CHAPTER - I

REVIEW OF LITERATURE

1.1 WEED RESEARCH IN INDIA :

In India uptill now extensive weed research had been done and is in progress of which literature is available in diverse reports, numerous research articles, proceedings of seminars published in various journals and books. Some of the important books comprising the weed research study are -

"Weeds" by Walter C. Muenscher (1962)
"Weed Control as a Science" by Glenn c. Klingman (1978)
"Weeds of the World" by Lawrence J. King (1974)
"Crop Production and Field Experimentation" by Vaidya, Sahasrabuddhe and Khuspe (1978)
"Ecological Approaches to Indian Weeds" by David N. Sen (1981)
"Weed Science" by Kingman, Ashton and Noordhoff (1982)
"Principles of Weed Science" by V.S.Rao (1983)
"Aquatic Weeds - Utility and Development" by F.Z. Majid (1986)
"Bibliography of Indian Weeds" by Gupta and Mittal (1983)

Rao (1979) reported on the current status of weed research in India. According to him all states of India, near about 42 weed research 'units' in different universities and research institutions are engaged in study of -

-Weed Taxonomy
-Weed Biology and Competition

-Herbicide Screening
-Adjuvants and Antidotes
-Herbicides residue
-Mode of action of herbicides
-Intergrated weed management
-Extension of weed research to farmers
-Herbicide Certification and Registration
-Aquatic Weed Control
-Weed Control in Non-agric and Non-aquatic Systems
-Spraying and spray equipments.

Universities and Research Institutions in India, where work on weeds is in progress can be listed as, -

Andhra Pradesh Agri. University Baptala
Sri Venkateshwara University, Tirupati
International Crop Research Institute for Semi Arid Tropics, Hyderabad

Allahabad Agriculture Institute, Allahabad
G.B. Pant Univ. of Agri. and Tech. Pantnagar
Haryana Agri. Univ. Hissar
Orisa Univ. of Agri. and Tech. Bhubaneswar
Universdity of Agri. Sci. Bangalore
Visva-Bharati Univ. Santiniketan
Calcutta University, Calcutta
University of Jodhpur
Central Rice Research Institute, Cuttack
Indian Institute of Sugarcane Research, Lucknow
Soil and Water Management Research Station, Govt. of Rajastan, Kota

In Maharashtra, universities having weed research unit are -

- Mahatma Phule Krishi Vishwa Vidyalaya, Rahuri
- Marathwada Agricultural University, Parbhani
- Marathwada University, Aurangabad
- Punjabrao Krishi Vidyapeeth, Akola

Binswanger and Shetty (1977) from their village studies in the Akola, Mahbubnagar and Solapur districts concluded that, weed control activity is clearly related to the quality of the resource base. The better the growth environment for the plants and weeds, the more and better weed control is undertaken by the farmers. These authors also concluded that, for dryland crops herbicides use cannot be advocated at present on the basis of cost consideration in the semi-arid tropics of India. Weed scientists have to look to the problems of poor and rich farmers.

In our Shivaji University, Kolhapur, the weed research is also in progress. Various weeds are studied for their basic physiology and the data can finally add towards the basic information in control of the weeds. The weed research in Shivaji University laboratory can be summarised as

A notorious weed Parthenium hysterophorus was studied in detail with respect to its autecology, physiology and chemical and biological control by Patil (1980).

Karadge (1981) has worked out Portulaca oleracea a succulent weed for its Basic Physiology.

Photosynthesis and senescence in Alternanthera, Ficoidea and Alternanthera paronychioides weeds have been studied in detail by Pathan (1982).

A grass Cymbopogon martinii was investigated for its eco-physiological aspects by Sabale (1983).

Upadhye (1986) has worked out Trianthema monogyna [a common C_4 succulent dicot weed] and Pennisetum purpureum [a C_4-monocat weed] for their physiolgoical changes during leaf ontogeny.

