CHAPTER - I

REVIEW OF LITERATURE

1. Introduction :

An abundance even sufficience of food, fibre and shelter from the plants that man manages depends not only on soil fertility, good tillage and favourable weather, but also on the control of natural enemies or diseases of crop plants. In attempting to check diseases of plants, knowledge of cause of the disease, life history of the parasite and of the circumstances which influence the establishment of parasitic relations between it and the host is usually required. Knowledge of the circumstances which increase or diminish the power of the injury of the parasite and the resistance to attack the host has greatly increased during the last twenty years, these circumstances, however, are so linked with small differences in climate and other external conditions, with the crop varieties grown or the strains of the parasite involved and also with the local agricultural practices. Man invades newer and newer areas with the newer crops, so also the weeds with him. Weeds are those plants which are harmful, interfere with the agricultural operations, increase labour, add to the cultivation and reduce the crop yield. Some weeds are also parasite on other crop plants. More than thousand species of seed plants, at least seven families parasitize other seed plants and induce in them harmful physiological processes that we recognize as disease. Some weeds exists as total parasites or semiparasites upon crop plants. *Balanophora* causes serious damage to coffee, *Cuscuta* to clovers, *Striga* to sorghum, pearlmillet and sugarcane, *Orobanche* to tobacco, tomato, brinjal and beans and *Loranthus* and *Viscum* to horticultural trees. These are very injurious weeds and cause great damage to crops. Mistletoes, dodders and *Orobanche* (broomrapes) have reduced crop yield and have killed economically important plants. According to Loomis and Wilson (1953), there are 2,500 species of parasitic flowering plants. The degree of parasitism varies also to a great extent.

2. Incidence of *Orobanche* :

Orobanche, which belongs to the more important angiosperm parasites, is a total root parasite commonly known as broomrape. Vaucher (1827) made fairly full descriptions on family *Orobanchaceae* and the plants it parasitizes, over 100 years earlier. The earliest report from India by Bamber (1916) records 8 species of the genus *Orobanche*, occuring in North West Frontier parts of Punjab and Kashmir.

Orobanche species and Witchweeds (*Striga* spp.) attack the roots of their hosts, tobacco and corn respectively. *Orobanche* spp. (Broomrapes) are important parasites of broad leaved plants and are important in hot and dry areas. Beck-Mannogetta (1930) described the family and the plants it parasitizes. The most important species and their main crop hosts are Orobanche aegyptiaca on broadbean, cotton, crucifers, cucurbits, egg-plant, potato, tobacco, tomato (Beck-Mannogetta, 1930). Orobanche aegyptiaca parasitizes plants mainly belonging to the family Brassicaceae (Singh and Singh, 1971) though its occurrence on other plants has been reported by Rao (1953).

Marudarajan (1950) reported O.cernua causes 'near wilt' appearance of tobacco crop in field, affecting the yield and quality of the leaves. Egg-plant (Solanum melangena L.) is parasitized by O.cernua in India, and is reported that 2-4-DES will give complete control, if irrigated immediately after application (Addy, 1956). Kadry and Tewfic (1956) reported the occurrence of O.cernua on Vicia faba in Egypt causes serious damage to crop. Boskovic (1962) reported that sunflower may be severely affected by Orobanche in USSR and Eastern Europe and has been shown that Orobanche can be distributed as contaminant on sunflower seed.

Dakshinamurty et al. (1964) studied that tobacco (Nicotiana tabacum L.) is affected by number of species of Orobanche and may have an adverse effect on the yield and quality of the crop and that it is worth harvesting. Rakhimov (1967) noticed that tobacco is parasitized by numerous species of Orobanche including O.aegyptiaca, O.cumana, O.muteli and O.cernua and also noticed that parasites of cultivated plants appear to have more hosts than do parasites of wild plants. An annotated bibliography of *Orobanche* on tobacco has been prepared by Central Tobacco Research Institute, India.

