CHAPTER II

REVIEW
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LITERATURE
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2.1 Crop Losses.

Weeds form a serious negative factor in crop production and are responsible for marked losses in crop yields (Gupta and Lamba, 1978).

2.1.1 Losses caused by weeds in crop fields:

Chakraborty (1963) on the basis of conservative estimation of 10 per cent reduction in crop field, quoted an annual loss of Rs 4.2 billion due to weed competition in the principal cereals, pulses, oil seeds, cotton, potato, sugarcane and chillies. Mani et al. (1968) stated that losses are on the high side in crops with poor competing ability. Bhardwaj and Verma (1959) estimated a loss of 2.4 million tonnes valued at 792 million rupees considering an average of 10 per cent loss in yield due to weeds.

2.1.2 Crop weed competition:

The competition between crop and weed entails serious damage to the crops and enormous loss to Indian farmers (Mitra, 1962). The problem of crop weed competition assumed importance because crop and weed have a common demand which eventually may become a limiting factor for the crop (Saraswat, 1974). Sen (1979) stated that weeds constitute 30 to 50 per cent of total dry matter production of cultivated fields, so a considerable competition exists between the weeds and the crop for space, nutrient, light and moisture.
2.1.3 Losses caused by weeds in jute fields:

Kundu (1959) reported that a large number of weed flora is found in jute field. If weeds are not removed at the right time the crop suffers very much ranging from 20 to 75 per cent loss of fibre. Dargan *et al.* (1966) noted a depression of 80 per cent in fibre yield as compared to weedy check plots. Saraswat (1976a) commented that the loss of nutrients due to weeds and superfluous jute plants is considerable. Ghosh (1983) stated that if weeding in jute is done perfunctorily or not done at all, the weeds may outgrow the crop which then fails completely.

2.1.4 Losses caused by weeds in rice fields:

Hedaytulla and Sen (1942) reported that losses in rice due to weeds may be from 5 per cent to total failure of the crop. Weeds cause two types of crop losses. The important is the direct yield loss resulting from competition followed by indirect loss from reduced crop quality (De Dutta, 1980). Pablico and Moody (1983) reported that yield losses due to weeds were higher in rice-based cropping patterns than in maize based and sorghum-based patterns. Weed competition is one of the important limiting factors in rice production. Unlike other field crops, the problem of weeds in rice is conspicuous as it is grown under environmental conditions favourable for the profuse growth and reproduction of semi aquatic weeds (Kolhe *et al.*, 1987), most of which produce large quantities of viable seeds (Smith and Shaw, 1966).
2.1.5 Effect of weeds on growth characters of rice:

Pons (1979) reported that presence of weeds reduced plant height. *Echinochloa* sps. had a greater effect on crop growth than did *Jassidea* sps. (Sashidhar, 1983). A reduction in tiller number due to *Echinochloa* competition was reported by Kleinig and Noble (1968).

Rethinam and Sankaran (1974) recorded significant reduction in the dry matter production of rice in unweeded crop as compared to weed free crop. Weed competition resulted in decreased leaf area and nitrogen content of rice (Yamagishi *et al.*, 1976), reduced growth rate due to weed competition (Kim and Moody 1980), reduction in panicle number per unit area by 37 per cent, number of filled grain by panicle by 13 per cent and test weight by four per cent (AICRPWC, 1983, b) with reduction in number of productive tiller (Biswas and Saraswat, 1983).

2.1.6 Effect on rice yield:

Nester (1969) observed yield reduction of 8 to 40 per cent with one barnyard grass per 31 rice plant per 0.3 m² if left to compete for 3 to 10 weeks. Weeds emerging at 15, 30, 45 and 60 days after transplanting reduced yield 6, 9, 47, 23 and 11 per cent, respectively, (Chang, 1970). Severe weed infestation resulted in 25.8 per cent reduction of yield of Kharif transplanted rice (Mukhopadhyay *et al.*, 1985).

