INTEGRATED WEED MANAGEMENT IN BRINJAL (*Solanum melongena* L.)

By

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DECLARATION

I hereby declare that this thesis entitled "**Integrated weed management in brinjal (*Solanum melongena* L.)**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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LIST OF ABBREVIATIONS

@	At the rate of
kg	Kilogram
ha	Hectare
ai	Active ingredient
g	Gram
mg	Milligram
cm	Centimeter
m	Meter
%	Per cent
^0C	Degree Celsius
t	Tonnes
N	Nitrogen
P	Phosphorus
K	Potassium
DAT	Days after transplanting
WP	Wettable powder
SL	Soluble liquid
EC	Emulsifiable concentrate
2,4-D	2,4 dichloro phenoxy acetic acid
PPI	Pre-planting incorporation
Fig.	Figure

INTRODUCTION

1. INTRODUCTION

Plants are man's most valuable assets without which he could not have survived on earth. But we cannot afford to let them grow indiscriminately all over the land and waterbodies, else a place for us and our activities will be difficult to find. Of more than 300,000 species of plants known in the world, hardly 3000 are of any economic value to us (Gupta and Lamba, 1978). When one grows any of the economic species of plants, invariably a variety of volunteer vegetation comes up simultaneously which is competitive and undesirable. These undesirable and competitive plants are known as "weeds".

The worldwide loss in crop biomass and production is mainly due to uncontrolled growth of weeds in crop fields. The growth of weeds in cropland deprives the commercial crops of valuable nutrients, water and even the incoming solar radiation. Thus it drastically reduces the crop yield. Estimates have been made about the annual loss of agricultural production due to various pests and it has been observed that in India, pests damage agricultural produce of the value of Rs. 6000 crores, out of which weeds accounts for the maximum loss (33 per cent) i.e., among all the pests, weeds alone are responsible for one third loss in crop production (Gautham and Mishra, 1995).

Present day, India has achieved self sufficiency and a good degree of stability in food grain production. With this great achievement on India's food front, the scientist are now being directed for improvement in the quality of agricultural produce. However self sufficiency in true sense can be achieved only when each individual in the country is assured of a balanced diet. Vegetable form the most important component of a balanced diet, widely adapted to diverse agroclimatic conditions and can be raised throughout the year to have availability of vegetable round the year. Vegetables are the only natural source of protective food as they supply protein, vitamins, minerals, etc.

Brinjal or egg plant is one of the most common, popular and principal vegetable crops grown in India and other parts of the world. It is highly productive and find it's place as the poor man's crop. Brinjal has been a stable vegetable in our diet since ancient times. Contrary to common belief, it is quite high in nutritive value and also possess medicinal value (Chowdhury, 1976).

Although a lot of research work has been done on various aspects of cultivation of brinjal yet some important problems have not been studied thoroughly and weed problem is one of them. The losses on account of high weed infestation are estimated to be much more in vegetables as compared to cereals and pulses. The practice of liberal dose of fertilizers, frequent irrigation, wider spacing and initial slow growth encourages the growth of weeds in brinjal. It has been estimated that loss in yield due to weeds in vegetables alone vary from 10 to 70 per cent depending on the extent of weed infestation (Mani *et al.*, 1968). Therefore, the weeds should be controlled as soon as they are seen.

Several methods are adopted for controlling weeds in crop field. Among them, manual weeding is the most effective method of weed control in vegetables. Due to the exorbitant wage rate combined with low efficiency and non availability of labour during the peak period, hand weeding becomes a burden for cultivators. Moreover in summer or rainy season vegetables, repeated flushes of weeds make the operation ineffective when farmers look forward for some selective herbicide.

Chemical control of weeds in vegetable farming is relatively new. Quite a few approved herbicides are available for weeding vegetables but unfortunately, no single herbicide controls all the weed species that may plague of vegetable grower. Moreover environmental contamination of air, water, soil and food with herbicide may alter the species richness, biological density, diversity and functional activities of ecosystem and may ultimately threaten the very survival of human race.

Therefore a system that combines herbicides with cultivation and other good crop husbandry practices like proper field selection, crop variation, stale seed-beds, good land preparation and other cultural practices should be practiced (Fischer, 1974). It is commonly known as "Integrated weed management".

Integrated weed management is an effective, dependable and workable weed management practice that can be used economically by the producer as a part of sound farm management practices. It's basic concern is with designing and implementing weed management practices that meet the goals of farmers, consumers and government in reducing losses due to weeds while, at the same time safeguarding against the long term risk of environmental pollution, hazards to human health and reduced agricultural sustainability.

With this background, an investigation was conducted with the following objectives.

i) To study the influence of weed management practices on the dominance and persistence of weed flora infesting brinjal.

ii) To assess the yield loss in brinjal due to weed interference

iii) To workout the efficiency of different weed management practices

iv) To workout the economics of different weed management practices.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Generally vegetables are poor competitors of weeds. In brinjal, the practice of liberal dose of fertilizers, frequent irrigation and wider spacing encourages profuse growth of weeds resulting in drastic yield reduction. However a perusal of the literature pertaining to the weed management of the crop revealed a dearth of information and hence relevant works on other vegetables are also considered and reviewed hereunder.

2.1 Weed flora infesting vegetables

Weed flora infesting vegetable crops varies widely with respect to prevailing soil and climatic conditions.

Patro *et al.* (1970) observed that *Cyperus rotundus*, *Digitaria sanguinalis*, *Echinochloa colonum*, *Eleusine indica*, *Eleusine aegyptica*, *Acanthospermum hispidum*, *Amaranthus* spp., *Celosia argentia* and *Commelina* spp. were the important weed flora of potato field in Orissa. In a study from Haryana, India *Trianthema portulacastrum*, *Chenopodium album*, *Cyperus rotundus*, *Sporobolus diander* were reported to be the predominant weeds infesting brinjal (Nandal and Pandita, 1988).

Pritam (1978) reported that *Cyperus rotundus*, *Ageratum conyzoides*, *Echinochloa colonum*, *Digitaria sanguinalis* and *Commelina nudiflora* were the important weeds of tomato in Solan while Reddy and Rao (1999) reported that *Dactyloctenium aegyptium*, *Cleome viscosa*, *Euphorbia hirta*, *Phyllanthus niruri* and *Cyperus rotundus* were the important weeds of tomato.

Singh *et al.* (1982) observed that *Cyperus rotundus, Echinochloa colonum, Portulaca quadrifida, Sorghum halepense* were major weeds in okra fields in Pantnagar. According to Leela (1993) *Cyperus rotundus, Cyperus iria, Cynodon dactylon, Euphorbia* spp., *Portulaca oleracea* were the major weeds in vegetable crops like tomato, bean, okra and radish.

The predominant weeds associated with Knol-Khol and radish were the monocotyledonous *Digitaria marginata, Brachiaria erusiformis, Setaria glauca, Cynodon dactylon,* sedges like *Cyperus rotundus* and broad leaved weed like *Commelina benghalensis* (Leela, 1987).

Cyperus rotundus, Eleusine indica, Trianthema portulacastrum, Celosia argentia, Portulaca spp. and *Amaranthus* spp. were the predominant weeds of vegetable fields of Jalandhar in Punjab (Saimbhi *et al.*, 1994). Malik *et al.* (1998) observed that *Trianthema portulacastrum, Echinochloa colonum, Amaranthus viridis, Digitaria ciliaris, Phyllanthus niruri, Commelina benghalensis, Dactyloctenium aegyptium, Cynodon dactylon, Cyperus rotundus, Orobanche nicotiana* etc., were the important weed flora infesting vegetables in India.

Kathiri (1994) reported that *Cynodon dactylon, Cyperus rotundus, Convolvulus arvensis, Echinochloa colonum,* were major weeds of vegetable fields of Yemen.

2.2 Crop weed competition

Crop-weed competition is complicated because various factors affect the extent to which it occurs. The total effect of the interference as reflected in crop growth and yield, results from competition for nutrients, moisture and sunlight (Rao, 2000).

2.2.1 Critical period of crop weed competition in vegetables

Knowledge on the susceptible period of crop life to weed infestation decides the weed management programme to be adopted. It is the critical period, at which the occurrence of weed competition greatly affects the quantity as well as the quality of the crop yield. The crop yield may be unaffected by the presence of weeds during the early stages and also if it is kept clean for a certain length of time, weeds that emerge and develop subsequently may not affect the yield. They termed this intervening period as "critical period" of weed competition (Hewson and Roberts, 1971).

Shadbolt and Holm (1956) observed that the period from emergence to four weeks was the critical stage in the competition of weeds in row planted vegetable crops. Paller *et al.* (1973) studied the duration of weed competition in transplanted onion and found that the presence of weeds for only two weeks reduced the yield by 42 per cent. They have concluded that weed free condition for seven weeks after transplanting gave the maximum yield.

Rajagopal and Sankaran (1979) studied the crop weed competition in tomato and found that the critical weed free period for tomato was upto 30 days from transplanting. The critical stages of crop weed competition was 15-30 days for okra was reported by Singh *et al.*(1982).

Nandal and Pandita (1988) reported that brinjal crop kept free from weeds between 20 to 40 days of transplanting, yielded equivalent to weed free condition and reduced the cost of weeding.

2.2.2 Effect of crop weed competition on growth characters

Shadbolt and Holm (1956) observed that under weed competition the number of leaves per plant did not increase but remained constant in onion. Consequently the leaf area was considerably reduced which in turn affected the bulb initiation, number of bulbs and the size of bulbs.

Maximum number of leaves per plant and neck thickness were recorded under weed free check in garlic and more number of leaves per plant under this treatment might have been due to less crop-weed competition for light, space, nutrient and moisture (Singh *et al.*, 1982 ; Vora and Mehta, 1999).

Reena (1997) observed that minimum plant height was recorded with weed free check in sesamum.

2.2.3 Effect of crop weed competition on yield and yield attributes

According to Balachandran (1980) the yield losses due to weeds in onion was upto 30 to 50 per cent while Bhalla (1980) reported a higher loss of 70 to 75 per cent due to weed competition. Loss of yield in okra is estimated between 50 and 90 per cent (Singh *et al.*, 1982).

Singh *et al.* (1993) reviewed the yield losses caused by weeds in vegetable crops and reported it to be ranging from 6 to 82 per cent. He also reported that the yield losses in tomato ranged from 42-71 per cent.

In garlic, the most favourable effect on yield attributes viz., diameter of bulb, number of cloves per plant, 100 cloves weight, bulb yield per plant and bulb yield q ha^{-1} was observed under weed free check (Vora and Mehta, 1999). Weed population under this treatment was less indicating little competition of weed with crop of garlic which in turn favourably influenced yield and it's attributes.

2.2.4 Effect on nutrient removal

Prabhakaran *et al.* (1977) observed negative correlation coefficient between nutrient uptake by weeds and crop yield and also reported that nutrient uptake was doubled under weed free condition compared to unweeded check in ground nut.

In a field trial at Khandwa, Madhya Pradesh, maximum concentration of N, P and K in okra plant at harvest was obtained with the application of fluchloralin @ 0.48 l ha^{-1} followed by one hand weeding (Bhalla and Parmar, 1982). Nandal and Pandita (1988) reported that N, P and K uptake by weeds was directly proportional to the dry matter accumulation. Maximum uptake of N, P, K at harvest was recorded with weedy check in brinjal.

Pannu *et al.* (1991) showed that integrating one hand weeding on 40 DAS with pre-emergence application of fluchloralin @ 1 kg a.i. ha^{-1} facilitated the maximum uptake of 183.6, 27.4 and 106.7 kg N, P and K ha^{-1} in groundnut.

2.3 Weed control methods in vegetables

2.3.1 Physical methods

According to Ahlgren *et al.* (1951) weed control by hoeing was an efficient method, but was laborious, costly, time consuming and unsuitable for large farms. Crafts and Robbin (1973) opined that hand pulling of weeds was an efficient method of eliminating annual and biennial weeds, which do not recover again.

According to Gupta and Lamba (1978) hand weeding was the most common practice of weed control in vegetables in the country. Despite its high cost, it is sometimes favoured because of its high cash returns from these crops. Leela (1989) studied the weed control efficacy of several herbicides applied immediately after planting in comparison with manual weeding and observed that manual weeding was effective but costly. According to Yadav *et al.* (1994) hand weeding at 30 DAS stage proved the most effective for controlling weeds and increase seed yield in cluster bean.

Mishra *et al.* (1998) reported that hand weeding twice at 20 and 40 DAS effectively controlled grasses, broad leaved weeds and sedges and recorded the lowest weed population in french bean. Hand weeding twice significantly increased the seed yield by 49.3 per cent in comparison to weedy check and also recorded highest weed control efficiency. Manual weeding is effective against annuals and biennials but do not control perennials and is expensive in areas where labour is scarce (Rao, 2000).

2.3.2 Cultural methods

2.3.2.1 Smother cropping

According to Gupta and Lamba (1978) an important role of smother crops in agriculture was to continue suppression of perennial weeds, after they have been weakened by intensive tillage during preceding fallow period.

Growing cowpea, greengram and soybean as an intercrop in maize could exert suppressing effects on weeds (Tosh, 1979).

Smeda and Putnam (1984) observed that rye cover crop was more effective than wheat or winter barely as a mulch to suppress weeds in the transplanted tomato. It was concluded that a rye cover crop was an acceptable alternative to pre plant herbicides for tomatoes.

Cropping system incorporating smother crops and or intercropping with cover crops greatly reduced the weed problems of *Cynodon dactylon*, *Cyperus rotundus* and other species seen on the sandy loam soils of Dholi, Bihar (Thakur *et al.*, 1989).

The smothering effect of pearl millet (*Pennisetum americanum*) or sesamum against *Cyperus rotundus* was reported by Tewari and Singh (1991) in Kanpur.

Brandster (1996) reported that living mulches suppressed weeds more effectively and for longer time than killed mulches. Bioassays indicated that some cover crops showed allelopathic potential against some weeds.

Smother crops like cowpea which grew most rapidly were very valuable in any weed control programme, since they filled the inter-row space with their canopy faster than the weeds (Rao, 2000).

2.3.2.2 Plastic mulching

Halappa and Sreenivas (1975) reported an increase of 39.5 to 44.97 per cent in cauliflower yield with the use of polythene mulches as compared to control. Polythene mulches also greatly reduced the weed density. According to Katan *et al.* (1975), use of polythene mulches increased crop yield by 300 per cent in brinjal and tomato. Srivastava *et al.*(1981) reported that the use of black polythene mulches significantly reduced the weed population. It also gave higher yield than the control. Konys and Konys (1992) observed that polythene mulching would be desirable as a means of reducing weeds in vegetable crop. Schonbeck (1998) reported that 32 μm thick embossed black polythene blocked weeds except for a few emerging through planting holes.

Use of black plastic mulch gave earlier harvesting and higher yield of cantaloupe melons than when the melons were grown in standard, raised beds in California. The plastic mulch also reduced the need for weed control, (Bell, 1984).

Mashingaidze *et al.* (1996) noticed that, the harvesting period of tomato was extended by black polythene mulching, subsequently the total yield. The enhanced growth and yield was attributed to the changed temperature and light microenvironment around the plants. Using polythene mulches increased earliness, yields and fruit quality in musk melon was reported by Brandenberger and Wiedenfeld (1997). Black low density polythene film mulch promoted the growth of okra, and resulted in yield of 223.7 q ha^{-1}, compared with 31.1 q ha^{-1} for unmulched controls. Black low density polythene film mulch also gave the maximum weed control efficiency (96.5 per cent) and maintained higher moisture and temperature regimes in the soil, (Saikia *et al.*, 1997).

According to Gutal *et al.* (1992) polythene mulches films increased soil temperatures by 5-7 °C which facilitated faster germination and better root proliferation. At the same time weed growth was checked and soil moisture was retained preserving soil structure. It was further observed that CO_2 around the plant was increased. Result of three years experiments with 25 μ black low density polythene film mulch also indicated that tomato yield could be increased by 55 per cent, over the control treatments without mulch.

2.3.2.3 Stale seed bed technique

Noll (1975, 1978) emphasized the benefits of stale seedbed weed control in cucumber using application of glyphosate and paraquats on stale seedbeds to control emerged weeds.

According to Gupta and Lamba (1978) the main advantage of stale seedbed was that crops germinate in a weed free environment and if selectively stimulated, they might close in before subsequent flushes of weeds appeared in the land. Burnside *et al.* (1980) reported that crops grown in shallow tilled seedbeds or treated with a non-selective herbicide had fewer weeds and greater yields than those grown in no-till cropping system.

Ali *et al.* (1979) and Sumner *et al.* (1981) observed that stale seedbed practice prior to planting reduced weed population. However in a stale seedbed programme, planting usually occur in some emerged vegetation, which necessitates the timely use of herbicide for weed control (Stougaard *et al.*, 1984 ; Elmore and Heatherly, 1988 ; Buchler and Werling, 1989 ; Bruff and Shaw, 1992).

According to Heatherly and Elmore (1983) successful form of reduced tillage was stale seedbed system which use some degree of tillage and thus controlled weeds. Gunsolus (1990) noted that rotary hoeing of stale seed beds in soybean and corn (*Zea mays*) after weed seed germination, but immediately prior to emergence reduced the number of weed seeds in the plow layer. According to Hosmani and Meti (1993) stale seedbed encouraged a flush of new weed seedling, which could be controlled very easily prior to planting and reduced the crop weed competition in succeeding crops. Johnson and Mullinix (1995) reported that shallow tillage of stale seedbed reduced numbers of certain weeds and improved weed control in peanut (*Arachis hypogea* L.) replacing the need for post emergence herbicides.

The advantage of stale seedbed practice in weed control was emphasized by Hosmani and Chittapur (1996) and Krishnarajan and Meyyazhagan(1996). Carroll and Benjamin (1998) reported that shallow tillage of stale seedbeds before planting improves weed control in cucumber. Although weed species response varied among stale seedbed management systems, florida pursely and yellow nutsedge densities were among the lowest in plots with stale seedbed. It was also reported that stale seedbeds integrated with a basic weed management programme eliminated the need for additional herbicides in cucumber production.

2.3.3 Chemical weed control

In recent years there is a trend of shift of labour force from rural areas to industry. So labour for agricultural operation is increasingly becoming unavailable and many a time it is not available for hoeing and other weed control operation (Gill and Brar, 1975).

Further more similarity of crop and weed plants doesn't permit effective hand weeding. Herbicides are a weapon that can relieve the grower of much of the drudgery and back breaking labour involved in cultivating hoeing or weed pulling (Muzik, 1970).

Brathwaite (1978) evaluated the efficacy of six herbicides on weed control of brinjal and reported that all the herbicides were effective and no crop injury was noted. Leela (1989) studied the weed control efficacy of several herbicides applied immediately after planting in comparison with manual weeding and the yield of brinjal was unaffected.

2.3.3.1 Weed control using fluchloralin

Efficacy of fluchloralin for weed control in vegetables has been studied by several workers.

Randhawa and Sandhu, (1978) reported that fluchloralin @ 0.9 and 1.25 kg a.i ha^{-1} gave 94.40 and 91.51 per cent weed control efficiency in okra. In tomato, fluchloralin @ 1.25 kg a.i ha^{-1} was most effective in improving growth, flowering, fruiting, early and total yield (Pandita and Sandyan, 1980). It was also effective in controlling weeds and improving the quality of harvested fruits. Khurana *et al.* (1985) observed that application of fluchloralin @ 1 kg a.i ha^{-1} to onion gave excellent control of broad leaved weeds. Weed dry weight was greatly reduced by fluchloralin. Pre-plant incorporation of fluchloralin @ 1.5 kg a.i ha^{-1} has been found to be very effective in reducing the weed problem in okra. (Singh *et al,* 1985).

Kolar and Dhingra (1986) found that application of 1.5 litres basalin (fluchloralin) per ha (presowing) gave effective weed control until 30-40 DAS resulting in yields of 1.1 t ha^{-1} compared with 0.99 t with two handweedings and 0.59 tonnes without weed control in mungbean. Basalin gave effective control of grasses and broad-leaved weeds but not the perennial weeds such as *Trianthema monogyna, Cyperus rotundus, Cynodon dactylon.*

Nandal and Pandita (1988) reported that the use of fluchloralin at the rate of 1.25 kg a.i ha^{-1} in brinjal yielded higher than two hand weedings and remained at par with weed free treatment. Bhalla and Tewari (1990) found that fluchloralin at a rate of 0.72 kg a.i ha^{1} gave significantly higher yield and also improved the quality characteristics of tomato fruit. According to Leela (1993) fluchloralin was very effective against the broad leaved weeds for 90 days in cabbage and cauliflower.

Pre plant incorporation of fluchloralin @ 1.12 kg a.i ha^{-1} gave 16 fold reduction in drymatter of weeds and increased the seed yield of Indian palak by a magnitude of 209.9 per cent (Ramana *et al.*, 1994). Nepalia *et al.* (1996) reported that preplanting incorporation of fluchloralin @ 1 kg a.i ha^{-1} resulted in decrease in weed drymatter at 30 days stage. Reddy and Rao (1999) found that use of fluchloralin @ 1.2 kg a.i ha^{-1} in tomato was effective against broad leaved weeds and grasses but it was not effective against *Cyperus rotundus*.

2.3.3.2 Weed control using glyphosate

There are several reports on effectiveness of glyphosate as a total weed killer.

Glyphosate at the rate of 125-1200 ml ha^{-1} was evaluated for use in brinjal and tomato transplant on no-till plots dominated by *Alopecurus* sp, *Commelina communis, Digitaria* sp., *Polygonum hydropiper, Echinochloa* sp and *Erigeron* sp Brinjal yield was highest where glyphosate was applied not later than 3 days before transplanting or glyphosate was applied not earlier than 3 days before transplanting (Gub *et al.*, 1979). Direct contact application of glyphosate using a rope wick applicator was also effective in controlling weeds in brinjal (Singh *et al*, 1991).

Creager (1982) reported that presowing spray with glyphosate at 4.5 kg a.i ha^{-1} in cucumber and cantaloupe crops was more effective in controlling weeds when compared to hand weeded control.

In a trial on a clay loam soil of pH-5, glyphosate was applied before sowing or transplanting tomato. Tomato sown immediately after glyphosate application suffered no injury but transplanted tomatoes showed various symptoms, even when 15 days elapsed between the herbicide application and transplanting (Andino *et al*, 1989).

Desai *et al.* (1996) conducted field experiments on red sandy loam soil to evaluate glyphosate @ 2-4 kg ha^{-1} as a means of controlling *Cyperus* *rotundus*. Result revealed that in glyphosate sprayed plots there was drying of the weeds after a week of spraying. Rhizome dry weight and sprouting were also reduced by glyphosate application.

2.3.3.3 Glyphosate + 2, 4-D

Many workers have reported that the combination of these herbicides was more effective than separate application.

Mangoensoekarjo (1979) recorded higher weed control efficiency in plots that received mixtures of 1.5 kg glyphosate + 0.5 kg 2, 4 - D salt.

Manickam and Gnanamoorthy (1994) conducted experiments to findout the effectiveness of chemical control of nutsedge. They found that spraying of glyphosate @ 1 per cent + 2,4 - D sodium salt @ 0.05 per cent considerably reduced the weed dry matter and recorded higher weed control index. The maximum mortality of nuts upto 66.6 per cent with minimum nut regeneration upto 23.3 were also noted under this treatment. They suggested that this might be due to the auxinic effect of 2, 4 - D on effective translocation to primary and secondary tubers when added at sublethal concentrations.

Inder Dev *et al.* (1996) reported that the efficacy of glyphosate @ 1.0 kg ha^{-1} was increased substantially when applied in combination with 2,4-D @ 1.0 kg ha^{-1} as compared to application of glyphosate alone. Addition of 2, 4-D to glyphosate reduced regeneration of weeds substantially.

In a weed management study to control *Cyperus rotundus* in maize, application of glyphosate @ 1.25 kg a.i ha^{-1} in combination with 2,4 - D sodium salt before sowing maize was found effective- in reducing population, drymatter and tuber number of *Cyperus rotundus* L. (AICRP, 1996).

Observation by Ameena (1999) have also shown that the efficacy of glyphosate @ 1.0 kg ha^{-1} was increased substantially when applied in combination with 2, 4 - D @ 1.0 kg ha^{-1} as compared to application of glyphosate alone. Addition of 2,4-D to glyphosate reudced regeneration of weeds substantially.

2.3.4 Integrated control of weeds

There is no single method by which all the weeds could be controlled effectively as the weed flora of crop consists of different species. Moreover, a sudden switchover to chemical weed control from hand weeding may not be the answer to alleviate the weed problem. Hence a judicious combination of different methods is the most effective weed management strategy (Joshi, 1973; Dall, 1977; Sankaran,1977).

Bhan *et al.* (1980) reported that fluchloralin @ 0.5 and 1 kg a.i. ha^{1} followed by one manual weeding at 45 DAS increased the yield of okra by 800 to 1000 kg ha^{-1} over herbicide alone. Fluchloralin at all doses significantly reduced the density and drymatter production of weeds.

