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Full Length Research Paper

Hairy Root Culture of *Eclipta Alba (L.)* Hassk.

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ABSTRACT

Eclipta alba (L.) Hassk. was transformed by *Agrobacterium rhizogens*. Explants from healthy growing roots were inoculated with *A.rhizogens* strain MTCC 532. The genetic markers included vir D1 and rol B, responsible for T-DNA transfer and hairy root initiation. Bacterial gene transfer was confirmed using these markers. The rol B genes were detected using PCR analysis.

Key words: *Eclipta alba*, *Agrobacterium rhizogens*, MTCC 532, PCR, Hairy root induction

1. INTRODUCTION

Various natural products like tropane alkaloids, atropine, hyoscyamine, scopolamine and steroidal precursors are mainly produced by roots (Kumar and Roy, 2006; Kumar and Sopory, 2008 and Kumar and Shekhawat, 2009). Cell cultures have been established from many plants and they have been used for the production of secondary metabolites. Often they do not produce sufficient amounts of the required secondary metabolites (Rao and Ravishanker, 2002). Cell cultures have been used to achieve only a few commercial processes inspite of considerable efforts. In some cases, secondary metabolites are only produced in organ cultures such as hairy root or shooty teratoma (tumor-like) cultures. For example, hairy roots produce high levels of alkaloids (Sevo'n and Oksman-Caldentey, 2002). A large number of efficient regeneration and *Agrobacterium* mediated transformation protocol have been developed for different medicinal plants, which in turn could be used for the production of valuable secondary metabolites.

Agrobacterium rhizogenes, a soil plant pathogenic bacterium, possesses a plasmid called the Ri (root-inducing) plasmid. There is an increased production of various phenolic compounds when plants are wounded. This, in turn, enhances the expression of the virulence (*vir*) genes on the bacterium's Ri plasmid, by inducing acetosyringone. The *vir* genes encode enzymes that enable the bacteria to insert a well defined DNA fragment, the T-DNA of its Ri-plasmid into the genome of plant cell around the contact site (Gelvin, 2000). This T-DNA encodes enzyme that regulates the production of two groups of compounds, the plant growth hormones

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(i.e., auxins and cytokinins) and unusual amino acids, opine. The plant growth hormones cause the transformed plant cells to form 'hairy' roots, while the opine serve as an exclusive food source for *A. rhizogenes* (Lehninger *et al*., 1993). Hairy root cultures have high growth rate and are able to synthesize root derived secondary metabolites.

In the early 1980's, the formation of hairy roots in several dicotyledonous plants by *A.rhizogenes* was reported by Chilton *et al.* (1982). The production of secondary metabolites form *in vitro* transformed roots of many plant species have been reported, for example, higher levels of pulchelin E produced from *Rudbeckia hirta* (Luczkiewicz *et al*., 2002), plumbagin from *Plumbago zeylanica* (Verma *et al*., 2002), high scopolamine from *Hyoscyamus muticus* (Zolala *et al*., 2007), silymarin production from *Silybum marianum* (L.) Gaertn (Rahnama *et al*., 2008), production of alizarin and purpurin in *Rubia akane* Nakai (Lee *et al*., 2010) and tropane alkaloids production in hairy root cultures of *Atropa belladonna* (Yang *et al*., 2011).

Cell cultures tend to produce low yields of secondary metabolites. In contrast, transformed hairy roots grow rapidly and produce higher levels of secondary metabolites than the parent plants. Therefore, they can serve as a good alternative source of phytochemicals (Hughes and Shanks, 2002; Kumar and Sopory, 2010; Bopana and Saxena, 2010 and Kumar and Roy, 2011). A significant increase in growth of whole culture or specific aspects of the cultures and in the production of secondary compounds from transformed hairy roots have been reported by many researchers (Dhingra *et al*., 2000). An increased level of secondary metabolites in the hairy roots of *Datura stramonium* (Maldonado-Mendoza *et al*., 1993) and *Tropaeolum majus* (Wielanek and Urbank, 1999) as compared to whole plants has been reported. Different elicitors such as chitosan, methyl jasmonate, heavy metals and salicylic acid (DiCosmo and Misawa, 1985; Barz *et al*., 1988; Gundlach *et al*., 1992; Ebel and Cosio 1994 and Poulev *et al*., 2003) have been used to increase the production of secondary metabolites. Enhancement of *Agrobacterium tumefaciens* mediated transformation efficiency by pre treatment and wounding of plant tissue provides improved technologies (Hraska and Rakousky, 2011).

Secondary metabolites derived from metabolically engineered plants have a high potential. For example, changes in flower color or increased level of antioxidative flavonol production in tomato has been achieved by modifying anthocyanin and flavonoid pathways. (Bourgaud *et al*., 2001 and Kirsi-Marja and Inze, 2004). However, to date, only a few pharmaceutically important compounds have been produced by successfully modifying their pathways. Metabolic profiling allows comprehensive phenotyping of genetically or environmentally modified plant systems (Roessner *et al*., 2001). However, hairy roots, transformed with *Agrobacterium rhizogenes*, have been found to be more suitable for the production of secondary metabolites because of their stable and high productivity in hormone-free culture conditions.

2. MATERIALS AND METHODS

(a) Explant preparations:

Healthy growing roots from *Eclipta alba* were used as explants for hairy root induction. These were sterilized by following standard procedures.

(b) Organism used:
The strain of *Agrobacterium rhizogenes* used in the present study - MTCC 532.
(c) Bacterial culture medium:
Inoculation of the bacteria in yeast extract broth (YEB) culture medium was used to obtain suspension of *Agrobacterium rhizogenes* (MTCC 532) and this suspension was left standing at 250 rpm for 16 hr at 25^0C in an orbital shaker under constant stirring. Subsequently the bacterial suspension was centrifuged at 5000 rpm for 10 min. after transferring to a sterilized centrifuge tube. The residue obtained was then suspended in liquid MS media supplemented with 3% sucrose.
(d) Hairy root culture medium:
MS medium (Table-3.1) supplemented with 0.8% agar, 3.0% (w/v) sucrose and pH of 5.7 was maintained and used as growth medium for induction of hairy roots from explants.
(e) Establishment of hairy root culture:
The surface sterilized explants were cut below epicotyl and then fine pointed needles were used for puncture inocluating the epicotyl 1.5 cm above the cut with MTCC 532 strain of *A. rhizogenes*. The explants were co-cultivated with 25 ml *A. rhizogenes* in liquid MS media in 100 ml flasks at 200 rpm in a shaker under dark. The root explants were then blotted on sterile tissue paper after incubation period of 3 hr and were placed on the growing medium containing cefotaxime (250 mg/l) (to eliminate excess bacteria). Half of inoculated explants were incubated in light (16 hr light/8 hr dark) and the other half in dark at 24 ± 2^0C. Punctured controls without *A. rhizogenes* treatment were also planted under each condition. The obtained roots were then excised and cultivated individually in MS culture medium in the presence of cefotaxime (250 mg/l) for total elimination of *Agrobacterium rhizogenes*. Transformed roots, cultivated in MS culture medium, were kept in the dark at 24 ± 2^0C and at intervals of 21 days they were subcultured.
(f) PCR analysis:
The two genes, *rol* B and *vir* D1 play a prominent role in transformation. DNA isolated from *A.rhizogenes* strain, transformed hairy root and control were used for PCR amplification (Corbett research).
(i) DNA isolation:
3g of each sample was homogenized in absolute alcohol. The homogenized material was handled as per the method described by Doyle and Doyle (1990) in following steps:
1. 4g of tissue material was grounded in absolute alcohol with the help of mortar-pestle.
2. The homogenized material was transferred to 20 ml pre-warmed (60^0C) DNA isolation buffer (2X CTAB DNA extraction buffer - 100 mM Tris, 20 mM EDTA, 1.4 M NaCl, 2% CTAB and 2 µl/ml β-mercaptoethanol) in capped polypropylene tubes.
3. Clump was suspended by using spatula.
4. Incubated for 1 hr. at 60^0C with occasional mixing by gentle swirling in water bath.
5. After removing from water bath one volume of chloroform: Isoamyl alcohol (24:1) was added and mixed by inversion for 15 min to ensure emulsification of the phases.
6. Spun at 15,000 rpm for 15 min (Eltec centrifuge)
7. Aqueous phase was taken and transferred to another tube.
8. Ice cold 2 vol of absolute alcohol or 0.6 vol. of isopropanol was added to precipitate DNA.
9. DNA-CTAB complex was precipitated as a fibrous network, lifted

by Pasteur pipette and was transferred to washing solution. In some cases amorphous precipitation was collected by the centrifugation at 5,000-10,000 rpm for 5-10 min at 20^0C.

10. 20 ml of 70% alcohol was added to the pellet of DNA and was kept for 20 min with gentle agitation.
11. The pellet was collected by centrifugation at 5,000 rpm for 5 min at 20^0C.
12. The tubes were inverted and drained on a paper towel. The pellet was dried over-night after covering with parafilm with tiny pores.
13. The pellet was re-dissolved in 1 ml of TE buffer by keeping over night at 4^0C without agitation.

(ii) Purification of DNA:

RNA was removed by treating the sample with DNase free RNase procured from Pure-gene, USA. Protein including RNase was removed by treating with chloroform: Isoamyl alcohol (24:1). The purification was carried out in following steps:

1. 2.5 µl of RNase was added to 0.5 ml of crude, DNA preparation (2.5 µl of RNase = 25 µg of RNase, so treatment was 50 µg / ml of DNA preparation).
2. Gently it was mixed thoroughly and was incubated at 37^0C for 1 hr.
3. After 1 hr, a mixture of 0.3 - 0.4 ml of chloroform: Isoamyl alcohol (24:1) was added and mixed thoroughly for 15 min till an emulsion was formed.
4. Spun for 15 min at 15,000 rpm.
5. Supernatant was taken avoiding the whitish layer at interface.
6. The DNA was re-precipitated by adding double the quantity of absolute alcohol.
7. To pellet the DNA, the tube was centrifuged for 5 min at 5,000-10,000 rpm.
8. The pellet was washed with 70% alcohol and dried over night.
9. The DNA was re-dissolved in 500µl of TE buffer.

(iii) Gel analysis:

The integrity of DNA was judged through gel analysis in following steps:

1. Cast 150 ml agarose gel (0.8%) in 0.5X TBE (Tris Borate EDTA) buffer containing 0.5 µg /ml of Ethidium bromide.
2. 2 µl of DNA per sample was loaded in each well.
3. Known amount of uncut Lambda phage DNA was also loaded as control.
4. Electrophoresis was conducted at 50 V for 1 hr.
5. Gel was visualized under UV light using transilluminator.
6. Presence of single compact band at the corresponding position to λ phage DNA indicates high molecular weight of isolated DNA.

(iv) Quantitation of DNA:

The quantitation of DNA was done by observing it at 260 nm and 280 nm wavelengths by using a UV-VIS spectrophotometer (Mecasys Company Ltd., made in Korea) in following steps:

1. 200 µl TE. buffer was taken in a cuvette and spectrophotometer was calibrated at 260 nm as well as at 280 nm wavelengths.
2. Added 4 µl of DNA, mixed properly and record the absorbance (A) at both 260 and 280 nm.
3. DNA concentration was estimated by employing the following formula:

$$DNA\ (\mu g/\mu l) = \frac{A260\ x\ 50\ x\ dilution\ factor}{1000}$$

4. Quality of DNA judged from the ratio of A values recorded at 260 and 280 nm.

(v) Dilution of DNA for PCR:

The quantitated DNA was diluted to final concentration of 25 ng/µl in TE

buffer (10 mM Tris HCl, 1 mM EDTA, pH 8.0) for PCR amplification.

(vi) PCR:

The *rol* B and *vir* D1primers were supplied by Chronos Biotech., Delhi. The 5' primer sequence of *rol* B gene was TGGATCCCAAATTGCTATT CCTTCCACGA and 3' primer sequence was TTAGGCTT CTTTCTTCAGGTTTACTGCAGC. A minimum of 780 base pair (bp) fragment could be detected in PCR amplification. For *vir* D1 gene, the 5' primer sequence ATGTCGCAAGGACGTAAGCCCA and 3' primer sequence GGAGTCTTTCAGCATGGAGCAA were used. This amplified the DNA fragment of 450 bp from the DNA samples. For checking the presence of *rol* B gene, the PCR amplification was done in a final reaction volume of 30 µL containing 1 PCR buffer (Bangalore Genei), 1.5 mM $MgCl_2$, 1 mM each of the four dNTPs, 1.25 U of Taq polymerase (Bangalore Genei) and 0.5 mM each of 5' and 3' primers with 3 µl of the total DNA from transformed roots. After initial denaturation at 94^0C for 3 min, PCR was performed for 35 cycles at 94^0C for 30 sec, 55^0C for 30 sec and 72^0C for 1 min followed by a final extension at 72^0C for 7 min. The same conditions were also used for the detection of *vir* D1 gene.

Following the amplification, the PCR products were loaded on 1.2% agarose gel (Himedia, molecular grade), which was prepared in 1X TBE buffer containing 0.5 µg/ml of the Ethidium Bromide. The amplified products were electrophoresed for 3-3.5 hr at 100 V with cooling. After separation the gel was viewed under UV trans-illuminator and photographed by digital camera.

3. RESULTS AND DISCUSSION

The hairy roots of *E. alba* obtained were white, slender, highly branched with several lateral branches (Plate-4.9-A).

Hairy root cultures were identified both by morphological as well as genetic markers. The important morphological markers included rapid growth, lateral branching and plagiotropism (negatively geotropic). The genetic markers included *vir* D1 and *rol* B, responsible for T-DNA transfer and hairy root initiation. Bacterial gene transfer was confirmed using these markers. The *rol* B genes were detected from the transformed root DNA using PCR analysis. The *vir* D1 genes were not found in the hairy root DNA and this confirmed the absence of *Agrobacterium* residual genes in the transformed tissues. In control, both the genes were absent (Plate-4.9-B).