Mijatovic and Stajannovic (1973) cite a case in Yugoslavia in which *Orobanche* (broomrape) reduced sunflower seed yields by 33%. Gharib (1973) stated that in Iraq broomrape is so destructive that entire field of tomatoes and tobacco are left uncropped. The loss of 40 to 70% of Sorghum by *Striga* (Witchweed) has been reported by Kasasian (1973). Fibre crops are similarly affected. Bhargava *et al*. (1976) have noticed the occurence of *Orobanche indica* on *Trigonella foenum-graecum* and *Phasalis minima*. The parasite was identified from infected Fenugreek growing in Jaipur, India. *P.minima* was a weed in the field. Both are new host records. Successful erradication of the parasite should include weed control for *P.minima*.

3. Biology :

Saghir and Dastgheib (1978) have studied the biology and control of *Orobanche*. They further reported that *Orobanche* species commonly known as broomrapes are important parasites of broad leaved plants, especially of Leguminosae and Solanaceae. They are very wide-spread throughout the semiarid regions of the world and are common in Eastern Europe, Mediterranean basin, the middle East Asia and parts of Russia. In the USA *Orobanche* spp. have been observed in California, Kentucky and Louisiana. In the mediterranean region two major species namely *O.ramosa* and *O.crenata* prevail and cause considerable yield losses in tomato, potato, tobacco, sunflower and broadbean amongst other crops. In the case of legume crops *O.aegyptiaca*, *O.crenata*, *O.lutea* and *O.minor* are considered to be serious.

Nassib *et al*. (1978) studied the parasitic weed broomrape (*Orobanche crenata*) resistance in broadbean. *O.crenata* without doubt is the most serious pest of all legume crops in Egypt attacking the important broadbean crop causing considerable damage.

Musselman and Nixon (1981) reported that *Orobanche ramasa* (*Orobanchaceae*) a serious pathogen of tobacco, tomato, potato, eggplant, texas and some other crops in middle East in Karnes Country, Texas. Gonzales-Torres *et al*. (1982) observed the distribution and virulence of *Orobanche cernua* in sunflower crops in Central Spain where the parasite was found in 25.9% of infested field including 13.9% of the acreage surveyed. Musselmann and Parker (1982) have reported the preliminary host ranges of some strains of economically important broomrapes (*Orobanche*). They noticed that *Orobanche cernua*, *O.aegyptiaca* and *O.ramosa* infecting tobacco, tomato. *O.crenata* grow vigorously on broad bean even when the original host was sunflower or coleus. *O.minor* was apparently developed several distinct strains.

Rao *et al*. (1982) noticed the maintenance of *Orobanche cermua* on brinjal plants (*Solanum melongena*) during the off season of tobacco (*Nicotiana tabacum* Linn.) and Naphthalene - Acetic Acid (NAA) at 60 ppm stimulated root growth of *Orobanche* and increased the number of its shoot. Hassan *et al*. (1986) assessed the broomrape tolerance in genus *Lycopersicon* and observed that all wild *Lycopersicon* accessions were highly susceptible to *Orobanche* but varied in their tolerance. Aalders and Pieters (1987) studied the resistance of *Vicia faba* to *Orobanche*.

Very little work has been done on the extremely harmful parasite, *Orobanche* under Indian conditions especially on tobacco crop. Detailed investigations on various fundamental as well as applied aspects would be of immense use to evolve the final effective, safe and economical methods of control. Krishnamurthy *et al*. (1977) have undertaken following studies :

1. Life cycle of *Orobanche* on tobacco,
2. Wilting pattern of diseased tobacco crop,
3. Yield losses of tobacco,
4. Screening of crop plants against *Orobanche*,
5. Influence of inundation on *Orobanche* seed germination,
6. Influence of season on the germination of *Orobanche* seed.

4. Anatomical studies :

Rawat and Ambasht (1958) studied the root relations of Orobanche and its hosts at Varanasi. They observed the root branches of cruciferous hosts, especially Brassica spp. on which the roots of Orobanche cernua grows are more developed than the normal roots of the plants.

Kuijt (1969) reported that xylem contimuity is observed between host and parasite in all mature and functional haustoria with exception of Balanophoraceae but nevertheless in Cuscuta and Orobanche elaborate phloem connections are observed.

Orobanche makes only one host connection but penetrates deeply into the root of the host (Eames and Laurence, 1972). Saghir et al. (1973) reported that Orobanche infecting tomato, seems able to modify host cortical cells into xylem elements that unite immediately with the stele of the parasite which after ramifying the host tissue form endophytic system.

