CHAPTER 2

REVIEW OF LITERATURE
2. REVIEW OF LITERATURE

In the ensuing section an attempt has been made to review the related research work done on direct sown rice with a special reference to weed management. The salient findings observed from India and abroad, related to this investigation have been reviewed briefly in this chapter.

2.1 Rice seeding method

Rice crop is either sown by drilling, broadcasting or transplanting. In transitional belt, majority of rice is grown by direct sown method (Mallappa and Hosmani, 1976). They also observed that weeds pose greatest hazard to a good rice husbandry. Sometimes on the rice is sown before the onset of monsoon, the crop and weeds emerge together. Moreover, the rainfall and quantity of water available for impounding in rice field is not sufficient which would have smothered weed growth, as a result success or failure of crop depends on the weed control. Drilling of rice seeds directly in the moist zone of the soil is by far the best, provided the field is kept ready for drilling by utilizing the premonsoon showers. If the fields are to be prepared after the monsoon sets in, timely sowing cannot be ensured and the germination may suffer badly in case of heavy rains in completely prepared field (Mahatim Singh, 1978).

Patnaik (1978) has broadly classified the traditional rice culture system in the kharif depending on the monsoon, into three categories such as upland rice, medium land rice and lowland 'aman' rice. On the uplands, early duration varieties
are grown direct seeded with the onset of first monsoon showers.
In the medium lands, medium duration varieties are directly
seeded and converted to flooded condition, the practice being
locally known as 'biasi' or 'bushening'. In the lowlands where
the photo-period sensitive 'aman' rice varieties are direct
seeded dry and converted to flood condition.

The choice of cultivar, seeding method, seedrate and
row spacing are some of the factors that influence weed incidence
in upland rice fields. Tosh et al. (1981) showed that seeding
rice in rows resulted in higher plant population, lower weed dry
matter accumulation and higher grain yield than did broadcast
seeding. Maintaining optimum plant density with high seedrate
helped in suppressing the vigorously growing weeds in the early
stages of plant growth. Williams and Ramsay (1981) tested three
new technique for broadcast seeding rice in North Australia.
In ridge and farrow sowing, the site was prepared with a disc
harrow to produce small ridges and furrows at 20 cm spacing
and sprayed with urea. This method extended the sowing period
by about 6 week gave good establishment and yield. In weed-mulch
sowing, dry seed was sown about 10 days after herbicide spraying.
Rice establishment among the dying weeds was quite good and 4-7 t/ha
grain yield was recorded.

Pillai (1982) made observation on different methods of
rice seeding under upland condition namely broadcasting, linesowing
behind the plough furrow and drilling by seed drill. He observed
that because of severity of the weed problem and difficulties
involved in weed management in broadcast sown crop, broadcast sown
crop should be discouraged. Higher grain yield and more net return was recorded under line sowing because of good crop stand and easy in weed control.

Rao et al. (1984) reported that density and drymatter production of weeds was significantly more under broadcasting method as compared to transplanting. Loss in grain yield due to weed competition under non-weeded condition was more in broadcasting method (49.9%) compared to transplanting (40.5%). Under broadcast situation application of herbicides gave excellent control of weeds which were at par with that of handweeding.

Chandrakar and Chandravanshi (1985) reported that rice seeding with seed drill and line sowing behind plough furrow produced significantly higher grain yield (29.63 and 28.31 g/ha respectively) over broadcast method of rice seeding. On making comparison amongst different weed control practices, cultural method with hand weeding twice, lowest weed dry weight with highest grain yield (36.34 g/ha). However, the use of butachlor @ 2 kg/ha was found better over their lower doses.

In Rio Grande do Sul (Brazil), the highest grain yield was obtained by sowing rice in rows of 15-25 cm apart. Rice, however, is broadcast on 90% of the area during the high spring rainfall. Disadvantages of broadcasting include using 30% more seederate than with drilling. When seed with about 85% germination capacity is broadcast on well prepared soil, the recommended rate is 500 seeds/m² for traditional and modern cultivar corresponding to 125-200 kg seed/ha. With drilling the seederate should be 100-150 kg/ha (Pedroso, 1985).
Toth (1965) observed in the 3 years of study that higher rice grain yield was obtained with surface sowing as compared to sowing into the soil. Mean yield differences were 96.7% for fertilizer. The number of panicles per m² and the number of filled grains per panicle were higher with surface sowing.

