	0	0
15	*Cressa cretica*	20	0	28		15	*Salsola baryosma*	6	0	0
16	*Crotolaria burhia*	0	5	8		16	*Scripustuberosus*	0	0	11
17	*Cyperus arenarius*	0	10	0		17	*Sonchus aspera*	12	0	41
18	*Cyperus bulbosus*	0	0	31		18	*Sporobolus helvolus*	63	0	44
19	*Cyperus iria*	0	10	0		19	*Suaeda fruticosa*	15	71	10
20	*Cyperus rotundus*	0	10	0		20	*Tephrosia purpurea*	4	0	0
21	*Cyperus compressus*	13	0	0		21	*Vernonia cinerea*	18	0	50
22	*Dactyloctenium aegyptium*	18	37	15						
23	*Dicoma tomentosa*	0	0	4		Summer				
24	*Eleusine compressa*	13	0	0			Species	S1	S2	S3

25	*Eragrostis ciliaris*	0	31	21		1	*Aeluropus lagopoides*	116	127	113
26	*Eragrostistremula*	0	10	0		2	*Calotropis procera*	0	23	0
27	*Fagonia cretica*	7	0	7		3	*Capparis decidua*	0	0	10
28	*Farsetia macrantha*	10	0	0		4	*Senna aungustifolia*	13	0	0
29	*Haloxylon recurvum*	11	0	0		5	*Convolvulus auricomus*	9	0	0
30	*Heliotropium curassavicum*	8	0	0		6	*Cressa cretica*	59	61	67
31	*Heliotropium marifolium*	9	33	0		7	*Crotolaria burhia*	5	0	0
32	*Indigofera cordifolia*	6	0	0		8	*Fagonia cretica*	16	0	0
33	*Leptadaenia pyrotechnica*	4	2	0		9	*Leptadaenia pyrotechnica*	11	14	0
34	*Melanocenchrusjacque montii*	0	0	23		10	*Oligochaete ramosa*	0	11	0
35	*Polygala irregularis*	10	0	0		11	*Salsola baryosma*	8	0	0
36	*Prosopis juliflora*	3	0	0		12	*Sonchus aspera*	9	0	34
37	*Pulicaria wightiana*	12	0	0		13	*Suaeda fruticosa*	19	65	29
38	*Salsola baryosma*	3	0	0		14	*Tamarix aphyla*	0	0	4
39	*Scripustuberosus*	0	9	0		15	*Vernonia cinerea*	14	0	42
40	*Sonchus aspera*	0	5	10						
41	*Sporobolus helvolus*	24	0	0						
42	*Suaeda fruticosa*	10	18	8						
43	*Tamarix aphyla*	0	0	3						
44	*Tephrosia purpurea*	6	3	10						
45	*Tragus racemosus*	0	28	10						
46	*Tribulus terrestris*	7	0	0						
47	*Vernonia cinerea*	11	0	21						

Species Diversity

Values of two diversity indices viz. Shannon and Weaver index (H') and Simpson index during different seasonal time and at different habitat are depicted in Table 3. Value of Shannon and Weaver index varies from 1.5 to 3.5 and rarely surpasses 4. Higher value indicates more diversity and vice-versa and this index is highly influenced by rare species. While Simpson index represents the Dominance of Concentration (DC). Lower DC indicates sharing of dominance by many species and higher DC values denote dominance of one (or a few) species indicating unequal sharing of resources. In present study higher diversity (High H' and DC values) were recorded during rainy seasons which continuously declined during other two sampling period (Table 3). Among the sites, site one was identified as more rich and diversified with compare to sites two and three.

Table 3. Diversity parameters of at three studied sites during different seasonal events

Diversity Parameters	Rain			Winter			Summer		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Richness	27	18	17	15	9	10	11	6	7
Shannon Index	1.4	1.1	1.1	0.94	0.69	0.86	0.8	0.64	0.7
Simpson Index	0.04	0.07	0.07	0.15	0.28	0.16	0.23	0.27	0.23

Site Similarity

Season wise site similarity values are presented in table 4. This analysis reveled the high sites similarities during summer season >70% and lowest during rainy seasons. In comparison to site two, site one showed more similarity with site three (70%) during winter seasons, while site two and three were more similar during rainy season as compared to site one. High site similarities during summer season can be explained with the high proportion of perennials while lowest during rainy season due to high annual presence.

Table 4. Site Similarity (Sorensen Index) values

	Rain			Winter			Summer		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
S1	-	26.5	37	-	38.9	70	-	70.7	74.2
S2	-	-	42.5	-	-	36.5	-	-	68

Dominance Diversity Curve

DD curve of at three studied sites during three sampling period are depicted in Figure 2. Within a plant community three basic types of distribution can be found viz. geometric, broken-stick and lognormal. In present study we observed a clear impact of temporal factor on plant community distribution pattern at selected habitats. We found log normal, broken-stick and geometric models during rainy, winter and summer seasons at all the sites, respectively. On log-normal model, peak of the curve represented by *Sporobolus helvolus* (23.9 IVI), *Dactyloctenium aegyptium* (37.5 IVI) and *Chloris virgate* (42.7) at site 1, 2 and 3, respectively. While tail of DD curves at these sites represented by *Cassia fistula* (1.1 IVI), *Leptadaenia pyrotechnica* (2.2 IVI) and *Tamarix aphyla* (2.8 IVI) respectively. The lognormal dominance–diversity curves indicate the heterogeneity of the species (May, 1975). Lognormal hypothesis assumes that the importance of species is governed by the interactions between a large numbers of factors determining success in the niche hyperspace (Whittaker, 1970). In connection to this, Whittaker (1965) noted that the log-normal series describes the partitioning of realized niche space among various species and is the consequence of the evolution of particular species diversity along the niche parameters which they exploit. Similar types of dominance–diversity curves have been reported in Harshin rangelands of the Somali Regional State in Eastern Ethiopia by Hailu (2017).

Geometric distribution type prevails at relative species poor community where a single environmental resource (like moisture) is extremely important to species survival and is utilized in a strongly hierarchical fashion. Under such condition a single dominant species preempts a large fraction of the resource; the next most successful species preempts a smaller fraction of the remaining resources and so forth. Broken-stick model assumes that the species in a community partition or utilize some critical resources with no overlapping between the species while large species assembly with sub-equal abundance is the characteristic feature of log normal model (Clark, 1990). Interestingly, in this study *Aeluropus lagopoides* (a saline grass) was identified a dominant species at the peak of broken-stick and geometric models during winter and summer seasons. While *Tephrosia purpurea, Crotolaria burhia* and *Capparis decidua* were the tail species of broken stick model at three sites, respectively. Similarly tails of geometric model were occupied *Capparis decidua, Oligochaete ramose* and *Tamarix aphyla*. Such findings would help us to create more resilient and sustainable plant community created

with the deliberately introduction of species with similar resource demand and acquisition capability.

Community Specialization Index

At the community level, a community specialization index (CSI) of species assemblages can be calculated as the average of each species SSI present in the assemblage (Devictor et al., 2008). Declining value of CSI indicates an increase of generalist species while its higher value shows higher proportion of specialized species of particular site (Vimal and Devictor, 2014). In present study, we found CSI values of 1.60, 2.77 and 2.94 during rain, winter and summer sampling period, respectively. Lower value of CSI during the rainy or resourceful period was due to adding of more generalized species in the community like *Aerva persica, Blepharis sindica, Boerhavia diffusa, Convolvulus auricomus, Farsetia macrantha, Dichoma tomentosa, Pulicaria wightiana, Sonchus aspera* and *Chorchorus tridens.* Higher values of this index during the other two seasons were due to dominant presence of more specialized species like *Aeluropus lagopoids, Cressa cretica, Suaeda fruticosa,* and *Sporobolus helvolus.* These species are indicators of saline grass. Thus, this index can be used as an interesting ecological indicator complementary to more traditional indicators based on diversity (Filippi-Codaccioni et al., 2010; Abadie et al., 2011). Mapping the CSI can thus provide a picture of spatial variation in the specialization level of communities, which can be related to independent sources of disturbance or used as a spatial guideline to identify sites of conservation interest (Devictor et al., 2008). This finding further linked with our spatial distribution of pattern of every species across different seasonal events.

Spatial Distribution Pattern

Based on index of dispersion (I_D) we got two types of spatial distribution i.e. random and clumped or aggregation (Table 4). Thus, our analysis revealed the absence of uniform pattern types of plant species on saline habitats. Based on available plant species during sampling seasons *Calotropis procera. Convolvulusauricomus, Sonchus aspera., Vernonia cinerea, Aerva persica, Cyperus iria, Heliotropium marifolium, Scripus tuberosus* and *Sporobolus helvolus* were represents clumped distribution pattern type only. While species *like Senna aungustifolia, Fagonia cretica, Leptadaenia pyrotechnica, Salsola baryosma, Suaeda fruticosa, Blepharis sindica and Tephrosia purpurea* showed temporal shifts in spatial distribution pattern from

random (rain) to aggregated (winter and summer). *Aeluropus lagopoides* showed random to clumped and clumped to random pattern during rainy-winter and winter –summer, respectively. *Cressia cretica* and C*rotolaris burhia* showed temporal shits from clumped to random and random to clumped, respectively. Thus, such information's would also help us to understand the introduction strategists of these species for reallocation and rehabilitation of the degraded lands. This analysis also provides an insight about the post emergence species behavior within the community and its preference and non-preference companion.

Agglomerative Hierarchical Clustering (AHC)

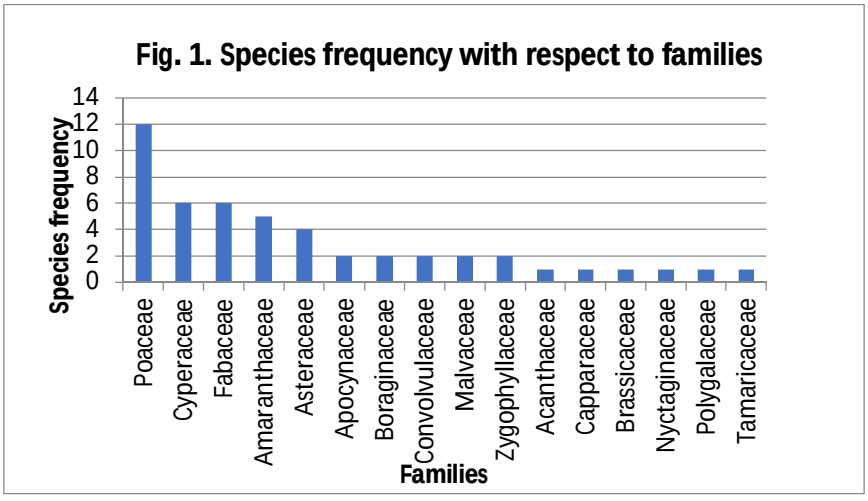
AHC dendrograms for species assemblage during three sampling periods are depicted in Figure 3. Such multivariate tool grouped the species on the basis of their IVI similarities and that provided good information about the selection of species for restoration/rehabilitation of degraded land with minimum competition for resources. During the rainy season AHC provided two distinct groups. Group one started with *Aeluropus lagopoides* and ended with *Convolvulsauricomus*, with total 22 species while group two started with *Aristida funiculata* and ended with *Tamarix aphyla*having 25 species. Group one which has only two saline *sps*. i.e. *Aeluropus lagopoides* and *Suaeda fruticosa* and seven woody perennials like *Aerva persica, Corchorus depressus, Crotolaria burhia, Tephrosia purpurea, Fagonia cretica, Boheravia diffusa, Vernonia cinerea*

Group two having four saline species i.e. *Tamarix aphyla, Salsola baryosoma, Sporobolus helvolus* and *Haloxylon recurvum* with woody perennials like *Leptadenia pyrotechnica, Blepharis sindica, Prosopis juliflora, Senna angustifolia, Cassia fistula, Calotropis procera*. However, this group having more grasses (total 10) then group one (6). During winter season we got a different scenario in which *Aeluropus lagopoides* showed proximity with *Sporobolus helvolus* and *Suaeda fruticosa* with *Salsola baryosoma*. This further changed during the summer seasons where both *Aeluropus lagopoides* and *Suaeda fruticosa* showed proximity with each other compared to *Salsola baryosoma*.

Table 5. Species Distribution patterns during sampling period

Species	**Rain**	**Winter**	**Summer**
Aeluropus lagopoides	Random	Aggregated	Random
Calotropis procera	Aggregated	Aggregated	Aggregated

Senna aungustifolia	Random	Aggregated	Aggregated
Convolvulus auricomus	Aggregated	Aggregated	Aggregated
Cressa cretica	Aggregated	Aggregated	Random
Crotolaria burhia	Random	Random	Aggregated
Fagonia cretica	Random	Aggregated	Aggregated
Leptadaenia pyrotechnica	Random	Aggregated	Aggregated
Salsola baryosma	Random	Aggregated	Aggregated
Sonchus aspera	Aggregated	Aggregated	Aggregated
Suaeda fruticosa	Random	Aggregated	Aggregated
Vernonia cinerea	Aggregated	Aggregated	Aggregated
Species	**Rain**	**Winter**	
Aerva persica	Aggregated	Aggregated	
Blepharis sindica	Random	Aggregated	
Cyperus iria	Aggregated	Aggregated	
Heliotropium marifolium	Aggregated	Aggregated	
Scripustuberosus	Aggregated	Aggregated	
Sporobolus helvolus	Aggregated	Aggregated	
Tephrosia purpurea	Random	Aggregated	



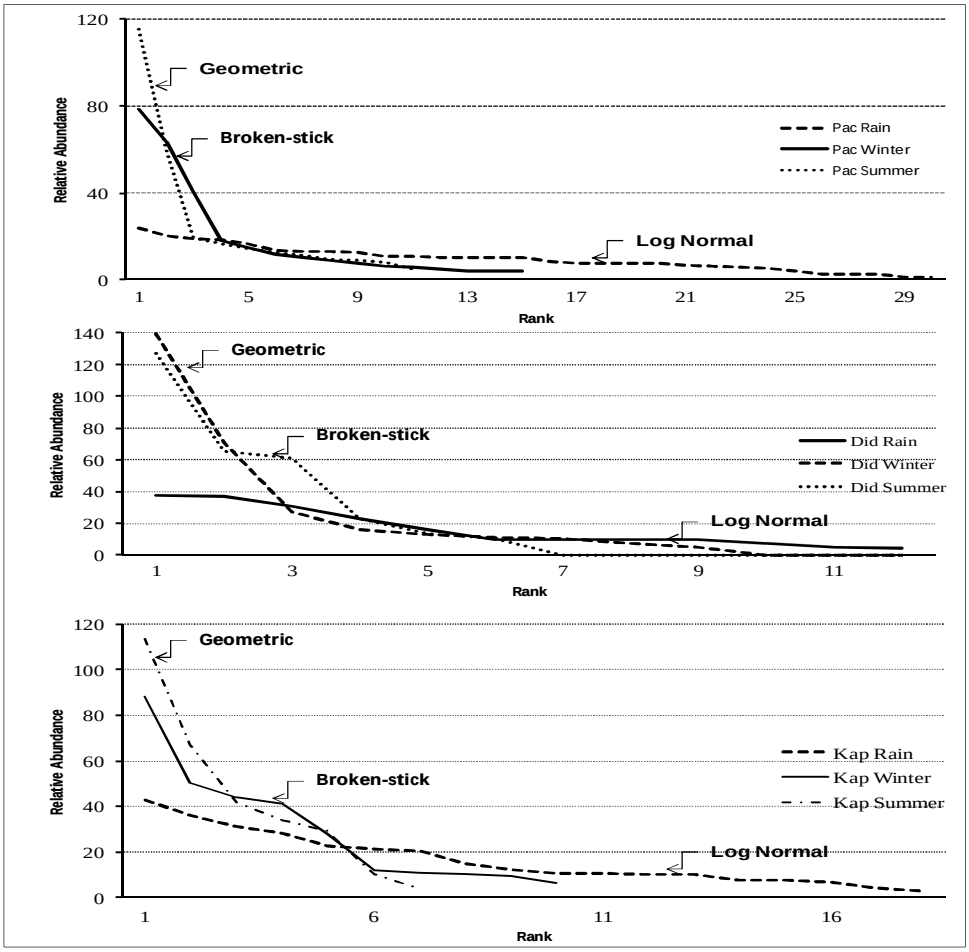


Figure 2. Diversity Dominance Curve at sampling sites during three sampling periods

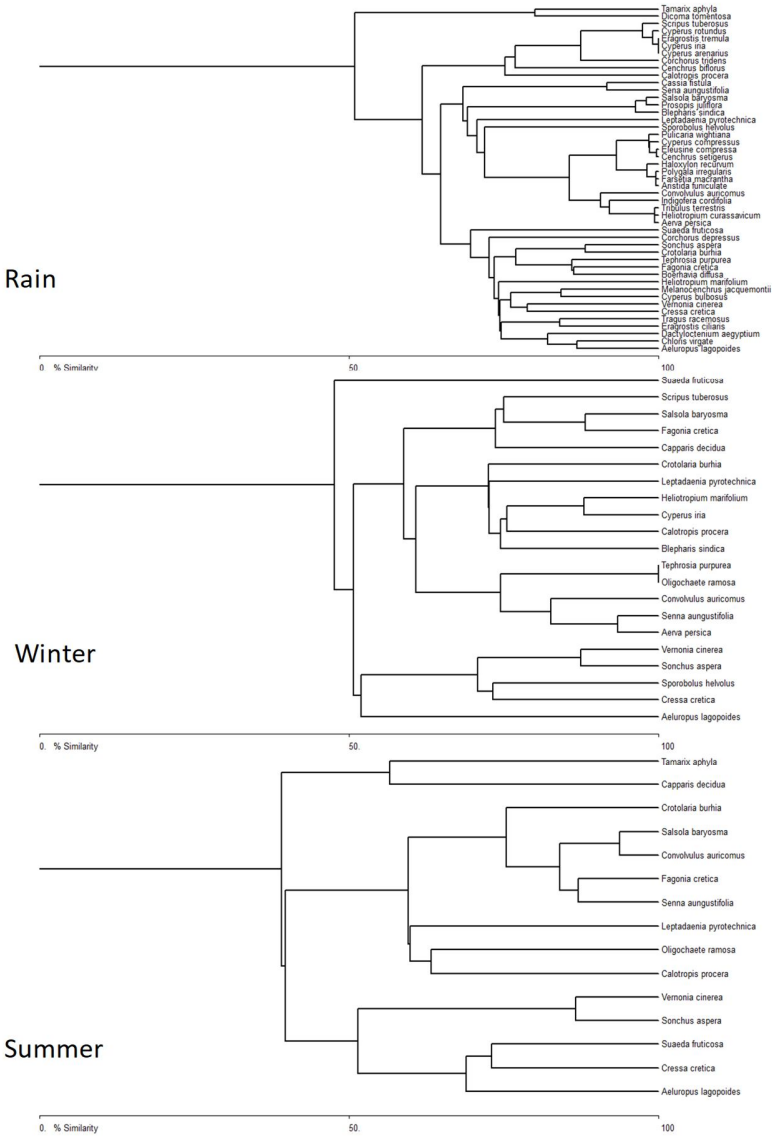


Figure 3. Agglomerative Hierarchical Clustering during different seasonal period

E. Molecular aspects of Desert Plants

Title: Molecular characterization and elucidation of HO (Hemeoxygenase) role in metal/salinity stress (Investigator: G.S. Shekhawat)

In continuation with previous report; effect of heavy metals ($CdCl_2$) and NaCl on *Vigna radiata* seedlings were observed at genetic level. The sublethal concentrations of metal (50 µM Cd, 20 mM NaCl and 60 mM NaCl) were selected for the polymormphic study.

