WEED MANAGEMENT IN SUGARCANE (*Saccharum officinarum* L.) THROUGH HERBICIDES AND INTERCROPS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"Weed management in sugarcane (*Saccharum officinarum* L.) through herbicides and intercrops"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Certified that the thesis entitled **"Weed management in sugarcane (*Saccharum officinarum* L.) through herbicides and intercrops"** is a record of research work done independently by Sri. Mahadev. S. Sarashetti under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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Dedicated to,

Sri. Jagadeesh. S. Gudagunti
Chairman and Managing Director
Sri Prabhulingeshwar Sugars and Chemicals Ltd.

&

My beloved Mother

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Chapter I

INTRODUCTION

In India, Agriculture is not an agribusiness, but a way of life. Sugarcane is one of the most valuable commercial crops contributing nearly 1.9% of the national Gross Domestic Product (Shahi, 2002). In Kerala sugarcane is cultivated in an area of 3,267 hectare with a production of 26,978 tonnes and Palakkad district leads in this regard (Government of Kerala, 2002). Being a long duration and wide spaced crop with initial slow growth, the problem of weeds in sugarcane is severe. The weeds grow luxuriantly and compete with sugarcane for moisture, nutrients and other growth factors.

Studies by many researchers revealed decline in yield of sugarcane due to weeds (Hunsigi *et al*, 1976, Kannapan and Ramaswamy, 1994). Several methods, including both intercropping and chemical control measures have been adopted to minimise the infestation of weeds. Peng (1984) observed that from the ecological point of view, integrated weed management is a safe option. But a high dose of herbicides is used in developed countries, where zero tillage is practiced (Mcintyre and Barbe, 1995).

Intercropping in sugarcane would be a feasible practice. Green manures as intercrop adds organic matter to soil and supply nitrogen and nutrients to the following crop. The initial slow growth of sugarcane can be profitably utilised initially for growing intercrops, which would reduce evaporation losses and weed growth. Cultural operations are effective in controlling weeds, but they are laborious and time consuming.

Keeping this in view, an experiment was conducted in farmer's field at Anjamile, Chittur taluk, Pallakkad district to study the effect of herbicides and intercrops on fertility of soil, weed growth, cane yield and quality. The following were the major objectives of the study.

1. To evolve the appropriate weed management methods for sugarcane.

2. To evaluate the effect of intercrops on soil fertility and weed management and

3. To study the influence of weed control methods on sugar yield and quality.

Review of Literature

Chapter II

REVIEW OF LITERATURE

Sugarcane (*Saccharum officinarum* L.) is considered as one of the most efficient plant in converting solar radiation to photosynthetic products. It is very much adapted to tropical and subtropical conditions. In India, sugarcane is one of the leading commodities in trade and industry.

A brief review pertaining to weed flora, methods of weed control and effect of different herbicides on control of weeds; growth, yield and quality parameters of sugarcane as well as the effect of green manuring crops are presented in this chapter.

2.1. WEED FLORA

In India, about 63 weed species belonging to 29 families are found to occur in sugarcane as reported by Sundara (1998). He has reported that the major weed flora observed in experimental field were *Portulaca oleracea, Mollugo pentaphylla, Trianthema portulacastrum, Ageratum conyzoides* and other minor weeds are *Euphorbia hirta, Corchorus olitorius, Solanum nigram, Cyperus rotundus, Commelina benghalensis* etc. *Cyperus rotundus* was the most dominant weed accounting for more than 70 percent of total weed population, where as *Cynodon dactylon* and broad leaved weeds shared 20 and 10 percent of the population, respectively in the studies conducted at Indian Institute of Sugarcane Research, Lucknow (Chauhan, 1992).

Studies conducted at Regional Research Station, Mandya revealed the highest incidence of *Cyperus rotundus* (43.63%) followed by *portulaca* sp. (28.50%). Monoctos (62%) dominated over dicots (38%) (SBI, 1992). On many occasions twining weeds like *Ipomea hispida, Convolvulus arvensis* and other seasonal weeds get established after final earthing up, interfering with growth and harvest of the cane (Mahadevaswamy *et al.*, 1994). In a survey conducted in

Palakkad region by Girija *et al.* (1993) it was observed that there is a wide variability in the extensiveness and infusiveness of weed flora in sugarcane field.

2.2. CROP WEED COMPETITION

2.2.1. Critical Period of Weed Competition

Knowledge of critical period of weed competition is necessary to decide on any weed management practice. Weed competition in early stage of sugarcane growth affects the yield severely. The initial 90 days period of the crop growth is considered as most critical (Sundara, 1998). Critical period of weed competition was up to 96 days after planting as reported by Srinivasan (1988). Crop-weed competition will be throughout the first three months of crop age (Krishna and Reddy, 2001).

Lavya and Pohlan (1988) reported that the critical time of exposure to weed competition was 40 to 70 days after planting. Studies of Phoghat *et al.* (1990) have shown that sugarcane can tolerate weed competition up to 60 DAP. Srivastava and Kumar (1996) found that the period between 60 and 120 days after planting was the most critical in spring planted sugarcane.

2.2.2. Competition of Weeds for Moisture

Weeds are known to absorb soil moisture. Sundara (1998) found that weeds present in one-hectare land could remove 750-1250 tonnes of water. Weeds that are present in the furrows i.e. along the cane rows cause more harm than that present in the inter- row space.

Study conducted by Dua *et al.* (1995) proved that pre-harvest irrigation given at 6-32 days resulted in increased sugar production per unit area. Srivastava (1996) reported that fertilizer and irrigation contribute 30 and 20 percentages, respectively to productivity of sugarcane in India.

Srivastava and Chauhan (2002) found that the frequent irrigation applied during formative phase (upto 120 days) favoured the weed growth also. They have also reported that presence of weeds results into greater depletion of water that amounts to one and a half times more than that removed by the crop under weed free condition. Srivastava *et al.* (1999) reported that sugarcane crop faces tough competition with weeds for moisture and nutrients during its early stage.

2.2.3 Competition of Weeds for Nutrients

Experiment conducted by Srinivasan (1988), revealed that weeds removed four times of nitrogen, phosphorus and two and half times of potassium during the first seven weeks of growth period. Sathyavelu (1990) found that 86.4kg, 19.1kg and 97.2kg N, P_2O_5 and K_2O per hectare were removed by the weeds within 90 days, much higher than herbicide treated plot.

Srivastava and Chauhan (2002) reported that weeds removed 162kg N, 24kg P_2O_5 and 263kg K_2O from one hectare of sugarcane field, whereas the removal of NPK in herbicide treatments and intercrop treatments were much lower. Fertility of soil affected the vigour of both crop plant and weeds (Muzik, 1970).

2.2.4 Competition of Weed for Light and Space

Germination of sugarcane takes about 30 days and then about two months to cover the ground by foliage. Rao *et al.* (1982) reported that in the initial 90 days period the soil nutrient, space and light left unutilised by the crop were utilised by the weeds.

2.3. ADVERSE EFFECTS OF WEEDS ON SUGARCANE

2.3.1 Effect of Weeds on Germination of Sugarcane

Sugarcane starts germination from the second day after planting and continues up to 30-35 days. During this period, frequent irrigations are being given and this favours rapid germination of weeds. Sugarcane fields are heavily infested with weeds due to its slow germination and wider space (Phoghat *et al.*, 1988).

Umaratha (1997) observed that heavy infestation of weeds reduce germination of sugarcane buds by 53 percent. In another work done by Agarwal *et al.* (1995), it was found that weeds depressed germination of sugarcane by 8.4 percent. Singh and Singh (1996) found that competition of weeds during germination and early shoot formation did not reduce the yield.

According to Mathew *et al.* (2002), effect of weed competition is more in early stage (germination and tillering) of cane growth and this limits the cane yield to the tune of 38 per cent. Mishra *et al.* (2003) reported that weeds compete with sugarcane crop particularly during germination for nutrients and moisture.

2.3.2 Effect of Weeds on Tillering and Millable Cane

Sathyavelu (1990) reported that weed infestation causes reduction in tiller production. Ponnuswamy *et al.* (1996[b]) and Umaratha (1997) reported a loss of 50-52.8 percent in the number of millable cane population due to weed infestation. Weeds in sugarcane need to be controlled at formative stage of crop growth according to Chauhan and Srivastava (2002).

Phoghat *et al.* (1988) got the lowest number of millable canes in the weedy check due to crop weed competition. Nagaraju *et al.* (2000) found that restriction on tiller production and reduction in millable canes are caused due to weed competition.

Nutsedge reduces the number of millable cane and yield up to 30.4 and 34.6 percent, respectively (Desai *et al.*, 1996). Agarwal *et al.* (1995) found that weeds in sugarcane depressed tillering and millable cane number by 51.4 and 51.6 percent, respectively.

2.3.3 Effect of Weeds on Growth of Sugarcane

Sathyavelu (1990) reported that reduction of plant height, girth and number of internodes of cane were 28.7, 20.1 and 37.7 percentage, respectively in the unweeded plot and very much lower compared to weeded plot. Mathew *et al.* (2002) found that biomass production and cane yield decreases to the tune of 38 percent due to weed competition. Singh *et al.* (1995) reported that effect of weeds on the early growth of sugarcane is not compensated at the later stages, which causes substantial reduction in yield.

2.3.4 Effect of Weeds on Sugarcane Yield

Several workers have reported that there exist a yield gap between the actually harvested yield and average yield in India. The extent of damage depends on type of weed flora and their intensity of infestation (Phogat *et al.*, 1988). The yield loss due to presence of weeds was estimated as 75 percent (Singh and Moolani, 1975), 30-50 percent (Singh and Singh, 1996), 10-70 percent (Srivastava, 1996) and 12-72 percent (Sundara, 1998).

Agarwal *et al.* (1995) reported that weeds in sugarcane depressed the yield by 52.6 per cent. Desai *et al.* (1996) reported that cane yield reduction to the tune of 34.6 percent due to weeds. About 38 percent reduction in yield has been reported by Chauhan and Singh (1993). Presence of weeds during the first 60-120 days after planting results in 40 percent reduction in yield (Pandian *et al.*, 1991), 35.4 percent (Srivastava, 2001) and about 62 per cent (Phoghat *et al.*, 1998).

The loss in cane yield vary from 20-40 percent as reported by Singh *et al.*(2001[a]) and 15-30 percent as reported by Brar and Mehra (1995). Mehra *et al.* (1990) reported that weeds compete with the crop for various growth factors and results in significant reduction in the cane yield to the tune of 15.75 percent. Krishna and Reddy (2001) proposed that if weed control practices are not taken, there will be a reduction of at least 15 tonnes of cane per hectare.

2.4. METHODS OF WEED CONTROL

2.4.1 Mechanical Method of Weed Control

Mechanical control of weeds involves use of hoes, cultivators, harrows, rotary weeders, disc ploughs, mowers etc.