Physiology of leaf ontogeny in Portulaca quadrifolia and Setalia italica was worked out by Thombre (1987). Jagtap (1990) has studied Tribulus terrestris Linn. for cytogenetical and physiological aspects. Yadad (1991) has worked out cytotaxonomic studies in genus Cynotis.

A weed Lippia (Phyla) nodiflora was investigated for its eco-physiological aspects by Pathak (1991).

Deshpande (1993) has worked out the phyllody disease of Parthenium hysterophorus L.

1.2 AQUATIC WEEDS :

INTRODUCTION

Water is the integral constituent of life and one of the most important natural resources. The present domain of life existing on the earth has evolved from water.

Water is often adversely affected by aquatic weeds, resulting in critical problems in agriculture, navigation, pisciculture and public health. The menace of water weeds is reaching alarming proportions in many parts of the world. The problem is global, but more pronounced in tropical and subtropical zone where warm weather supports profuse growth of aquatic plants.

Panama canal is feared to be impossible within a few years if the prevailing weed control measures are discontinued.

In India large irrigation projects have been reported to be adversely affected by profusely growing aquatic weeds, that block canals, reducing water flow as much as four-fifths.

The plant community of stoloniferous floating aquatic weeds, forming vast impenetrable floating mats in natural waters, canals, lakes, rivers and other water bodies has created a nuisance, since it blocks drainage, channels and renders navigation and fishing almost impossible. In some parts of the world, aquatic weeds are spreading at an alarming rate; obviously it has become a serious concern to the governments of many countries and international agencies.

The menace of aquatic weeds can be overcome by their utilization in a number of ways. The scientists and technologists therefore, gradually changed their destructive attitude towards these apprantly troublesome plants and tried to turn them to productive use.

GENERAL ACCOUNT :

Aquatic weeds are generally classified as floating, submerged and emergent. Floating types are often recognized by general mass of people as an aquatic weeds, such as, Eichhornia crassipes and Monochoria vaginalis (water hyacinth), Pistia stratiotes (water lettuce), Salvinia cuculata and S. natans (Slavinia) Spirodela polyrhiza, Lemna minor and Wolffia arrhiza (duck weeds), Azolla pinnata (water fern), etc. The roots of most of the floating plants hang in the water and are not attached to the soil.

Weeds gorwing below the water surface are called submerged, such as, Hydrilla verticillata (hydrilla) and Myriophyllum spicatum (water milfoil). Vigorous growth of submerged aquatic weeds sometimes form a dense barrier of vegetation from the bottom of the water to the water surface. Rooted aquatic weeds extending above the water surface, are then called emergent, such as, Typha spp. (cattails), Cyperus papyrus (Papyrus) Scirpus spp. (bulrush), Phragmites communis (reed), etc.

Fibrous stem are not developed in submerged aquatic plants owing to the fact that, their weight is supported by water. Floating plants and emergent plants need more skeletal strength in their aerial parts hence they have more fibre than most of the submerged plants. Floating plants possess spongy leaves and stems, which enable them to float.

In contrast to terrestrial plants, air canals in many aquatic plants form gas-filled intercellular system. The oxygen of photosynthesis is accumulated in the air canals and conducted throughout the entire plant. The above device enables the roots of water plants to survive in oxygen deficient water and bottom mud.

Aquatic weeds are generally more productive than terrestrial plants. Water hyacinth's productivity has been reported to be tremendous.

Water content of aquatic plants is higher than that of terrestrial plants (85-95% in aquatic plants and 70-90% in terestrial plants). The dry matter content of aquatic plants is therefore, very low, usually from 5-10% while that of terrestrial plants is generally 10.30%.