Genomic DNA Extraction

Plant genomic DNA was isolated from leaves and roots tissue (approx. 1 gm) of hydroponically grown seedlings of *Vigna radiata*. Genomic DNA was extracted by CTAB method (Doyle and Doyle 1990), for which plant tissues were fixed in liquid nitrogen and crushed using autoclaved prechilled mortar and pestle. Extracted genomic DNA was quantified using nanodrop and the quality was checked on agarose gel electrophoresis. 0.8% agarose gel prepared in 1X TBE buffer was used for agarose gel electrophoresis.The electrophoresis was carried at 150V for 1-2 hours. The gel was then observed on a UV transilluminator (Syngene) and DNA was seen as fluorescent bands. 1Kbp DNA ladder was loaded for comparing the size of the isolated genomic DNA.

Polymorphic analysis using SCOT 1 primer

The extracted genomic DNA (50 ng/ µl) was used for study the polymorphism in crop plants treated with cadmium chloride for a period of 96 hours using SCOT 1 primer (5'-CAACAATGGCTACCACCA-3'). The PCR reactions were performed in a total reaction volume of 15 µl (12 µl of master mixture + 3µl of genomic DNA) using T100 thermocycler (Biorad). The reaction mixture contained 10 X PCR buffer, $MgCl_2$ solution, 10 mM dNTPs, Taq polymerase (3U) and SCOT 1 primer. A standard PCR cycle was used: an initial denaturation step at 94 ºC for 4 minutes, followed by 35 cycles of 94 ºC for 1min, 58.5 ºC for 1min and 72 ºC for 2 minutes; the final extension at 72 ºC was held for 10 minutes. All PCR amplification products were separated on 1.2% agarose gels in TBE stained with EtBr and visualized under UV light). In the present study, the high level of polymorphism was noticed at varying concentrations of NaCl and Cd after exposing the seedlings of crop plant for 96 hours. The number and intensity of polymorphic band was higher in roots tissue in comparison to leaves (Fig. 3). In lane no.5, lane no. 7 and lane no. 9 a new polymorphic band of approximately 4kbp and 2.8 kbp, 2.5 kbp, 2 kbp (lane no. 7) were observed which might be due to the upregulation of antioxidants during stress environment. The pattern of polymorphism was observed in between 1 kbp to 4 kbp.

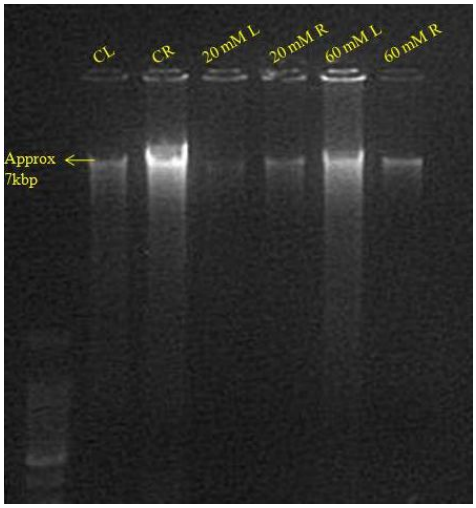


Fig. 1: Represents the Genomic DNA from leaves and roots tissue of *V. radiata* seedlings exposed to 20 mM and 60 mM NaCl for a period of 96 hours. Lane first represents 1 Kbp ladder while lane 2 to 6 represents samples.

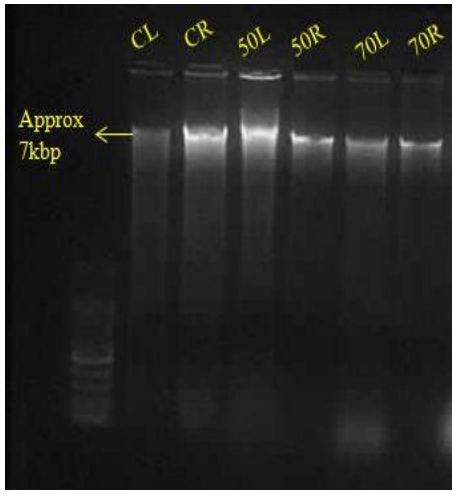


Fig. 2: Represents the Genomic DNA from leaves and roots tissue of *V. radiata* seedlings exposed to 50 µM and 70 µM $CdCl_2$ for a period of 96 hours. Lane first represents ladder while 2 to 6 represents samples.

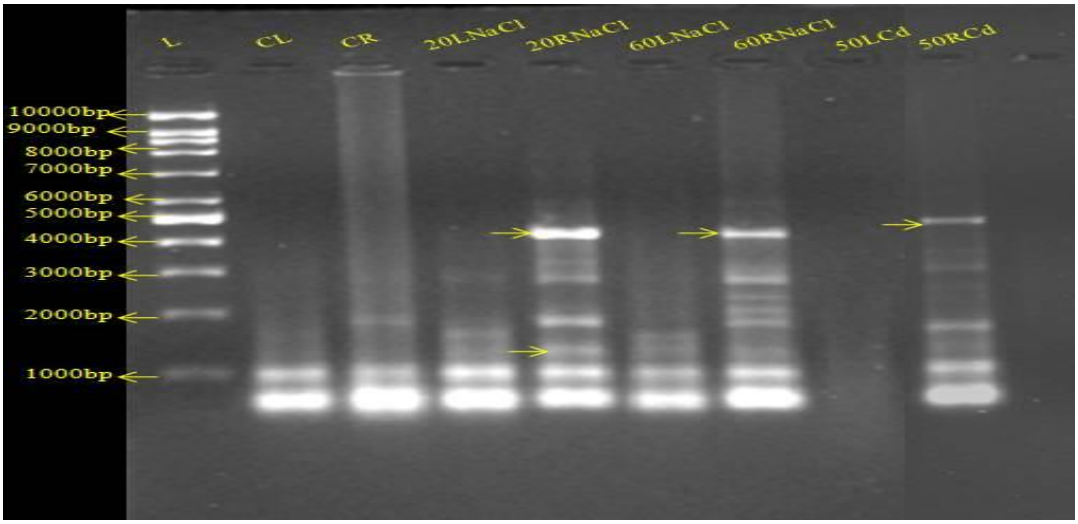


Fig-3: Polymorphism in stressed seedlings using SCOT 1 primer from leaves and roots tissue of *V. radiata* seedlings exposed to NaCl (20 mM and 60 mM) and $CdCl_2$ (50 µM) for 96 hours

Title: Identification of novel genes for abiotic stress tolerance from Indian Thar desert plants through comparative proteomics approach (Dr. Shweta Jha).

Work done:

We have optimized seed germination conditions for Atriplex spp. collected from Dwarka, and observed that removal of bracteoles exerted a great effect on germination, and markedly improved the germination percentage. Soaking of seeds in distilled water for overnight also helped in removal of inhibitory compounds from seed coat, thereby increasing rate of germination. Morphological, physiological and biochemical characterization of Atriplex spp. was performed under salinity stress conditions.

1. Effect of salinity on seed germination

To determine effect of salinity on seed germination of Atriplex, ebracteate seeds were surface sterilized, soaked overnight in distilled water and germinated under different salt concentrations (0, 50, 100, 200, 300 and 400 mM NaCl) on moistened filter paper in closed petri-plates at 20°C under continuous fluorescent light (25-100 µmol m^{-2} sec^{-1}). At least 50 seeds (for one replicate) were used for each treatment, and three independent biological replicates were analyzed for each concentration. The number of seeds germinated was counted daily for 20 d. Seeds were considered germinated when the radicle emerged 1 mm from the

seed. These data were used to determine the germination time and percent germination in different NaCl concentrations. As the salt concentration increased, the Atriplex species exhibited a decreasing trend of germination rate. Although the germination of Atriplex seeds was strongly inhibited when they were subjected to salt stress, the degree of inhibition differed markedly. After 20 days, only 10% seed were found to be germinated under 200 mM NaCl, as compared to 69% in control, whereas germination was completely inhibited under 300 and 400 mM NaCl (Fig. 1). On the other hand, seed germination was slightly affected upon exposure to 50 mM and 100 mM NaCl concentrations. The speed of seed germination was also significantly affected under treatment conditions.

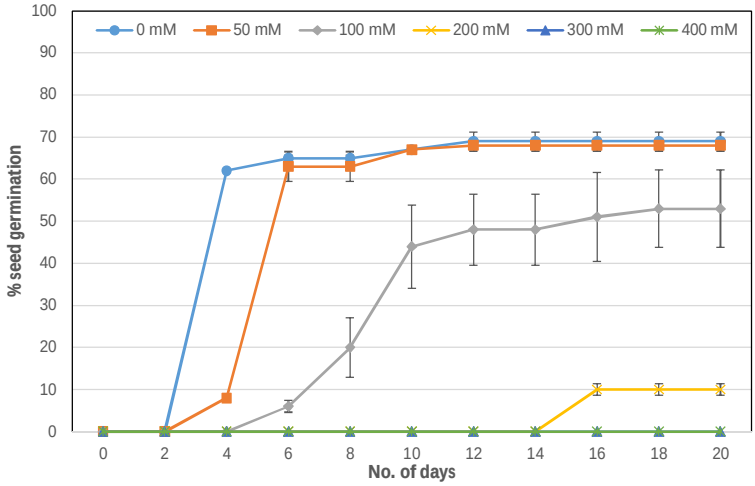


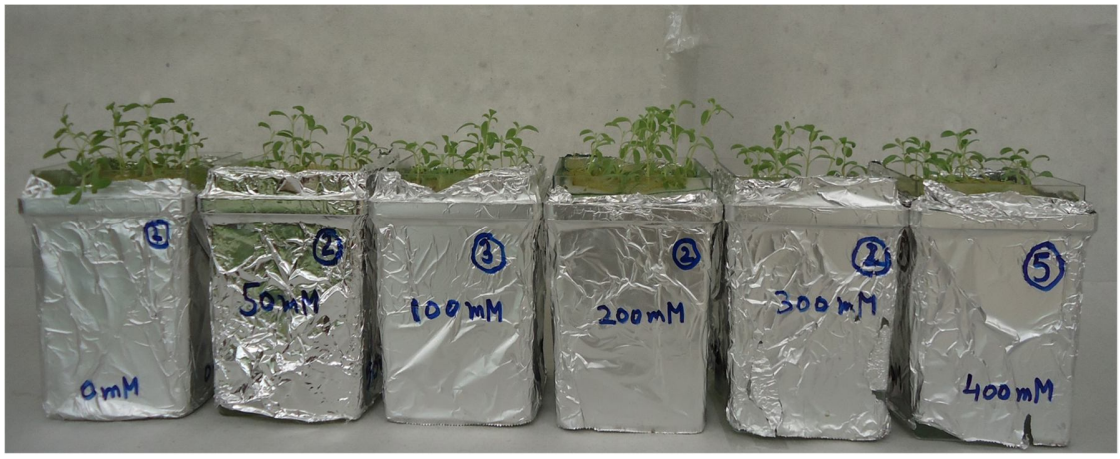
Fig. 1 Seed germination assay to assess the impact of salinity on seed germination of Atriplex spp. Seeds of Atriplex were germinated in presence of different concentration of NaCl (0-400 mM), and germination percentage was recorded every day, upto 20 days.

2. Effect of salinity on seedling growth

Phenotypic characters of Atriplex such as shoot and root length (cm) fresh weight (mg) and no. of leaves were recorded at different salt treatment conditions for the purpose of determining effect of salinity on seedling growth. In our study, the growth of Atriplex seedlings slightly increased with increasing salt concentration, and optimal growth occurred under 200 mm NaCl conditions, which showed that low salt could promote the seedling growth of a halophyte (Fig. 2). Further increases in salinity caused a gradual declinein growth and an

increase in salt-injury (Fig. 2, 3). However, plants did not experience any seedling death after 7 days of treatment with higher concentration of salt. Results of the present study indicate that Atriplex is a moderately salt tolerant species and low concentration of salt (upto 200 mM) significantly promotes its growth and biomass.

(a)



(b)

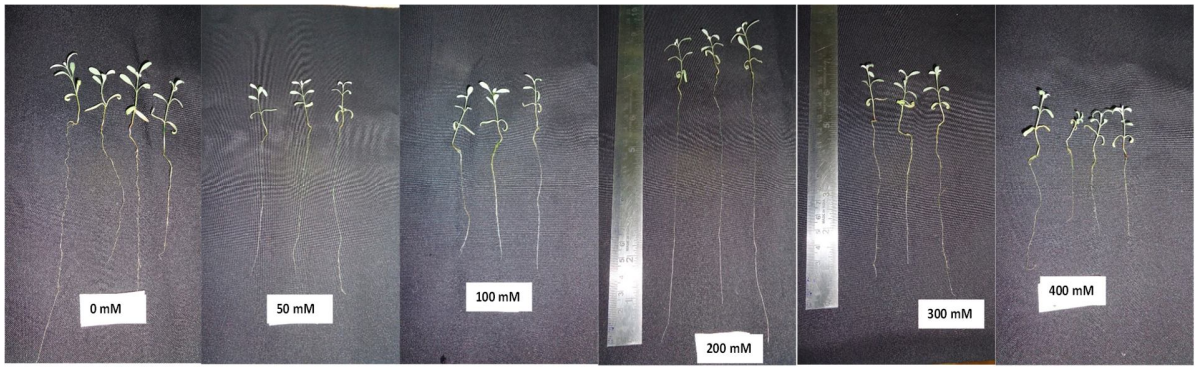


Fig. 2 Phenotype of Atriplex seedlings after 7 days of NaCl treatment at 0 mM (control), 50 mM 100 mM, 200 mM, 300 mM and 400 mM concentrations. Plants were grown in Hoagland's medium supplemented with different concentration of NaCl, or without NaCl (control).

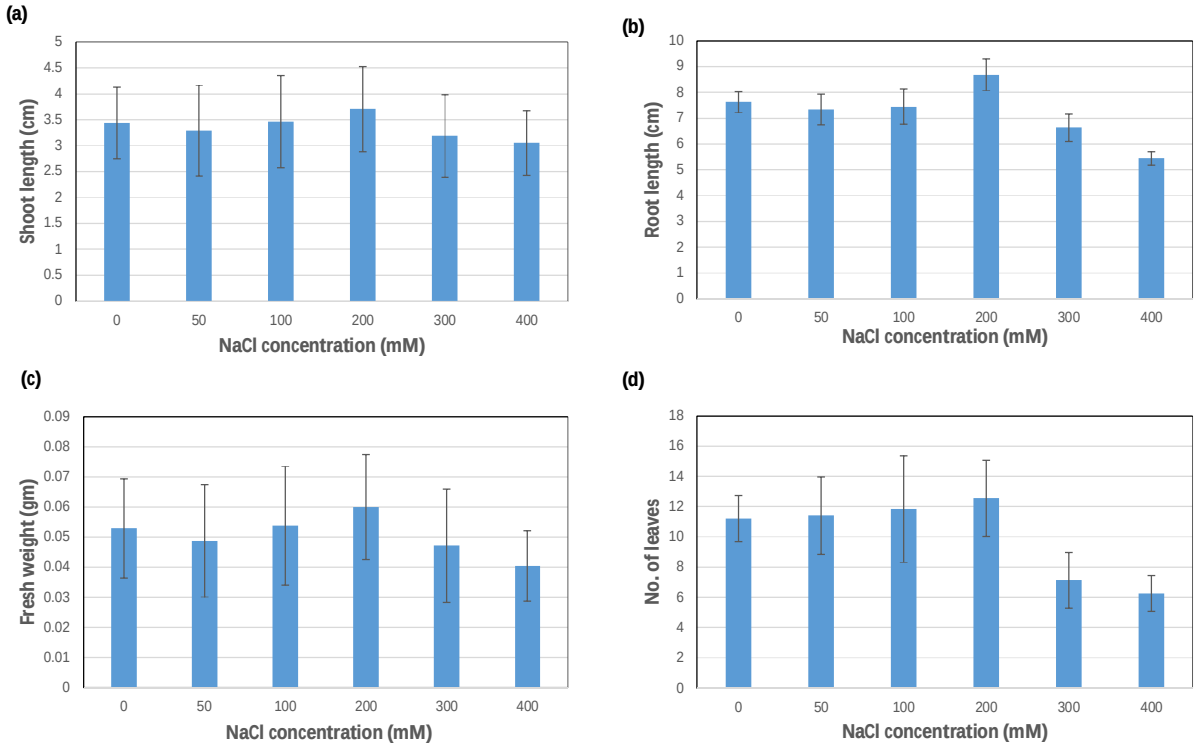


Fig. 3 Growth characteristics of Atriplex seedlings after 7 days of NaCl treatment at 0 mM (control), 50 mM 100 mM, 200 mM, 300 mM and 400 mM concentrations. (a) Shoot length, (b) root length, (c) fresh weight and (d) number of leaves.

3. Physiological responses of Atriplex under salt stress

3a. Pigment estimation

Chlorophyll content in plants correlates directly to the healthiness of plant. The resistance of photosynthetic systems to salinity is associated with the capacity of the plant species to effectively compartmentalize the ions in the vacuole, cytoplasm and chloroplast. High levels of salinization induces a significant decrease in content of pigment fractions and consequently of the total chlorophyll content. The effect of different concentrations of salts on pigment content of seedlings of Atriplex is shown in Fig. 4. It is evident from the results that chl-b content was not much affected by the salinity, whereas significant changes were observed for chl-a (Fig. 4 a,b). Total chlorophyll content, which is an indicator of greenness of plants, also followed the similar trend as chl-a (Fig. 4c). The ratio of chl-a and b (chl a/ chl b) significantly decreased at only 400 mM NaCl concentration (Fig. 4 d).