2.2 Nature of weed problem in rice

The weed flora and density of rice differ widely amongst different rice seeding methods. In upland rice environment it is very favourable for the germination of a variety of weeds almost simultaneously with the crop seedlings. In hot and highly humid micro-climate of rice fields, these weeds grow rapidly into vigorous stands and over-power rice plants. Frequent fluctuations in flood level in upland rice induce 2 to 3 flushes of weeds before the crop closes in. Several workers attempted to identify different weed flora and its density in paddy field.

Antognini (1967) observed that as low as 10 plants per sq.m. density of Barnyard weed reduced grain production in rice by 10% where the weed was allowed to compete with crop for only 3 weeks. A four weeks competition reduced rice yield by 40%. The yield attributes of rice affected by weed-competition were the number of panicle/m², spikelets/panicle and filled grains/panicle depending upon the weed-crop competition.

Noda et al. (1969) studied the degree and pattern of damage to rice plants caused by competition from Barnyard grass.
They observed that high densities of Barnyard grass increased
the height of rice plants at middle of the cropping season and
seriously reduced the tillers from late July onwards. The number
of panicle bearing tillers were reduced by 50% and caused a delay
in heading by one or two days. The productive structure of rice
plant was changed markedly, and they attributed into the reduction
of sunlight and nutrients.

The effect of weeds on rice was evaluated by Chang (1970)
for 4 weed species at densities of 0,100 and 200 weeds/m². The
results indicated that Echinochloa crus-galli, Cyperus difformis,
Marsilea sp. and Monochoria vaginata reduced the grain yield by
an average of 85, 72, 62 and 9% respectively. Weed infestation
of 100-200 weeds/m² reduced the yield by an average of 54-64% when
compared to weed free control. Panicle number also suffered most
followed by the number of grains/panicle. But test weight and
sterility percentage were affected slightly.

Findings of experiment conducted by Mukhopadhyay et al.
(1972) on dwarf rice under upland land condition indicated that
out of 21 weed species present, grasses comprised 85% of total
population and 91% of the total weed dry matter. They reported
that Echinochloa spp. was the dominant species which reduced the
yield by 74 to 98%. Moorthy (1980), Nanjappa and Krishnamurthy
(1980) and Ali and Sankaran (1984) have also reported similar
results.

Field trials conducted by Pillai et al. (1975) have shown
that the predominant weed species under lowland rice culture are
mostly grasses and sedges. Under upland conditions perennial
sedges such as Cyperus spp. and grasses such Cynodon sp. pose major
problem.
Kusangi (1978) reported that weed damage is particularly noticeable at tillering and between earbearing and early ripening. Simultaneous control of both weeds may be obtained at the early growth stage of the crop, when the growth stage of *Echinochloa* spp. is the limiting factor.

Bhan *et al.* (1980) reported that the intensity of grassy weed was more in plots maintained weed free for initial 15 to 30 days. Broadleaf weed population increased at later stage when weed free maintenance was kept from 30 to 45 DAS. Population and dry matter produced by weeds have influenced the grain yield. Grain yield in grassy weed infested plots was reduced because of severe competition. Keeping the crop weed free for initial 45 days resulted in greater yield than in weedy check.

Nair *et al.* (1982) listed the weed species in unweeded control treatment in order of their predominance in their population. These are *Fimbristyliis millettiae*, *Cyperus iria*, *Ludwigia parviflora*, *Echinochloa* spp., and *Monochoria vaginalis*. Results indicated that the competition with weeds during the first 15 days of sowing had no significant effect on the yield of rice. Competition upto 15 days after sowing caused a much reduction in yield. There was significant increase in the grain yield with the increase in the duration of weed free period upto 45 days of sowing. These findings are supported by the findings of Govindra Singh *et al.* (1985) and Singh *et al.* (1985).
Crop raised through conventional dry tillage sustained sedges, dicots and grasses constituting a population density of 40, 34 and 26 per cent respectively at 20 DAS (Zeheruddeen and Prakash Rao, 1983). However, at 50 DAS, the population density of grasses (39%) increased, while a negligible change (44%) was observed with sedges. This indicated interspecific competition among different weeds. The biomass production of grasses as reflected by dry matter weight increased from 21.3% at 20 DAS to 57.5% at 50 DAS. The grasses and the sedges are therefore considered to be of greater significance than dicots in rainfed upland rice fields.