ECONOMIC IMPORTANCE OF AQUATIC WEEDS :

Aquatic weeds are still regarded by general mass of people as a 'menace' and 'nuisance', because they are not yet aware of the great potential and economic value of these profusely growing, un-controllable plants. These highly productive plants are generally more productive than conventional terrestrial crops. Moreover, when grown on wastes, they do not compete with conventional crops for fertilizer, water or land. Their natural profuse growth in the humid tropical and subtropical areas of the world, requiring no intensive cultivation, make them a promising source of multipurpose raw material. As a matter of fact, these plants have been proved to be good source of livestock feed, human food, fish feed, organic or biofertilizer, energy, fibre and paper. Furthermore the aquatic weeds have the capacity to purify waste water through the uptake of dissolved nitrogen, phosphorus and undesdirable excessive minerals, including heavy metals.

1.3 WATER HYACIANTH [Eichhornia crassipes] MOST TOUBLESOME WEED

Eichhornia crassipes solms, family Pontederiaceae is popularly known as 'water hyacinth'. Sen (1981), Majid (1986) has considered Eichhornia crassipes and Monodacri visinalis under the term water hyacinth. Eichhornia crassipes is a native of Brazil, now very common in U.S.A., Australia, Jawa, Siam, Burma and India. It is very likely that, this plant species has been purposely introduced in all these countries as a garden plant for the sake of its pretty flowers and fine foliage. Perhaps there is no other weed in any country, that proved so notorious as E. crassipes.

The plants may flower at an early age and normally produce minute, oblong, pointed, striate and greyish coloured seeds. Seed production varies from a few to as many as 500 seeds per plant. The seeds sink to the bottom and may remain viable for at least 15 years (Chandra Singh & Rao 1976). Movement of seeds in mud is facilitated through water courses. The loss of water through evapo-transpiration from the leaves was reported as 26% higher than evaporation from a free water surface (Brenzny et al 1973). However Timmer and Weldon (1967) estimated from pool experiments that the evaporation of water hyacinth was only 3.7 times higher than evaporation from free water surface.

Because of high water content, water hyacinth takes time to dry out after removal from water. The seeds remain dormant for atleast one year and maintain their viability for several years. Seeds cannot germinate in the absence of oxygen, so keeping tanks flooded, presents a possibility of preventing their germination (Sharma 1971).

Since this aquatic weed is present in enormous quantities, attention has been diverted to find out some uses of this plant, so that, its eradication would entail some financial returns. Sharma (1971) has listed the manifold uses to which this weed has ben put to :

(i) as fertilizer, compost and mulch

(ii) as fodder, silage and food for pigs, cattle, sheep and fish

(iii)in providing raw materials for industries and

(iv) as protein source for other chemicals.

Being rich in potash it makes a valuable manure when properly decomposed. Papers of inferior quality are also prepared from the pulp of this weed. Flowers yield a sort of blue colour and pink dye is prepared from it.

Man has tried to keep the weed under control in one way or the other to protect the more valuable aquatic resources. The earliest method was simple manual removal which is still practised in most of the developing countries. In India manual clearing of water-hyacinth in confined water bodies is common. The pre-rainy period (April-May) is more suitable for manual (and mechanical) removal as the weed is confined to a relatively smaller area. (Ambasht and Ram, 1976; Phillipose 1959, 1968). Depending upon the density of the weed mat, 100-300 man-days per-hectare are required to remove the weed (Phillipose 1963; Ramchandran 1963).

Another simple method of control is to construct floating barriers which prevent water hyacinth from reaching the other water bodies. The floating barriers reduce time, labour and cost (Grant 1962; Hearne 1966) as the accumulated weed is removed by draglines.

The entry of water-hyacinth mats into new-waters can be physically checked with a strong bamboo screen though sometimes such screens may give way resulting in overnight disasters. The infestation of Keetham lake (Agra) has been found to be the result of such tumbling of a barrier at Okhla, New Delhi (Gupta, 1979).

In still another method, the inability of water hyacinth to tolerate salt has been made use of. In Queensland and New South wales the water hyacinth is flushed into the sea (Jamieson et al. 1977).