Agarwal *et al.* (1986) reported that one hoeing in November and three hoeings in March, April and May, in October planted sugarcane recorded a cane yield of 100.46 t ha^{-1}, which was higher by 33.5 t ha^{-1} compared to the traditional practice of one hand hoeing. Hand hoe weeding showed significantly lower dry weight of 68.0kg ha^{-1} and higher weed control efficiency as reported by Kathiresan and Manoharan (1994). Sankpal *et al.* (1997) observed minimum weed intensity in conventional weeding i.e. three hoeing followed by three hand weeding at monthly interval.

Singh and Singh (1996) proved that earthing up during July and May months controls major weeds in sugarcane and the practice of harrowing across the row is the most common method of weed control in sugar cane crop. Angadi *et al.* (1998) reported that hand weeding at 30,60and 90 days after planting gave the highest weed dry yield of 432.4 kg ha^{-1}.

Singh *et al.* (1995) revealed that one hoeing and weeding after germination and trash mulching of 3.5 t ha^{-1} recorded lowest weed dry weight. Studies conducted by Srivastava *et al.* (1999) revealed that three manual hoeings was superior to atrazine + 2,4-D and atrazine + 2,4-D+ one hoeing.

2.4.2 Chemical Method of Weed Control

2.4.2.1 Pre-emergence Herbicide Application of Weed Control

Herbicides have been discovered during 1950's and prior to that manual weeding was the main practice for weed control. With the advent of herbicides weed control could be done effectively at a low cost.

Singh *et al.* (1998) reported that atrazine @ 2.0 kg ha^{-1} gave satisfactory control of *Trianthema portulacastrum*. Liu (2002) proved that pre-emergence application of atrazine or diuron was more effective in controlling weeds. Rao and Veeranna (1996) reported that atrazine (@ 2.5kg ha^{-1} (or) 2,4-D (@2.5kg ha^{-1} was equally effective as hand weeding, resulting in lower dry weight of weeds.

Rao *et al.* (1982) studied the effect of atrazine as pre-emergence at 2.0 kg ha^{-1} and found that it was effective in controlling the weeds upto 90 days in sugarcane and produced lowest dry weight. Kannappan and Ramaswamy (1994) reported that pre-emergent application of isoprotuon at 1.0 kg ha^{-1} effectively controlled the weeds in sugarcane. Singh *et al.* (1997) proved that oxyfluorfen @ 0.23kg ha^{-1} as pre-emergence application reduced weed competition in sugarcane+ mustard system.

Studies conducted by Durai (1990) revealed that metribuzin @ 2kg ha^{-1} as pre-emergent spray resulted in good weed control. Chauhan (1988) reported that diuron or metribuzin (1 or 2 kg ha^{-1}) as pre-emergence herbicides for weed control resulted in 12 percent greater weed control efficiency than control plot. Thakur *et al.* (1991) reported that hand weeding+ metribuzin @ 1.0kg ha^{-1} reduced the density and dry weight of weeds. Nagaraju *et al.* (2000) got the lowest weed index by pre-emergence application of metribuzin @ 1kg ha^{-1}.

2.4.2.2 Post emergence Herbicides to Control Weeds

Studies conducted by Mahadevaswamy *et al.* (1994) revealed better weed control with post emergence application of 2.4-D. Honyal and Yandagoudar (1999) reported that 2.4-D showed significantly lower sprouting (85.4%) due to its reduced effect on weed growth with advance of time. Kathiresan and Duraisamy (2001) reported that spraying 2.4-D @ 2 kg ha^{-1} as pre-emergence + 10 percent solution of urea or common salt as post-emergence before flowering stage controlled *striga sp.* up to 85 percent.

Singh *et al.* (1988) reported that 2,4-D gave good weed control efficiency (WCE). Chauhan and Singh (1993) observed lowest WCE of 48 percent with 2,4-D sprayed as post emergent application @ 1.5 kg ha^{-1}. Research conducted by Patil *et al.* (1986) revealed that slow action of 2.4-D gave inferior weed control. Sankpal *et al.* (1997) found that spray of paraquat @ 5kg ha^{-1}, four weeks after planting followed by trash mulch in ratoon sugarcane reduced weed population.

2.4.3 Herbecide Mixture to Control Weeds

Ponnuswamy *et al.* (1996) reported that pre-emergence application of atrazine @ 2kg ha^{-1}+ 2.4-D @ 1 kg ha^{-1} as tank mixture controlled the weeds.

In the studies conducted by Kanwar *et al.* (1992) it was found that application of atrazine with 2.4-D each @1 kg ha^{-1} at 45 DAP controlled 80-90 percent of monocots and more than 90 percent of dicot weeds. Application of atrazine combined with 2,4-D resulted in higher mortality of weeds compared to herbicide used alone (Thakur *et al.* 1996).

Chauhan and Singh (1993) reported that atrazine and 2,4-D combination resulted in 28 percent higher cane yield over unweeded control. Patel *et al.* (1993) reported that combined application of 2.4-D + paraquat (1.0+1.5 kg ha^{-1}) was very effective in controlling weeds than hand weeding alone.

2.4.4. Intercropping System in Sugarcane

2.4.4.1 Effect of Intercrops on Controlling Weeds

Green manure crops interfere with the life cycle of weeds and restrict the growth of weeds and there by control of weed can be achieved effectively. Sunhemp, daincha and blackgram restrict the availability of light, water and food materials to weeds. They are useful in controlling annual weeds as well as to improve the fertility status of soil and enhance cane yield.

Bengalgram and peas in autumn planted sugarcane; and mung, urd and cowpea in spring planted sugarcane reduced the weed competition (Srivastava and Chauhan, 2002). Baumann *et al.* (2000) reported that the relative cover of weeds that emerged was reduced by 41 percent in the intercrop and the weed dry matter got reduced.

Krishna and Reddy (2001) reported that intercropping of sugarcane with blackgram controlled the weed intensity in the early stages of cane growth. According to Rao and Shetty (1977), intercropping in cane increases competitive ability of crops and reduced the weeds growth. Kannappan and Ramaswamy (1995) observed that intercropping system did not influence the population of grasses, sedges or broad leaved weeds population and also that magnitude of reduction in weed growth in intercropping of sugarcane depends on the nature of intercrop and their spatial arrangement.

2.4.4.2 Effect of Intercrops on Fertility Status of Soil

Intercropping of sugarcane with blackgram was found to be beneficial (Krishna and Reddy, 2001). Green manures as intercrop adds organic matter to the soil and supply nitrogen and other nutrients to the crop (BSRI, 1998).

Roodagi *et al.* (2000) reported that growing of sunhemp as green manure significantly enhanced nitrogen uptake (249.30 $kgha^{-1}$) compared to other intercrops. It was also reported that growing sunhemp, cowpea and soyabean as green manures significantly increased soil P and K but differed compared to sole sugarcane. Enhanced nutrient efficiency due to sunhemp and cowpea has been reported by Yadav and Prasad (1986) and Kathiresan and Ayyamperumal (1996).

Physical characters of problem fields were improved due to addition of organic matter when cowpea was grown as green manure (Durai *et al.*, 2002). Mahendran *et al.* (1997) found that daincha as green manure was better because of its high biomass and N accumulation than sunhemp.

2.4.5. Integrated Weed Management

In the present age of escalation of cost of chemicals on one hand and the scarcity of human labour on the other, it is essential to integrate more than one method, which ensures least damage to ecological balance.

Sathyavelu *et al.* (2000) reported that glyphosate with three disc harrowings reduced weed population. Singh *et al.* (2001[a]) observed that pre emergence application of atrazine or metribuzin followed by trash mulching gave lower weed dry matter compared to other herbicides. Paraquat 0.6kg ha^{-1}+ 2.4-D @ 2kg ha^{-1} as post-emergence followed by hand weeding at 35 DAP recorded lowest weed count (Nagaraju *et al.*, 2000).

Sathyavelu *et al.* (2000) has reported that pre-planting application of glyphosate with three disc harrowings recorded higher WCE (88.8%) than other treatments of herbicides. Application of metribuzin @ 1.0 kg ha^{-1}+ hoeing controls weed effectively (Naidu *et al.*, 1996). Mahadevaswamy and Kailasam (1994) reported that application of atrazine @ 1kg ha^{-1} followed by trash mulching at 90 DAP recorded lesser dry matter of weeds. Mishra *et al.* (2003) observed that application of ametryn @ 2kg ha^{-1} as pre-emergence followed by one hoeing at 60 DAP recorded lowest weed dry weight at 120 DAP.

Chauhan and Srivastava (2002) revealed that pre-emergence application of atrazine (2kg ha^{-1}) followed by one hoeing at 45 DAP was the best weed control method. Singh *et al.* (1995) reported that one hoeing + three weeding yielded 53 percent more commercial cane sugar (8.36t ha^{-1}) than weedy check (5.02 t ha^{-1}).

2.5. EFFECT OF HERBICIDES ON GROWTH PARAMETERS OF SUGARCANE

2.5.1 Effect of Herbicides on Germination of Sugarcane

Sathyavelu (1990) reported that herbicide did not affect the germination of cane buds adversely. Enhancement of germination due to use of herbicides was observed by Ponnuswamy *et al.* (1996[a]) and Umaratha (1997). Ponnuswamy *et al.* (1996[b]) reported that application of atrazine pre-emergence @ 2 kg ha^{-1} or oxyfluorfen @ 0.18 kg ha^{-1} favoured tiller germination in sugarcane. Umaratha (1997) found that pre-emergence application of atrazine ((@1.98 kg ha^{-1}) followed by post-emergence application of ethoxysulfuron (@80g ha^{-1} at 15 and 30 DAP increased germination by 45.5 percent than unweeded control treatment.

Germination of setts was not influenced by herbicides and cultural practices as reported by many workers (Nagaraju *et al.*, 2000, Mathew *et al.*, 2002 and Phoghat *et al.*, 1988).

2.5.2. Effect of Herbicide on Tiller Production of Cane

Application of pre-emergence herbicide coupled with one hoeing at 60 or 90 DAP, significantly increased shoot population (Mishra *et al.*, 2003).

Singh *et al.* (2001[a]) observed that application of atrazine @ 2kg ha^{-1} as pre emergence followed by 2.4-D 2kg ha^{-1} increased tiller count than control. Pre and post emergence application of herbicides, atrazine (2kg ha^{-1})+ isoplanotox (@ 3 kg ha^{-1}) improves tillering and germination (Agarwal *et al.*, 1995).

Nadagoudar *et al.* (1983) studied the weed control in sugarcane with different herbicide and found that they increased production of tillers.

Ponnuswamy *et al.* (1996[b]) found that pre-emergence application of atrazine or oxyfloufen improves tillering capacity. Application of metribuzin @ 1kg ha^{-1} as post-emergence shows higher germination (Phoghat *et al.*, 1988). Angadi *et al.* (1998) reported that herbicides did not affect any of the cane quality parameters.