Fluchloralin @ 0.48 l ha^{-1} followed by one handweeding gave the lowest fresh and dry weight of weeds and highest seed yield of okra and highest net profit (Bhalla and Parmar, 1982). This finding was supported by Singh *et al.* (1982). Sanone *et al.* (1982) observed that incorporation of fluchloralin @ 1 kg a.i. ha^{-1} before transplanting followed by one hand weeding decreased the weed population and increased the yield in okra. Application of fluchloralin @ 1 kg a.i. ha^{-1} with supplementary weeding gave highest fruit numbers and yields of green pods of okra per ha (Pandey and Singh, 1983). This was in line with the findings of Tewari *et al.* (1985), Bhalla and Parmar (1986), Leela (1993) in many vegetable crop.

Fluchloralin @ 0.09 kg ha^{-1} + 1 hoeing significantly decreased the populations and dry weight of weeds and increased the bulb yield of onion (Randhawa *et al.*, 1985).

Pannu *et al.* (1991) obtained the maximum weed control efficiency through soil incorporation of fluchloralin 1.5 kg a.i. ha^{-1} with one handweeding in groundnut.

Teasdale and Colacicco (1985) reported that black polythene mulch in combination with herbicide application provided the most consistent weed control and highest profit. Treatment without, black polythene provided good weed control, but yields and profits were lower than treatments including it.

2.3.5 Herbicide persistence in the soil

Persistence in soils is an important feature of a herbicide as it determines its suitability or otherwise in a particular soil and cropping situation (Rao, 2000).

2.3.5.1 Persistence of fluchloralin

Seshaiah *et al.* (1978) observed no residual toxicity of fluchloralin applied @ 0.72 kg ha^{-1} to groundnut. Jacques and Harvey (1979) studied the persistence of dinitroaniline herbicide and reported that these herbicides remain in the surface 7.5 cm of soil and were biologically active until 75 to 100 days. After this, according to them, there was not much difference in their activity. Leela (1993) conducted the bioassay technique for detecting herbicide residues in soil and reported the persistency of fluchloralin for 90 days in the soil.

Sandhu and Randhawa observed that the use of fluchloralin at 1.2 kg ha^{-1} in okra (1979) and in onion (1980), had no deleterious effect on the succeeding crops namely radish, carrot, turnips, peas and spinach and okra, bottle gourd, squash and musk melon, respectively. A field experiment was conducted by Subramonium *et al.* (1998) to study the residual effect of the herbicide fluchloralin applied to groundnut on bajra and ragi which were grown as succeeding crops. The results revealed that fluchloralin had no adverse effect over the succeeding crops. The germination percentage, drymatter production per plant, seedling vigour and root to shoot ratio did not differ significantly in both the seasons in bajra and ragi crop.

Residual toxicity of fluchloralin, oxyflurofen, 2,4-D sodium salt, benthiocarb and oxidiazone was studied on succeeding crop using cucumber, a sensitive crop for weedicides. The residue of 2,4-D sodium salt and oxyflurofen adversely affected the germination, shoot length, root length and dry weight of seedlings as compared to the residues of benthiocarb, fluchloralin and oxidiazone (Dhanapal and Bomme, 1996).

2.3.5.2 Persistence of glyphosate

According to Singh and Gupta (1978) glyphosate applied @ 1.25 l ha^{-1} for controlling nutsedge was safe even five days after spraying for growing crops like bhindi, cotton and brinjal. Leveille *et al.* (1993) evaluated the effects of glyphosate residues in soils 15 months after treatment and it was found that six of them contained no detectable residues and the average for all samples was 0.1888μg g^{-1}.

Reynolds *et al.* (1993) conducted chemical and biological studies upto three years after the treatment in order to study the environmental fate and impacts of the herbicide glyphosate in temperate coastal rain forest. They found that glyphosate residues rapidly dissipated and degraded in the natural environment. After one year the remaining residues were strongly adsorbed to organic matter and soil particles where they appeared to be inactivated and immobilized.

Thompson *et al.* (1994) observed that the initial foliar residues of glyphosate were dependent on application rate and increased by a similar factor for each kilogram per ha applied, irrespective of the formulation type. Mean time to 50 per cent dissipation were two days and for 90 per cent dissipation were less than 16 days for all herbicide formulations. Glyphosate residues dissipation was independent of the salt formulation applied.

Jaganathan and Nadanam (1996) conducted field experiments to study the residual effect of glyphosate on germination of cowpea, greengram and cassava. It was found that glyphosate at 2.0 kg ha^{-1} had no phytotoxic effect and did not affect the germination of these crops, irrespective of the time of sowing after application.

2.3.5.3 Persistence of 2,4-D

Thakur (1966) did not find any 2,4-D residue four months after planting. 2,4-D persisted in the soil only for two weeks after its application This was inline with the findings of Sokolov *et al.* (1974).

Balyan *et al.* (1981) studied the toxicity and residual effect of 2,4-D and reported that use of 2,4-D in the previous crop did not cause any phytotoxicity on the succeeding crop.

Ameena (1999) reported that germination of cucumber seed was not affected when sown on the same day of herbicide application but its further growth was found weakened. However germination percentage and growth characters of cucumber was not affected when sown 10 days after spraying.

2.3.6 Economics of weed management in vegetables

Cost analysis studies by Djimu and Diemkouma (1986), in brinjal and tomatoes showed that saving in water use due to weed control and higher productivity with the use of black polythene mulching in these crops justified the investment in mulching during cool season. Gutal *et al.* (1992) observed that a 20 per cent saving in weeding cost could be achieved by the use of black low density polythene film mulch in brinjal. Mulching with black low density polythene film promoted okra growth and resulted in yield of 223.7 q ha^{-1} compared with 31.1 q ha^{-1} for unmulched control and highest cost benefit ratio of 1 : 3.1 was reported by Saikia *et al.* (1997).

In tomato and okra integrating fluchloralin or pendimethalin (0.5 - 1 kg a.i. ha^{-1}) with one hand weeding 40 days after sowing was found more economical than hand weeding twice (Leela, 1993). Highest cost benefit ratio of 1 : 1.42 was obtained from the treatment fluchloralin 0.5 - 1 kg a.i. ha^{-1} followed by one hand weeding 40 days after sowing of okra was reported by Gogoi *et al.* (1997).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was carried out to evolve a suitable weed management technique for brinjal cultivation. The materials used and methods adopted for the field experiment are detailed here under.

3.1 Experimental site

The experiment was undertaken in Block IV of the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala. The farm is located at $8^0 30'$N latitude, 76^0 9' E longitude and at an altitude of 29 m above mean sea level.

3.1.1 Climate

A humid tropical climate prevails in the area of the experimental site.

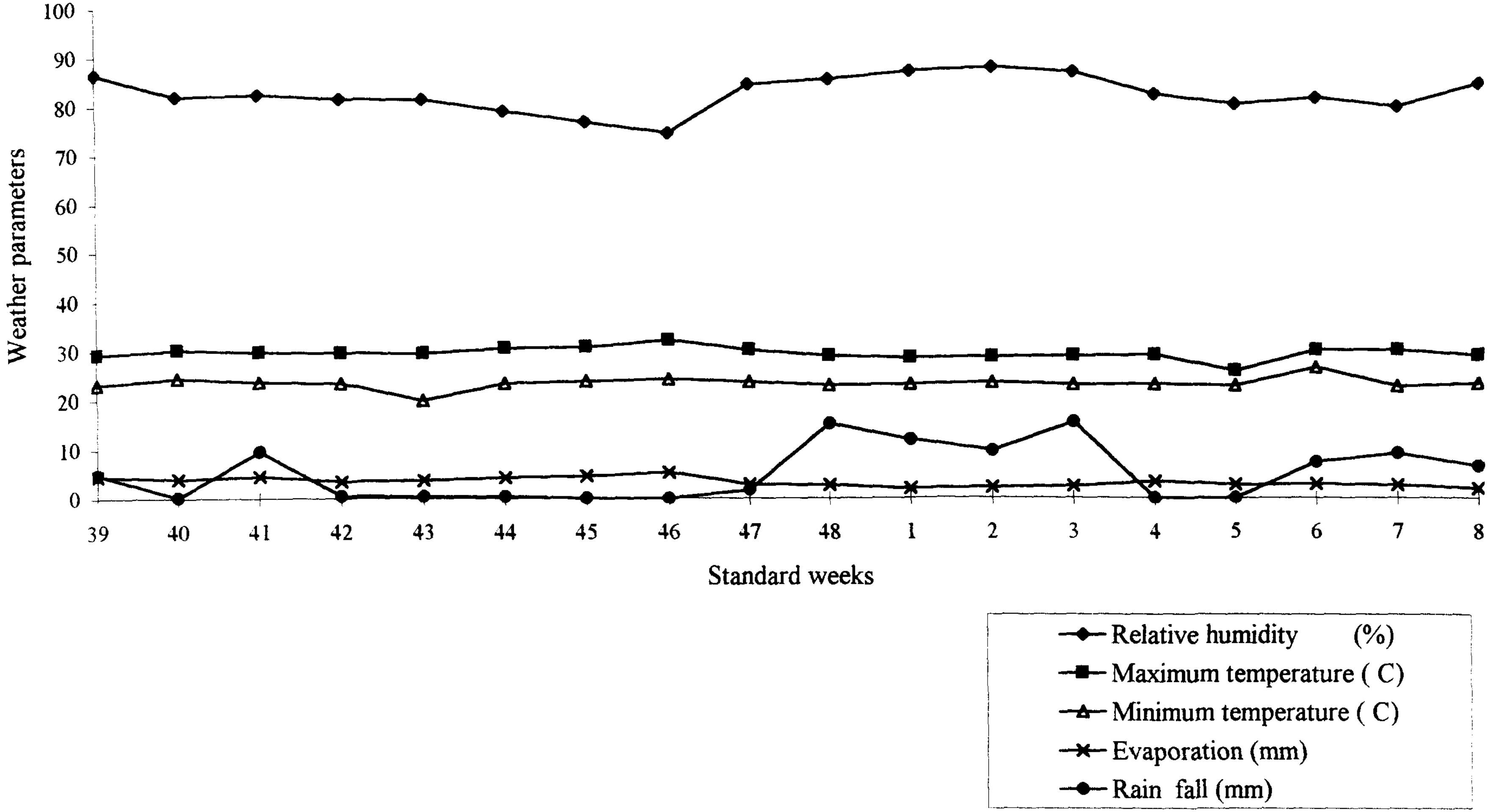
The weekly averages of temperature, relative humidity and rainfall during the cropping period were collected from the observatory attached to the Instructional farm and the data are presented in Appendix I and illustrated graphically in Figure I.

The weather condition during the period of the study was favourable for the satisfactory growth of the crop.

3.1.2 Cropping season

The experiment was conducted during August 1999 to November 1999. Sowing in nursery bed and transplanting in the field were done on 3^{rd} July and 3^{rd} August respectively.

Fig. 1 Weather parameters during the cropping period (August to November, 1999)



3.1.3 Soil

Prior to the experiment, composite samples of the soil were drawn from a depth of 0-15 cm and analysed for physico-chemical properties and the data are presented in the Table 1.

The soil of the experimental site was sandy clay loam, belonging to the taxonomical order Oxisol. It was acidic in reaction and medium in available nitrogen, available phosphorus and low in available potassium content.

Table 1 Soil characteristics of the experimental site

Sl. No.	Fractions	Content in soil	Methods used
A.	Mechanical composition		
1.	Coarse sand (%)	36.35	International pipette method (Piper, 1966)
2.	Fine sand (%)	15.00	
3.	Silt (%)	17.50	
4.	Clay (%)	30.00	
5.	Textural class : Sandy clay loam		
B.	Chemical properties		
1.	Available Nitrogen (Kg ha^{-1})	282.24	Alkaline Permanganate Method (Subbiah and Asija, 1956)
2.	Available P_2O_5 (Kg ha^{-1})	40.56	Bray colorimetric Method (Jackson, 1967)
3.	Available K_2O (Kg ha^{-1})	115.53	Ammonium acetate Method (Jackson, 1967)
5.	Soil reaction (pH)	4.8	1 : 2 : 5 soil solution ratio using pH meter with glass electrode (Jackson, 1967)

3.1.4 Cropping history of the field

The experimental site was lying fallow for one year prior to the experiment.

3.2 Materials

3.2.1 Crop variety

The brinjal variety, Swetha released from Kerala Agricultural University was used for the experiment. The variety is of bushy growth habit, with slight purple tinge on leaf stalk. Plants are non prickly. The duration is four months. Fruits are white, medium long and of excellent cooking quality. The variety is tolerant to fruit borer and the yield potential is 31 t ha^{-1}.

3.2.2 Source of the seed material

The brinjal seeds for the experiment were obtained from the Instructional Farm, Vellayani.

3.2.3 Manures and fertilizers

Farm yard manure (0.4, 0.3, 0.2 per cent N, P_2O_5, K_2O respectively) was used for the experiment. Urea (46 per cent N), Mussoriephos (20 per cent P_2O_5) and Muriate of Potash (60 per cent K_2O) were used as source of nitrogen (N), Phosphorus (P) and Potassium (K) respectively.

3.2.4 Herbicides

The herbicides glyphosate, 2,4-D sodium salt and fluchloralin were applied according to the treatments.

1. Glyphosate : N (phosphonomethyl) glycine

Formulation	:	41 per cent SL
Trade name	:	Round up
Produced by	:	Monsanto chemicals, USA
Price	:	Rs. 480 per litre

2. 2,4-D sodium salt : 2,4- dichlorophenoxy acetic acid

Formulation	:	80 per cent WP
Trade name	:	Fernoxone
Produced by	:	Imperial chemical industries, U.K
Price	:	Rs. 120 per kg

3. Fluchloralin : N-(2- chloroethyl)-2, 6-dinitro- N- propyl - 4 (trifluromethyl) aniline

Formulation	:	45 per cent EC
Trade name	:	Basalin
Produced by	:	BASF, Germany
Price	:	Rs. 530 per litre

3.2.5 Cowpea seeds

V-26 variety of cowpea obtained from the Instructional Farm, Vellayani, was used as the smother crop.

3.2.6 Cucumber seeds

Cucumber seeds used for herbicide residue test were collected from the Instructional farm, Vellayani.

3.2.7 Mulching material

Black polythene sheets of 0.3 mm thickness was used as the mulching material.

3.3 Methods

3.3.1 Design and layout

The layout plan of the experiment is given in Figure 2.

Design : Randomised Block Design

Number of treatments = 14

Number of replication = 3

Gross plot size = 4.5 x 4.2 m^2

Net Plot size = 3 x 3 m^2

Total number of plots = 42

Two rows of plants were left as border on all the sides and the observations were taken from the net plot area.

3.3.2 Treatments

The treatment details are furnished in Table 2.

In T_3 the manual weedings were done at 15^{th} and 30^{th} day of seedling transplanting.

In the integrated methods (T_4, T_5, T_9, T_{13}) manual weeding was done on the 20^{th} day of seedling transplanting.

Black polythene mulching was done on the day of seedling transplanting.

Fig. 2 LAYOUT PLAN OF THE EXPERIMENT

R_1T_3	R_1T_{12}	R_1T_4	R_1T_{10}	R_1T_2	R_1T_{14}	R_1T_6	R_1T_9	R_1T_{13}	R_1T_7	R_1T_8	R_1T_5	R_1T_{11}	R_1T_1	**Replication I**
R_2T_5	R_2T_{14}	R_2T_1	R_2T_8	R_2T_4	R_2T_{13}	R_2T_7	R_2T_{11}	R_2T_6	R_2T_{10}	R_2T_3	R_2T_{12}	R_2T_9	R_2T_2	**Replication II**
R_3T_1	R_3T_{13}	R_3T_9	R_3T_{14}	R_3T_7	R_3T_8	R_3T_6	R_3T_{12}	R_3T_2	R_3T_{11}	R_3T_4	R_3T_{10}	R_3T_3	R_3T_5	**Replication III**

Design - RBD
Net plot size - 3 x 3 m^2
Replication - 3

Table 2 Treatment details of the experiment

Sl.No.	Notations	Treatments
1	T_1	Weedy check
2	T_2	Weed free check
3	T_3	Two manual weedings at 15 and 30 days after transplanting
4	T_4	Smother crop + one manual weeding
5	T_5	Stale seedbed + one manual weeding
6	T_6	Stale seedbed + smother crop
7	T_7	Black polythene mulching
8	T_8	Fluchloralin @ 1.5 kg. a.i ha^{-1} alone
9	T_9	Fluchloralin @ 1.5 kg. a.i ha^{-1} + one manual weeding
10	T_{10}	Fluchloralin @ 1.5 kg. a.i ha^{-1} + smother crop
11	T_{11}	Glyphosate @ 1.5 kg. a.i ha^{-1} alone
12	T_{12}	Glyphosate @ 1.5 kg. a.i ha^{-1} + 2,4-D
		Sodium salt @ 0.25 kg. a.i ha^{-1}
13	T_{13}	Glyphosate @ 1. 5 kg. a.i ha^{-1} + one manual weeding
14	T_{14}	Glyphosate @ 1. 5 kg. a.i ha^{-1} + smother crop

Plate 1 General view of the experimental site

As a smother crop two rows of cowpea were planted at the time of seedling transplanting at a spacing of 20 x 10 cm in between brinjal rows which was incorporated insitu at 25^{th} day (maximum growth stage).

Fluchloralin was applied as preplant incorporation (PPI) and glyphosate application was done 15 days before planting the seedlings.

3.3.3 Field culture

All the cultural practices except weed management were carried out as per the package of practices- Recommendation - Crops (Kerala Agricultural University, 1996).

3.3.3.1 Nursery

Brinjal seeds were sown in well prepared raised nursery beds of 1.2 m width and 15 cm height with channels around, to facilitate drainage of excess water. Seedlings were irrigated daily. Hand weeding and plant protection measures were undertaken periodically. The seedlings were transplanted to the mainfield after 32 days.

3.3.3.2 Main field preparation

The experimental site was ploughed, clods broken, stubbles removed and the field was laid out into blocks and plots. The plots were separated by a bund of 30 cm width and the blocks by 50 cm bunds.

3.3.3.3 Application of manures and fertilizers

Farm yard manure at the rate of 20-25 t ha^{-1} was applied at the time of land preparation and mixed well with the soil. N, P_2O_5 and K_2O were applied in the form of urea, mussoriephos and muriate of potash respectively. The recommended fertilizer dose was 75 : 40 : 25 kg ha^{-1} of NPK (Kerala Agricultural University, 1996).

Half of the nitrogen, full phosphorus and half of the potash were applied as basal dose before transplanting. One fourth of nitrogen and half of potash were applied 20 days after transplanting and the remaining nitrogen was applied one month after the first application.

3.3.3.4 Transplanting

Thirty days old seedlings were carefully uprooted and transplanted to the mainfield at a spacing of 75 x 60 cm. Shade was provided to the transplanted seedlings using coconut fronds and banana leaves.

3.3.3.5 Gap filling

Gap filling was done with healthy seedlings, wherever necessary.

3.3.3.6 Irrigation

Crop was irrigated daily till establishment and further at 2 days interval.

3.3.3.7 Weed management

3.3.3.7.1 Hand weeding

Hand weeding was done as per the treatments. In T_3 the two manual weedings were done at 15 and 30 days after transplanting and in the integrated methods (T_4, T_5, T_9, T_{13}) hand weeding was done on the 20^{th} day of seedling transplanting.

3.3.3.7.2 Herbicide application

Herbicidal spray solution was prepared as per the treatments and sprayed uniformly in the respective stages of application. Glyphosate alone as well as mixed with 2,4 -D sodium salt were applied over the weed flora 15 days before transplanting the brinjal seedling. Fluchloralin was applied 2 days before transplanting and mixed well with the top soil (PPI).

3.3.3.7.3 Smother crop

As a smother crop, two rows of cowpea were sown at a spacing of 20 x 10 cm, in between the brinjal rows and incorporated insitu at it's maximum growth stage, i.e., at 25 days after sowing.

3.3.3.7.4 Black polythene mulching

After transplanting the seedlings, black polythene strips of 40 and 30 cm width were spread over the whole field leaving a square space of 10 cm x 10 cm on all sides of the plant facilitating irrigation and fertilizer application.

3.3.3.7.5 Stale seedbed

Three weeks before transplanting the brinjal seedlings, the stale seedbed plots were prepared thoroughly and irrigated to stimulate germination of weed seeds. The weed seedlings emerged were then destroyed by shallow cultivation just before planting the brinjal seedlings.

3.3.3.7.6 Weed free check

By removing the weeds as and when they appeared, weed free check was maintained throughout the experiment.

3.3.3.7.7 Weedy check

In weedy check no weed control operation was taken up.

3.3.3.8 Plant protection

Attack of shoot and fruit borer was noticed in all the treatments. Carbaryl @ 0.15 per cent was applied two times at intervals of 15 days, to control the pest attack.

3.3.3.9 Harvest

First harvest was taken 45 days after transplanting (DAT) and subsequent harvests were done as and when the fruits were ready. The final harvest was done at 105 days after transplanting.

3.4 Observations

3.4.1 Observations on the weeds

3.4.1.1 Weed flora

The weed species which infested the experimental site were identified and recorded.

3.4.1.2 Absolute density (Ad)

Absolute weed density was recorded by placing 25 x 25 cm quadrat at random in 3 sites in each plot and calculating the average. The weeds were categorised into grasses, sedges and broad leaved weeds and the absolute density was recorded at 15^{th}, 30^{th}, 60^{th} days after transplanting (DAT) and at the time of final harvest (105 DAT), using the formula suggested by Philips (1959).

Ad = Total number of plants of a given species per m^2

3.4.1.3 Relative density (Rd)

Relative density (Rd) of grasses, sedges and broad leaved weeds were calculated using the formula suggested by Philips (1959).

$$Rd = \frac{\text{Absolute density of a species}}{\text{Total absolute density of all species}} \times 100$$

3.4.1.4 Absolute frequency (Af)

Absolute frequency was calculated using the formula suggested by Philips (1959).

$$Af = \frac{\text{Number of quadrats in which a given species occur}}{\text{The total number of quadrat used}} \times 100$$

3.4.1.5 Relative frequency (Rf)

Relative frequency was calculated by using formula suggested by Philips (1959).

$$Rf = \frac{\text{Absolute frequency for a species}}{\text{Total number of the absolute frequencies for all species}} \times 100$$

3.4.1.6 Summed dominance ratio (SDR)

SDR was computed using the following equation by Sen (1981).

$$SDR = \frac{\text{Relative density} + \text{Relative frequency}}{2}$$

3.4.1.7 Weed drymatter

After counting weed density, weed sample from any one of the quadrat was taken, grouped into grasses, sedges, broad leaved weeds, dried and weighed, weed drymatter was expressed category wise in g m^{-2}.

3.4.1.8 Weed control efficiency

Weed control efficiency was calculated by adopting the formula suggested by Mani *et al.* (1973).

$$WCE = \frac{WDWC - WDWT}{WDWC} \times 100$$

where,

WCE = Weed control efficiency

WDWC = Weed dry weight in unweeded (control) plot

WDWT = Weed dry weight in treated plot

3.4.2 Observations on the crop

Five plants were selected at random from the net plot area of each plot and tagged. The following observations were recorded from these sample plants and the mean values worked out.

3.4.2.1 Growth characters

3.4.2.1.1 Plant height

The height of the plant was recorded at 60 days after transplanting. The height was measured from the ground level to the growing tip and expressed in cm.

3.4.2.1.2 Number of branches per plant

The total number of branches of each sample plant were counted at the maximum growth stage and then the average was worked out.

3.4.2.1.3 Number of leaves per plant

Number of leaves of each sample plant was counted at the 50 per cent flowering stage and the mean numbers of leaves per plant $^{-1}$ worked out.

3.4.2.2 Yield attributing characters

3.4.2.2.1 Number of flowers per plant

Number of flowers produced in the observational plants were counted and the mean value was worked out.

3.4.2.2.2 Number of fruits per plant

Number of fruits per plant was counted and mean value worked out.

3.4.2.2.3 Days to 50 per cent flowering

Number of days taken by 50 per cent of the plants for the emergence of flowers, in each treatment was noted and recorded.

3.4.2.2.4 Per cent fruit set

Based on the total number of fruits harvested per plot and the total number of flowers produced per plot, the percentage fruit set was worked out.

$$\text{Per cent fruit set} = \frac{\text{Total number of fruits}}{\text{Total number of flowers}} \times 100$$

3.4.2.2.5 Fruit yield per ha

The weight of fruits from the net plot were recorded from each harvest, the total was worked out and expressed in t ha^{-1}.

3.4.2.2.6 Harvest index

The harvest index was worked out from the data on total drymatter production and fruit yield as follows

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Fruit yield}}{\text{Total dry matter production}}$$

3.4.2.3 Weed index

Weed index (WI) was calculated using the formula suggested by Gill and Vijayakumar (1969).

$$WI = \frac{X - Y}{X} \times 100 \quad \text{where}$$

X = Yield from weed free plot or the treatment which recorded the minimum number of weeds.

Y = Yield from the plot for which weed index is to be worked out.

3.4.2.4 Shelf life under ambient condition

Sample fruits were taken treatmentwise and kept in polythene cover with good aeration and the days upto which quality was maintained without any deterioration i.e. change of colour, shrinkage, microbial growth etc was recorded.