Gupta (1976) has pointed out that, in coastal areas in India, tidal sea water has been used successfully to control the weed. The manual control is very labour expensive, time consuming and unsatisfactory. (Hamdoun et al. 1977). Therefore, several mechanical devices have been developed, of which the draglines and floating boom are the simplest (Gangstad 1976).

To obviate various problems of mechanical control, the chemical control is the most effective and cheap method (Bhutarobol 1951; Dias 1967, Ramchandran 1963). The chemicals include a number of inorganic compounds like ammonia (Anonymous 1968-69, Ramchandran and Ramprabhu 1973), formaline (Bose 1923), barium chloride, sodium chloride, sulphuric acid (Bose 1945), arsenic oxide (Mc-Lean 1922) and copper-sulphate. Arsenic and soda spray have been used in Panama canal region upto 1935, and copper sulphate upto 1952 (Hearne 1966). Sodium arsenite and di-calcium aresenite have been used but their use was abandoned in 1937 (Hearne 1966; Wunderlich 1962, 1964). It has been shown that 3.5 ppm copper sulphate inhibits growth of water-hyacinth (Sutton and Blackburn, 1971). In one of the studies, copper sulphate applied as mud pellets has been shown to prevent recurrence of water-hyacinth (Musil and Breen 1977).

ECOLOGY :

Community, Structure and Competition :

Water hyacinth multiplies so rapidly that, usually it forms dense monospecific stands covering the entire water body. This thick mat cuts off light from reaching under water and therefore the submerged vegetation is eliminated. It is common observation that, removal of water-hyacinth results in regrowth of submerged plants. When the density of water hyacinth is low it occurs with a number of other free floating plants like Azolla species, Pistia stratiotes, Salvinia species, various Lemnids, etc. In dense old stands, the mat provides suitable habitat for germination and establishment of seedlings of a number of emergent species. The dust trapped by the mat and large quantities of suspended organic matter produced by water hyacinth itself results in development of floating islands (or sudds) which gradually become covered by marsh species, grasses and even tree seedlings. Trivedy et al (1978) have described the formation of such islands in India. Gay (1960) reports occurrence of Vossia cuspidata and Cyprus papyrus among the mats of water hyacinth on the White Nile. In India the common taxa growing on the floating mats include Typha spp., Phragmites spp., Polygonum, Rumex and several grasses. Little (1966) reports that, in lake Apanas (Nicaragua) the water hyacinth competes with Pistia, and Pistia is shown to be replaced by water hyacinth in mixed cultures. (Tag El.seed 1972). This is largely due to the fact that, the large leaf canopy enables water hyacinth to occupy the surface and shades smaller Pistia (Tag El. seed 1972). The pH of the habitats also appears to favour water hyacinth in its competition with Pistia (Tag El.Seed, M., 1975). Water-hyacinth is also associated with a specific animal community. Monakev (1969) listed eleven crustaceans and several rotifers in addition to aquatic insects and their larvae. He also showed that, the zoo planktons increased in White Nile after the invasion of water hyacinth. Similar observations made by other workers (Adam 1975; Monakev 1969; Yousif A.M. 1974). El Moghraby (1975) in his detailed studies of zooplanktons recorded the following species from water-hyacinth infestations - Moina dubia, Mesocyclops leuckarti, Ceriodaphnia dubia, Mesocyclops naupli, Ceriodaphnia cornuta, Thermodiaptomus galebi, Diaphonosoma excisum, Thermocyclops neglectus, Asplanchana brightwelli, Branchionus quadridentatus.

Several investigations have revealed the association of some non-symbiotic nitrogen fixing bacteria with the roots and leaves of water hyacinth. Iswaran et al. (1973) reported Azotobacter chroococcum from the leaf surface of water hyacinth growing in a pond near lipa (Philippines). Later it was reported that, the bacteria favoured the growth of leaves stem and roots, and the germination of the seeds of Secale cereale possibly due to the production of growth substances like gibberellin, thymine or raboflavin. (Iswarn, 1976). In another study (Purchase 1977), Azotobactor was found associated with the slime around the petiole bases. Nayak et al. (1979) reported, Azospirillium lipoferum from the roots and phyllosphere of water-hyacinth.