2.5.3 Effect of Herbicide on Cane Girth and Cane Weight

Angadi *et al.* (1998) reported that yield-attributing characters like cane height, cane girth and cane length were not affected by herbicides. Sathyavelu *et al.* (2000) reported that pre-plant application of glyphosate with three disc harrowing registered significantly superior cane length. Mathew *et al.* (2002) reported that application of herbicides increased growth and development of cane thereby influencing cane girth.

Kannappan and Ramaswamy (1994) observed that application of isoproturon at 1.0 kg ha^{-1} followed by one hand weeding produced higher cane girth (3.04cm) than control (2.84cm). They reported that pre-emergence and post-emergence application of atrazine recorded higher cane girth and cane length.

Ponnuswamy *et al.* (1996[a]) observed that pre-emergence application of atrazine+ 2.4-D increased the cane weight by 64.5 percent and cane girth by 13.5 percent compared to unweeded check.

Umaratha (1997) reported that atrazine as pre-emergence followed by three rounds of post-emergence application of ethoxysulfuron on 15, 30 and 45 DAP increased the cane weight by 22 percent.

2.5.4. Effect of Herbicide on Cane Yield and Sugar Yield

According to Kannappan and Ramaswamy (1994) application of isoproturon @ 1.0 kg ha^{-1} followed by one hand weeding gave higher cane yield (123.2 t ha^{-1}) than the control (106.5 t ha^{-1}).

Sathyavelu *et al.* (2000) reported that pre-plant application of glyphosate with three disc harrowings was superior and recorded a cane yield of 142.3 and the increase was to the tune of 66.4 percent over control.

Mathew *et al.* (2002) reported that the pre- and post- emergence application of oxyfluorfen had produced the highest cane and sugar yield. Mehra and Brar (1994) found cane yield increase significantly by 80 percent due to control of weeds either through herbicide application (diuron @1.6 kg ha^{-1} as pre-emergence) or by mechanical measures.

Chauhan *et al.* (1999) reported that higher cane yield (103.0 t ha^{-1}) was obtained by application of ametryn @ 4 kg ha^{-1} as early post-emergence at 35-45 DAP. Nagaraju *et al.* (2000) found that metribuzin alone or in combination with trash mulch @8 t ha^{-1} recorded higher cane yield. Singh *et al.* (2001[a]) reported that pre- emergence application of klass @ 1.4kg ha^{-1} and sencor @ 0.7kg ha^{-1} were favourable to increase cane yield.

Among all herbicides, metribuzin @1.0kg ha^{-1} (PE) followed by atrazine @ 2kg ha^{-1} (PE) registered highest sugar yield (Nagaraju *et al.*, 2000). Mahadevaswamy and Kailasam (1994) reported that pre-emergence application of atrazine @ 1.0 kg ha^{-1}+ trash mulching (3.5 t ha^{-1}) at 90 days recorded highest sugar yield (10.26 t ha^{-1}) than control (7.82 t ha^{-1}).

2.6 EFFECT OF HERBICIDES ON QUALITY OF JUICE

Mathew *et al.* (2002) observed that sucrose per cent and CCS percent were not affected in herbicide plots compared to three hoeing at 30, 60 and 90 DAP.

Research conducted by Singh *et al.* (2002) found that Brix, sucrose purity, and CCS were affected in herbicide plots compared to hand weeded plot.

Srivastava *et al.* (1999) observed that pol percent was not much affected in herbicide plot (17.8) compared to three hoeing (17.7). Umaratha (1997) reported that quality of cane was not affected significantly by the weed infestation.

Mahadevaswamy *et al.* (1994) proved that CCS percent was less in herbicide plot compared to hoeing and weeding plot. Mahadevaswamy and Kailasam (1994) studied the influence of weeds on CCS percent and found that it was affected on chemical weeded plot (7.82) compared to that of the plots with hoeing and weeding (9.37). Singh *et al.* (2001[a]) reported that CCS was less in herbicide plot (4.6) compared to hand weeding plot (5.7) and also found that the CCS was very less in weedy plot (10.36) compared to one hoeing and two weeding treatment (17.04).

2.7. EFFECT OF HERBICIDES AND INTERCROPS ON CANE YIELD AND JUICE QUALITY

2.7.1. Effect on Juice Quality

Mahadevaswamy and Kailasam (1994) reported that pre emergence application of atrazine @1kg ha^{-1} followed by trash mulching at 90 DAP improved CCS by 11.54 percent than control.

Nagaraju *et al.* (2000) reported that juice quality parameters did not differ due to herbicide treatments. Similar results have been reported by Agarwal *et al.* (1997), Sathyavelu *et al.* (2000) and Mathew *et al.*(2002).

Research conducted at TNAU by Kannappan and Ramaswamy (1995) revealed that application of isoproturon @ 1.5kg ha^{-1}+ hand weeding significantly increased Brix percent, pol percent and CCS percent to the tune of 2.82, 18.97 and 13.95 over unweeded check (2.73, 18.00 and 13.69,respectively).

Mishra *et al.* (2003) found that pendimethalin @ 1kg ha^{-1} with one hoeing at 60 DAP recorded highest polarity percent (18.85) than control (17.82). Post-emergence application of sencor @ 1.4 kg ha^{-1} gave highest CCS percent compared to all other treatments (Singh *et al.*, 2001[c]). Quality of juice was not affected by any of the herbicide treatments as reported by Chauhan *et al.* (1999).

2.7.2. Effect of intercrops on cane yield and quality parameters

Durai *et al.* (2002) reported that cowpea as intercrop in sugarcane and its incorporation at 60 DAP registered highest cane yield which gave 38 percent increase over control. However, Kannappan and Ramaswamy (1995) reported that sugarcane yield was the highest in sole sugarcane than intercropping sugarcane with soyabean or blackgram. Chakor *et al.* (1997) observed that intercropping blackgram with cane causes minimum reduction in millable cane yield.

Research conducted at Indian Institute of Sugarcane Research (IISR), Lucknow by Shivakumar and Srivastava (1994) revealed minimum reduction in cane yield under cane intercropping with blackgram than sunflower, maize, cowpea and green gram.

Mahendran *et al.* (1997) reported that daincha intercropping in sugarcane recorded higher cane yield (128.26 t ha^{-1}) than that with sunhemp (123.08 t ha^{-1}).

Materials and Methods

They also found higher CCS with daincha (15.13 t ha^{-1}) than sunhemp intercropping (14.11 t ha^{-1}) and that intercrops did not influence juice quality.

Roodagi *et al.* (2000) found that intercropping of sunhemp with sugarcane gave higher cane yield than that with cowpea intercropping. Biradar *et al.* (1995) found that intercrops did not affect the germination significantly but tiller count at 110 DAP got reduced due to intercrops. Harlapur *et al.* (1995) reported severe reduction in cane yield due to intercropping with maize.

2.8 EFFECT OF HERBICIDES ON WEED INDEX (WI) AND WEED CONTROL EFFICIENCY (WCE)

Pre-emergence application of sencor @ 1.4 kg ha^{-1} + trash mulch @ 3.5 t ha^{-1} at 45 DAP leads to lesser weed index (WI) and higher weed control efficiency (WCE) than control (Thakur *et al.*, 1995).

The WCE was higher for trash mulching followed by atrazine+2.4-D (Singh, *et al.*, 2002). Kathiresan and Manoharan (1994) reported that hand hoe weeding at 30 and 60 DAP recorded the highest WCE (91%) followed by chemical spray of atrazine @ 1.4 kg ha^{-1}+ hand weeding.

Sankpal *et al.* (1997) reported that conventional practice (three hoeing+ three weeding) results into higher WCE than herbicide treated plot Pre-plant application of glyphosate with three disc harrowing recorded higher WCE (Sathyavelu *et al.*, 2000). Mahadevaswamy and Kailasam (1994) found that conventional practice of hoeing at 30, 60 and 90 DAP resulted in higher WCE (94.6%). Atrazine and metribuzin gave higher WCE than isoproturon and oxyfluorfen as reported by Nagaraju *et al.* (2000). Kannappan and Ramaswamy (1994) reported that weed management through isoproturon at 1.4 kg ha^{-1} followed by one hand hoeing achieved better WCE (55.88%) than control.

Materials and Methods

Chapter III

MATERIALS AND METHODS

Field experiments was conducted at Anjamile, K.K.Patty post, Chittur taluk, Palakkad district to study the effect of different weed management techniques in sugarcane on weed control, yield and quality of sugarcane.

3.1 MATERIALS

3.1.1 Location

The experiment was conducted in the farmer's field at Anjamile located at Chittur, under irrigated condition during 2002-2003. Anjamile is situated in Palakkad district of Kerala at 10°46'N latitude and 76° 31' E longitude and at an altitude of 97m above mean sea level (MSL).

3.1.2. Field and Soil

The soil of experimental field falls under black alkali with a pH of 7.8. The soil was sandy clay loam in texture. The physical and chemical properties of soil are given in Table 1.

3.1.3 Climate

The weather data observations taken during the period of experimentation are presented in Fig.1a and b and Appendix 1.

3.1.4 Season and Date of Planting

The crop was planted on 12-11-2002 and harvested on 23-09-2003, which took 311 days for maturity.

3.1.5 Variety

Madhurima (Cul. 527/85) was the test variety used for the experiment. This is resistant to red rot, tolerant to drought and water logging. This is suitable for sugar, particularly for jaggery preparation.