3.4.2.5 Seed viability

Fifty seeds of brinjal from each experimental plot were sown in petridishes lined with germination paper moistened with distilled water. Germination count was noted on 8^{th} and 10^{th} days and expressed in percentage.

3.5 Chemical analysis

3.5.1 Plant analysis

The crop and weed samples collected for dry matter studies were dried to constant weight in an electric hot air oven at 80 ± 5^0 C, ground into fine powder using wiley mill and used for chemical analysis.

3.5.1.1 Total nitrogen

Total nitrogen was estimated by modified microkjeldhal method (Jackson, 1967).

3.5.1.2 Total phosphorus

Total phosphorus content was estimated by vanado molybdo phosphate yellow colour method after extraction with triple acid (9: 4: 1 of HNO_3, H_2SO_4 and $HCl\ O_4$ respectively). The intensity of yellow colour developed was read in a klett Summerson photoelectric colorimeter at 470 nm (Jackson, 1967).

3.5.1.3 Total potassium

The same extract used for phosphorus estimation was used for the estimation of total potassium using EEL flamephotometer method (Jackson, 1967).

3.5.2 Soil analysis

Soil analysis was done before and after the experiment. Initially a representative soil sample of the field obtained by mixing the soil samples collected from different parts of the field was used for the determination of available nitrogen, available phosphorus and available potassium of the experimental site. After the harvest of the crop soil samples were taken from the individual plots and analysed for the N,P,K status.

3.5.2.1 Available nitrogen

Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956).

3.5.2.2 Available phosphorus

Available $P_2 O_5$ was determined by Dickman and Bray's molybdenum blue method in a klett Summerson photoelectric colorimeter. The soil was extracted with Bray's reagent No. 1 (0.03 N ammonium fluride in 0.025 N hydrochloric acid) (Jackson, 1967).

3.5.2.3 Available potassium

Available K_2O was determined in the neutral normal ammonium acetate extract and estimated using EEL flame photometer (Jackson, 1967).

3.6 Uptake studies

The N,P and K uptake by the crop and the weeds were worked out as the product of content of these nutrients and the dry weight of crop or weeds and expressed in Kg ha^{-1}.

3.7 Herbicide persistence in the soil

The residual effect of the herbicides was studied by observing germination and early seedling growth of cucumber (*Cucumis sativas* L.), a sensitive indicator plant (Rao, 2000). Ten seeds of cucumber were sown in each soil samples collected from the herbicide treated plots and control plots immediately after the final harvest and germination percentage and growth response was observed.

3.8 Economics of cultivation

The economics of cultivation was worked out based on the cost of cultivation and prevailing price of the crop produce.

Net income (Rs ha^{-1}) = Gross income- total expenditure

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.9 Statistical analysis

The data generated from the experiment were subjected to analysis of variance technique (ANOVA) as applied to randomised block design described by Cochran and Cox (1965), after appropriate transformation wherever needed. Important correlation coefficients were estimated and tested for their significance (Snedecor and Cochran, 1967).

RESULTS

4. RESULTS

A field experiment was conducted at College of Agriculture, Vellayani to assess the yield loss in brinjal due to weed interference and to workout an efficient and economic weed management practice for the crop. The data recorded were analysed statistically and the results are presented in this chapter.

4.1 Observation on weeds

4.1.1 Weed flora

The weed species that were prevalent in the experimental field before and during the experiment were collected, identified and grouped into grasses, sedges and broad leaved weeds. The important species observed are presented in Table 3.

4.1.2 Absolute density

4.1.2.1 Absolute density of grasses

Data on absolute density of grasses at various stages (15, 30, 60 and 105 DAT) are presented in Table 4.

The data indicated that the weed management practices had significant influence on the absolute density of grassy weeds infesting the crop at various stages.

When observed at 15 DAT (just before first manual weeding) highest density (29 number m^{-2}) was recorded by T_3 (2 manual weeding) followed by T_1 (weedy check) and all the other treatments had significantly lower count.

Table 3 Major weed flora of the experimental field

Scientific name	Common name	vernacular name	Family
Grasses			
Dactyloctenium aegyptium	Crowfoot grass	Kakka kalan	Poaceae
Digitaria sanguinalis	Large crab grass		Poaceae
Eleusine indica	Goose grass	Muthanga pullu	Poaceae
Digitaria ciliaris	Crab grass		Poaceae
Broad leaved weeds			
Spermacoce latifolia		Tharavu	Rubiaceae
Trianthema portulacastrum	Horse purslane	Vella Thazhuthama	Aizoaceae
Cleome viscosa		Kattu kaduku	Capparidaceae
Amaranthus viridis	Slender amaranthus	Kuppa cheera	Amaranthaceae
Phyllanthus niruri	Niruri	Keezhar nelli	Euphorbiaceae
Acanthospermum hispidum	Bristly starbue	Kattunjerinjil	Asteraceae
Euphorbia hirta	Spurge		Euphorbiaceae
Borreria hispida		Tharakala	Rubiaceae
Gynandropsis pentaphylla	Caravelle seed		Capparidaceae
Eclipta prostrata	False daisy	Kayyoonni	Asteraceae
Sedges			
Cyperus rotundus	Purple nutsedge	Muthanga	Cyperaceae

Table 4 Effect of weed management practices on the absolute density of grasses (Number m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	27.33	31.00	25.67	25.67
T_2	-	-	-	-
T_3	29.00	10.00	8.00	9.33
T_4	16.33	11.00	16.33	13.33
T_5	15.33	9.67	17.33	14.33
T_6	11.00	15.00	18.33	16.00
T_7	3.33	4.00	0	0
T_8	4.67	5.33	6.33	5.00
T_9	5.33	4.33	5.67	3.67
T_{10}	3.43	5.67	6.33	5.00
T_{11}	20.33	25.33	20.33	16.33
T_{12}	17.67	20.00	19.67	10.67
T_{13}	26.33	6.67	16.00	13.67
T_{14}	19.00	16.33	19.00	18.33
F	63.14**	124.95**	50.75**	68.79**
CD (0.05)	3.82	2.23	3.11	2.47

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

There was practically no weed kept in the weed free check (T_2) so that the absolute density was considered zero for this treatment. Excluding T_2 (weed free check), T_7 (Black polythene mulch) recorded the lowest absolute density (3.33 number m^{-2}) of grasses and was on par with T_8, T_9 and T_{10}.

Throughout the crop growth absolute density of grasses remained high in the unweeded control (T_1) but under T_3 (2 manual weeding) the absolute density decreased considerably at 30, 60 and 105 DAT. Excluding weed free check (T_2), the absolute density was the lowest in T_7 on 30 DAT and at later stages the density was zero. Fluchloralin + one manual weeding (T_9) had the absolute density next to T_2 and T_7 treatments at 30, 60 and 105 DAT and that in turn was on par with T_8 and T_{10}. Though significantly lower than that in weedy check (T_1) grassy weed growth in T_{11}, T_{12}, T_{14}, T_5, T_6 and T_4 was substantial throughout the crop growth.

4.1.2.2 Absolute density of broad leaved weeds

Data on absolute density of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 5.

The data indicated that weed management practices had significant influence on the absolute density of the broad leaved weeds at all stages.

When observed at 15 DAT broad leaved weeds were maximum (41.67 number m^{-2}) in weedy check (T_1) followed by T_{11} (35.00 number m^{-2}). Black polythene mulch (T_7) had the least number of broad leaved weeds (2.33 number m^{-2}) and was on par with the T_9 and T_{10}. When compared to unweeded control (T_1) all the treatments had significantly lower absolute density of broad leaved weeds.

Table 5 Effect of weed management practices on the absolute density of broad leaved weeds (Number m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	41.67	22.33	12.00	10.00
T_2	-	-	-	-
T_3	27.33	12.33	8.00	6.67
T_4	20.00	11.67	9.33	4.00
T_5	15.00	12.33	10.00	7.67
T_6	11.67	15.33	15.00	9.67
T_7	2.33	3.33	0	0
T_8	6.33	4.67	4.33	3.33
T_9	5.33	3.67	4.00	3.33
T_{10}	3.67	5.33	4.33	3.67
T_{11}	35.00	19.67	6.33	7.00
T_{12}	32.33	20.00	7.67	9.00
T_{13}	32.00	13.33	4.67	4.00
T_{14}	27.33	19.67	11.00	9.67
F	118.05**	38.94**	21.25**	15.66**
CD (0.05)	3.62	3.14	2.56	2.33

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

At 30 DAT, absolute density of broad leaved weeds under T_{11}, T_{12}, T_{14} were on par with the weedy check (T_1). Black polythene mulching (T_7) and treatments with fluchloralin (T_8, T_9 and T_{10}) restricted the emergence of broad leaved weeds.

At 60 DAT the absolute density of broad leaved weeds in T_6 (15.00 number m^{-2}) was next to weedy check (T_1) and that was followed by T_{14}. While black polythene mulch (T_7) had no broad leaved weeds at this stage. Among the other treatments T_9 had the lowest population (4.00 number m^{-2}) which was on par with the other fluchloralin treatments (T_8 and T_{10}).

At 105 DAT, T_{14}, T_{12} and T_6 were on par with weedy check (T_1) and the other treatments had significantly lower broad leaved weed population.

4.1.2.3 Absolute density of sedges

Data on absolute density of sedges at 15, 30, 60 and 105 DAT is given in Table 6.

When observed at 15 DAT, the absolute density of sedges in T_9 and T_8 were found significantly higher than that in weedy check while T_3, T_5 and T_{10} were on par with T_1. Polythene mulching (T_7) and treatments involving glyphosate (T_{11}, T_{12}, T_{13} and T_{14}) had substantially lower sedge population than in the other treatments.

The trend was more or less the same at 30 DAT also wherein T_8 recorded the highest density of 42 number m^{-2} followed by T_{10} and all three fluchloralin treatments (T_8, T_9 and T_{10}) had sedges significantly higher than in the weedy check (T_1). The glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) had lower sedges population and among them T_{13} had the least number. The treatments T_3, T_4, T_5, T_6 and T_{12} were on par with weedy check.

Table 6 Effect of weed management practices on the absolute density of sedges (Number m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	15.67	5.33	11.33	11.67
T_2	-	-	-	-
T_3	17.33	4.00	4.33	4.67
T_4	8.33	3.33	5.67	5.33
T_5	15.00	3.33	7.00	9.33
T_6	12.33	5.67	9.00	10.00
T_7	3.33	2.33	0	0
T_8	19.33	42.00	41.67	41.33
T_9	20.33	17.33	33.33	31.67
T_{10}	15.00	29.00	36.67	35.67
T_{11}	6.00	2.67	2.67	2.33
T_{12}	7.33	3.33	2.67	2.67
T_{13}	5.33	2.00	2.33	2.00
T_{14}	3.33	2.33	2.00	2.33
F	25.37**	165.62**	211.75**	191.26**
CD (0.05)	3.53	2.84	2.95	3.01

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

At 60 and 105 DAT, the sedge density was zero under polythene mulching (T_7) and under the other treatments, the trend remained more or less similar to that in the earlier stages.

4.1.3 Relative density (Rd)

4.1.3.1 Relative density of grasses

Data on relative density of grasses at 15, 30, 60 and 105 DAT are presented in Table 7.

Weed management practices had significant influence on the relative density of the grassy weeds at various stages of crop growth.

At 15 DAT, relative density of grasses was highest in T_{13} (39.43) which was on par with T_3, T_4, T_7 and T_{14}. The fluchloralin treatments (T_8, T_9 and T_{10}) in general had lower relative density (Rd) and all three were significantly more efficient than the other treatments in reducing relative density of grasses.

At 30 DAT glyphosate @ 1.5 kg a.i. ha^{-1} (T_{11}) alone registered the highest relative density (53.15) and was on par with the weedy check (T_1) and T_{12} and the others had significantly lower values. Fluchloralin treatments (T_8, T_9 and T_{10}) continued to record lower relative density of grasses. Under polythene mulching (T_7) the relative density of grasses was comparatively higher at 30 DAT.

At 60 DAT, the Rd of grasses was significantly higher in glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) than the other treatments, while at 105 DAT T_{11}, T_{13}, T_{14} registered similar response.

Table 7 Effect of weed management practices on the relative density of grasses

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	32.25	52.92	52.31	54.00
T_2	-	-	-	-
T_3	39.43	37.94	39.29	44.63
T_4	37.46	42.66	52.30	58.71
T_5	34.07	38.45	50.63	46.02
T_6	31.32	41.64	43.48	44.98
T_7	37.31	41.07	0	0
T_8	15.55	10.27	12.11	10.74
T_9	17.26	17.14	11.91	9.98
T_{10}	15.14	14.31	13.39	11.28
T_{11}	33.12	53.15	69.30	64.06
T_{12}	30.71	46.12	65.31	47.75
T_{13}	41.39	30.30	69.53	69.39
T_{14}	38.23	42.69	60.03	60.68
F	15.77**	32.97**	156.97**	129.81**
CD (0.05)	6.74	7.13	5.65	6.07

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

4.1.3.2 Relative density of broad leaved weeds

Data on relative density of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 8.

Relative density of broadleaved weeds was found significantly influenced by the weed management practices.

At 15 DAT, T_{11} (Glyphosate alone) recorded the maximum relative density of 57.01 which was on par with T_{12} and T_{14}. The fluchloralin treatments (T_8, T_9 and T_{10}) showed significant reduction in relative density of broad leaved weeds and were on par among themselves.

At 30 DAT, T_{13} registered the highest relative density (60.61) of broad leaved weeds. Treatments T_8, T_9 and T_{10} recorded lower values than others at this stage also.

When observed at 60 DAT, T_3 recorded the maximum relative density of 39.37 while T_{12} had the higher relative density of 40.31 at 105 DAT. At both stages T_7 had no broad leaved weed emergence. Fluchloralin treatments (T_8, T_9 and T_{10}) had significantly lower relative density of broad leaved weeds at these stages.

4.1.3.3 Relative density of sedges

Data on relative density of sedges at 15, 30, 60 and 105 DAT are presented in Table 9.

From the data it was evident that the fluchloralin treatments (T_8, T_9, T_{10}) recorded higher relative density of sedges throughout the crop period. On the other hand, the glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) had relative density significantly lower than most of the other treatments. Relative density of sedges in T_7 was high during 15 and 30 DAT but was zero at 60 and 105 DAT.

Table 8 Effect of weed management practices on the relative density of broad leaved weeds

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	49.21	38.00	24.52	20.99
T_2	-	-	-	-
T_3	37.05	46.82	39.37	32.22
T_4	45.88	44.52	29.50	17.80
T_5	33.23	48.39	29.09	24.19
T_6	33.36	42.48	35.41	27.10
T_7	25.74	34.34	0	0
T_8	20.88	8.59	8.27	7.12
T_9	17.04	14.76	8.57	9.08
T_{10}	16.66	13.34	9.17	8.23
T_{11}	57.01	41.26	21.66	26.91
T_{12}	56.02	46.15	25.79	40.31
T_{13}	50.20	60.61	20.31	20.44
T_{14}	55.09	51.27	34.67	31.67
F	57.41**	57.01**	35.40**	36.47**
CD (0.05)	5.78	6.13	5.99	5.65

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

Table 9 Effect of weed management practices on the relative density of sedges

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	18.54	9.07	23.16	24.79
T_2	-	-	-	-
T_3	23.51	15.24	21.33	23.15
T_4	19.16	12.81	18.19	23.48
T_5	32.68	13.16	20.26	29.91
T_6	33.43	15.88	21.10	27.92
T_7	36.94	24.58	0	0
T_8	63.50	80.77	79.61	88.80
T_9	65.69	68.10	70.71	86.34
T_{10}	68.20	72.34	77.44	80.49
T_{11}	9.86	5.58	9.04	9.03
T_{12}	12.74	7.72	8.89	11.94
T_{13}	8.40	9.09	10.15	10.18
T_{14}	5.67	6.04	6.34	7.74
F	126.96**	227.73**	132.64**	118.73**
CD (0.05)	5.78	5.36	7.13	8.39

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

4.1.4 Absolute frequency

Data on absolute frequency was not statistically analysed. Averages were worked out and presented in the table.

4.1.4.1 Absolute frequency of grasses

The data on absolute frequency at four stages of crop growth is given in Table 10.

The data indicated that in all treatments except in T_8, T_9, T_{10} and T_7 grassy weeds were present in all the sampling quadrats and showed 100 per cent absolute frequency.

In T_7 (black polythene mulching), at 15 and 30 DAT grassy weeds could be identified but recorded zero values thereafter.

4.1.4.2 Absolute frequency of broad leaved weeds

Data on absolute frequency of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 11.

The trend was similar to that under grasses.

4.1.4.3 Absolute frequency of sedges

The data on absolute frequency of sedges at 15, 30, 60 and 105 DAT are presented in Table 12.

The data on absolute frequency of sedges at 15, 30, 60 and 105 DAT showed that sedges were present in all the sampling units in weedy check (T_1) and fluchloralin treatments (T_8, T_9 and T_{10}) at all four stages, thus recorded

Table 10 Effect of weed management practices on the absolute frequency of grasses

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	100	100	100	100
T_2	-	-	-	-
T_3	100	100	100	100
T_4	100	100	100	100
T_5	100	100	100	100
T_6	100	100	100	100
T_7	66.67	66.67	-	-
T_8	66.67	66.67	66.67	66.67
T_9	66.67	66.67	55.55	33.33
T_{10}	66.67	66.67	66.67	66.67
T_{11}	100	100	100	100
T_{12}	100	100	100	100
T_{13}	100	100	100	100
T_{14}	100	100	100	100

DAT - Days after transplanting

Table 11 Effect of weed management practices on the absolute frequency of broad leaved weeds

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	100.00	100.00	100.00	100.00
T_2	-	-	-	-
T_3	100.00	100.00	100.00	100.00
T_4	100.00	100.00	100.00	100.00
T_5	100.00	100.00	100.00	100.00
T_6	100.00	100.00	100.00	100.00
T_7	66.67	66.67	-	-
T_8	66.67	66.67	66.67	66.67
T_9	66.67	66.67	66.67	66.67
T_{10}	66.67	66.67	66.67	66.67
T_{11}	100.00	100.00	100.00	100.00
T_{12}	100.00	100.00	100.00	100.00
T_{13}	100.00	100.00	100.00	100.00
T_{14}	100.00	100.00	100.00	100.00

DAT - Days after transplanting

Table 12 Effect of weed management practices on the absolute frequency of sedges

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	100.00	100.00	100	100.00
T_2	-	-	-	-
T_3	100.00	66.67	88.88	100.00
T_4	100.00	88.88	88.88	100.00
T_5	100.00	88.88	100.00	100.00
T_6	100.00	44.44	100.00	100.00
T_7	66.67	33.33	-	-
T_8	100.00	100.00	100.00	100.00
T_9	100.00	100.00	100.00	100.00
T_{10}	100.00	100.00	100.00	100.00
T_{11}	55.55	44.44	33.33	44.44
T_{12}	88.88	66.67	44.44	44.44
T_{13}	55.55	33.33	33.33	33.33
T_{14}	66.67	44.44	33.33	44.44

DAT - Days after transplanting

100 per cent absolute frequency. Glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) recorded lower absolute frequency throughout. Under black polythene mulch (T_7), there was no sedge growth at 60 and 105 DAT while T_3, T_4, T_5 and T_6 showed inconsistent response at different stages.

4.1.5 Relative frequency

4.1.5.1 Relative frequency of grasses

The data on relative frequency of grasses at 15, 30, 60 and 105 DAT is presented in Table 13.

At 15 DAT the lowest relative frequency of 28.57 was recorded by T_8, T_9 and T_{10}, while T_{13}, T_{11} and T_{14} registered relative frequency significantly higher than that of weedy check. The trend remained more or less same throughout the crop growth. When compared to weedy check, T_{12} was on par at 15 DAT but recorded significantly higher relative frequency at later stages.

Black polythene mulch (T_7) was comparable to weedy check (T_1) at 15 DAT, but was significantly lower at 30 DAT and recorded zero values at 60 and 105 DAT.

4.1.5.2 Relative frequency of broad leaved weeds

The data on relative frequency of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 14.

All the fluchloralin treatments (T_8, T_9 and T_{10}) recorded lower relative frequency of broad leaved weeds compared to others, whereas all the glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) gave relative frequency higher than the weedy check at all stages of crop growth.

Table 13 Effect of weed management practices on the relative frequency of grasses

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	33.33	33.33	33.33	33.33
T_2	-	-	-	-
T_3	33.33	37.50	34.72	33.33
T_4	33.33	34.72	34.72	33.33
T_5	33.33	41.07	33.33	33.33
T_6	33.33	28.57	33.33	33.33
T_7	33.33	28.57	-	-
T_8	28.57	28.57	28.57	28.57
T_9	28.57	28.57	30.16	16.66
T_{10}	28.57	28.57	28.57	28.57
T_{11}	39.28	41.07	42.85	41.07
T_{12}	34.72	37.50	41.07	41.07
T_{13}	39.28	50.00	50.00	50.00
T_{14}	37.50	41.07	42.85	41.07
F	20.42**	38.80**	55.63**	85.51**
CD (0.05)	2.34	2.91	2.61	2.61

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 14 Effect of weed management practices on the relative frequency of broad leaved weeds

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	33.33	33.33	33.33	33.33
T_2	-	-	-	-
T_3	33.33	37.50	34.72	33.33
T_4	33.33	34.72	34.72	33.33
T_5	33.33	34.72	33.33	33.33
T_6	33.33	41.07	33.33	33.33
T_7	33.33	40.00	-	-
T_8	28.57	28.57	28.57	28.57
T_9	28.57	28.57	30.16	33.33
T_{10}	28.57	28.57	28.57	28.57
T_{11}	39.28	41.07	42.85	41.07
T_{12}	34.72	37.50	41.07	41.07
T_{13}	39.28	50.00	50.00	50.00
T_{14}	37.50	41.07	42.85	41.07
F	20.42**	38.81**	55.63**	48.72**
CD (0.05)	2.34	2.91	2.61	2.61

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

The relative frequency of broad leaved weeds under T_7 was on par with weedy check (T_1) at 15 DAT, significantly higher at 30 DAT, zero at later stages.

4.1.5.3 Relative frequency of sedges

The data on relative frequency of sedges at 15, 30, 60 and 105 DAT are presented in the Table 15.

Relative frequency of sedges at four different stages indicated that all the fluchloralin treatments (T_8, T_9 and T_{10}) recorded significantly higher relative frequency than that of the weedy check (T_1) throughout the crop growth period while glyphosate treatments (T_{11}, T_{13} and T_{14}) had a reverse response.

4.1.6 Summed dominance ratio (SDR)

4.1.6.1 SDR of grasses

The data on SDR of grasses at 15, 30, 60 and 105 DAT are presented in Table 16.

SDR of grasses at all stages was significantly influenced by various weed management practices.

SDR of grasses in the fluchloralin treatments (T_8, T_9 and T_{10}) was significantly lower than that of weedy check at all stages while other treatments showed variation in response at different stages. Glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) had comparatively higher SDR at all stages. AT 15, 60 and 105 DAT, maximum SDR was recorded by T_{13} while at 30 DAT, T_{11} had the highest SDR.

Table 15 Effect of weed management practices on the relative frequency of sedges

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	33.33	33.33	33.33	33.33
T_2	-	-	-	-
T_3	33.33	24.99	30.55	33.33
T_4	33.33	30.55	30.55	33.33
T_5	33.33	30.55	33.33	33.33
T_6	33.33	17.85	33.33	33.33
T_7	33.33	20.00	-	-
T_8	42.86	42.86	42.85	42.86
T_9	42.86	42.86	45.23	50.00
T_{10}	42.86	42.86	42.86	42.86
T_{11}	21.42	17.85	14.28	17.85
T_{12}	30.55	24.99	17.85	17.85
T_{13}	21.42	14.28	14.28	14.28
T_{14}	24.99	17.85	14.28	17.85
F	20.41**	26.78**	43.82**	41.86**
CD (0.05)	4.68	5.83	5.14	5.24

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 16 Effect of weed management practices on the summed dominance ratio of grasses

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	32.79	43.13	42.82	43.77
T_2	-	-	-	-
T_3	36.38	37.72	37.00	38.98
T_4	35.41	37.99	43.51	46.02
T_5	33.70	36.59	41.98	39.68
T_6	32.32	41.35	38.41	39.15
T_7	35.33	40.54	-	-
T_8	22.06	19.42	20.34	19.66
T_9	22.92	22.86	21.04	13.33
T_{10}	21.86	21.44	20.98	19.92
T_{11}	36.21	46.99	56.08	52.57
T_{12}	32.72	40.81	53.19	44.41
T_{13}	40.34	40.15	59.77	59.69
T_{14}	37.87	41.88	51.44	50.88
F	26.85**	43.99**	147.19**	114.05**
CD (0.05)	3.45	3.94	3.34	3.93

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

4.1.6.2 SDR of broad leaved weeds

The data on SDR of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 17.