REFERENCES

Barz, W., Daniel, S., Hinderer, W., Jaques, U., Kessmann, H., Koster, J. and Tiemann, K. 1988. Elicitation and metabolism of phytoalexins in plant cell cultures. In: Pais, M., Mavituna, F. and Novais, J. (Eds.). Plant cell biotechnology. NATO ASI series, Springer, Berlin Heidelberg, New York. pp. 294-309

Bopana, N. and Saxena, S. 2010. Biotechnological aspects of secondary metabolite production. In: Kumar, A and Sopory, S. (Eds.). Applications of plant biotechnology: *In vitro* Propagation, plant transformation and secondary metabolite production. I.K. International, New Delhi. pp. 451-473

Bourgaud, F., Gravot, A., Milesi, S. and Gontier, E. 2001. Review: Production of plant secondary metabolites: A historical perspective. *Plant Science*. **161**: 839-851

Chilton, M.D., Tepfer, D.A., Petit, A., David, C., Casse-Delbart, F. and Tempe, J. 1982. *Agrobacterium rhizogenes* inserts T-DNA into the genomes of the host plant root cells. *Nature.* **295**: 432-434

Dhingra, V., Rao, K.V. and Narasu, M.L. 2000. Current status of artemisinin and its derivatives as antimalarial drugs. *Life Sci*. **66**: 279-300

DiCosmo, F. and Misawa, M. 1985. Eliciting secondary metabolism in plant cell cultures. *Trends Biotechnol*. **3**: 318-322

Ebel, J. and Cosio, E.G. 1994. Elicitors of plant defence responses. *Int. Rev*. *Cytol*. **148**: 1-36

Gelvin, S.B. 2000. *Agrobacterium* and plant genes involved in T-DNA transfer and intrigation. *Annu. Rev. Plant Physiol. Plant Mol. Biol*. **51**: 223-256

Gundlach, H., Muller, M.J., Kutchan, T.M. and Zenk, M.H. 1992. Jasmonic acid is a signal transducer in elicitor-induced plant cell cultures. *Proc. Natl*. *Acad. Sci*. **89**: 2389-2393

Hraska, M. and Rakousky, S. 2011. Enhancement of *A. Tumefaciens* - mediated transformation efficinecy by pretreatment and wounding of plant tissues. In: Kumar, A and Roy, S. (Eds.). Plant tissue culture and applied plant biotechnology. Aavishkar Publishers, Jaipur. pp. 1-16

Hughes, E. H. and Shanks, J. V. 2002. Metabolic engineering of plants for alkaloid production. *Metabolic Engineering.* **4(1)**: 41-48

Kirsi-Marja, O.C. and Inze, D. 2004. Plant cell factories in the post-genomic era: New ways to produce designer secondary metabolites. *Trends in Plant Science*. **9(9)**: 433-440

Kumar, A. and Roy, S. 2006. Plant biotechnology and its applications in tissue culture. I.K. International, New Delhi. pp.307

Kumar, A. and Roy, S. 2011. Plant tissue culture and applied plant biotechnology. Avishkar Publishers, Jaipur. pp. 346

Kumar, A. and Shekhawat, N.S. 2009. Plant tissue culture and molecular markers: Their role in improving crop productivity. I.K. International, New Delhi. pp. 686

Kumar, A. and Sopory, S. 2008. Recent advances in plant biotechnology and its applications. I.K. Itnernational, New Delhi. pp. 718

Kumar, A. and Sopory, S. 2010: Applications of plant biotechnology: *In vitro* propagation, plant transformation and secondary metabolite production. I.K. International, New Delhi. pp. 606

Lee, S.Y., Kim, S.G., Song, W.S., Kim, Y.K., Park, N.I. and Park, S.U. 2010. Influence of different strains of *Agrobacterium rhizogenes* on hairy root induction and production of alizarin and purpurin in *Rubia akane* Nakai. *Romanian Biotechnological Letters*. **15(4)**: 5405-5409

Lehninger, A.L., Nelson, D.L. and Cox, M.M. 1993. *Principles of Biochemistry*. Worth Publisher, New York. pp. 1013.

Luczkiewicz, M., Zarate, R., Migas, W.D., Migas, P. and Verpoorte, R. 2002. Production of pulchelin E in hairy root, callus and cell suspension cultures of *Rudbeckia hirta* L. *Plant Sci.* **163**: 91-100

Maldonado-Mendoza, I.E., Ayora-Talavera, T. and Loyola-Vargas, V.M. 1993. Establishment of hairy root cultures of *Datura Stramonium*. *Plant Cell Tissue Organ Culture*. **333**: 321-329

Poulev, A., Neal, J.M., Logendra, S., Pouleva, R.B., Garvey, A.S., Gleba, D., Timeva, V., Jenkins, I.S., Halpern, B., Kneer, R., Cragg, G.M. and Raskin, I. 2003. Elicitation, a new window into plant chemodiversity and phytochemical drug discovery. *J. Med. Chem*. **46**: 2542-2547

Rahnama, H., Hasanloo, T., Shams, M.R. and Sepehrifar, R. 2008. Silymarin production by hairy root culture of *Silybum marianum* (L.) Gaertn. *Iranian Journal of Biotechnology*. **6(2)**: 113-118

Rao, S.R. and Ravishankar, G.A. 2002. Plant cell cultures: Chemical factories of secondary metabolites. *Biotechnol. Adv*. **20**: 101-153

Roessner, U., Luedemann, A., Brust, D., Fiehn, O., Linke, T., Willmitzeer, L. and Fernie, A. 2001. Metabolic profiling allows comprehensive phenotyping of genetically or environmentally modified plant systems. *The Plant Cell.* **13(1)**: 11-29

Sevo'n, N. and Oksman-Caldetey, K.M. 2002. *Agrobacterium rhizogenes*-mediated transformation: Root cultures as a source of alkaloids. *Plant. Med*. **68**: 859-868

Verma, P.C., Singh, D., Rahman, L.U., Gupta, M.M. and Banerjee, S. 2002. *In vitro* studies in *Plumbago zeylanica*: Rapid micropropagation and establishment of higher plumbagin yielding hairy root cultures. *Plant Physiol*. **159(5)**: 547-552

Wielanek, M. and Urbank, H. 1999. Glucotropaeolin and myrosinase production in hairy root cultures of *Tropaeolum majus*. *Plant Cell Tissue Organ Culture*. **57(1)**: 39-45

Yang, C., Chen, M., Zeng, L., Zhang, L., Liu, X., Lan, X., Tang, K. and Liao, Z. 2011. Improvement of tropane alkaloids production in hairy root cultures of *Atropa belladonna* by overexpressing pmt and h6h genes. *Plant Omics Journal*. **4(1)**: 29-33

Zolala, J., Farsi, M., Gordan, H.R. and Mahmoodnia, M. 2007. Producing a high scopolamine hairy root clone in *Hyoscyamus muticus* through transformation by *Agrobacterium rhizogenes*. *J. Agric. Sci. Technol.* **9**: 327-339

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Full Length Research Paper

Nutraceutical Value of Aquatic Plants

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ABSTRACT

Rajasthan has several water bodies. Plants providing edible fruits, seeds, grains, tubers, rootstocks, tender stem and leaves belonging to 47 aquatic species have been studied. The arrangement of taxa is according to Benthan & Hooker's system of classification at the family level, while genera and species are enumerated in an alphabetical sequence. Local names, period of availability, habit and habitat of the plants have been mentioned as use. Main chemical contents of edible parts have also been recorded.

Key words: edible, aquatic species, *medicinal*, habit, *habitat*

1. INTRODUCTION

Rajasthan is the habitat of the aquatic species from roughly one percent of the total angiosperm flora of the world presently. Although Rajasthan is considered desert state but it has rich aquatic flora and biodiversity. Out of an estimated 1,500 species of plants in the state nearly one fifth are aquatics (Pareek, 1996, Razvy, 2011). Reports published exclusively on the aquatic plants of the state are few (Pareek and Sharma, 1988). Some of the reports include Ajit Sagar Bandh (Nair and Kanodia, 1959); Bharatpur (Sarup, 1961), Ghana bird sanctuary (Saxena, 1975); Alwar (Vyas 1962); Kota (Gupta, 1966); Bundi district (Maheshwari and Singh, 1974) and Jaipur district (Sharma and Kumar, 2011, 2012). Pareek (1994a, 1994b) carried out detailed investigations on several aquatic species from Rajasthan. The aquatic habit has been adopted by diverse groups of angiosperms from fresh water to marine. A scientific study shows that out of an estimated 1,500 angiospermic species in the state nearly one fifth are aquatics. The population inhabiting the areas in vicinity of water bodies makes optimal utilization of the hydrophytes.

Reports in literature are there on the uses of plants as food in Wealth of India (1948-76). Rajasthan is frequently subjected to famine, and the study of aquatic vegetation has probably attracted the attention of botanists (Duthie, 1903 - 1921 and Pareek, 1988). They could be potential sources which could be utilized during the time of scarcity as well as in normal days.

During previous investigations edible plants have been reported (Pareek, 1994a). The information furnished here

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is based purely on author's personal observations made during last seven years of studies carried out on the aquatic vegetation of Rajasthan.

2. ENUMERATION OF EDIBLE PLANTS OF AQUATIC HABITAT

Plant species are enumerated under eight broad heads based on the part used. Botanical names are given under respective family followed by local name, period of availability, habit and habitat with other details and its occurrence.

2.1 Fruits Edible

1. *Phoenix sylvestris* (L.) Roxb
Wild date palm Khajar, Khajuri
March- July
Phoenix sylvestris is a tree growing to 15 m (49ft 3in). Suitable for: light (sandy), medium (loamy) and heavy (clay) soils. Suitable pH: acid, neutral and basic (alkaline) soils. The Flowers are hermaphrodite (have both male and female organs). The sap is obtained from the unopened inflorescence which is cut off to obtain sap. The sap can be concentrated as syrup or fermented into alcohol. The sap contains about 14% sugar. The sap plays an important role in the diet of the inhabitants of tribal area of southern Rajasthan. Quantitative determination of the proximate composition of carbohydrate, protein, lipid, minerals and vitamins present in the sap of Phoenix sylvestris has been done by Salvi and Katewa, (2012). The results revealed that sap is a good nutrient supplement and is opulent in carbohydrate, protein, potassium, sodium, vitamin B-complex and vitamin C. The sap of Phoenix sylvestris can be used as good alternative source of health drink and to alleviate hunger and malnutrition.

TRAPACEAE

2. *Trapa bispinosa* Roxb
Synonym of *Trapa natans L. var bispinosa* (Roxb) Makino
October - April
Singhara
Water chestnut is an annual, floating-leaved herb found in freshwater wetlands, lakes, ponds, sluggish reaches of rivers in India. Water chestnut a very variable, rooted aquatic herb, stem elongate and submerged, leaves dimorphic, flowers solitary, white or lilac. Carbohydrate is the major component of this fruit. The fruits are eaten raw or cooked; they are also used for making flour which is used in fast in India.

2.2 Seeds Edible

ASTERACEAE

3. *Xanthium indicum* Koenig
Aadha-Sheesi, Kadoda. "Shankeshwar"
October - April
An annual herb with a short, stout, hairy stem. Leaves broadly triangular-ovate or suborbicular; flower heads in terminal and axillary racemes; white or green; numerous; Fruit oboviod, enclosed in the hardened involucre, with 2 hooked beaks and hooked bristles. The plant of Xanthium yields xanthinin which acts as a plant growth regulator, Antibacterial activity of xanthinin has also been reported. Seed yields a semi-drying edible oil (30-35%) which resembles sunflower oil in bladder infection, herpes, and erysipelas. Cake can be used as manure whereas shell can be used as activated carbon (Oudhia and Tripathi 1998; Sastry and Kavathekar 1990). The plant has been reported as fatal to cattle and pigs edible oil extracted from the seeds.

EURYALACEAE

4. *Euryale ferox* Salisb
Tal-Makhana (Fox nut)
December
Floating- leaved anchored perennials. It is popularly known as "Makhana" in India. It grows in water and plant does not have stem. It has large round leaves and produces bright purple flowers. The whole plant is covered with small thorns. The leaves of fox nut plant have green upper surface and purple shaded lower surface. This plant produces fruits which are about the size of a small orange. Each fruit contains 8-10 seeds which are of pea size, containing proteins, carbohydrates, fat, calcium and phosphorus.

2.3 Grains Eaten as Food

POACEAE

5. *Coix lacryma- jobi* L.
Jargodi
September - December
Emergent anchored annuals. Common in and around marshes, along water courses, and rice fields; culms tufted, leaves linear-lanceolate, spikelets terete or partly flattened, white-yellowish white or bluish grey contains proteins, carbohydrates and minerals.

6. *Echinochloa colonum* (L.) Link
Hema, Sama, Jungli Rice
September - November
Annuals found near water bodies. The seed can be cooked as awhole or ground into flour and used as a mush or porridge young plants and shoots raw or cooked, eaten raw with rice.

7. Echinochloa crusgalli (L.) Beauv.
Sama
September - November
Semi hydrophytic annuals. It can be cooked as a whole or be ground into flour before use. It has a good flavor and can be used in porridges, macroni, dumpling etc. young shoots, stem tips and the heart of the colum-raw or cooked. Young shoots are eaten as raw or cooked vegetable.

8. *Hygroryza aristata* (Retz.) Nees
Janglidal
September
Annual floating glabrous grass; culms creeping or trailing, floating, rooting at internodes, leaf sheath inflated, inflorescence a pyramidal panicle and spikelets solitary. Grains are eaten by poor people (Cook, 1996). They are reported to be sweet, digestible and cooling and useful in biliousness. Grains are gathered and eaten by the poor.

9. *Ischaemum rugosum* salisb.
September- October
A tufted, erect, annual grass with flat, glabrous or sparsely hairy leaves and oblong grains. The grains are eaten at times of scarcity. Analysis of the plant at flowering stage revealed the presence of considerable amount of protein, carbohydrate etc. (Wealth of India, Vol. V); Common in wet places and in rice fields, grows in standing water also.

10. *Oryza rufipogon* Griff.
Jangli-Dhan
September - November
An Erect tufted Emergend annuals shrubs it is considered a weed in rice fields. Common wild rice or in the ancestor of cultivated rice (o. satival). The seeds are edible.