2.2 Crop Weed Association:

Moody (1977) reported that each crop has its own characteristic weeds and there are weed species that
build up rapidly when same crop is grown continuously in the same land every year. Pablico and Moody (1983) reported that different cropping patterns resulted in different weed population. In the pattern with rice as the first crop Ipomoea triloba L. dominated; in the other patterns Amaranthus spinosus L. was most important. Rottboellia exaltata was important when sorghum was in the cropping pattern. Sebillote (1967) showed that a weed infestation consisting mainly of Lolium rigidum Gaud. was much less in a corn-wheat-rape rotation, than in a rape-wheat-corn rotation. Therefore, he suggested to take care in the order of the crops to be planted in a rotation if weeds are to be kept to a minimum.

2.2.1 Weed spectrum in jute field:

Maiti and Mazumder (1975), Saraswat (1980), Kundu (1980) and Ghosh (1983) have reviewed the flora of jute field.

Among the monocot weeds following species are common to jute field.

Group A : Pernicious
1. Cyperus rotundus L.
2. Eleusine indica Gaertn.

Group B : Frequent and often difficult
3. Echinochloa colona (L) Link.
4. Digitaria sanguinalis Scop.
5. Dactyloctenium aegyptiacum (L) Beauv.
7. Leptochloa chinensis (L) Nees.
8. Panicum repens L.
Group C: Occasional to frequent

11. Brachiaria repens
12. Paspalum scrobiculatum L.
15. Sporobolus diander
16. Phyllanthus niruri L.
17. Euphorbia hirta L.
18. Eclipta alba L.
19. Amaranthus viridis L.
20. Melilotus alba

2.2.2 Weed spectrum in rice field:

Weeds belonging to different species of grasses, sedges and broadleaf weeds are associated with paddy cultivation. The dominance of Echinochloa crus-galli (L) Beauv. in grasses, Cyperus difformis L. in sedges, Eclipta alba L. and Ammania senegalensis L. in broad leaf weeds were reported in rice fields of Punjab (AICRPWC, 1983, a).

2.3 Intercultural practices for weed control:

Field experiments with various crops, seems to show that chief benefit of tillage is the removal of weeds. In certain crops the inter-tilling is found as much useful for promotion of tilth and aeration as for removal of weeds. In the great majority of cases, some form of tillage is the most practical method of combating annual weeds and perennial weeds (Robbins et al. 1942). The secondary objective of tillage is to loosen or cut the root system so the weed plant dies.
from drying out before it can re-establish its roots. Small weeds are most easily controlled by this method (Klingman, 1973).

2.3.1 Intercultural practices in jute:

Interculture in jute consists mainly of light harrowing by a 'bida' and removal of weeds by 'nirani' or 'khurpi' may be called hand hoes. The crop is usually sown broadcast with the onset of monsoon. The crop receives 2-3 wheel hoeings, rather raking, followed by as many as three hand weedings and thinning. Raking is done by a bullock drawn implement locally called 'bida' which is given along and across the field. The first raking is done when jute plants are 5-7 centimeters high followed by weekly or biweekly intervals. The raking improves the tilth at the same time removes some of the weeds and excess plant population.

Sanyal (1953) and Kundu et al. (1955) have shown that interculture entails the biggest expenditure in jute cultivation, sometimes as high as 40 per cent in broadcast plots, in row crop they, however, observed this to be less due to reduced manual labour for weeding which could be largely replaced by a wheel hoe fitted with either tines or sweep, operated by one man, they also observed row cropping increases yield by about 10-16 percent and reduces seed rate by 40 percent. Sanyal (1953) further reports that one hand weeding and thinning in addition to wheel hoeing, are necessary. Das et al. (1962) found reduction in fibre yield by 58 percent when 2 hand weedings, thinning and 4 wheel hoeings were compared with one raking,
thinning and wheel hoeing. Further wheel hoeings, however, reduced the fibre yield, they concluded that two hand weedings coupled with four wheel hoeings are essential for better returns and high profits.

2.4 Weed management in multiple cropping systems:

Multiple cropping systems constitute agricultural systems diversified in time and space (Altieri and Liebman, 1986) and one of the primary objectives of crop rotation is the control of weed flora of crop field. Effective weed management systems involves integration of soil fertility and water management, tillage practices, choice of crop sequence, crop density, crop species and cultivars, insect management, labour, available traction power and cash inputs (Bantilan et al., 1974).

