Chapter - II

REVIEW OF LITERATURE
2. REVIEW OF LITERATURE

The investigations carried out regarding bioefficacy of herbicides against weed species management in soybean in India and abroad have been reviewed briefly in this chapter under the following sub-headings:

2.1 WEEDS OF SOYBEAN ECOSYSTEM

The various species of grasses, sedges and broad-leaf weeds associated with soybean crop cause nutritional and functional stress on growth and yield. The competition between weeds and crop becomes more severe when competing species have need for the same factors of the environment. The greater stress on growth occurs when the demand of the plants for moisture, nutrients, light and possible carbon dioxide exceeds the available supply.

In a crop-weed ecosystem, both the crop plants and weeds grow and mature in the state of mutual suppression, resulting in a severe reduction in yield. The crop also suppresses the weeds, a condition often found in row crop culture. This is logical sequence in a soybean niche where both cultural and herbicidal methods may suppress the weed growth.
In soybean ecosystem, Bhan et al. (1970) noted 19 species of weeds belonging to different families at Pantnagar. The major species were of Corchorus, Echinochloa and Cyperus and constituted 30, 10 and 50 per cent of the total population in the field, respectively. They also reported annual monocot weeds such as Cyperus iria, Dactyloctениum aegyptium, Digitaria adscendens, Echinochloa spp., Eleusine indica, Setaria glauca and Commelina spp., while annual dicot weeds viz., Corchorus acutangulus, Ipomoea spp., Phyllanthus niruri, Solanum nigrum, Physalis minima, Celosia argentea, Amaranthus viridis etc. Some perennial weeds reported were Cynodon dactylon, Cyperus rotundus and Phragmites karka.

Bajpai et al. (1972) reported Phyllanthus niruri, Indigofera spp., Alysicarpus spp. and Commelina jacobi under broad-leaf weeds and Eleusine indica, Digitaria adscendens and Dichanthium annulatum amongst grasses and Cyperus rotundus among sedges as dominant weeds of soybean.

Shukla (1972) noted Cyanotis axillaris, Commelina benghalensis, Corchorus spp., Alysicarpus spp., Cynodon dactylon, Setaria glauca etc. as dominant weeds in cultivated fields of Ujjain during rainy season.

Malik and Lal (1973) found Echinochloa colonum, Cyperus rotundus, Physalis minima, Commelina benghalensis, Eclipta alba, Leucas aspera and Corchorus acutangulus as the most important weeds of soybean in Rewa (M.P.).
Maley et al. (1977) noted Cyperus spp. and Echinochloa spp. as dominant along with Caesulia axillaris, Eclipta alba and Euphorbia spp. in soybean at Jabalpur.


Lokras et al. (1984) and Jain et al. (1985) found association of Echinochloa crusgalli, Cyperus spp., Phyllanthus spp., Corchorus acutangulus, Aeschynomene indica and Hibiscus micranthus in soybean ecosystem.

The dominance of Echinochloa colonum, Setaria glauca, Cyperus iria, Digitaria sanguinalis, Panicum distachyum, Phyllanthus niruri and Aeschynomene indica was also reported by Singh and Kharwara (1984) in soybean fields.

Recently, Agrawal (1990) has reported Phyllanthus niruri, Echinochloa crusgalli, Cyperus spp., Eclipta alba, Ageratum conyzoides, Cyanotis axillaris, Digitaria adscendens and Caesulia axillaris as dominant weeds in soybean at Jabalpur.

Jain et al. (1990) have found association of Echinochloa crusgalli, Digitaria adscendens, Cyperus rotundus, Commelina communis and Phyllanthus spp. in soybean ecosystem.
Maurya et al. (1990) concluded that the most dominant weeds were *Cyperus* spp. and *Echinochloa crusgalli* among monocots, while *Physalis minima*, *Ageratum conyzoides* and *Phyllanthus* spp. among dicot in soybean fields.

Mishra et al. (1990) at Pantnagar found that the major weeds in soybean fields were *Echinochloa colonum* and *Celosia argentea*.

Sharma and Khan (1990) observed that *Echinochloa crusgalli*, *Cyperus rotundus*, *Cynodon dactylon*, *Commelina benghalensis*, *Corchorus acutangulus*, *Eclipta alba* and *Launaea aspleniifolia* constituted the major bulk of weeds in soybean.

Raikwar et al. (1990) concluded that the most dominant weeds were *Cynodon dactylon*, *Paspalum distichum*, *Commelina communis*, *Caesulia axillaris*, *Echinochloa* spp., *Cyperus* spp. and *Echinochloa crusgalli* in soybean fields.

Thakur and Dubey (1990) at Jabalpur reported that the weed flora consisted of *Digitaria adscendens*, *Echinochloa crusgalli*, *Eragrostis ciliaris*, *Setaria glauca*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria*, *Ageratum conyzoides*, *Amaranthus viridis*, *Caesulia axillaris*, *Commelina benghalensis*, *Eclipta alba*, *Euphorbia hirta* and *Phyllanthus niruri* in soybean ecosystem.

Tiwari et al. (1990) at Jabalpur concluded that in soybean crop, the major grassy weeds were *Echinochloa crusgalli*,
Digitaria ascendens and Cynodon dactylon. Other associated weeds were Commelina communis, Alysicarpus rugosus, Eclipta alba, Corchorus spp., Phyllanthus niruri, P. simplex and Rotala indica amongst broad-leaf weeds and seiges were Cyperus rotundus, Cyperus spp. and Fimbristyliis spp.

Ved Prakash et al. (1990) revealed that the soybean crop was predominantly infested by Gratiola parviflora, Commelina benghalensis, Digitaria sanguinalis and Ageratum conyzoides at Almora.