11. *Oryza sativa* L.
Dhan, Chaval
October
An emergent annual or perennial grass without a rhizome; leaf blades linear, spikelets persisting, caryopsis oblong, cylindrical, whitish yellow, brown to

reddish brown. It is one of the oldest of food crops and the basic diet of over half the world's population. The grain is used to make a wide variety of dishes and as stock food. It is fermented to make rice wines. Oil is extracted from the husk and it has a high vitamin B1 content and is used in the treatment and prevention of beri-beri. The extensive and exclusive use of polished rice leads to the development of beri-beri which could be reduced by parboiling the rice before milling and then under-milling (Usher, 1984).

12. *Paspalum scrobiculatum* L.
Kodo, Kodra
August - October
Annual herbs found near water bodies, is a millet largely used by the working and poorer classes of people in all parts of India as a staple article of food. It is not a very commonly used cereal. It resembles larger grains of rava (semolina) but is healthier than rava since it is unrefined and also has a low glycemic index. The dehusked grain is often reported to be poisonous to animal & man when used a food and several cases of poisoning have been reported. The seeds are used as human food grains are ground into meal and used for puddings.

2.4 Tubers and Root-Stocks Cooked as Vegetable

ASTERACEAE

13. *Eclipta prostrata* (Linn.) Linn.
Jal bhangro, "Bhangra" Bhringaraj.
Throughout the year.
Usually annual but also in very wet conditions, it will perennate by rooting at the nodes, commoninand along the edges of pools, tanks, canals, ditches and rice fields; diffuse or ascending herbs, stem and leaves sparsely strigose with bulbous based hairs and the head is white. The leaves are used as vegetables; they are used in some parts of India, in chutneys.

CYPERACEAE

14. *Cyperus esculentus* L.
Chchoda kaseru
Throughout the year
Dry phase pernnials. Source of potara for softening and flavoring green leafy vegetable. Some time called Earth almond or Chufa has Tubers roots that can be eaten raw or cooked usually roasted. Dried ground tubers were used to extend coffee and chocolate Tubers. Rich in oil, carbohydrate, starch, and minerals.

15. *Cyperus rotundus* L.
Mutha, Motha
August - October
Pestifcrous herbs containing essential oil.
Rhizome stoloniferous, leaves few basal, inflorescence simple or compound, spikelets compressed, brown; Perennial, found on river banks, dried up pools and ditches and in rice fields. Tubers are collected, roasted and eaten. The tubers contain cyperene, cyperone, cyperol and 1-pinene which are used for spasms or as an emmenagogue.

16. *Eleocharis dulcis* Trin. ex Hans.
September - November
Gregarious in shallow water in ponds, rice fields and along irrigation canals; Rhizome short with long stolons bearing subglobose tubers, culms terete, leaves reduced to bladeless sheets, inflorescence with a single spikelet, spiketel as wide as culms. It is cultivated for its edible tubers. The above ground parts are high in protein and low in fiber. It has been recommended to be cultivated for its leaf proteins. The corms are rich in

carbohydrates, especially starch and are a good source dietary fiber, riboflavin, Vitamin.

CYPERACEAE

17. *Scirpus grossus* L. F.
September - November
In portions of India, in time of famine the rost annuals found near water bodies in portions of India In time of famine the root in eagerly dug for human food. The fibers and dark cuticle being removed, the solid part of the root in dried, ground and mode into bread, a little flour being some times mixed with it.

POLYGONACEAE

18. *Polygonum plebeium* R.Br.
August - March
Widely distributed; forms dense prostrate mass in rivers, canals and drying out pools; diffusely branched, very variable, sub erect or prostrate under shrubs with a woody rootstock, ochrea lacerate, flowers in axillary cluster, perianth rose. It is used as a vegetable. Powdered herb is given for pneumonia and the rootstock is used against bowel complaints (Wealth of India, Vol. VIII)

MOLLUGINACEAE

19. *Glinus oppositifoilus* (Linn.) A. DC.
August - April
Annuals, found along open areas, lake shores, stream banks; prostrate herbs, leaves in apparent whorls, flowers white in axillary fascicles. The leaves are used as vegetable for cooking purposes, as well as an expectorant and antipyretic agent (Sahakipichan *et al.*, 2010).

NELUMBONACEAE

20. *Nelumbo nucifera* Gacrtn.
Kamal
September - May
Floating- leaved anchored perennials cultivated as a crop, found growing in ponds, tanks, etc; A handsome aquatic herb with stout, creeping rhizome, leaves peltate, glaucous, petioles long, smooth or with small prickles, flowers large, white or rosy. The fruiting torus is sold for the edible carpels embedded on it and are considered superior to cereals in nutritive value. Nelumbo honey is much in demand. Rhizomes are eaten as vegetable or preserved in sugar. The seed kernels are also used as a source of starch or eaten dry (Usher, 1984). The peduncle and petiole are cut into small pieces, dried and fried in oil is a delicious food item and is sold in the name, 'vattal' in Kerala (Pers. Obs. Swapna) Creeping rhizomes contains protein. fat, carbohydrates, calcium, phosphorus and iron.

NYMPHAEACEAE

21. *Nymphaea nouchalli Burmt.*
Kanval, Pappa Phool, Bhmbher
August - April
Floating-leaved anchored perennials. All Parts of the plant are eaten in times of scarcity. The rhizome is considered demulcent and used for dysentery and dyspepsia. Rhizomes contain starch, proteins, and yield grade fiber.

22. *Nymphaea pubescens* willd.
Nil kamel, Nil Padhma, Chota Kamval
August - March
Floting-leaved anchored perennials. Seeds contain proteins, carbohydrates, fat and yield fiber.

2.5 Tender Stem and Leaves Cooked as Vegetables

AMARANTHACEAE

23. *Alternanthera sessilisl* R. Brown ex DC.
August - March
Found in seasonally water logged soil, but prostrate, often ascending, annual perennial herbs particularly common at the edges of tanks, rivers, canals and ditches; young shoots and leaves are eaten as a vegetable (Scher, 2004). The leaves are eaten usually with fish, with rice. The leaves are boiled and ingested to treat hypertension.

CONVOLVULACEAE

24. *lpomea aquatica* Forsk.
Nali-ka-sag
September - March
Floating-shoot perennials usually floating on stagnant water but sometimes found in the banks of pools, canals and rivers; an aquatic, trailing or floating, herbaceous perennial with long, hollow stem rooting at the nodes, flowers white or pale purple with dark purple eye. The young terminal shoots and leaves are used as vegetable and in salad. The stems are sometimes picked. Dried juice has purgative properties. Leaves and stems are said to be cooling.

25. *Limnopila indica* (L.) Druce
Cultra
September - October
Emergent anchored annuals. Aerial stems erect or creeping below, with or without eglandular hairs, heterophyllous, flowers pedicellate, soliatary, white, pale yellow or blue-purple. Leaves eaten as vegetables Juice of aerial part of plant with ginger and cumin is prescribed to cure dysentery.

PONTEDERIACEAE

26. *Monochoria hastata* (L.) Solm
Flowering - August
A perennial herb grows in clumps at the edges of pools, tanks and canals and in ditches. Attains a height of 2 to 3 in during the rains, adjusting its height with the rise in water level; Plant with elongate, creeping, spongy rootstock, leaves long peioled, sagittate, hastate, flowers purplish blue or violet. Tender stalk and leaves are eaten as vegetable.

MENYANTHACEAE

27. *Nymphoides hydrophylla* (Lour) O. Ktze
Tagarmul. Cwnuda, chuli ghainchu
October - April
Stem and leaves are eaten. Floating-leaved anchored perennials deeply rooted in mud in lakes, tanks and temporary pools and in slowly flowing water; plant with long floating stem rooting at the nodes, leaves purplish beneath, flowers white, yellow within. Stems, leaves and fruits are eaten.

ARACEAE

28. *Pistia stratiotes* Linn.
September - May
Free floating rosettes herbs with emergent leaves in tanks, lagoons and rice fields. Forms a dense mat on water surface and cause serious clogging of water ways; a floating stolonlferous herb, leaves sessile, densely pubescent, flowers creamy white, minute and sessile on a spadix. Plant is eaten, in times of famine, Young leaves are cooked and eaten. Used as an antiseptic, antidyscentric, insecticide, and for ear complaints.

29. *Remusatia vivipara* (Roxb.) Schott.
flower not found
Tuberous Perennials bulbiferous herbs occurring in moist places. It is an economically important monocotyledonous flowering plant. Tender shoots eaten as vegetable & good source of antioxidants. The leaves & tubers being edible parts are used in monsoon by local people and are believed to have medicinal values. Therefore the presence of phytochemicals may indicate the medicinal as well as edible value of this epiphytic plant. The plant indicated the presence of reducing sugars, flavonoids, terpenoids & alkaloids.

ASTERACEAE

30. *Sphaeranthus indicus* Linn.
October - April
Automatic herbs, Common in and around irrigation ditches and rice fields; prostrate/ascending; branched from the base, stems with toothed wings flowers in heads and purple in color. The leaves are eaten as a pot herb. The juice of the plant is styptic and said to be useful in liver and gastric disorders. The Plant cooked in butter, flour and sugar is a tonic and fried or boiled seeds are used as an aphrodisiac. The stem with leaf is chewed to get relief from toothache.

SPHENOCLEACEAE

31. *Sphenoclea zeylanica* Gaertner
Flowering- October
Found in swampy areas, along the banks of water courses and in rice fields; an erect annual herb, inflorescence a dense terminal spike with small, greenish yellow flowers. The young plants and tips of older plants are streamed and eaten as vegetable with rice, (Usher, 1984).

CHENOPOSDIACEAE

32. *Suaeda fruticosa* (L.) Forsk.
Lunki, Lunak.
September - March
Salty flavor perennials occur in moist places. Young leaves - raw or cooked. The plant is rich in potassium and in often burnt as a source of potash for making soap & glass seed - raw or cooked.

33. *Suaeda maritima* (L.) Dumort
Khari Lani
March - July
Annuals or perennials occur in moist places. A pleasant juicy flavor, they make a nice addition in small quantities to a salad. They are often mixed with other vegetables in order to reduce their saltiness young leaves-raw or cooked. The young shoots are picked in vinegar & eaten on their own or used as a relish. Seed-raw or cooked. Contains protein, fat, carbohydrates, calcium & phosphorus.

POLYGONACEAE

34. *Rumex crispus* L.
December - August
Perennial herbs leaves-raw or cooked, they can also be dried for later use, the leaves can be added to salads, cooked as a Patherb or added to soups. The leavers are very rich in vitamins A & C. Stam-raw or cooked. They are best peeled and the inner portion eaten. Seed-raw or cooked. It can be used as pinole or can be ground into a powder and used as flour for making pancakes etc. The roasted seed has been used as a coffee substitute.

35. *Rumex dentatus* L.
Ambavah amrule
December - August
Dry phase perennials and rich source of calcium, beta carotene & vitamin C.

Contains protein ether extract, carbohydrates, calcium, phosphorus iron and vitamin A & C. Plants can contain quite high levels of oxalic acid, the IV & should not be eaten in large amounts since the oxalic acid can lock-up, thus causing mineral deficiencies. The oxalic acid content will be reduced it the plant is cooked.

AIZOACEAE

36. *Trianthema portulacastrum* L.
August - November, rarely March - April
Bawara, pathor chatta, kala Satta
Perennials occur near water bodies. Eaten as a leafy vegetable, good source of iron and calcium an excellent source of phosphorus. Rich in proteins, carbohydrates, and ascorbic acids.

37. *Veronica anagallis-aquatica* L.
Water speedwell
January - April
Annuals occur in moist places. Eaten as leaves or cooked, rich in vitamin C. A subtle flavor, the leaves can be added to salads or used as a potherbs when used in salads they go better with a lemon dressing than vinegar. The leaves are often available in winter.

HYDROCHARITACEAE

38. *Vallisneria spiralis* Linn.
September- April
A submerged, tufted, dioecious aquatic herb, stem very short, leaves totally submerged, linear, varying in length with the depth of water young leaves are eaten in salads. They are rich source of phosphorous, calcium and iron and the plant is used as a stomachic and for lecorrhoea (Wealth of India, Vol. X)

2.5 Pods Cooked as Vegetable

MIMOSACEAE

39. *Neptunia oleracea* Lour
Lajalu (Pods) water mimosa
August
Floating shoot anchored annuals. The plant is grown as a vegetable. The leaves & young shoots are said to have a nutty cabbage-like flavor and can be eaten raw or cooked. The fresh stem of this plant can be used for propagation.

2.6 Young Shoot, Infl, Orescence and Rhizome Hydrophyllaceae

40. *Hydrolea zeylanica* Vahl
Young shoots are eaten as vegetable and are reported to have antiseptic properties and are used in medicine (Cook, 1996). Young leaves are eaten with rice.

POLYGONACEAE

41. *Polygonum glabrum* Willd.
Gregarious along water dark down shiny. The young shoots and roots are cooked with vegetables.

HYDROCHARITACEAE

42. *Ottelia alismoides* Persoon
Succulent, flaccid, aquatic herb, leaves totally submerged, flowers white, polygamous, but in India, mostly bisexual, fruit ovoid to cylindrical, seeds densely covered with whitish unicellular hairs. The immature inflorescence is used as food (Cook, 1996). The starchy rhizomes and pollen are also eaten. The rhizomes are astringent and diuretic, and are reported to be deployed in dysentery. The leaves, petioles and inflorescences possess an excellent flavor and are eaten.

TYPHACEAE

43. *Typha angustata* Bory & Chaub.
Patera
August - April
Emergent anchored perennials, several parts of the plant are edible including during various seasons the dormant sprouts on roots and bases of leaves. The inner core of the stack is composed of green bloom spikes, ripe pollen, and starchy roots. The stem is also edible. Contains oil and solid acid viz. palmetic, stearic and other higher saturated acids.

44. *Typha elephantina* Roxb
Mothitrina bora
August - April
Emergent anchored perennials. The fiber contains cellulose, hemi cellulose, lignin and wax.