Work on Orobanche by Dorr and Kollmann(1975) show peripheral transfer cells which may ultimately seem to differentiate into normal trachery elements. The hyphae arising from huastorium (Dorr, 1972) are specialized conducting elements designed to transport solutes from the sieve tube members. Dorr & Kollmann (1976) studied the structural features of parasitism of Orobanche by light microscopy and electron microscopy. They observed that the haustorial cells of the root parasite Orobanche within the xylem of the host (Vicia faba) tissue. Upon contact with tracheary elements of the host these cells shows usual differentiation before turning into water conducting xylem element.

Saghir and Dastgheib (1978) studied the early development of the Orobanche seedling and establishment of the physiological contact with the host which is relatively a complex process, considerably influenced by the host itself through its root exudes. Studies of O.ramosa have established xylem elements and the undifferentiated parenchyma of the host and the parasite to be continuous in the haustorium, but no phloem continuity with the host has been observed.

Pennypacker et al. (1979) studied the anatomical changes resulting from the parasitism of tomato (Lycopersicon esculentum) by Orobanche ramosa. The point of attachment of parasite to the host consists of a mass of undifferentiated, polymorphic Orobanche parenchyma cells extending from the tomato epidermis to the xylem tissue. The undifferentiated cells probably absorbed nutrients from the sieve cells via sieve areas and transported the nutrients back to the parasite. O.ramosa established both xylem and phloem connection with the host.

Malik and Singh (1979) have studied the physiological, biochemical aspects of parasitism by Cuscuta. They observed considerable changes in host metabolism and also anatomical changes in host due to Cuscuta.

5. Physiological studies :

Although Orobanche has been studied by biologists for a long time, only few investigations have been made on the physiology of its host-parasite relationship. Previous studies on Orobanche concern mainly with its anatomy, mode of penetration and seed germination (Schmucker, 1959; Rangaswami, 1963; Brown, 1965). Khanna et al. (1968) have, however, recently studied the biochemistry of parasitism of Orobanche, Cuscuta and Dendrophthoe.

Izard (1959) noticed that young tobacco roots cause Orobanche ramosa to germinate and only older fibre roots are generally parasitized, which is not the case in other hosts, the degree of parasitism in vegetables appear to be less on older roots.

Gill and Hawksworth (1961) noticed that some genera of parasite derive only minerals and water from the host, where as others can only limited photosynthesis. They further reported that in parasitic angiosperms there is accumulation of organic compounds and starch. Singh et al. (1971) noticed that Orobanche cernua Loeffl. infection brings about marked decrease in the growth of tomato (Lycopersicon esculentum Mill.), which suffers a loss of about 28 per cent of its dry weight at the final growth stage of the parasite.

A) Organic constituents :

Baccarini and Melandri (1967) have made an investigation about some aspects of Orobanche hederae physiology in relation to its parasitism, the pigment composition and $^{14}CO_2$ incorporation with in light and dark and showed that in O.hederae chlorophyll, if present is contained in a negligible amount, on the contrary, carotenoids are largely and fairly uniformly distributed through out the plant. $^{14}CO_2$ incorporation is completely heterotrophic type, being in no way stimulated by light.

Singh and Krishnan (1971) have reported that petunia infected with Orobanche has reduced the chlorophyll content in the leaves of host and elevated root respiration but not shoot respiration. Singh & Singh(1971) studied the respiratory metabolism of host root and Orobanche and also the ensuring changes in the process of respiration due to infection. The respiratory rate of mustard (Brassica campestris L.) and tomato (Lycopersicon esculentum Mill.) serving as hosts for total root parasites Orobanche aegyptiaca Pers. and O.cermua was measured which shows increase in rate of respiration of host root at the site of parasite contact.

Singh et al. (1967) have shown that infection by angiosperm parasites results in depletion of protein in host plant and an alteration in specific activity of some enzymes. Decreased phosphorylase activity was observed by Mattoo et al. (1969) in the leaves of Nicotiana tabacum and Petunia hybrida increased in infected by Orobanche aegyptiaca.