2.2 Yield Losses in Soybean Due to Crop-weed Competition

The losses in yield due to weed infestation range from 20 to 40 per cent. The range of losses has been reported from 30 to 100 per cent in India, 20 to 40 per cent in USSR, 8 to 24 per cent in USA and 6 to 50 per cent in U.K. (Anonymous, 1972).

Agronomic research in major soybean growing countries of the world revealed that the effect of weed competition depends on the growth habits of weeds, their relative density and periodicity. In addition to the above factors, methods of sowing, climatic parameters and competition for nutrients, soil moisture, space and mutual shading of the crop and weeds also have profound effect on growth and productivity of soybean. The shading effects of soybean on weeds are well substantiated and soybean has been ranked high as a smother crop.
Vega et al. (1968) obtained optimum yield of soybean when the fields were kept weed free up to 40 days after sowing. Yield declined with the increase in the duration of weeds after sowing, during which weeds were allowed to compete with crop.

Kasasian and Seeyave (1969) concluded that the first 25 to 30 per cent of the growth cycle appears to be the critical period with regards to weed competition with soybean crop which eventually gave good ground cover.

Bhan et al. (1970) noted that first 80 days weed free growth of soybean appears to be optimum period for obtaining higher yield and was comparable with those plots which were kept weed free throughout the growing season.

Ashton and Craft (1973) reported that weeds germinate in different flushes due to dormancy and density of weeds increases throughout the crop season, and increased the final weed biomass. It was also reported that heavy infestation of weeds suppresses the crop, resulting in greater reduction in soybean yield.

Malik and Lal (1973) and Bhan (1976) noted reduction in soybean yields by 41 to 45 per cent due to weeds, whereas Roquib and Chatterjee (1977) revealed 32 per cent drop in yield.
Wilson and Hines (1977) reported that annual grasses resulted 16 per cent decline in soybean growth.

Madrid and Manimuth (1979) revealed Rottboellia compressa and broad-leaf weeds such as Ipomoea triloba and Cleome viscosa as detrimental to the soybean crop.

Tiwari et al. (1984) reported that under field conditions, the infestation of Panicum antidotale and Cyperus rotundus at 40 per cent weed density caused reduction in soybean yields by 20 and 30 per cent, while at 80 per cent density, the reduction was 45 and 44 per cent, respectively.

Muniyappa et al. (1986) noted 53 per cent decline in soybean seed yield due to weed stress in unweeded control as compared to weed free plots.

Agrawal (1990) reported that first 30 days weed free growth of soybean appeared to be the optimum period for obtaining higher yield as compared to control.

Mishra (1990) concluded that uncontrolled weeds caused 87 per cent reduction in grain yield of soybean.

Sharma and Paradkar (1990) observed that weeds cause little loss in soybean yield if weed free period is maintained for first 30 days after sowing.
2.3 Cultural Practices

The competition among crop and weeds is reduced to minimum either by hand weeding or hoeing or other interculture operations. Manual weeding is the oldest recognised successful method except under adverse conditions. In general, even today, the results accomplished by this method cannot be attained by any other method under complex weed ecosystem, but this practice is expensive, time consuming, requires more manpower and backbreaking.

Slife (1955) revealed that cultural practices are the best for weed control in soybean and that herbicides are to be recommended in badly infested areas only.

Dawson (1964) reported that the first five to seven weeks after sowing of soybean was the most critical period for weed control because weeds emerging during this period were more competitive than later germinating weeds.

Vega et al. (1968) recorded optimum yield from soybean kept weed free for 40 days after sowing. The yield declined with increase in the duration of the period after sowing during which weeds were left to compete with crop.

Kasasian and Seeyave (1969) noted that the first 25 to 33 per cent of the growth cycle appeared to be the critical period with regard to weed competition for crops which eventually give good ground cover.
Bhan et al. (1970, 1974) at Pantnagar (U.P.) found that the first 30 days after sowing is the optimum period for which soybean should be kept weed free and it eventually yielded as high as those kept for all growing season.

Madrid et al. (1972) at Philippines revealed that for getting optimum yields, soybean should be kept weed free at least for 42 days from the sowing time.

Thurlow and Buchanan (1972) found that if weeds were removed at two to four weeks after sowing or emergence, no further weed control was necessary in soybean.

Malik and Lal (1973) stated that one hand weeding or interculture operation may do the job of weed control. Use of bullock and hand driven hoes supplemented with one hand weeding was also found quite useful for control of good number of weeds in soybean.

Hammerton (1973) found that controlling weeds for the period up to 6 weeks after crop emergence, results in bean yield of 85 per cent under clean control weeded condition and where weeding was initiated at three and six weeks after crop emergence, soybean yields were 89 and 69 per cent, respectively.

Bhan (1976) reported that weeds emerging 30 to 35 days after sowing did not influence soybean yield and he suggested that the crop should be maintained in weed free conditions during above mentioned period after sowing to obtain maximum yield.
Singh and Mani (1979) concluded that two hand weeding operations, once at three and another at six weeks, proved beneficial to soybean crop.

Dowler and Parker (1979) found that soybean variety, weed control system and year to year variations appeared to be the major factors influencing the weeds present at harvest. The highest population of weeds occurred where these were controlled by cultivation only, while the lowest was recorded at cultivated plots that were hand weeded as required until the soybean had formed a canopy.

Aquino and Pamplona (1982) obtained the highest yields from the plots kept weed free for the first 40 days.

Two hand weedings at 30 and 45 days after sowing produced higher yields (1342 kg/ha) in soybean (Anonymous, 1984).