2.4.1 Crop rotations for weed control:

The importance of choosing an appropriate crop in crop rotation for weed control was effectively demonstrated by Hodgson (1958) in a six-year investigation at Bonzeman, Montana. Crop rotations are used to manage weeds by utilizing differences in the morphology, physiology and production practices of the crop grown (Harper, 1956). Practicing crop rotation, the possibility of undisturbed development of weed on a given land is greatly reduced and thus weed build up is prevented (Moody, 1977). Crop rotation systematically allowed removal of easily controlled weeds while allowing other weeds to become better established (Fryer and Chancellor, 1970a). Interactions between two or three plant species can

Recent advances in development of short duration, photoinsensitive and high yielding varieties of rice have made it possible to adopt multiple cropping in the jute growing tracts of West Bengal and Assam, India. A major breakthrough in total crop production can be achieved by augmenting the production potential per unit area through adoption of cropping pattern as well as use of optimum amount of inputs in general and weed control in all component crops of cropping sequence in particular (Biswas, 1984).

Some sets of multiple cropping pattern have been explored at Jute Agricultural Research Institute, Barrackpore, West Bengal, by Pandey and Goswami (1968), Mitra et al. (1972) and (1973), Patel et al. (1972) which are as follows:


Zemanek (1976) observed in permanent plot trials in 1971-75 that continuous cultivation of winter wheat increased population of *Apera spica-venti* while continuous cropping with spring barley increased population of *Sinapis arvensis* and *Avena fatua*. Jereza and De Dutta (1976) demonstrated that various crops, soil, water and weed control practices brought about changes in the weed community. They demonstrated that
under continuous low land rice, the perennial sedge *Scirpus maritimus* persisted and remained relatively constant over a 3-year period but annual weeds tended to increase and because of this, yield decreased. Under these conditions, there were no *Cyperus rotundus* plants. *C. rotundus* appeared under upland conditions. Dospekhov *et al.* (1980) reported that rotary cultivation for 7 years increased infestation of annual weeds by 62% and of perennials by 20% compared with conventional cultivation. Six years deep ploughing combined with rotary cultivation reduced weeds by 21 percent and combining 3 depth and deep ploughing and rotary cultivation reduced weeds by 10 percent. Kim *et al.* (1983) stated that the weed vegetation of a particular area is determined by many interrelated factors such as climatic, edaphic and biotic factors. In a given environment, however, the weed vegetation is most strongly affected by biotic factors, particularly cultural practices, such as irrigation, fertilizer, cultivar grown, tillage, herbicide used and crop rotation. Summer *et al.* (1975) noted that certain crop rotations may not be economical because of the increase of some pests. They observed that it was not possible to control *Cyperus esculentus* L. in an all vegetable crop rotation whereas in a turnip-corn-turnip rotation, minimal inputs might be needed to control this weed.

### 2.5 Herbicides for weed control:

One of the most revolutionary innovations in agricultural practice has been the wide spread use of herbicides to control weeds. The innovation has also allowed large change in crop husbandry, so that
herbicides has directly or indirectly, altered the weed flora of arable land. Fryer and Chancellor (1970,b) concluded that the major effect of herbicide usage in arable fields is to reduce rather than to eliminate weed population. They also stated that the effect of herbicides on the weed flora must be viewed against changing agricultural practices, which in themselves have a profound effect upon the abundance and status of individual weed species.

2.5.1. Weed control in jute

Weeding in jute though very essential becomes a problem and rather appears to be unwildy and extremely costly, since every bit of soil is to be hand weeded and that too within a very short period, Labour availability during that period also becomes acute and rains interfere in normal operations as a result the proper cultural operations are usually not done properly and timely. In such situations any of the herbicide which may provide selective weed control will be much helpful to small and large farm units of West Bengal in the growing regions (Saraswat, 1974).

2.5.2 Chemical weed control in jute

Use of TFP-Sodium (tetrapion) and other new herbicides:

TFP - Sodium (tetrapion) is a newly developed herbicide having distinct selectivity, and very low mammalian toxicity (Anonymous, 1971). It has a strong activity on Gramineous and Cyperaceous weeds.
and on some leguminous weeds (Nakamura and Yoshimura, 1965). Being a slow acting herbicide, tetrapion controls weed by inhibiting the growth over a long period. Sometimes only one application of this compound could control troublesome grasses for a long period (Yamada, 1970 and 1971). Selective control of grasses and sedges in certain vegetable crops and other vegetable crops as pre-emergence application with tetrapion was first reported by Aelbers et al. (1969) followed by Bastiaansen et al. (1970) and Richardson et al. (1971). Selectivity of this compound in pot experiment on jute, sesame and kenaf against the two weeds Amaranthus retroflexus and Eleusine indica was reported by Dean and Parker, (1971). Saraswat (1976) reported that tetrapion, incorporated into the soil before sowing of jute seeds, gave the best control of annual grasses and to some extent, sedges.