Effect of Nutrients :

The plants responds directly to the level of nutrients in water. The growth has been shown to be directly correlated with the level of nitrogen and phosphorus in perticular. Hitchock et al. (1959) observed optimum growth with the addition of 100-150 g compost soil per liter of water. Increased growth in sewage has been reported in several studies (Center and Balciunas 1976; Wakefield and Beck 1962). N.P.K. fertilizers promote growth (Boyd and Scarsbrook 1975; Datta et al. 1966). In different studies different concentrations of N and P have been found to result in optimum growth : 25 ppm, N (Chadwick and Obeid 1966) or 100 ppm N (Zettler and Freeman, 1972), 20 ppm. P (Haller and Sutton 1973). It is reported that, the critical level of phosphorus for growth is 0.1 ppm (Haller et al. 1970), though luxury consumption occurs at higher concentrations (at 40 ppm phosphorus level in water plants accumulated 9.1 mg per g dry weight).

The light intensity has been demonstrated to have a direct influence on the uptake of phosphorus but not of nitrogen and potassium (Slamet, and Sukowati 1975).

The plants grow only in fresh water and do not tolerate salinity (Center and Balciunas 1976; Das 1968; Penfound and Earle 1948). Haller et al. (1974) in an experimental study observed that the plants tolerate salinity upto 0.25 per cent though the growth adversely affected.

Effect of pH :

The influence of pH on growth of Eichhornia crassipes has been extensively studied in different parts of the world. Parija (1934) observed that the optimum growth occurs at pH 6 to 8 and plants growing in more acidic or alkaline waters tend to change the pH within this range. At low or high pH the growth is checked but the plant is not killed as the calcium in leaf raphides escaping from the decaying leaves antagonises H^+ ions. Haller and Sutton (1973), observed maximum growth at pH 4.0 (which changed to 4.6 after 4 weeks) and more or less the same growth upto pH 8 (which changed to 7.3 after 4 weeks). Other workers have found optimum growth at pH 7. [Chadwick and Obeid 1966; Obeid and Chadwick 1964; Salmet and Sukowati 1975; Salmet and Sukowati 1975; Santiago 1973; Salmet and Sukowati 1975; Soekisman 1977). It has been observed that, the plants absorb more phosphorus at pH 4 and more nitrogen and potassium at pH 7 (Chadwick and Obeid 1966).

Effect of temperature and light :

The effect of different environmental factors on growth and flowering in water hyacinth have been investigated in detail by Penfound and Earle (1948), Das (1968) and Francois (1970). These studies have shown that the plant is heliophilous and grows best under high light intensity and high temperature.

The optimum temperature requirement of the plant is 27-30°C (Francois 1970 and Knipling et al. 1970). The plant ceases to grow when water temperature is below 10°C or above 40°C. The plants do not withstand higher temperatures.

It has also been reported that, along with low light intensity high temperature promotes elongation of petioles (Boresch 1912).

In another study low temperature has been shown to result in more stolons per unit area and reduced leaf size (Anderson 1977). Krikland (1977) has demonstrated recently that the temperature affects nutrient uptake and transpiration.

Hitchcock et al. (1959) and Francois (1970) have found that, the flowering is affected by temperature during day and night but is not influenced by light period. Parija (1934) studied the effect of drought in relation to physiological changes in the plants. He observed that, the plants Survive in a soil with only 5.7% moisture of the saturation level.

PHYSIOLOGY :

Sen (1930) has reported that, air dried water hyacinth has nitrogen in the range of 1.45 to 1.73 %. Smith (1932-33) has recorded 0.9% of nitrogen in leaf on dry wt. basis. Dymond (1947) has recorded 1.33 to 2.01% nitrogen in leaf on dry wt. basis.