Singh et al. (1984) noted the highest yield and yield attributes viz., number of pods per plant, number of grains per pod, test weight and yield per plant under weed free treatment, closely followed by weeding twice and weeding once.

Singh and Kharwara (1984) found that two hand weedings controlled the weeds efficiently and also produced higher soybean yield, coupled with minimum dry weight production of weeds.
Singh and Singh (1984) reported that manual weeding at 45-day stage would provide desired degree of weed control in soybean.

Halwankar et al. (1986) recorded 66.38 per cent weed control efficiency in soybean with three hand weedings at 15, 30 and 45 days after sowing.

Jain et al. (1990) found that the maximum yield of soybean was observed under hand weeding.

Significantly greater seed yields were reported under weed free conditions in soybean as compared to control (Maurya et al., 1990; Mishra et al., 1990; Raikwar et al., 1990 and Raghuwanshi et al., 1990).

Sharma and Paradkar (1990) reported maximum soybean seed yield (15.52 q/ha) under two hand weedings (20 and 35 DAS) which was at par with weeding at 15 and 25 days after sowing (14.76 q/ha).

Upadhyaya and Kushwah (1990) noted the highest seed yield (27.39 q/ha) and weed control efficiency (95.74%) under hand weeded plots. Similar findings have also been reported by Thakur and Dubey (1990) and Ved Prakash et al. (1990).

2.3.1 **Stale seedbed conditions**

A stale seedbed is one where one to two flushes of weeds are destroyed before planting of main crop. Most weed
seeds germinate from top 4 to 5 cm of surface soil. If a finally prepared seedbed is withheld from planting and it contains adequate moisture in its top 4 to 5 cm of soil, a flush of young weed seedlings will grow on it in about a week's time.

Gummerson (1971) reported that delayed sowing had the same effect on plant numbers of *Avena fatua* and considerably increased weight per plant. Thorough cultivation followed by delayed sowing gave upto 90 per cent control, but reduced crop yields in some trials where chemical treatments were omitted.

Gill (1976) noted that a number of cultivation operations are helpful in reducing the infestation of weeds. Thorough cultivation preparing the seedbed leaving it undisturbed for some time, increases the germination of weeds which can be ploughed finally before sowing. This practice known as *Dab* in Punjab is helpful in killing a number of annual weeds in wheat crop.

*Phalaris minor* Retz. was considered as the most damaging weed of soybean crop. The density of this weed and other weeds was reduced to 39.5 per cent and 44.5 per cent, respectively when the weed seeds were given a chance to germinate and then placed the first flush which emerged in the stale seedbed (*Dab* system) at various places in the Northern Plain Region (Anonymous, 1980).
Pandey (1981) reported that pre-emergence application of pendimethalin at 1.0 kg gave the highest grain yield of both timely and late sown wheat and better control of *Phalaris minor* and other weeds as compared to other pre-emergence herbicides like metribuzin (1.5 kg/ha), isoproturon (1.0 kg/ha) and metoxuron (1.75 kg/ha). Triburil gave good yield under normal and reduced yield under late planting. Isoproturon proved effective and gave good yield of both timely and late sown wheat and proved effective against *Phalaris minor* Retz. and other weeds. Its application at 1.75 kg/ha appeared to have slight adverse effect on crop growth.

Singh *et al.* (1985) reported that intensity of *Phalaris minor* Retz. plants at 60 days after sowing was less under delayed planting. *Phalaris minor* Retz. heads at harvest and dry weight of weeds was less when planting was delayed. These effects were more pronounced due to planting of wheat in late December. Late planting caused significant reduction in the grain yield of wheat which was much higher during early planting as compared to delayed planting. Observations revealed that though there might be reduction in the density and growth of *Phalaris minor* Retz. due to delayed sowings and killing of weeds prior to sowing but at the cost of grain yield of wheat.

Ahmad *et al.* (1986) reported that the conventional and chemical weed control practices suppressed weed population.
Maximum yield (44.87 g/ha) was obtained where diuran MA was applied after emergence. Dab, the commonly used practice in Punjab and Pakistan was the next best choice. The difference between one and two Dab appeared to be the more suitable practice. Hand weeding was less economical as compared with the use of herbicide and Dab.

In upland rice crop also, Mukhopadhyya and Hossain (1990) observed that the stale seedbed technique was the next superior treatment in reducing the weed competition.

2.4 Effect of Different Herbicides on Weed Control

2.4.1 Fluchlorsalin (Basalin 48%)

The discovery of selective hormone type of weed killers excited the agricultural world. Hormones are the substances which are capable of modifying the growth of the plants.

In order to overcome the difficulties met with the traditional methods (hand weeding and hand pulling) of weed control, the control of weeds by chemicals is much easier, cheaper and many times faster than the traditional methods.

Ashton and Craft (1973) stated that grasses are more sensitive to dinitroaniline herbicides than broad-leaf species.
Fluchloralin is a new selective pre-planting herbicide which is found effective on large number of important annual grasses and broad-leaved weeds. It should be applied at the rate of 0.75 to 1.75 kg/ha depending upon the texture, humus content of the soil and intensity of the weed flora (Anonymous, 1976).

Rafel et al. (1976) concluded that when weed populations were assessed 70 days after treatment, the most effective herbicide was fluchloralin 0.75 kg/ha.

Soundra Rajan et al. (1976) stated that higher rate of fluchloralin (2.57 kg/ha) as pre-sowing incorporation was effective for weed control and at par to one hand weeding and increased the pod yield of groundnut.

Davis et al. (1979) reported that annual grasses could be controlled by dinitroaniline herbicides.