The weed flora in rice fields varies widely with the method of cultivation (Mohammad Ali and Sankaran, 1984). In upland rice grasses form major weed although nut sedge and broadleaf weeds also grow in competitive forms. Heavy nitrogen and phosphatic fertilization aggravates algae problem in rice fields. Terrestrial weeds, including Echinochloa spp., Susbania sp. and Curly indigo, may be serious on ridges where water does not cover the land adequately. Regarding critical stages of weed competition in rice it was found that yield reduction caused by weed is most severe in the early stages of growth. Weed free condition upto 21 days from planting was sufficient for getting economic yield in rice.

2.3 Nature of weed-crop competition
Agricultural crops suffer from heavier losses due to associated weeds. Weeds compete for three essential requirements like (i) moisture (ii) nutrients and light. When these essential needs are limiting, crop growth and yield are adversely affected by weeds due to their competitive influences.
2.3.1 Competition for solar energy

About 99% of dry matter in plants is made up of organic matter that is dependent on solar energy. When plants are mutually shaded, their production potential is greatly reduced even though water and other nutrients are available to them in abundance. During seasons when weeds grow earlier to crop plants in the fields, the crop seedlings get shaded and become chlorotic and weak. This effect of weeds is most pronounced in slow germinating crops (Donald, 1961). Bleasdale (1959) also concluded that in years of normal rainfall competition between crops and weeds was principally for nitrogen and light; the magnitude of these two factors depends upon the weed species.

Noda et al. (1968) observed that high densities barnyard grass attributed to the reduction of sunlight. Light intensity was reduced by as much as 70% at half of the height of the barnyard grass. Dry weight of leaves and nutrient assimilation were greatly reduced due to competition from barnyard grass. Yoshida (1972) and Sahu and Murty (1976) concluded that the progressive decrease in light intensity correspondingly reduced the growth and yield attributing parameters. Lower grain yield under shade was due to the cumulative effect of reduction in the number of panicle per unit area as well as formation of grains/panicle and increase in more sterile grains.

Direct influence of low solar radiation with high sterility percentage has been aptly cited by Palit et al. (1976). The retarded translocation of carbohydrate to developing grain during ripening under illumination might be an additional factor for high sterility as observed by Nogachi and Nakayama (1978). Under low light intensity, the reduction in dry matter content is related to impaired photosynthesis.
Since a considerable proportion of grain carbohydrate is contributed by the reserved assimilate at flowering during wet season i.e. under low light, it is essential to select varieties capable of accumulating higher dry matter prior to flowering stage for low light situations (Murty and Venkateswarlu, 1978).

Spikelet sterility in rice is higher in wet than in dry season. Nutrient present in the plant body play a major role in determining sterility. Of those the most potent nutritional factors affecting the ripening of spikelets seem to be protein and carbohydrate synthesis and their translocation to developing kernel. Any disturbance or abnormal change in the above constituents may have serious effect on the fertility of spikelets (Khan, 1973). Murty and Murty (1982) studied the variation in carbohydrate and nitrogen content in high (Ratna) and low (Pallavi) sterility rice cultivar under normal and low light (50% normal) conditions. The high sterility line Ratna invariably showed lower carbohydrate and higher soluble nitrogen contents than the low sterility cultivar Pallavi in both light regimes indicating that sterility in rice associated with lower carbohydrates and greater soluble nitrogen accumulation in all the plant parts including the panicle.