The earlier work on weed control in jute by Tosh (1977), Mukhopadhyay and Ghosh (1978), Bhattacharya (1976), have suggested that one pre-emergence application of fluchloralin was effective in controlling annual grasses but it was ineffective against sedges.

2.5.3 Chemical weed control in rice:

For increasing the productivity of rice per unit area, timely weed control is important which necessitates the use of chemical at time of labour scarcity (Navarez et al. 1979).
In view of lack of adequate opportunity of spraying herbicides in rainy season and having more chances of washing out of chemicals applied, use of granular forms of herbicides in rice fields just after transplanting operation may be considered as handy tools to fight against weeds by the farmers (Chakraborty and Mukhopadhyay, 1977, Yogeswara Rao and Padmanabham, 1972).

Among the many herbicides (propanil, thio-bencarb molinate, nitrofen, MCPA, oxadiazon, dichlobenil and butachlor) tested so far by different workers for use in transplanted rice, butachlor at 1.87-2.5 kg.a.i./ha is being used increasingly for pre-emergence weed control in transplanted rice in Tamilnadu (Chandra Mohan and Subramaniam, 1976; Balu and Sankaran, 1977), in Orissa, (Yogeswara Rao and Padmanabham, 1972), in West Bengal, (Chakraborty and Mukhopadhyay, 1977) and in Western countries (Flinchman, 1970).

**Butachlor for transplanted rice:**

Chela and Gill (1980) found that butachlor at 1.0 to 1.5 kg.a.i./ha applied three days after transplanting gave effective control of *E. crus-galli* L. and decreased the dry weight by 96.5 per cent. Subbian (1983) reported decreased weed population and weed dry matter with the application of butachlor 2-4 kg.a.i./ha. Studies at Ludhiana revealed higher yields with the application of butachlor at 2.0 kg.a.i./ha (AICRPWC 1984,d). Increased yield attributes viz., number of panicles per unit area, panicle length, panicle weight and number of grains per panicle were reported by Satyavan and Harbir Singh (1986). Mukhopadhyay and De (1980) also reported effective results with butachlor (G) at the rate of 2.0 kg a.i./ha.
2.5.4 Chemical weed control in *Rabi* crops

Prevot (1970) stated that the use of nitrofen at (2-2.5 kg a.i./ha) pre-emergence in wheat in W. Europe was safe but not in barley and oats.

Mehrotra *et al.* (1969) reported that application of nitrofen (at 1.5 kg a.i./ha) at pre-emergence gave the highest tuber yield of potato (420.4 q/ha). Bhan and Tripathi (1981) reported that alachlor (at 1.5 kg a.i./ha) gave good control of weeds in potato field and provided higher yield of potato tubers.

Singh *et al.* (1960), Gupta (1973) and Walia and Gill (1977) reported that pre-emergence application of atrazine (at 1.0 kg a.i./ha) was most effective in controlling broadleaf and grassy weeds in the maize crop.

Ubrizsy (1968) in Hungary showed that regular use of triazine herbicide in maize reduced weed cover by 13-77%. Similarly, the use of growth regulator herbicides in winter wheat caused reduction of 9.25% of weed cover. Dowler and Hauser (1974) reported that herbicides were more effective in controlling weeds than were cultural practices in all cropping sequences involving corn.

2.6 Long term effects of herbicide in crop rotations:

Mani *et al.* (1972) reported that the techniques of herbicide use has been found to serve as a valuable tool in maize-wheat, maize-peas, maize-linseed, jowar-wheat, multiple rotations.
Research on long-term experiments where crops were rotated and herbicides were applied in each year exerted a favourable influence on the growth of crops, increased crop yield appreciably and repeated herbicide application did not exert any influence on the agro-chemical characteristics of the soil (Zemanek and Mydlilova, 1971). Weed population was rather changed in response to diversification of cropping system (Bantilan et al., 1974).