Table 1. Physico-chemical properties of soil

No.	Soil characters	Method	Values for initial soil	Reference
1	Particle size analysis	Hydrometer method		Piper (1942)
	Coarse sand		35.56(%)	
	Fine sand		22.88(%)	
	Silt		25.09(%)	
	Clay		16.77(%)	
2	Bulkdensity (gm^{-3})		1.39	
3	Soil pH	1:2.5 soil water suspension using pH meter	7.8	Jackson (1958)
4	Electrical conductivity (dsm^{-1})	E.C. of above suspension using conductivity bridge	0.07	Jackson (1958)
5	Organic carbon (%)	Walkley and Black method	1.23	Jackson (1958)
6	Available N ($kgha^{-1}$)	Alkaline permanganate distillation	218.3	Subbiah and Asija (1956)
7	Available P ($kgha^{-1}$)	Olsen extractant ascorbic acid blue colour method	16.33	Watanabe and Olsen (1965)
8	Available K ($kgha^{-1}$)	Neutral normal ammonium acetate extract, flame photometric method	298.54	Jackson (1958)

Fig. 1a Monthly weather data during the crop period (November 2002 to September 2003)

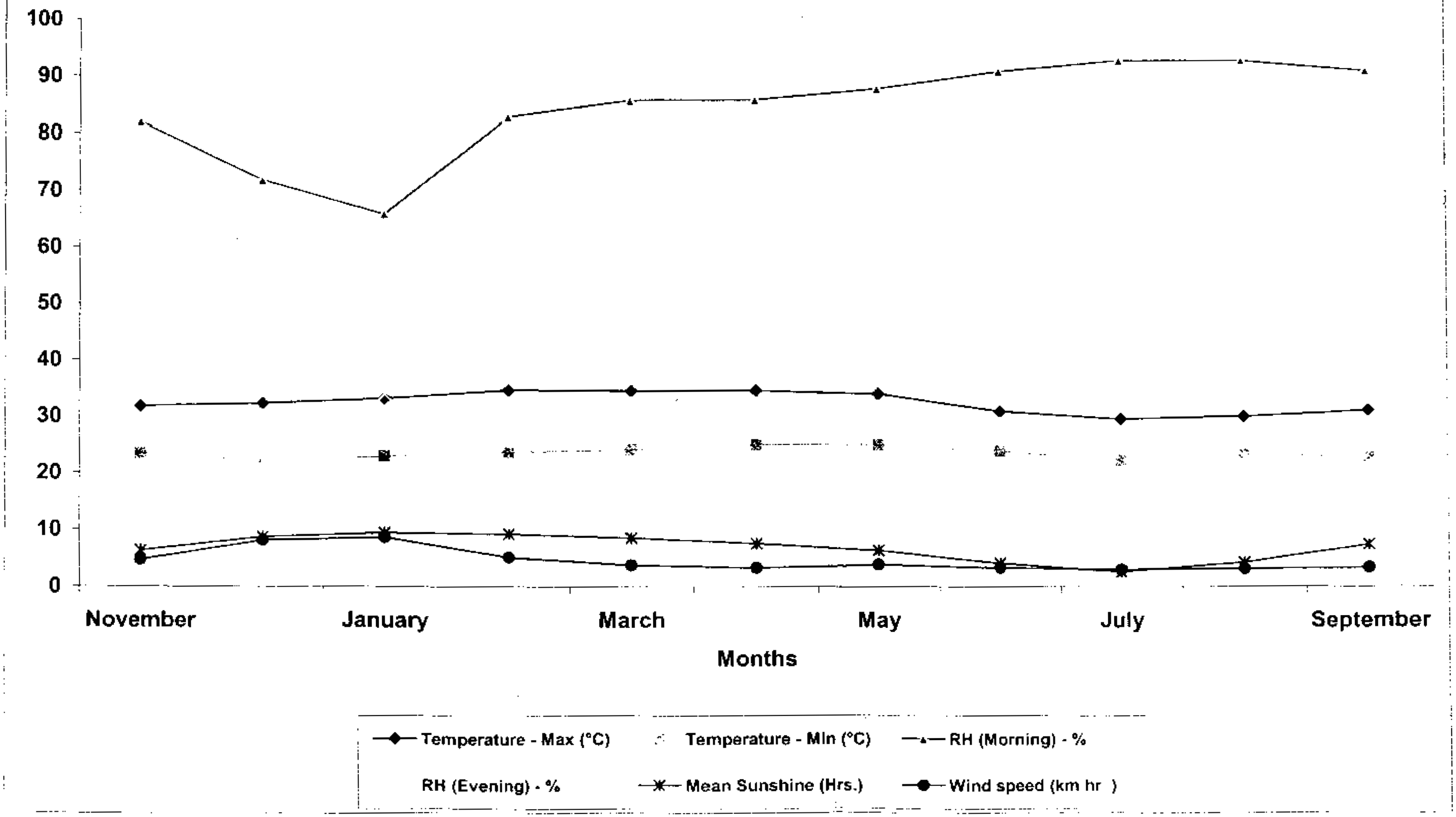
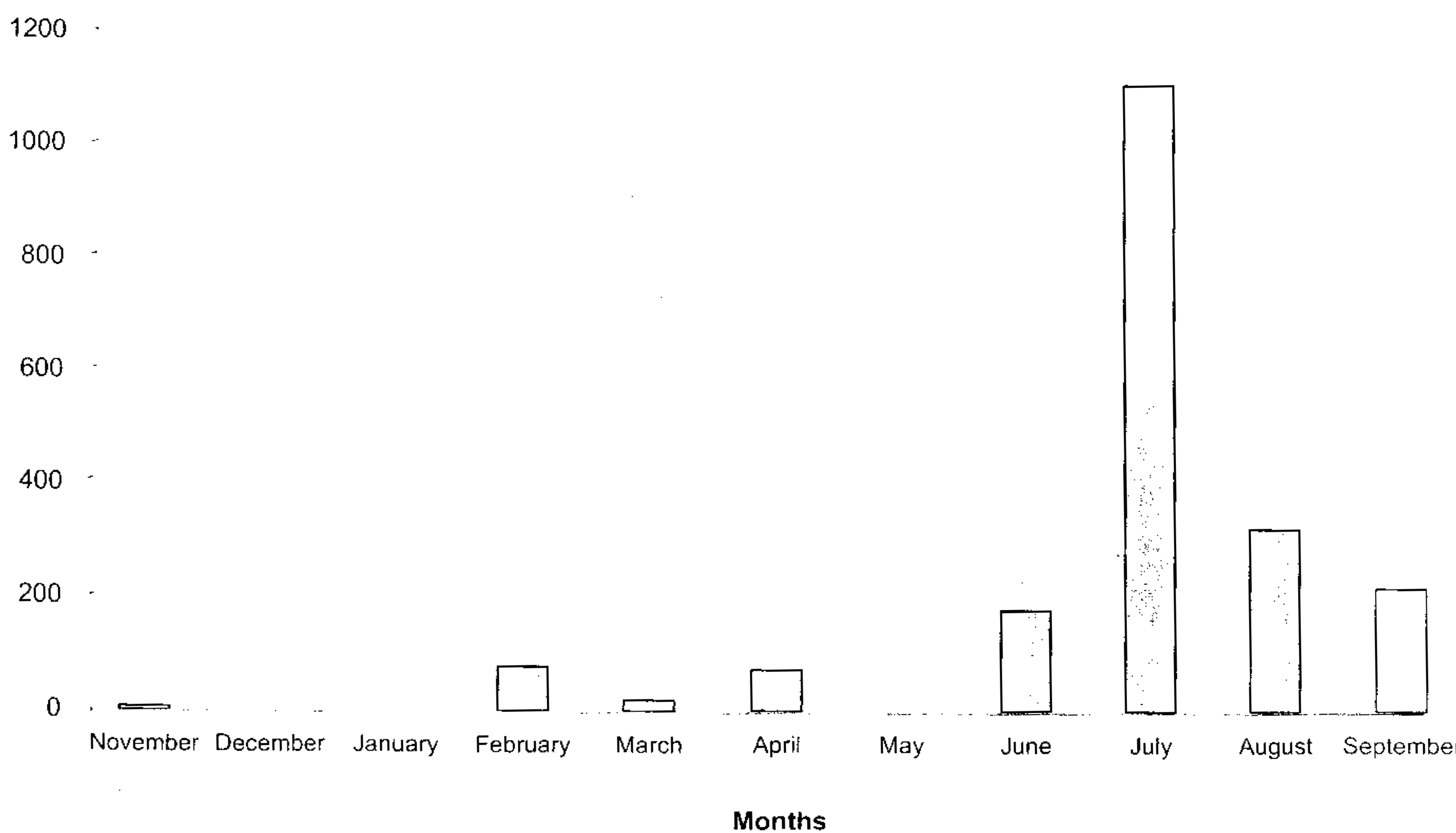


Fig.1b Monthly total rainfall (mm) during the crop period (November 2002 to September 2003)



3.1.6 Irrigation Source

Bore well water was used for irrigation whenever rainfall was absent.

3.2 METHODS

3.2.1 Experimental Design and Layout

The experiment was laid out in a Randomised Block Design (RBD) with three replications and shown in Fig. 2.

3.2.2 Treatments

1. Absolute control (unweeded control)
2. Complete weed control (Three hoeings at 30,60 and 90 DAP)
3. Recommended herbicides viz., atrazine 2kg ha^{-1} as pre- emergence (PE) at 3 DAP fb hoeing and earthing up at 90 DAP
4. Oxyfluorfen 0.20 kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP
5. Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP
6. Glyphosate 1kg ha^{-1} at 20 DAP as directed spray fb 2.4-D 1kg ha^{-1} at 60 DAP
7. Intercropping blackgram and incorporation at 45 DAP
8. Intercropping balckgram for grain and incorporation of bhusa at 90 DAP
9. Intercropping daincha and incorporation at the time of digging at 45 DAP
10. Intercropping sunhemp and incorporation at the time of digging at 45 DAP
11. Intercropping daincha and desiccation by 2.4-D 1kg ha^{-1} at 45 DAP
12. Intercropping sunhemp and desiccation by 2.4-D 1kg ha^{-1} at 45 DAP

fb= followed by, DAP= days after planting.

Intercrops were sown at the time of planting sugarcane.

3.2.3 Plot Size

Each plot was prepared with a gross area of 6.0x6.9 m^2 and planting was done at 75cm x 30 cm spacing in all treatments.