Reduced light intensity coupled with low sunshine hours is considered to be one of the typical agroclimatic environmental constraints that affect the yield potentiality of rice during kharif (wet) season. Murty et al. (1975), Venkateswarlu, (1976) have reported that under low light, dry matter accumulation is impeded obviously due to low rate of photosynthesis (Tanaka et al. (1966).
Under continuous subdued light intensity the tillering is impaired and panicle weight and drymatter content are considerably reduced. Among the yield components, low light affects mainly the grain number per panicle, through lower number of filled grains induced by higher percentage of spikelets sterility.

Several constraints affect the production of rice during kharif or wet monsoon season. Of these low radiation intensity prevailing during this period (250-300 cal/day) might play the major role, which affects the photosynthetic efficiency during the cloudy monsoon (Padmnabhan 1976). Investigations in laboratory on the screening of rice cultivars (Nayak et al. 1978) stated that the effect of reduced light intensities i.e. 35, 50 and 70 percent of normal radiation (250-300 cal/day) on leaf chlorophyll content, photosynthesis and photorespiration on shade tolerant (Vijaya) and Shade susceptible (IR8), varieties indicated that Vijaya was efficient under low light because of higher chlorophyll content mostly chlorophyll 'b' tration, greater photosynthesis especially under blue light and lower photorespiration. The efficiency in photosynthesis under blue light might indicate the relative adaptability of rice varieties to low light intensity.

Mandal et al. (1978) presented some climatological problems in kharif season which are not very favourable for growing high yielding varieties of rice. Of these high temperature, insufficient solar radiation due to cloudy weather and water logging are major problems. High temperature during early vegetative phase favoured tiller development. But cloudy
weather at this stage reduced the number of effective tillers. The photo period-insensitive dwarf varieties passed through panicle initiation and development stages under insufficient light and high temperature conditions result in lower grain number per panicle. Noguchi and Nakayama (1978) studied the influence of shade of weeds namely *Cyperus spp.*, *polygonum nodosum* and upland rice. The height of *Cyperus spp.* increased at 75% shade but growth was very inhibited at 93% shade. Plant tillering and shooting was inhibited by shade. The drymatter weight of foliage was reduced by 84% shade. Heading, flowering and ripening were retarded by shade. The results suggested that more than 80-90% shade is required to diminish significantly the growth of weeds.

Jennings et al. (1979) reported that the main competition in rainfed rice is for light. Competition begins early in the tillering stage and increases in intensity proportionate to the increase in plant size and the density of planting. Competition for nitrogen may occur at later growth stages but is readily overcome by adding fertilizer. But adding nitrogen aggravates the competition for light because it induces tall plants to grow taller. Competition for light is also increased by close spacing, the length and intensity of the rainy season and weeds that reduce the penetration of light into populations. Competition is caused by differential growth rates of plants. Large plants invade the space occupied by smaller ones, shade the other plants, and capture a disproportionate share of the solar radiation. The smaller plants have reduced tillering, produce weak and spindly culms, accumulate less drymatter, exhibit premature leaf senescence, and have pronounced spikelet sterility.
Nayak and Murty (1980) observed that the effect of varying light intensities viz. normal light (400 cal cm/d.), 75% ($S_1$), 50% ($S_2$) and 25% ($S_3$) of normal light (NL) on yield and growth attributes. In two rice cultivars (Shade sensitive and shade adapted). The grain yield in general was reduced by 47%, 57% and 74% in $S_1$, $S_2$ and $S_3$ respectively mostly due to impairment in drymatter production, harvest index, panicle number and grain/panicle. Exposure to low light from primordial initiation to harvest was more detrimental to yield than from establishment (15 DAP) to harvest or from flowering to harvest (Spitter and Van 1982).

The adverse effects of high population density on leaf photosynthesis is due to mutual shading. Higher grain yield in wider spacing than in closer spacing is observed mostly due to better light availability in the former spacing (Ibrahim et al. 1980). The regulation of senescence in plant organs by manipulation of light regimes and photosynthesis. Light prevented senescence by providing a source of ATP versus cyclic photo phosphorylation. Thus in turn maintained the synthesis of chlorophyll, protein N and nucleic acids in leaf. Such favourable influence of light might have ultimately enhanced current photosynthesis and prolonged the mobilization of photosynthates to panicle for efficient grain filling and panicle yield/tiller (Goldthwait and Laetsch, 1967).