Carotenoids in all higher plants are synthesized and located in the chloroplast along with the chlorophyll. These are of two types, xanthophyll and carotene. They protect chloroplast from photo-oxidative damage and act as accessory light harvesting pigments. They also play an important role in the protection against oxidative stress. The response shown by the plants with respect to accumulation of carotenoids under the salinity stress varies from plant to plant. In our study, upto ~0.3-fold reduction in carotenoid content has been observed under 400 mM NaCl concentration (Fig. 4 e). Interestingly, salt concentrations lower than 400 mM NaCl did not exhibit significant reduction in pigment content, further proving salt-tolerant nature of Atriplex.

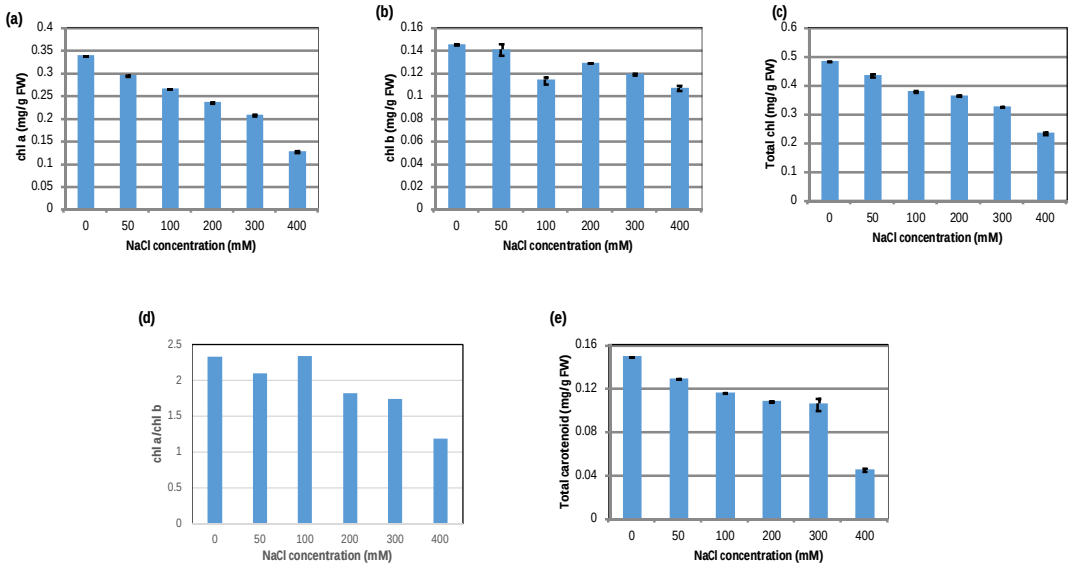


Fig. 4 Pigment estimation in seedlings of Atriplex spp. after 7 days of NaCl treatment at 0 mM (control), 50 mM 100 mM, 200 mM, 300 mM and 400 mM concentrations. (a) Chl a, (b) Chl b, (c) total chlorophyll (d) chla/chl b and (e) total carotenoid contents.

3b. Proline content

Plants can protect themselves against salinity stress by accumulating compatible solutes in cytosol which help in maintaining osmotic potential of the cell and stabilizing proteins and other cellular structures. Proline is one of the most common compatible osmolyte which maintains the cellular redox homeostasis by direct scavenging of excess reactive oxygen species (ROS), protecting ROS scavenging enzymes and activating alternate detoxification pathways. During the present investigation, Atriplex seedlings performed well under salt stress conditions and accumulated higher level of proline under salinity stress. A progressive increase in the levels of free proline was recorded in seedlings of Atriplex exposed to increasing concentration of salt, (Fig. 5a). This accumulation of proline act as an adaptive mechanism for salinity stress tolerance.

3c. Lipid peroxidation (MDA content)

Salinity is known to cause extensive lipid peroxidation resulting in damage to cellular membrane. It is used as an indicator for stress-induced oxidative damage. Malondialdehyde (MDA) is a lipid breakdown product and generated by oxidation of poly-unsaturated fatty acids

(PUFA) in membranes. MDA concentration varies in response to abiotic stress; hence it can be used as marker for assessing the extent of lipid peroxidation and membrane damage, and the rate of lipid peroxidation indicates the sensitivity of plants to salt stress. In our study, Atriplex species showed ~1.7-fold increase in MDA content upon treatment with 400 mM NaCl, showing membrane damage at this concentration. On the other hand, no significant difference in MDA content was found at NaCl concentrations lower than 400 mM, indicating reduced oxidative damage to membranes that has been attributed to its salinity tolerant behavior (Fig. 5b).

3d. Total soluble sugar

In abiotic stress, increased sugar content help in combating the effect of stress by osmotic adjustment and used as potential biochemical indicator for salinity stress in plants. In our study total soluble sugar content exhibited no significant change upon salt treatment (Fig. 5c), confirming the stress-tolerant nature of Atriplex.

3e. Relative Electrolyte Leakage

Relative electrolyte leakage (REL) is an indicator of membrane damage. After 7-day salt treatment, NaCl treatment caused a slight increase in REL at lower concentrations (upto 200 mM), whereas significant electrolyte leakage upto 1.8 and 2.3-fold was observed for 300 and 400 mM NaCl treatments, respectively as compared to control (Figure 5d). In contrast, membrane stability index did not show significant change at lower salt concentrations, while it showed reduction upto 0.5-fold at 400 mM NaCl (Fig. 5 e). This suggests that salt tolerance capability of Atriplex may be closely related to the maintenance of ion homeostasis and membrane recovery under salt stress.

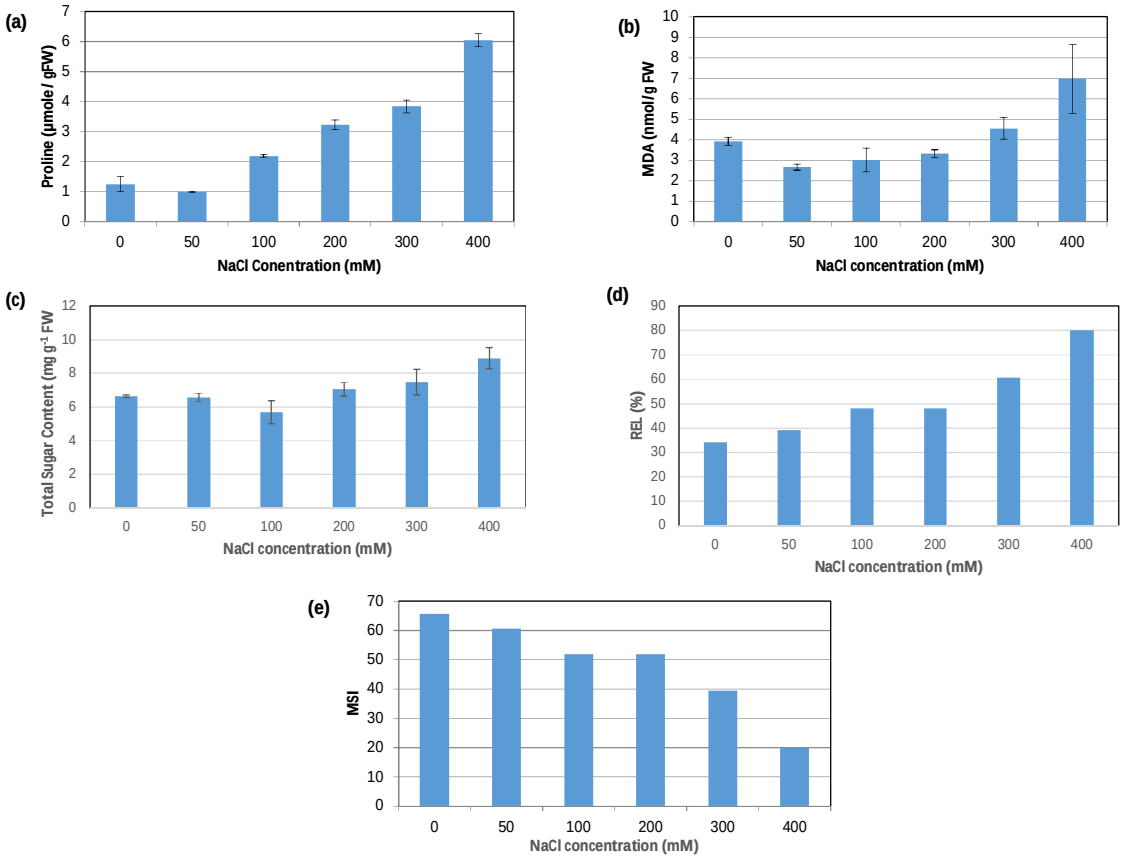


Fig. 5 Effect of salt stress on physiology of Atriplex seedlings after 7 days of NaCl treatment at 0 mM (control), 50 mM 100 mM, 200 mM, 300 mM and 400 mM concentrations. (a) Proline content (µmole/ g FW), (b) lipid peroxidation (nmoles MDA content / g FW), (c) total sugar content (mg/ g FW), (d) relative electrolyte leakage (REL, %) and (e) membrane stability index (MSI).

3f. Anti-oxidant enzyme activity

Due to high salinity plants produce reactive oxygen species (ROS) such as superoxide radical, hydrogen peroxide and hydroxyl radical. These ROS cause oxidation of biomolecules in the cytoplasm and membrane resulting in extensive cell damage. Oxidative stress can lead to inhibition of photosynthesis and respiration and, thus, plant growth. Plants have evolved enzymatic and non-enzymatic systems to scavenge reactive oxygen species. In enzymatic systems, for example, ROS are scavenged by antioxidant enzymes such as catalase, SOD, APX, POD, GR etc.

In the present study, we have analyzed activity of these important antioxidant enzymes to support our phenotype data for salt-tolerant nature of Atriplex. CAT, POD and APX activities showed similar trend in Atriplex under salt stress condition. Their activity did not show significant change upto 200 mM NaCl concentration. Whereas it was significantly increased at higher concentrations, and exhibited upto 1.4-fold, 1.3-fold and 2.1-fold increase at 400 mM NaCl concentration for CAT, POD and APX respectively, as compared to unstressed control (Fig. 6 a,b,c). In contrast, GR activity was found to be gradually reduced upon exposure to different concentrations of salt, and it exhibited upto 0.3-fold reduction at 400 mM NaCl, as compared to control (Fig. 6d). The reduction in GR activity in salt tolerant halophyte indicates that this enzyme may not be directly involved in protection against oxidative stress.

These antioxidant enzyme assays indicate that salt tolerance in Atriplex species may be related to higher constitutive levels of catalase and peroxidase, and a greater capacity to regulate ascorbate peroxidase activity. This is additional evidence supporting the salt-stress tolerant capabilities of Atriplex plants.

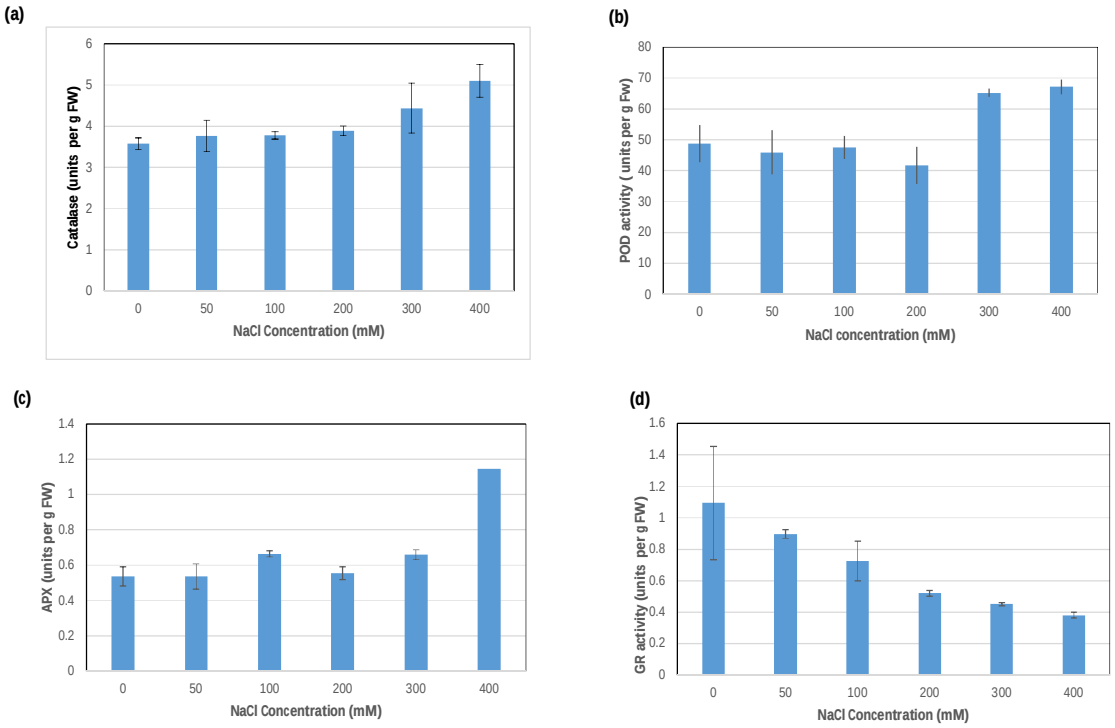


Fig. 6 Effect of salt stress on antioxidant enzyme activity in seedlings of Atriplex spp. after 7 days of NaCl treatment at 0 mM (control), 50 mM 100 mM, 200 mM, 300 mM and 400 mM concentrations. (a) Catalase activity expressed in units per gram FW. (b) Peroxidase (POD) (Guaicol) activity expressed in units per gram FW. (c) Ascorbate peroxidase (APX) activity expressed in units per gram FW. (d) Glutathione reductase (GR) activity expressed in units per gram FW.

Non - Thrust Area (Stress Physiology)

Investigators

i. **Dr.B.R.Gadi (Incharge)**
ii. **Mr.Ramesh Kumar (Member)**

Title of Research : Stress tolerance mechanism of some wild/native plants of Thar Desert

Work Done

Plant (*Lasiurus sindicus* Henr) materials were collected from different sites of Jaisalmer, Barmer, Jodhpur and Bikaner districts of Rajasthan. Most of these plants were collected from different sandy habitat of the Desert, near canal region, plain area and rocky habitat. Biochemical parameters like proteins, proline ,sugars pigments, and antioxidants were assayed under different levels of water and salinity stress in *in vivo* grown plants . Total genomic DNA was extracted from the collected leaf sample using CTAB (Cetyl trimethyl ammonium bromide) method . Further the extracted DNA is used for the amplification with RAPD primers in thermo cycler.

***In Vivo* Studies**

Effect of of NaCl (50,100 and 150mM) and PEG 6000 (5,10 and 20 %) on biochemical and enzyme activities were studied on *Lasiurus sindicus* grown *in-vivo* at 15, 30 and 45 days after treatment (DAT).

Effect of NaCl on and Water stress on following parameters :

(I) Plant metabolites (soluble protein, proline and total soluble sugars) content.

(II)Photosynthetic pigments (Chl-a and Chl-b) content.

(III) Membrane integrity parameters-Chlorophyll Stability Index (CSI%), Membrane Stability Index (MSI%) and lipid peroxidation in term of Malondialdehyde (MDA) content.

(IV) Enzymes -Nitrate reductase (NR) activity and Antioxidant- non-enzymatic (Ascorbic acid and Total Phenols) content and enzymatic (SOD, POX and CAT) activities.

Effect of NaCl

NaCl stress has negative effects on plant growth as it decreased the soluble protein, pigments CSI , MSI and NR activity at 15,30 and 45 days after treatment (DAT). Proline, ascorbate, phenol and total soluble sugars content increased significantly with increasing concentration of NaCl. The proline and total soluble sugars content was more at 45 DAT with 150 mM NaCl .

The peroxidase, catalase and superoxide dismutase (SOD) activities as well as MDA content showed an increasing trend with concentration and duration of treatments. Phenols initially increased, but showed a lower value for 150 mm NaCl at 45 DAT as compared to 30 DAT.

Table1: Effect of salt stress on total phenols ,total soluble sugars content and peroxidase activity in *in-vivo* grown seedlings of *L.sindicus*.(±Standard error of mean)

Treatments	Phenol			total soluble sugars			Peroxidase activity		
	DAT			DAT			DAT		
	15	30	45	15	30	45	15	30	45
Control	23.41 ±0.754	25.35 ±0.843	28.45 ±1.323	40.81 ±1.173	44.76 ±1.329	49.04 ±0.873	66.17 ±0.807	69.24 ±0.916	71.92 ±0.825
NaCl 50	23.81 ±1.365	26.87 ±1.443	28.82 ±1.432	42.19 ±1.282	46.32 ±0.421	50.54 ±1.432	67.37 ±0.392	72. 28 ±0.422	74. 54 ±0.712
NaCl 100	26.21 ±1.545	28.37 ±1.544	30.42 ±1.343	48.25 0.984	52.71 ±1.428	53.11 ±1.036	79.15 ±0.683	86.67 ±0.724	88.63 ±0.892
NaCl 150	29.62 ±1.232	35.50 ±2.332	34.12 ±2.432	57.360 ±1.577	62.25 ±0.473	65.59 ±1.018	86.59 ±0.824	89.59 ±1.026	94.37 ±1.137

Effect of Water stress

PEG treatment caused more pigments (Chl a and Chl.b) reduction than NaCl treatment and maximum decrease in pigment content was observed at 45 DAT treated with 20 % of PEG.Percentage of chlorophyll stability index and MSI gradually decreased with duration and increasing concentration of PEG and salt. Maximum decrease in CSI% and MSI % was recorded in drought stress with 20 % PEG at 45 DAT.

It was also observed that proline level increased with increasing concentration and duration of PEG treatment in *Lasiurus* seedlings, and higher increase in level of proline was reported in 20 % of PEG treatment at 45 DAT.

Activity of nitrate reductase and protein content was declined under water stress over control seedlings. Maximum reduction in NR activity was observed with drought stress compared to salt stress.

Table 2 : Effect of PEG-6000 on chlorophyll stability index (CSI), Peroxidase (POD) activity and Protein content in *in-vivo* grown plants of *L.sindicus* .(±Standard error of mean).

Treatments	CSI %			POD			Protein		
	DAT			DAT			DAT		
	15	30	45	15	30	45	15	30	45
Control	76.13 ±0.754	78.24 ±0.843	79.56 ±1.323	66.17 ±0.807	69.24 ±0.916	71.92 ±0.825	24.33 ±0.741	25.27 ±0.173	28.5 1 ±0.374
5 % PEG	74.53 ±1.365	78.19 ±1.443	78.38 ±1.432	66.321 ±1.323	71.25 ±0.433	75.38 ±1.761	23.53 ±0.235	24.16. ±0.345	27.48. ±0.324
10% PEG	73.31 ±1.545	76.37 ±1.544	76.91 ±1.343	74.54 ±1.433	75.82 ±1.434	79.43 ±1.031	20.31 ±0.544	22.28 ±0.522	22.93 ±0.567
20% PEG	70.14 ±1.232	70.02 ±2.332	69.03 ±2.432	82.40 ±1.657	97.38 ±0.545	90.25 ±1.126	17.14 ±0.127	16.29 ±0.463	15.62 ±0.245

The lipid peroxidation product in the form of MDA content was greatly increased when plants were subjected to both stresses of NaCl and PEG. It was also observed that with increasing duration of stress, MDA level was increased as compared to control. The activities of antioxidant enzymes such as superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) increased significantly with increasing concentration of PEG. In different concentration of PEG (5,10 and 20 % PEG), activities of all three examined enzymes (SOD, POD and CAT) varied greatly.