SDR of broad leaved weeds at various stages showed a trend similar to that of SDR of grasses. SDR of broad leaved weeds in fluchloralin treatments (T_8, T_9 and T_{10}) were lower throughout the crop growth. At 15 DAT, T_{11} recorded the highest SDR, while at 30 DAT T_{13} and at 60 and 105 DAT, T_{14} were found to record the highest SDR values. Compared to weedy check the summed dominance ratio of broad leaved weeds in T_7 was significantly lower at 15 DAT, on par at 30 DAT and zero at later stages.

4.1.6.3 SDR of sedges

The data on SDR of sedges at 15, 30, 60 and 105 DAT are presented in Table 18.

SDR of sedges at four different stages was also found significantly influenced by the weed management practices. When compared to weedy check, SDR of all fluchloralin treatments (T_8, T_9 and T_{10}) were significantly higher at all stages of crop growth, whereas treatments involving glyphosate (T_{11}, T_{12}, T_{13} and T_{14}) were found to have significantly lower SDR. Polythene mulch (T_7) recorded SDR significantly higher than that of weedy check at 15 DAT, was on par at 30 DAT and zero at 60 and 105 DAT.

4.1.7 Weed dry weight

4.1.7.1 Dry weight of grasses

The data on dry weight of grassy weeds at 15, 30, 60 and 105 DAT are presented in Table 19.

Table 17 Effect of weed management practices on the summed dominance ratio of broad leaved weeds

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	41.27	35.67	28.93	28.93
T_2	-	-	-	-
T_3	35.19	42.16	37.05	36.35
T_4	39.60	39.62	32.11	31.41
T_5	33.29	41.56	31.21	31.21
T_6	33.46	41.77	34.37	34.37
T_7	29.54	37.17	-	-
T_8	24.72	18.76	18.42	18.42
T_9	22.81	21.78	18.58	20.96
T_{10}	22.62	20.96	18.87	18.87
T_{11}	48.13	41.17	32.26	31.36
T_{12}	45.37	41.83	33.43	33.43
T_{13}	44.74	55.31	35.15	35.15
T_{14}	46.29	46.17	38.76	37.87
F	77.94**	76.34**	37.88**	49.53**
CD (0.05)	3.01	3.56	3.47	2.83

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 18 Effect of weed management practices on the summed dominance ratio of sedges

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	25.94	21.20	28.25	28.25
T_2	-	-	-	-
T_3	28.42	20.12	25.94	27.33
T_4	26.25	21.68	24.38	25.77
T_5	33.01	21.86	26.79	26.80
T_6	33.38	16.86	27.22	27.22
T_7	35.14	22.29	-	-
T_8	53.18	61.81	61.23	61.23
T_9	54.28	55.48	57.98	60.36
T_{10}	55.53	57.60	60.15	61.15
T_{11}	15.64	11.72	11.60	13.45
T_{12}	21.65	16.36	13.37	13.37
T_{13}	14.91	11.69	12.22	12.22
T_{14}	15.33	11.95	10.31	12.09
F	162.44**	179.45**	118.38**	149.29**
CD (0.05)	3.33	3.99	5.18	4.63

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 19 Effect of weed management practices on the dry weight of grasses ($g\ m^{-2}$)

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	3.00	17.47	156.73	146.80
T_2	-	-	-	-
T_3	2.77	2.40	26.53	26.73
T_4	1.67	6.57	76.73	68.43
T_5	1.37	6.73	79.17	69.63
T_6	1.17	10.87	129.30	118.07
T_7	0.17	0.33	0	0
T_8	0.53	0.63	5.40	5.90
T_9	0.53	0.23	4.63	4.37
T_{10}	0.40	0.53	5.47	5.33
T_{11}	2.00	12.77	169.40	163.83
T_{12}	1.43	8.57	101.20	101.77
T_{13}	2.03	1.87	75.97	73.47
T_{14}	1.73	8.80	98.87	96.70
F	146.23**	214.76**	647.59**	835.96**
CD (0.05)	0.21	1.11	6.81	5.69

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

From the data it was evident that dry weight accumulated by grassy weeds was maximum in weedy check at first two stages (3 g m^{-2} 15 DAT and 17.47 g m^{-2} at 30 DAT) while T_{11} recorded the highest dry weight of grassy weeds at later stages (169.40 g m^{-2} at 60 DAT and 163.83 g m^{-2} at 105 DAT).

When observed at 15 DAT (just before first manual weeding) T_3 recorded weed dry weight higher than that of any other weed management practice but at later stages it was lower.

Excluding weed free check, lowest dry weight was recorded in T_7 treatment at 15 and 30 DAT (0.17 and 0.33 g m^{-2} respectively) and there was no weed growth at 60 and 105 DAT. The fluchloralin treatments (T_8, T_9 and T_{10}) were also found very effective in minimising growth of grassy weeds.

4.1.7.2 Dry weight of broad leaved weeds

The data on dry weight of broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 20.

From the data it was evident that dry weight accumulated was found maximum in weedy check (T_1) at all stages of crop growth (5, 21.9, 59.87, 62.53g m^{-2} at 15, 30, 60 and 105 DAT respectively). All the weed management practices were found to reduce dry weight of broad leaved weeds significantly except in the case of T_3 at 15 DAT (wherein the observation was taken immediately before first manual weeding). Among the treatments excluding T_2, dry weight was minimum in T_7 (0.17 g m^{-2} and 0.2 g m^{-2} respectively at 15 and 30 DAT and zero at 60 and 105 DAT). Fluchloralin treatments (T_8, T_9 and T_{10}) were on par with T_7 at 15 and 30 DAT and at later stages also the

Table 20 Effect of weed management practices on the dry weight of broad leaved weeds (g m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	5.00	21.90	59.87	62.53
T_2	-	-	-	-
T_3	4.83	4.70	27.37	25.67
T_4	1.37	1.53	28.30	36.27
T_5	0.93	1.07	29.67	42.23
T_6	0.77	17.73	36.97	46.93
T_7	0.17	0.20	0	0
T_8	0.20	0.37	4.33	4.43
T_9	0.23	0.23	3.53	3.53
T_{10}	0.17	0.37	4.23	4.43
T_{11}	3.23	8.00	12.77	15.27
T_{12}	3.27	7.73	21.13	10.40
T_{13}	3.30	5.80	10.60	10.10
T_{14}	3.13	6.03	25.70	14.83
F	220.76**	200.93**	323.87**	367.57**
CD (0.05)	0.36	1.42	2.74	3.01

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

treatments were found effective in controlling broad leaved weeds. Stale seed bed + one manual weeding (T_5) was found to record low weed dry weight at early stages, but at later the weed dry matter was found to increase, though still significantly lower than that of weedy check.

4.1.7.3 Dry weight of sedges

The data on dry weight of sedges at 15, 30, 60 and 105 DAT are presented in Table 21.

In general, the glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) inhibited dry weight accumulation of sedges and at all stages, these plots recorded dry weight significantly lower than that in weedy check. Black polythene mulching (T_7) recorded dry weight of 0.23 and 0.33 g m^{-2} at 15 and 30 DAT respectively and had zero values at later stages. The fluchloralin treatments (T_8, T_9 and T_{10}) were found least effective in controlling sedges and recorded higher dry weight than weedy check (T_1). Under fluchloralin alone @ 1.5 kg a.i. ha^{-1} (T_8) dry matter accumulation of sedges was 25.73, 117.17 and 115.90 g m^{-2} at 30, 60 and 105 DAT. In T_6 dry weight of sedges was only 0.9 g m^{-2} at 15 DAT but increased to 7.83 g m^{-2} at 30 DAT, 6.93 g m^{-2} at 60 DAT and 7.83 g m^{-2} at 105 DAT.

4.1.7.4 Total dry weight of all types of weeds

The data on total dry weight of all types of weeds at 15, 30, 60 and 105 DAT are presented in Table 22.

The data on total dry weight of weeds at different stages revealed that among the treatments excluding T_2, polythene mulching (T_7) was the most

Table 21 Effect of weed management practices on the dry weight of sedges (g m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	3.03	9.20	8.83	9.13
T_2	-	-	-	-
T_3	2.60	0.10	5.00	3.57
T_4	0.89	0.89	6.07	6.03
T_5	1.90	0.97	6.60	7.10
T_6	0.90	7.83	6.93	7.83
T_7	0.23	0.33	0	0
T_8	4.23	25.73	117.17	115.90
T_9	4.30	8.27	31.57	31.47
T_{10}	3.70	10.77	51.17	50.57
T_{11}	0.60	5.57	4.70	2.93
T_{12}	0.43	4.77	3.03	3.40
T_{13}	0.30	2.23	1.33	1.50
T_{14}	0.27	4.40	2.27	2.80
F	271.07**	216.22**	5599.61**	5151.36**
CD (0.05)	0.28	1.35	1.28	1.33

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 22 Effect of weed management practices on the dry weight of all types of weeds (g m^{-2})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	11.03	48.57	225.43	218.47
T_2	-	-	-	-
T_3	10.20	8.10	58.90	55.97
T_4	3.93	9.00	111.10	110.73
T_5	4.20	8.77	115.53	116.63
T_6	2.83	35.90	173.20	172.83
T_7	0.57	0.90	0	0
T_8	5.00	26.00	126.90	126.13
T_9	5.07	8.73	39.73	39.37
T_{10}	4.27	11.67	60.87	60.33
T_{11}	6.57	26.33	186.87	182.63
T_{12}	5.13	21.06	125.37	115.57
T_{13}	5.63	9.89	87.90	85.07
T_{14}	5.13	19.23	126.83	114.33
F	213.59**	513.08**	567.98**	931.17**
CD (0.05)	0.55	1.72	7.63	5.82

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

effective practice for controlling weed dry matter accumulation. T_7 recorded total dry weight of 0.57 and 0.9 g m^{-2} at 15 and 30 DAT respectively and there was no weed emergence at later stages. Next to T_7, fluchloralin + one manual weeding (T_9) recorded lower weed dry weight throughout the growth period. Weedy check (T_1) accumulated weed dry matter significantly higher (11.03, 48.57, 225.43, 218.47 g m^{-2} at 15, 30, 60 and 105 DAT respectively) than in all other treatments. Manual weeding twice (T_3) was found effective in reducing weed dry matter except at 15 DAT.

Weed dry matter accumulation was found substantially reduced in T_4, T_5 and T_6 at 15 and 30 DAT, but at later stages, the effect was not maintained. Among the glyphosate treatments, T_{13} (Glyphosate + one manual weeding) accumulated significantly lower weed dry weight than others (T_{11}, T_{12} and T_{14}) at 30, 60 and 105 DAT.

4.1.8 Weed control efficiency (WCE)

4.1.8.1 Weed control efficiency for grasses

The data on weed control efficiency for grassy weeds at 15, 30, 60 and 105 DAT are presented in Table 23.

The results indicated that the weed control efficiency for grassy weeds was significantly influenced by the different weed management practices.

At all stages the WCE for T_1 (weedy check) was taken as zero and that for weed free check (T_2) was 100 per cent. Among the other treatments T_7 was found to record the highest weed control efficiency of 94.50 and 98.07 per cent at 15 and 30 DAT respectively and at later stages it did not allow the emergence of grassy weeds at all. At all stages, the fluchloralin treatments

Table 23 Weed control efficiency of different weed management practices for grasses (per cent)

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	0 (1)	0 (1)	0 (5)	0 (5)
T_2	100.00 (10.08)	100.00 (10.08)	100.00 (11.18)	100 (11.18)
T_3	7.69 (2.95)	86.13 (9.33)	82.99 (10.39)	81.77 (10.33)
T_4	44.24 (6.73)	61.91 (7.93)	50.72 (8.70)	53.32 (8.85)
T_5	54.73 (7.47)	60.89 (7.87)	49.09 (8.61)	52.47 (8.80)
T_6	61.24 (7.89)	37.21 (6.18)	16.22 (6.45)	19.43 (6.67)
T_7	94.50 (9.77)	98.07 (9.95)	100.00 (11.18)	100 (11.18)
T_8	82.91 (9.16)	96.35 (9.87)	96.55 (11.02)	92.91 (10.86)
T_9	82.07 (9.11)	98.64 (9. 98)	97.02 (11.05)	94.35 (10.92)
T_{10}	86.69 (9.36)	96.91 (9.89)	96.49 (11.02)	92.91 (10.86)
T_{11}	33.12 (5.84)	25.59 (5.16)	-9.18 (3.98)	-12.09 (3.59)
T_{12}	52.04 (7.28)	50.20 (7.16)	34.99 (7.75)	30.62 (7.46)
T_{13}	31.73 (5.72)	89.24 (9.50)	51.37 (8.74)	50.21 (8.67)
T_{14}	41.49 (6.52)	48.89 (7.06)	36.66 (7.85)	35.34 (7.77)
F	214.54**	240.74**	185.58**	298.26**
CD (0.05)	0.52	0.48	0.51	0.41

(Figures in paranthesis indicate transformed values)

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

(T_8, T_9 and T_{10}) recorded higher weed control efficiency than all the other treatments except T_7.

Under manual weeding (T_3), the WCE was significantly low (7.69 per cent) at 15 DAT, but at later stages the values were 86.13, 82.99 and 81.77 respectively.

The efficacy of glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) for controlling grasses was comparatively low at all stages except in the case of T_{13} at 30 DAT. The weed control efficiency of T_4 and T_5 ranged between 40 to 60 per cent over the growth period while T_6 which recorded 61.24 per cent efficiency at 15 DAT had a low weed control efficiency of 16.22 per cent at 60 DAT.

4.1.8.2 Weed control efficiency for broad leaved weeds

The data on weed control efficiency for broad leaved weeds at 15, 30, 60 and 105 DAT are presented in Table 24.

The glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) were found to have better efficiency for controlling broad leaved weeds at 30, 60 and 105 DAT. Under manual weeding (T_3) WCE was very low (3.26 per cent) at 15 DAT but improved at later stages. Fluchloralin treatments (T_8, T_9 and T_{10}) were found efficient in controlling broad leaved at all stages. Stale seed bed + smother crop (T_6) could control broad leaved weeds at 15 DAT but allowed weed emergence at later stages, while the weed control efficiency of T_4 and T_5 was better at 15 and 30 DAT.

4.1.8.3 Weed control efficiency of sedges

The data on weed control efficiency of sedges at 15, 30, 60 and 105 DAT are presented in Table 25.

Table 24 Weed control efficiency of different weed management practices for broadleaved weeds (per cent)

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	0 (1)	0 (1)	0 (1)	0 (1)
T_2	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
T_3	3.26 (2.06)	77.51 (8.86)	54.21 (7.43)	58.88 (7.74)
T_4	72.42 (8.57)	92.95 (9.69)	52.66 (7.33)	41.76 (6.54)
T_5	81.33 (9.07)	95.08 (9.80)	50.22 (7.15)	32.45 (5.78)
T_6	84.52 (9.25)	18.15 (4.38)	38.12 (6.25)	24.59 (5.06)
T_7	96.63 (9.88)	98.93 (9.99)	100.00 (10.05)	100.00 (10.05)
T_8	95.30 (9.81)	98.33 (9.97)	92.75 (9.68)	92.91 (9.69)
T_9	95.30 (9.81)	98.93 (9.99)	94.07 (9.75)	94.35 (9.76)
T_{10}	96.51 (9.87)	98.30 (9.97)	92.91 (9.69)	92.91 (9.69)
T_{11}	35.22 (6.02)	63.33 (8.02)	78.48 (8.92)	75.58 (8.75)
T_{12}	34.50 (5.96)	65.64 (8.16)	64.47 (8.09)	83.36 (9.18)
T_{13}	33.98 (5.91)	81.15 (9.06)	82.21 (9.12)	83.83 (9.21)
T_{14}	36.97 (6.16)	72.32 (8.56)	56.78 (7.60)	76.27 (8.79)
F	372.70**	1386.69**	940.67**	361.20**
CD (0.05)	0.45	0.20	0.22	0.39

(Figures in paranthesis indicate transformed values)

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

Table 25 Weed control efficiency of different weed management practices for sedges (per cent)

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	0 (7.07)	0 (15.81)	0 (3.11)	0 (3.18)
T_2	100.00 (12.25)	100.00 (18.71)	100.00 (3.15)	100.00 (3.20)
T_3	14.25 (8.02)	89.15 (18.42)	42.35 (3.13)	61.45 (3.19)
T_4	69.91 (10.95)	90.23 (18.45)	31.40 (3.12)	34.08 (3.19)
T_5	36.87 (9.32)	89.52 (18.43)	25.36 (3.12)	22.32 (3.18)
T_6	70.08 (10.96)	14.83 (16.27)	21.59 (3.12)	14.28 (3.18)
T_7	92.18 (11.92)	96.04 (18.60)	100.00 (3.15)	100.00 (3.20)
T_8	-39.91 (3.18)	-187.56 (7.90)	-1241.59 (1.77)	-1170.55 (2.52)
T_9	-42.55 (2.73)	10.10 (16.13)	-258.59 (3.02)	-244.47 (3.09)
T_{10}	-22.24 (5.27)	-17.05 (15.26)	-479.65 (2.91)	-454.03 (3.02)
T_{11}	80.08 (11.41)	39.37 (17.01)	46.87 (3.13)	68.01 (3.20)
T_{12}	85.91 (11.66)	48.17 (17.27)	65.78 (3.14)	62.78 (3.19)
T_{13}	90.16 (11.84)	75.71 (18.05)	84.98 (3.14)	83.74 (3.20)
T_{14}	91.50 (11.90)	52.15 (17.38)	74.47 (3.14)	69.46 (3.20)
F	314.81**	166.20**	51.63**	672.03**
CD (0.05)	0.55	0.63	0.51	0.02

(Figures in paranthesis indicate transformed values)

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

The results indicated that among all treatments T_7 was the best for controlling sedges recording 92.18 per cent and 96.04 per cent efficiency at 15 and 30 DAT respectively and 100 per cent at later stages. Next to T_7 treatments, T_{13} (glyphosate + one manual weeding) recorded good WCE for sedges throughout the growth period. Fluchloralin treatments (T_8, T_9 and T_{10}) recorded negative efficiency (except T_9 at 30 DAT) allowing emergence of more number of sedges than the weedy check.

4.1.8.4 Weed control efficiency for all the weeds (Total weed control efficiency)

The data on weed control efficiency for all the weeds at 15, 30, 60 and 105 DAT are presented in Table 26.

At all the stages, weed control efficiency for T_1 was taken as zero and that for weed free check (T_2) was 100 per cent. Among the other treatments T_7 recorded highest efficiency of 94.85 per cent and 98.14 per cent at 15 and 30 DAT respectively and the value was 100 per cent at later stages. Next to T_7, the weed control efficiency was higher with T_9 except at 15 DAT.

When observed at 15 DAT stale seed bed + smother crop (T_6) was found effective in controlling all types of weeds but the effect was not maintained, while T_4 and T_5 had the maximum efficiency at 30 DAT.

Manual weeding twice (T_3) registered good efficacy at 30, 60 and 105 DAT but allowed weed growth up to 15 DAT. The efficacy of glyphosate treatments (T_{11}, T_{12}, T_{13} and T_{14}) were comparatively low throughout the observations and the lowest was in T_{11}.

Table 26 Total weed control efficiency of different weed management practices (per cent)

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	0 (1)	0 (1)	0 (1)	0 (1)
T_2	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
T_3	7.54 (2.92)	83.31 (9.18)	73.82 (8.65)	74.37 (8.68)
T_4	64.43 (8.09)	81.44 (9.08)	50.56 (7.18)	49.31 (7.09)
T_5	61.97 (7.94)	81.89 (9.10)	48.54 (7.04)	46.49 (6.89)
T_6	74.25 (8.67)	26.07 (5.20)	22.73 (4.87)	20.87 (4.68)
T_7	94.85 (9.79)	98.14 (9.96)	100.00 (10.05)	100.00 (10.05)
T_8	54.65 (7.46)	46.46 (6.89)	43.53 (6.67)	42.33 (6.58)
T_9	54.07 (7.42)	82.00 (9.11)	81.98 (9.11)	81.98 (9.11)
T_{10}	61.33 (1.89)	76.03 (8.78)	72.37 (8.57)	72.37 (8.57)
T_{11}	40.50 (6.44)	45.62 (6.83)	16.87 (4.23)	16.37 (4.17)
T_{12}	53.37 (7.37)	56.55 (7.59)	47.08 (6.93)	47.08 (6.93)
T_{13}	48.88 (7.06)	79.63 (8.98)	61.03 (7.88)	61.03 (7.88)
T_{14}	53.31 (7.37)	60.36 (7.83)	47.64 (6.97)	47.64 (6.97)
F	567.15**	1279.45**	455.09**	1543.40**
CD (0.05)	0.30	0.19	0.33	0.18

(Figures in paranthesis indicate transformed values)

** Significant at 0.01 level
* Significant at 0.05 level
DAT Days after transplanting

4.2 Observation on the crop

4.2.1 Growth characters

4.2.1.1 Plant height

The data on plant height of brinjal recorded at 50 per cent flowering stage are presented in Table 27.

The data indicated that the plant height was significantly influenced by the weed management practices. Maximum height of 77.63 cm was recorded by T_{10} (Fluchloralin + smother crop) and it was on par with T_4, T_6 and T_9. The lowest plant height of 61.27 cm was recorded with weed free treatment (T_2) and it was on par with T_1 (weedy check).

4.2.1.2 Number of branches per plant

The data on the number of branches recorded at 50 per cent flowering stage are presented in Table 27.

The weed removal was found to have significant influence on the number of branches produced by the crop. The maximum number of branches per plant (7.93) was recorded by weed free (T_2) treatment which was comparable with T_3 and T_9. Minimum number of branches (3.00) was recorded with weedy check (T_1) and it was on par with T_{11} (Glyphosate alone). All the treatments were significantly superior to weedy check.

4.2.1.3 Number of leaves per plant

The number of leaves per plant recorded at 50 per cent flowering are presented in Table 27.

Table 27 Effect of weed management practices on growth parameters of plant

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant
T_1	66.40	3.00	25.55
T_2	61.27	7.93	75.50
T_3	69.30	7.10	72.04
T_4	76.30	6.17	51.59
T_5	68.10	6.30	51.83
T_6	73.57	6.47	49.50
T_7	62.67	6.27	66.00
T_8	70.73	6.60	48.33
T_9	72.47	6.87	65.00
T_{10}	77.63	6.07	72.54
T_{11}	65.78	3.37	29.60
T_{12}	66.73	4.23	45.81
T_{13}	69.12	5.77	61.00
T_{14}	69.06	4.97	59.17
F	4.45**	9.22**	47.79**
CD (0.05)	6.46	1.36	6.37

** Significant at 0.01 level
* Significant at 0.05 level

Number of leaves per plant was found significantly influenced by the weed management practices. The maximum number of leaves (75.50) was recorded by the weed free treatment (T_2) and it was on par with T_3 (2 manual weeding) and T_{10} (Fluchloralin + smother crop). Weedy check (T_1) recorded the lowest number of leaves (25) and this was in turn on par with T_{11}. All the treatments except T_{11} were significantly superior to the weedy check (T_1).

4.2.2 Yield attributing characters and yield

4.2.2.1 Number of flowers per plant

Data on number of flowers per plant is presented in Table 28.

The result indicated that weed management practices could significantly influenced the number of flowers per plant. The weed free treatment (T_2) had the maximum number of flowers (15) per plant and was on par with T_9 (Fluchloralin + one manual weeding). Treatment T_{11} recorded the minimum number of flower (7.33) and was on par with T_1, T_6, T_8 and T_{12}.

4.2.2.2 Number of fruits per plant

The data on number of fruits per plant presented in Table 28 revealed that the weed management practices exerted significant influence on this yield attribute.

The highest number of fruits per plant (12.00) was recorded by T_2 (weed free check) and was significantly superior to all the other treatments. Fluchloralin + one manual weeding (T_9) was the best among the others followed by T_7. Weedy check (T_1) had the lowest number of fruits per plant (2.67) and was comparable with T_{11}.

4.2.2.3 Days to 50 per cent flowering

Data on days to 50 per cent flowering is presented in Table 28.

The number of days taken to 50 per cent flowering was not influenced by the weed management practices.

4.2.2.4 Per cent fruit set

Data on per cent fruit set is presented in Table 28

Per cent fruit set in brinjal was significantly influenced by the weed management practices. Fruit set per cent was maximum (79.94 per cent) in weed free (T_2) treatment closely followed by T_7 (78.91 per cent) and T_9 (78.61 per cent). Lowest setting percentage of 35.41 per cent was recorded in the unweeded control (T_1) and it was significantly inferior to all other treatments.

4.2.2.5 Crop yield per hectare

Data on the crop yield per hectare is presented in Table 28.

The effect of weed management practices on fruit yield per hectare was in line with the effect on number of fruits per plant. The highest fruit yield of 27.25 t ha^{-1} was recorded under weed free situation (T_2) while there was drastic yield reduction in unweeded control (11.29 t ha^{-1}). Black polythene mulch (T_7) and T_9 (Fluchloralin + one manual weeding) yielded 24.66 and 24.37 t ha^{-1} respectively and were on par among themselves. When compared to the unweeded check (T_1), all the weed management practices were significantly better.