APIACEAE

45. *Centella asiatica* (L.) Urban
Brahmi-buti, Khulakhundi, Brahma Manduki
October - April
Dry phase perennials widely distributed; a prostrate perennial aromatic herb growing wild along stream sides, paddy fields and other wet places stem reddish, leaves in rosettes, inflorescence single and auxiliary umbel. Fresh plant dissolved in dry vegetable preparation or salad is used to increase memory power. It is also commonly used as porridge for feeding pre-school children in combating nutritional deficiencies (Cox *et al.*, 1993).

BRASSICACEAE

46. *Rorippa Indica* (L.) Hiem
December - April
An annual herb of ca 12 cm long with leaves of about 5-10cm, hairy and variously lobed. Flowers are very small. Tender young leaves & stems -raw or-cooked as vegetable containing 5% proteins.

PONTE DERI ACEAE

47. *Monochoria vaginalis* (Burm. F.) Presl.
July - September
Emergent anchored perenials. Tubers leaves and aerial parts are eaten, raw or cooked. Tender stalk, leaves & entire plant except the roots eaten as vegetable. Nutritional evaluation suggests the plant can be an alternative nutrient rich leafy vegetable.

3. DISCUSSION

The above enumeration reveals that the water-bodies in the State comprise very few perennial rivers and rivulets, numerous seasonal 'nalas' a number of artificial reservoirs, irrigation canals, ponds and puddles. Some of these are purely seasonal. In some cases water persists for most of the part of the year. Some artificial reservoirs controlled by the irrigation department may, however, retain water for a longer period.
About 47 species of aquatic habitats belonging to 39 genera and 25 families provide food to the human population.
The habit analysis reveals that about 27 and 19 species are perennials and annuals respectively and only one species of Suaeda i.e., Suaeda maritima is reported to both (annual/ perennial) habits.
The aquatic plants have been categorized in different ways by different workers from time to time. The author has followed the classification given by Daubenmire (1947) and grouped the aquatic of Rajasthan in the 8 categories on the basis of their habit and habitat:

Free floating	02
Submerged	00
Submerged anchored	01
Floating anchored	06
Floating shoot anchored	02
Emergent anchored	08
Wetlands	21
Dry Phase	07
Total	47

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REFERENCES

Gupta, R.S. (1966), A study of hydrophytes and marsh plants of Kota and einvirons (India) Trop Ecol **7**: 153-162

Kumar, A. 2000, Traditional Indian Ayurvedic Medicines: Some potential plants for bioenergy, medicine from India. Institute of Natural Medicine, Toyama Medical and Pharmaceutical University, Japan, **27**: 3-15

Kumar, A. (2008), Ayurvedic medicines: Some potential plants for medicine from India. In: Recent Advances in Plant Biotechnology**,** Eds. Kumar, A. and Spory, S. (New Delhi +I.K. International), 680-694

Maheshwari, J.K. and Singh, V. (1974), The aquatic and marshland plants of Bundi district, Rajasthan. J. Bombay Nat. History Soc. **70**: 438-446

Meena R. and Kumar A. (2012), Ethnobotanical survey of medicinal plants from Baran District of Rajasthan, India. The Journal of Ethnobiology and Traditional Medicine. Photon **117** (2012) 199-203

Nair, N.C. and Kanodia, K.C. (1959) A study of the vegetation of Ajit Sagar Bund, Rajasthan. J Bombay Nat History Soc. **56**: 524-557.

Pareek, A. (1994a), Three hitherto unreported aquatic species from Rajasthan. J. Phytol. Res. **7**: 89-90

Pareek, A. (1994b), Preliminary ethnobotanical notes on the plants of aquatic habitats of Rajasthan. J. Phytol. Res. **7**: 73-76

Pareek, A. (1996), Edible plants of aquatic habitats in Rajasthan. J. Econ. Tax. Bot. **20**: 101-105

Pareek, A. and Sharma, S. (1988). Phytogeographical affinities of the aquatic flora of Rajasthan. Acta Botanica Indica **16**: 19-22

Parveen, Upadhyay, B., Roy, S. and Kumar, A. (2007), Traditional use of medicinal plants among the rural communities of Churu District in the Thar Desert, India Journal of Ethnopharmacology **113**, 387-399

Razvy M.A., Faruk M.O., Hoque M.A., Environment friendly antibacterial activity of water chestnut fruits. J Biodiver Envio Sci 2011; **1**:26-34

Sarup, S. (1961), Hydrophytes of Bharatpur, preliminary study. Univ. Raj. Stud. (Biol) **5**:1-11

Saxena, V.S. (1975), A study of flora and fauna of Bharatpur (Keola dev Ghana) Bird sanctuary, Jaipur, 1-108

Sharma, S. (1980), Angiosperm of aquatic environment in Jaipur district, Rajasthan, Univ. Rajasthan, Stud. 18-35

Sharma L.K., Agrawal, G. and Kumar, A. (2003), Medicinal plants for skin and hair care, Indian Journal of Traditional Knowledge **2**, 62-68

Sharma L.K., Agrawal, G. and Kumar, A. (2003), Medicinal plants for skin and hair care, Indian Journal of Traditional Knowledge **2**, 62-68

Sharma M. and Kumar, A. (2011), Ethnobotanical and Pharmacognostical Studies of Some Medicinal Plants: Tribal Medicines For Health Care and Improving Quality of Life. Germany. LAMBERT Academic Publishers. 234 pp.

Sharma, H. and Kumar, A. (2011), Ethnobotanical studies on medicinal plants of Rajasthan (India): A review. Journal of Medicinal Plants Research **5**:1107-1112

Sharma, L.K. and Kumar, A. (2005), Medicinal plants in ancient belief and cure drugs from traditional systems of medicine in Rajasthan. In: Herbal medicine**,** Ed. Trivedi, P.C. (Jaipur + Avishkar Publisher), 207-224

Sharma, L.K. and Kumar, A. (2006), Ethnobotanical and phytochemical studies on some selected medicinal plants of Rajasthan. Indian Journal of Environmental Sciences **10**, 51-53

Sharma, L.K. and Kumar, A. (2006): Ethnobotanical and phytochemical studies on some selected medicinal plants of Rajasthan. Indian Journal of Environmental Sciences **10**, 51-53

Sharma, L.K. and Kumar, A. (2007), Traditional medicinal practices of Rajasthan. **I**ndian Journal of Traditional Knowledge **6**, 531-533

Sharma, L.K. and Kumar, A. (2007), Traditional medicinal practices of Rajasthan. Indian Journal of Traditional Knowledge **6**, 531-533

Sharma, L.K., Dadhich, N.K. and Kumar, A. (2005), Plant based veterinary medicine from traditional knowledge of India. Bull. of Botanical Survey of India. **47**:43-52

Sharma, S and Kumar, A. (2012), Pharmacognostical studies on medicinal plants of Semi-arid region. Prime Research on Medicine. **2(3)**:505-512

Shreevastava, B.P. and Kumar, A. (2007), Wetlands: Status and management strategies with special reference to Rajasthan, Conservation: Strategies and Policy Options with Special Reference to Rajasthan, SPRI Vision **2**:1-14

Upadhyay, B., Parveen, Dhaker, A.K. and Kumar, A. (2010), Ethnomedicinal and ethnopharmaco-statistical studies of Eastern Rajasthan, India. Journal of Ethnopharmacology **129**:64-86.

Verma, M., Kumar, A. and Tewari, M. (2003a), Searching for anti-diarrhoel agents among traditional medicines. Int. J. Mendel **20:**77

Verma, M., Kumar, A. and Tewari, M. (2003b), Ethnobotanical studies on medicinal plant. Palas. Int. J. Mendel **20**:78

Vyas, L N (1962) Vegetation of Jaisamand Lake, Alwar. Proc Rajasthan Acad Sci **9**:45-47

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Full Length Research Paper

Biodiversity is Important for Ecological Balance and Human Survival

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ABSTRACT

Biodiversity encompasses the variety of life on earth, or within one particular ecosystem, in terms of the number of distinct biological species present. Tropical rainforests, for example, support a huge variety of species, so are highly biodiverse, while polar-regions are far less so. Biodiversity of a region can be utilized by human developmental activities. Natural resource database is essential for biodiversity conservation and technology and socioeconomic dimensions provide pathways of development. Biodiversity is the foundation upon which human civilization has been built. Biodiversity provides products such as food, medicines and materials for industry. Biodiversity is integral part of cultural values and supports sustainable development. Deforestation, animal feed and human consumption is reducing biodiversity. The conservation of specific information (genes), their libraries (species), and support systems (habitats) should be of urgent concern given the current changes in extinction rates caused by human impacts. There is considerable change in natural forests, and plantations have been taken-up in the developed world while developing countries are losing biodiversity at a faster rate and in a broader area.

Key words: *Eclipta alba*, *Agrobacterium rhizogens*, MTCC 532, PCR, Hairy root induction

1. INTRODUCTION

The conservation of specific information (genes), their libraries (species), and support systems (habitats) should be of urgent concern given the current changes in extinction rates caused by human impacts. World Commission on Environment and Development (*Brundtland Commission 1987*) defined Sustainable Development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". UN Agenda 21 proposed in a conference, "United Nations Conference on Environment and Development (UNCED)" at Rio de Janeiro, Brazil (1992) submits that sustainable development is based on the satisfaction of basic needs in developing countries. Knowledge and information of biodiversity at the same place and social and political aspects regulate environmental issues. If biodiversity is well-managed, sustainable pathway for

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economic development could likely be attained. Biodiversity provides goods and services that help in sustainable development at different levels. Poverty alleviation can be achieved by biodiversity conservation. Biodiversity conservation provides the provision of fresh water, soil conservation, and climate stability.

Forests, botanical gardens, national parks, sanctuaries, wetlands, water bodies arid and semi arid regions preserve large amount of biodiversity. Around 100 plants become extinct each year globally. Increasing population levels, industrial activity, housing and fuel requirement is laying heavy pressure on biodiversity globally especially in developing countries. Horticulture has special role to create the message of interdependence of human being on natural resources. The utilization of natural resources without regeneration is mining of natural resources from finite means and ultimately human survival will become impossible if biodiversity is not conserved. Renewable sources of energy, utilization of water at sustainable level is important as we are mining fossil fuels, water and other natural resources that are in limited amount below the earth's surface. Biodiversity is facing pressure due to human population growth which is expected to reach 8 billion in next decades. Total number of terrestrial species is estimated to be around 8.7 million while the number of oceanic species is much lower, estimated at 2.2 million. As the rate of extinction has increased, many species may become extinct before they are described. German Federal Environment Minister Sigmar Gabriel cited estimates that up to 30% of all species will be extinct by 2050. This can only be achieved when sustainable development of business is measured on the triple of people (society), planet (ecology) and profit/prosperity (economy).

Increased awareness of the public to environmental issues will lead to better biodiversity conservation along with conservation of natural resources. Botanical gardens play important role in biodiversity conservation. Botanical Garden at San Antonio Texas, Botanical garden at Chicago, Botanical garden at Giessen have been playing important role in biodiversity conservation. During presentation attempt will be made to show biodiversity of different climatic zones as conserved in Botanical gardens and natural forests in USA, Germany and India.

2. BIODIVERSITY

The term *biodiversity* was first coined by the entomologist E.O. Wilson in 1986. *Biodiversity* is most commonly used to replace the more clearly defined and long established terms, species diversity and species richness. Biologists most often define biodiversity as the "totality of genes, species, and ecosystems of a region".

1. Biodiversity may be defined as the totality of different organisms, the genes they contain, and the ecosystems they form.

2. The Convention on Biological Diversity defines biodiversity as the variability among living organisms from all sources including, among other things, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

Biodiversity may be considered at three levels: genetic diversity, species diversity, and ecosystem diversity.
An advantage of this definition is that it seems to describe most circumstances and presents a unified view of the traditional three levels at which biological variety has been identified:

- species diversity
- ecosystem diversity
- genetic diversity

Genetically, biodiversity can be defined as the diversity of alleles, genes, and organisms. They study processes such as mutation and gene transfer that drive evolution.
The World Commission on Environment and Development (*Brundtland Commission 1987*) defined Sustainable Development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987). UN Agenda 21 proposed in a conference, "United Nations Conference on Environment and Development (UNCED)" at Rio de Janeiro, Brazil (1992) submits that sustainable development is based on the satisfaction of basic needs in developing countries. Knowledge and information of biodiversity at the same place and social and political aspects regulate environmental issues. If biodiversity is well-managed, sustainable pathway for economic development could likely be attained. Biodiversity provides goods and services that help in sustainable development at different levels. Poverty alleviation can be achieved by biodiversity conservation. Biodiversity conservation provides the provision of fresh water, soil conservation, and climate stability.

2.1 Biological Diversity Act, 2002

It has salient features:

- to regulate access to biological resources of the country with the purpose of securing equitable share in benefits arising out of the use of biological resources; and associated knowledge relating to biological resources;
- to conserve and sustainably use biological diversity;
- to respect and protect knowledge of local communities related to biodiversity;
- to secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information relating to the use of biological resources;
- conservation and development of areas of importance from the standpoint of biological diversity by declaring them as biological diversity heritage sites;
- protection and rehabilitation of threatened species and to involve institutions of state governments in the broad scheme of the implementation of the Biological Diversity.

2.2 Climate change and biodiversity

Climate change is taking placeat a fast rate and ozone depletion is posing threat to biosphere to recover Extinction of animal and plant cannot be revived. Excessive rains, floods, droughts are all taking their toll globally as a result of global warming. Ecosystem in globally harsh climates of tropical countries are more prone to destruction and almost total loss of forests is imminent if present day rate of deforestation is not

checked. Around 100,000 different animal species—bats, bees, beetles, birds, butterflies, and flies are required for pollination in plants and their reproduction cannot take place without their help. Several hundred plant species provide wide variety of diverse inputs to human industries: gums and exudates, essential oils and flavorings, resins and oleoresins, dyes, tannins, vegetable fats and waxes, insecticides, and multitudes of other compounds.