Salt and PEG treatments caused an increase in non enzymatic (ascorbic acid and phenolic content) and enzymatic antioxidants (SOD, POD and CAT) that depended on the concentration and duration of exposure to stress of PEG and NaCl applied to the plants.

Genetic Diversiy analysis of *L. sindicus*

DNA extraction

Young leaves of *Lasiurus sindicus* were collected from plants grown in arid region of western Rajasthan. The leaves were stored in liquid nitrogen. DNA was extracted CTAB method described by Murray & Thomson (1980) with slightly modifications. The pre-chilled mortar and pestle was used togrind leaf (1.0 g) samples in liquid nitrogen. Precipitated DNA was kept for air dry. Then re-suspend DNA appropriate volume of TE for storage at 4^0 C.

Quantity and purity also check by nanodrop spectrophotometer through 260/280 ratio.The DNA was examined using the agarose gel electrophoresis method. 0.8% (w/v) agarose was dissolved in 1X TAE buffer and electrophoreses with marker DNA (λ Hind III DNA marker) . The gel was visualized and photographed under UV transilluminator to visualize the fluorescent bands of ethidium bromide-stained DNA.

Polymerase Chain Reaction (PCR) optimization and Data analysis

PCR Optimization and selection of primers

Varying concentrations of (i) template DNA (20, 30, 40, 50 and 60 ng), (ii) Taq DNA polymerase (0.5- 2 U) and (iii) Mg^{++} salt (1- 5 mM) were used to optimize the reaction conditions of the PCR using one specific DNA sample. 10 RAPD primers from the kits OPA, OPB, OPC, OPD and OPK (Operon Technologies, USA) were assayed to screen primers that produced bestamplification products. Three RAPD primers (OPA 10, OPA 07 and OPK 01) were finally selected.

40 ng template DNA, 15ng RAPD primer , 0.24mM dNTP, 2.5 mM Mg^{++}, and 1U Taq DNA polymerase making up to final volume as 25 µl was used for PCR amplification.The amplification was carried out for 40 cycles with DNA denaturation at 94 ^{0}C for 5 min followed by 45 cycles of denaturation (94 ^{0}C for 1 min), annealing (37 ^{0}C for 1min), and extension (72^{0}C for 2 min), with a final extension at 72 ^{0}C for 7 min in a thermal cycler.

Gel electrophoresis

Aliquots of amplified PCR products, along with DNA ladder were run in 1.2 % (w/v) agarose gel in 1X TAE buffer . The 100bp and 1 kb ladder was taken as the standard marker in each amplification. The ethidium bromide stained agarose gels were visualised under ultra violet and photographed.

The quality of DNA extracted was found to be good and good RAPD profiles (Fig1-2) were obtained with the chosen primers in different accessions of *L.sindicus*

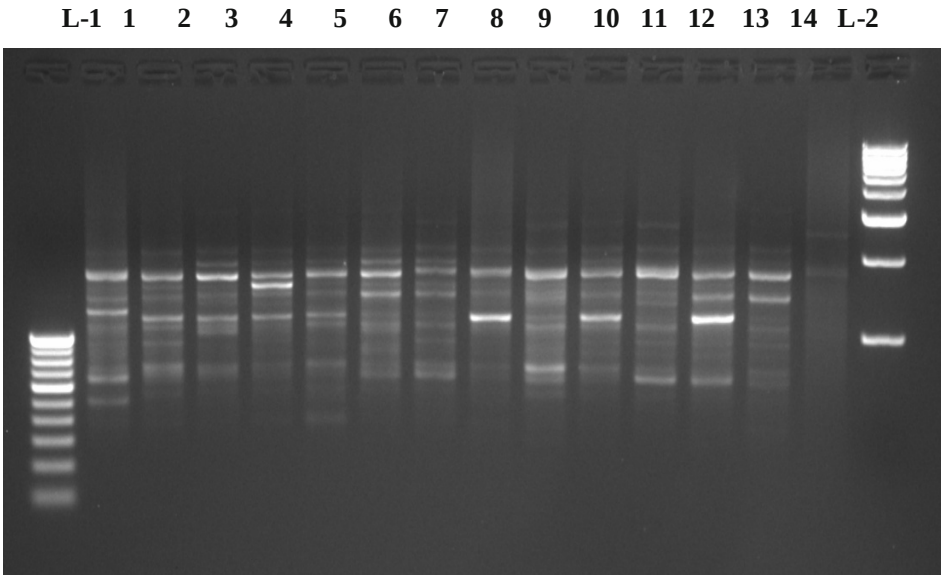


Fig.1. **RAPD (OPA-10)** Primer profile of *Lasiurus sindicus* lane 1-14 &**L-1** is 100 bp ladder and **L-2** is 1 kb ladder.

L-1 1 2 3 4 5 6 7 8 9 10 11 12 13 14 L-2

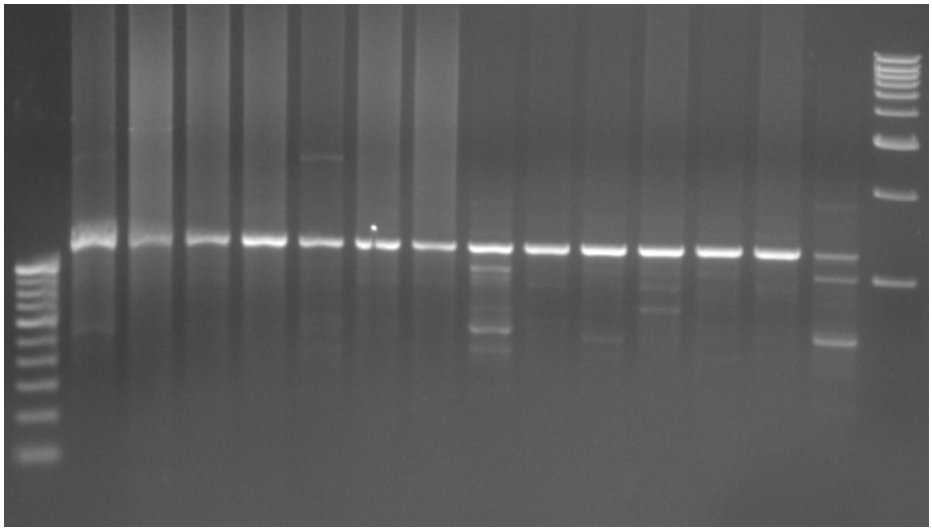


Fig.1. **RAPD (OPK-7)** Primer profile of *Lasiurus sindicus* lane 1-14 &**L-1** is 100 bp ladder and **L-2** is 1 kb ladder.

Department of Botany, Center of Advanced Study
JNV University, JODHPUR

APPLICATION FOR DST- FIST ASSISTANCE-2016

Application for [please tick one] **Level I** [ ] **Level II** [√]

1	a)	Name of the Department & Year of Establishment	:Department of Botany Center of Advanced Study
	b)	Name of the University	:Jai Narian Vyas University, Jodhpur
	c)	Address for correspondence including Telephone, Telegram, FAX, e-mail etc	:Department of Botany JNV University, Jodhpur 342001 jnvusundar@rediffmail.com; jnvuhodbotany@gmail.com 9414871532; 0291-2720799
	d)	Year of Commencement of PG Program in the Department & its Financial Status (General/ Self-financed)	1962 General
2		Status of the Institute/ University (attach supporting documents)	
	a)	Academic Status	University
	b)	Financial Status	State University

3. a) Name & Number of Faculty members in position:
   a) Professors = 3
   b) Associate Professors = 8
   c) Assistant Professors = 15

Name of Faculty Member	Designation	Age	Highest Qualification
Dr. S. Sundaramoorthy	Professor	57	M.Sc., Ph.D.
Dr. P.K. Kasera	Professor	53	M.Sc., Ph.D.
Dr. H.S. Gehlot	Professor	56	M.Sc., Ph.D.
Dr. Anil Vyas	Associate Professor	55	M.Sc., Ph.D.
Dr. H.R. Dagla	Associate Professor	47	M.Sc., Ph.D.
Dr. Sunita Arora	Associate Professor	44	M.Sc., Ph.D.
Dr. Gyan Singh Shekhawat	Associate Professor	39	M.Sc., Ph.D.
Dr. Ganpat Singh Deora	Associate Professor	54	M.Sc., Ph.D.
Dr. Parveen Gehlot	Associate Professor	43	M.Sc., Ph.D.
Dr. Bhana Ram	Associate Professor	42	M.Sc., Ph.D.
Dr. Santosh Kumar Mehar	Associate Professor	42	M.Sc., Ph.D.

Dr.(Mrs.)Vinod Kataria	Assistant Professor	41	M.Sc., Ph.D.
Mrs. Vandana Meena	Assistant Professor	38	M.Sc.
Dr. Sharad Bissa	Assistant Professor	36	M.Sc., Ph.D.
Dr (Ms.) Shweta Jha	Assistant Professor	36	M.Sc., Ph.D.
Dr.(Mrs.) Suman Parihar	Assistant Professor	35	M.Sc., Ph.D.
Dr.(Ms.) Nisha Tak	Assistant Professor	32	M.Sc., Ph.D.
Dr. Ashok Kumar Patel	Assistant Professor	30	M.Sc., Ph.D.
Dr.(Mrs.) Rachna Dinesh Nee Modi	Assistant Professor	44	M.Sc., Ph.D.
Dr. (Mrs.) Kamna Sharma	Assistant Professor	34	M.Sc., Ph.D.
Mr. Alkesh Tak	Assistant Professor	34	M.Sc., M.Tech.
Dr.(Mrs.) Sumitra Kumari Choudhary	Assistant Professor	33	M.Sc., Ph.D.
Dr. Kheta Ram	Assistant Professor	38	M.Sc., Ph.D.
Mrs. Seema Sen	Assistant Professor	31	M.Sc.
Mrs. Meena	Assistant Professor	36	M.Sc.
Mr. Ramesh Kumar	Assistant Professor	34	M.Sc.

b) Sanctioned Strength
   a) Professors = 1
   b) Associate Professors = 5
   c) Assistant Professors = 24

4 Distinction earned by faculty members like National and International Awards, Professional Societies
   a. Prof. Sundaramoorthy is Fellow of Indian Botanical Society; Indian Agroforestry Society; Arid Zone Research Association
   b. Prof. P.K. Kasera is Fellow of Arid Zone Research Association; Soil Science Society of India
   c. Prof. H.S. Gehlot is Fellow of Indian Plant Physiology Association; awarded Visiting Scientist under UGC-Indo-Hungary Educational Exchange Programe-2013-14 (April-May, 2014) to visit Biological Research Centre, Hungarian Academy of Sciences, Szeged, Hungary; awarded DBT-VRP NER Visiting Research Professor award (2015-16) to visit NEHU, Shillong, ME for six months
   d.
   e.

5 a) Actual Current student strength
   (i) In M.Sc. COSIST Botany Previous 30 Final 25

   (ii) Total Full Time Ph. D scholars in each sub-discipline
   a. Biotechnology Laboratory = 4
   b. BNF Laboratory = 5

c. Cytogenetic Laboratory = 4
d. Ecology Laboratory = 10
e. Microbiology & Biotechnology Laboratory = 4
f. Molecular Biology Laboratory = 3
g. Pathology Laboratory = 3
h. PBMB Laboratory = 4
i. Stress Physiology Laboratory = 2
j. Taxonomy Laboratory = 2

b) Degree-wise actual number of passing out students in last five years:

No. of Students in each degree	YEARS 2011	2012	2013	2014	2015	Total
M.Sc. COSIST	24 out of 24	25 out of 25	28 out of 29	28 out of 29	20 out of 20	24+25+28+28+20 = 125

c) (i) Number of Students (year-wise) who qualified in NET in M. Sc. Program

UGC-CSIR NET	2011	2012	2013	2014	2015	Total
	2+0	2+2	1+4	3+1	5+2	June 13 + December 9 = 21

(ii) Number of Full Time Ph. D. research scholars with fellowships awarded from any agency in the department

S No.	Name of Ph.D. scholar	Date of joining	Fellow ship awarding agency	Current Fellowship amount (Rs)
1.	Ms. Krishna Sodha	January 14, 2011	CSIR-NET	28000/-
2.	Ms. Renu	January 14, 2011	CSIR-NET	28000/-
3.	Ms. Anupama Sagar	May 16, 2012	CSIR-NET	28000/-
4.	Ms. Deepmala Goswami	October 18, 2012	UGC-NET	28,000/-
5.	Ms. Tanvi Agarwal	January 17, 2013	CSIR-NET	28000/-
6.	Ms. Arti Soni	February 5, 2013	CSIR-NET	28000/-
7.	Mr. Raju Ram Meghwal	April 1, 2013	UGC-PDF	46,500/-
8.	Dr. Ruchika Sharma	October 1 , 2013	DST-SERB	55,000/-
9.	Ms. Deepika Matwa	January 1, 2014	JNV University	600/-
10.	Ms. Sonam Meena	January 27, 2014	UGC-RGNF	25,000/-
11.	Dr. Monoj Rai	June 4, 2014	DST-SERB	55,000/-
12.	Ms. Kushboo Khator	August 1, 2014	JNV University	600/-
13.	Mr. Bhuwnesh Goswami	July 1, 2015	CSIR-NET	25000/-
14.	Mr. Udit Sharma	July 24, 2015	UGC-NET	25,000/-
15.	Ms. Illam Bhano	July 24, 2015	UGC-NFO	25,000/-
16.	Ms. Jatan Shekhawat	July 24, 2015	UGC-NET	25,000/-
17.	Ms. Sushila Kumari	July 24, 2015	UGC-NET	25,000/-
18.	Ms. Sonam Rathi	September 2, 2015	UGC-NET	28,000/-

d) Placement of graduating post-graduate & Ph D students in the Department:

For 2011-12:

- Dr. Mangal Singh Rathore, Scientist, Discipline of Wasteland ResearchCentral Salt & Marine Chemical Research Institute (CSMCRI) (CSIR).G.B. Marg, Bhavnagar, (Gujarat- 364021) India

For 2012-13:

- Two M.Sc. students (Harshita Singh, Priyanka Kayshap), and one Ph.D. scholar (Neetu Joya) have been selected in Nationalized Banks as Bank Officers
- One M.Sc. student (Amitap) selected in Rajasthan Electricity Board as an Officer

For 2013-14:

- Indu Singh Sankhla- Assistant Prof. of Botany at Rajasthan University, Jaipur
- Neelam Poonar- Assistant Prof. of Botany at Rajasthan University, Jaipur
- Sunil Choudhary- Research Assistant, Arid Forest Research Institute, Jodhpur
- Aparna Raturi: Assistant Prof. of Biotechnology, HNBG University, Uttarakhand
- Priya Dudi - Assistant Prof. of Botany at Rajasthan University, Jaipur
- Deepika Lodha - Research Assistant, Arid Forest Research Institute, Jodhpur

For 2014-15

- Amit Kumar selected for Sr. Science Teacher, UP Staff Selection Commission

For 2015-till date:

- One M.Sc. student (Abishek) selected as Bank Officer in SBI
- Dr. Mahendra Pulwariya has been selected as Scientist in DOEn, New Delhi

6. Indicate the development grant received from UGC during the Eleventh and Twelfth Plan.

	11th Plan	12th Plan
Building	Nil	Nil
Equipment	10,00,000.00	14,28,571.00

7 What is the annual grant available to the department from your university during the last two years?

Year	For Teaching	For Research
2014-15	Laboratory grant 3,00,000/- Garden 30,000/- Others 60,000/- Plant Material collection 1,00,000/-	Note: The grant allotted is not distinguished. Most of the Laboratories have R&D research project funds/UGC-CAS Thrust Area fund to meet research needs.
2015-16	-do-	

8 Has the Department received any major infrastructure research grant during the last five years from S&T agencies including UGC/AICTE. If yes, details.