Denton (1967) has collected water hyacinth from non-polluted and polluted sites and he has studied the chemical composition of water hyacinth for major nutrients. He has recorded 1.37% nitrogen in water hyacinth collected from non-polluted site and 2.61% nitrogen collected from polluted site.

According to Sinha and Sinha (1969) nitrogen content of water hyacinth ranges from 0.97 to 2.57%.

Boyd and Vickers (1971) have collected water hyacinth from 17 different polluted and non-polluted sites and studied these plants for their nitrogen contents. They have recorded 1.03 to 3.33% nitrogen. Nag (1976) has studied the destruction of water hyacinth by its utilization. During his study he has recorded 4.0% nitrogen.

Nitrate is the major source of nitrogen available to most plant sepcies. Enzyme nitrate reductase [NR] reduces nitrate to nitrite with the help of NADH in cytoplasm. The activity of NR is stimulated by CO_2, light and nitrate. The half life of Nitrate reductase (NR) is short.

Properties of Nitrate Reductase [NR] :

Based on ultracentri-fugation studies, it is concluded that, molecular weight of N.R. from wheat is 5,00,000 to 6,00,000. N.R. from spinach behaves in an anomolous manner on gel chromatography and sucrose density centrifugation indicating a non-spherical molecule. Using Biogel A – 0.5 it is found that it has a size equivalent to a molecular wt. 2,40,000 of NR from spinach, although it has also been reported to be 5,00,000. The estimated value of molecular weight of spinach, enzyme is 1,52,000 employing sucrose density gradient centrifugation. The molecular weight of barley NR is around 2,30,000. The molecular weight of maize NR is 1,60,000.

Chemical Composition ;

The enzyme nitrate reductase [NR] is found to be constituted of sevral components which have been briefly summarized below –

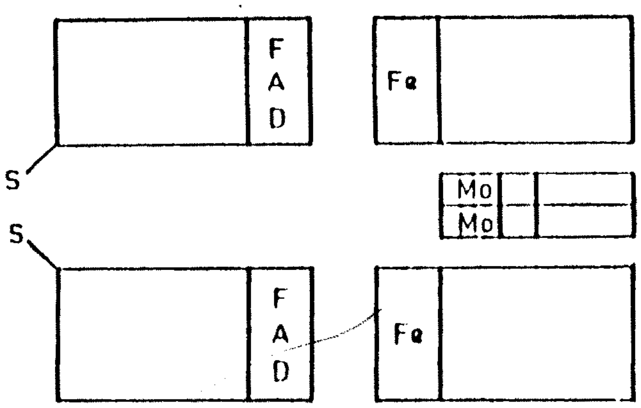
a) Molybedenum : MO by analysis has found to be present at 0.8 atom mol^{-1} of 1,85,000 molecular wt. of pure enzyme in Chlorella vulgaris and 0.82 atom mol^{-1} of native enzyme from Neurospora crassa.The molybdenium atom mol^{-1} of enzymes seems to vary between one and two depending on the species.

b) Flavins – A computed reduced versus oxidised spectrum produced a through at 450 nm in highly purified Spinach enzyme. This is indicative of flavin.

c) Haem – The presence of cytochrome b 557 in spinach NR has recently been confirmed.So in higher plants nitrate reductase appears to be a molybdo flavo-haem containing protein.

Structural Model of NR :

At present there is no single model which fits the rather incomplete data representative for different eukaryotic sources, of the enzyme. Desai (1986) has given a structural model for enzyme nitrate in higher plants which is shows as,



[Simplified Theoretical Structural model of Spinach Nitrate reductase. [From Desai, 1986]

The principle site of NR activity is leaf tissue, where quick activity occurs (Reported by Desai 1986).The young fully developed, well illuminated, physiologically matured and expanding leaf has high NR activity due to grater ability of nutrient uptake, Co_2 fixation and protein synthesis (Jordon and Huffakar 1972; Schlesier 1977; Streit and Feller 1982; Munjal et al. 1983). Hatam (1978) found highest NR activity in upper most expanded leaves which declined with the leaf position lower in the canopy.