2.6.1 Long term effect of herbicides on weeds

Herbicides reduced weed population and this effect was reintroduced by the 6-course rotation (Krzymuski and Niewiadomski, 1974), caused reduction in yellow nutsedge and the total number of weeds (Hauser, 1974). Four seasons application of alachlor in maize increased broadleaf weeds, however continuous application of atrazine resulted in increase in grass weed population (Doll and Piedrahita, 1975). Repeated application of butachlor and nitrofen at recommended dose for annual weeds increased yearly weed dry weight and created predominance of perennial sedge while broadleaf weed decreased (Ahn et al., 1975).

Browning (1975) stated that predictive trends for weed populations are harder to establish because of the relative lack of quantitative studies. Continuous application of tribunil for 7 years in cereals increased thitles and *Galium aparine*, but *Synapis arvensis* appeared to have eliminated (Cremer, 1976).
The influence of four different crop rotation systems and repeated herbicide application on the changes of the number of individual weed species was followed in stationary experiments carried out at Praha-Ruzyme in the years 1971-1975. With crop rotation (Winter wheat-sugar beet -spring barley-pea-winter wheat) the number of weeds grew only slightly even in the untreated controls. The application of different herbicide type selected according to the crops and main weed species, decreased the total amount of weeds especially of the following species: *Synapis arvensis*, *Chenopodium album*, *Veronica* sp., as compared with the initial state in 1971, as well as with the corresponding untreated controls in 1975 (Zemanek and Sterba, 1976).

Stryckers et al.(1976) from Belgium reported about the effect of long-term application of herbicide in 6-course rotation. They observed changes in the composition of weed flora and striking spread of *Ranunculus sarosis* following simazine + methoprotryne and *Aphanes arvensis* after repeated application of mecoprop. In the beginning the yield levels were increased but with increase of weeds the yields decreased.

In long-term field trials, Zemanek (1977) found that crop rotations with a major proportion given over to cereals had a decisive influence on changes in the field weed community. Herbicide application over many years did not increase weed infestation in fields, but contribute to an unfavourable change in the field weed community especially if the same herbicide
(e.g. MCPA) was always applied. Crop rotations as well as a change in the herbicides used, decreased the number of weeds.

Gummesson (1978) from Sweden reported about the effect of long-term application of herbicide, who observed that broadleaf weeds were controlled more effectively by chemical than mechanical means. The desired level of control of perennial weeds like nutsedge was not achieved in a single season, however, when selective pressure was maintained on this weed throughout rotation system, population could be reduced to a manageable level in 3-year (Keeley *et al.*, 1979 and 1983). Continuous use of herbicide with the same active ingredient can make certain weeds become dominant (Basuki & Ruswandi, 1980), e.g. *Sida spinosa* has become a problem weed in cotton due to long-term use of certain grass herbicide (Elmore, 1981). Herbicide which are mainly effective against annual weed is the major cause for the increase in perennial weeds (Moody, 1982). With repeated use of triazine in maize field, *Echinochloa crusgalli*, *Amaranthus retroflexus*, *Digitaria sanguinalis* and *Setaria glauca* which were not important before herbicide application became important after herbicide use over years (Mixner, 1981). Eight years of herbicide treatment in crop rotation with major proportion of cereals reduced weed number by 45%. A trend emerged for greater yield when general yield was low (Zemanek and Kotrba, 1982).

The effects of intensive systems can neither be generalized nor predicted because of enormous variety of systems utilized throughout the world. The information
on the effects of multiple cropping on weed abundance are scarce, however, it seems that much work is needed before a general theory of the effects of multiple cropping on weeds can be developed.

2.7 Shifts in weed species composition in multiple cropping:

It has long been recognised that different species of weeds are commonly associated with different crops (Plucknett et al. 1977; Muenchert, 1980). This is the result not only of differences in weed control techniques normally associated with specific crops (e.g., tillage, herbicides), but also of differences in the nature of crop weed interferences (Buchanan et al. 1975). These species-specific types of interactions result in shifts in weed species dominance between crops (IRRI, 1975), and for this reason, crop rotation can be used as an effective means of preventing population increases of any single weed species (Walker and Buchanan, 1982).