Jacques and Haney (1979) stated that dinitroaniline herbicides remained biologically active for longer duration under low soil moisture condition. The drier condition may account for their apparently slower degradation rate and corresponding higher level of activity.

Sankaran and Balasubramaniam (1981) recommended pre-sowing treatment of fluchloralin 1.0 kg/ha for effective weed control in rainfed blackgram.
Bisen *et al.* (1982) concluded that fluchloralin 0.5 kg/ha as pre-plant effectively controlled both grassy and dicot weeds and reduced weed intensity by 65.20 and 69.30 per cent, respectively. Significant increase in soybean yield by this herbicide was recorded over control.

Application of fluchloralin 1.0 kg/ha showed effective control of *Echinochloa* spp., *Corchorus olitorius*, *Aeschynomene indica* and *Phyllanthus niruri* and also showed effective reduction in the plant population of the above mentioned weeds (Anonymous, 1984).

Kurlekar and Khulpe (1984) tried six concentrations of fluchloralin (0, 1.5, 2.0, 2.5, 3.0 and 3.5 kg/ha) at three times (pre-sowing, pre-emergence and post-emergence) and found that both monocot and dicot weeds were effectively controlled by pre-sowing and pre-emergence application of fluchloralin.

Lal *et al.* (1984) reported that fluchloralin 1.5 kg/ha pre-emergence gave satisfactory control of weeds and reduced the weed dry matter per unit area significantly and recorded maximum yield of green fodder.

Lokras *et al.* (1984) revealed that fluchloralin 1.50 kg/ha pre-plant gave soybean seed yield at par with two and three hand weedings and significantly superior to weedy check.
Singh and Kharwara (1984) found that fluchloralin 1.0 kg/ha pre-plant controlled the weeds effectively in soybean.

Halwankar et al. (1986) obtained 47.62 per cent higher yield with fluchloralin 1.50 kg/ha as compared to weedy check and two hand weedings.

Agrawal (1990) reported that fluchloralin gave significantly higher yield (10.86 q/ha) over all other treatments.

Raghuwanshi et al. (1990) stated that amongst herbicides, fluchloralin 1 kg/ha ppi established its superiority over trifluralin and ethalfluralin.

Sharma and Khan (1990) concluded that fluchloralin 0.75 kg + oxadiazon 0.5 kg/ha gave the maximum grain yield of soybean.

Upadhyaya and Kushwah (1990) stated that among herbicides, the highest grain yield and WCE (20.10 q/ha, 43.72%) were obtained from the plots treated with fluchloralin 1.0 kg/ha, followed by butachlor (15.14 q/ha, 27.71%).

Urkurkar et al. (1990) revealed that fluchloralin 0.8 kg/ha with sand carrier and pre-plant soil incorporation produced the maximum seed yield of soybean.

Ved Prakash et al. (1990) revealed that amongst different herbicides taken, fluchloralin was quite effective in increasing the seed yield of soybean.
Venkatakrishnan et al. (1990) stated that fluchloralin 1.0 kg/ha pp in was next to alachlor 2 kg/ha pre with one hand weeding in the lowest weed number and highest grain yield.

2.4.2 Oxadiazon (Ronstar 25%)

Hunton et al. (1974) revealed that oxadiazon controlled a wide range of broad-leaf weeds at 0.75 to 1.0 kg/ha, while grasses required slightly higher rates for effective control. Soybean yields were not reduced by rates necessary for effective weed control. Pre-emergence application of 0.75 and 1.50 kg/ha were selective over a wide range of soil types and climatic conditions.

Bullow and Rodriguez (1975) found that oxadiazon at 1.0 to 1.50 kg/ha applied to soybean on clay and silty loam soils, controlled grassy weeds for 60 days.

Hoque and Kirby (1975) stated that oxadiazon 0.75 to 2.0 kg/ha pre-emergence gave good control of most small seeded grasses and broad-leaf weeds.

Wilson and Mines (1977) evaluated oxadiazon for 5 years on sandy loam soil as pre-emergence herbicide for soybean. The control of Chenopodium album was excellent and control of three species of annual grasses was good, although 1.0 kg/ha resulted in 16 per cent initial reduction in soybean growth.
Mathis and Oliver (1978) determined the susceptibility of several species of *Ipomoea* in a three year study and oxadiazon was found as the most effective pre-emergence herbicide in soybean crop.

Madrid and Manimthim (1979) reported that oxadiazon 1.0 to 2.0 kg/ha pre-emergence gave excellent control of *Rottboellia compressa* and *Ipomoea triloba*. In another trial, oxadiazon 1.5 kg/ha controlled *Rottboellia compressa* and broad-leaf weeds such as *Ipomoea triloba* and *Cleome brachycarpa* but severely injured the crop.

Bisen *et al.* (1982) revealed significant differences in yield of oxadiazon treated and untreated plots. Oxadiazon was highly effective against dicot and monocot weeds but exhibited phytotoxic effect on blackgram.

Application of oxadiazon 0.50 kg/ha pre-emergence in soybean crop showed effective control of *Echinochloa* spp., *Corchorus olitorius*, *Aeschynomene indica* and *Phylanthus niruri*. Oxadiazon showed reduction in the population of *Cyperus rotundus* also (Anonymous, 1984).

Pre-emergence application of oxadiazon at 0.50 to 0.75 kg/ha gave higher soybean seed yield. Application of oxadiazon at higher doses decreased the plant population and resulted in stunted crop growth as evident through lower plant population at harvest but it was proved very much effective for weed control in soybean (Anonymous, 1984).
Bajpai et al. (1984) determined that oxadiazon at 1.00 kg/ha as pre-emergence can be used for weed control in soybean.