Fig.2 Layout plan of experiment

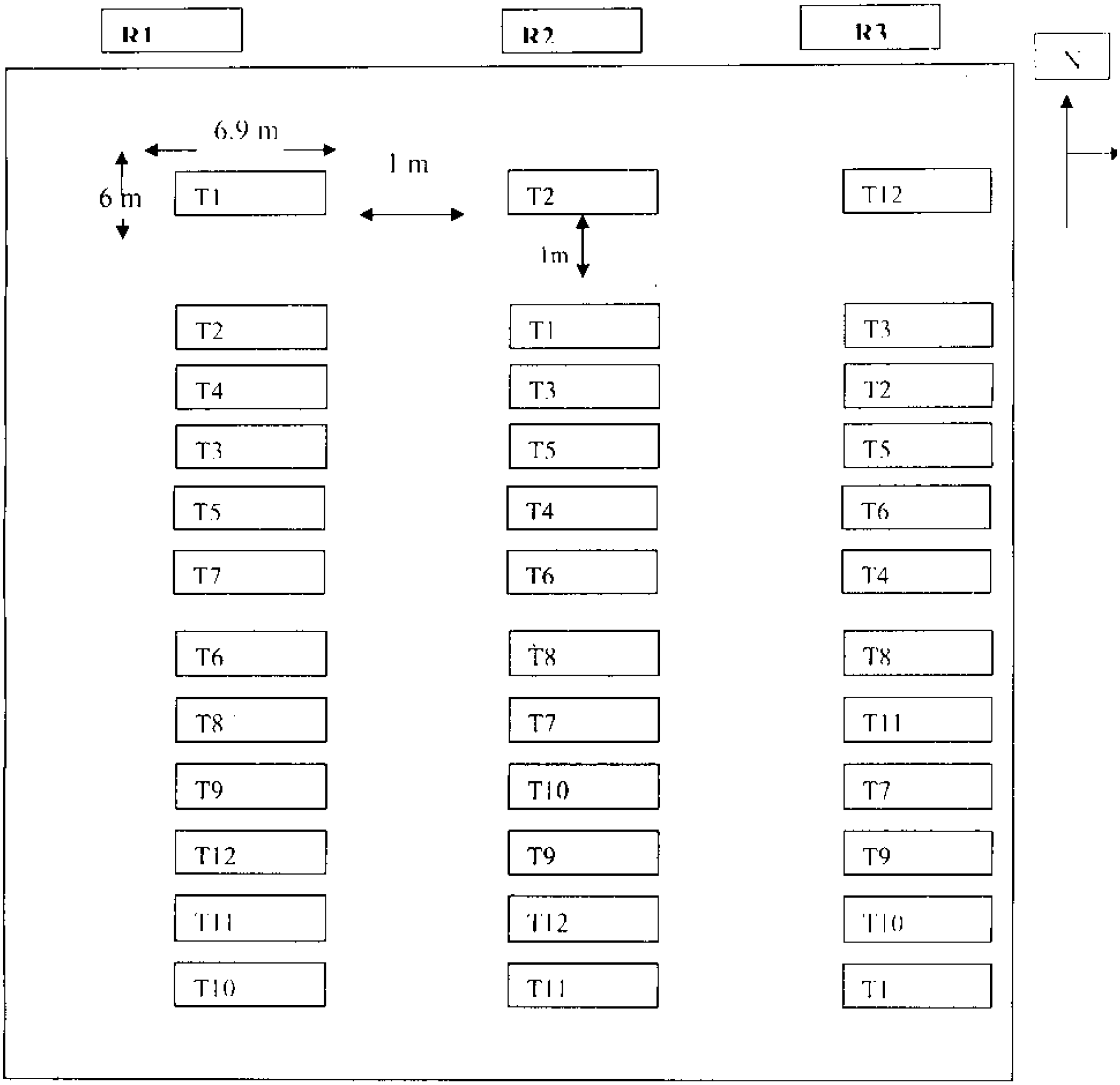


Plate 1. The overall view of the experimental plot

3.2.4 Cultivation Practices

3.2.4.1 Field preparation

The field was thoroughly ploughed with disc plough and harrowed thrice to bring the soil to fine tilth. After levelling, ridges and furrows were formed at a uniform spacing of 75cm.Setts were planted at 30 cm spacing within the rows. Irrigation and drainage channels were provided according to the slope of fields.

3.2.4.2 Setts and planting

Healthy seed materials obtained from seven month old nursery crop were used for planting. Recommended seed rate of 45,000 setts ha^{-1} (three budded setts) was adopted. Setts were pre-treated with bavistin solution (125 gm bavistin+ 2.5kg urea in 250 litre water) for five minutes, to control soil borne fungal pathogens. Irrigation water was let into the plots to soak the soil. The setts were then planted horizontally at the middle of the furrow by keeping all the buds at lateral position to facilitate easy germination of all buds.

3.2.4.3 Fertiliser Application

Nitrogen as urea (46% N), phosphorus as rajphos (18% P_2O_5) and potassium as muriate of potash (60% K_2O) were applied at the rate of 225-75-75 $kgha^{-1}$. Full dose of P was applied by placement in the furrows at planting while N and K were applied in two equal splits at 45 and 90 DAP along with earthing up.

3.2.4.4. Plant Protection

Plant protection measures were taken by drenching of chlorpyriphos @ 2.5 ml l^{-1} to control root grub. And also carbaryl 10% dust was applied in the furrows to control termite and white grubs.

3.2.4.5 Irrigation

Irrigation was scheduled during the cropping period as follows:

A	Germination phase	(1-35 days)	Once in	10 days
B	Tillering phase	(36-100 ")	"	7 "
C	Grand growth phase	(101-270 ")	"	10 "
D	Maturity phase	(271-harvest)	"	14 "

3.2.4.6 Weed Management

Weed management was done as per treatment schedule. In manual weeding (T_2) hoeing was given at 30,60 and 90 DAP. Atrazine, oxyfluorfen and ametryn 2kg ha^{-1}, 0.2kg ha^{-1} and 2kg ha^{-1}, respectively were sprayed on 3 DAP as pre-emergence herbicide. Application of glyphosate 1kg ha^{-1} at 20 DAP and 2.4-D 1kg ha^{-1} at 60 DAP were also given as per treatment.

3.2.5. Sowing of Intercrops

Seeds of intercrops viz., blackgram, sunhemp and daincha were broadcasted on 3 DAP between two rows of sugarcane. Intercropping of blackgram for grain purpose was sown at a spacing 25×15 cm in T_8.

(1). Blackgram

The blackgram (*Vigna mungo* L.) variety TMV-1 with a duration 85-90 days was broadcasted in T_7. It was cut and incorporated in furrows at 45 DAP in the same plot. The same variety was sown at a spacing 25×15 cm for grain purpose (T_8) and harvested at 90 DAP, and the bhusa incorporated into the soil of the same plot.

(2). Daincha: Seeds of the daincha was broadcasted in T_5 and T_{11} treatment. It was cut and incorporated into the soil at 45 DAP in the respective treatments.

(3).Sunhemp: Seeds of sunhemp was broadcasted in T_{10} and T_{12} treatments and cut and incorporated in furrows at 45 DAP in their respective treatment.

3.2.6. Harvest

Matured canes from the net plot area of 3m×3.60m, after leaving two border rows on 6.9m side and four border rows on 6.0m side. Weeds and intercrop observations were recorded on 6.0m side leaving two outside rows as border rows. The matured canes were cut close to the ground separately, stripped and weighed for final cane yield and expressed as t ha^{-1}. The crop was harvested at the age of 10 months.

3.3 OBSERVATIONS RECORDED

Within the net plot area, 10 canes were selected at random, peg marked and subsequently used for recording the required observations.

3.3.1. Growth Attributes

3.3.1.1 Germination Count

Germination count was recorded at 30 DAP and expressed as percentage to the total number of setts planted.

3.3.1.2 Shoot Count

The total number of shoots in each plot were counted and recorded at 90 and 180 DAP and expressed as number of shoots per hectare.

3.3.1.3 Cane Girth

Diameter of internodes were recorded at bottom, middle and top of the millable canes at harvest from the already selected 10 canes and expressed in cm as cane girth.

3.3.1.4 Plant Height

Pegs were fixed near the bottom of ten randomly selected shoots and height measurements were recorded from the peg level to the 3rd visible dewlap of cane (Dillewijn, 1952). The plant heights were taken at 90,150,210 DAP and at harvest.

3.3.1.5 Internodal Length

The distance between two consecutive nodes at the middle portion of the cane at harvest was measured from the selected canes and the average value expressed in cm as internode length.

3.3.1.6 Cane Length

After removing the tops of the randomly selected canes, the length in cm were recorded at harvest and the average value expressed as cane length.

3.3.1.7 Single Cane Weight

Cane weight was recorded at the time of harvest from the already selected 10 canes and data expressed as individual cane weight (kg cane^{-1}).

3.3.2 Crop Yield and Quality

3.3.2.1 Cane Yield

Canes harvested from the net plot area were weighed and cane yield expressed in t ha^{-1}. The sample canes harvested for juice analysis were also weighed and added to net plot weight.

3.3.2.2 Sugar Yield

Sugar yield was calculated from the commercial cane sugar percent (CCS%) at harvest and the cane yield computed as detailed below and expressed in t ha^{-1}.

$$\text{Sugar yield (t ha}^{-1}) = \frac{\text{CCS (\%)} \times \text{Cane yield (t ha}^{-1})}{100}$$

3.3.2.3 Millable Cane Count (MCC)

Total number of millable canes per plot were recorded at harvest and expressed as MCC per hectare(' 000 ha^{-1}).

3.3.2.4 Commercial Cane Sugar (CCS)

The CCS was calculated from the Brix andSucrose using the formula,

$$CCS(\%) = (S - 0.4(B - S) \times 0.73)$$

Where S= Sucrose% in juice and

B= Corrected Brix at 27°c

3.3.2.5 Juice Recovery

Extractable cane juice was estimated at harvest using the following formula and expressed as percentage.

$$\text{Juice recovery (\%)} = \frac{\text{Weight of juice}}{\text{Weight of millable cane}} \times 100$$

3.3.2.6 Purity

The purity per cent of juice was calculated from total soluble solids (Brix) and sucrose percent by the following formula.

$$\text{Purity (\%)} = \frac{\text{Sucrose (\%)}}{\text{Brix (\%)}} \times 100$$

3.3.2.7 Brix and Sucrose

From the juice sample, the total soluble solids was estimated by using brix hydrometer and sucrose was estimated by Horne's dry lead sub-acetate clarification method (Meade and Chen, 1977).

3.3.3 Observations on Weeds

3.3.3.1. Weed Count

Weed count was observed species wise at 45,60 and 90 DAP using $0.25m^2$ quadrant from two randomly fixed places in diagonally opposite sides in each plot outside the net plot area but inside the border rows and expressed as number of weeds per square metre (No.m^{-2}).

3.3.3.2 Weed Dry Weight and NPK Content at 45, 60 and 90 DAP

The whole portion of weeds including roots were uprooted, washed and cleaned, dried under shade, then oven dried at 75-80°c for attaining constant weight and expressed in gram per square metre (gm^{-2}).

The oven dried weed samples were powdered and analysed for nitrogen (N), phosphorus (P) and potassium (K) and the total removal of nutrients expressed as Kg ha^{-1}. The following methods were used in estimating N, P and K content of weeds and intercrops.

Table 2. Methods used for analysis of plant samples.

No.	Plant nutrient	Method	Reference
1	Nitrogen	Micro-kjeldahl digestion and distillation	Jackson (1958)
2	Phosphorus	Vanadomolybdate yellow colour method in HNO_3 medium using spectrophotometer	Koeing and Johnson (1942)
3	Potassium	Direct reading by flame photometer method	Jackson (1958)

3.3.3.3 Weed Index (WI)

The formula given by Gill and Vijaykumar (1969) was used to calculate the weed index

$$WI = \frac{\text{Cane yield in hand weeded plot - Cane yield in treated plot}}{\text{Cane yield in hand weeded plot}} \times 100$$

3.3.3.4. Weed Control Efficiency (WCE)

WCE was calculated by using the following formula (Chauhan, 1988).

$$WCE = \frac{WPC - WPT}{WPC} \times 100$$, where WPC= weed population in control plots and

WPT = weed population in treated plots and expressed as percentage.

3.3.4 Observations on Intercrops

3.3.4.1 Wet and Dry Weight and NPK Content of Intercrops at Incorporation

The 0.25m^2 quadrant was placed at two places at randomly outside the net plot area but inside the border rows. The whole portions of the enclosed intercrops were removed. The wet weights were taken, dried till constant weight was obtained in hot air oven at 80°C. The wet and dry weight were expressed in kg ha^{-1} .The NPK content of intercrops were estimated from dry weight of intercrops and percentage of NPK.