Narsinga Rao and Murty (1984) and Spitter (1984) made studies on the percentage of total solar energy utilization (%) for drymatter production (TDM) at progressive growth stages and for
grain yield at harvest on traditional tall rice cultivars from extent of three and five times in Eu% for TDM (0.38-1.64) and grain yield (0.13-0.67) respectively was apparent among the varieties. The energy utilisation was maximum at flowering stage. Energy utilisation and total dry matter production more in wet than in dry season. Leaf area index at flowering and harvest index were highly associated with energy utilisation for TDM and grain yield respectively.

2.3.2 Competition for moisture

For producing equal amount of dry matter, the weeds in general, transpire more water than most crop plants. This may not be of importance where the rainfall exceeds potential evapotranspiration or where water is easily available for irrigation round the year. But it is certainly of concern to farmers in the dry land agriculture. Here the actual evapotranspiration from crop yields with inter-rows occupied by weeds is much more than the evapotranspiration from a weed-free field. Thus, in weedy field, soil moisture is exhausted by the time the crop reaches the flowering stage which is often the peak consumptive use period of the crop. This results in poor grain quality and quantity of the crop as the case may be (Misra, 1961, Moolani and Uppal, 1966).

In fallow fields the weeds are a source of depletion of valuable stored soil moisture. At Haryana Dry Farming Research Station, removal of weeds during fallow season was found to save additional 7 to 12 ha cm of soil moisture which was capable of
producing about 15-20 q/ha of grain in the following winter season. In another study while a kharif weedy fallow retained only about 5 ha cm water up to the winter season, the clean fallow fields contained 10 ha cm of available soil moisture. Obviously, the weeds consumed by transpiration half of the available soil moisture during the fallow season (Smika and Wicks, 1968, Wiese and Vandiver, 1970).

Studies conducted by Paul et al. (1974) clearly indicate that it is not only possible to establish rice by direct sowing but also it is economical and a better practice for higher yields provided weeds are kept under control with the help of chemical or physical means. Beneficial effect of direct seeding is obtained mainly through better utilization of monsoon rain by well established seedlings. Suzuki et al. (1975) stated that total weed populations were higher under upland rainfed than under irrigated condition and both at the tillering stage of rice and at pollen cell division. But this difference had disappeared by the ripening stage. A single irrigation after pollen cell division resulted in maximum growth of weeds. Under dryland conditions and a single irrigation, large Echinochloa spp. and Digitaria sp. were predominant. Weed population were highest at soil moisture content of 90% (Wt/wt) and sharply decreased below 70%.

The problem of weed growth was severe under upland conditions. The dry weight of weeds in the non-weeded plots excelled the total drymatter production of the crop. The weeds being deep rooted, they could grow for more vigorously than the
rice seedlings under the moisture stress-situation by making use of the sub-soil moisture. The competition under such circumstances for moisture, space, sunlight and nutrient elements was more serious and damaging to the crop. The situation was further worsened because of the slow initial growth vigour and delayed canopy closure that took place in the care of the rice cultivars (Pillai et al., 1976).

It has been demonstrated repeatedly that competition ability in rice is negatively correlated with agronomic value for areas with reasonable water control. Thus, the more competitive plants are the least valuable and the desirable ones are lost in competition. Yield experiments with rice of known competitive ability invariably demonstrate that weak competitors yield more when grown in pure stands. This yield advantage increases with applied nitrogen, close spacing and improved water and weed control. Strong competitors might yield better under primitive and severely limiting agronomic practice (Coffman and Kauffman, 1979). Direct sowing rice under puddled condition could be as effective as transplanting provided that the crop is grown under weed free environment. Weeds were reported to cause yield reduction of 35% and a loss of 50 kg/ha of available nitrogen during the crop season. Water management practices can also play an important role in reducing weed growth. Several studies in India and abroad (Pillai and Rajat De 1980, Spitter and Aerts 1983; Rao et al., 1984) have indicated that the superiority of continuous shallow submergence of water on smothering of weed growth over cyclic or rotational irrigation practices.
Limited moisture supply has a definite impact, either reversible or irreversible on yield attributes in crop plants. A decrease in growth and yield components in dwarf rice was observed with moisture stress at vegetative phase which could be reversed when no stress conditions were created in the successive phases. The reproductive and ripening phases were vulnerable and crucial for moisture stress which resulted in permanent damage to growth and yield factors. The panicle number was not influenced by the different moisture regimes thereby indicating that the stress created is not severe in a high humid environment (Surya Prakash Rao, and Venkateswarlu, 1983).