Jain et al. (1984) stated that the weed free plot had the highest soybean yield and oxadiazon 1.0 kg/ha and fluchloralin 1.50 kg/ha were next in respect of seed yield and weed control. The maximum weed biomass and minimum seed yield were obtained in control plot.

Malviya et al. (1984) revealed the higher seed yield with weed free condition which was comparable with oxadiazon 1.25 kg/ha and fluchloralin 0.90 kg/ha. The maximum economic return was obtained with oxadiazon 0.625 kg/ha (Rs.1901/ha) and 1.25 kg/ha (Rs.2032/ha), closely followed by fluchloralin 0.90 kg/ha (Rs.1738/ha).

Lokras et al. (1985) obtained effective weed control under oxadiazon 0.50 kg/ha as pre-emergence which gave seed yield at par with two and three hand weedings and significantly superior over control.

Jain et al. (1988) found that two hand weedings had higher weed control efficiency, followed by oxadiazon 1.0 kg/ha pre-emergence, fluchloralin 1.0 kg ppi and metribuzin 0.50 kg/ha pre-emergence.

Jain et al. (1988) noted that oxadiazon 0.50 kg/ha pre-emergence was most effective for weed control in soybean
and comparable with weed free conditions in respect of seed yield.

Jain et al. (1990) stated that amongst the herbicides oxadiazon produced the significantly higher seed yield of soybean as compared to other herbicides.

Maurya et al. (1990) revealed that pre-emergence application of oxadiazon at 0.75 and 1.0 kg/ha increased the crop-shoot biomass and grain yield of soybean, markedly over rest of the treatments.

2.4.3 Haloxyfop-methyl (Gallant 12.5%)

In India, research on this herbicide is very meagre and very few people have studied the effect of this herbicide in soybean.

Sharma and Khan (1990) concluded that the lowest weed intensity was recorded with haloxyfop-methyl 0.750 kg/ha plus oxadiazon 0.750 kg/ha which controlled the most grassy weeds in soybean.

Tiwari et al. (1990) revealed that haloxyfop-methyl was effective against grassy weeds only and it was better amongst all the herbicidal treatments applied @ 0.5 kg/ha 21 DAS and did not show any phytotoxic effect on soybean. Higher yield (22.28 q/ha) was obtained under haloxyfop-methyl.
Malik et al. (1990) evaluated haloxyfop-methyl for the control of carpet weed (*Trianthema portulacastrum* L.) in groundnut and reported that it was not effective against the weed and did not show significant increase in yield over weedy check.

Singh et al. (1990) noted that haloxyfop-methyl appeared to be significantly superior over unweeded control in reducing the weed growth and registering the higher grain yield of rice.

2.5 *Effect of Plant Geometry on Yield and Yield Attributes*

Osler and Cartter (1954) reported that an average maximum height was attained at the first planting date and then it progressively declined with delay in planting.

Torrie and Briggs (1955) concluded that planting date had little effect on the yield in early maturing varieties, whereas increased yield was obtained with late varieties if planting was done after May, 20.

Abel (1961) observed that the period from planting to maturity by all the varieties was reduced due to successive delay in planting, by nearly the same magnitude as the delay in planting since the actual date of maturity was delayed relatively little. The shortening of growth cycle occurred in the reproductive period by the earliest variety and in the vegetative period of the latest variety.
Lokras and Tiwari (1971) concluded that planting at the commencement of monsoon was the best, while a delay of 45 days in planting reduced the yield by 32 per cent. Similar observations have also been recorded by Asthana et al. (1984).

Saxena and his associates (1971) concluded that soybean could be sown from the onset of monsoon to the beginning of August without much reduction in yield.

Yusuf et al. (1971) found significant differences in yield due to different dates of sowing at IARI. Earlier sowing in the first week of June yielded the maximum grain yield. All the treatments matured more or less at the same time (1,15,30th June and 15th July sown). Early sown plots naturally had longer growing season and also longer days than the subsequent ones.

Verma et al. (1971) concluded from a field trial at Jabalpur with Bragg and Clark-63 soybean varieties that Bragg outyielded Clark-63 (2248 and 1480 kg seed/ha, respectively) when sowing was done at the start of rainy season, but with increased delay in planting, the yield decreased and there was less difference in cultivars. The sowing dates considered in the trial were start of rainy season and 10,20,30 days later.

Maley and Sharma (1973) obtained 40 per cent more yield with soybean planted on 15th June as compared to that planted
on 25th June. Delayed planting reduced the yield tremendously. Amongst varieties tested, Clark-63 was found to be the best.

Singh et al. (1974) observed that delay in sowing of soybean from June 11 to July 21 resulted in decreased plant height, number of pods and branches per plant.

Singh et al. (1974) observed that an increase in plant population increased the lodging and mortality percentage and reduced the yield. A plant population of 0.2 million produced the maximum yield.

Lokras and Tiwari (1976) reported high mortality percentage with increase in plant population. The highest plant mortality was observed in Ankur due to close plant to plant spacing, followed by JS2 and Black soybean under 100 kg seed rate per hectare.

Tiwari et al. (1977) reported that sowing date had effect on leaf area index, apparent photosynthetic efficiency, seed weight and productivity of soybean varieties. The climate had an important role on the physiological processes affecting the productivity and maturity of plants.

Maley (1977) observed significantly greater plant height and more number of leaves, branches and pods per plant under 2nd July sowing than those of 2nd August sowing at Jabalpur. Dry matter accumulation in plants, seed weight and nodulation were also significantly superior in 2nd July sowing.
The grain yield data showed significantly higher seed yield of soybean viz., 3571 kg/ha in 1971 and 3694 kg/ha in 1972 under 2nd July sowing as against the seed yield of 2124 kg/ha and 2027 kg/ha during 1971 and 1972, respectively under 2nd August sowing.