Table 28 Effect of weed management practices on the yield attributing characters and yield of brinjal

Treatments	Number of flowers per plant	Number of fruit per plant	Days to 50 per cent flowering	Per cent fruit set	Yield (t ha^{-1})	Harvest index
T_1	8.00	2.67	56.67	35.41	11.29	0.28
T_2	15.00	12.00	53.00	79.94	27.25	0.43
T_3	11.66	8.00	57.67	68.63	21.60	0.38
T_4	10.66	7.00	58.67	65.65	20.11	0.36
T_5	9.33	5.70	58.67	61.11	19.02	0.35
T_6	7.66	4.50	59.67	58.57	18.00	0.31
T_7	13.33	9.33	55.67	78.91	24.66	0.41
T_8	8.33	4.90	58.66	58.68	18.03	0.32
T_9	13.66	10.67	57.66	78.61	24.37	0.40
T_{10}	11.00	8.00	58.00	72.57	22.45	0.39
T_{11}	7.33	3.33	58.33	47.55	15.54	0.30
T_{12}	8.66	4.33	58.00	52.77	18.50	0.33
T_{13}	11.00	7.37	59.33	66.95	21.31	0.37
T_{14}	9.33	5.77	57.33	61.85	19.52	0.35
F	19.01**	64.46**	1.83	128.19**	38.57**	123.58**
CD (0.05)	1.60	0.99	-	3.24	1.88	0.01

** Significant at 0.01 level
* Significant at 0.05 level

4.2.2.6 Harvest index

Data on harvest index are presented in Table 28.

Between treatments, significant variation in harvest index was recorded. Highest harvest index was under weed free situation (0.43) while the index was the lowest in weedy check (0.28). Under black polythene mulching (T_7) treatment, the harvest index was 0.41 while T_9 recorded 0.40.

4.2.3 Weed index

The data on weed index are presented in Table 29.

Weed free check was taken as the base for calculating weed index. The result indicated that yield loss due to the weeds was significant when the crop was left unweeded (T_1). Highest weed index of 58.43 was recorded in weedy check while T_7 had the minimum index (9.58) followed by T_9 (14.07). The T_{11} recorded high weed index of 42.64, next to the weedy check. The weed index recorded by T_{10} ant T_3 were also lower being 17.57 and 20.83 respectively.

4.2.4 Shelf life of fruits under ambient condition

Data on shelf life of fruits under ambient condition are presented in Table 30.

The result revealed no significant influence of treatments on the shelf life of the fruits under ambient conditions.

4.2.5 Seed viability

Data on seed viability are presented in Table 30.

The seed viability of brinjal was not influenced significantly by the weed management practices. Viability recorded was100 per cent under all the treatments.

Table 29 Effect of weed management practices on weed index (per cent)

Treatments	Weed index
T_1	58.43
T_2	-
T_3	20.83
T_4	26.05
T_5	30.32
T_6	33.87
T_7	9.58
T_8	33.79
T_9	14.07
T_{10}	17.57
T_{11}	42.64
T_{12}	31.88
T_{13}	21.73
T_{14}	28.20
F	44.04**
CD (0.05)	5.63

** Significant at 0.01 level
* Significant at 0.05 level

Table 30 Effect of weed management practices on seed viability and shelf life of brinjal fruit

Treatments	Shelf life (days)	Seed viability (per cent)
T_1	5.66	100
T_2	6.33	100
T_3	5.66	100
T_4	6.00	100
T_5	6.33	100
T_6	6.00	100
T_7	6.00	100
T_8	6.33	100
T_9	6.00	100
T_{10}	6.33	100
T_{11}	5.33	100
T_{12}	6.00	100
T_{13}	5.66	100
T_{14}	6.00	100
F	1.24	-
CD (0.05)	-	-

4.3 Chemical analysis

4.3.1 Nutrient uptake by weeds

4.3.1.1 Nitrogen uptake

Results obtaied at 15, 30, 60 and 105 DAT are presented in Table 31.

Nitrogen uptake by weeds was significantly influenced by different weed management practices at all stages of observation.

Throughout the growth period, uptake of nitrogen by weeds was highest in the weedy check (5.50, 8.23, 13.33, 13.17 kg ha^{-1} at 15, 30, 60 and 105 DAT respectively) followed by T_{11} treatment. Use of black polythene mulch (T_7) recorded the minimum nitrogen uptake of 0.50 and 1.03 kg ha^{-1} at 15 and 30 DAT respectively and at later stages since no weed growth was observed, the nitrogen uptake was zero. Next to T_7, T_9 recorded the lowest uptake of nitrogen at 30, 60 and 105 DAT. Between stages, there was increase in nitrogen uptake with advancing crop stage at 30 and 60 DAT in all treatments except T_3 and T_7. At 105 DAT the uptake was not consistent.

4.3.1.2 Phosphorus uptake by weeds

The data on phosphorus uptake by weeds at 15, 30, 60 and 105 DAT are presented in Table 32.

From the data it was evident that weed management practice had significant influence on the phosphorus uptake by weeds.

Throughout the growth period phosphorus removal was comparatively higher (2.3, 3.23, 4.13 and 4.17 kg ha^{-1} at 15, 30, 60 and 105 DAT respectively) in the unweeded (T_1) plots while T_7 registered the minimum

Table 31 Effect of weed management practices on nitrogen uptake by the weeds (kg ha^{-1})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	5.50	8.23	13.33	13.17
T_2	-	-	-	-
T_3	3.47	3.40	4.13	4.00
T_4	2.17	4.37	5.33	5.10
T_5	2.07	4.17	5.40	5.30
T_6	2.20	5.47	8.33	8.48
T_7	0.50	1.03	-	-
T_8	2.70	4.57	6.33	6.09
T_9	2.60	2.13	3.17	2.98
T_{10}	1.83	3.17	4.47	4.29
T_{11}	3.83	6.37	11.67	12.55
T_{12}	2.40	4.03	6.67	6.27
T_{13}	2.07	3.20	4.67	4.41
T_{14}	3.53	4.63	6.50	6.57
F	31.85**	69.87**	84.12**	127.57**
CD (0.05)	0.44	0.53	0.98	0.84

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 32 Effect of weed management practices on phosphorus uptake by the weeds (kg ha^{-1})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	2.30	3.23	4.13	4.17
T_2	-	-	-	-
T_3	2.17	0.90	1.30	1.20
T_4	0.83	1.17	1.87	1.77
T_5	0.67	1.03	1.07	1.07
T_6	1.67	2.37	3.23	3.07
T_7	0.06	0.17	-	-
T_8	0.70	1.50	2.17	2.03
T_9	0.60	0.53	0.83	0.87
T_{10}	0.57	0.93	1.50	1.33
T_{11}	1.90	2.83	3.67	3.77
T_{12}	1.33	1.97	2.40	2.23
T_{13}	1.23	0.90	1.60	1.43
T_{14}	0.83	1.33	2.60	2.40
F	52.02**	70.47**	95.03**	107.88**
CD (0.05)	0.28	0.31	0.32	0.30

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

uptake of 0.06 and0.17 kg ha^{-1} at 15 and 30 DAT respectively and at later stages, the uptake was zero. At 15 DAT, uptake by fluchloralin treatments (T_8, T9 and T_{10}) were on par among themselves but at later stages T_9 recorded phosphorus uptake significantly lower than all the other treatments except T_2 and T_7. Between stages, there was increase in phosphorus uptake with advancing crop stage at 30 and 60 DAT in all treatments except T_3 and T_7. At 105 DAT the uptake was not consistent.

4.3.1.3 Potassium uptake by weeds

The data on potassium uptake by weeds at 15, 30, 60 and 105 DAT are presented in Table 33.

All the weed management practices were found to reduce potassium uptake by weeds significantly over that under weedy check. However at 15 DAT, the uptake recorded by T_{11} (glyphosate @ 1.5 kg a.i. ha^{-1}) and T_6 (stale seeded + smother crop) were found comparable to that of weedy check (T_1). The uptake values under polythene mulching was negligible being 0.09 and 0.60 kg ha^{-1} at 15 and 30 DAT respectively and zero at later stages. When compared to other treatments there was reduction in potassium uptake by T_9, T_{10} ad T_{13}. Between stages, there was increase in potassium uptake with advancing crop stage at 30 and 60 DAT in all treatments except T_3 and T_7. At 105 DAT the response was not consistent.

4.3.2 Nutrient uptake by the crop

Results are presented in the Table 34.

Table 33 Effect of weed management practices on potassium uptake by the weeds (kg ha^{-1})

Treatments	15 DAT	30 DAT	60 DAT	105 DAT
T_1	4.26	7.33	9.30	9.23
T_2	-	-	-	-
T_3	3.27	1.20	2.10	2.00
T_4	1.93	2.80	3.87	3.57
T_5	1.77	3.37	4.03	4.00
T_6	3.86	5.27	6.77	6.60
T_7	0.09	0.60	-	-
T_8	2.63	4.47	5.20	5.10
T_9	1.23	1.03	1.83	1.83
T_{10}	1.53	1.17	2.27	2.43
T_{11}	3.97	6.27	7.43	7.47
T_{12}	3.17	4.37	5.03	4.93
T_{13}	1.90	1.80	3.30	2.97
T_{14}	2.83	3.53	5.00	4.90
F	27.32**	326.21**	322.13**	427.76**
CD (0.05)	0.67	0.35	0.38	0.32

** Significant at 0.01 level
* Significant at 0.05 level
DAT - Days after transplanting

Table 34 Effect of weed management practices on the nutrient (N, P, K) uptake by the crop (kg ha^{-1})

Treatments	N uptake	P uptake	K uptake
T_1	21.67	9.50	13.83
T_2	53.33	19.00	45.33
T_3	37.33	14.33	30.67
T_4	33.00	12.83	27.67
T_5	31.00	12.17	25.33
T_6	28.33	11.10	21.33
T_7	48.00	17.60	40.33
T_8	29.67	11.50	21.67
T_9	45.67	17.50	40.00
T_{10}	41.67	16.00	35.67
T_{11}	24.67	10.33	17.17
T_{12}	29.33	11.60	20.33
T_{13}	36.33	14.67	29.67
T_{14}	31.33	12.50	25.17
F	105.33**	45.55**	131..50**
CD (0.05)	2.60	1.27	2.38

** Significant at 0.01 level
* Significant at 0.05 level

The nitrogen, phosphorus and potassium uptake by the brinjal crop was found significantly influenced by the weed management practices. Highest nutrient uptake (53.33 kg nitrogen per hectare, 19.00 kg phosphorus per hectare, 45.33 kg potassium per hectare) was recorded with weed free treatment followed by T_7 and T_9. Weedy check (T_1) recorded the lowest uptake of 21.67 kg, 9.50 kg and 13.83 kg N, P and K per hectare respectively and that was significantly lower than all the other treatments.

4.3.3 Nutrient status of soil after the experiment

The data on nutrient status of the soil after the experiment are presented in Table 35.

The content of nitrogen, phosphorus and potassium in soil after the experiment was found significantly influenced by various weed management practices.

The nitrogen content of soil was the highest under T_7 (250.88 kg ha^{-1}) and was on par with the weed free check (T_2). The lowest nitrogen content of 176.67 kg ha^{-1} was estimated with T_{11} which in turn was comparable with T_1, T_6 and T_{12}.

The highest phosphorus of 47.33 kg ha^{-1} was estimated with T_7 which was comparable with weed free situation (T_2) while T_6 recorded the lowest phosphorus content of 29.67 kg ha^{-1}.

In the case of potassium, also content was highest under T_7 (130.67 kg ha^{-1}) and this was on par with T_2 and T_9 treatments. On the other hand the lowest potassium content of 120.67 kg ha^{-1} was registered in weedy check.

Table 35 Nutrient status of the soil after the experiment (kg ha^{-1})

Treatments	Nitrogen	Phoshorus	Potassium
T_1	186.28	30.66	120.67
T_2	240.72	42.33	128.67
T_3	196.28	32.33	125.66
T_4	195.00	31.67	125.00
T_5	195.67	30.33	123.00
T_6	188.33	29.67	122.67
T_7	250.88	47.33	130.67
T_8	195.04	32.33	124.66
T_9	220.67	40.00	128.67
T_{10}	223.38	35.67	124.33
T_{11}	176.67	31.00	121.33
T_{12}	178.34	33.33	122.33
T_{13}	196.28	32.66	124.00
T_{14}	207.37	31.67	123.33
F	16.90**	10.58**	3.08
CD (0.05)	15.83	5.19	3.70

** Significant at 0.01 level
* Significant at 0.05 level

4.4 Herbicide persistence in the soil

The persistence of the herbicide in the soil was studied by observing the germination and early growth response of a sensitive indicator plant cucumber (*Cucumis sativus* L.) grown in soil sample taken from the treated plot after the experiment. The results obtained are presented in the Table 36.

The data indicated that the germination and early growth characters like shoot length, root length, fresh weight and dry weight of the seedlings were not significantly influenced by the herbicide treatment.

4.5 Economics

Economics of brinjal cultivation are presented in Table 37.

The data revealed that among the treatments T_9 (Fluchloralin + 1 hand weeding) was the most remunerative practice followed by T_3 (2 manual weeding). The net income was the lowest under weed free treatment (T_2) although the gross return was the highest. Benefit cost ratio was also the highest (1.59) under T_9 treatment. Weedy check and weed free treatment recorded negative value for net income and both registered benefit cost ratio less than one.

4.6 Correlation studies

Simple correlations of weed and crop characters with crop yield were worked out and the results are presented in the Table 38 and 39.

The fruit yield of brinjal was found significantly and positively correlated with number of branches, number of leaves per plant, number of flowers per plant, number of fruits per plant, per cent fruit set, harvest index and nutrient (N, P, K) uptake by the crop.

Among the weed characters weed dry weight and nutrient (N, P, K) uptake by weeds at all stages recorded significant negative correlation with crop yield while weed control efficiency registered significant positive correlation with yield.

Table 36 Residual effect of herbicide application on germination and early growth of cucumber

Treatments	Germination percentage	Shoot length (cm)	Root length (cm)	Fresh weight mg/plant	Dry weight mg/plant
Untreated control	100.00	14.25	4.36	2906.67	150.00
Fluchloralin treatment	100.00	14.33	4.78	2906.67	150.33
Glyphosate alone	100.00	14.34	4.78	2913.33	150.50
Glyphosate + 2, 4-D sodium salt	100.00	14.29	4.76	2906.67	150.00
F	-	0.22	0.93	0.18	0.69
CD (0.05)	-	-	-	-	-

Table 37 Effect of weed management practices on economics of brinjal cultivation

Treatments	Normal cost of cultivation excluding weeding (Rs ha^{-1})	Expense for weeding (Rs ha^{-1})	Total expenses (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit cost ratio (BCR)
T_1	60500	0	60500	56436	-4063	0.93
T_2	60500	84000	144500	136225	-8275	0.94
T_3	60500	14000	74500	107976	33476	1.45
T_4	60500	9800	70300	100566	30266	1.43
T_5	60500	19600	80100	95535	15435	1.19
T_6	60500	15450	75950	90013	14063	1.18
T_7	60500	27500	88000	123305	35305	1.40
T_8	60500	8843	69343	90125	20782	1.34
T_9	60500	15843	76343	121833	45490	1.59
T_{10}	60500	11693	72193	112228	27848	1.39
T_{11}	60500	8720	69220	77715	8495	1.12
T_{12}	60500	8776	69276	92476	22200	1.33
T_{13}	60500	15720	76220	106563	30343	1.40
T_{14}	60500	11520	72020	97648	25628	1.36

Cost of fluchloralin	-	Rs. 530 l^{-1}
Cost of glyphosate	-	Rs. 480 l^{-1}
Cost of 2,4-D sodium salt	-	Rs. 120 kg^{-1}
Cost of black polythene mulch	-	Rs. 17 m^{-2}
Wage rate of ordinary labourer	-	Rs. 140 day^{-1}
Wage rate of skilled labourer (for spraying)	-	Rs. 145 day^{-1}
Rent of sprayer	-	Rs. 4 $hour^{-1}$
Cost of farmyard manure	-	Rs. 425 t^{-1}
Cost of urea	-	Rs. 4.25 kg^{-1}
Cost of mussoriephos	-	Rs. 5 ka^{-1}
Cost of muriate of potash	-	Rs. 3.5 kg^{-1}
Price per kg brinjal	-	Rs. 5 kg^{-1}

Table 38 Simple correlation coefficients of important crop characters with crop yield

Character	Crop yield
1. Plant height	-0.0562
2. Number of branches per plant	0.7001**
3. Number of leaves per plant	0.8705**
4. Number of flowers per plant	0.8553**
5. Number of fruits per plant	0.9139**
6. Per cent fruit set	0.9293**
7. Harvest index	0.9244**
8. Nitrogen uptake by plant	0.9288**
9. Phosphorus uptake by plant	0.8990**
10. Potassium uptake by plant	0.9229**

** Significant at 0.01 level
* Significant at 0.05 level

Table 39 Simple correlation coefficients of weed characters with crop yield

	Characters	Crop yield
1.	Dry weight of weeds at 15 DAT	-0.6166**
2.	Dry weight of weeds at 30 DAT	-0.8553**
3.	Dry weight of weeds at 60 DAT	-0.9192**
4.	Dry weight of weeds at 105 DAT	-0.9160**
5.	Weed control efficiency at 15 DAT	0.6246**
6.	Weed control efficiency at 30 DAT	0.8506**
7.	Weed control efficiency at 60 DAT	0.9240**
8.	Weed control efficiency at 105 DAT	0.9140**
9.	Nitrogen uptake by weed at 15 DAT	-0.6875**
10.	Nitrogen uptake by weed at 30 DAT	-0.8663**
11.	Nitrogen uptake by weed at 60 DAT	-0.8941**
12.	Nitrogen uptake by weed at 105 DAT	-0.8966**
13.	Phosphorus uptake by weed at 15 DAT	-0.7185**
14.	Phosphorus uptake by weed at 30 DAT	-0.8807**
15.	Phosphorus uptake by weed at 60 DAT	-0.8644**
16.	Phosphorus uptake by weed at 105 DAT	-0.8590**
17.	Potassium uptake by weed at 15 DAT	-0.7674**
18.	Potassium uptake by weed at 30 DAT	-0.9193**
19.	Potassium uptake by weed at 60 DAT	-0.9155**
20.	Potassium uptake by weed at 105 DAT	-0.9146**

** Significant at 0.01 level
* Significant at 0.05 level

DISCUSSION

5. DISCUSSION

A field experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani during August to November, 1999 on weed management in brinjal. The results of the experiment presented in the previous chapter are discussed hereunder with an approach to bring out the impact of weed competition on growth and yield of the crop and to assess the efficacy and economic feasibility of the weed management practices.

5.1 Observation on the weeds

5.1.1 Weed spectrum

The degree and nature of competition between crop and weeds is dependent on the weed species growing in association with the crop (Kim and Moody, 1980).

The results of the present study revealed that grasses, broad leaved weeds and sedges competed with the vegetable crop. Among the grassy weeds *Dactyloctenium aegyptium, Digitaria sanguinalis, Eleusine indica* and *Digitaria ciliaris* were the predominant ones while *Spermacoce latifolia, Cleome viscosa, Amaranthus viridis, Phyllanthus niruri, Acanthospermum hispidum, Euphorbia hirta, Borreria hispida, Gynandropsis pentaphylla, Eclipta prostrata* topped the list of broad-leaved weeds. *Cyperus rotundus* was the only sedge weed present in the field.

5.1.2 Effect of the weed management practices on growth of weed vegetation

In the present study, the distribution and growth pattern of the weed flora as affected by the weed management practices, were determined by working out the vegetation analysis parameters weed absolute density (Ad), relative density (Rd), absolute frequency (Af), relative frequency (Rf), summed dominance ratio (SDR) and weed control efficiency (WCE).

The data on weed density per unit area indicated that the weed population could be effectively checked by some of the treatments included in the study. It was evident that weeds failed to emerge under black polythene mulch (T_7) and under this treatment the few weeds recorded were those coming up from the planting hole. The effectiveness of mulches in reducing weed growth has been reported by earlier workers like Katan *et al* (1975) and Srivastava *et al.* (1981). Schonbeck (1998) reported that black polythene mulch blocked weeds effectively except for a few emerging through the planting hole. In the present experiment, there was no distinguishable weed growth even from the planting hole beyond 30 days, probably because of thorough weed removal for sampling, and the closing in crop canopy preventing further weed emergence. All three groups of weeds (grasses, broad-leaved weeds and sedges) were present in the weed samples taken and among them broad-leaved weed population was the least.

The fluchloralin treatments were found to show spectacular inhibitory effect on the emergence of broad-leaved weeds and grasses and the treatment recorded low weed count throughout the crop growth. The herbicide which was applied as pre-plant incorporation, alone (T_8) as well as when integrated with either smother crop (T_{10}) or one manual weeding (T_9), effectively

Fig. 3 Effect of weed management practices on the absolute density of grasses (Number m^{-2})

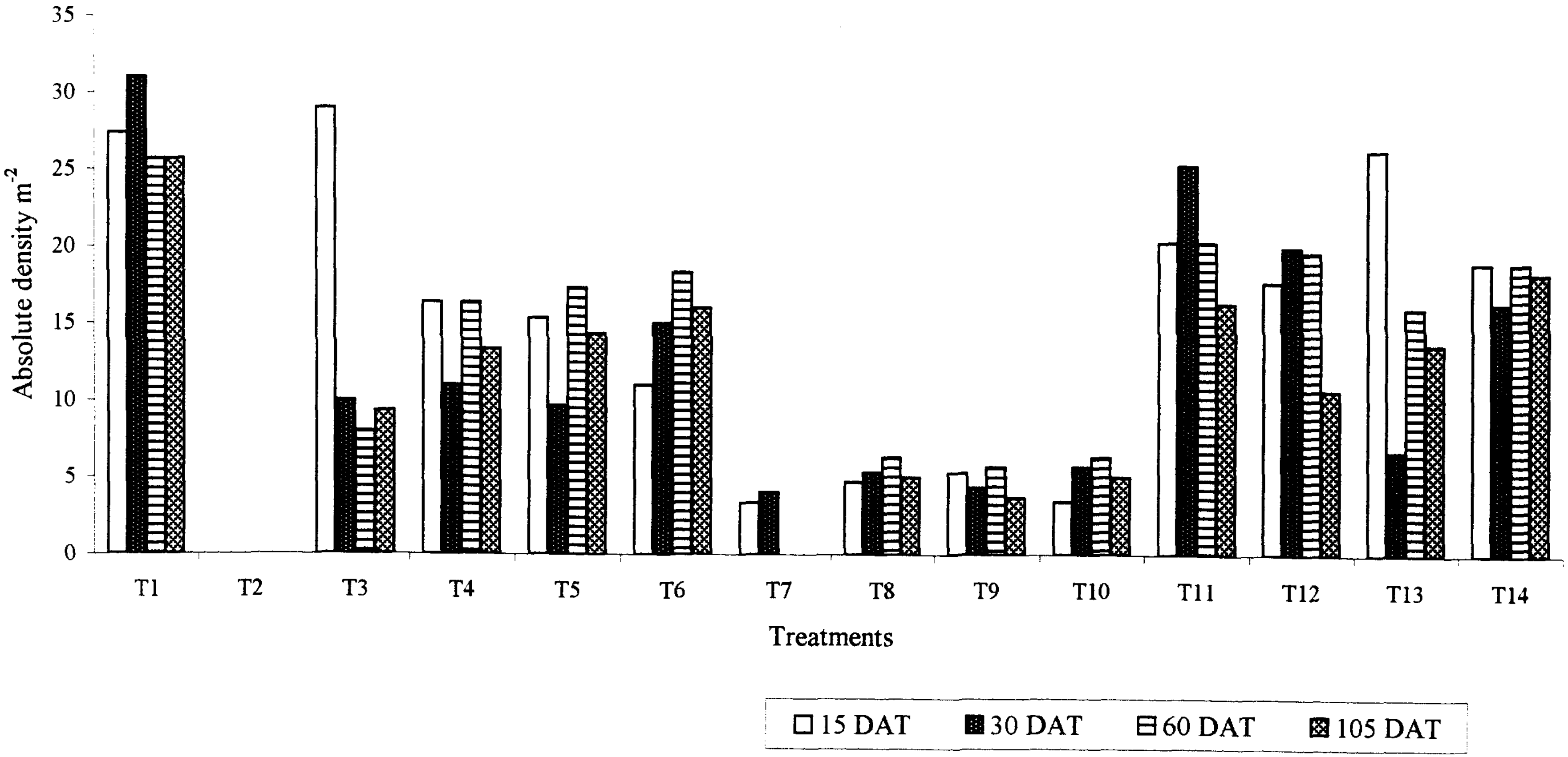


Fig. 4 Effect of weed management practices on the absolute density of broad leaved weeds (Number m^{-2})