3.3.5 Soil Fertility Analysis

3.3.5.1 Initial Soil Fertility

One composite initial soil sample, individual plot samples at 120 DAP ard at post-harvest stage were taken from a depth of 30 cm. The samples were analysed for organic carbon, available NPK and are expressed as kg ha^{-1}.

The methods followed for the estimation of soil NPK and organic carbon content and the values obtained are given in Table 1.

3.3.6 Statistical Analysis

Analysis of variance was performed on the data collected from the experimental field, using statistical package 'MSTAT' (Freed, 1986). Comparisons among treatment means were done by using Duncan's Multiple Range Test (DMRT). Correlation analysis (Singh and Choudhary, 1977) was also done to work out the relationship between different parameters.

Results

Chapter IV

RESULTS

The present experiment "Weed management on sugarcane (*Saccharum officinarum* L.) through herbicides and intercrops" was conducted at Chittur, Palakkad district during 2002-2003. The data on various observations were subjected to statistical analysis and the results are presented in this chapter.

4.1 WEED COUNT

Four major weed species observed in the experimental field were *Portulaca oleracea*, *Mollugo pentaphylla*, *Trianthema portulacastrum* and *Ageratum conyzoides*. Other minor weeds such as *Euphorbia hirta*, *Corchorus olitorius*, *Solanum nigrum*, *Commelina benghalensis*, *Panicum repens*, *Amaranthus viridis*, *Parthenium hysterophorus*, *Cynodon dactylon* and *Tridax procumbens* etc were also observed.

4.1.1 *Portulaca oleracea*

The data in Table 3 shows that *Portulaca* sp. was highest in unweeded plots at 45 DAP, 60 DAP and 90 DAP with a population of 15.60, 18.64 and 18.90 per square metre, respectively. The weed population in other treatments was much lesser. In general, lesser number of *Portulaca* sp. was observed in plots treated with pre-emergence herbicide (T_3, T_4 and T_5) compared to hand weeding thrice (T_2) and unweeded control (T_1). Among the herbicide treated plots, oxyfluorfen 0.2 kg ha^{-1} (T_4) registered the lowest population which was on par with atrazine 2 kg ha^{-1} as pre-emergence at 3 DAP (T_3) and ametryn 2 kg ha^{-1} (T_5) and complete weed control (T_2). Glyphosate spray at 20 DAP 1.0 kg ha^{-1} registered comparatively higher number of weeds, which was on par with intercropping black gram and incorporation at 45 DAP (T_7). The weed population in T_8, T_9 and T_{12} were comparably higher. Among the intercrops, sunhemp incorporation (T_{10}) or daincha desiccation (T_{11}) registered lower number of

Table 3. Effect of treatments on population of *Portulaca oleracea*

Treatments	Weed count (No m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	15.60^{a}	18.64^{a}	18.90^{a}
T_2 - Complete weed control	1.93^{ef}	1.42^{ef}	1.20^{f}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	$0,80^{f}$	0.90^{f}	0.90^{f}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.65^{f}	0.72^{f}	$.050^{f}$
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.95^{f}	0.85^{f}	0.88^{f}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	12.00^{b}	6.50^{b}	2.64^{e}
T_7 - Blackgram incorporation at 45 DAP.	12.00^{b}	2.50^{de}	2.80^{de}
T_8 - Blackgram bhusa incorporation.	8.00^{c}	6.00^{b}	4.50^{c}
T_9 - Daincha incorporation at 45 DAP.	7.50^{c}	4.00^{c}	4.00^{cd}
T_{10} - Sunhemp incorporation at 45 DAP.	3.50^{e}	2.80^{cd}	3.50^{cde}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	5.30^{d}	5.80^{b}	4.00^{cd}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	8.00^{c}	4.00^{c}	6.64^{b}

DAP = Days after planting PE = Pre-emergence
fb = followed by

weeds. At 60 DAP, it was observed that application of pre-emergence herbicide viz., atrazine (T_3), oxyfluorfen (T_4) or ametryn (T_5) controlled *Portulaca* sp. effectively and was as good as hoeing (T_2). The T_7, T_9, T_{10} and T_{12} recorded less population than T_6, T_8 and T_{11}. The weed population in plots of glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray (T_6), intercropping blackgram for grain (T_8) and intercropping daincha and desiccation by 2,4-D 1.0 kg ha^{-1} at 45 DAP (T11) were on par.

At 90 DAP also the herbicidal treatments (T_3, T_4 and T_5) gave equally effective control of portulaca and recorded the lowest weed population. Intercropping treatments (T_8, T_9, T_{10} and T_{11}) was on par but poor than herbicide treatments. Incorporation of blackgram (T_7) and glyphosate fb 2,4-D at 45 DAP (T_6) also gave less weed population but more than T_3, T_4 and T_5.

4.1.2 *Mollugo pentaphylla*

The *Mollugo* sp. population (Table 4) was highest in unweeded plot at 45 DAP, 60 DAP and 90 DAP and lesser in other treatments.

At 45 DAP, in general, herbicide treated plots registered less number of weeds. Among all, oxyfluorfen (T_4) registered lowest weed population and it was on par with T_3 and T_5 and gave control as good as hoeing. Glyphosate spray at 20 DAP (T_6), intercropping black gram (T_7) or sunhemp desiccation by 2, 4-D (T_{12}) also gave effective control of *Mollugo* sp. at 45 DAP. Intercropping blackgram for grain (T_8) registered more number of weeds and it was on par with intercropping daincha (T_9) and gave more weed count.

At 60 DAP, among pre-emergence herbicide treated plot, oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (T_4) registered lowest number of weeds and it was on par with atrazine 2 kg ha^{-1} as pre-emergent at 3 DAP (T_3) and ametryn 2 kg ha^{-1} as pre-emergence (T_5) and intercropping blackgram for grain (T_8) and gave weed control even better than hoeing treatment (T_2). Among intercrops, intercropping black gram for grain (T_8) registered lowest number of weeds.

Table 4. Effect of treatments on population of *Mollugo pentaphylla*

Treatments	Weed count (No m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	12.00^{a}	14.50^{a}	15.20^{a}
T_2 - Complete weed control	1.50^{de}	1.60^{cdef}	1.64^{de}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.95^{de}	0.95^{ef}	0.85^{e}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.65^{e}	0.67^{f}	0.80^{e}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.85^{de}	0.70^{ef}	1.20^{e}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.64^{d}	3.10^{b}	3.20^{c}
T_7 - Blackgram incorporation at 45 DAP.	1.62^{de}	2.64^{bc}	2.64^{cd}
T_8 - Blackgram bhusa incorporation.	8.00^{b}	1.32^{f}	5.60^{b}
T_9 - Daincha incorporation at 45 DAP.	8.64^{b}	2.50^{bcd}	2.64^{cd}
T_{10} - Sunhemp incorporation at 45 DAP.	4.64^{c}	1.48^{def}	2.50^{cd}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	5.64^{c}	2.50^{bcd}	2.80^{cd}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.32^{de}	1.80^{cde}	1.90^{de}

DAP = Days after planting PE = Pre-emergence
fb = followed by

Intercropping treatments (T_9, T_{10}, T_{11} and T_{12}) gave weed control effect as good as hoeing (T_2). Glyphosate spray (T_6) was poor than other treatments but was better than unweeded control (T_1).

At 90 DAP also, herbicide treatments (T_3, T_4 and T_5) except glyphosate gave effective control of weeds. Intercropping sunhemp and desiccation by 2,4-D (T_{12}) controlled weeds effectively as that of hoeing (T_2). Intercropping blackgram (T_7) or daincha (T_9) registered equal weed population followed by intercropping daincha and desiccation by 2,4-D (T_{11}) and intercropping sunhemp as green manure (T_{10}) which were on par and better than unweeded control.

4.1.3 *Trianthema portulacastrum*

At all stages of observation, unweeded control (T_1) registered highest weed population (Table 5). At 45 DAP, herbicide treatments T_3, T_4, T_5 and T_6 registered less weed population than that in hoeing plots (T_2). Intercropping blackgram (T_8) or sunhemp (T_9) were poor than hoeing (T_2) but better than other intercropping treatments. Intercropping daincha (T_9 and T_{11}) or sunhemp desiccation by 2,4-D (T_{12}) were on par and registered higher weed population than herbicide treatments.

At 60 DAP, glyphosate 1.0 kg ha^{-1} at 20 DAP (T_6) gave higher weed population but significantly lesser than unweeded control. The *Trianthema* sp. populations in all other treatments were on par.

At 90 DAP, among all the treated plots, glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray fb 2,4-D at 60 DAP (T_6) showed highest weed population followed by sunhemp incorporation at 45 DAP(T_{10}) and were on par with each other. There was no difference in *Trianthema* sp. population between other treatments.

Table 5. Effect of treatments on population of *Trianthema portulacastrum*

Treatments	Weed count (No m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	4.00^a	5.32^a	8.52^a
T_2 - Complete weed control	0.50^d	0.55^c	0.62^c
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.42^d	0.45^c	1.32^c
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.41^d	0.45^c	0.48^c
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.45^d	0.48^c	0.52^c
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.52^d	2.67^b	2.80^b
T_7 - Blackgram incorporation at 45 DAP.	2.64^b	0.50^c	0.62^c
T_8 - Blackgram bhusa incorporation.	1.32^c	0.54^c	0.68^c
T_9 - Daincha incorporation at 45 DAP.	2.64^b	0.62^c	1.42^c
T_{10} - Sunhemp incorporation at 45 DAP.	1.32^c	0.56^c	2.64^b
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	2.64^b	0.62^c	0.62^c
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	2.64^b	0.58^c	0.52^c

DAP = Days after planting PE = Pre-emergence
fb = followed by

4.1.4 *Ageratum conyzoides*

The number of *Ageratum* sp. (Table 6) was higher at all stages in unweeded plot.

At 45 DAP, all herbicide treated plots (T_4, T_3, T_5 and T_6) registered lower weed population that was on par with hoeing (T_2). Intercropping, in general, gave higher weed count than herbicide but definitely better than unweeded plots. Sunhemp as intercropping (T_{12}) registered highest weed population followed by intercropping blackgram for grain (T_8), whereas intercropping sunhemp (T_{10}) registered lowest weed population.

At 60 DAP, among the treatments, intercropping sunhemp and desiccation (T_{12}) gave the highest weed population (2.64 m^{-2}) followed by glyphosate (T_6) and intercropping black gram for grain (T_8), where the weed population were 1.32 and 1.49 per sq m. The weed population in herbicide and other intercrop treatments were significantly lower than that of the above treatments.