Essa (1980) indicated that planting date had a significant effect on seed yield, though cultivars were not always consistent in their response to planting date. In general, the late cultivars produced taller plants and more number of branches per plant than early cultivars.

Mahmoud et al. (1980) reported that 15th April planted crop, produced the highest seed weight, number of pods and seeds per plant as compared to 15th May planted crop. Rao (1980) obtained decreased seed yield of three soybean CVs with delay in sowing after 15th May in Andhra State of India. Amongst varieties, JS72-44 was the most promising as compared to JS2 and Black soybean.

Bhatnagar (1981) from a date of planting-cum-varietal trial conducted at Jabalpur, revealed that 8th July was suitable date for sowing as compared to 1st and 16th July. Amongst four varieties tried viz., JS2, JS72-44, JS75-19 and Kalitur, the highest yield was obtained from JS2 as compared to other varieties.

Shrivastava et al. (1982) pointed out that late June or early July seemed to be the best period as coincided best
with the rainfall pattern for sowing soybean under Bareilly conditions of India.

Griffin and Hobetz (1983) reported that maximum seed yields were obtained by sowing on 29th May and thereafter, yields were reduced by 14.33 kg/ha for each day delay in sowing. The seed yield was directly related to plant height.

Bhatnagar (1985) reported that the pre-monsoon sowing outyielded later dates of planting viz., onset of monsoon and 15 days after the onset. Amongst varieties, PK-472 gave the highest yield when sowing was done before onset of monsoon, whereas MACS-75 was superior when planted at onset of monsoon. JS72-44 and MACS-75 were at par in late sowing but superior to all other varieties.

Hema et al. (1985) found that yield attributing characters viz., number of pods, number of grains per plant and test weight were significantly more in the crop sowing on commencement of monsoon (June–July). Delayed sowing by 20 days reduced 14.28 per cent yield. This was due to the adverse effect of delayed sowing on yield attributing characters.

Singh et al. (1985) obtained the highest soybean yield when planting was done on 15th May and the lowest when planting was done on 15th July. There was linear reduction in yield due to delayed sowing (sowing dates 15th May, 1st June, 15th June, 30th June and 15th July).
2.6 *Effect of Herbicides on Yield and Yield Attributes*

Bhan *et al.* (1972) concluded that increase in yield per hectare was accompanied by simultaneous increase in number of pods/plant and weight of grains per plant under different herbicidal treatments.

that

Bhan *et al.* (1974) revealed that the increase in grain yield due to increase in the period of weed-free maintenance was accompanied by simultaneous increase in number of pods and weight of grains per plant. Plant population remained unaffected.

Santharam and Shivashankar (1982) reported that leaf area index differed significantly among different weed control treatments from 40th day onwards. The LAI was more than double at all the stages in all the weed control treatments over the unweeded control. Weed control treatments had 60 per cent higher pod number and seed weight per plant than unweeded control. The treatments did not differ in number of seeds per pod and 100-seed weight.

Aman and Hosmani (1983) concluded that lower pod number and lower pod weight per plant were observed in metribuzin treatments, followed by lower doses of alachlor and nitrofen.

Dubey *et al.* (1984) reported significant reduction in pod number per plant, seed number per pod and 100-seed weight in weedy check treatments which also reduced the crop biomass...
and seed yield per hectare. This was also reported by Bajpai et al. (1973), Malik and Lal (1973), Shrivastava et al. (1976) and Lokras et al. (1984).

Lokras et al. (1985) concluded that significant reduction in branches, nodules, pods per plant and 100-seed weight was also noted under weedy check which significantly lowered the yield, whereas these yield attributing characters were higher in fluchloralin, oxadiazon and hand weeding.

Jain et al. (1988) reported that all the weed control treatments resulted in significant increase in number of branches, pods, seeds per plant, seeds per pod, seed yield per plant and 100-seed weight over weedy check. These favourable effects resulted in significantly higher crop dry weight and yield per hectare. Significantly shorter plant height was observed in oxadiazon treated plots but this did not reduce the seed yield per hectare.

Two hand weedings produced the higher number of branches, pod bearing nodes per plant, pods per plant, seeds per plant, seed yield per plant and remained at par with oxadiazon 1.0 kg/ha and 2 hand hoeings at 30 and 45 DAS. The crop biomass and seed yield were higher under two hand weedings. Oxadiazon 1.0 kg/ha and two hand hoeings were at par. Significantly lower crop biomass and seed yield were noted under weedy check as compared to other treatments.
Thakur and Dubey (1990) concluded that the highest grain yield (1724 kg/ha) of JS72-44 was obtained due to higher LAI, branches per plant, dry weight accumulation per plant, number of pods per plant, grain yield per plant and 100-seed weight under hand weeding treatments.

2.7 Nutrient Uptake by Weeds and Soybean

Singh and Mani (1973) reported that soybean treated with herbicides like Treflan, Vernam or Eptal removed 87.3, 4.8 and 34.1 kg of nitrogen, phosphorus and potassium per hectare, respectively. The uptake of nutrients under repeated weeding was 162.1 kg N, 90.2 kg P₂O₅ and 74.3 kg K₂O per hectare by the crop.

Mani (1975) calculated that weeds growing in crop field during kharif drain off 46.6 kg N, 12.1 kg P and 73.3 kg K/ha. Further, he reported that 5 to 8 weeks period was very crucial for nitrogen competition. The extent of nitrogen removed by weeds within 5 to 8 weeks worked out to be about 80 per cent of the amount removed by the crop during this period.