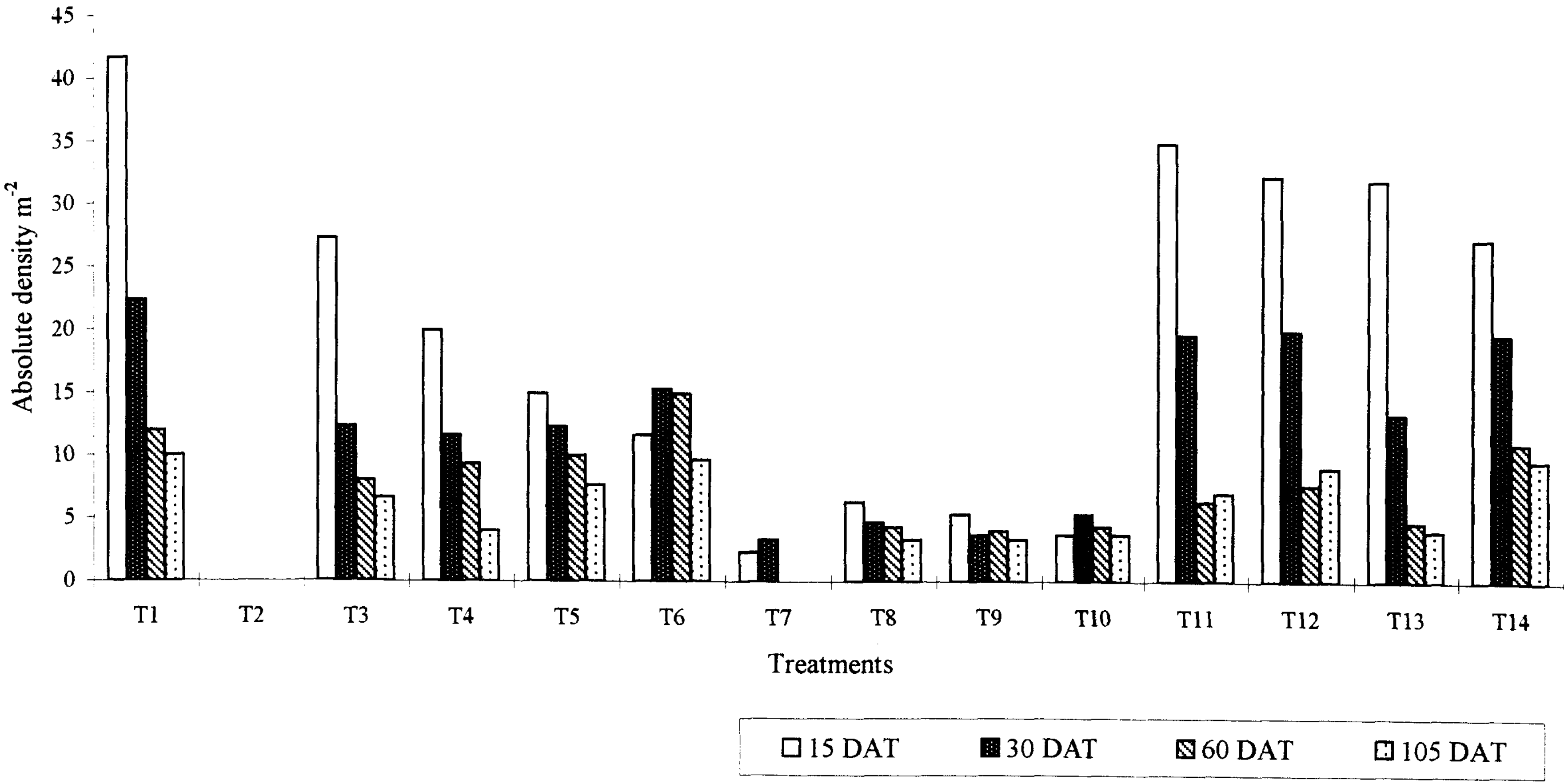
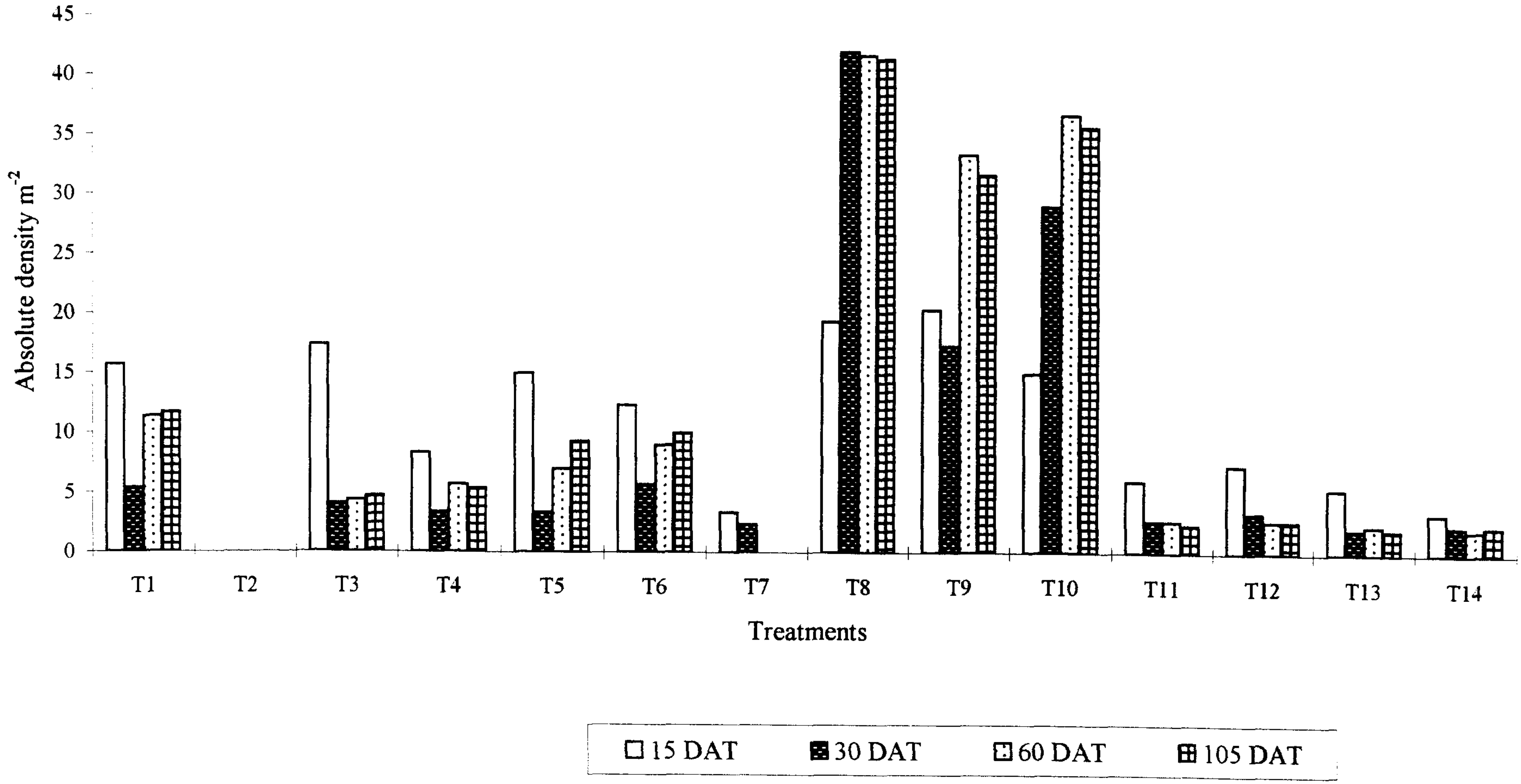


Fig. 5 Effect of weed management practices on the absolute density of sedges (Number m^{-2})



controlled the emergence of such weeds. These results are in line with the report of Kolar and Dhingra (1986) in mungbean, Leela (1993) in cabbage and cauliflower, Reddy and Rao (1999) in tomato. Anderson (1977) observed that fluchloralin is a mitotic poison which inhibit both root and shoot development of susceptible plants. They are root absorbed or absorbed by the shoots of seedlings as the shoot grow and push through the soil towards the soil surface. It was also evident that the weed control efficiency improved when the chemical was integrated with one manual weeding which implied that the persistence of the herbicide was short and for season long weed control, it has to be integrated with other control methods. This is in conformity with the report of Pannu *et al.* (1991).

However the vegetation analysis parameters showed that sedge growth under T_8, T_9 and T_{10} was even higher than that recorded under weedy check (T_1). Such enhanced growth was presumably because the spaces vacated by the broad-leaved weeds and grasses in these plots were occupied by the sedges. The practical implication of the above response is that, though fluchloralin is a safe and effective herbicide for the vegetable, it is not recommendable in areas where sedges predominate.

Application of glyphosate did show some control of all three types of weeds (grasses, broad leaved weeds and sedges) during the early crop growth stage (15 DAT) but the effect was considerably less in later stages. The variation was more marked at 60 and 105 DAT. However, when glyphosate treatment combined with 2,4-D sodium salt (T_{12}) as well as when integrated with either one manual weeding or smother crop (T_{14}) the weed control efficiency registered significant improvement over glyphosate alone. This is in conformity with the results of Mangoensoekarjo (1979) who reported higher weed control efficiency in plots that received mixtures of 1.5 kg glyphosate + 0.5 kg 2,4-D salts. Inder Dev *et al.* (1996) reported that the efficacy of glyphosate at 1.0 kg ha^{-1} was increased substantially when applied in combination with 2.4-D @ 1.0 kg ha^{-1} as compared to application of glyphosate alone. Addition of 2.4-D to glyphosate reduced the regeneration of weeds substantially.

Subramonium *et al.* (1993) has recommended the use of glyphosate as a post emergent herbicide in vegetables for clearing weeds before sowing and planting the crops. However in the present study there was considerable weed growth in the plots treated with the herbicides especially towards the later crop growth. Such response is primarily indicative of the potential weed seed bank in the experimental site. Glyphosate being a herbicide which is foliage active did not have any inhibitory effect on germination of the weed seeds in the soil and thus allowed subsequent weed flushes. It may also be mentioned that in the present study, at the time of the herbicide application the weeds infesting the experimental site were mostly in fruiting or drying up stage. The result emphasized the importance of considering the growth stage of the weeds for successful herbicide use.

However the herbicide registered substantial control over sedge population as evident from the relative density and summed dominance ratio for sedges. Glyphosate is easily translocated to underground organs and inhibits the aromatic aminoacid biosynthesis pathway resulting in death of tubers (Jawarski, 1972). Ameena (1999) reported that both glyphosate @ 1.5 kg a.i. per ha alone as well as glyphosate + 2, 4-D sodium salt were effective in

Plate 2 Unweeded control plot of brinjal (T_1)

Plate 3 Completely weed free plot of brinjal (T_2)

Plate 4 Polythene mulched brinjal plot (T_7)

Plate 5 Brinjal crop immediately after uprooting of smother crop cowpea (T_4)

Plate 6 Fluchloralin alone (T_8)

Plate 7 Fluchloralin + one manual weeding (T_9)

controlling tuber production in *Cyperus rotundus*. However, the decrease in weed control efficiency over the stages is indicative of the regeneration of the tubers as reported earlier by Liu and Twu (1993).

The overall efficacy of T_3 (two manual weeding at 15 and 30 DAT) was considerable during 30, 60 and 105 DAT. It is noteworthy that manual weeding allowed unchecked weed growth upto 15 DAT (the time of first weeding), thus causing considerable depletion of resources during the early crop growth. Gupta and Lamba (1978) observed that by manual weeding, weeds were removed after they have put forth considerable competition to crop and rarely at the ideal time, whereas herbicides provided the benefit of timely weed control.

Critical analysis of the data on weed vegetation parameters from T_4 (smother crop + one manual weeding), T_5 (Stale seed bed + one manual weeding) and T_6 (Stale seed bed + smother crop) indicated that these cultural methods controlled the weeds during the early stages but allowed considerable weed growth later. Smother crop + one manual weeding (T_4) registered better efficacy than stale seed bed + one manual weeding (T_5), and both treatments recorded significantly higher weed control efficiency than stale seed bed + smother crop (T_6). Such response implied that both smother cropping and stale seed bed technique need to be integrated with one manual weeding to remove weeds that emerged later. The SDR values indicated that grasses and broad-leaved weeds were dominant over sedges under these treatments.

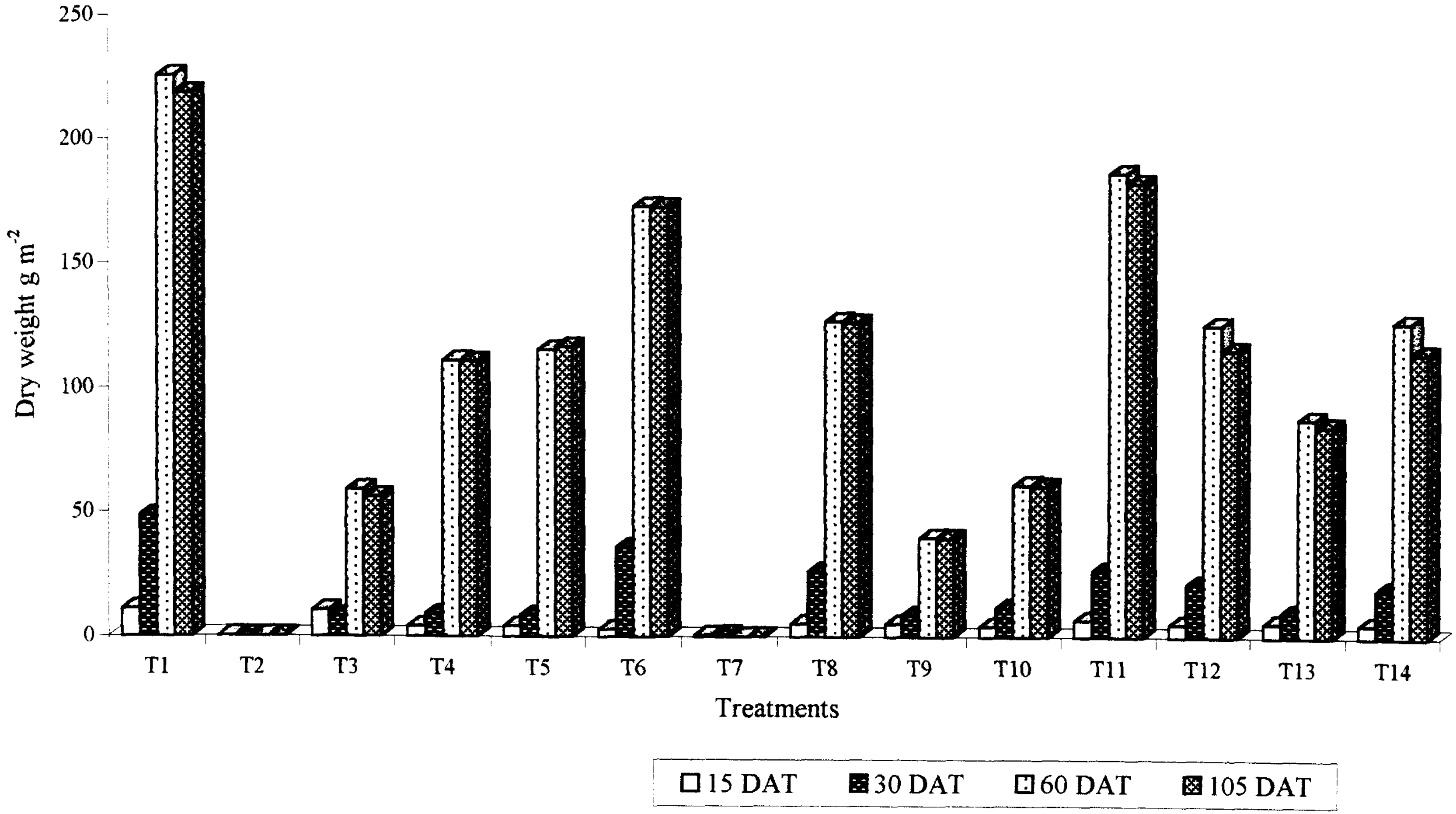
According to Gupta and Lamba (1978) the main advantage of stale seed bed was that crops germinated in a weed free environment and if selectively stimulated they might close in before subsequent flushes of weeds appeared in the land. In this case it was clear that the closing in of brinjal canopy was not sufficient to deter weed emergence. The prospect of stale seed bed technique in weed management was discussed and summarised by Rao (2000). He reported that stale seed beds could be highly effective in India, in controlling weed in rabi season but in kharif, the frequent showers might make stale seed beds too compact, leading to ultimate failure of the practice.

It was that the smother crop cowpea had suppressed weeds during the early crop growth as in accordance with the observations of Rao (2000). But once it was incorporated insitu at the maximum growth stage, weeds emerged in the inter-rows presumably since the closing in of the crop canopy was not complete by 25th day. Such response is also indicative of the immense weed seed inoculum that was present in the soil, allowing frequent flushes of weed growth. It also appeared that the extra benefit of enrichment of soil by the leguminous smother crop was made use of, by the aggressive weeds that emerged later, in these plots.

5.1.3 Weed dry matter production and nutrient uptake

The dry matter accumulated by the weed was maximum under weedycheck throughout the crop growth period. Unchecked weed growth exploited the available nutrients and water resulting in better growth and dry matter production. Similar observations have been made by Nandal and Pandita (1988) who reported that maximum dry weight of weeds was found in weedy check in brinjal. It was also evident that the dry matter accumulation increased drastically in weedy check with advancing crop age, while in other treatments the increase was at a slower rate. Use of black polythene mulch

Fig. 6 Effect of weed management practices on the total weed dry weight (g m^{-2})



recorded dry weight of 0.57 and 0.90 g m^{-2} at 15 and 30 DAT respectively and the value was zero in further observations. Ricketson and Thorpe (1983) observed that plastic mulches allowed early season weed growth but later the weed growth was confined and suppressed by the mulch.

The overall observation on the effect of weed management on weed drymatter accumulation at different stages of crop growth indicated that, next to black polythene mulching (T_7), fluchloralin + one manual weeding (T_9) was the best treatment for controlling dry matter accumulation by weeds throughout the growth period. In similar lines Bhalla and Parmar (1982) have reported that fluchloralin application followed by one hand weeding gave the lowest fresh and dry weight of weeds in vegetables.

Dry matter accumulation by weeds in hand weeded plots (T_3) recorded high value at 15 DAT, wherein the observation was taken just before first manual weeding, but at later stages, the weed dry weight was considerably lower than that in weedy check indicating the effectiveness of the method for controlling grasses, sedges and broad-leaved weeds, in accordance with the findings of Mishra *et al.* (1998) in French bean. The response of treatments T_5 (stale seed bed + one manual weeding), T_6 (stale seed bed + smother crop) and T_4 (smother crop + one manual weeding) in terms of weed dry weight reemphasized the need for integrating these cultural methods with manual weeding.

The nutrient uptake by the weeds is the product of dry matter production and nutrient content of weeds. In the present study the uptake of N, P and K was maximum under unweeded check and in comparison, the other treatments recorded significantly lower uptake values. Excluding weed free

Fig. 7 Effect of weed management practices on the nutrients uptake by the weeds at 60 days after transplanting (kg ha^{-1})

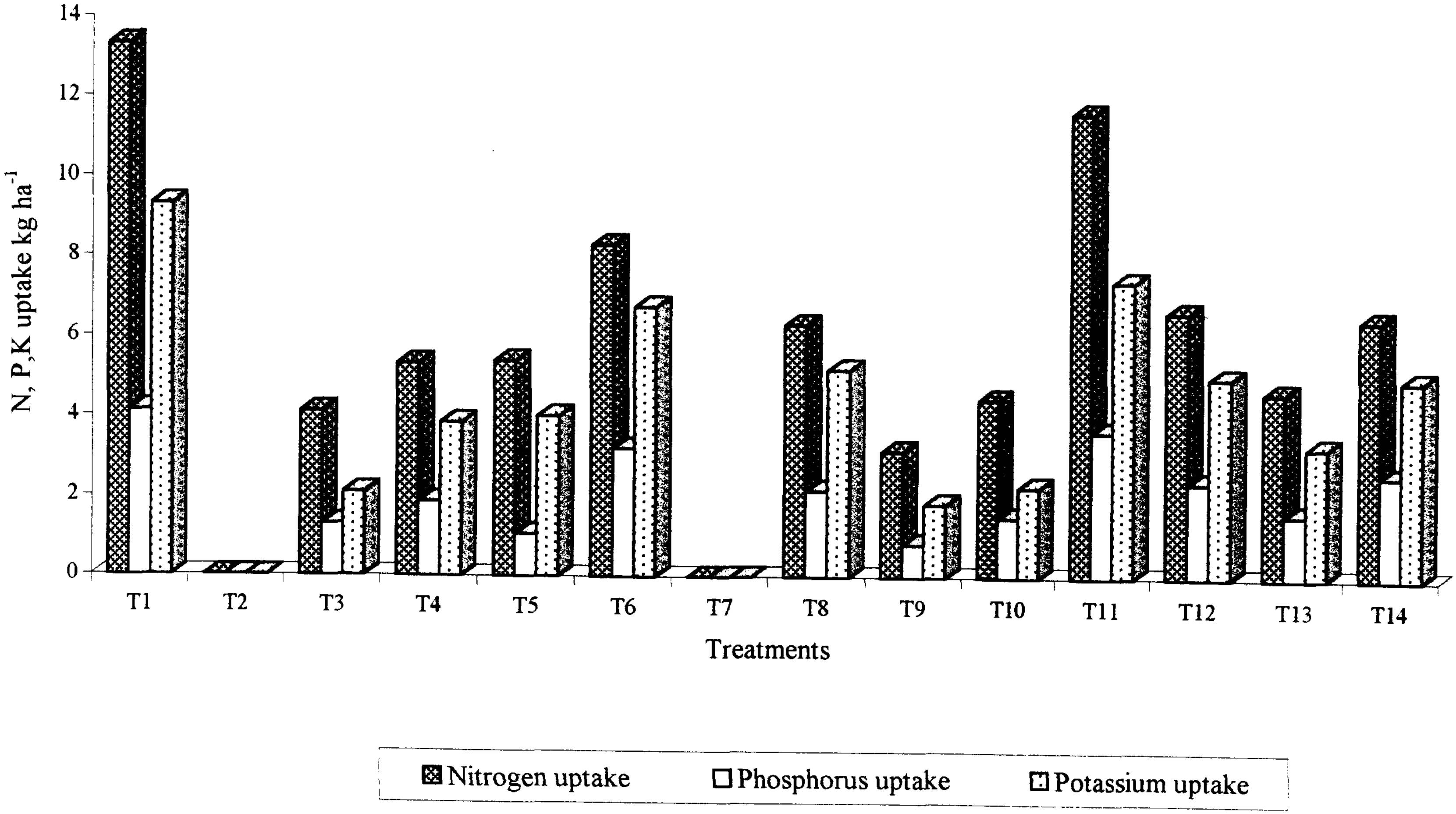


Fig. 8 Weed control efficiency of different weed management practices for grasses

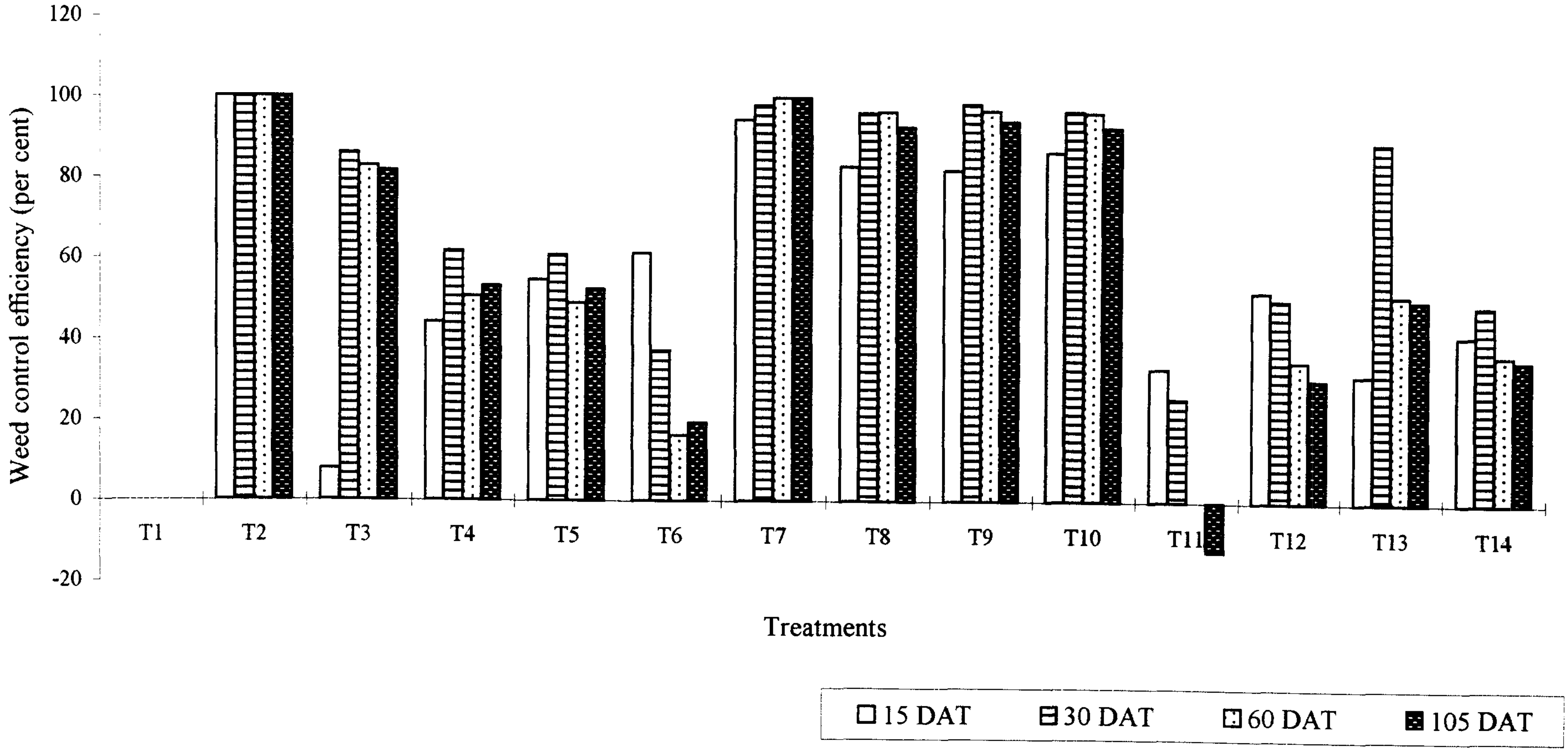


Fig. 9 Weed control efficiency of different weed management practices for broad leaved weeds