2.7.1 Shifts in weed flora due to weed control methods:

Use of growth regulator herbicides in winter wheat replaced the indigenous weed flora by cosmopolitan weeds (Ubrizsy, 1968). Herbicide use although diminished the number of weeds but the weed flora is perhaps able to maintain its diversity of species (Fryer and Chancellor, 1970b). Similarly, Thurston (1969) also supported the theory of maintenance of species diversity from their experience of famous Broadbalk Experiment at Rothamsted. Kott (1971) has,
infact, asserted that the pressures of agriculture, including herbicide use, are shortening the life span of annuals. Zemanek (1974) reported on the effect of four different types of herbicides on changes in weed communities. He reported that two application of MCPA increased *Agropyron repens*. Gramoxone herbicide, suppressed this weed but increased the population of *Convolvulus arvensis*.

Dowler and Hauser (1974) reported that, over a three year period, fluometuron decreased the broadleaf weed population and shifted the population to *Cyperus esculentus* and annual grasses. Similarly Weber *et al.* (1974) reported that annual applications of prometryn and fluometuron greatly decreased *Digitaria sanguinalis* but the plots became almost completely infested with *Cyperus esculentus* and *Dactyloctenium aegyptiacum*.

Intensification of upland rice cropping associated with the use of herbicides to control weeds, grasses and sedges have been built up and tend to dominate in the weed flora (IRRI, 1974). The population shift was due to the successive elimination of herbicide sensitive species and their gradual replacement by resistant species.

One study suggests that *Compositae* and *Commelinaceae* species become dominant in fields where other weeds have been controlled with pre-emergence herbicides (Akobundu and Fagade, 1978). Bhandari and Moody (1981) reported that *Cyperus rotundus* populations increased in plots where pendimethalin was used to
control *Rottboellia exaltata* in rainfed, rice-based cropping systems. Munroe *et al.* (1981) reported that continuous application of butachlor caused a shift from monocots to dicots. A similar shift favouring *C. rotundus* was reported by Navarez *et al.* (1983) when pre-emergence pendimethalin was followed by post-emergence 2,4-D in rice and when pendimethalin was applied pre-emergence in the succeeding mungbean crop to control *R. exaltata* in a rice-mungbean sequence. Sankaran and De Dutta (1984) reported that *Commelina benghalensis* became dominant in upland rice where *R. exaltata* was competely controlled by pre-emergence applications of pendimethalin. A shift favouring slow growing broadleaf weeds over fast growing annual grasses is desirable because it significantly reduces weeding time. Unfortunately, the shift sometimes is from a moderately easy-to-control weed to one that is difficult to control (Mercado, 1983).

A long-term experiment initiated at PAU, Ludhiana, Punjab, to study shifts in weed flora due to continuous use of herbicides under different rotations revealed that problem of *Phalaris minor* was on the increase in wheat after paddy as compared to in maize-wheat and cotton-wheat (AICRPWC, 1989).

2.8 Residual effects of herbicides:

Zhelev *et al.* (1967) noticed adverse residual effects of atrazine at the rate of 2 kg/ha in wheat in years of adequate rainfall. In dry years residues from atrazine was only toxic from rates 2 and 4 kg/ha, respectively. However, herbicide residues had no
adverse effects on purity, germination capacity of wheat, or on the 1000 grain weight of wheat seed. Kapski and Lipinski (1974) submitted an interim report in Warshaw on a long-term experiment began in 1971 with herbicide used in vegetables. He stated that residue tests one month after treatment showed large amount of herbicide in the soil but these had disappeared completely at the end of the growing season, except in the case of double rate of lenacil which caused a slight inhibitory effect. Melville and Oakes (1976) stated that the herbicide atrazine applied to maize, diuron to cotton, chloramben to soyabean produced no direct or residual harmful effects on yields in rotation of cotton, maize and soyabean during 15 years.

Rahaman et al. (1976) conducted experiments over a period of 2 years on the phytotoxicity and presistance of alachlor, atrazine, linuron in peat and mineral soil of New Zealand using soyabean and oats as indicator plants. Bioassay data on the residual toxicity of alachlor, atrazine in both peat and mineral soil indicated that at the end of the cropping season none of the chemicals persisted in amounts large enough to cause any abnormalities or reduction in the shoot growth of test species.