Most of the higher plants prefer NO_3^- as a nitrogen source. Assimilation of NO_3^- is a continuous process beginning with uptake of NO_3^- by the roots. The NO_3^- absorbed must be reduced to ammonia which is then assimilated into organic compounds mostly amino acids and then proteins.

Reduction of NO_3^- to NH_4^+ takes place both in the leaves as well as in roots which is achieved in two stages involving enzymes nitrate reductase and nitrite reductase. Nitrate reductase -NR (EC 1.6.6.2) catalyses reduction of NO_3^- to NO_2 .

Nitrate reductase is a complex, oligomeric enzyme having molecular wt. 197 to 460 K daltons (KD) and is composed of a variable number of apparently identical sub units. FAD, cytochrome b-557 and MO are ubiquitous prosthetic groups. The enzyme consists of two sub-units one Flavin and Flavo-protein with molybdenum. Flavin components accepts electrons first, then transferred to FAD and flavo-protein components and MO is essential for this transfer. Finally electrons are accepted by NO_3^- which itself gets reduced to NO_2^-. The reaction is summarised as,

$$NAD(P)H \downarrow (FAD\text{-}cyt.B - 577\text{-}MO) \downarrow NO_3^- \downarrow NO_2^-$$

The NO_2^- thus produced is further reduced to NH_3^+ and this reduction is catalysed by another important enzyme system nitrite reductase ONir (EC 1.6.6.4). The end product of nitrate reduction is NH_4^+. It is further incorporated into organic compounds.

According to Boyd (1970a and Dyki-jova (1979), the chemical composition and accumulation of nutrients in aquatic plants depend on chemical nature of the habitat, plant parts and many other environmental factors. The elemental content of water hyacinth has been extensively studied by Boyd and Vickers (1971) who obtained results from 17 different sites. No significant correlation was found between the environmental and tissue levels of the 13 elemental macronutrients which were investigated. However the highest levels of phosphorus and potassium in tissue were associated with their high levels in the water. On dry matter basis levels of nitrogen varied from 1.3 to 3.3%, phosphorus from 0.14 to 0.8% and potassium from 1.6 to 1.7%.

The scope of chemical analysis of water hyacinth has been extended to include several trace elements and perticularly heavy metals, which are known water pollutants are absorbed and accumulated by water hyacinth (Howard and Junk 1977). Knipling et al. (1970) have stated that, in comparison to grass and alfalfa forage water hyacinth has high nutrient content. The crude protein content of hyacinth grown in fertilized water is high. The essential amino acid content is high as compared to that of corn and rice. The earlier studies on chemical composition of water hyacinth reported by Gosset and Norris (1971), Roger and Davis (1972), Steward (1970), Wooten and Dodd (1976) and Yount and Crossman (1970) indicated its value as a fodder and sdource of protein.

Photosynthesis in water hyacinth :

Soekisman (1977) has studied the growth of water hyacinth in terms of carbon dioxide assimilation. The CO_2 compensation point was 60 ppm and the rate of carbon assimilation ranged from 1.61 to 15.52 mg $CO_2/dm^2/hr$. Earlier Chen et al. (1970) also observed a compensation point 40 ppm. CO_2 and an assimilation rate of 1.8 mg $CO_2/dm^2/hr$. On these observations, E. crassipes appears to follow C_3 photosynthetic path. However, it differs from other C_3 plants in the fact that the photosynthetic mechanism does not exhibit light saturation at 30 klx or more. Presence of photorespiration in E. crassipes is detected by Patterson and Duke (1978,1979). This also adds towards the C_3 type of photosynthetic path of E. crassipes.