Alkamper (1976) emphasised that weeds usually absorb nutrients faster and in relatively larger amounts than crops and therefore, derive greater benefit.

Maley (1977) found that soybean crop significantly removed higher amounts of NPK in plots which were less infested with weeds.
Singh and Mani (1977) reported that in soybean, uncheck ed weed growth depleted soil nutrients as much as 35.9, 10.6 and 56.1 kg of N, P and K per hectare, respectively, whereas Trifluralin + Vernolate treated plots lost only 9.0, 2.3 and 12.1 kg N, P and K per hectare, respectively.

Jain et al. (1981) reported that weeds remove 5 to 6 times of nitrogen, 5 to 12 times of phosphorus and 2 to 5 times of potassium than the cotton crop at early stages which reduced the raw cotton yield from 54 to 85 per cent.

Jain et al. (1990) concluded that greater NPK drain by weeds was under weedy check (23.5, 3.24, 55.61 kg/ha), while minimum under hand weeding (2.9, 0.46, 10.7 kg/ha), followed by oxadiazon (4.4, 0.48, 15.4 kg/ha). The maximum uptake of NPK by soybean crop was under oxadiazon (168.1, 13.5, 100.1 kg/ha). The lowest utilization of NPK in crop biomass and seeds was under control (92.9, 7.4 and 52.3 kg/ha). Inverse relationship was observed between nutrient uptake by weeds and crop.

2.8 Effect of Herbicides on Symbiosis

Kaszubiak (1966) reported the reduction in nodule number probably due to inhibitory effects of herbicides, whereas Kecskes (1972) found both inhibitory and stimulatory effects of herbicides on Rhizobia.
Elward et al. (1972) did not find adverse effects of chloramben on nodulation under field condition. Subramanyam (1975) also did not observe significant effects of herbicidal treatments including weed free on effective nodule number and nodule biomass over control. However, among the herbicides, the increasing trend was noted for number of effective nodules under chloroxuron and for nodule biomass under amiben.

Vaishya et al. (1981) noted that the closer row spacing gave higher nodulation in early crop growth stages.


Jai Prakash and Pahwa (1984) reported that oxyfluorfen 0.1 kg/ha increased the weight of shoot, number of leaves and number of nodules per plant but reduced the shoot length in comparison to control in pea crop.

The work of Lokras et al. (1985) illustrated the effective weed control by metribuzin 0.5 kg/ha pre-emergence than fluchloralin 1.0 kg/ha pre-emergence. They further stated that number of nodules, branches per plant and seed yield (kg/ha) were also higher under metribuzin than other herbicides and weedy check.

Bisen (1986) reported that under cultural treatments, hand hoeing twice and herbicidal treatment of oxadiazon 1.0
kg/ha pre-emergence gave significantly more number of nodules as compared to weedy check and other herbicidal treatments.

Pahwa and Jai Prakash (1988) revealed from a pot experiment that fluchloralin (0.5, 1.0 and 1.25 kg/ha), metribuzin (0.25, 0.5 and 0.75 kg/ha) applied 15 DAS reduced shoot and root lengths, dry weight and number of leaves per plant in soybean. Number of nodules per plant was also reduced but leghaemoglobin content was more than control plant.

Nitrogen content of all parts of herbicides treated plants was higher as compared to control.

Jain et al. (1990) found that at initial stage, the number of nodules and nodule dry weight per plant were significantly reduced under herbicidal treatments but at 50 and 75-day stages, greater nodulation was under oxadiazon and oxyfluorfen. None of the herbicides had inhibitory effects on nodulation and vis-a-vis rhizobial activity in soybean.

2.9 **Effect of Herbicides on Photosynthesis**

Light, one of the most common form of competition, in the soybean community, may occur when weed population blocks off light, which constitutes a key external variable of the photosynthetic process. Donald (1958) found that competition for light was an important component of total competition when two grasses grew in association at a nitrogen supply level that restricted yield.
Kust and Smith (1969) found improved weed control in narrow rows probably due to absorption of light wave lengths by soybean leaves, that may be most unfavourable for photosynthesis and negative growth of some weed species.

Subramanyam (1975) reported that LAI, RGR, CGR and NAR were higher in the herbicidal and weed free treatments as compared to control.

Maley (1977) marked that increase in leaf area index affected soybean yield significantly by having the highest number of pod bearing branches and pods per plant. Higher dry matter production of soybean was observed in two hand weedicings.

Shrivastava et al. (1976) reported significant reduction in photosynthetic productivity at flowering and sink filling stages due to weeds. The CGR and RGR were negatively correlated with weed population ($r = -0.6709, r = -0.7150$). The reduction in CGR and RGR was due to shading effects and sharing the soil nutrients and radiant energy.

Scarascia and Losavio (1980) reported that CGR reached a peak 54.69 days after emergence of soybean and NAR, RGR and RLGR declined with increasing age of plants.

Reddy and Saxena (1983) studied various growth parameters and indicated that in varieties Hark and Clark-63, maximum dry matter accumulation reached at 60 days after
sowing, and decreased afterwards, LAI increased progressively up to 60 days in Hark; CGR of each variety rose to a peak first and then decreased.

Jain et al. (1990) reported that the LAI (1.41, 4.92, 6.16) increased with age and at 75-day stage, maximum LAI was noted under fluchloralin (6.97), followed by metribuzin (6.81 and oxyfluorfen (6.19). The CGR increased with age up to 75-day stage and declined afterwards. The maximum CGR was under oxadiazone (19.60 gm⁻² day⁻¹), while it was the lowest in weedy check (12.74) at 75-day stage. Almost similar trend was noted for RGR. The NAR declined due to increased age and leaf area. It was maximum under oxadiazone (0.18) during pod filling.