Jaggi, et al. (1986) made studies in Chhattisgarh region situated in South East Part of Madhya Pradesh receiving about 1,000 mm of rainfall during monsoon season with uneven distribution. They reported that seasonal water use under continuous submergence was 1,285 mm, out of which 32% occurred during vegetative phase, 45% during reproductive phase and 23% during ripening phase. Grain yield under low levels of N was not affected by the water regimes, suggesting that continuous submergence at reproductive phase is not generally necessary and therefore a drainage period of two to three days between two irrigations should be provided resulting in considerable saving of irrigation waters.

Sharma et al. (1986) observed that the total biomass of weeds increased from June to September in all fields except in cultivated and weeded one. Weed biomass was quite low in cultivated and weeded plots in July and August. In uncultivated and unweeded
plots the weed biomass showed an increasing trend in October too, but not in cultivated and unweeded plots. The water use efficiency in the cultivated unweeded field was as high as 1.21 and 1.53 g/m²/mm in August and September which coincided with the vegetative and reproductive stage of the rice crop.

2.3.3 Competition for mineral nutrients

Weeds accumulate high concentration of plant nutrients in their tissues which, in many cases, are more than those found in common crop plants. Weeds like Cyparissus spp and Echinochloa spp accumulate 2.17 and 2.96% N, 0.26 and 0.40% P₂O₅ and 2.73 and 2.96% K₂O while Oryza sativa accumulates 1.13 N, 0.34 P₂O₅ and 1.1% K₂O (Gupta 1960). Several studies on mineral nutrients (mainly N, P, and K) removed by weeds growing in association with rice crop have been reported. Mukhopadhyay (1974), Mani (1975), Nanjappe and Krishnamurty (1980), Mohamed Ali and Sankaram (1984) and Rao and Agrawal (1984) obtained very elucidating data on nutrient removed by weeds and crop components under weedy and weed control conditions. The weed and crop removes 37.1 kg and 1.4 kg/ha N respectively. Under chemical weeded plots 80.2 kg/ha N, removed by crops and weeds uptake only 10.8 kg/ha of nitrogen. Mobbayad et al. (1977) reported that in upland rice field, handweeding 15, 25 and 35 days after emergence or treated with butachlor 2 kg/ha followed by one handweeding yield and were increased substantially with 60 kg N/ha without weed control. Increase in rates of nitrogen application resulted in no increase in grain yield.

Chakroborty (1973) studied the competition of weeds with rice and reported that the nitrogen content was significantly higher in weeds than rice straw, but in rice, there was no significant difference in the nitrogen content of rice plants at the tillering
stage. Rice straw contained a higher proportion of nitrogen where three handweedicings were done. Weed species contained much nitrogen at the vegetative, flowering and post-flowering stages indicating severe competition for nitrogen by weed throughout growing season of rice under dryland conditions.

Shetty and Gill (1974), Swain et al. (1975) observed that the competition between crop and weeds was principally for nitrogen in a year of normal rainfall. The severity of competition in direct sown rice was maximum in early stages of crop growth. Weeds competed with the crop plants up to the level of 60 kg N/ha, but when the levels of fertilization was increased to 80 kg N/ha, the crop was benefitted the most.

Crop-weed competition for nutrients made by Pillai et al. (1976) indicated the data on composite samples of weeds collected from the different treatments contained on an average, 2.13% N, 0.57% P₂O₅ and 2.07% K₂O. A conservative estimate of the major plant nutrients robbed away by weeds. The non-weeded control plots produced 43.70 q/ha of dry weed phytomass and removed 93.1 kg N, 24.9 kg P₂O₅ and 90.5 kg K₂O/ha under upland condition. These are in agreement with the findings of Hallidays (1975), Mani et al. (1976) who suggested that weeds are currently depriving rice crop in India, on an average, by at least 40-45 kg of available nitrogen per hectare during the growing season.