It has been demonstrated that water hyacinth can utilise dissolved carbon dioxide through roots for photosynthesis. In experiments using $H^{14}CO_3$, ten percent of total plant carbon come from fixation of dissolved CO_2. Such high dissolved CO_2 concentrations are of common occurance under the mats of water hyacinth (Ultsch and Anthony, 1973).

Stomatal studies :

Stomatal frequency varies among plant species, from leaf to leaf of the same plant and even in different parts of some leaf. Location, number and distribution of stomata on upper and lower epidermis of leaf also varies (Noggle and Fritz 1986).

In order to understand the basic physiology of water hyacinth we have added sdtomatal density as a one more parameter.

Chlorophylls :

Leaf has got a paramount importance in the plant body because it is directly concerned with photosynthesis and thereby all living weorld. The internal morphology of the leaf is complex and varies considerably from species to species. Chlorophyll content of *E. crassipes* is taken as a tool to corelate the photosynthesis and stomatal density during present study.

ROLE IN WATER POLLUTION :

One of the most serious problems faced by mankind today is the problem of water pollution. Billions of gallons of wastes from cities and housing settlements, industries and agriculture are thrown to freshwaters everyday. Lack of wastewater treatment facilities or their inefficiency is the single greatest cause of gross pollution of freshwaters. The domestic waste contains excess of organic matter, excess nitrogen and phosphorus, suspended soils, sodium chloride and pathogenic micro-organisms. The entry of these pollutants to freshwaters causes a chain of undesirable effects in freshwaters manifested in the deteriorated waterquality for drinking , domestic, industrial and agricultural purposes.

However, the very ecologically devastating properties of water hyacinth make it an ideal candidate for the treatment and nutient absorption from wastewaters. The wastewater is treated by simply growing water hyacinth in that for a specific period and in turn the BOD, COD, solids, nutrients, phenols, pesticides, toxic elements and a number of other pollutants are reduced from the wastewater (Gopal and Sharma 1981; Gupta 1982; Trivedy 1983; Mehrotra 1982).

One acre of hyacinth can remove 1394.5 kg N/year (Rogers and Devis 1972). Wolverton et al. (1979) has reported that, suspeneded solid level was reduced below 30 mg/l in a facultative wastewater lagoon.

PHYTOPATHOLOGY :

Pathology is the study of the nature, development and control of diseases. Plant pathology is the study of the diseases of plants and covers the entire field of biological and scientific activity concerned with the understanding of this complex phenomenon. During recent years a large number of phyto-pathogens have been reported from water hyacinth. Studies have been made in detail on the pathogenecity, host specificity and biological control potential of many of them.

Aghakar and Banerjee (1932) were the first to report a fusarium spp. from water hyacinth which caused redish brown spots on petioles followed by chlorosis and withering of leaves. The species was later identified as Fusarium equiseti (Banerjee 1942) and further changed to Fusarium roseum (Synder and Hanson 1945). Nag Raj (1965) reported thread blight of water hyacinth - which is caused by Marasmiellus spp.

Nagraj and Ponappa (1967 and 1970) reported, Myrothecium roridum var. eichhorniae, Corticum sasakii, Marasmiellus indoderma and a new species which was named

Alternaria eichhorniae (Nag Raj and Poonappa, 1970), which cause diseases on water hyacinth.

Padwick (1946) reported the Cephalosporium zonatum causing leaf spots on the water hyacinth in Pakisthan. Bipolaris stenospila was reported by Charudattan et al. (1976) from Dominican Republic. It is a virulent pathogen of water hyacinth. However, its potential has not been tested beyond the quantitative green house stage. The fungus attacks bermuda grass (Cynodon dactylon) and sugarcane (Saccharum officinarium) (Faris 1972 and Freeman et al. 1976) in nature and also under glasshouse conditions (Charudattan et al. 1976 and Freeman et al. 1976). Its patho-genecity on such important crop plants may preclude its use in biological control of water hyacinth.