Heads Name of Agency/ Scheme with year and amount: UGC-CAS

Building	Nil
Equipment	89,00,000/-
Books	1,00,000/-PA
Supplies and Materials	2,00,000/- + 2,00,000/- PA (Contingencies + Consumables)
Computing & Networking	Nil
Facilities	4,00,000/- [Reprographic facilities]

9 Is the Department recognized under DRS (Departmental Research Support), DSA (Departmental Special Assistance), CAS (Centre for Advanced Study) and COSIST schemes of UGC for receiving support? Please [tick] one:

DRS [ ] DSA [ ] CAS [√] COSIST [√]

Note: The Department received one time grant Assistance under COSIST during July 1999 and the scheme of teaching under COSIST is continued till date with the only chance from 2015 is to opt for Choice Based Credit System in M.Sc. COSIST Botany

10 Details of research grant received from different agencies during the last five years:

Name of the Investigator	Title of the project and duration	Amount sanctioned	Funding Agency
Dr. B.R. Gadi	Evaluation of Genetic Diversity and stress tolerance mechanism in Lasiurus sindicus Henr.: Native to Thar Desert of Rajasthan.	20,60000/-	SERB - DST (New Delhi)
Dr. H R Dagla	In vitro studies on growth and development of two important plant species of Indian Arid Environment	6, 06, 800/-	UGC, New Delhi
Dr. Kheta Ram	Molecular characterization and in vitro studies of Cordia myxa of arid and semi arid region of Rajasthan	6,00,000/-	UGC-Start up grant
Dr. Kheta Ram	Molecular characterization and in vitro studies of Cordia myxa of arid and semi arid region of Rajasthan	6,00,000/-	UGC-Start up grant
Dr. Nisha Tak	Phylogenetic studies of novel root nodule bacterial strains isolated from native legumes of Indian Thar Desert on the basis of multi locus sequence analysis (MLSA)	6,00,000/-	UGC-Start up grant
Dr. Nisha Tak	Molecular Characterization and Symbiotic promiscuity studies using GFP reporter gene of some novel root	22,00,000/-	DST-SERB-Young

	nodule microsymbiont associated with native arid legumes of Indian Thar Desert		Scientist Project
Dr. Rachana Dinesh nee Modi	Characterization of germplasms and in vitro studies on two horticulture plants of arid and semi arid regions of Rajasthan (Date palm and Pomegranate)	6,00,000/-	UGC-Start up grant
Dr. Shweta Jha	Comparative proteomic analysis for salinity stress tolerance in Pearl millet (Pennisetumglaucum (L.) R. Br.)	24,40,000/-	DST-SERB
Dr. Shweta Jha	Comparative proteomic analysis of xero-halophyte saltbush - Atriplex under salt stress	6,00,000/-	UGC (Start-up grant)
Dr. Sumitra Kumari Choudhary	Molecular characterization and micromorphological studies on selected edible Cucurbits of Rajasthan	6,00,000/-	UGC-Start up grant
Prof. Hukam Singh Gehlot	Screening and molecular characterization of salt and temperature tolerant nitrogen fixing root nodule bacterial strains isolated from native legumes of Indian Thar desert	14,40,000/-	UGC-MRP
Prof. Hukam Singh Gehlot	Characterization and evaluation of PGP activity of rhizobial isolates native to arid regions of Rajasthan	33,61,000/-	DBT, New Delhi
Prof. Pawan K. Kasera	Bioprospecting, agrotechniques and phytochemical characterization of commercially exploitable and endangered medicinal plants of the Indian Thar desert	6, 27, 800/-	UGC, New Delhi
Prof. S. Sundaramoorthy	Impact of allelopathic plant material on soil biology and rhizophere modifications for sustainable farming in arid Agroforestry	7,62,800/-	UGC, New Delhi
Dr. Ruchika Sharma Young Scientist	Diversity assessment of Actinomycetes based on 16s rRNA from Indian Thar desert and their antimicrobial potential	27,20,000/-	DST, SERB

Dr. Manoj Kumar Rai Young Scientist	Molecular characterization of *Prosopis* and *Acacia* species- Well accepted agro-forestry tree of Indian Thar desert	29,22,000/-	DST, SERB
Dr. Manoj Kumar Rai DS Kothari Post-Doctoral Fellowship	Molecular characterization, propagation and *in* vitro conservation of guava (*Psidium guajava* L.)	14,46,939/-	UGC, New Delhi
Dr. Mahendra Phulwaria UGC Post-Doctoral Fellowship for SC/ST	Development of Biotechnological Tools for *Arnebia hispidissima* - Characterization, Conservation and Utilization for production of alkannins	23,02,112/-	UGC, New Delhi
Dr. Pooja Khurana DST Women Scientists Scheme (WOS-A)	Application of aeroponics in desert specific plants for biomass production	23,60,000/-	DST, SERB

Dr. G.S. Shekhawat and Dr. Santosh Kumar Mehar has received five and three R&D research project funding in the University where they were previously serving, respectively. Prof. H.S. Gehlot is a Co-Investigator for a R&D project operative at NEHU, Shillong

11 Details of any other Resource Generation Avenues (other than Sponsored Research Grants). NIL

12. Indicate the research activities of the faculty members as per the following pro-forma

Name the of Faculty	Designation	Major areas of Research	Number of Ph. Ds produced (in last 5 years)
Dr. S. Sundaramoorthy	Professor	Ecology	2
Dr. P.K. Kasera	Professor	Ecology & Resource Biology	4
Dr. H.S. Gehlot	Professor	Biological Nitrogen Fixation	5
Dr. Anil Vyas	Associate Professor	Microbiology	4
Dr. H.R. Dagla	Associate Professor	Tissue culture and molecular biology	2
Dr. Sunita Arora	Associate Professor	Cytogentics	1
Dr. Gyan Singh Shekhawat	Associate Professor	Molecular biology	8*
Dr. Ganpat Singh Deora	Associate Professor	Taxonomy	1*
Dr. Bhana Ram	Associate Professor	Stress Physiology	2

Dr. Santosh Kumar Mehar	Associate Professor	Ecology, Microbial Ecology	3*

* Guided in other Universities where they were serving previously

13 a) List of Research Publications in SCI Journals coming from the Department during the last five years (Authors Names, Title of Paper, Name of the Journal, Volume, Page nos., Year).

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b) List of Publications in Conference Proceedings during last five years (Authors Names, Title of Paper, Name of the Conference, Volume, Page nos., Year).

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Gadi, B. R., Ram, A. and Verma, P. 2011. Effect of salicylic acid on nitrate reductase activity in *Citrulluslanatus* under NaF stress. In: National workshop on Stress agriculture and climate change: Exploring synergy with natural resource management in agriculture (NaRMA-III). Jodhpur, Rajasthan.

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Gehlot, H.S. 2010. Participated as "Invited Speaker" in 1st Asian N Fixation Conference at Miyazaki-JAPAN 20-24 September

Gehlot, H.S. 2012. Invited as "Invited Speaker" and participated in 2nd Asian N Fixation Conference held at Phuket, Thailand, 28-31 October.

Gehlot, H.S. 2013. Invited speaker and chaired session in 11 Desert Technology International conference at San Antonio, TX, USA, November 19-22

Gehlot, H.S. 2014. Delivered guest lecture at Biological Research Centre of Hungarian Academy of Sciences, Szeged, Hungary, April 15-30.

Gehlot, H.S. 2014. Delivered guest lecture at Department of Microbiology, University of Szeged, Hungary 19th April

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Harish, Gupta, A.K., Ram, K., Phulwaria, M. and Shekhawat N.S., 2011. Isolation of PCR usable genomic DNA from *Anogeissusrotundifolia*. In: Proceeding of National Symposium on 'Recent Advances in Plant Tissue Culture and Biotechnological Researches in India' & XXXII Annual Meet of PTCA (India). 4-6 February, Organized by M.N. Institute of Applied Sciences, Bikaner, Rajasthan, (Poster presentation)

Jh,a S., Sanyal, I., Amla, D.V. and Singh B.D. 2015. "*Engineering thermotolerance in recombinant human α_1-proteinase inhibitor (α_1-PI) expressed in Escherichia coli*." 56th International Conference "AMI 2015", December 7-10 at Jawaharlal Nehru University, New Delhi.

Jha S., Sanyal I. and Amla D.V. 2013. *Single amino acid substitutions in recombinant α_1-antitrypsin confer enhanced stability and efficacy*"; in Asian Congress on Biotechnology (ACB-2013), under the aegis of Asian Federation of Biotechnology (AFOB), December 15-19 at IIT, New Delhi.

Jha S., Sanyal I.,AmlaD.V. 2015. *High-level expression and purification of a therapeutic recombinant serine protease inhibitor from transgenic tomato plants*. In: International Conference on Recent Trends in Engineering Science and Management (ICRTESM-2015) March 15 at Jawaharlal Nehru University, New Delhi.

Jha S., Sanyal, I., and Amla, D.V. 2014. *Targeting of recombinant human α_1-proteinase inhibitor to ER enhances yield, biological activity and stability in transgenic tomato plants*; In: International Conference on Proteomics & 6th Annual Meeting of the Proteomics Society, India PS(I)held on December 7-9 at IIT, Bombay. Conference proceedings published in *JOURNAL OF PROTEINS AND PROTEOMICS* (Special issue: Dec. 2014) (NAAS Rating 3.75)

Jha S., Sharma M., Giri J., Tyagi A.K 2015. Overexpression of a rice A20/AN1 zinc-finger protein modulates defence response against pathogen infection in tobacco3rd International Plant Physiology Congress, held on December 11-14 at Jawaharlal Nehru University, New Delhi.

Karra, S. and Mehar, S.K. 2012. Importance and applications of phytoremediation, especially phytoextraction. Proc. AP Science congress, 14th-16th November, 287p.

Karra, S. Shaik, G., Murali, O., Varalakshmi, S. and Mehar, S.K. 2013. Neutraceuticals. Souv. National seminar on perspectives of phytomedicine and medicinal plants conservation (nsppmc-2013), 22nd-23rd March, 47p.

Kasera, P.K. 2010. Status and opportunities of some important medicinal plants of Indian arid zone. In: National Seminar on Current Status and Opportunities in Medicinal Plants of Thar Desert, Mahila PG Mahavidyalaya, Jodhpur, 9-11 December, 2010.

Kasera, P.K. 2016. Invited as speaker. In: Dissemination of Agro technology of importan medicinal plants developed through NMBP – Issues and Challenges. 28-2 February, Ch. Brahm Prakash Ayurveda CharakSansthan& AYUSH, GOI,, Nev Delhi,

Kasera, P.K., Lal, H. and Mohammed, S. 2012. Distribution, seed germination behaviour, cultivation, uses and conservation of *Commiphorawightii* - a critically endangered medicinal plant from the Indian arid zone. In: National Conference on Biodiversity Depletion: Causes, Consequences and Solutions, 28-29 September M.L.V. Govt. College, Bhilwara

Kataria ,V. and Shekhawat, N.S. 2016 Micropropagation of Capparisspinosa (Caper): An important medicinal plant. In: UGC sponsored conference on Recent

advances in Biological Sciences, Biotechnology & Sustainable development 18 th -19 th March, organized by Departmnet of Botany MLS University, Udaipur(oral)

Lal, H. and Kasera, P.K.2012. Guggal: a critical endangered medicinal plant from the Indian arid zone. In: National Seminar on Environment & Biodiversity Conservation (Present Status & Future Strategy), 6-7 October, Govt. Lohia P.G College, Churu,

Murali, O. and Mehar, S.K. 2013. Bioremediation of Cobalt and Chromium by using cyanobacteria. Souv. 7 National Teacher's Science Congress ,14-17 December, 204p.

Murali, O. and Mehar, S.K. 2014. Plants of eastern ghats used with proven medicinal potential. Souv. National conference on Conservation of Eastern Ghats, 4th-5th December, SV University, Tirupati and Greence's Alliance for conservation of eastern ghats, Hyderabad, 118p.

Patel, A.K. and Shekhawat, N.S. 2014. An efficient in vitro plant regeneration system from leaf of mature plant of *Leptadeniareticulata* (Jeewanti): an endangered woody climber of pharmaceutical importance. National Conference on "Plant Bioresource and Management Biotechnology", January 29th to 31st, organized by Department of Botany, University of Rajasthan, Jaipur,

Patel, A.K. and Shekhawat, N.S. 2014. Direct shoot regeneration and rooting protocols for the propagation of *Pentatropis spiralis* (Forsk.) Decne.: a medicinally important Asclepiadaceous plant species.National Conference on "Harmony with Nature in Context of Environmental Issues and Challenges of the 21st Century", November 28th to 30th, Organized by Department of Environmental Sciences Faculty of Earth Sciences M. L. Sukhadia University Udaipur.

Patel, A.K. andShekhawat, N.S. 2014.Micropropagation technology for the conservation of *Caralluma edulis* (Edgew.) Benth. & Hook. f.: a rare and endangered anti-diabetic plant species from Indian Thar Desert. National Symposium on "Green Economy and Harnessing Natural Products for Sustainable Development", July 12th, organized by The Indian Science Congress Association, Jaipur Chapter and Indian Society for Life Sciences (ISLS). (BEST POSTER PRESENTATION AWARD)

Patel, A.K., Lodha, D. andShekhawat, N.S.2014. Transverse thin cell layer induced micropropagation of *Caralluma edulis* (Edgew.) Benth. & Hook. f.: a rare and nutraceutically important plant of extreme arid regions. 84th Annual Session of the National Academy of Sciences, India and the National Symposium on "Desert Science – Opportunities and Challenges" December 4th to 6th, organized by Faculty of Science, Jai Narayan Vyas University, Jodhpur.

Patel, A.K., Lodha, D., Ram, K. and Shekhawat, N.S. 2015. Conservation of two threatened and medicinally important Asclepiadaceous species of Indian Thar Desert through in vitro technology.ICCB: 27th International Congress for Conservation Biology; 4th European Congress for Conservation Biology, MONTPELLIER – FRANCE, August 2-6

Patel, A.K., Lodha, D., Ram, K., Shekhawat, S. and Shekhawat, N.S. 2015. Evaluation of physiochemical factors affecting high frequency plant regeneration of *Blyttia*

spiralis (Forssk.) D. V. Field & J. R. I. Wood [Synonym: *Pentatropis spiralis* (Forssk.) Decne.], a threatened climber of medicinal values.XXXVIII All India Botanical Conference 2015 and "National Symposium on Emerging Trends in Plant Sciences". October 26th to 28th, organized by Department of Botany, University of Rajasthan, Jaipur

Ram K. and Shekhawat N.S. 2016. Cell Cultures and morphogenesis in *Arnebiahispidissima* (Lehm.) DC.- Dye/Shikonin production in Cultures. In: Proceeding of National Symposium on 'Plant Biotechnology for Crop Improvement and 37th Annual Meeting of PTCA (India), 25-27 February. (Poster presentation)

Ram K. and Shekhawat N.S., 2011. In vitro and ex vitro rooting of regenerated shoots of some medicinally and economically important plants of arid regions. In: Proceeding of National Symposium on 'Recent Advances in Plant Tissue Culture and Biotechnological Researches in India' & XXXII Annual Meet of PTCA (India); Organized by M.N. Institute of Applied Sciences, Bikaner, Rajasthan, 4-6 February (Poster presentation)

Ram K., Patel A.K., Shekhawat N.S. and Kasera P.K. 2016. Agrotechnology of *Leptideniaraticulata*. Invited as speaker in National Seminar on "Dissemination of Agro Technology of Important Medicinal Plants Developed thorugh NMBP-Issues and Challenges", 28-29 February, organized by National Medicinal Plant Board, India,

Ram K., Rathore J. S., Phulwaria M. and Shekhawat N.S., 2010. Micropropagation of *Capparis decidua* (Forsk) Edgew- medicinal and famine food plants. In: International conference on folk and herbal medicine. 25-27 November, organized by MLSU, Udaipur, Rajasthan (India), (Poster presentation).

Ram, A. Verma, P. and Gadi, B.R. 2014. Salicylic acid induced changes in activities of anti oxidative enzymes of *Citrulluscolocynthis* seedlings under drought stress. In: National conference on Harmoney with naturein context of environmental issues and challenges of the 21stCentury", November28-30, at M.L.S.University, Udaipur

Ram, A. Verma, P. Goswami, B. and Gadi, B.R. 2015. Fluoride induced oxidative stress and protective role of salicylic acid on watermelon seedlings. In: XXXVIII All India conference of the Indian Botanical Society & National Symposium on "Emerging trends in Plant Sciences", October26-28, at Department of Botany, University of Rajasthan,

Shaik, G. and Mehar, S.K. 2011. Medicinal usage of plants for common and fortuitous health problems by chenchu tribes of Andhra Pradesh. In: International conference on updates on protein drug discovery, formulation and production challenges, 28th-29th October, Sri PadmavathiMahilaViswaVidyalayam, Tirupati, 113p,

Shaik, G. and Mehar, S.K. 2012. Addition of allelopathic litter of *Prosopis juliflora* supports the activity of the soil microbial community in rice fields. Proc. National seminal seminar on advances in Microbial technology, 4p, 13th-14th February, Sri padmavathi Mahilaviswavidyalayam, Tirupati,.

Shaik, G. and Mehar, S.K. 2012. Allelopathic affect of *Prosopis juliflora* leaves on the growth of algae. 14th-16th November, AP Science congress, 190p,

Shaik, G. and Mehar, S.K. 2012. *Ceanorhabditis elegans* - an eco-friendly tool for heavy metal detoxification in soil. Souv. International seminar on emerging threats and challenges o biodiversity: policy framework for sustainable management, 2nd-4th March, Sri Venkateswara University, Tirupati, 207p,

Shaik, G. and Mehar, S.K. 2012. Invasive plant mesquite: assessing the extent of its negative influence on rice. Souv. International seminar on emerging threats and challenges o biodiversity: policy framework for sustainable management, 2nd-4th March, Sri venkateswara University, Tirupati, 193p

Shaik, G. and Mehar, S.K. 2014. Laboratory assay for evaluating the effect of *Prosopis juliflora* extract on seed germination and seedling growth of rice. Souv. Global summit on Emerging science and Technologies: Impact on Environment and human health, 1st-3rd August, 185p.

Shaik, G. and Mehar, S.K. 2014. Medicinally useful trees of Eastern Ghats of Andhra Pradesh. Souv. National conference on Conservation of Eastern Ghats, 42p, 4th-5th December, SV University, Tirupati and Grrence's Alliance for conservation of eastern ghats, Hyderabad,

Shaik, G. and Mehar, S.K. 2014. Promoting effects of allelopathic extract on nitrate reductase activity in rice. Souv. National Seminar on Present Status andFuture Prospects of Modern Biotechnology and Their Applications, 27-29th March, Dravidian University, Kuppam, , 61p.

Shekhawat S., Ram K., Choudhary S. and Shekhawat N.S., 2010. Cloning of traditional medicinal plants of *Lyciumbarbarum*. In: International conference on folk and herbal medicine. 25-27 November, Organized by MLSU, Udaipur, Rajasthan (India), (Poster presentation).

Shekhawat, G.S. and Hynei D. 2011. In vitro synthesis of Cds, ZnO, Ag and Tio2 nanoparticles and evaluation of their effect on cellular metabolism of Brassica juncea,. In NanoFlorida, Sept. 30- Oct. 1,Florida International University, Miami, USA,

Shekhawat, G.S. 2010. National symposium on Advanced Functional Materials: opportunities and challenges in new global era (NSAFM-2010). Organized by Department of Physics, Banasthali University

Shekhawat, G.S. 2010. National workshop on Biological data bases and data mining approaches, Dec.18-20, organized by Bioinformatics center Department of Bioscience and Biotechnology, Banasthali University,

Shekhawat, G.S. 2011. Podium presentation on Biological synthesis of metal nanoparticles and evaluation of their impact on Plants. In: Research one Oktberfest, October, 21, at University of South Florida, Tampa Florida, USA,

Shekhawat, G.S. and Mahawar, L. 2015. Metabolic adaptation to cadmium induced oxidative stress in Brassica juncea and role of Hemeoxygenase (HO) In: XXXVIII All India Botanical Conference and National Symposium on Emerging trends in Plant Sciences". from 26th- 28th October held at Department of Botany, University of Rajasthan, Jaipur (Rajasthan)

Shekhawat, G.S. and Rao, S. 2010. Biological and chemical synthesis of Ag, CdS, ZnO and TiO2 nanoparticles: evaluation of their Regulatory Effect on Plant Defense and Metabolism. In: National symposium on advanced functional materials opportunity and challenges in new global era. 4-5 Oct, Banasthali University,

Shekhawat, G.S. and Rao, S. 2011. National symposium on Materials for advanced technology. March 27-29,organized by Department of physics, Banasthali University (NSMAT-2011),

Shekhawat, G.S. and Verma, K 2011. Podium presentation in vitro biochemical evaluation of cadmium tolerance mechanism in callus and seedlings of Brassica juncea. In National Symposium on "Recent Advances in Plant Tissue Culture and Biotechnological Researches in India"& XXXII Annual Meet of Plant Tissue Culture Association (India), Feb. 4-6,organized by M. N. Institute of Applied Sciences, Bikaner,

Shekhawat, G.S. Dixit, S; Mahawar, L 2014. In vitro evaluation of Heme oxygenase1 (HO1) role in plant defence and study mitochondrial–chloroplast subcellular localization in Glycine max. In: national conference on plant bioresorce management and biotechnology, Jan.29-31, at University Of Rajasthan Jaipur,

Shekhawat, G.S. Dixit, S; Mahawar, L and Khator,K 2014. Hemeoxygenase-1 in modulating antioxidant defence responses under metal induce stress and its mitochondrial-chloroplast localization in Glycine max". In: 84th Annual Session of the National Academy of Sciences (NASI), India & Symposium on Desert Science-Opportunity and Challenges: December 4-6, at J.N.V. University, Jodhpur.