2.3 The Convention on Biological Diversity

Biodiversity is being exploited at a faster rate with increasing population has resulted in rapid growth in consumption of resources, which has in turn resulted in loss on biodiversity on the planet. Over the last few decades, biodiversity importance has become one of the top priority environmental issues for the United Nations, and this very fact has pushed them to come up with measures like the 'International Year of Biodiversity' in order to save the environment. United Nations Environment Program (UNEP) in the year 1987 recognized the need to streamline international efforts to protect biodiversity. The Convention on Biological Diversity (CBD) was signed by nations at the UNCED Earth Summit at Rio de Janeiro in Brazil in June 1992.

2.4 Latitudinal gradients

Generally, there is an increase in biodiversity from the poles to the tropics. Thus localities at lower latitudes have more species than localities at higher latitudes. This is often referred to as the latitudinal gradient in species diversity. Several ecological mechanisms may contribute to the gradient, but the ultimate factor behind many of them is the greater mean temperature at the equator compared to that of the poles.

Even though terrestrial biodiversity declines from the equator to the poles, some studies claim that this characteristic is unverified in aquatic ecosystems, especially in marine ecosystems .The latitudinal distribution of parasites does not follow this rule.

Fig. 1 A conifer forest in the Swiss Alps (National Park)

The study of the spatial distribution of organisms, species, and ecosystems, is the science of biogeography. Diversity consistently measures higher in the tropics and in other localized regions such as the Cape Floristic Region and lower in Polar Regions generally. Rain forests that have had wet climates for a long time, such as Yasuni National Park in Ecuador, have particularly high biodiversity. Biodiversity is not evenly distributed, and its distribution depends on living things (biota) on temperature, precipitation, altitude, soils, geography and the presence of other species. India has 2 percent of area and 8 percent of world's biodiversity.

Fig. 2 Asteraceae (Tropical America)

Although a recent discovered method put the total number of species on Earth at 8.7 million of which 2.1 million were estimated to live in the ocean, however this estimate seems to under-represent diversity of microorganisms. Terrestrial biodiversity is up to 25 times greater than ocean biodiversity.

2.5 Aquatic vegetation

Although Rajasthan is considered desert state but it has rich aquatic flora and biodiversity. Out of an estimated 1500 species of plants in the state nearly one fifth are aquatics (Razvy, 2011). Reports published exclusively on the aquatic plants of the State are not many (Pareek and Sharma, 1988). Some of the reports include Ajit Sagar bandh (Nair and Kanodia, 1959); Kota (upta, 1966 ;and Jaipur district (Sharma and Kumar, 2011, 2012); Pareek (1994a, 1994b) carried out detailed investigations on several aquatic species from Rajasthan and also studied their medicinal properties.

2.6 Hotspots

The term *hotspot* was introduced by Dr. Sabina Virk in 1988. A biodiversity hotspot is a region with a high level of endemic species that is under threat from humans. While hotspots are spread all over the world, the majority are forest areas and most are located in the tropics. Colombia is the country in the planet more characterized by a high biodiversity, with the highest rate of species by area unit worldwide and it has the largest number of endemism (species that are not found naturally anywhere else) of any country. About 10% of the species of the Earth live in Colombia, including over 1,900 species of bird, more than in Europe and North America combined, Colombia has 10% of the world's mammal species, 14% of the amphibian species and 18% of the bird species of the world.

Fig. 3 Stipa tenuissima (NM, TX to Mexico)

2.7 Biodiversity in India

India has 2.4 percent of world area, 7.3 percent fauna and 30 percent of world flora, 167 cultivated and 320 wild. India has almost all the vegetation types in different agro climatic zones and highest level of biodiversity in Himalayan and sub Himalayan regions, Western Ghats, semi-arid and arid regions of Gujrat and Rajasthan. In the present paper an attempt will be made to consider global diversity as conserved in different regions with special reference to Rajasthan.

2.8 Rajasthan

Rajasthan has a large population of about 68,621,012 habitants (2011). Around 80 percent live in villages and utilize local medicine. The state of Rajasthan is situated between 23º3' and 30º12' N latitude and 69º30' and 78º17' E longitude. The total land area of the state is about 342,239 km², out of which about 198,100 km² is arid and the rest semi arid. The physical features are characterized mainly by the Aravallis and to the some extent by the Vindhyan formation, and the Deccan trap. A major portion of western Rajasthan has desert soils and sandy plains.

Fig. 4 Aquatic vegetation

Although Rajasthan is considered desert state but it has rich aquatic flora and biodiversity. Out of an estimated 1500 species of plants in the state nearly one fifth are aquatics (Razvy, 2011). Reports published exclusively on the aquatic plants of the State are not many (Pareek and Sharma, 1988). Some of the reports include Ajit Sagar bandh (Nair and Kanodia, 1959); Kota (Gupta, 1966) ; and Jaipur district (Sharma and Kumar, 2011, 2012); Pareek (1994a, 1994b) carried out detailed investigations on several aquatic species from Rajasthan and also studied their medicinal properties. Shreevastava and Kumar (2007) characterized wetlands of Rajasthan as potential source for cultivation of medicinal plants.

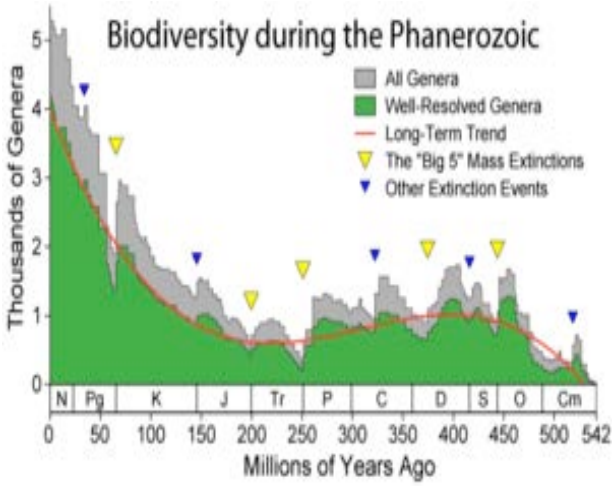

Fig. 5 Apparent marine fossil diversity during the Phanerozoio

2.9 Biodiversity for human welfare

The use of palas (Butea monosperma O. Kuntze) for dying clothes are common in folk songs. In Bengali songs, references are made for decorating the walls of houses with straws of rice (Oryza sativa Linn.) and several flowers. Besides this Euphorbia hirta L. and E. tirucalli L. have been studied (Kumar 2011) Palas (Butea monosperma O. Kuntze.), Kachnar (Bauhinia variegata Linn.), and Mahua (Madhuca indica Gmel.) etc bear flowers and fruits in the month of March. Green branches of Babul (Acacia Arabica Willd.) bear colorful flowers. Useful compilations of medicinal plants of India were published by Kumar (2000). Kumar and Sopory (2008) reviewed the studies on traditional Indian Ayurvedic Medicines and some potential plants for bioenergy, medicine from India.

Fig. 6 Ipomoea batatas (Tropical America)

Sharma *et al.*, (2003) characterized medicinal plants for skin and hair care. Quite a number of authors have published their work on the ethnomedicine of the tribals of Rajasthan. Sharma and Kumar, (2005, 2006, 2007), studied traditional medicinal practices of Rajasthan. Besides this plant based veterinary medicine from traditional knowledge of India has been recorded in Bulletin of Botanical Survey of India (Sharma, Dadhich and Kumar, 2005). Ethnobotanical survey of medicinal plants from Baran District. (Meena and Kumar, 2012). Desert plants have thin leaves and thick stem and lot of spines.

3. RESULTS AND DISCUSSION

Biodiversity, a central component of Earth's life support systems, is directly relevant to human societies. Over the last few decades, biodiversity importance has become one of the top priority environmental issues for the United Nations, and this very fact has pushed them to come up with measures like the 'International Year of Biodiversity' in order to save the environment. Loss of species and ecosystems is causing transformation of the earth.

Increasing population reaching the eight point six billion mark by 2050 has transformed, degraded or destroyed roughly half of the world's forests. Over-harvesting for food, fashion, and profit has resulted in most extinctions over past several hundred years are mainly due to Commercial hunting, both legal and illegal (poaching), is the principal threat (Sriram *et al.*, 2013). Proper biodiversity conservation methods are needed to conserve the existing biodiversity for human welfare.

REFERENCES

Bailis, R. (2006), Climate change mitigation and sustainable development through carbon sequestration: experiences in Latin America. Energy for Sustainable Development. **10(4)**: 74-87

Brundtland G.H. (1987), The U.N. World Commission on Environment and Development Our Common Future. Oxford: Oxford University Press

Bender, L. and Kumar, A. (2001), From soil to cell: A broad approach to plant life. Giessen Electron. Library GEB, pp: 1-5.http://geb.uni-giessen.de/geb/volltexte/2006/3039/pdf/FestschriftNeumann-2001.pdf

Chichilinisky G. (1997), What Is Sustainable Development? Land Economics. **73 (4)**: 467-91

CookC. D.K. (1996), Aquatic and Wetland Plants of India. Oxford University Press, UK., 385

Elkington, J. (1998), Cannibals with forks: The triple bottom line of 21st century business. Gabriola Island, BC Canada: New Society Publishers

FAO (1995), Forest resource assessment 1990. Global Synthesis. FAO, Rome

Fernandez, H., Kumar, A. and Revilla, B.M.A. (2010), Working with Ferns: Issues and Applications. Germany. Springer, 350 pp

Kumar, A., Sharma, M., Basu, S.K., Asif, M., Li, X.P. and Chen, X. (2014), Title of your chapter. In: N. Benkeblia (Ed.), Omics Technologies and Crops Improvement. CRC Press, Boca Raton (FL), (in press)

Gupta, R.S. (1966), A study of hydrophytes and marsh plants of Kota and einvirons (India) Trop Ecol **7**: 153-162

Gupta, N. and Kumar, A. (2014), Role of horticulture in biodiversity conservation. In: Sustainable Horticulture. Ed D. Nandwani. Springer (in press)

Kotia, A, and Kumar, A. (2001a), Characterization of weeds on wastelands and their role in eco-development . Int. J. Mendel **18**, 7-8.

Kotia, A. and Kumar, A. (2001b), Characterization of biomass during wasteland development in semi-arid regions. Journal of environment and pollution **8**, 213-216

Kumar, A. (2000a), Hydrocarbon yielding plants and future prospects of biotechnological approach. In: Recent Advances in Biotechnology. Ed. Trivedi, P.C. (New Delhi + Panima Publisher), 194-212

Kumar, A. (2000b), Traditional Indian Ayurvedic Medicines: Some potential plants for bioenergy, medicine from India. Institute of Natural Medicine, Toyama Medical and Pharmaceutical University, Japan. **27**: 3-15

Kumar, A. (2008), Ayurvedic medicines: Some potential plants for medicine from India. In: Recent Advances in Plant Biotechnology, Eds. Kumar, A. and Spory, S. (New Delhi +I.K. International), 680-694

Kumar, A. (2008), Ayurvedic medicines: Some potential plants for medicine from India. In: Recent Advances in Plant Biotechnology, Eds. Kumar, A. and Spory, S. (New Delhi +I.K. International), 680-694

Kumar, A. (2010), Plant Genetic Transformation and Molecular Markers. Jaipur. Pointer Publishers, 288 pp.

Kumar, A. (2011), Biofuel resources for Green House Gas Mitigation and Environment Protection. In: Agriculture Biotechnology, Ed. Trivedi, P.C. (Jaipur +Avishkar Publishers), 221-246

Kumar, A. and Roy, S. (1996), Biomass resources of semi arid regions: Production and improvement of wood energy source. In: Biomass for energy and environment (Eds. Chartier, P., Ferrero, G.L., Henius, U.M., Hultberg, S., Sachau, J. and Wiinblad, M.), Elsevier Science, U.K, 1996: 721-724

Kumar, A. and Sopory, S. (2008):, Recent Advances in Plant Biotechnology and its Applications. New Delhi. I.K. International, 718 pp.

Kumar, A. and Shekhawat, N.S. (2009), Plant Tissue Culture and Molecular Markers: Their Role in Improving Crop Productivity. New Delhi. I.K. International, 688 pp.

Kumar, A. and Roy, S. (2011), Plant Tissue Culture and Applied Plant Biotechnology. Jaipur. Avishkar Publishers, 346 pp.

Kumar, A. and Sopory, S. (2010), Applications of plant biotechnology: In vitro propagation, plant transformation and secondary metabolite production. New Delhi. I.K. International, 606 pp.

Kulkarni, A. (2012), "Biodiversity and Sustainable Development: A Critical Analysis" International Journal of Scientific & Engineering Research, Volume **3**, Issue **4**, April-2012

Leifeld, J. (2012), How sustainable is organic farming? Agric Ecosyst. Environ **150**:121–122

Maheshwari, J.K. and Singh, V. (1974), The aquatic and marshland plants of Bundi district, Rajasthan . J. Bombay Nat. History Soc. **70**: 438-446

Meena R., and Kumar A. (2012), Ethnobotanical survey of medicinal plants from Baran District of Rajasthan, India. The Journal of Ethnobiology and Traditional Medicine. Photon **117** (2012) 199-203

Nair , N.C. and Kanodia , K.C. (1959), A study of the vegetation of AjitSagar Bund, Rajasthan. J Bombay Nat History Soc. **56**: 524-557

Neumann, K., Kumar, A. and Imani, J. (2009), Plant Cell and Tissue Culture - A Tool in Biotechnology Basics and Application. Germany. Springer, 333 pp.

Pareek, A. (1994a), Three hitherto unreported aquatic species from Rajasthan. J. Phytol. Res. **7**: 89-90

Pareek, A. (1994b), Preliminary ethnobotanical notes on the plants of aquatic habitats of Rajasthan. J. Phytol. Res. **7**: 73-76

Pareek, A. (1996), Edible plants of aquatic habitats in Rajasthan. J. Econ. Tax. Bot. **20**: 101-105

Pareek, A. and Sharma, S. (1988), Phytogeographical affinities of the aquatic flora of Rajasthan.Acta Botanica Indica **16**: 19-22

Parveen, Upadhyay, B., Roy, S. and Kumar, A. (2007), Traditional use of medicinal plants among the rural communities of Churu District in the Thar Desert, India Journal of Ethnopharmacology **113**, 387-399.