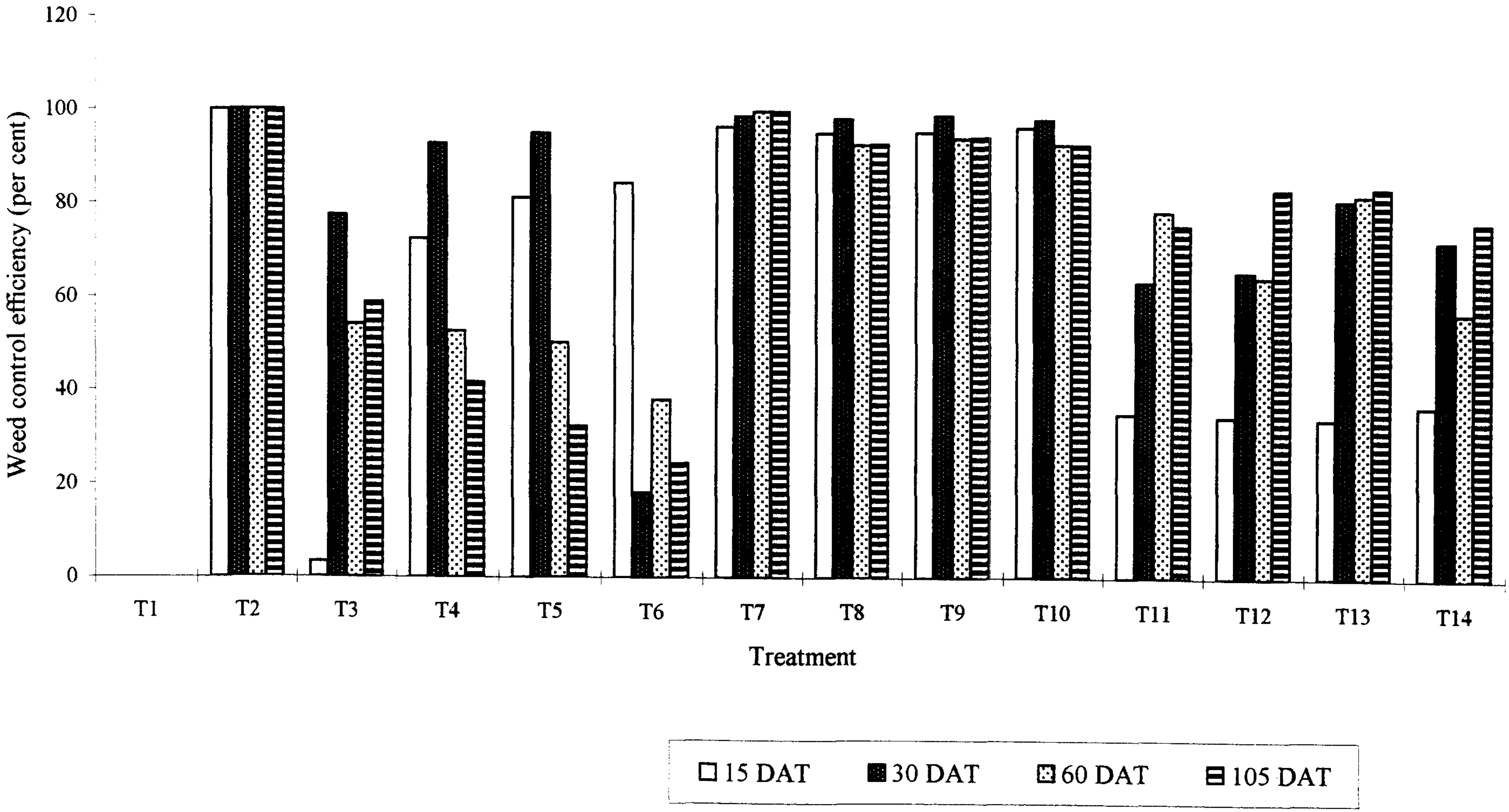


Fig. 10 Weed control efficiency of different weed management practices for sedges

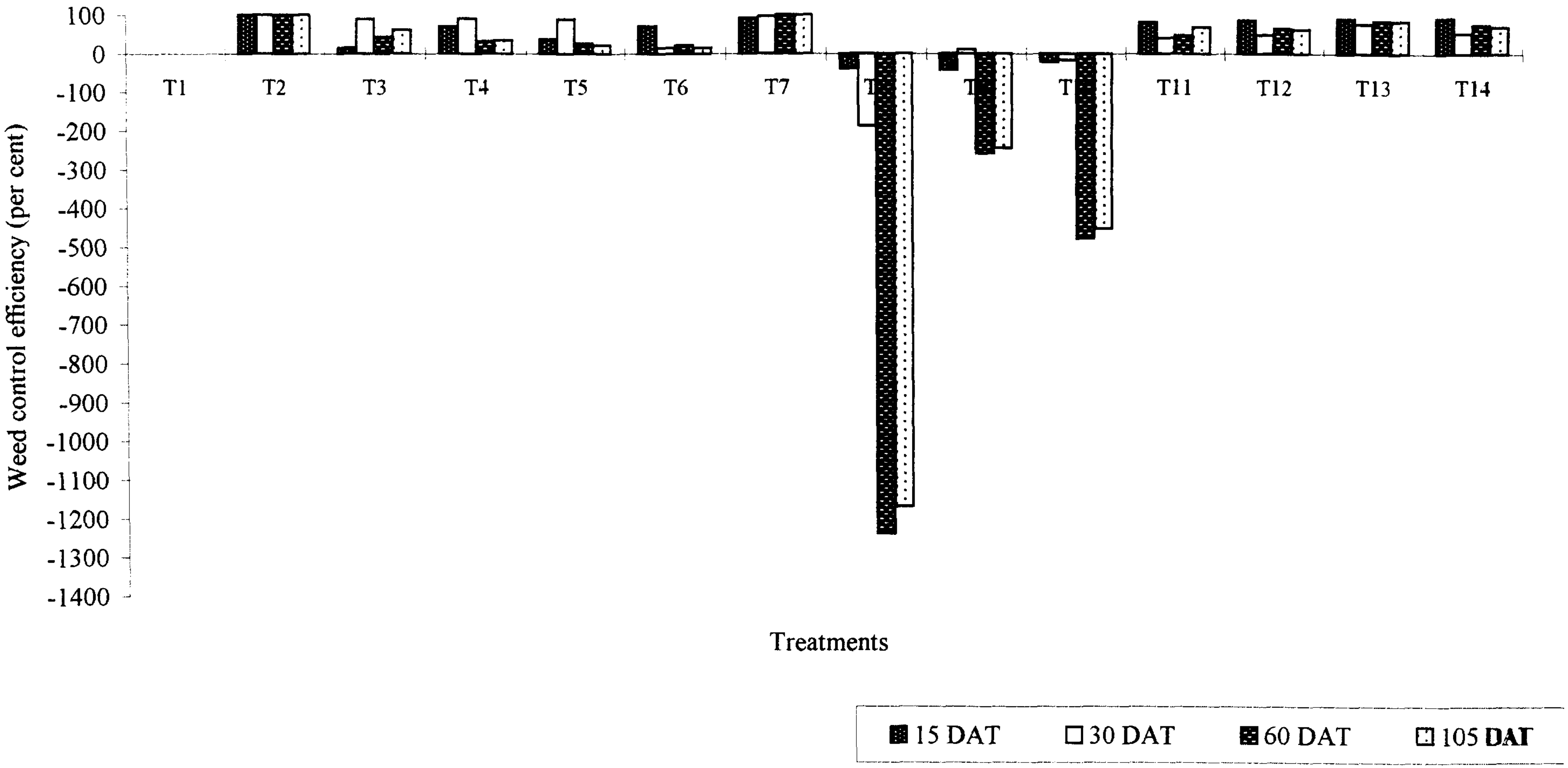
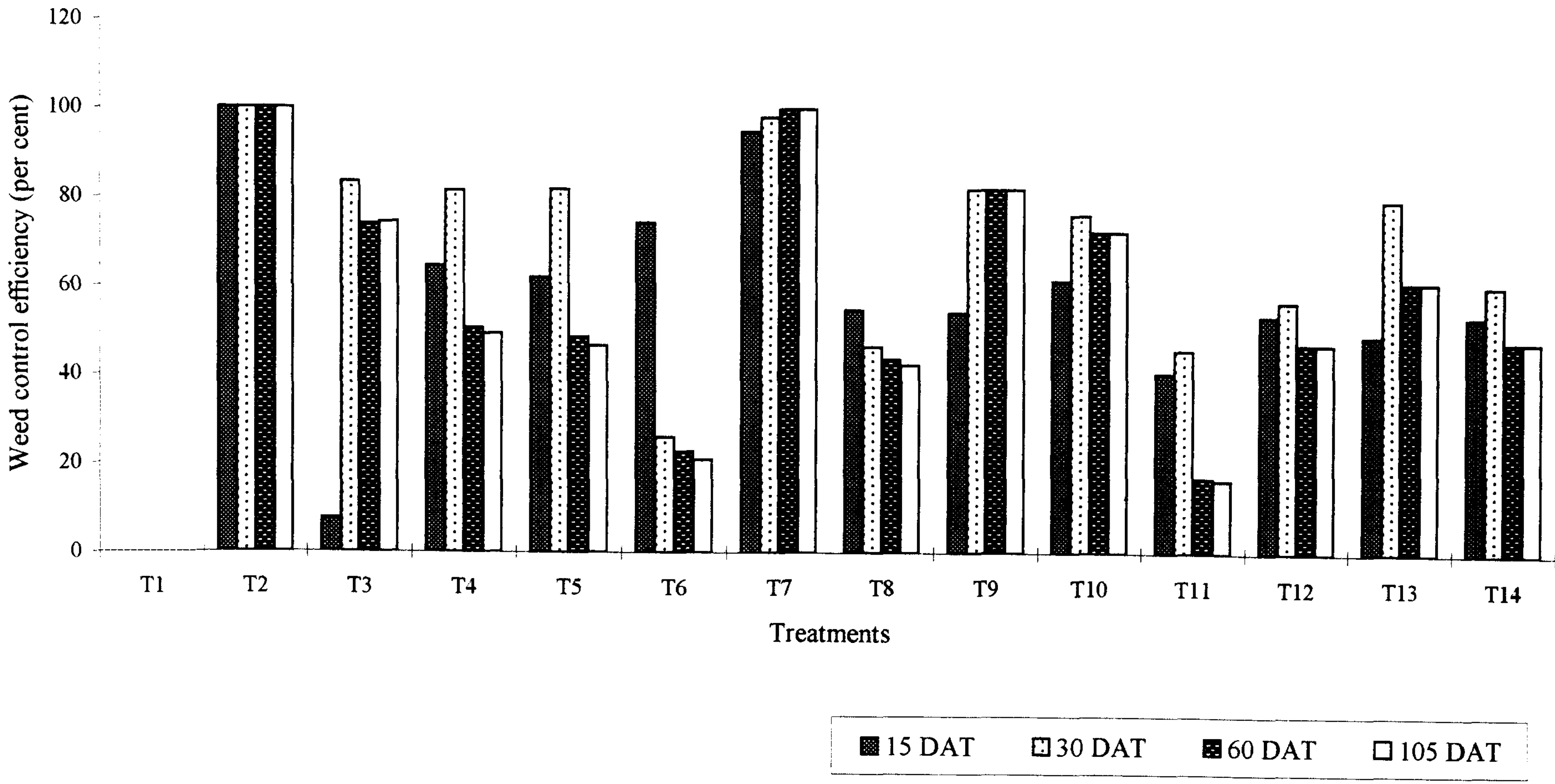


Fig. 11 Weed control efficiency of different weed management practices for all types of weeds



check, the uptake was minimum under black polythene mulch followed by T_9 (Fluchloralin + one manual weeding). The uptake of nutrient by weeds was considerable under glyphosate alone (T_{11}), glyphosate + smother crop (T_{14}) and also under stale seeded + smother crop (T_6) at 60 and 105 DAT, which implied that these treatments allowed weed growth towards the latter crop growth stages. Such response is also indicative of the non-persistent nature of the herbicide studied. The result of the herbicide persistence studies is also in conformity with this inference.

5.2 Observation on the crop

5.2.1 Effect of weed management practices on crop growth characters

The overall indication from the results was that the growth characters of brinjal were significantly influenced by the weed management practices studied.

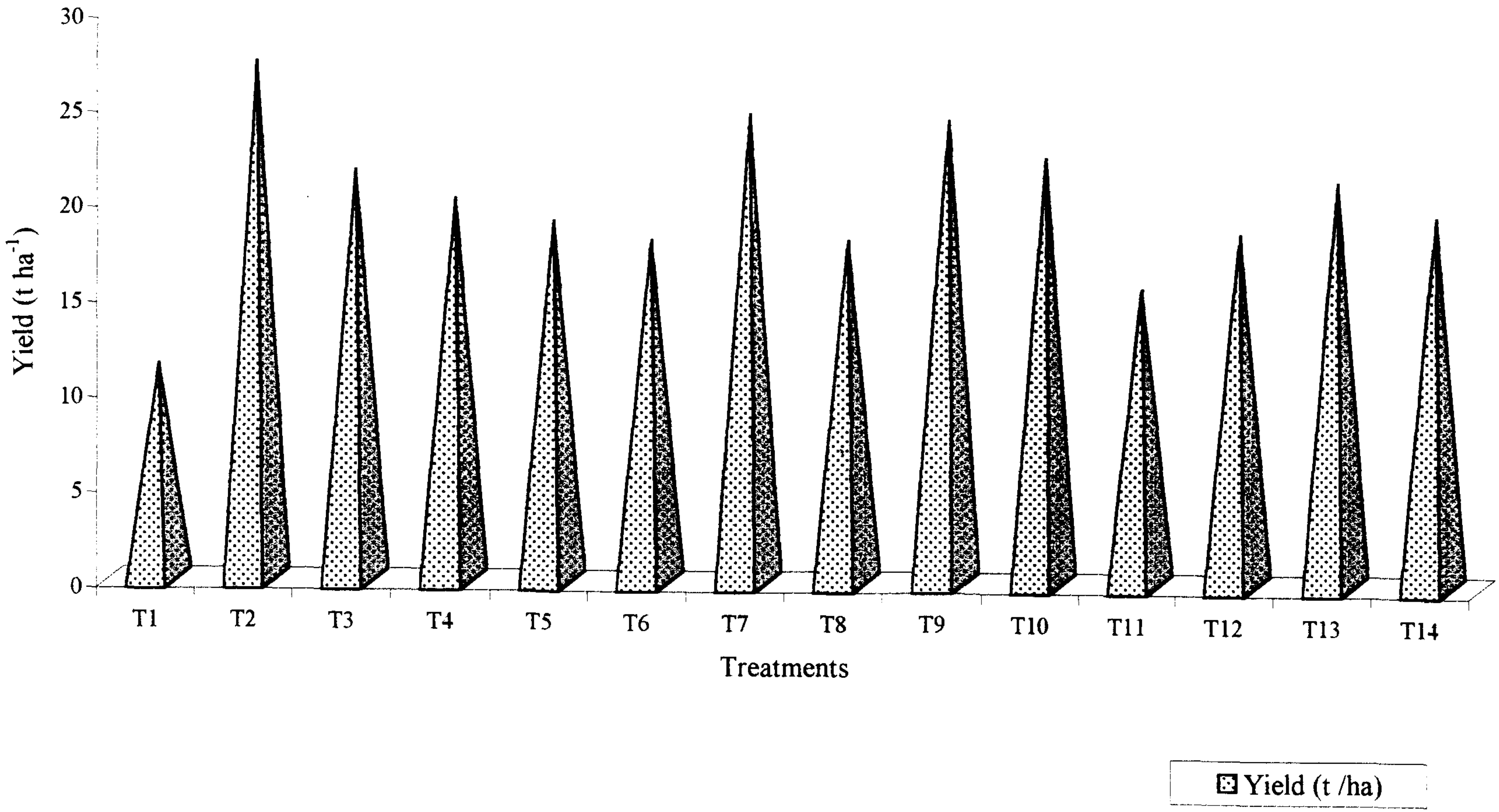
Plant height in all the treatments except the weed free check (T_2) was significantly superior to that of weedy check. Maximum plant height (77.63 cm) was recorded by T_{10} (Fluchloralin + smother crop) and it was on par with T_9, T_6 and T_{14}. Similarly weed removal had some positive influence in the number of branches per plant also. Weed free check (T_2) had the maximum number of branches per plant and all the treatments except T_{11} (glyphosate alone) were significantly superior to weedy check (T_1). Similar was the response noted in the case of leaf production per plant.

From the above response pattern it was evident that the presence of weeds had significant negative influence on the crop growth characters, especially branches and leaf production. Though weed free check recorded the lowest plant height that was compensated by more number of branches and leaves per plant. In unweeded control, the unchecked weed growth suppressed the crop growth as indicated by the fewer number of branches and leaves. Similar effects of weed competition have been reported by Ramana *et al.* (1994) in Indian palak and Reena (1997) in sesamum. Weeds compete with crop plants and the major factor which decide on the extent of weed competition and subsequent adverse effect on crop growth is the severity of weed infestation. The treatments which recorded fewer number of weeds per m^{-2} or higher weed control efficiency had recorded better crop growth characters. The result is in conformity with the observation of Rao (2000) that, for every unit of weed growth, there will be one unit less of crop growth.

5.2.2 Effect of weed management practices on the yield attributing characters and yield of brinjal

From the data it was evident that effective weed control did have a positive role in determining the yield of brinjal. Under completely weed free situation (T_2), the brinjal plant recorded maximum number of flowers, highest number of fruits (12.00) and also maximum percentage fruit set (79.94 per cent). This was closely followed by balck polythene mulch (T_7) and fluchloralin + one manual weeding (T_9). The days to 50 per cent flowering was however not affected by the treatments. The favourable impact of weed removal on these yield attributing characters was reflected in fruit yield of the crop. The yield was maximum under T_2 (weed free situation) while the unweeded check (T_1) had the lowest yield. This is in line with the studies of Singh *et al.* (1982) who reported that highest yield in okra was recorded by weed free plot and it gave 90.6 per cent more yield compared to weedy check.

Fig. 12 Effect of weed management practices on the yield of brinjal (t ha^{-1})



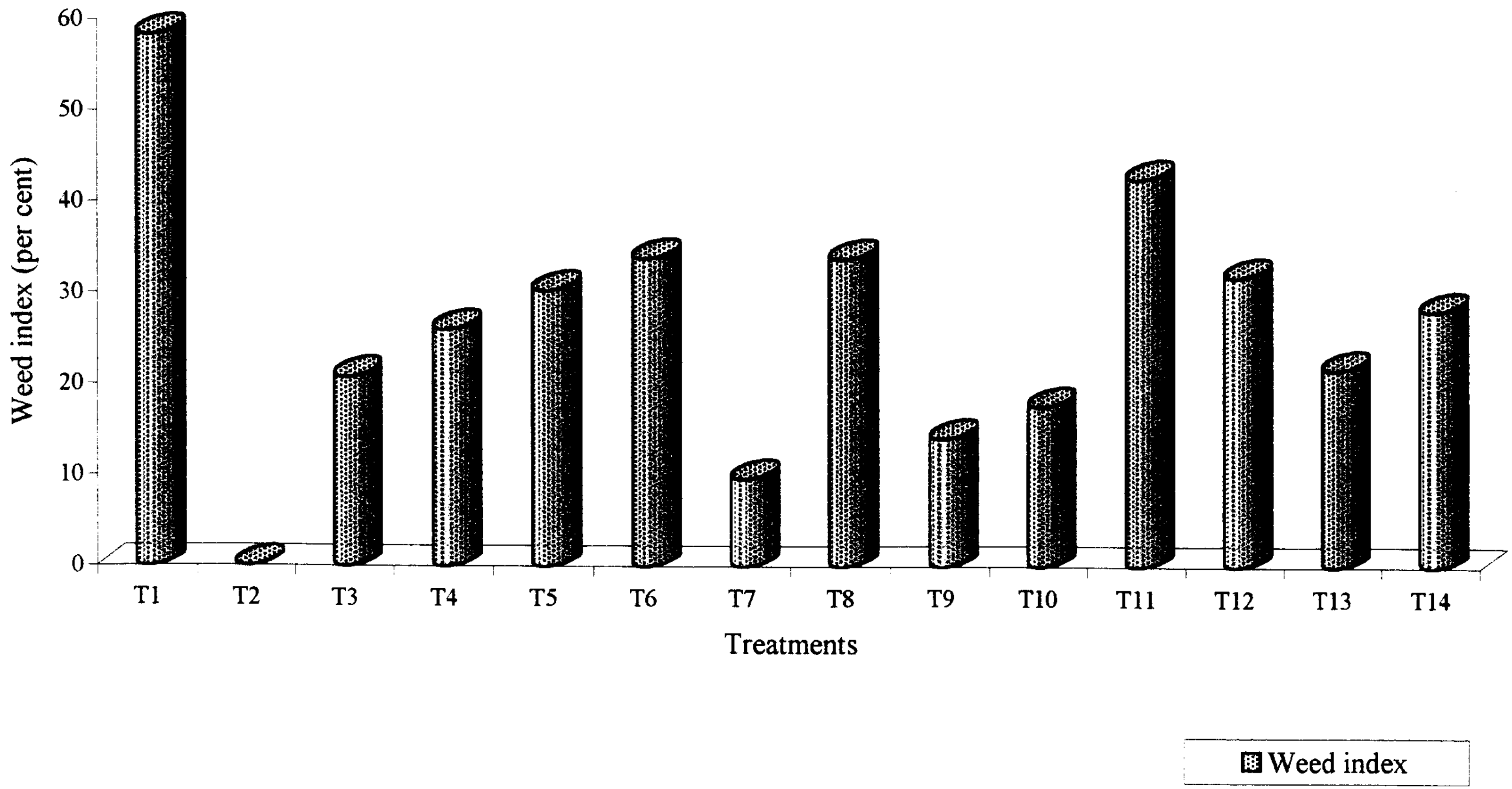
In the present study, the harvest index values were also better in treatments which recorded lower weed growth, and the highest harvest index was recorded by weed free check.

A critical analysis of the yield data clearly showed that the crop yield was higher in treatments which were effective in controlling weeds. When the field was kept completely weed free during the entire crop season, the yield increase was significantly higher than the other plots. Thus the extent of weed growth and the consequent competition appeared to be the main factor which decided the final yield. The result of the correlation studies reaffirms this inference. The enhanced yield was consistent with the enhanced crop growth parameters discussed earlier. Moreover the data on harvest index indicated that in treatments recording higher weed control efficiency, proportionately more of the photosynthates were translocated for fruit production.

The direct influence of weed competition on yield characters and yield of vegetables has been reported by several workers like Singh *et al.* (1982) in okra and Singh *et al.* (1993) in tomato. The effectiveness of fluchloralin + manual weeding for weed control and consequent yield increase was reported by Nandal and Pandita (1988) in brinjal while Saikia *et al.* (1997) reported that mulching with blackpolythene promoted okra growth and yield.

The weed indices give the extent of crop loss due to weed competition in brinjal, taking the crop yield from weed free plot as the reference. The yield loss was maximum (58.43 per cent), under unweeded control plot while T_7 (black polythene mulch) had the minimum loss (9.58 per cent). Such response indicated the direct correlation between intensity of weed competition and crop loss. Among the herbicide treatments, fluchloralin + one manual weeding

Fig. 13 Effect of weed management practices on weed index of brinjal



recorded 14.07 per cent crop loss while glyphosate @ 1.5 kg a.i. ha^{-1} alone had a high weed index of 42.64 per cent. Under manual weeding the crop loss was comparatively low (20.83 per cent) which explained why the practice still remains prevalent among the vegetable growers.