Shekhawat, G.S. Rao, S. 2010. Bio-Chemical Synthesis of CdS, ZnO TiO2 & Ag Nanoparticles and evaluation of their Regulatory Effect on Plant Defense and Metabolism. March 30, Poddar International College Jaipur,

Tak, N. and Gehlot, H.S. 2013. Whole genome sequence of Novel nodulatingEnsifer strain (TW10) native to Indian Thar Desert. In: 54th Annual Conference of Association of Microbiologists of India (AMI-2013) at Rohtak, Haryana 18-21st November (Poster presentation)

Vinod Kataria and NS Shekhawat 2011 Micro propagation and somatic cell genetics of some important plant of Rajasthan. In: National Symposium on PTC and Biotech & XXXII PTCA (I) meet, 4^{th} -6^{th} Feb, MN Institute of Applied Sciences. Bikaner.

c) List of Patents obtained or applied for during last five years. – Nil

d) List of scientific/ technical Books written by Faculty Members in the Department (including chapters in books)

Bohra, A., Bohra, A. and Bissa, S. 2013. *Advances in Medicinal Plant Research* (Edited). Agrobios, Jodhpur (INDIA).

Dagla, H. R., Nair, S., Vyas, D. K. and Upendra, J. M. 2014. *In vitro* culture of plants from arid environments. In: Tuteja N, Gill S S (eds.) *Climate Change and Abiotic Stress Tolerance*. Wiley-VCH Verlag GmbH & Co. KGaA, 933-938.

Gehlot, P., Bohra, N. and Harwani, D. 2015. Endophytic microorganisms and their function. In: Microbes: In Action Singh, J. and Gehlot, P. (eds.). Agrobios India. Pp. 167-187.

Gehlot, P., Raliya, R., Singh, S.K. Pathak, R. 2015. Role of Fungi in biosynthesis of nanoparticles. In: Microbes: In Action Singh, J. and Gehlot, P. (eds.), Agrobios India. Pp. 317-336

Gehlot, P., S. Kaur and Sharma, K. 2012. Preservation of Anamorphic Fungi. In: Phytotechnology: Emerging Trends, Daniel, M & Arya, A. (eds.), Scientific publisher, Jodhpur.

Gehlot, P., S. Kaur and Sharma, K. 2012. Preservation of Anamorphic Fungi. In: *Phytotechnology: Emerging Trends,* Daniel, M. & Arya, A. (eds.), scientific publisher, Jodhpur.

Gehlot, P., Singh, S.K., Lakhani, J. and Harwani, D. 2015. Secondary Structure modeling of ITS1, 5.8S and ITS2 ribosomal sequences for intra-specific differentiation among Aspergillus species. In: Microbes: In Action , Singh, J. and Gehlot, P. (eds.), Agrobios India. Pp. 337-354.

Jha, S. and Pudake, R.N. 2016. Advances in Understanding Molecular Mechanism of Plant-Nanoparticle Interactions, In: *Plant Nanotechnology - Principles and Practices* (Springer)

Kasera, P.K. 2014. *Evolvulusalsinoides*Linn. Syn. *Convolvulus alsinoides*Linn. Fam. Convolvulaceae. In: *Agro-techniques of Selected Medicinal Plants*, Vol. II. NMPB, Department of AYUSH, Ministry of Health & Family Welfare, GOI, New Delhi, pp. 42-44.

Kasera, P.K. 2014. *Salvadorapersica*Linn. Syn. *S. indica* Wt. Fam. Salvadoraceae. In: *Agro-techniques of Selected Medicinal Plants*, Vol. II. NMPB, Department of AYUSH, Ministry of Health & Family Welfare, GOI, New Delhi, pp. 88-90.

Kasera, P.K. 2016. *Prosopis cineraria* (Linn.) Druce Syn. *P. spicigera*L. Fam. Mimosaceae. In: *Agro-techniques of Selected Medicinal Plants*, Vol. II. NMPB, Department of AYUSH, Ministry of Health & Family Welfare, GOI, New Delhi, pp. (in press)

Kasera, P.K. and Mohammed, S. 2010. Ecology of inland saline plants. In: *Desert Plants: Biology and Biotechnology*, K.G. Ramawat (ed.). Springer-Verlag, New York, USA, pp. 299-320.

Kasera, P.K., Lal, H. and Mohammed, S. 2013. Status, distribution and cultivation of *Commiphorawightii*– a critically endangered medicinal plant of the Rajasthan desert. In: *Advances in Medicinal Plant Research*, Bohra, A. Bohra, A. and Bissa, S. (eds.). Agrobios (India), Jodhpur, pp. 69-74.

Kasera, P.K., Mohammed, S. and Sen, D.N. 2011. Techniques for seed germination and cultivation of some desert medicinal plants. In: *Medicinal Plant in Changing Environment*, Ahmad, A. Siddiqi, T. M. and Iqbal, M. (eds.). Capital Publishing Company, New Delhi, pp. 249-263.

Mathur, Shaifali and Shekhawat,G.S.2012. Plant Tissue Culture Technology: A Promising Approach for Biodiversity Conservation and Sustainable Resource Utilization. In: Biodiversity Management and Conservation Khan, J.B & Singh,

G.S (eds.), Lap Lambert Academic Publishing AG & CO. KG, DudwellerLandstr, Germany

Mehar, S.K. and Sundaramoorthy, S. 2015. Horizontal gene transfer: A determining factor of microbial diversity. In: *Microbes: In Action*, Singh, J. and Gehlot, P. (eds.). Agrobios, India 189-199pp.

Ojha, A., Rao, C.S., Tak, N., Gehlot, H.S., Rao, S. R. 2015. Genetic diversity analysis of rhizobial symbionts associated with legumes of India for Efficient Biological Nitrogen Fixation (BNF) Technology and Natural Soil Fertility In: Biology, Biotechnology and Sustainable Development. Research India Publications. Chapter 9- Pg: 183-196)

Panwar, D., Tak, N., Gehlot, H.S. 2014. Nodulated Native Legumes in an Arid Environment of Indian Thar Desert. In: M.H. Fulekar & R. K. Kale (eds.) Recent Trends in Plant Sciences-I.K. International Publishing House Pvt. Ltd. New Delhi, India. (Chapter 16- pg: 284-298).

Pathak, R., Gehlot, P. and Singh, S.K. 2016. Seed Priming mediated induced disease resistance in arid zone plants. In: Microbial mediated induced systemic resistance in Plants, Choudhary, D.K. and Verma, A. (eds.), Springer Science Media, pp. 57-67. ISBN 978-981-10.

Raturi, A., Gyaneshwar, P., Singh, S.K., Tak, N., Gehlot, H.S. 2014. Bacterial endophytes and their significance in the sustainable production of food in non-legumes. In: Tuteja, N. and Gill, S. S. (eds.) Climate change and plant abiotic stress tolerance–VCH Verlag GmbH & Co. KGa AWeinheim. Pg: 1013-1039.

Shekhawat, G.S. 2012. United Botany part I. Ramesh Book Depot. Jaipur-Rajasthan.

Shekhawat, G.S. 2013. Microbiology, Fungi and Plant pathology B.Sc. Part I. Ramesh Book Depot. Jaipur-Rajasthan.

Shekhawat, G.S. and Jana, S. 2012. *In Vitro* Organogenesis: Induction, Regulation and Applications. In: Plant Tissue Culture: Totipotency to transgenic. Sharma H.P. (ed.) Agrobios Publications, Jodhpur

Shekhawat, N.S., Phulwaria, M., Harish., Gupta, A.K., Ram, K., Shekhawat, S., J.B.,Vibha., Rai, M.K., Kataria, V., Kaur, G., Patel, A.K., Rathore, J.S. and Singh, R.P. 2014. Biotechnology: applications for conservation and sustainable use of plants of fragile arid ecosystems. In: Fulekar, M.H. (Ed.) *Recent Trends in Life Sciences*.

Shekhawat, N.S., Rai, M.K., Phulwaria, M., Rathore, J.S., Gupta, A.K., Purohit, M., Patel , A.K., Kataria, V. and Shekhawat, S. 2014 Tree Biotechnology with Special Reference to Species of Fragile Ecosystems and Arid Environments In: Tree Biotechnology, Ramawat, K.G., Mérillon, J.M. and Ahuja, M. R. (eds.) CRC Press Pg 187-222

Shekhawat, N.S., Rai, M.K., Phulwaria, M., Rathore, J.S., Gupta, A.K., Purohit, M., Patel, A.K., Kataria, V. andShekhawat, S. 2014. Tree Biotechnology with Special Reference to Species of Fragile Ecosystems and Arid Environments. In: Ramawat, K.G., Mérillon, J. M. and Ahuja, M.R. (Eds) *Tree Biotechnology, CRC Press,*

Shekhawat, N.S., Rathore, M.S. Shekhawat, S., Choudhary, S.K., Phulwaria, M., Rai, M.K., Vibka, J.B., Rathore, N.S., Patel, A.K. and Kataria , V. 2014 Micropropagation of Aloe vera for Improvement and Enhanced Productivity In: Climate Change and Plant Abiotic Stress Tolerance, Tuteja, N. And Sarvajeet, S. Gill (eds.), Wiley-VCH Verlag GmbH & Co. KGaA pg 857-880

Shekhawat, N.S., Rathore, M.S., Shekhawat, S., Choudhary, S.K., Phulwaria, M., Harish., Rai, M.K., Vibha, J.B., Rathore, N.S., Patel, A.K. and Kataria, V.2014. Micropropagation of *Aloe vera* for Improvement and Enhanced Productivity. In: Tuteja, N. and Gill, S.S. (Eds) *Climate Change and Plant Abiotic Stress Tolerance*, First Edition. Wiley-VCH Verlag GmbH & Co. KGaA, DOI: 10.1002/9783527675265.ch32

Srivastava, A. and Shekhawat, G. S. 2011. BIOFILMS: Formation, Sustenance and Significance. In: Recent advances in environmental biotechnology, Jain, P. K. et al (eds.), Lap Lambert Academic Publishing AG & CO. KG, DudwellerLandstr, Germanypp 24-46

Sundaramoorthy, S., Santosh Kumar Mehar and Manohar Singh Suthar 2010. Soil Biology in Traditional Agroforestry Systems of theIndian Desert. In: *Desert Plants: Biology and Biotechnology*. Ramawat, K.G. (ed.), Springer-VerlagBerlinHeidelberg. 91-120pp

Verama, K. and. S. Shekhawat (eds.) 2012. Phytochrome-Chromophore Biosynthesis and Chloroplast Development: Possible role and regulation of HO (Haemoxygenase). In Phytochrome-Chromophore Biosynthesis and Chloroplast Development. Nova Science Publishers, Hauppauge, NY (U.S.A.)

e) Average Impact Factor of the publications and Name of the Major Journals in which publications are made: 2± 1.5; basic Botany research papers were published in low impact factor journals, whereas applied/molecular biology research papers in high impact factor journals, hence high variations. As many as twenty major international journals have publications from the Department of Botany, JNV University. A few journals are as under:

Acta Physiol Plant
Acta Physiologiae Plantarum
American Journal of Biology and Life Sciences
Annals of Botany Plants
AoB Plants
Applied Biochemistry and Biotechnology
Biologia plantarum
Biometals
BMC Virology Journal
Critical Reviews in Biotechnology
Gene
In Vitro Cellular and Developmental Biology of plant
Industrial Crops and Products
International Journal of Pharmaceutical Sciences and Research
International Journal of Biological Macromolecules
International Journal of Plant Production
Journal of Arid Environments

Journal of Arid Land Studies
Journal of Biotechnology
Journal of Crop Science and Biotechnology
Journal of Environmental Chemical Engineering
Journal of Experimental Botany
Journal of Plant Growth Regulation
Journal of Stress Physiology & Biochemistry
Molecular Biology Reports
National Academy Science Letters
New Forest
Nitric Oxide: Biology and Chemistry
Pharmacology Reviews
Physiology and Molecular Biology of Plants
Plant and Soil
Plant Cell Biotechnology and Molecular Biology (PCBMB)
Plant Cell, Tissue and Organ Culture
Plant Science Today
Proceeding of the National Academy of Sciences, India Section B: Biological Sciences
Protoplasma
Review in Inorganic Chemistry
Scientia Horticulturae
Standards in Genomic Sciences

14 Give a list of Equipment, which are available and functional in the Department costing Rs.5 lakhs and above

Name of Equipment	Year of Purchase	*Status*
Electrophoresis Systems 1-D and 2-D	2007	Working and in use
Electroporation cum Protoplast Fusion System	2005	Working and in use
Fluorescence Microscope	2010	Working and in use
HPLC system	2010	Require replacement of spare parts
Microbial storage facility	2015	Working and in use
Micropropagation/Green House Facilities	2004 (2015)	Working and in use, renovated
Portable Photosynthetic system Li-6400	2000	Require additional chambers, CO_2, light, temperature and humidity control accessories and calibration

Real Time-PCR	2013	Working and in use
Atomic Absorption Spectrophotometer	2016	Working and in use
Lypolizer	2015	Working and in use
Nano drop Spectrophotometer	2015	Working and in use

15. Library facilities - List the Journals received in your department/ university library in the concerned discipline:

Springer journals are made available online; and with reduced fund allocation to Library for journals, University library subscribing to international journals is in abeyance for couple of years now. From 2016, with RUSA funding, the Department anticipate subscription restoration to fifteen national/international journals; including new online journal is anticipated. However, the Faculty members receive:

a. Journal of Indian Botanical Society
b. Indian Journal of Agroforestry
c. Journal of Tree Science
d. Annals of Arid Zone
e. Current Science
f. Indian Journal of Plant Physiology

16. Details of computing and networking facilities available in your department and institution.

University has LAN-NET work facility and all the laboratories in the Department of Botany are connected, the service connectivity is by fiber optics with capacity of 100mbps.

The centralized computing facility for scholars and teachers established using FIST I assistance is over lived and all the computers are outdated and nonfunctional now; hence a new Computational facility laboratory with a server and at least fifteen client systems is requested now. Statistical softwares shall be procured and put in to the use for all teachers and scholars in the Department/ Faculty.

17 Details of facilities in Central Instrumentation Centres such as RSIC, USIC etc., if any:

The limited facility that is in USIC has been utilized by the Department; mechanical and glassware fabrications are mostly used.

18. Details of Post-graduate Teaching & Research profile/ plans of the Department for next 5 years:

Postgraduate Teaching: The Department continuing the COSIST scheme and provides vast amount of reading materials to our students every year. From the academic year 2015-16, the Department has taken a lead in offering Choice Based Credit system with semesterization of examinations for students in M.Sc. Ten subject specific elective papers including newer domains in Botany and as many as ten effective skill courses are offered now to the students.

The course papers offered in M.Sc. semester-wise is as under:

SEMESTER I

Bot 101. Cell and Molecular Biology of plants
Bot 102. Cytology and Genetics
Bot 103. Biology and Diversity of Microbes, Algae and Fungi
Bot 104. Biology and Diversity of Archegoniate
SC I Skill course I (for students of Botany Department only)

SEMESTER II

Bot 201. Taxonomy and Diversity of Seed Plants
Bot 202. Plant Development and Reproductive Biology
Bot 203. Plant Resource Utilization and Conservation
Bot 204. Plant Physiology
SC II Skill course II (for students of other Departments)

SEMESTER III

Bot 301. Plant Ecology
Bot 302. Plant Metabolism
Elective I Elective paper I
Elective II Elective paper II
SC III Skill course III (for students of Botany Department only)

SEMESTER IV

Bot 401. Applied Ecology
Bot 402. Biotechnology and Genetic Engineering of Plants
Elective I Elective paper I
Elective II Elective paper II
SC IV Skill course IV (for students of other Departments)

Elective paper group – First – Semester III

Bot 303A. Genomics, Proteomics and Bioinformatics - I
Bot 303B. Plant Molecular Biology and Biotechnology
Bot 303C. Principles of Plant Pathology
Bot 303D. Plant Microbe Interaction (PMIs) - I
Bot 303E. Cytogenetics and Plant Breeding -I
Bot 303F. Industrial Microbiology - I

Elective paper group – Second – Semester III

Bot 304A. Population Biology
Bot 304B. Microbial Ecology-I
Bot 304C. Stress Physiology-I
Bot 304D. Advanced Physiology
Bot 304E. Biosystematics of Plants -I
Bot 304F. Environmental Monitoring, Management and Restoration - I

Elective paper group – First – Semester IV

Bot 403A. Genomics, Proteomics and Bioinformatics - II
Bot 403B. Applied Molecular Biology and Plant Biotechnology
Bot 403C. Plant Diseases and their Management
Bot 403D. Plant Microbe Interaction (PMIs) - II
Bot 403E. Cytogenetics and Plant Breeding - II
Bot 403F. Industrial Microbiology - II

Elective paper group – Second – Semester IV

Bot 404A. Desert Ecology
Bot 404B. Microbial Ecology-II

Bot 404C. Stress Physiology-II
Bot 404D. Advanced Physiology
Bot 404E. Biosystematics of Plants - II
Bot 404F. Environmental monitoring, management and Restoration-II

Skill Courses in Botany

Bot-SC-1 Intellectual Property Rights
Bot-SC- 2 Agrotechniques for Desert Plants
Bot-SC- 3-Data Analysis and Presentation
Bot-SC- 4-Bioinformatics
Bot-SC- 5-Micropropagation
Bot-SC- 6-Value Addition for Bioresources
Bot-SC- 7-Chromosome Analysis
Bot-SC- 8-Mushroom Cultivation
Bot-SC- 9-Molecular Techniques
Bot-SC- 10-Nutrient Mangement

Research plans: After pondering over current research endeavours of the various laboratories that are working independently with no joined theme that is expected to have a major impact for the Department at national and international level, the Department proposes the following combined and focused themes for next five/ten years:

(i) Biosynthesis and characterization of nanoparticles using xeric/haloxeric plants and microbes
(ii) Characterization and evaluation of phytotoxicity of engineered metal nanoparticles
(iii) Nano-particles utilization and response assessment for in-vitro propagated plants of arid region
(iv) Effects of nanoparticles on plant growth promoting bacteria nodulation and their efficacy in enhancing productivity of arid pulse crops
(v) Role of nanoparticles in enhancing the production antibacterial secondary metabolites in plants
(vi) Application of nanoparticles for abating abiotic stress including changes in photosynthetic/transpiration parameters and with modified CO_2, light, humidity parameters.
(vii) Nanoparticles effect on proteomics and genomic expressions of heavy metal tolerant algae/ plant growth promoting bacteria that significantly enhances pulses productivity / stress tolerance in crops

19 The research profile of the Department may fall in the following categories. Please [tick]:

Make in India ☐ Swachch Bharat ☐ Digital India ☐ Swastha Bharat ☐

Start-up India ☐

20. Details of Strength of the Department/ School/ Centre and Deliverables in the proposal:

i) Existing Faculty and Infrastructure strengths of Deptt/ Centre/ School justifying the Proposal:

The Department of Botany is one of the leading Department in teaching and research in India from inception. Eminent teachers/scholars nurtured this Department to highly appreciable standards. And during 2013, five Associate Professors and thirteen Assistant Professors joined the Botany fraternity here and most of them are very enthusiastic researchers with vast expertise in the field of their research; Assistant Professors who were/are receiving special training including training from Australia on specialized areas infused newer blood to research endeavours.