The interaction of fertilizer and weed control on upland rice was examined by Narayanswami and Sankaran (1978), O'Brien and Price (1983) using data regression estimates of the relationship
between yield and inputs indicated that yield response to hand-weeding increased with N application up to 75 kg N/ha, above which yields decreased unless handweeding was done. Alternative combination of fertilizer, handweeding and herbicides, which achieve equivalent yields are reported.

Katati and Pradhani (1980) reported that fertilizing on upland rice without adequate weed control measures is uneconomic because weeds are a big menace for nitrogen under upland conditions. The highest response of 11.7 kg grain per kg of the nutrient was observed in 60 kg N/ha. The highest response of 27.9 kg N/ha when the weeds were allowed to grow unchecked. The weeds caused grain yield loss up to 81%.

Muniyappa et al. (1980) reported that rice grain yield obtained in 100% fertilizer dosage supplemented with one handweeding (55.37 q/ha) was comparable to the yield obtained in 75% of the fertilizer dose plus butachlor (51.73 q/ha). This comparable yield in spite of reducing the fertilizer dosage was mainly due to better control of weeds which enabled plants to express their potentials in terms of increased panicles/m² and grains/panicle.

Pillai and Sreedevi (1980) observed the least value for dry weight of weeds in handweeded plots followed by butachlor. In case of spacing 60 cm line showed highest value for the dry weight of weeds. NPK uptake by weeds were lowest in handweeded treatments. Among the herbicides, butachlor resulted in lowest uptake of NPK which was due to low drymatter accumulation of weeds.
Rami Reddy *et al.* (1980) concluded that presence of weeds in rice field drastically reduced the efficient use of fertilizer. The practice of puddling the field reduced weed infestation and increased fertilizer efficiency which led to maximum yield of rice. Dry matter of weeds in this treatment was only 550 kg/ha as against 3910 kg/ha in dry ploughing treatment.

Maximum reduction in density and dry matter of weeds and more grain yield of rice was found in the plots treated with butachlor. The dry matter production and N-uptake by weeds were negatively and significantly correlated with crop dry weight; N-uptake by crop; number of panicles/m²; number of grains/panicle; leaf area index and grain yield of crop. However, significantly positive correlation was observed between dry matter production and N-uptake by weeds. Significant negative correlation between weed dry weight and grain yield of crop was also observed (Das and Singh 1984).

Uptake of nitrogen, phosphorus and potassium by drilled rice under upland condition and associated weeds were estimated and reported by Govindra Singh *et al.* (1984); uncontrolled weeds during the entire crop season removed 107.5 kg N, 58.8 kg P₂O₅ and 66.8 kg K₂O/ha. The total uptake of N, P and K by the crop in weedy and weed-free condition was 13.5, 8.8 and 4.7 in weedy plots and 122.2, 45.7 and 99.5 kg/ha in weed-free plots respectively. Competition with the weeds during the first 30 days only resulted into the loss of 62.7 kg N/ha by weeds. The loss of P and K during this was the highest. When competition with the weeds was avoided during first 30 days, uptake of nutrients at the later stages was very low. Weeds emerging during the period between 15 and 90 days remove 50.1 kg N, 41.9 kg P₂O₅ and 57.0 kg K₂O/ha.
One manual weeding at 30 days stage could reduce the loss of the nutrients to 19.3 kg N, 24.1 kg $P_2O_5$ and 31.0 kg $K_2O$/ha. Two manual weedings were very effective in minimising these losses.

2.4 Weed management practices

Weed management is the process of limiting weed infestation so that the crops could be grown efficiently and profitably. Physical methods of weed control utilize manual energy, animal power or run implements that cut or dig the weeds. They are sometimes distinguished as manual and mechanical methods. The physical methods of controlling weeds are by far the oldest and most practical methods available with us even to day. The physical method does not involve any skill but is high labour requiring method (IRRI 1970).