5.2.3 Effect of weed management on nutrient removal by the crop

Maximum uptake of N, P and K was recorded by the weed free treatment, while weedycheck registered the minimum uptake values for all the major nutrients. The enhanced growth characters in weed free situation contributed to high dry matter production and nutrient uptake being a product of dry matter production and nutrient content, was enhanced under such situations. It was evident that with minimum weeds to compete with, and share resources, the uptake of nutrients by the crop was facilitated, resulting in more vigorous crop growth and better yield.

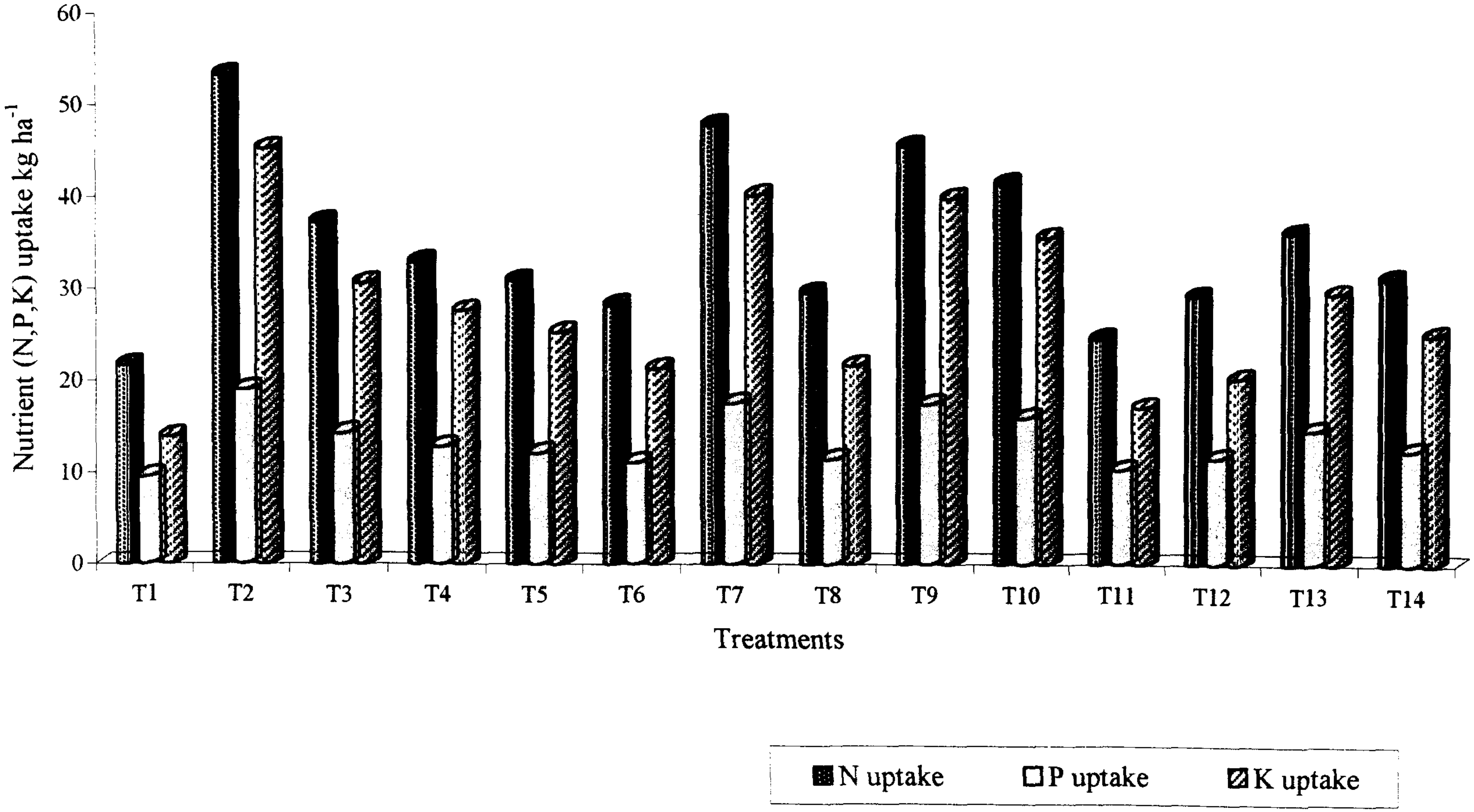
5.2.4 Keeping quality of fruits and seed viability

The result of the present study, indicated that the weed management practices included in the study had no significant influence on the keeping quality of the brinjal fruits. The shelf life ranged between 5.3 to 6.3 days. The viability of seeds was 100 per cent in all the treatments which implied that seeds collected from the herbicide treated plots also could be safely used for sowing purpose.

5.3 Nutrient status of the soil after the experiment

The nutrient status of the soil after the experiment registered a marginal

Fig. 14 Effect of weed management practices on the nutrients uptake by brinjal (kg ha^{-1})



decrease in nitrogen content over the initial status. The phosphorus content also showed a similar trend except under T_2 and T_7, while there was little improvement in potassium status. Among the treatments, the status of all the nutrients was the highest under T_7. The effectiveness of the mulch for preventing weed growth must have indirectly conserved the nutreints also. Similar effects of plastic mulch has been reported by Jaiswal (1995). The N, P and K status of soil under weed free check (T_2), black polythene mulch (T_7) and fluchloralin + one hand weeding (T_9) also indicated that effective weed control could have such positive effect on soil nutrients. However the expected beneficial effect of the leguminous smother crop, in improving the nitrogen status of soil was not distinguishable, probably because they allowed considerable weed growth during the later part of the crop growth.

5.4 Herbicide persistence in soil

Herbicides which decompose too readily are undesirable in some situation as they cannot be effective on weeds that emerge later. At the same time, herbicides which are having longer persistence of activity are unsuitable as their phytotoxic residues can injure sensitive crops grown in rotation. In the present study, the persistence of the herbicides fluchloralin, glyphosate and 2,4-D in soil was studied by observing the germination and early growth of an indicator plant (cucumber) in soil samples collected from the treated plots after the experiment. The results were found comparable with that of untreated control. Presumably all the herbicides had degradaed, leaving little toxic residue in soil. This is in conformity with the reports of Subramonium *et al.* (1998) who observed that fluchloralin had no adverse effect over the succeeding crop. Singh and Gupta (1978) reported the glyphosate applied @ 1.25 l ha^{-1} was safe even five days after spraying for growing crops like bhindi, cotton and brinjal. Similarly results on non-persistent nature of 2,4-D was reported by Balyan *et al.* (1981). Ameena (1999) who studied the herbicide residue in soils treated with glyphosate @ 1.5 kg a.i. ha^{-1} and glyphosate @ 1. 5 kg a.i. ha^{-1} + 2,4-D sodium salt @ 0.25 kg ha^{-1} also reported in similar lines. The result thus showed that fluchloralin, glyphosate and 2,4-D when applied to brinjal do not persist in soil and can have no adverse effect on the succeeding crops.

5.5 Economics of weed management

The results of the present study revealed that the remuneration from the vegetable crop was highly dependent on weed management practices adopted. Pre plant application of fluchloralin @ 1.5 kg a.i. ha^{-1} integrated with one hand weeding at 20^{th} days after transplanting recorded a net return of Rs. 45490 and benefit cost ratio of 1.59 and was found to be most remunerative weed management practice. Manual weeding twice (T_3) registered net return of Rs. 33,476 and was the next best treatment. Though the fruit yield was maximum under weed free check, the data on net income and benefit cost ratio were found negative which implied that it was uneconomic and unnecessary to keep the field weed free during the entire crop growth period. This is particularly so, if hired labour was to be used. The net income was found negative under weedy check emphasizing the importance of weed management in profitable vegetable production.

Acceptability of any farming practices essentially depends upon its economic viability. The results of the present study revealed that the

Fig. 15 Effect of weed management practices on the net profit from brinjal (Rs ha^{-1})

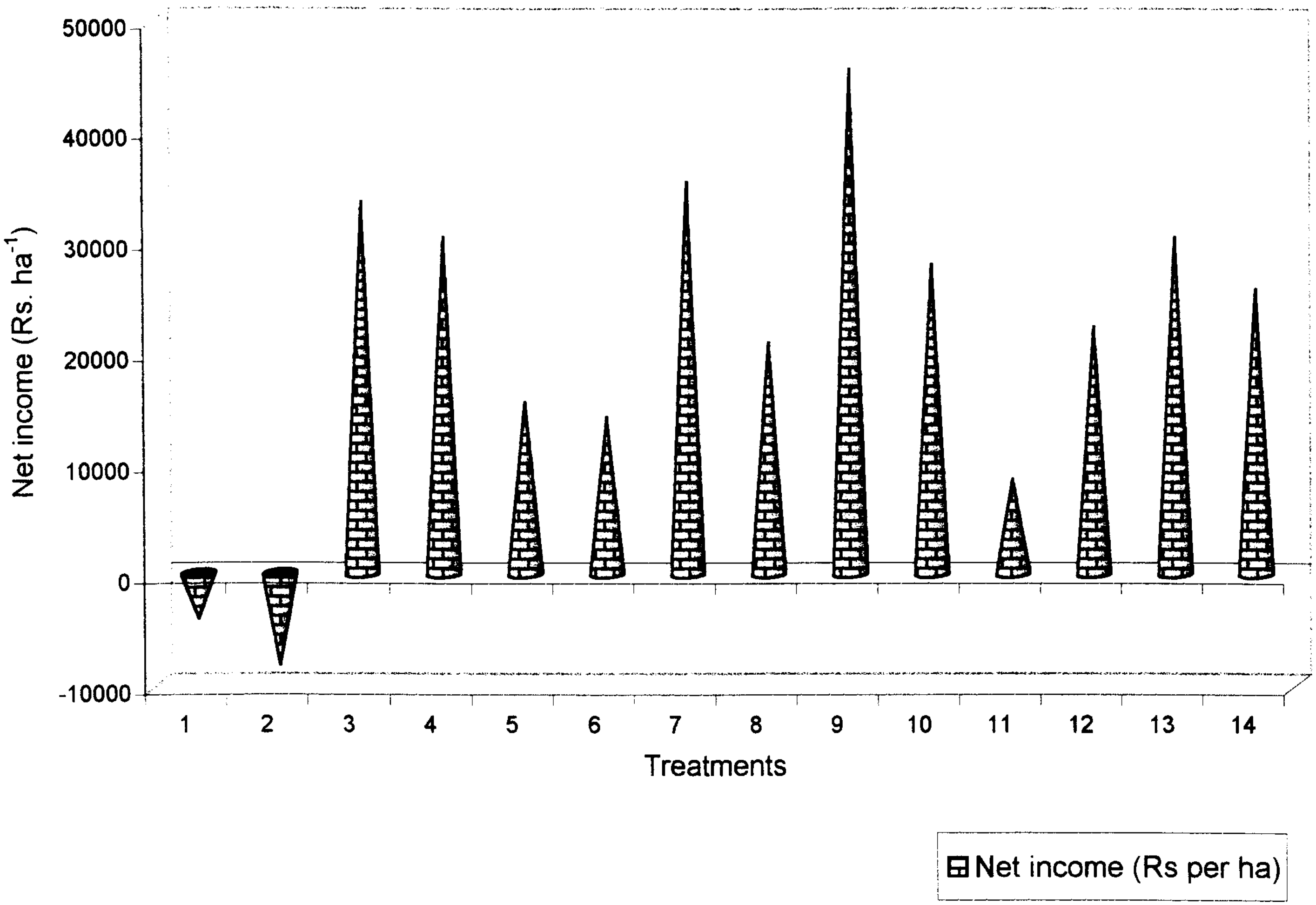
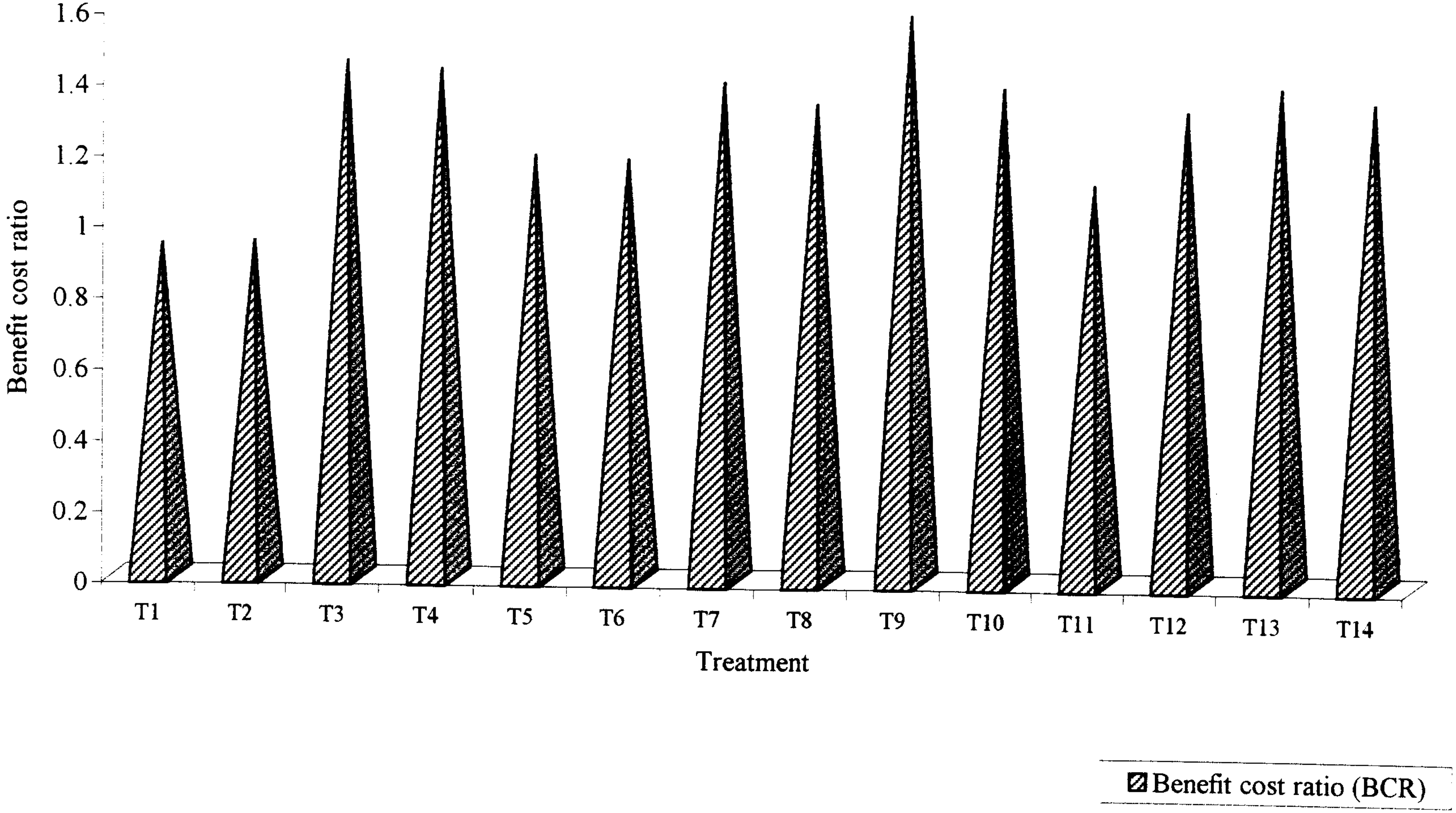


Fig. 16 Effect of weed management practices on the benefit cost ratio of brinjal cultivation



economics favoured the pre-emergent use of fluchloralin especially when it was integrated with one hand weeding. Profitability of integrating chemical method with hand weeding was observed earlier by Leela (1993) who reported that in tomato and okra fluchloralin + one manual weeding was more economical than hand weeding twice.

5.6 Correlation studies

The results showed that fruit yield of brinjal was significantly and positively correlated with number of branches and leaves per plant. Among the yield attributing characters, number of flowers, number of fruits, per cent fruit set were found correlated with yield.

Among the weed characters, weed dry weight and nutrient uptake by the weeds at all stages of crop growth recorded significant negative correlation with yield while weed control efficiency registered significant positive correlation with yield. It was evident that the correlation coefficients varied with crop growth stages. Higher correlation between weed control efficiency and yield was recorded at 60 DAT and 105 DAT which implied the importance of adopting weed management practices which gave consistent and season long weed control. The response is also indicative of the beneficial effect of integrating pre-plant or pre-emergent use of herbicides with post emergent weed control practices like hand weeding.

SUMMARY

6. SUMMARY

The present study entitled "Integrated weed management in brinjal (*Solanum melongena* L.)" was undertaken in the Instructional Farm, College of Agriculture, Vellayani during the period from August to November, 1999. The main objectives were to study the influence of weed management practices on the dominance and persistence of weed flora infesting brinjal, to assess the yield loss in brinjal due to weed interference, workout the efficiency and economics of different weed management practices.

The field experiment was laid out in randomised block design with fourteen treatments and three replications. The treatments consisted of chemical, cultural and physical methods of weed control applied alone or in combination, with weedy check and weed free check as controls. Herbicides used were glyphosate, 2,4-D sodium salt and fluchloralin. Stale seed bed, smother crop and black polythene mulching were the cultural methods tried. Hand weeding twice was the physical method studied. To assess the residual effect of the herbicides in soil, germination percentage and early growth characters of cucumber was observed.

The salient results of the experiment are summarised below.

1. The prominent weeds that infested the experimental site were *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Eleusine indica* and *Digitaria ciliaris* among the grasses, *Spermacoce latifolia*, *Cleome viscosa*, *Amaranthus viridis*, *Phyllanthus niruri*, *Acanthospermum hispidum*, *Euphorbia hirta*, *Borreria hispida*, *Gynandropsis pentaphylla*, *Eclipta prostrata* among the broad leaved weeds and *Cyperus rotundus* among the sedges.

2. Unweeded control registered maximum weed growth throughout the crop growth period.
3. The farmers practice of giving two manual weeding (15 and 30 DAT) allowed unchecked weed growth upto 15 DAT but showed comparatively high weed control efficiency at 30, 60 and 105 DAT.
4. The smother crop (cowpea) suppressed weeds during the early crop growth period, but after it was incorporated insitu, weeds emerged infesting with the crop growth.
5. Weed control efficiency of smother crop + one manual weeding (T_4) was higher than that of T_5 (Stale seed bed + one manual weeding) and both the treatments in turn were better than T_6 (stale seed bed + smother crop).
6. The summed dominance ratio (SDR) indicated that grasses, broadleaved weeds were dominant over sedges under T_4, T_5, T_6.
7. Weeds of all three categories (grasses, broadleaved weeds, sedges) failed to emerge under the black polythene mulch (T_7) and the few weeds recorded were those coming up from the planting hole. There was no distinguishable weed growth even from the planting hole beyond 30 DAT.
8. Application of fluchloralin as pre-plant incorporation (T_8, T_9, T_{10}) was found to have spectacular inhibiting effect on emergence of broadleaved weeds and grasses.
9. The weed control efficiency of fluchloralin treatment was enhanced when integrated with one manual weeding (T_9)
10. Fluchloralin + smother crop (T_{10}) registered better weed control efficiency than T_8 and T_9 at 15 DAT but at later stages T_9 was the better treatment than T_{10}.

11. Application of glyphosate was found to reduce weed population during the early crop growth but allowed weed emergence later.
12. Efficiency of glyphosate application for weed control could be improved by integrating the herbicide application with either manual weeding or smother cropping.
13. Combination of glyphosate application + one manual weeding (T_{13}) was found to be a better option for weed control than glyphosate alone (T_{11}) or glyphosate + smother cropping.
14. The efficacy of glyphosate could be improved by combining it with a sublethal dose of 2,4-D sodium salt (T_{12}).
15. Unchecked weed growth exploited the available nutrients and water resulting in better growth and drymatter production.
16. Uptake of nitrogen, phosphorus and potassium by weeds was maximum under unweeded check.
17. Excluding the weed free check (T_2), the nutrient uptake by weeds was minimum under black polythene mulch (T_7) followed by fluchloralin + one manual weeding (T_9).
18. The growth characters of brinjal was significantly influenced by the weed management practices. Maximum plant height was recorded by T_{10} and it was on par with T_9, T_6 and T_{14}.
19. Weed free check (T_2) had the maximum number of branches per plant and all the treatments except T_{11} (glyphosate alone) were significantly superior to weedy check (T_1). A similar response was noted in the case of leaf production also.

20. Weed free treatment (T_2) had the maximum number of flower per plant, highest number of fruits and also maximum setting percentage but the days to 50 per cent flowering was not influenced by the weed management practices.

21. The favourable impact of weed removal on the growth and yield attributing characters of brinjal was reflected in crop yield The yield was maximum under weed free situation (T_2) and minimum under unweeded control (T_1). The harvest index values were also better in treatments which recorded lower weed density.

22. The yield loss due to weeds indicated by the weed indices, was maximum under unweeded control. Next to weed free, black polythene mulch (T_7) had the minimum followed by fluchloralin + one manual weeding (T_9) and two manual weeding (T_3).

23. Maximum uptake of N, P and K by crop was recorded with the weed free treatment (T_2) while weedy check had the lowest uptake (T_1).

24. Weed management practices included in the study had no significant influence on the keeping quality of brinjal fruits.

25. The viability of seeds was 100 per cent in all the treatments which implied that the seeds collected from the herbicide treated plots could be safely used for sowing purpose.

26. Fluchloralin @ 1.5 kg a.i. per ha + one hand weeding at 20 DAT was the most remunerative weed management practices studied followed by manual weeding twice (T_3).

27. It was uneconomic to keep the field completely weed free during the entire crop growth period.

Future line of work

From the result of the present study fluchloralin + one hand weeding was found to be a remunerative method for weed control. However, this practice was inefficient for controlling sedges. Hence indicious herbicide combinations which can control sedges as well, need to be studied. The use of low cost biodegradable plastics for weed control is another area to be studied in detail. The technical and economic feasibility of combining stale seed bed technique/smother cropping with post emergent herbicides may also be investigated.

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* Original not seen

APPENDIX

APPENDIX – I

Weather parameters during the cropping period (August 1999 to November 1999)

Standard weeks	Relative humidity (%)	Maximum temperature (°C)	Minimum temperature (°C)	Evaporation (mm)	Rain fall (mm)
39	86.50	29.20	23.20	4.49	4.86
40	81.92	30.21	24.43	3.97	0.17
41	82.36	29.83	23.71	4.56	9.66
42	81.71	29.83	23.60	3.53	0.57
43	81.57	29.71	20.09	3.71	0.46
44	79.25	30.80	23.57	4.30	0.40
45	77.07	30.98	24.01	4.69	0.11
46	74.71	32.29	24.39	5.37	0.00
47	84.71	30.39	23.80	2.93	1.72
48	85.71	29.16	23.13	2.76	15.26
1	87.29	28.67	23.26	2.04	12.01
2	88.07	28.80	23.57	2.18	9.63
3	87.14	29.00	23.09	2.46	15.46
4	82.57	29.27	23.21	3.46	0.0.6
5	80.50	25.89	22.94	2.77	0.014
6	81.79	30.23	26.64	2.89	7.40
7	80.07	30.20	22.84	2.69	9.23
8	84.71	29.10	23.39	2.00	6.51

INTEGRATED WEED MANAGEMENT
IN
BRINJAL (*Solanum melongena* L.)

By

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ABSTRACT OF THE THESIS
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ABSTRACT

A field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram to study the technical and economic feasibility of different weed management practices for brinjal. The study was carried out during the period from August to November, 1999.

The experiment was laid out in Randomised Block Design with fourteen treatments and three replications. The treatments consisted of physical, cultural and chemical methods of weed control alone or in combination. Unweeded check and completely weed free check were included as control treatments. 'Swetha' was the variety of brinjal used for the study.

Results of the study revealed that grasses, broadleaved weeds and sedges competed with the brinjal crop. The weed intensity and distribution was found significantly influenced by the weed management practices included in the study. It was evident that weeds failed to emerge under the black polythene mulching and the few weeds recorded were those emerging from the planting hole. There was no distinguishable weed growth even from the planting hole beyond 30 days after transplanting (DAT). The farmers practice of giving two manual weeding at 15 and 30 DAT allowed unchecked weed growth upto 15 DAT, but had comparatively high weed control efficiency at later stages. Application of fluchloralin as pre-plant incorporation (PPI) was found to inhibit early emergence of grasses and broadleaved weeds, but gave poor control of sedges. Fluchloralin + one hand weeding at 20 DAT was found to give season long control of weeds and was a better option than fluchloralin alone and fluchloralin + smother cropping.

The cultural practices of stale seed bed technique and smother cropping gave early season weed control but allowed weed emergence later and gave improved weed control efficiency when integrated with one hand weeding. The effect of glyphosate application also was found to respond in similar lines.

The weed management practices were found to exert considerable influence on growth and yield characters of the crop. Under weed free situation the plant produced the highest number of branches and leaves and had the maximum number of flowers and fruit also. The crop yield was found to bear a direct positive correlation with the weed control efficiency of the management practices. Weedy check recorded the lowest yield and the yield losses worked out was 58.43 per cent. Excluding the weed free check, the yield loss was minimum under black polythene mulching followed by fluchloralin + one hand weeding.

The most remunerative treatment was found to be fluchloralin + one hand weeding (T_9) followed by two manual weeding (T_3). The herbicides were found non persistent leaving little toxic residue in the soil after the experiment.