Later at 90 DAP, among the treated plots, intercropping daincha and desiccation by 2,4-D (T_{11}) registered lowest weed population which was on par with oxyfluorfen 0.20 kg ha^{-1} (PE) fb 2,4-D 1.0 kg ha^{-1} at 60 DAP (T_4) and ametryn 2 kg ha^{-1} (PE) fb 2,4-D 1 kg ha^{-1} at 60 DAP (T_5) whereas highest weed population was shown by intercropping blackgram for grain (T_8). Complete weed control (T_2) was on par with atrazine 2 kg ha^{-1} at 3 DAP fb hoeing and earthing up at 90 DAP (T_3) and incorporation of blackgram at 45 DAP (T_7). In intercropping blackgram for grain incorporation of bhusa (T_8) or intercropping sunhemp and desiccation by 2,4-D 1.0 kg ha^{-1} at 45 DAP (T_{12}), the weed population was higher than the other intercrop and herbicide treatments.

4.1.5 Total Weed Population

Table 6. Effect of treatments on population of *Ageratum conyzoides*

Treatments	Weed count (No m^{-2})		
	45 DAP	60 DAP	90 DAP.
T_1 - Absolute control (unweeding)	8.00^{a}	9.64^{a}	9.85^{a}
T_2 - Complete weed control	0.41^{f}	0.45^{d}	0.48^{ef}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.25^{f}	0.32^{d}	0.36^{ef}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.15^{f}	0.18^{d}	0.27^{f}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.27^{f}	0.29^{d}	0.27^{f}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.27^{f}	1.32^{c}	1.35^{d}
T_7 - Blackgram incorporation at 45 DAP.	4.64^{c}	0.29^{d}	0.32^{ef}
T_8 - Blackgram bhusa incorporation.	5.20^{bc}	1.49^{c}	3.20^{b}
T_9 - Daincha incorporation at 45 DAP.	2.60^{d}	0.56^{d}	1.32^{d}
T_{10} - Sunhemp incorporation at 45 DAP.	1.50^{e}	0.52^{d}	0.85^{de}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	4.50^{c}	0.15^{d}	0.15^{f}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	5.50^{b}	2.64^{b}	2.64^{c}

DAP = Days after planting PE = Pre-emergence
fb = followed by

Table 7. Effect of treatments on total weed population

Treatments	Weed count (No m^{-2}).		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	42.30^a	55.63^a	62.35^a
T_2 - Complete weed control	6.53^f	6.82^e	4.82^f
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	2.50^g	3.15^f	4.12^{fg}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.15^g	2.85^f	2.95^h
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.95^g	3.15^f	3.52^{gh}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	17.23^d	16.68^b	11.90^d
T_7 - Blackgram incorporation at 45 DAP.	24.48^c	7.95^e	7.85^e
T_8 - Blackgram bhusa incorporation.	27.70^b	11.70^c	15.15^b
T_9 - Daincha incorporation at 45 DAP.	23.78^c	9.50^d	11.65^d
T_{10} - Sunhemp incorporation at 45 DAP.	12.67^e	6.85^e	12.10^d
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	19.26^d	11.25^c	8.12^e
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	19.26^d	11.55^c	13.59^c

DAP = Days after planting PE = Pre-emergence
fb = followed by

The total weed count (Table 7) was highest in unweeded plot (T_1) at all stages of observation with the values of 42.30; 55.63 and 62.35 per sq metre at 45, 60 and 90 DAP respectively.

In general, herbicide treated plots (T_3, T_4 and T_5) showed less number of weeds compared to all other treatments, at all stages of observation.

At 45 DAP, lowest weed population was recorded by oxyfluorfen 0.2 kg ha^{-1} as pre-emergence (T_4) followed by atrazine 2 kg ha^{-1} (T_3) and ametryn 2 kg ha^{-1} as pre-emergence (T_5). Among intercrops, lowest weed population of 12.67 per square metre was registered by sunhemp incorporation at 45 DAP (T_{10}) compared to other intercropping treatments. Comparatively higher weed population was recorded by glyphosate spray (T_6) and it was on par with daincha and sunhemp desiccation (T_{11} and T_{12}), whereas those in daincha incorporation (T_9) and blackgram incorporation (T_7) were on par and higher. At 60 DAP also, T_{10} showed lesser number of weeds. However, at 90 DAP these treatments showed more population than T_7 and T_{11} slightly, but very much lower than unweeded control (T_1).

4.2 DRY MATTER PRODUCTION OF WEEDS

4.2.1 *Portulaca oleracea*

The dry matter production of weeds as influenced by different weed control treatments at different growth stages are given in Table 8.

The weight of *Portulaca* was highest in un-controlled plot at all stages of observation. The values were 33.28, 48.46 and 52.37 g m^{-2} at 45, 60 and 90 DAP, respectively. The herbicide treatments in T_3, T_4 and T_5 gave statistically equal weight and were lower at all stages of observation. They were effective as good as hoeing. Intercropping treatments (T_8, T_9, T_{10}, T_{11} and T_{12}) gave less weed dry matter but were not as effective as herbicide treated plots (T_3, T_4 and T_5).

Table 8. Effect of treatments on dry matter production of *Portulaca oleracea*

Treatments	Weed dry weight (g m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	33.28^{a}	48.46^{a}	52.37^{a}
T_2 - Complete weed control	2.88^{e}	2.98^{de}	3.36^{fg}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	1.28^{e}	1.89^{e}	2.52^{g}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.04^{e}	1.51^{e}	7.23^{g}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.52^{e}	1.78^{e}	2.46^{g}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	19.20^{b}	13.65^{b}	5.05^{f}
T_7 - Blackgram incorporation at 45 DAP.	19.20^{b}	5.25^{d}	7.84^{e}
T_8 - Blackgram bhusa incorporation.	12.80^{c}	12.60^{b}	12.6^{c}
T_9 - Daincha incorporation at 45 DAP.	12.00^{c}	8.40^{c}	11.20^{cd}
T_{10} - Sunhemp incorporation at 45 DAP.	13.60^{c}	8.50^{c}	9.80^{bc}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	8.48^{d}	12.18^{b}	11.20^{cd}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	12.80^{c}	8.40^{c}	18.59^{b}

DAP = Days after planting PE = Pre-emergence
fb = followed by

At 45 DAP, among all the treated plots, glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray (T_6) and intercropping blackgram (T_7) recorded higher dry matter production and were on par. At 60 DAP higher dry matter production was registered by glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray after unweeded control and it was on par with intercropping blackgram for grain (T_8) and daincha desiccation by 2,4-D 1.0 kg ha^{-1} at 45 DAP (T_{11}). Among the intercrops, lowest dry matter was recorded in blackgram incorporation at 45 DAP (T_7) followed by intercropping daincha or sunhemp and incorporation at 45 DAP (T_9 and T_{10}) and intercropping sunhemp and desiccation by 2,4-D at 45 DAP (T_{12}) but were higher than hoeing (T_2). At 90 DAP, among the intercropping treatments, blackgram incorporation (T_7) gave the lowest weed weight, followed by incorporation of daincha (T_9) and desiccation of daincha by 2,4-D at 45 DAP (T_{11}) and incorporation of sunhemp at 45 DAP (T_{10}). The weed dry weights in these treatments were significantly higher than that in T_3, T_4 and T_5 but lower than unweeded control.

4.2.2 *Mollugo pentaphylla*

The data on Table 9 reveals that the *Mollugo* sp. weight was very less in T_3, T_4 and T_5 at all stages of observation (0.27 to 0.4 g m^{-2} at 45 DAP, 0.55 to 0.75g m^{-2} at 60 DAP and 0.83 to 1.25 g m^{-2} at 90 DAP) which was effective as good as hoeing (0.64, 1.26 and 1.72 g m^{-2} at 45, 60 and 90 DAP, respectively). The effect of intercropping was more pronounced at 60 DAP and 90 DAP. At 60 DAP, T_8, T_9, T_{10}, T_{11} and T_{12} recorded lower weights and at 90 DAP, desiccation of sunhemp by 2,4-D (T_{12}) gave the lowest weight followed by incorporation of sunhemp at 45 DAP (T_{10}), incorporation of daincha (T_9) and desiccation of daincha (T_{11}).

4.2.3 *Trianthema portulacastrum*

The data in the Table 10 shows that at 45 DAP the lowest weed dry matter production observed by oxyfluorfen 0.20 kg ha^{-1} as pre-emergent (T_4) was

Table 9. Effect of treatments on dry matter production of *Mollugo pentaphylla*

Treatments	Weed dry matter (g m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	12.96^{a}	15.70^{a}	18.18^{a}
T_2 - Complete weed control	0.64^{e}	1.26^{de}	1.72^{h}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.40^{e}	0.75^{f}	0.88^{i}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.27^{e}	0.53^{f}	1.25^{i}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.36^{e}	0.55^{f}	0.83
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.13^{de}	2.45^{b}	3.34^{c}
T_7 - Blackgram incorporation at 45 DAP.	0.69^{e}	2.09^{bc}	2.76^{e}
T_8 - Blackgram bhusa incorporation.	3.43^{b}	1.04^{f}	5.85^{b}
T_9 - Daincha incorporation at 45 DAP.	3.68^{b}	1.98^{bc}	2.75^{e}
T_{10} - Sunhemp incorporation at 45 DAP.	1.98^{c}	1.66^{cd}	2.61^{f}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	2.40^{c}	1.98^{bc}	2.92^{d}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	0.56^{e}	1.42^{de}	1.98^{g}

DAP = Days after planting PE = Pre-emergence
fb = followed by

Table 10. Effect of treatments on dry matter production of *Trianthema portulacastrum*

Treatments	Weed dry matter ($g\ m^{-2}$)		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	12.82^a	12.28^a	18.62^a
T_2 - Complete weed control	0.68^e	1.38^c	2.57^c
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.57^f	1.08^c	5.48^d
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.56^f	1.08^c	2.7^c
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.61^f	1.07^c	2.99^c
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.71^e	5.97^b	8.38^b
T_7 - Blackgram incorporation at 45 DAP.	3.57^c	1.12^c	3.56^c
T_8 - Blackgram bhusa incorporation.	1.81^d	1.20^c	3.92^c
T_9 - Daincha incorporation at 45 DAP.	3.63^b	1.38^c	6.14^d
T_{10} - Sunhemp incorporation at 45 DAP.	1.81^d	1.24^c	7.41^c
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	3.63^b	1.37^c	3.57^c
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	3.68^b	1.29^c	2.99^c

DAP = Days after planting PE = Pre-emergence
fb = followed by

significantly less than hoeing (T_2) plots and it was on par with atrazine (T_3) and ametryn (T_5) treatments. Highest dry matter was noticed in intercropping sunhemp and desiccation (T_{12}) followed by intercropping daincha (T_9) and daincha desiccation (T_{11}) were on par. Glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray (T_6) was as effective as hoeing (T_2).

At 60 DAP, among the treatments highest dry matter production was observed by glyphosate 1.0 kg ha^{-1} at 20 DAP as directed spray. The lowest dry matter production recorded by ametryn (T5), which was on par with T_3, T_4, T_7, T_8, T_9, T_{10}, T_{11} and T_{12} and were effective as that of hoeing. Among the intercrops, highest value was observed in daincha incorporation at 45 DAP (T_9) followed by daincha desiccation by 2,4-D (T_{11}) which were on par whereas lowest value was recorded by blackgram incorporation (T_7).