Aber et al. (1983) reported that the transfer of organic substances from the host (Vicia faba) to attached parasite (Orobanche crenata) by short exposure of the host foliage to $^{14}CO_2$. Autoradiograms of the host root system bearing O.crenata showed that tubercles of the parasite were much more labelled than the broad bean roots. The greatest part of total radioactivity found in the parasite was associated with ethanol soluble substances, mainly in carbohydrates. Among the labelled sugars, most of the radioactivity was found in sucrose. This result suggests than sucrose may be the main metabolite involved in the transfer of organic substances from the host plant to the parasite.

Mattoo et al. (1969) have studied the biochemical aspects of parasitism by angiosperm parasites, host-parasite inter relationship. They reported that Solanum melongena, Nicotiana tabacum and Petunia hybrida infected with Orobanche cernua results in significant losses in total fresh weight, contents of dry solids, in most cases protein. *Petunia* infected with *Orobanche* has less root protein and less root biomass, a characteristic also noted for pine seedling infected with dwarf mistletoe (Knutson and Toevs, 1973).

Hull and Leonard (1964) and Kuijt (1955) have studied the physiological aspects of parasitism in mistletoes and further noticed that an accumulation of sugars and other metabolites around the parasite contact region for angiospermic infections might also be true for *Orobanche*.

Singh *et al*. (1968) have studied the biochemical aspects of parasitism by the angiosperm parasites. The investigation dealt with starch accumulation in four species of *Cuscuta* (*Cuscuta compestris*, *C.indecora*, *C.planiflora* and *C.reflexa*) a leafy mistletoe (*Dendrophthoe falcata*) and a chlorophyll lacking root parasite (*Orobanche aegyptiaca*). They further noticed that the highest content of starch occured in *O.aegyptiaca* with a maximum of 45 per cent of dry weight and the host infected by *Cuscuta* had significantly less starch per plant than control. The protein content of tissues of *Cuscuta* and *Orobanche* was lower level than that of host system or foliage, indicating that parasite differed from the host in having a higher carbon (of starch) to nitrogen (of protein) ratio.

Singh *et al*. (1968) have observed that leaf blades and roots of *Nicotiana tabacum* and the leaves, defoliated stem and roots of *Petunia hybrida* and *Solanum melongena* shaws decrease in starch content as a result of infection by *Orobanche aegyptiaca*.

Smith *et al*. (1969) have reported that in parasitic angiosperms, there is accumulation of sugar alcohols which are probably of host origin and are formed and maintained by considerable expenditure of energy. Singh and Singh (1971) observed an increased level of sugar in *Orobanche* infected host plants.

Singh *et al*. (1972) studied different carbohydrate and nitrogen fractions in tomato (*Lycopersicon esculentum* Mill.) and mustard (*Brassica campestris* L.) infected with *Orobanche cernua* and *O.aegyptiaca* respectively. They further noticed that infection raised the level of reducing and total sugar in the host with simultaneous decrease in the level of acid-hydrolysable and total carbohydrates in the constituent organs of infected hosts. Also the insignificant differences between the relative proportion or different nitrogen fractions to the pool of total nitrogen in healthy and infected host which indicated the nitrogen metabolism was not deranged in any way due to infection. Whitney (1973) has shown that, sucrose is the most common carbohydrate transported in host plant, but it is glucose and fructose that accumulate in the tissue of parasites. Saghir *et al*. (1973) have shown that the movement of sucrose and inorganic ions (Sulfur, phosphorus) from host is well established for Orobanche. Whitney (1972) has shown that Osmotic pressure of Orobanche is higher than that of broad bean (Vicia faba) roots but lower than that of tips which suggests water is drawn from the host roots but not from the host leaves or stems.

The investigation on the biochemical aspects of parasitism by angiosperm parasites, phenolics in parasites and hosts by Khanna et al. (1968) showed that contents of total phenolics in three parasitic angiosperms, Cuscuta species, Orobanche aegyptiaca, Dendrophthoe falcata and their respective hosts. O.aegyptiaca tissues had higher contents of phenolics than the tissues of the hosts Nicotiana tabacum and Petunia hybrida. Infection accompanied by an increase in the phenolics in leaves, defoliated stems and roots of Petunia hybrida, but there was no demonstratable effect in roots and leaf blades of Nicotiana tabacum. In D.falcata, the phenolic content varied widely in the parasitic leaves from different host trees without a direct relationship between the content in parasite and its host. The filaments of Cuscuta had higher content of phenolics than the tissues of the infected hosts, Medicago sativa. The high amount of phenolics in Cuscuta species and in Orobanche is parallel in the accumulation of starch (Singh et al., 1968).