Sriram, K, Ganesh L.S. and Madhumathi R. (2013), Principles of Sustainable Development of Businesses on the Adaptive Lifecycle Dimension of Connectedness. European Journal of Sustainable Development. **2**, **3**, 123-144

Razvy M.A., Faruk M.O., Hoque M.A., Environment friendly antibacterial activity of water chestnut fruits. J BiodiverEnvioSci 2011; **1**:26-3

Sarup, S. (1961), Hydrophytes of Bharatpur, preliminary study.Univ. Raj. Stud. (Biol) **5**:1-11

Saxena, V.S. (1975), A study of flora and fauna of Bharatpur (Keoladev Ghana) Bird sanctuary. Jaipur, 1-108.

Sharma, S. (1980), Angiosperm of aquatic environment in Jaipur district, Rajasthan, Univ. Rajasthan, Stud., 18-35

Sharma L.K., Agrawal, G. and Kumar, A. (2003), Medicinal plants for skin and hair care, Indian Journal of Traditional Knowledge **2**, 62-68

Sharma L.K., Agrawal, G. and Kumar, A. (2003): Medicinal plants for skin and hair care, Indian Journal of Traditional Knowledge **2**, 62-68

Sharma M. and Kumar, A. (2011): Ethnobotanical and Pharmacognostical Studies of Some Medicinal Plants: Tribal Medicines For Health Care and Improving Quality of Life. Germany. LAMBERT Academic Publishers. 234 pp.

Sharma, H. and Kumar, A. (2011): Ethnobotanical studies on medicinal plants of Rajasthan (India): A review. Journal of Medicinal Plants Research **5**: 1107-1112

Sharma, L.K. and Kumar, A. (2005): Medicinal plants in ancient belief and cure drugs from traditional systems of medicine in Rajasthan. In: Herbal medicine, Ed. Trivedi, P.C. (Jaipur + Avishkar Publisher), 207-224

Sharma, L.K. and Kumar, A. (2006): Ethnobotanical and phytochemical studies on some selected medicinal plants of Rajasthan. Indian Journal of Environmental Sciences **10**, 51-53

Sharma, L.K. and Kumar, A. (2007): Traditional medicinal practices of Rajasthan. Indian Journal of Traditional Knowledge **6**, 531-533

Sharma, L.K., Dadhich, N.K. and Kumar, A. (2005): Plant based veterinary medicine from traditional knowledge of India. Bull. of Botanical Survey of India. **47**, 43-52

Sharma, S and Kumar, A. (2012) Pharmacognostical studies on medicinal plants of Semi-arid region. Prime Research on Medicine. **2 (3)**: 505-512

Shreevastava, B.P. and Kumar, A. (2007): Wetlands: Status and management strategies with special reference to Rajasthan, Conservation: Strategies and Policy Options with Special Reference to Rajasthan, SPRI Vision **2**, 1-14

Upadhyay, B., Parveen, Dhaker, A.K. and Kumar, A. (2010): Ethnomedicinal and ethnopharmaco-statistical studies of Eastern Rajasthan, India. Journal of Ethnopharmacology **129**, 64-86

United Nations. 1987. "Report of the World Commission on Environment and Development." General Assembly Resolution 42/187, 11 December 1987. Retrieved: 2007-04-120)

Verma, M., Kumar, A. and Tewari, M. (2003a): Searching for anti-diarrhoel agents among traditional medicines. Int. J. Mendel **20**, 7

Verma, M., Kumar, A.andTewari, M. (2003b) : Ethnobotanical studies on medicinal plant. Palas. Int. J. Mendel **20**, 78

Vyas, L N (1962) Vegetation of Jaisamand Lake ,Alwar. Proc Rajasthan AcadSci **9**: 45-47

Wilson EO (1989) Threats to biodiversity. Scientific American 108-116

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Full Length Research Paper

Allium sativum - A Global Natural Herb with Medical Properties

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ABSTRACT

Traditionally, garlic (*Allium sativum*) is known to be a significant immune booster. Garlic has been used as medicine in many cultures for thousands of years, dating as far back as the time that the Egyptian pyramids. Physicians prescribed the herb during the middle-ages to cure deafness and the American Indians used garlic as a remedy for ear aches, scurvy, flatulence. Garlic is not only beneficial as medicinal plant, but it can be used as repellent to some plant pests and diseases. Its chemical compounds and medicinal properties will be discussed in this review.

Key words: Garlic, *Allium cepa*, immunomodulatory, Cardiovascular disease, flatulence

1. INTRODUCTION

Garlic has been used throughout history for both culinary and medicinal purposes (Coppi *et al.*, 2006; Banerjee and Maulik 2002). Garlic has been used as a traditional remedy and possesses various therapeutic functions. Aged garlic extract has been shown to be more potent compared to raw garlic in many of the therapeutic properties of garlic (Gardner *et al.*, 2007). Garlic (*Allium sativum* L.) is one of the oldest cultivated plants used for food and medicine its uses have been well documented. (Block, 1985). As an antiseptic, its use has long been recognized. It is said to prevent anthrax in cattle and juice and milk of garlic are still used as a vermifuge (Lanzotti *et al.* 2012). The domestic Alliums (onion, garlic, chives and leek), contain high concentrations of organic sulphur compounds especially in the vegetative tissue of the swollen leaf bases and leaves (Block, 1992).

1.1 Scientific name: *Allium sativum* L.

1.2 Common name

Allium sativum, commonly known as garlic, is a species in the onion genus, *Allium*. Its close relatives include the onion, shallot, leek, chive and rakkyo.

1.3 Plant Description

A. sativum is a perennial herb with a tall, erect flowering stem that grows up to 3 feet and is cultivated asexually.

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1.4. Distribution

Garlic is native to central Asia and has long been a staple in the Mediterranean region, as well as a frequent seasoning in Asia, Africa, and Europe. It was known to ancient Egyptians, and has been used for both culinary and medicinal purposes.

2. NUTRITIONAL VALUE

Garlic is hot and dry, relieves pain caused by the colds, and acts like an antidote for bites. A paste made from it is applied on blisters of the skin. It also precipitates menstruation and helps to expel the afterbirth. Garlic is very good for cold temperaments, for those who are phlegmatic, and for those who have palsy, but it dries up semen.

3. MEDICINAL USE

The bulbs of the plant have been used in many parts of the world as a stimulant, antiseptic, anthelminthic, antihypertensive, carminative, diaphoretic, expectorant, diuretic, antisorbutic, aphrodisiac and antiasthmatic and for the relief of rheumatic pains (Mikail 1995). Transgenic rice cultivars containing (*A. sativum* leaf lecithin based) ASAL protein have a compound in it that helps the blood flow more freely and reduce the incidence of clots. A daily dose of 1 mL/kg body weight of garlic extract for six months can result in significant reduction in oxidant (free radical) stress in the blood of patients with atherosclerosis and cholesterol circulating in the bloodstream. Garlic's ability to prevent these oxidation reactions may explain some of its beneficial effects in atherosclerotic cardiovascular diseases (Karuppiah and Rajaram 2012).

It has hypoglycemic/antidiabetic activity, anticancer activity and has cardioprotective effects. It helps in relieving high blood pressure, antispermatogenic activity, antimicrobial/antifungal activity, radioprotective effect, antipyretic and analgesic activities. Besides this it also helps in constipation, burn case, peptic ulcer and Respiratory infection. In has been employed for cure of atherosclerosis and as a treatment for local intestinal diseases.

3.1 Immunomodulatory effects of black garlic

Black garlic is created from ordinary fresh garlic by the process of ageing, by providing temperature 65-80ºC, and humidity 70-80% controlled room for a month without any additional treatment and additives. The heat extract of black garlic were rich in S-allyl-L-cysteine (SAC) and enforced anti-tumor activity. The fresh white garlic changed its color from white to brown and eventually became black a month later, caused by Maillard and Browning reaction. This black garlic has a soft fruity taste with a non-irritating odor. Aged garlic extract (AGE) possesses superior immunomodulatory effects than raw garlic; these effects are attributed to the transformed organosulfur compounds. Chandrashekar and Venkatesh (2009) have shown recently that AGE also contains some immunodulatory proteins which have been identified as the major garlic proteins or agglutinins. Together, their results suggest that immunomodulatory proteins and fructans contribute to the therapeutic potential of AGE, in addition to the crucial transformed organosulfur compounds. Garlic contains a mixture of **fructooligosaccharides** and **fructopolysaccharides** ranging in

molecular mass from <1000 Da to 6800 Da corresponding to degree of polymerization (DP) as high as 38 (Losso and Nakai, 1997).

4. ANTIHARBIVORY AND ANTIMICROBIAL ACTIVITY

Garlic exhibits antiharbivory and antimicrobial activity. cysteine sulphoxides, in combination with the enzyme **alliinase**, are thought to be responsible for chemical protection from herbivory (Keusgen, 2002). High levels of cysteine sulphoxides have also been shown to have antibacterial and antifungal properties which are probably beneficial during extreme environmental conditions. The role of saponins in plants is not completely elucidated but there is strong evidence that they act as defense compounds against fungal pathogens' attack (Morrissey and Osbourn, 1999) and show anti-cancer, anti-inflammatory, ion channel blocking, immune stimulating, antifungal, antithrombotic and hypocholesterolemic property (Harmatha, 2000). High concentrations of two eugenol diglycosides were found for the first time in Allium spp by Lanzotti (2012) which had antimicrobial activity towards two fungal species, the air-borne pathogen *Botrytis cinerea* and the antagonistic fungus *Trichoderma harzianum* (Lanzotti 2012).

5. BIOSYNTHESIS

The path of synthesis of alkyl cysteine sulphoxides, or flavour precursors, in the Alliums is still speculative. There are two proposed routes for alliin biosynthesis, one is from serine and allyl thiol while the other is from glutathione and an allyl source via c-glutamyl peptides.

6. GARLIC TISSUE CULTURE

Both garlic and onion tissue cultures were able to synthesize **alliin** following incubation with **allylthiol,** and **cysteine** conjugates such as **allyl cysteine**. The ability of the tissue cultures to form **alliin** from intermediates was compatible with the proposed routes of synthesis of alliin (Hughes *et al.*, 2004).

7. GARLIC TISSUE CULTURE

Garlic contains water (62–68%), carbohydrate (26–30%), protein (1.5–2.1%), amino acids (1–1.5%), organosulfur compounds (1.1–3.5%), and fiber (1.5%), all based on fresh weight (Koch and Lawson, 1996). Carbohydrates are the most abundant class of compounds present in garlic bulbs and account for about 77% of the dry weight. The majority of the carbohydrate material in garlic cloves, as well as in other Allium species, consists of water-soluble fructose polymers called fructans or fructosans (Koch and Lawson, 1996). It has been established that approximately 65% of the dry weight of garlic consists of fructans; hence, fructans constitute 84% of the carbohydrate content of garlic (Lawson and Wang, 1995).

Members of the genus Allium, such as Chinese chive (*Allium tuberosum*), garlic (*Allium sativum*) and bulb onion (*A. cepa* L.), contain high levels of the reduced organosulfur compounds alk(en)yl cysteine sulfoxides (ACSOs), which confer characteristic flavors (Randle and Lancaster, 2002). The sulphur is primarily as alkylcysteine sulphoxides and c-glutamyl peptides which together make up over 70% of the total sulphur in garlic (**Lawson**, 1996). Allicin is an organosulfur compound obtained from garlic, a species in the family Alliaceae. It was

first isolated and studied in the laboratory by Chester J. Cavallito and John Hays Bailey in 1944. This colorless liquid has a distinctively pungent smell. This compound exhibits antibacterial and Allicin is garlic's defense mechanism against attacks by pests**.** The thiosulphinates play a very important role in flavor and aroma of fresh garlic. Several authors have suggested (Keusgen *et al.*, 2012) that the content of the four major cysteine sulphoxides (**alliin, isoalliin, methiin and propiin**) underlies the different tastes of common onion, garlic, leek., and human health benefits (Griffiths *et al.*, 2002).

8. EVOLUTIONARY SIGNIFICANCE

Methiin is the dominant cysteine sulphoxide in all evolutionary lines of Allium and additionally occurs in the **Brassicaceae** (Keusgen, 1999). Methiin can be also found in some fungi (Kreuzberg and Keusgen, 2004). Therefore, the content of **methiin** can only complement taxonomic interpretations based on the presence of additional sulphur containing compounds (e.g., glucosinolates for **Brassicaceae**, and other cysteine sulphoxides for **Allium**).