2.10 Effect on Seed Quality

Johnson and Jellum (1969) applied various herbicides (chloroxuron, trifluralin, chloramben), systemic insecticides and fungicides alone and in combination to soybean and noted that fatty acid composition of oil, oil content and protein content of soybean seed were not affected.

Rao (1974) concluded that application of weedicides increased the percentage of protein as compared to weed-free treatment in soybean.

Pahuja et al. (1985) conducted experiment at Hissar on the effects of weed control methods on the quality of
soybean crop and reported nitrogen and phosphorus contents in grains and stover. Protein and oil contents were found to be maximum under weed free treatments and these were minimum under weedy check. Further, they noted oxyfluorfen at 0.2 kg/ha as phytotoxic to crop plants at early stages of crop growth, thereby affecting the quality of crop.

Sankaran et al. (1988) revealed that crop treated with fluchloralin 0.75 kg/ha pre-emergence, followed by one manual weeding 30 DAS, had the highest uptake of nutrients in sunflower at harvest and resulted in higher grain yield, protein content and oil yield. Manual weeding (20 and 40 DAS) was the next best treatment.

2.11 Correlation Studies

Moomaw and Robinson (1971) indicated that each four kg dry matter of weeds per hectare reduced soybean yield by one kg per hectare.

Bhan et al. (1972) reported that the grain yield showed positive correlation with crop growth and negative correlation with weed growth.

Subramanyam (1975) revealed that weed population density had negative correlations with CGR, RGR and NAR.

Coble and Ritter (1978) reported the inverse relationship between weed density and crop yield and a linear reduction was noted in yield with increasing weed population in soybean.
Burnside (1979) also observed an inverse relationship between soybean stand and weed growth. Soybean seed weight and seed number per plant increased as the weed growth decreased.

Bustaman and Nurain (1982) reported from Indonesia that soybean yields were significantly correlated with plant height, number of fertile nodes per plant and pods per plant, the period from flowering to harvest, the period from sowing to harvest and 100-seed weight. Seed yield varied from 175.87 to 227.39 g/plant depending on CV.

Reddy and Saxena (1983) noted significantly higher yield of soybean varieties. Correlation studies showed that the seed yield was positively correlated with primary branches \((r = 0.785)\), while negatively correlated with number of seeds per pod \((r = -0.448)\), but the coefficient was significant with primary branches only.

Tiwari et al. (1984) revealed that weed population at early stage had significant positive association with final weed population and weed biomass at harvest \((r = 0.970, 0.963)\) in wheat. These three factors exhibited significantly negative correlation with effective tillers/plant, grain weight/ear, 1000-grain weight, crop biomass/ha and grain yield/ha. They noted that one weed plant/m² can cause the reduction in grain yield of wheat by 1.574 kg/ha, while the accumulation of one quintal biomass/ha by weeds can reduce the grain yield by 517 kg/ha.
Jain et al. (1985) reported that the correlations of yield with biomass, sink parameters and photosynthetic efficiency (biomass production) revealed that yield of soybean had significantly positive correlation with crop biomass ($r = 0.6860$). Positive correlation of yield attributing characters such as number of pods per plant, yield per plant and test weight with grain yield was also noted but these correlation coefficients were not significant.

Urkurkar et al. (1990) noted negative correlation between weed biomass and soybean yield.

Jain et al. (1990) revealed that the weed biomass (kg/ha), total weed population ($m^2$), number of *Echinochloa crusgalli*, *Digitaria adscendens*, *Phyllanthus* spp. and *Cyperus rotundus* had negative correlations with seed yield. The strong positive correlations of seed yield with crop biomass ($r = 0.9069$), fillwed pods per plant ($0.6409$), branches per plant ($0.6113$) and 1000-seed weight ($0.3772$) were obtained. Path coefficient analysis revealed that crop biomass had strong direct positive effect on seed yield ($0.4255$), followed by branches per plant ($0.1477$), while the weed biomass had greater negative and direct effect on seed yield ($0.7189$).

2.12 Economics

Jain et al. (1990) concluded that the most advantageous herbicide was oxadiazon, yielding 30.4 g/ha, with net profit
of Rs.10,432/ha under favourable season, while 18.03 q/ha yield and Rs.4,896/ha profit was obtained under less favourable season. Other better treatments were metribuzin with Rs.9940/ha net profit and 4294 kg/ha yield, and hand weeding with Rs.9200/- per hectare net profit and 3970 kg/ha yield. The lowest profit was under weedy check (Rs.4722 profit and 2237 kg/ha yield).

Upadhyaya and Kushwah (1990) obtained greater net profit (Rs.5941.33/ha) in the hand weeded plots, followed by fluchloralin.

Urkurkar et al. (1990) revealed that application of fluchloralin 0.80 kg/ha with sand carrier and pre-plant soil incorporation gave maximum profit of Rs.7.00 on per rupee investment, followed by butachlor 1.5 kg/ha pre which gave the profit of Rs.5.80 on weed control treatments.

The above cited literature indicated that in India and abroad, although maximum attention has been given on chemical weed control, however, the studies on cultural manipulation viz., stale seedbed and deviation in sowing period for reducing the weed infestation, are very meagre. It further revealed that the different methods were tackled individually. Moreover, such studies are still limited in India and the recommendations made elsewhere are not appropriate as per the infrastructure, soils and climatic conditions, weed flora and sowing practices of Madhya Pradesh. The studies on chronological weed emergence in soybean fields are
almost lacking in India. Hence, investigations on integrated weed control approach would be of greater importance for effective and economic weed management in soybean.