For the proposed combined-focused theme, we have trained hands who can form a team with the rest to zeal in all frontiers so as to reach the target. The team formed for successfully achieving the target is:

a. Prof. S. Sundaramoorthy – Coordinator
b. Prof. Pawan Kumar Kasera – Member
c. Prof. Hukam Singh Gehlot – Member
d. Dr. H.R. Dagla – Member
e. Dr. G.S. Shekhawat –Member
f. Dr. Vinod Kataria – Member

ii) Specific Objectives of the Proposal in relation of above strengths:

The teachers trained in nanoparticle on biological systems can assist others; with active collaboration with Defense Research Laboratory and CAZRI, Jodhpur, wherein we have recognized Scientist having/ wish to have joint ventures, shall ensure smooth and successful completion of the targets proposed in this project

iii) Expected Academic Outcomes (experimental facilities to be created, UG/PG programs supported as well as research themes to be enabled by these facilities, publications with impact factor) from the implementation of the proposed proposal:

Being a combined-focused research with many principal and subsidiary experimentations including molecular tools to field evaluations, we anticipate high quality holistic research publications having very high impact factor in future. The themes shall involve most of the teachers in the Department, hence joint effect expected to be additive.

The instruments requested in this FIST assistance shall assist this Department to venture to a new frontier in biological research and strengthen the research endeavours of all teachers and scholars in the Department.

The newer courses proposed/ under preparation is expected to get a booster with new modern equipment facility in the Department

iv) Definite Product/Process/Design/Software/System Development efforts that will be added by the proposal:

Increasing productivity and stress tolerance in crops, increased mass multiplication with nanoparticles are expected to abate the arid zone agrarians in sustainable fashion.

v) Potential beneficiaries (specify industry segment and/ or strategic programs) or societal paybacks envisaged at the end of the project, if supported.

a. Productivity enhancement for pulse crops
b. Increased tolerance to abiotic stress
c. Insight to the mechanisms at molecular level

21 Has the Department applied in previous years & not been recommended for support?

If yes, indicate (in 200 Words) year & the major developments in the Department in last 3 years:
Not applicable, received funds during both the times i.e. 2000, 2007

22 Has the Department received support under the FIST Program in previous years? If so, indicate the details of support received their utilization and the impact of that support in Department's profile & growth.
During 2000 and 2007 the Department received support under FIST program that enabled this Department to guide students to excel in research endeavours; nearly three students per academic year qualified UGC-CSIR-NET examinations with invariable one/two within the first fifty rank indicates the tremendous progress the Department could make with the support. The twenty/twenty five research publications from various disciplines of Botany in well reputed journals per year is considered as a major achievement. The continued progress the Department could achieve with the support of UGC and DST enabled to move to the status "Center of Advanced Study"

23. Details of funds requested for 5 years (Cost in Rs. (FE component in US$)

S.No.	Items Name	Total FE Cost (in US $)	Total INR Cost (in lakhs)
A. Equipment (Name of each Equipment)			
For Advanced Research			
i.	LC ESI MS/MS, Q-TRAP hybrid system	289856.00	200.00
ii	Field Emission Scanning Electron Microscope (FESEM)	289856.00	200.00
iii	High speed Cooling centrifuge	86957.00	60.00
vi	Biolog Micro plate reader for studying metabolic fingerprinting	36232.00	25.00
vi	Trinocular Research Fluorescence Microscope with Cytogenetics System for Karyotyping and FISH analysis with additional camera for tissue observation	31885.00	22.00
vii	Gas Chromatography Mass Spectrometry (GC-MS)	28986.00	20.00
viii	Fourier transform infrared spectroscopy (FTIR)	21740.00	15.00
For further Strengthening research endeavours			
i	UV-Vis Spectrophotometers		10.00
ii	High accuracy electronic balances		10.00
iii	High speed Cooling centrifuge with fixed angle rotor for 1.5-2 ml tubes		10.00
iv	Herbarium scanner with digital herbaria software		10.00
v	Deep freezers		5.00

vi	Online UPS		5.00
For Teaching			
i	Trinocular Research Microscope with photographic attatchment	14493.00	10.00
ii	Mastercycler® pro S, with Control Panel, 230 V/50 – 60 Hz	10870.00	7.50
iii	Gel Documentation System	10870.00	7.50
iv	Stereomicroscope with photographic facility, illuminator, and accessories	10145.00	7.00
For upgradation/ repair of existing equipment			
i	Li-Cor 6400 PS	10145.00	7.00
ii	Waters HPLC	10145.00	7.00
iii	Canopy Analyzer & Porometer	1450.00	1.00
B. **Infrastructure Facilities (Books, Renovation of Labs etc.)**			
	Glass House (with three chambers) light, humidity and temp control Size: 12 X 36 feet.		25.00
	Poly houses with controlled temperature facility		10.00
	Renovation of mass culture room facility		5.00
	Renovation of electric supplies with circuit breakers, etc for seven research laboratories and two M.Sc. Laboratories		5.00
	Books		5.00
C. Networking & Computational Facilities etc.			
	Computer lab with one server and 15 client facility		10.00
	Statistical softwares (SPSS) for institutional use	14493.00	10.00
	Software for 2-D iamge analysis (IMP7) for existing GE system	11595.00	8.00
D. Maintenance of Equipment			
	To pay AMC for major equipments from second year to fifth year		20.00
	Total	**869581.00**	**737.00**

24. Details of each Budget Heads with full justifications for each item as given at Item No. 23 including details of similar support from any other sources

For Biolog Micro plate reader : The metabolic fingerprinting data/ information will help us to raise our publication standards as well as formal description of novel species. This is a

new generation microbial/bacterial identification based on metabolic phenotypes (unique metabolic fingerprint) generated by a species of bacteria on a set of carbon sources and biochemical. The biolog data is essential now days for the description of any new species under the polyphasic approach.

For FESEM: Scanning electron microscope is an indispensable tool for research evaluation in materials science and environmental biology, in the biological and medical sciences. The FESEM is routinely used to generate high-resolution images of shapes of objects (SEI) and to show spatial variations in topology morphology, particle size and local chemical analysis. The SEM is also widely used to identify phases based on qualitative chemical analysis and/or crystalline structure. Precise measurement of very small particles and objects down to 50 nm in size is accomplished using the SEM. Back scattered electron images can be used for rapid discrimination of phases in multiphase samples. SEMs equipped with diffracted backscattered electron detectors can be used to examine microfabric and crystallographic orientation in many materials.

For FTIR: Several faculties in the department of Botany are working on the metal stress/metal phytotoxicity and its related physiological consequences on different plant species and FTIR is quite important equipment required to know metal concentration/accumulation in plant samples.

FOR GC-MS: The estimation of ARA activity directly that gives nitrogenase efficacy so it will be useful in raising standards of our publication in addition to getting important information having applied aspect. Further for characterization of volatile secondary metabolites

For Gel Doc system: The highest performance gel doc system necessary for visualization and photography of amplified fragments in the gel(s).

For Glass Houses: One chamber to study ability of some of these novel strains of *Ensifer's* to nodulate crop legumes and other wild legumes to establish host range of several novel strains of N fixing *Ensifer*, *Bradyrhizobium* and *Rhizobium*. Another chamber shall assist scholars to assess nanomaterial impact analysis in controlled condition. The third to assist the other users in the department to do studies in controlled glass house conditions.

For High speed centrifuges: Essentially separating particle and also required for centrifugation of large volumes (for DNA, RNA, Protein work) and for 96-well plates (for PCR/RT-PCR).

For LC ESI MS/MS, Q-TRAP hybrid system: Essentially required for proteomics work, for qualitative and quantitaive protoemics, protein identification etc. Outsourcing of this work is very expensive (ranging from Rs. 3000-10000 per sample). We can aslo generate revenues for our deptt. by offering outsourcing, as its not available anywhere in Rajasthan.

For Microscope: Chromosomal, FISH, and advanced research, Image analysis and high quality imaging systems (two) for M.Sc. teaching/ research laboratory.

For PCR: For inter-generic and inter-species diversity analysis and downstream DNA barcoding of threatened and endemic plants of the Thar Desert.

For repairs: The instruments procured from different agencies support, additional spares and calibrations require FE component for which we need specific sanctions.

For Soft wares: It is for strengthening research, statistical softwares are very essential and integral part in every data analysis. This availability shall enable M.Sc. students to have hand on practice on various data analysis modules that they learn in theory classes.

For equipment to strengthen research: Many of the scholars and teachers work for long hours and hence require additional/ independent equipment facilities.

25. Specify the recipient of the Grant (Registrar/ Director / Any other) by attaching an endorsement from Head of Institution/ University:

Information submitted as above is true and is correct.

Signatures

(S. Sundaramoorthy) (Prof. R.P. Singh)

Professor & Head Vice Chancellor

DEPARTMENT OF CHEMISTRY

(UGC SAP DRS)

UNIVERSITY GRANTS
COMMISSION NEW DELHI

PROGRESS REPORT ANNUAL/FINAL REVIEW
UNDER SAP (DRS)

Name of the University:	Jai Narain Vyas University, Jodhpur (Raj) 342001
Name of the Department:	Department of Chemistry, JNVU, Jodhpur
Date of first approval with level at inception: 11/04/2018	
Date of implementation of current phase as noted by the UGC:	
Status (CAS/DSA/DRS with phase):	DRS II
Period of Report:	1/04/2019 to 31/03/2020
Amount allocated for 5 years:	34.50 (NR) + 46.00 (R)= 80.50 lac + Two PF
Amount sanctioned during the year:	10.50 lac
Amount utilized during the year:	Rs. 777045.00
Date of first sanction (current phase):	07/02/2020
Total grants received since inception:	10.50 lac +550927
Coordinator's Name:	Prof. Kailash Daga
Dy. Coordinator's Name:	Prof. R.C Meena
Address:	Department of Chemistry, Jai Narain Vyas University, Jodhpur (Raj)
City:	Jodhpur
Pin:	342005
State:	Rajasthan
Tel:	0291-2720840
Fax:	0291-2720840

1. (a) Thrust Area(s):
   (i) Identified since inception: Solar energy conversion and Environmental Chemistry
   Ongoing:
   Modified to, if any, and when inception approval reference no and date: NA

(ii) Thrust Area Approved: a. Solar Energy Conversion and Storage
b. Environmental studies

(b).UGC nominees with Address, City, Pin, State,Tel.,Fax, e- mail (as approved by the UGC) :

I. Prof. N.B. Singh, Department of Chemistry, Sarda University, Greater Noida, E-mail:nbsingh43@gmail.com, Mob.-7838500311.

II. Prof. Anshu Dandia, Department of Chemistry, University of Rajasthan, Jaipur, E-mail:dranshudandia@yahoo.com, Mob.- 9414073436.

2. **Major Achievements**:

(i) Research

a. Research (highlight major objectives set-forth (as proposed) and achievements made with breakthrough, innovation brought in, technology transferred, international collaboration which have created resources):

Academic Achievements in Thrust Area (Solar Energy Conversions)

A. National Conference

1. **Prof. R C Meena** represented his research paper in National Conference on Indian Council of Chemist (ICC) held in December 2019 at Jaipur National Institute Jaipur.
2. Prof. K. R. Genwa attended International Conference on Trombay Symposium on Radiation & Photochemistry held on January 5-9, 2020 in DAE, BARC, Mumbai.

B. Research Publications

1. **Dr. Pooran Koli**, Natural sunlight irradiated Rhodamine B dye sensitized and surfactant enhanced photo galvanic solar power and storage, *International Journal Ambient Energy*, TAEN_2018-0677; Taylor & Francis, Accepted
2. **Prof. R. C. Meena**[a] Pramod Kumar Meena*[a] and **Dr. S. L. Meena**[a] Study of Natural photo sensitizer (*Punica granatum*) to enhance storage capacity of photo galvanic cell Journal of energy and environment, published RSC 2020 (7) 4-8.
3. K. R. Genwa, Chanchal Mahavar and Virendra Soni, Evaluation of solar conversion efficiency in Dye Sensitized Solar Cell using cobalt nitrate and magnesium sulphate in mixture of dyes. J. Mat. Sci. 6(4), 45-58 (2020).

C. Other Achievements

1. **Dr. S L Meena** participated in Scientific Event on Nanotechnology held in IIT Jodhpur on 15th oct, 2019

Academic Achievements in Thrust Area (Environmental Chemistry)

A. National Conference / Seminar Attended

1. Dr. Priyanka Purohit presented a poster in International conference on Recent Advances at Interfaces of Physical and Life Sciences held on 2019 in Department of,Chemistry university of Rajasthan.
2. Dr. Priyanka Purohit presented a paper in International conference on Environmental Conservation and management by Jambhoji Philosophy through public participation held on 2019 in Guru Jambheshwar environment Conservation Research Bench,J.N.V.University,Jodhpur
3. Dr. Priyanka Purohit presented a poster in National conference on Energy and Environment : Perspective & Challenges held on 2019 in Department of Chemistry, Jai NarainVyas University, Jodhpur.
4. Dr. Priyanka Purohit presented research paper in National Seminar on Recent Trends and Advancement in Chemical , Physical and Life Sciences held on 2019 in Department of Chemistry, Jai NarainVyas University, Jodhpur.
5. Dr. Priyanka Purohit attended a National workshop on Bioinformatics held on 2019 in IIT, Jodhpur.
6. Dr Anurag Choudhary attended International conference on environment protection and management by public participation through Jambhoji philosophy held on 05-06 June, 2019 in Guru Jambheshwar environmental protection thesis.
7. Dr Anurag Choudhary presented oral paper in 38th Annual National Conference held on 26th -28th December 2019 in Indian Council of Chemists at Jaipur National University , Jaipur.
8. Dr. Om Prakash presented oral paper in 38th Annual National Conference held on 26th -28th December 2019 in Indian Council of Chemists at Jaipur National University , Jaipur .

B. Research Publications

1. S.Loonker and A.Maheshwari, Microwave assisted synthesis, characterization and biological evaluation of newly synthesized1,3,5-thiadiazole derivative of Guar Gum. International Journal of Pharmaceutical Sciences and Research. vol.10(2) ,666-671(2019).

2. Vikal Gupta, One Chepter "Nanomaterial: Synthesis and characterization. Published in book" Nano Scale Engineering in Agricultural Management" CRS Press, Taylor and Francis group, New York (2019).

3. Vikal Gupta, Removal of Cu(II) from aqueous solution using chemically activated banana peels as an adsorbent,Poll Res.(3)(2020).

4. Pallavi Mishra and Shipra Singh, A comparative study of different bioadsorbents obtained from domestic waste material for the fluoride removal poll res. 38 (2),104-111 (2019).

5. Pallavi Mishra and Rajshri Soni, Monitoring Of Heavy Metals Content In The Soil Samples Collected From The Industrial Areas And Agricultural Fields Near Jojari River In The Jodhpur City, Poll Res., 38 (3),248-252 (2019).
6. S Kothari, T Kachawa, R Kalal and D Panday, Mechanistic studies of the oxidation of some alpha amino acids by benzamidazolium dichromate,Oxid. Commun. 42,307-317(2019).

7. Priyanka Purohit, Rekha Sharma, Deepika Soni, and Pradeep K Sharma,Oxidation of some Organic Sulfides by Pyridinium Dichromate: A Kinetic & Mechanistic Approach,Journal of Emerging Technologies and Innovative Research, 6(4),136-145(2019).

C. Other Achievements

1. Dr Anurag Choudhary completed Refresher course in chemistry (with Grade $A^{+)}$ from 18th November 2019 to 01 December 2019 at UGC-HRDC , Gujarat University, Ahmedabad.
2. Dr.Om Prakash attended Refresher Course held at HRDC University of Rajasthan, Jaipur during 29th July to 10th August 2019.
3. Dr. Ramlal Saini attended Online Refresher course in Chemistry for higher education, organized by Swayam from 1st sept to 31st Dec 2019.

4. Dr. Ramlal Saini attended Interdisciplinary workshop on Innovations in Research, Teaching Learning and Women empowerment, from 02 to 08 Jan 2020, J.N.V.University (Jodhpur).

5. Dr. Sangeeta Parihar attended one refresher course in chemistry on "Advancement in Science & Technology", at UGC, HRDC, Jaipur, 2019.

Dr. Sangeeta Parihar attended one week National Workshop on "Strategic Quality Initiatives in Technical Education" Organised by Engineering Staff College of India held at Port Blair, 19-23 December, 2019.

7. Dr. Seema Parveen attended Refresher course in Advancements in Science and Technology (Inter-Disciplinary) held on 29.07.2019 to 10.08.2019 in University of Rajasthan.
8. Dr. Seema Parveen attended Interdisciplinary workshop on Innovations in Research, Teaching Learning and Women empowerment held on January,02-08 2020, J.N.V.University Jodhpur.

If the objectives set-forth could not be achieved, the specific reasons thereof: N. A

b. Utilization of findings in policy formulation, development and modification of strategies (for Social Science departments mainly): Autonomy under M.Sc. Chemistry course for the university under department of chemistry.

(ii) **Human Resource Training** :

a. **Persons trained (Nos.):** UG- PG- 2 (UG) and 3 (PG)
b. **Rural/Tribal-** More than 60% PG students come from rural and tribal areas of Western Rajasthan specially desert region of India.
c. **Industrial-** Industrial training is a part of curriculum of PG course.
d. **International-** Extension lectures are organized regularly by eminent scientist and professors from foreign universities to give international exposure to our PG students. And some of our faculty members are trying to established International collaboration.
e. **From other agencies-** Various competition are organized for school children for awareness about the development in science and technology.