Lubigan and Vega (1971) clearly stated that two critical stages of rice growth viz, the maximum tillering stage and the one just after heading are the most sensitive to weed competition. The competition at the above mentioned stages reduced the number of effective tillers, height, nitrogen uptake in plants. A severe and significant reduction of rice yield was caused by barnyard grass due to its vigour and growth during the early growth of rice. Weed competition reduced the light transmission ratio, the exchangeable nitrogen and chlorophyll content of rice plant with the increase in weed dry weight.

When row spacing of dry seeded rainfed rice is sufficiently wide, inter row cultivation by animal drawn implements has been successful (Moody, 1975). Uprooting or severe damage of the rice plants occurred when interculture was too near the rice row.
Thus weeds within and near to the rows are not controlled and these are the most deleterious with regard to the weed competition. Singh et al. (1981) found inter row cultivation followed by a light handweeding in the crop rows, was better than the conventional labour intensive handweedings.

Several workers attempted on weed control and reported that handweeding is more efficient compared to other methods of weed control. Although handweeding is the best method, it is tedious and time consuming and required much labour. One handweeding no matter how properly timed will not provide season long weed control in upland rice (De Datta, 1980, Singh and Reddi 1984). They have also suggested that when fields are moderately infested with weeds, two weeding one at the third and the second at the fifth week after sowing are sufficient.

The results obtained from trails of International Rice Research Institute during 1976, revealed that multiple cropping of rice in rainfed areas requires the first crop be sown in a dry soil which favours weed growth. All plots were weeded at 40 DAS to prevent yield loss. Weeding time ranged from 58 man hours for plots treated with butachlor 2 kg/ha as against 356 man hours/ha for an untreated control, although it reduced the rice stand, butachlor gave the highest yield (IRRI 1976).

While working with weed management Rathi and Tiwari (1979) found in upland rice that application of chemical alone failed to provide satisfactory control of weeds and necessity of removal of weeds by hand even after the use of herbicide was clearly established.
Herbicide followed by one hand weeding at 25 DAS could bring the yield of paddy in the same bracket with complete weed free condition created by manual weeding three times.

2.4.1 Herbicidal control of weeds

Herbicides are chemicals capable of killing or inhibiting the growth of plants. In the last 40 years or so, the weeding efficiency has greatly improved upon by supplementing conventional weeding methods with herbicides. It has saved farmers in advanced countries of much involved in cultivating and hoeing and has helped in obtaining satisfactory weed control where physical methods often fail. As stated earlier a variety of grasses form primary weed flora in upland rice. Nitrofen, Oxadiazon, Molinate, Propanil, Thiobencarb and Butachlor are approved for selective control of annual grasses in rice (Singh et al., 1973). These compounds also control many broad leaf annuals and nut sedges (Singh and Singh, 1983). But it caused phytotoxicity when the chemical was applied soon after seeding.

Experimental results of International Rice Research Institute showed that chemical weed control in upland rice is not only possible but also effective and economical (De Datta et al., 1973). It is the only method of weed control suitable for large scale rice production.

For controlling rice weeds Flinchum (1970), Bhan and Maurya (1972) obtained satisfactorily weed control with little injury to rice when butachlor at 3 and 4 kg/ha was applied as pre-emergence to rice before the weed flushing. Effective weed control was obtained using parquat (1 kg/ha) followed by butachlor (1.5 kg/ha),
but reduced plant height, number of tillering and yield components. Grain yield were reduced to 60-70% of those given by traditional production methods (Chin and Lin, 1977).

Research results on weed control in upland rice (De Datta, 1981, Walkar and Buchann, 1982) indicate that there is no complete control for all weeds with a single pre or post emergence herbicide application. An application of a combination of herbicides followed in 3 or 4 weeks by hand or hoe weeding gave satisfactory weed control in several countries.

Chandrakar and Chandrawanshi (1985) made studies on weed control under various rice cultivation method, and the result indicated that butachlor @ 2 kg/ha effectively controlled weeds on broadcast sowing and plots sown by drilling, cultural method weed control was efficient. The usual practice of broadcast without a weed management significantly reduced rice production.