B) Inorganic constituents :

Inorganic phosphorus, potassium and nitrogen all accumulate at the infection site to the levels of substantially higher than in adjacent host tissue in Orobanche, Cuscuta, Viscum, Loranthus (Nicoloff, 1923; Gill and Hawksworth, 1961) Arceuthobium (McDowell, 1964).

Saghir and Dastgheib (1978) made an investigation about the physiology of Orobanche and its hosts under broomrape (Orobanche) infection. They reported that broomrape infestation brings about considerable changes in host's mineral content. Percentage of nitrogen and potassium were reduced in beans (Vicia faba) infected by O.crenata, but no changes in phosphorus and calcium content were observed. Infection of Petunia hybrida and Nicotiana tabacum by O.aegyptiaca resulted in 35-70% reduction in hosts C:N ratio. No marked changes have been found in the net assimilation rate of tomato as a result of broomrape infestation and it has been proposed that internal factors controlling photosynthesis and protein synthesis are not affected by parasitism.

The effect of Orobanche cernua Loeffl. on growth and mineral composition of tomato (Lycopersicon esculentum Mill.) were studied by Singh et al. (1971). They reported that infection by O.cernua results in an increase in nitrogen, magnesium and decrease in phosphorus and potassium content in the infected host. No variations in calcium content due to infection were consistent. Wolswinkel (1978) studied the accumulation of mobile mineral elements at the site of attachment of Cuscuta europea L. to the host Vicia faba. Mineral analysis showed that potassium and magnesium were drained by the parasite, but draining action was not observed in case of calcium.

Singh et al. (1979) observed the effect of removal of host shoot on carbohydrate and mineral contents in Orobanche. They further noticed that host shoot removal decreased the growth of O. aegyptiaca and O. cernua, under these conditions the plants drained their own reserved carbohydrates. Orobanche spp. showed limited capacity to absorb minerals through their own root system and the concentration of nitrogen, phosphorus, potassium, calcium, magnesium decreased in the absence of host root.

6. Control measures :

Prasad (1954) has reported that Orobanche on tobacco is controlled by 2-4, dichlorophenoxyethyl sulphate which is selective in action not affecting tobacco. The incidence of Orobanche has been reduced by varying the normal planting time in Cuba, early planting is helpful (Span, 1958), while in Bulgaria delayed planting achieves the same end (Aleksiev, 1967). Span (1958) observed that 0.2% allyl alcohol in water sprayed on Orobanche and on the soil around the parasitized tobacco has killed the parasite without injurying the crop, watering immediately after treatment was found to be useful. Hodosy (1980) studied the biological control of Orobanche ramosa, a parasite of tomato by using hyperparasites on Orobanche, Fusarium solani and F.oxysporum in small plot field trials which gives 93.14% of the broomrape control. Lolas (1986) has reported the control of broomrape (Orobanche ramosa) in tobacco (Nicotiana tabacum) using ten herbicides. Of the preplant incorporated (PPI) herbicides, only Pebulate (S-propyl butylethyl carbamothioate) at 7.2 Kg ai/ha followed by glyphosate (POE) at 0.2 Kg ai/ha at 40 days after transplanting give good control which results in increased tobacco yield significantly, but nicotine, total nitrogen and reducing sugar contents were not significantly affected.

From the foregoing review of literature available on the influence of Orobanche, a total root parasite infection clear that the parasite attack more cultivated plants than the wild plants and bring about considerable physiological, biochemical changes and anatomical changes in host plants, tobacco, tomato brinjal, Petunia which profoundly reduce the quality and yield of these plants. Although Orobanche has been studied by biologists from a long time, only few investigations have been made on the physiology of the host parasite relationship. Previous studies on Orobanche concern mainly with its anatomy, mode of penetration and seed germination.