Himme et al. (1981) carried out tests on a sandy loam soil in Belgium and observed that herbicide residues were broken down rapidly, enabling rescue crop to be sown after only 5 weeks.
Rahaman et al. (1986) studied on the residual activity of repeated annual applications of atrazine in the top 10 cm of clay loam and silt loam soil of New Zealand over 8 growing seasons. They reported that atrazine persisted larger in silt loam soil. However, there was no indication of a build up of herbicide residues in either soil even after 8 years of repeated use in same soil.

2.9 Long term effects of herbicides on microorganisms

The potential extensive use of certain herbicides has made it desirable to study their effects on soil microorganisms. Microorganisms are important to soil fertility because they transform potential plant nutrients into active or available forms (Chandra et al.; 1960). Greaves (1979) also reviewed the long-term effects of herbicides on soil microorganisms.

2.9.1 Effect of herbicide on soil bacteria, fungi and actinomycetes:

Cole (1976) reported from an analysis of soil in which maize has been grown annually for 9 years ± annual application of 3-4 kg/ha atrazine indicated that long-term atrazine use had little effect upon soil microbes or biochemical processes, with the exception of a transient inhibition of bacterial growth during the first week after field application. Repeated application did not affect the number of viable bacteria or fungi or relative abundance of bacteria producing hydrolytic enzymes or soil enzymes levels...

Enkina and Vasil’EV (1975) conducted trials on heavy loam chernogem soil in 1968-71 and reported that alachlor at 6 kg/ha applied at pre-emergence did not influence bacteria, fungi or actinomycetes but
bacterial population tended to increase in numbers (11-51%). An increase of 45% in the nitrate-N content of the soil compared with a clean weeded control was observed. Alachlor tended to stimulate nitrification, the formation of amino acid and cellulose decomposition. Jones et al. (1974) reported that crop changes in crop rotation may cause greater effects on soil microorganisms, than long-term cultivation of, and pesticide use, in the same crop.

2.10 Economics in use of herbicide:

Campbell (1968) stated that the efficiency of small farms in the tropics is affected by a number of socio-economic and physical factors. Some are complex and not always solved by farmers, which at times may considerably improve efficiency of production by relatively simple changes. He further narrated that traditional practices consume large amount of labour without contributing proportionately to the total production and most serious of these wasteful practices is mechanical weed control. A major step in this direction can be made by substituting the labourers: hand methods of controlling weeds with herbicides and diverting labourers for more productive use. Steele (1965) enlightened possibilities of use of herbicides for economic weed control, if these are cheap, non-toxic, highly selective and can be applied by simple machinery. Economic feasibility, its effect on cost, yield, timeliness and alternative use of labourers are factors considered by Armstrong et al. (1968). Economic uses of herbicides are also suggested by Sinha and Sinha (1970), Sinha and Thakur (1970) and Jain et al. (1966) in different crops in India.
Lybecker et al. (1988) carried out an economic analysis of four weed management systems employed on four crop sequences in a barley-corn-pinto bean-sugarbeet rotation in Eastern Colorado. An income risk analysis showed that the herbicide-intensive weed management system was not risk efficient and that producers would select one of the other three less herbicide-intensive weed management systems depending upon their risk preferences.

2.11 Summary and scope of present work

In the literature it has been stated that weeds cause enormous loss to crops if weeds are not removed or controlled in time. So attempts have been made by various workers to reduce weeds in crop field through interculture, hand weeding, crop rotation and by application of herbicides. Among these hand weeding is the best method of controlling weeds. But with the rising cost of manual labours, non availability of labour during the peak period, hand weeding is becoming costlier day by day. Hence it seems necessary to find out economical method to control weeds in jute and rice field with the combination of crop rotation and herbicide use. And for that studies on the changes in the composition of weed flora due to continuous use of herbicides, and possible consequences on the yield of succeeding crops in rotation is also pertinent. The efficacy of small farms by relatively simple changes in the traditional method may be improved and wasteful practices of mechanical weed control may be avoided by substituting herbicides in crop rotations to obtain uniform crop yield year after year without impairing the soil fertility and productivity.