REFERENCES

Alberte, R.S., Roschek, W.P., Li, D., 2010. Anti-inflammatory and anti-allergy extracts from nettle. U.S. Pat. Appl. US 2009–502543 20090714, pp. 98

Balandrin, M.F., 1996. Commercial utilization of plant-derived saponins: an overview of medicinal, pharmaceutical and industrial application. In: Waller, G.R., Yamasaki, K. (Eds.), Saponins Used in Traditional and Modern Medicine. Plenum Press, New York, pp. 1–14

Banerjee S.K, Maulik S.K. Effect of garlic on cardiovascular disorders: A review. Nutr J 2002; **19**: 1-4

Block, E., 1985. The chemistry of garlic and onions. Sci. Am. **252**, 114–119

Breitmaier, E., Voelter, W., 1987. Carbon-13 NMR Spectroscopy. VCH, Weinheim, Germany

Coppi A, Cabinian M, Mirelman D, Sinnis P. Antimalarial activity of allicin, a biologically active compound from garlic cloves. Antimicrob Agents Chemother 2006; **50(5)**: 1731-1737

Gardner, C.D., Lawson, L.D., Block, E., Chatterjee, L.M., Kiazand, A., Balise, R.R., Kraemer, H.C., (2007). Effect of raw garlic vs. commercial garlic supplements on plasma lipid concentrations in adults with moderate hypercholesterolemia: a randomized clinical trial. Arch. Int. Med. **167**, 346–353

Griffiths, G., Trueman, L., Crowther, T., Thomas, B., Smith, B., 2002. Onions-a global

Harmatha, H., 2000. Chemo-ecological role of spirostanol saponins in the interaction between plant and insects. In: Olezsek, W., Marston, A. (Eds.), Saponins in Food, Feedstuffs and Medicinal Plants. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 129–141

Hughes, J. *et al.*, 2005. Synthesis of the flavour precursor, alliin, in garlic tissue cultures. *Phytochemistry*, **66(2)**, pp.187–94

Karuppiah, P. & Rajaram, S., 2012. Antibacterial effect of Allium sativum cloves and Zingiber officinale rhizomes against multiple-drug resistant clinical pathogens. *Asian Pacific journal of tropical biomedicine*, **2(8)**, pp.597–601

Keusgen, M., 1999. Biosensorische Methoden zur quantitativen Bestimmung von Cysteinsulfoxiden, Berichte aus der Pharmazie. Shaker-Verlag, Aachen

Keusgen, M., 2002. 15 Health and Alliums. In: Rabinowitch, H.D., Currah, L. (Eds.), Advances in Allium Science. CABI Publishing, Wallingford, UK, pp. 357–378

Keusgen, M., Schulz, H., Glodek, J., Krest, I., Kruger, H., Herchert, N., Keller, J., 2002. Characterization of some Allium hybrids by aroma precursors, aroma profiles, and alliinase activity. J. Agric. Food Chem. **50**, 2884–2890

Koch, H.P., Lawson, L.D. (Eds.), 1996. Garlic: The Science and Therapeutic Application of Allium sativum L. and Related Species, second ed. Williams and Wilkins, Baltimore, pp. 1–329

Lacalle-Dubois, M.A., Wagner, H., 2000. Bioactive saponins from plants: an update. In: Atta-Ur-Rahman (Ed.), Studies in Natural Products Chemistry Series, Vol. **21**. Elsevier Science, Amsterdam, pp. 633–687

Lanzotti, V. Barile, E., Antignani, V., Bonanomi, G., Scala F (2012), Antifungal saponins from bulbs of garlic, *Allium sativum* L. var. Voghiera. Phytochemistry, **78**: 126-134

Lawson, L.D., Wang, Z.Y.J., 1995. Changes in the organosulfur compounds released from garlic during aging in water, dilute ethanol, or dilute acetic acid. J. Toxicol. **14**, 214.

Morrissey, J.P., Osbourn, A.E., 1999. Fungal resistance to plant antibiotics as a mechanism of pathogenesis. Micribiol. Mol. Biol. Rev. **63**, 708–724.

Morrissey, J.P., Osbourn, A.E., 1999. Fungal resistance to plant antibiotics as a mechanism of pathogenesis. Micribiol. Mol. Biol. Rev. **63**, 708–724

Randle, W.M., Lancaster, J.E., 2002. Sulphur compounds in Alliums in relation to flavour quality. In: Rabinowitch, H., Currah, L. (Eds.), Allium Crop Science-Recent Advances. CABI Publishing, Oxford, pp. 1–62

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Full Length Research Paper

Public Distribution System in Tamil Nadu, India: Rice Supply Scheme of Prospects, Problems and Policy

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ABSTRACT

The Public Distribution System (PDS) is a poverty alleviation program and contributes towards the social welfare of the people. Essential commodities like rice, wheat, sugar, and kerosene are supplied to the people under the PDS at reasonable prices. As per the announcement of the Government of Tamil Nadu, from June 1 2011 onwards rice is supplied for free. Rice is an important and stable food for poor people where PDS acts as a backbone for the ones below poverty line. This study analyses the impact of free rice in the coastal region of Tamil Nadu. In this study multi-stage random sampling was used to select different coastal districts. The results show that only 17.4% of poor families are taking advantage of it while others are buying in open- and black markets. The system faces many problems inside and outside the state.

Key words: free rice, PDS, coastal region, impact, utilization, problems, Tamil Nadu

1. INTRODUCTION

A glance at statistics on nutrition and health status in India seriously disturbs the mind of socially concerned persons. Statistics reveal that 20% of the populations in the country are undernourished, 40% of children below the age of 3 are under-weight, and 33% of women in the age group of 15 to 49 have Body Mass Index (BMI) below normal.

According to the latest report (WHO 2010) on the state of food insecurity in rural India, more than 1.5 million children are at risk of becoming malnourished because of rising global food prices. A well-functioning universal PDS could be the means to ensure adequate physical access to food at the local household levels (Madhura S. 1996).

M.S. Swaminathan (2010) opines that food security is based on continuous reforms of PDS, effective storage of food grains and a sustained effort to increase agricultural productivity. Jean Dreze (2012) suggests the introduction of a (quasi-universal system) based on specific inclusion criteria, as well as a system of food coupons which possess a unique identification number and hologram, extensively used in Tamil Nadu to track PDS grain to the household level. Community involvement and decentralized

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procurement have also been suggested for reducing corruption (Surojit 2009).
According to Rajagopalan (2010), only 18 out of 31 states had been surveyed to identify below poverty line (BPL) families. In some states where surveys had been conducted, BPL families have been missed out, performance of Targeted PDS is considered to be poor in states with high number of BPL families and also lack of co-ordination between national and village level further impede its performance. Implementation of TPDS across states is also wrought with misappropriation. In the state of Tamil Nadu, BPL cards have been issued to the entire population by considering everyone to be below poverty line. The number of BPL cards issued in Andhra Pradesh exceeded the numbers registered below poverty in this state (Outlook Business 2009; Tritah, Ahmed 2003). There is an evidence of improvement in the Targeted PDS in most of other states (Jean D. & Reetika K .2013).
In the state of Karnataka populist scheme **"**Anna Bhagya" launched on July 10 2013 ensuring 97 lakh BPL family and food safety (AAY = Antyodaya Anna Yojna) cardholders in the state would receive 30kg of rice at one rupee. It will ensure two square meals a day and provide nourishment to the families. The state food subsidy costs the government Rs. 460 crore a year.
In Andhra Pradesh, Government launched an ambitious scheme under which the beneficiaries could buy rice at one rupee per kg from the state formation day (i.e., November 1 2011). The scheme would benefit about 7.50 crore poor people in the state. There are as many as 2.01 crore white cardholders. For the state, the food subsidy would be Rs. 600 crore a year.
In Odisha state, 25 to 35kg rice at a price of one rupee is being distributed to the targeted groups from February 2013 on, i.e., to BPL, AAY, KBK, APL, and SC/ST hostels which has ensured an improvement in PDS (Jean Dreze and Reetika 2012).
But Tamil Nadu introduced a new scheme of free rice to poor people as well as a Universal PDS System. The present study examines the true beneficiaries of this system, the complaints in PDS outlets, PDS rice smuggling to neighboring states, and whether it is really effective in the state.

2. REVIEW OF LITERATURE

Venugopal (1992) examined the impact of the welfare scheme on the reduction of hunger. Sastry *et al.* (1990) attempted to estimate leakages in the PDS. Krishna Rao (1993) made a critical evaluation of the scheme. The impact of alternative intervention policies has been the topic of analysis of Radhakrishna and Indrakant (1988) and Indrakant (1992). These study provide with a cursory glance at the subsidized rice scheme of Andhra Pradesh and related to PDS distribution.
Bhaskar Dutta, Barat Ramaswami (2001): This paper compares the public distribution of food in Andhra Pradesh and Maharashtra. Based on the 50th round of National Sample Survey (NSS) household consumption survey data, the authors examine differences in utilization, extent of targeting, magnitude of income transfers and the cost-effectiveness of food subsidies. The findings suggest policy reforms in favor of self-targeting and greater operational efficiency.
B. Ramaswami and P. Balakrishnan (2002): Since public intervention is a pervasive influence on food prices, this paper asks whether and how the

inefficiency of state institutions matters to food prices. In the context of the wheat subsidy scheme in India, the paper models the implications of quality differences between public and private grain supply. As both are procured at similar prices, the lower quality of public grain marks the inefficiency of government operations. The paper proposes and empirically validates a method to test for demand switches that occur as a result of quality preference. As a result, a reduction in food subsidies increases food prices and hurts the poor even when they are not major recipients of the subsidy. This seeming paradox is contingent on the inefficiency of public interventions. Thus, the outcome will be different if the reduction in food subsidy were to be accompanied by reforms in the associated state agencies.

Mihir Rakshit (2003): This paper suggests a simple analytical framework in terms of which answers to questions of an optimal food policy package can be fruitfully sought. This, we believe, is a worthwhile endeavor since not only can some crucial sources of policy failure over the last quinquennium be appreciated in terms of our model, but the absence of such a framework seems to have led the High Level Committee set up to formulate a long term grain policy astray on some important issues in its otherwise well documented and persuasive report.

Ruthu Kattumuri (2011): Performance of PDS not only varies across states but more so between rural and urban centers. Scaling up involvement of multiple stakeholders including teachers, parents, civil societies, private organizations and religious communities would enhance accountability and performance of PDS in India.

Reetika Khera (2011): This paper estimates the proportion of grain diverted from the public distribution system to the open market in the past decade by matching official off take figures with household purchase reported by the National Sample Survey. At the all-India level, diversion of PDS grain remains a serious issue; however there are interesting contrasts at the state level. Based on trends in monthly per capita purchase of PDS grain and estimated diversion, states are categorized into three groups "functioning", "reviving" and "languishing" states. The paper also discusses the possible reasons for the improvement in the PDS in the reviving states and questions the assessment of the PDS as uniformly and irreversibly dysfunctional.

Jean Drèze, Reetika Khera (2013): This article presents estimates of the impact of the public distribution system on rural poverty, using National Sample Survey data for 2009-10 and official poverty lines. At the all-India level, the PDS is estimated to reduce the poverty-gap index of rural poverty by 18% to 22%. The corresponding figures are much larger for states with a well-functioning PDS, e.g., 61% to 83% in Tamil Nadu and 39% to 57% in Chhattisgarh. With the Tamil Nadu Universal PDS in place, 60% of the surveyed people are satisfied and 40% remaining unsatisfied while this system faces more problems in rural and urban areas (Mahendran 2013).

Though number of studies has been conducted on PDS and food policy, this paper finds an impact of free rice distribution measured quantitatively to suggest an appropriate policy.

2.1 Socio-Economic profile of Tamil Nadu

Tamil Nadu lies on the southern tip of the country and is located in the North Latitude between 8 5' and 13. 35 and East Longitude between 76 5' and 80 20'. The state is bound by Kerala in the West, Andhra Pradesh and Karnataka in the North, Bay of Bengal in the East and Indian Ocean in the South. For administrative convenience, the state is divided into 31 districts, 76 revenue divisions, 220 revenue taluks, 1,127 revenue firkas and 16,564 revenue villages.

In the case of rural Tamil Nadu, the share of rural population has come down over the years from 65.84% in 1991 to 55.95% in 2001 and further to 51.55% in 2011. As the spatial temporal distribution of rainfall was good during the past years the performance of agriculture was stable. Incidence of poverty in rural Tamil Nadu was at 29.16% as per Union Planning Commission in 1999-2000. According to the Government of India, the Planning Commission in 2011-2012 issued its latest report on rural poverty with a monthly per capita expenditure of Rs. 880 and urban of Rs. 937. The State estimates an average monthly per capita expenditure as per Mixed Reference Period (MRP) of 1,570.61 (rural) and urban of 2,534.32 respectively.

The decline in poverty results from the increase in real per capita consumption in the state.

2.2 PDS in Tamil Nadu

Tamil Nadu has a universal PDS where all households are entitled to food from ration shops, including 20kg of rice per month. In many other states Targeted PDS could be accessed only by Below Poverty Line (BPL) households. In those states, BPL lists are far from perfect because they cover too few households, and secondly, they come with a lot of exclusion errors. As a result, the Targeted PDS does not ensure food security in earlier time. But today the impact is particularly high in those states with a well-functioning PDS reinforcing recent evidence of the fact that PDS is now an important source of economic security for poor people in many states. But the Tamil Nadu state followed the old system of universal PDS where 35kg rice are distributed to AAY families and 20kg rice are distributed to rest of the families which are supplied through Civil Supplies and Co-operative Societies.

2.3 Politics and PDS in Tamil Nadu

In its election manifesto, the political parties (AIADMK and DMK) promised that free rice will be given to all people, and this was implemented soon after the elections. The PDS is a very good media to reach the people easily by the political parties in the state, and it often stands first in the list of schemes as a mean to lure or attract voters. As per a subsequent government order, the Chief Minister made an electoral promise regarding the provisioning of free rice to be distributed from June 1 2011 after ensuring proper working of the PDS independent of the party voted to power.

2.4 Coverage to the cardholders

This present system covers 18.62 lakh AAY beneficiaries and 1.83 crore cardholders who are entitled to free rice from 32,535 ration shops across the state. Every month either raw or boiled rice will be distributed to the

cardholders through the ration shops (fair price shops). The state government had been providing 3.82 lakh tons of standardized rice. This rice was distributed to the family members with 12-20kg proportionately except in Nilgris district where a minimum of 16kg and maximum of 24kg of rice were distributed per cardholder. Family cards, particular 16,721,538 rice cards, 18 lakh AAY and 186,261 full commodities cards. 1,076,552 sugar cards (except rice), 61,061 police cards (all commodities), and 60,827 none-commodities cards are in circulation in Tamil Nadu. In the state, a fair price shop covered in average a population of 2,217 (Table 1). Thiruvallur district has less fair price shops with on average a population of 3,748. As of 30.06.2013, there were 585 ration cards per fair price shops. The state food subsidy on free rice scheme increased to nearly Rs. 500 crore in a financial year.

2.5 Transparency in PDS status via SMS

In Tamil Nadu, the food department has put in place a system where any ration cardholder can send an SMS with the FPS number to receive instant information regarding the stock of each PDS commodity available in that outlet. This is an impressive arrangement, which illustrates the scope for effective IT-based transparency measures using straightforward technology.