3. Infrastructure Developed: The Department has developed an Instrumental laboratory and also established CCT vigilance of the department.

a. Name major Equipments(>Rs.3 lacs): i. Stop Flow for Fast Kinetics (DRS-I)
ii. Electrochemical Analyzer (DRS-I)

b. **Central Schemes/facilities for PG, Research and Extension Activities** :

(i) USIC / RSIC (ii) Patent Promotion Cell (iii) Guesthouse with capacity of 30 rooms (iv) Seminar / Conference Room with capacity of 50 no. (v)Regional/Mainframe computing facilities- net facility and 40 computers (vi) Women Development Cell.

c. **Networking**: (i) Library (ii) Laboratory (iii) University Department.

4. Knowledge disseminated to (in the thrust area identified):

(i) Other teaching institution (Name, No. of faculty involved): NA

(ii) Industry (Name with amount received if any): DST IDP project with Surana Scientifics, Jodhpur.

(iii) Rural/Tribal/Govt./NGOs(Provide No. with amount): Approved testing centre

(iv) International (name organization): INSA, Canfield University UK

(v) Others: DMRC, Defense Lab, CAZRI and IIT Jodhpur

(vi) Innovation/excellence brought in: Area of Biosensors has been developed.

5 Breakthrough (already organized): Patent has been approved in the field of Biosensors.

6. Emerging/Hi-tech/Priority area generated: Biosensors and Trace Electro analysis, sensors and fast kinetics.

7. Resource generation (specify amount, Rs.16 lac per annum): One section of 40 students for M.Sc. Chemistry (SAP) under SFS (Self Finance Scheme) is running.

Items	Amount
SFS	Rs.147500/year
One section of PG Chemistry under Self Finance Scheme	

a. International students: NA
b. Industrial: NA
c. Extension Activities: NA
d. Other Courses: NA

a. Total amount of resource generated from all sources above: Rs.20 lacs

b. Also mention development grant received from University in other areas of the Department: Rs. 30.0 lacs received from Faculty of Science.

8. Use of output of research, teaching in (tick and fill up the right one)

Item	No.
a. Industries:	40% of PG students
b. Other user depts.Research lab, DRDO, ICMR lab & CSIR lab:	20% of PG students
c. National Organizations:	20% of PG students
d. Other organizations:	20% of PG students

9. Other activities:

1. Items		Numbers
Seminar	-	2 days each
Summer Institute	1	2 weeks
Conference	2	2 days each

b. Autonomous Character: Yes for M.Sc. Chemistry (SAP):
a. Financial: Yes
b. Administrative: Yes
c. Academic: Yes

d. Others

c. Advisory Committee Meeting (No. with Dates): No

10. Faculty Involved

a. Faculty Strength:	Position Available	Working	Vacant
	54	27	27
Created			
Professor:	13		
Associate Prof.:	02		
Assistant Prof.:	12		
Others:			

b. In the identified thrust area(s)*:

Faculty	Name	Membership (INSA/BHATNAGAR/BIRLA)	Specialisation/ Specific Areas of expertise
Professor			
1.	Prof. Kailash Daga		Environmental Chemistry
2.	Prof. Sangeeta Loonker		Environmental Chemistry
3.	Prof. Vikal Gupta		Environmental Chemistry
4.	Prof. A.V. Singh		Environmental Chemistry
5.	Prof. Vimla Chaudhary		Environmental Chemistry
6.	Prof. Pallavi Mishra		Environmental Chemistry
7.	Prof. R.C. Meena		Solar Energy Conversion & Storage
8.	Prof. K.R. Genwa		Solar Energy Conversion & Storage
Associate Prof.			
1.	Dr. P. Kohli		Solar Energy Conversion & Storage
Assistant Prof.			
1.	Dr. S.L. Meena		Solar Energy Conversion & Storage
2.	Dr. Jaishree Rathore		Solar Energy Conversion & Storage
3.	Dr. Anita Meena		Solar Energy Conversion & Storage
4.	Ms. Meenakshi Jonwal		Solar Energy Conversion & Storage

c. Intake(Please put numbers)		Identified thrust area	Other than thrust area
Ph.D.	:	39	19
PG	:	130	
Fellows	:	04	01
NET scholar	:	08	02
GATE Scholar	:	04	01
Res. Asso.	:	-	01
Proj. Asstt.	:	-	--
Others(INSPIRE fellow)	:	04	--

11. National/Nodal Character of the Department National/Nodal/All India Centre:

a. Resource Persons Invited (Nos.)-

International: National: 2

b. Serving for outside user departments in (Nos. & hrs.)

i. Hands-on OR technical training to university/college teachers: NA
ii. Collaborative (international): yes
iii. Teaching to neighboring institute: Yes

iv. Visiting Teachers to foreign university: Yes
v. Equipment facilities: A separate Instrumental lab established: yes
vi. Other major infrastructure facilities: yes AAS

12. Most critical and essential requirements that may be required to continue the programmes if the UGC agrees to continue or extend support based on the evaluation and final review by expert committee.

Non-Recurring: 34.50 lacs

Recurring : 46.00 lacs + 2 Project fellow

S.No.	Items	Amount
1	contingency @ 1.0 lac per annum	5.00 lac
2	Chemical and consumables @ 2.0 lac per annum	10.00 lac
3	Advisory committee meeting @ 0.5 lac per annum	2.50 lac
4	Books and journals @ 1.00 lac	5.00 lac
5	Travel/field work @ .05 lac per annum	2.50 lac
6	Visiting fellow @ 0.50 lac	2.50 lac
7	Seminar organization in thrust area @ Rs. 1.0 lac (two)	2.00 lac
8	Hiring the services of Technical/industrial/Secreterial assistance @ Rs. 1.00 lac	5.00 lac
9	Project Fellows (two)	Actual
	Total	34.50 lacs+ two project fellow
	Grand Total (NR+R+PF)	80.50lacs+2 PF

13. a. Whether the State Government will take up the liability of the faculties and the staff approved under SAP after cessation of the tenure of the programme i.e. five years: NA

b. Whether the State Government has already agreed or has taken up the liability after five years of completion of the tenure of the programme as was communicated along with the approval letter?: NA

c. How the Department is going to maintain infrastructure and the status if UGC disagrees to continue the support further. Whether the Department /University will agree for up gradation of the status on no cost basis, if it so happens as per the recommendation of the Committee:

14. Utilization Certificates may be provided as per the UGC format. The accounts of the earlier phase be completed, finalized, audited and duly authenticated by the competent authority (Registrar and Finance Officer both) (item-wise and year-wise) for all the allocations and sanctions given to the Department for ongoing/current phase are to be submitted by the Department so that UGC, if provides support again, may immediately release the funds for the phase to be approved as per the above activities.(Annexure-I Enclosed)

COUNTER SIGNED

REGISTRAR
Jai Narain Vyas University
Jodhpur (Raj.)

Signature :
Programme
DY Coordinator

Dy. Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

Signature:
Programme
Coordinator

Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

Signature:
Registrar of
the University

Certificate

Certified that the grant has been utilized for the purpose for which it was sanctioned and in accordance with terms and conditions attached to the grant.
If as a result of check or audit objection, some irregularity is noticed at a later stage, action will be taken to refund, adjust or regularize the objected amount.

COUNTER SIGNED

REGISTRAR
Jai Narain Vyas University
JODHPUR (Raj.)

Signature Coordinator DRS-II (SAP-1)	Signature Dy. Coordinator DRS-II (SAP-1)	Signature Registrar with Seal

N.B. : This may not include any amount related to orders placed or likely to be placed, commitments entered into or amount for specific items likely to be obtained.

Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

Dy. Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

ANNEXURE -I

UNIVERSITY GRANTS COMMISSION
PROGRESS REPORT OF EXPENDITURE

University__JNV University, Jodhpur_____
Sanction letter No. & Date___No. F 540/1/DRS-II/2018(SAP-I) Dated 07/02/2020
Statement of Actual expenditure during 2019-20
And estimated expenditure for_2020-21

NON-RECURRING ITEMS:

(As approved by the UGC)

Item of expenditure	Total grant approved In Lakh	Actual grant received In Lakh	Actual expenditure incurred (bills actually paid) Rs.	Excess expenditure during 2019-20 Rs.	Estimated expenditure during 2020-21 in Lakh	Remarks
Contingency	5.00	1.00	100167/-	167/-	1.00	
Chemicals	10.00	2.00	198303/-	Nil	2.00	
Travel Field	2.50	.50	19200/-	Nil	.50	
Visiting Fellow	2.50	.50	Nil	Nil	.50	
Organizing Seminars	2.00	1.00	Nil	Nil	1.00	
Hiring Services	5.00	1.00	99059/-	Nil	1.00	
Advisory Committee	2.50	.50	Nil	Nil	.50	
Books and Journals	5.00	1.00	94316/-	Nil	1.00	
Project Fellow Two	Actual	3.00	266000/-	Nil	3.36	
Total	34.50+ Actual	10.50	777045/-	167/-	10.86	

Total N.R.

RECURRING ITEMS:

(As approved by the UGC)

Item of expenditure	Actual grant received	Actual expenditure	Excess Saving (difference of Col. 3 & 4	Estimated expenditure during 2019-20	Remarks
Equipments	Nil	Nil	Nil	46 Lakh	

Total Recurring
Grand Total (Recurring + Non-recurring)

Certificate

Certified that the grant has been utilized for the purpose for which it was sanctioned and in accordance with terms and conditions attached to the grant.
If as a result of check or audit objection, some irregularity is noticed at a later stage, action will be taken to refund, adjust or regularize the objected amount.

COUNTER SIGNED

REGISTRAR
Jai Narain Vyas University
JODHPUR (Raj.)

Signature
Coordinator
DRS-II (SAP-1)

Signature
Dy. Coordinator
DRS-II (SAP-1)

Signature
Registrar
with Seal

N.B. : This may not include any amount related to orders placed or likely to be placed, commitments entered into or amount for specific items likely to be obtained.

Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

Dy. Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

ANNEXURE-VI

UNIVERSITY GRANTS COMMISSION
UTILIZATION CERTIFICATE

It is certified that the amount of Rs. 777045/-
(Rupees_Seven Laks Seventy Seven Thousand Fourty Five only) out of the total grant of Rs.10.50 lacs (Rupees Ten lakh fifty thousand) sanctioned to DRS-II (SAP-1) Department of Chemistry, JNV University, Jodhpur by the University Grants Commission vide its letter No. F. 540/1/DRS-II/2018- (SAP-I) dated 07/02/2020 towards Research in the thrust areas under DRS-II SAP-I scheme has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions as laid down by the Commission.

If as a result of check or audit objection some irregularities are noticed at a later stage, action will be taken to refund, adjust or regularize the objected amount.

COUNTER SIGNED

REGISTRAR
Jai Narain Vyas University
JODHPUR (Raj.)

Signature
Registrar with Seal

Signature
Finance Officer with Seal

Assistant Registrar (Accounts)
Jai Narain Vyas University
Jodhpur

Signature
Dy.Coordinator of SAP

Dy. Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

Signature
Coordinator of SAP

Coordinator (DRS-II)
Department of Chemistry
JNV University, Jodhpur (Raj.)

UC attached
Chartered Accountant
with Seal and Registration No.
Prior to the audit of Statutory
Auditors)

DEPARTMENT OF PHYSICS

(UGC SAP DRS)

विश्वविद्यालय अनुदान आयोग
(मानव संसाधन विकास मंत्रालय, भारत सरकार)
बहादुर शाह जफर मार्ग, नई दिल्ली - 110 002
University Grants Commission
(Ministry of Human Resource Development, Govt. of India)
Bahadur Shah Zafar Marg, New Delhi - 110 002
www.ugc.ac.in
Ph: 011-23604105, 23604516, 23604407, 23604503
सत्यमेव जयते
ज्ञान - विज्ञान विमुक्तये

SPECIAL ASSISTANCE PROGRAMME (SAP)
IMPACT CREATION POINTS/OUTCOME PARAMETERS

SAP ID: FILE NO.: **F.530/12/DRS-II/2016(SAP-I**) dtd:08.03.2016

NAME OF THE UNIVERSITY: **Jai Narain Vyas University, Jodhpur (Raj)**

NAME OF THE DEPARTMENT: **Department of Physics**

LEVEL (DRS/DSA/CAS): **DRS – II** TENURE: **01/04/2016 - 31/03/2021**

THRUST AREA: **MATERIALS SCIENCE**

MAJOR ACHIEVEMENTS: (AVERAGE OF OUTCOMES IN GIVEN TENURE)

1) Paper Publications – Journals (numbers only):

Refereed Journals	Other Journals	Average Impact Factor	Average H - Index
16	Nil	3	

2) Paper Publications – Conferences (numbers only):

Outside the University	Within the university
Nil	Nil

3) Patents (numbers only):

No. of Patents granted	No. of Patents licensed
Nil	Nil

4) Copyright (numbers only):

Filed	Granted
Nil	Nil

5) Adoption of Interdisciplinary Approach:

S.No.	No. of Interdisciplinary Departments	Name of Collaborating Departments

6) Revenue Generated:

Source of revenue	Amount generated (Rs. in Lakhs)
Nil	Nil

7) Students:

Programme	Ph.D.	PG	UG	Other, if any (specify)
No. of students awarded				
No. of students attached from neighboring Universities/Colleges				

8) Sponsored Research / Consultancy Details:

No. of funding agencies	Name of Funding agencies	Amount of funding
Nil	Nil	Nil

9) Industrial / Commercial attachment:

No. of collaborating industries	Types of collaborating industry	Whether within or outside the Country	Brief details of collaboration output
Nil	Nil	Nil	

10) Research / Academic Collaboration (within the Country):

No. and type of academic institutions	Names of academic institutions	Details of collaboration, indicating specific outcomes
2 R&D Institutions of CSIR	CSIR-NISCAIR & HRDC, New Delhi	Collaboration in characterization and interpretation of experimental work, and publications of some results in international journals

11) Research / Academic Collaboration (outside the Country):

No. and type of academic institutions	Names of academic institutions	Details of collaboration, indicating specific outcomes
Nil	Nil	Nil

12) Faculty training:

No. of faculty training programmes organised	No. of faculty members benefitted
1	3

13) Student training:

No. of student training programmes organised	No. of students benefitted
3	5

14) Student Placement:

Average pass % of students – clearing exams in minimum time (entry to exit)	No. of students placed in industry	Percentage placement	Average salary
N/A	N/A	N/A	N/A

15) Exam and Curriculum reforms details:

Reform type	Details (in bullet points)

N/A	N/A

16) Noticeable facilities creation:

Infrastructure / equipment facilities created	Details (in bullet points)
1. Differential Scanning Calorimetry (DSC)	➢ Differential scanning calorimetery (DSC) Netzsch Polyma 214, Germany, is purchased in SAP DRS-II grant and installed in the department. ➢ Crystalline phase melting temperatures, degree of crystallity, and glass transition temperature of different polymer nanocomposites (PNCs) and solid polymer electrolytes (SPEs) are cheracterized using the DSC instrument. ➢ Thermal stability of the materials are explored and the results have been published in the following international journals.
2. Impedance Analyzer (RF impedance and material analyzer over frequency range 1 MHz to 1 GHz) with dielectric material test fixture	➢ Impedance Analyzer (Model: E4991B of Keysight Technologies, Inc., USA) and its compatible solid material dielectric test fixture (Product No.: 16453A) of frequency range 1 MHz to 1 GHz generator was established. ➢ Broadband radio frequency complex dielectric permittivity, dielectric loss tangent and AC electrical conductivity of various PNCs and SPEs are measured using Impedance Analyzer. ➢ Dielectric polarization behaviour of the materials is examined and with the help of measured dielectric parameters the significance of PNCs as Nanodielectrics in advances of radio frequency electronic devices and SPEs in the energy storage devices are suggested. ➢ The results of dielectric properties of these materials have been published in following international journals.
3. UV-VIS-NIR Spectrophotometer	➢ The UV-Vis spectrophotometer (Cary 60, Agilent Technologies, USA) of double beam geometry and wavelength range from 200 nm to 800 nm is established. ➢ Various PNC films are characterized recording the absorbance spectra and optical parameters including energy band gaps are determined using UV-Vis spectrophotometer. ➢ In-depth analysis of the hybrid nanocomposites and solid polymer nanocomposite electrolytes are made and suitability of these materials in advances of flexible optoelectronic devices are suggested. ➢ The results have been published in the following journal of high impact factor:

Publications:

[1]. Ionics (2020) 26:2259–2275
[2]. Macromolecular Research 27 (2019) 1009–1023
[3]. Journal of Polymer Research 26 (2019)196
[4]. Composite Interfaces 28 (2021) 827–842
[5]. Journal of Macromolecular Science, Part B (2021) https://doi.org/10.1080/00222348.2021.1971839
[6]. Functional Composites and Structures 3 (2021) 025008
[7]. Indian Journal of Pure & Applied Physics 59 (2021) 92-102
[8]. Journal of Applied Polymer Science DOI: 10.1002/app.51599
[9]. Journal of Materials Science: Materials in Electronics 32 (2021) 9661–9674.
[10]. Journal of Polymer Research 28 (2021) 63
[11]. Materials Letters 299 (2021) 130081
[12]. Optical Materials 113 (2021) 110837
[13]. Optik - International Journal for Light and Electron Optics 233 (2021) 166594
[14]. Optik - International Journal for Light and Electron Optics 241 (2021) 167215
[15]. Physica B 613 (2021) 412989
[16]. Journal of Physics and Chemistry of Solids (2021) communicated

- In all these publications the SAP DRS-II assistance granted by the UGC, New Delhi is acknowledged with the grant number.
- The work on HPNCs, SPNEs and Nanofluids are in progress by employing the above-mentioned experiment facilities generated in SAP DRS-II grant.
- Several students have registered for Ph. D. programme and taking the training on these equipments for completion of their research work.
- Several JRF and NET qualified students are registered for Ph. D. because of these advance experimental techniques created, and further several more students are trying to registered in the Physics Department of JNV University because of these advanced equipments.
- In future moreresearch work will be published for the academic point of view and technological advances in next generation flexible device technologies with the acknowledgement to UGC for SAP DRS-II grant.
- Intra Departmental collaboration of JNVU on the experimental facilities is in progress
- Collaboration with other institutes/universities of the Jodhpur is in progress for utilisation of the experimental facilities developed through SAP DRS-II grant

17) Any other outcome that resulted in Impact creation / enhanced effectiveness:

Outcome	Impact (in bullet points)
N/A	N/A

18) Community outreach / Extension Programmes, if any:

No. and type of programme	Details of the programme, indicating specific outcomes
N/A	N/A

19) Utilisation of UGC Funds:

Grant received (NR + R) (Rs.)	Grant utilised (NR + R) (Rs.)	% utilisation
7610000.00 (Grant was received in 3rd financial year (2nd half of financial year i.e., dtd: 04.10.2018) due to which the whole work schedule of the project was disturbed)	**7378402.00**	96.957

Head
Department of Physics
Jai Narain Vyas University, Jodhpur (Raj)

Professor (Dr.) R. J. SENGWA
Co-ordinator SAP DRS-II
(with Stamp)