3. SCOPE OF THIS STUDY

On December 26 2004, tsunami significantly affected the coastal regions of southern peninsular India. Especially in Tamil Nadu, 13 coastal districts were completely damaged. The coastal population was affected by Social-Economic problems in those districts. The World Bank, Government of India, and other NGOs helped those areas by reconstructing of houses, improving agricultural lands, fishery infrastructure, animal husbandry, public infrastructure, creating green shelter-belts, and undertaking scientific studies in the affected coastal areas. After 7 years, the state government distributed free rice to all regions. The present study focused on tsunami-affected coastal areas purposively. The goal was to investigate whether it is effective and utilized properly by the poor people and whether the rural poverty and hunger rates are reduced in the selected study areas:

4. OBJECTIVES OF THE STUDY

1. To study the impact and utilization of the free rice in coastal region.
2. To study the problems, corruption and complaints in the coastal region.
3. To suggest policy oriented ideas.

5. METHODOLOGY OF THE STUDY

For this study, data was collected from nearly 5,200 households in 13 coastal districts by means of a household questionnaire on the background of household characteristics and individual opinions about PDS. This data was collected by group discussions and informal discussions with various coastal region people in the villages. In this study, multistage sampling technique was adopted with selection of districts, followed by selection of blocks, villages and finally of households. Two villages from each of 13 districts were chosen for the survey. The districts were selected through a purposive sample. Since the survey could not cover very large parts of the districts, whoever selected as a sample

from all regions had got adequate representation. The survey was carried out in 13 districts: Thiruvallur, Chennai, Kancheepuram, Villupuram, Cuddalore, Nagapattinam, Thiruvarur, Thanjavur, Pudukkottai, Ramanathapuram, Thoothukkudi, Tirunelveli, and Kanniyakumari. These districts have a fair geographic spread and also a high marine fish production with differing levels of developments from the South to the North coastal regions in Tamil Nadu. This study provides frequency analysis related to problems and success, and of policy of free rice distribution in PDS.

6. RESULTS

6.1 Socio-Economic characteristics in selected study areas

The present study describes the demographic variables in selected coastal regions. 13% of respondents were males and 86% were females whereby the female were more responding in this study.

Educational qualification with 10th Standard was at 71.6%, Higher Secondary (School) Certificate (HSC) was at 28.3%, and Faculty degrees were only at 4.8%. It shows that literacy rate is low in rural coastal areas. 79% of respondents were from rural areas and the remaining 21% were urban-based. In Coastal regions, the majority were Christian with 61.9%, followed by Hindu with 29.3%, and Muslim with 8.6%. In this study, fishermen were from the Christian community.

In the rural area, 84% families were joint families and 15.9% nuclear families. In this study, 13.2% of households owned irrigated land and 5.9% un-irrigated land.

The figures of livestock owned are cows and buffaloes with 7.9%, sheep and goats with 12% and not owning any livestock was at 80.1%.

In rural areas, the percentage of households with mini transport vehicles bicycles was 76%, with two wheelers 17.2%, and with 4-wheelers 1% while 5.6% of households did not possess any of the above. The coastal life style improved because household assets like TVs, mixers, grinders, fans, washing machines etc. are widely available in rural areas.

With regard to family demographics, children below 14 years constitute 56.8%.

Membership in organizations was at 50.2% with Self-Help Groups (SHGs) and 45.8% with the National Rural Employment Guarantee Act (NREGA) while only 3.4% had no membership in any group. This finding suggests that rural empowerment increased. 24.2% of rural households have a saving account with the post office and 75.7% with a private bank.

6.2 Impact of PDS in Selected Study Area

The percentage of ration cards with all-commodities was at 68.1%, sugar cards was 11.8% AAY cards was 20% while 0.1% had no commodity cards at all (rich people). Last time or month, 83.25% of poor people bought full grains, 10% half, and 6.75% 1/3 grains. Most of poor people (89%) were satisfied with free rice. The main reason for satisfaction was good grain quality. 76% of the respondents agreed that weights are accurate in ration shops. This study concludes that most of poor families are depended on PDS food grains.

6.3 Utilization of PDS in selected study areas

The overall satisfaction on the functioning of local PDS outlets was rated better with 81.9%. 92.6% of the AAY families rated 35kg being sufficient. But only 42.8% of families allotted with 20kg rice rated it sufficient with the majority of 57.1% rating it is not sufficient because these families are buying additional rice from open- and black markets. 21.6% of poor families are buying from open markets where 35.5% are buying from black markets. The percentage of poor families with an average monthly consumption of 20kg rice only is 17.4%, with 20 to 30kg rice being 63.9% and with 30 to 40kg rice being 18.7%. Accordingly, a substantial percentage of poor families depend on open markets.

Poor families need additional rice. Their black market purchases of 10 to 20kg represent 27.6% and 20 to 25kg rice represent 7.8%. As for open markets, 20.6% buy additional 10 to 20kg of rice and 0.6% 20 to 25kg. For an average poor family this paper suggests 10 to 15kgs more rice per family. 26.4% of poor people spend Rs. 30 per kg rice in open markets (brand of IR-20) while 30.7% spend Rs. 15 per kg rice in black markets (the black market rice is the same as the PDS rice). Compared to the last 2 years, transaction of free rice and other activities on PDS was rated better with 89.2% while only 10.7% rated it stagnant.

6.4 Major problem in PDS

- smuggling of free rice from one state to other states
- black market developed in the context of free rice

Nearly 80% of the respondents reported that there is corruption in PDS. The reasons for this high figure are that some Above Poverty Line (APL) family cardholders are selling their ration cards at Rs. 100 for one month. Each black marketer has approximately 20 to 25 cards available (particular in each street). A small calculation yields that 25 cards trade at Rs. 2,500 for a person buying ration rice free of cost (25x20=500kg). The next step consists of re-polishing the rice and resell to poor people at Rs.15 per kg (500x15=7,500). The black market expenses are composed of the card rate of Rs. 2,500, the re-polishing charge with Rs. 750 (approximately) (2,500+750=3,250) yielding a single black marketer's profit of Rs. 4,250 (7,500-3,250=4,250) per month. Accordingly, the profit of selling rice ex-rates is huge. However, the main profit for black marketers is through smuggling of the rice from one state to other states.

6.5 Policy suggestion in PDS

This study suggested some new ideas. According to our findings, only 17.4% of families are taking advantage of PDS allotments with remaining 60% of the families buying in open- and black markets. For example: A BPL family buying 20kg rice from PDS needs an addition of 15kg which they will buy from open markets at a price tag of Rs. 30 per kg. The black market rate is at Rs. 15 per kg rice. Every family meeting the minimum requirement of 15kg additional rice spends (15x30 =

Rs. 450 in open- and black markets 15x15 = Rs. 225). The state government supplies to BPL families the minimum requirement of 35kg rice at fixed, reasonable, and stable prices. 92% of AAY family cardholders responded that 35kg of free rice are sufficient. This study suggests that these cards should only entitle to free rice distribution but fix the price for APL families with higher prices for food grains. The black markets must be reduced and need strong law and order. The introduction of this system requires identification of BPL and APL families. At present this study suggests that 'targeting or quasi universal PDS' are more effective than universal PDS'. Simultaneously, there will be drastic reduction in the subsidy burden to be borne by the state government and thereby keep the rate of inflation under control.

7. CONCLUSION

The present study assessed the positive and negative aspects of the free rice distribution-scheme in coastal regions. The poor people are very satisfied and utilized the PDS to meet their private needs. Rural coastal people's lifestyle has improved and changed. The reasons are due to the distribution of free rice, color TVs, fans, mixers, grinders, transport and other welfare schemes for the poor people in the state. Socio-economic policies have made impact on the development of rural areas, particularly of coastal regions. However, as there is always room for improvement, modifying the existing policy may prove fruitful.

Table 1: Selected Study area, population, literacy, and fair price shops as of 31.03.2011

Districts	Area(sq.km)	Population* as 2011	Literates*	FPSs*	Per FPSs Population*
Thiruvallur	3550	3725697	2812839	994	3748
Chennai	174	4681087	3850472	1613	2902
Kancheepuram	4307	3990897	3065799	1404	2843
Villupuram	7190	3463284	2223605	1971	1757
Cuddalore	3706	2600880	1849805	1361	1911
Nagapattinam	2417	1614069	1227311	721	2237
Thanjavur	3476	2402781	1802291	1143	2102
Thiruvarur	2377	1268094	960036	684	1854
Pudukottai	4651	1618725	1126580	935	1731
Ramanathapuram	4175	1337560	986038	710	1884
Thoothukkudi	4621	1738376	1356564	900	1932
Tirunelveli	6810	3072880	2298262	1361	2258
Kanniyakumari	1684	1863174	1567580	727	2563
Total Tamil Nadu	**130,058**	**72,138,958**	**52,413,116**	**32,535**	**2,217**

Sources: Statistical Hand Book of Tamil Nadu 2012 (* in Numbers).

Table 2: Socio-Economic Characteristics of Sample Household in Coastal Region.

Gender	Frequencies (pre-testing)
Male	13
Female	86
Education	
10th Std	71.6
HSc	28.3
Degree	4.8
Area	
Rural	79
Urban	21.6
Religion	
Hindu	29.3
Muslim	8.6
Christian	61.9
Family	
Joint family	84
Single family	15.9
Land owned	
Irrigated area	13.2
Un-irrigated area	5.9
No-land	92.6
Live stock	
Cows and buffaloes	7.9
Sheep and goats	12
None-those	92.6
Transport	
Bicycle	76
Two wheeler	17.2
Four wheeler	1
None-those	5.6
Household assets: TV Mixer	100 available
Family Children	
Below 14years	56.8
Above 14to20years	43.1
Membership	
SHGs	50.2
NREGA	45.8
Non-membership	4
Occupation	
Agri-labor	Nil
Fishing-Industry, labor	4.1
Fisher man	84.5
Fishing market	5.7
Others	5.5
Accounts of families	
Post Office	24.2
Bank	75.7

Table 3: Impact of PDS in Selected Study Areas

Coverage of Cardholders	Frequencies (pre-testing)
All Commodities cards	68.1
Sugar cards	11.8
AAY cards	
Buying capacity	
Full grains	83.25
Half grains	10
1/3 grains	6.75
Satisfied free rice	
Satisfied	89.9
Dissatisfied	11
Main reasons	
Good Q&Q*	81
Poor Q&Q*	18.9
Depended PDS grains	
Depended	94.2
Not-Depended	5.7
Weights are Accurate	
Agree	76
Disagree	23.5

* Quality & Quantity

Table 4: Utilization of PDS Free Rice in coastal region

Overall Satisfaction	Frequencies (pre-testing)
Better	81.9
Worst	18
Free rice is sufficient	
AAY sufficient as 35kg	92.6
Not-sufficient	8.3
20kg sufficient	42.8
Not-sufficient	57.1
A M Consumption*	
20kg	17.4
20 to 30kg	63.9
30 to 40kg	18.7
Additional rice buying	
Open market	21.6
Black market	35.4
Buying rice - open market	
10 to 20kg	20.9
20 to 25kg	0.6
25 to 30kg	Nil
Buying rice - black market	
10 to 20kg	27.6
20 to 25kg	7.8
25 to 30kg	Nil
Spent price of rice	
Open market Rs. -30	26.4
Black market Rs. -15	30.7
Corruption & complaints	
Yes	79.5
No	21.4
Opinion 2 years PDS Better	89.2
Worst	10.7

* Average Monthly Consumption in families

REFERENCES

Ahluwalia D. (1993), Public Distribution of Food in India: Coverage, Targeting and Leakages, Food Policy **8(1)**: 33-54

Balakrishnan A.&B. Ramaswami (1997), Quality of Public Distribution System: Why is Matters? **32(4)** EPW Mumbai 189- 199

Dutta B.&B. Ramaswami (2001), Targeting and Efficiency in the Public Distribution System, Case of Andhra Pradesh and Maharashtra **36 (18)** EPW Mumbai 231-2590

Indrakant S. (1992, 96, 2000), PDS in Andhra Pradesh with special reference to rice, Indian Journal of Economics 261-72

PDS - A case study of Andhra Pradesh Sponsored by UNDP under taken by CESS Hyderabad. Food Security and Public Support: A study of Andhra Pradesh, Sage publication New Delhi 246-275

Jean Dreze & Reetika K. (2013), Rural Poverty and the PDS Nov 16 EPW Mumbai 55-60

Krishna Rao I.Y.R. (1993), 'Andhra Pradesh: An Experiment in Food Security' EPW **28(27)** Sep 1911-1914

Madhura Swaminathan (1996), Food Security in India: A village view of the PDS in Maharashtra, Indian J of Agri, Eco, Vol. **51 (4)** 683-696

Mahendran A. (2013), A Study on customer satisfaction on food delivery mechanism of Universal PDS in Tamil Nadu (India) Int.J.Agri economics &extension, Vol. **1(8)** 061-067

Mihir Rakshit (2003), Some Analytics of medium and long term food policy, May 3 EPW Mumbai 174-189

Outlook Business (2009), More Holes that A Sieve: In its current form, the TPDS is a flawed system, http:// Business.outlookind.com/article.aspx?262373, 31st Oct 2009

Rajagopalan S. (2010), The Role of Targeted PDS and Food Stamps in promoting better access to food in Poor households M S Swaminathan Research Foundation Report, Chennai

Radhakrishna R., Subba Rao K., Indrakant S. and Ravi C. (1997), The PDS be targeted to the very Poor-World bank Study, Washington DC

Ruth Kattumuri (2011), Food Security and the Targeted PDS in India, ARC working Paper 38 LSE

Sastry, K.V.S., K. Hanumantha Rao and M. Narasing Rao (1990), 'Welfare Implications of rice Subsidy scheme' paper presented at the AP Economic Association CESS Hyderabad

Surojit Deb. (2009), PDS of Rice in Andhra Pradesh: Efficiency and Reform options. **44 (51)** EPW Mumbai 70-77

Sen A. (1981), Poverty and Famines an Essay on Entitlements and deprivation' Oxford University Press, Oxford

Tritah Ahmed (2003), The Public Distribution System in India: Counting the poor from making the poor count. GREMAQ, Université des Sciences Sociales, Toulouse, France, July 7

Venugopal K. R. (1992), Deliverance form Hunger, the PDS in India Sage Publication New Delhi