At 90 DAP, oxyfluorfen 0.20 kg ha^{-1} (T_4) followed by 2,4-D 1 kg ha^{-1} (T_4) accounted for lowest dry matter production and was on par with T_2, T_5 and T_8, T_{11} and T_{12} Glyphosate spray (T_6) recorded highest dry matter followed by sunhemp intercropping (T_{10}), whereas lowest dry matter was observed in sunhemp desiccation by 2,4-D (T_{12}).

4.2.4 *Ageratum conyzoides*

The dry matter production of *Ageratum* sp. at 45, 60 and 90 DAP are given in Table 11. The effect of herbicides in T_3, T_4 and T_5 on weed control was evident at all stages of observation. The weight of weed was lowest in these treatments almost parallel to that of hoeing (T_2).

At 45 DAP, intercropping sunhemp and desiccation by 2,4-D (T_{12}) gave highest weed dry matter after unweeded control followed by blackgram for grain (T_8) and were on par. Among intercrops, intercropping sunhemp incorporation (T_{10}) recorded lowest dry matter (1.35 g m^{-2}) whereas highest dry matter (4.95 g m^{-2}) was by sunhemp desiccation by 2,4-D (T_{12}). Glyphosate directed spray (T_6) was effective to control *Ageratum sp.*

Table 11. Effect of treatments on dry matter production of *Ageratum conyzoides*

Treatments	Weed dry matter ($g\ m^{-2}$)		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	15.84^{a}	21.83^{a}	24.31^{a}
T_2 - Complete weed control	0.36^{f}	0.59^{de}	0.749^{ef}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.22^{f}	0.42^{def}	0.63^{ef}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.13^{f}	0.23^{ef}	0.46^{ef}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.24^{f}	0.38^{def}	0.53^{ef}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.24^{f}	1.74^{c}	2.35^{d}
T_7 - Blackgram incorporation at 45 DAP.	4.14^{c}	0.38^{def}	0.56^{ef}
T_8 - Blackgram bhusa incorporation.	4.68^{b}	1.74^{c}	5.60^{b}
T_9 - Daincha incorporation at 45 DAP.	2.34^{d}	0.73^{d}	2.31^{d}
T_{10} - Sunhemp incorporation at 45 DAP.	1.35^{e}	0.68^{d}	1.48^{e}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	4.05^{c}	0.15^{f}	1.25^{f}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	4.95^{b}	3.52^{b}	4.54^{c}

DAP – Days after planting PE – Pre-emergence
fb = followed by

At 60 DAP, intercropping black gram (T_7 and T_8), daincha incorporation (T_9 and T_{11}) and sunhemp incorporation (T_{10}) were effective in controlling *Ageratum* growth.

At 90 DAP blackgram incorporation (T_7) produced lowest dry matter (0.56 g m^{-2}) among all intercropping treatments, whereas highest value of 5.60 g m^{-2} was recorded in intercropping blackgram for grain (T_8) followed by intercropping sunhemp and desiccation by 2,4-D (T_{12}). Glyphosate spray (T_6) was on par with daincha (T_9) and sunhemp incorporation (T_{10}).

4.3 TOTAL WEED DRY MATTER PRODUCTION

The total weed dry matter weight (Table 12) was highest in unweeded control plot (T_1) at all stages of observation. The values were 76.20, 100.30 and 118.50 g m^{-2} at 45, 60 and 90 DAP respectively.

Herbicide treated plots (T_3, T_4 and T_5) showed lower dry matter production compared to all other treatments at all observations, the range being 2.27-3.12, 4.78-6.73 and 8.81-13.25 g m^{-2} at 45,60 and 90 DAP, respectively.

At 45 DAP lowest weed dry matter production was observed in oxyfluorfen 0.2 kg ha^{-1} as pre-emergence (T_4) followed by atrazine 2 kg ha^{-1} (T_4) and ametryn 2 kg ha^{-1} (T_5). Among intercrops, any definite variation could not be seen except in T_7 and T_8 which was much higher compared to other treatments. Weed dry matter in blackgram for grain (T_8) was on par with intercropping daincha (T_9), which was on par with sunhemp desiccation by 2,4-D (T_{12}).

At 60 DAP, interestingly blackgram incorporation (T_7) showed lesser dry matter production followed by intercropping daincha (T_9) and sunhemp (T_{10}). Among intercrops, at 90 DAP weed weight was lowest in blackgram incorporation (T_7) and it was higher in blackgram bhusa incorporation (T_8) and sunhemp desiccation (T_{12}).

Table 12. Effect of treatments on total weed dry matter production

Treatments	Weed dry matter (g m^{-2})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	76.20^{a}	100.30^{a}	118.50^{a}
T_2 - Complete weed control	5.20^{g}	7.32^{g}	11.32^{f}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	2.87^{h}	5.16^{hi}	13.52^{f}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.29^{h}	4.78^{i}	8.81^{g}
T_5 - Ametryn 2kg ha (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	3.12^{h}	6.73^{gh}	8.81^{g}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	22.18^{d}	25.10^{b}	21.26^{d}
T_7 - Blackgram incorporation at 45 DAP.	28.32^{b}	10.98^{f}	16.62^{e}
T_8 - Blackgram bhusa incorporation.	24.56^{c}	18.63^{c}	29.92^{b}
T_9 - Daincha incorporation at 45 DAP.	22.80^{cd}	14.68^{e}	24.42^{c}
T_{10} - Sunhemp incorporation at 45 DAP.	20.24^{ef}	14.80^{e}	23.10^{cd}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	19.24^{f}	17.99^{cd}	21.24^{d}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	21.36^{de}	16.83^{d}	30.10^{b}

DAP = Days after planting PE = Pre-emergence
fb = followed by

4.4 WEED CONTROL EFFICIENCY AND WEED INDEX

4.4.1 Weed Control Efficiency (WCE)

Weed control efficiency as influenced by various weed control treatments on sugarcane at different growth stages are presented in Table 13.

At 45 DAP weed control efficiency ranged from 34.52 to 94.92 percent in T_9 and T_4, respectively. In pre-emergence (PE) herbicide plots the WCE were higher (93.03 to 94.92%). Highest weed control efficiency was noticed in oxyfluorfen 0.20 kg ha^{-1} (T_4) and was on par with atrazine 2 kg ha^{-1} (T_3) and ametryn 2 kg ha^{-1} (T_5). All pre-emergence herbicides gave higher weed control efficiency than hoeing (T_2). Glyphosate 1.0 kg ha^{-1} as directed spray (T_6) showed lower weed control efficiency. The WCE in intercropping treatments were significantly lower than PE herbicide treatments. Among intercrops, sunhemp (T_{10}) gave better weed control efficiency (70.05) than other intercropping treatments. Other treatments, glyphosate 1.0 kg ha^{-1} (T_6), daincha desiccation by 2,4-D (T_{11}) and sunhemp desiccation by 2,4-D (T_{12}) were on par and gave weed control efficiency lower than pre-emergent herbicide (T_3, T_4 and T_5) and sunhemp incorporation (T_{10}).

Both 60 and 90 DAP weed control efficiency were higher in pre-emergence herbicide plots fb 2,4-D, which ranged form 94.34 to 94.88 percent at 60 DAP and from 93.40 to 95.27% at 90 DAP, almost as good as hoeing (T_2) treatment (87.75 at 60 DAP and 92.27% at 90 DAP).

Among the intercrops, sunhemp incorporation (T_{10}) gave the highest weed control efficiency followed by blackgram incorporation (T_7) and daincha incorporation (T_9) at 60 DAP .At 90 DAP, black gram incorporation (T7) gave the highest weed control efficiency which was on par with daincha desiccation (T11) followed by daincha (T9) and sunhemp (T10) incorporation.

Table 13. Effect of treatments on weed control efficiency

Treatments	Weed Control Efficiency (%) at		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	-	-	-
T_2 - Complete weed control	84.57^{b}	87.75^{b}	92.27^{b}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	93.50^{a}	94.34^{a}	93.40^{ab}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	94.92^{a}	94.88^{a}	95.27^{a}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	93.03^{a}	94.34^{a}	94.36^{ab}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	59.27^{d}	70.02^{e}	80.92^{d}
T_7 - Blackgram incorporation at 45 DAP.	46.08^{e}	85.71^{bc}	87.41^{c}
T_8 - Blackgram bhusa incorporation.	34.52^{f}	78.97^{d}	75.71^{f}
T_9 - Daincha incorporation at 45 DAP.	43.79^{e}	82.93^{bcd}	81.32^{d}
T_{10} - Sunhemp incorporation at 45 DAP.	70.05^{c}	87.69^{b}	80.60^{d}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	54.47^{d}	79.98^{cd}	86.98^{c}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	54.47^{d}	79.24^{cd}	78.22^{e}

DAP = Days after planting PE = Pre-emergence
fb = followed by

4.4.2 Weed index (WI)

Weed index denotes the reduction in cane yield in different treatments compared to weed free plot and expressed as percentage.

The weed index (Table 14) ranged from 5.05 (T_{10}) to 45.30 percent (T_1). The highest weed index of 45.30 percent was noticed in unweeded control (T_1) followed by daincha desiccation by 2,4-D (T_{11}), which gave 33.57 percent. The lowest weed index was observed in intercropping sunhemp (T_{10}) and it was followed by atrazine 2 kg ha^{-1} (T_3), oxyfluorfen 0.20 kg ha^{-1} (T_4) and ametryn 2 kg ha^{-1} (T_5) which gave weed index as 12.70, 18.86 and 19.94, respectively. All treatments gave weed index significantly lower than unweeded control. Among the treatments, sunhemp incorporation (T_{10}) gave significantly lowest weed index and between other treatments spectacular variation was not evident.

4.5 BIOMASS PRODUCTION AND NUTRIENT CONTENT OF INTERCROPS

Blackgram, daincha and sunhemp were taken as intercrops in sugarcane to study their effect on weed control on sugarcane growth and yield. The biomass and nutrient content in these intercrops were estimated at 45 DAP (except in T_8) and are given in Table 15. In T_8, bhusa was analysed at 85 DAP at the time of incorporation. Among the intercrops, the growth and biomass production was higher for sunhemp (T_{10} and T_{12}), which produced wet biomass of 10.73 to 10.79 t ha^{-1} and 4.96 to 5.04 t ha^{-1} dry matter. The daincha (T_9 and T_{11}) biomass production was almost half to that of sunhemp. The performance of blackgram (T_7 and T_8) was very poor compared to sunhemp and daincha. Among these treatments, the bhusa recovery in blackgram for grain (T_8) was lowest possibly because of inadequate sunlight and other growth factors. Blackgram (T_8) did not flower satisfactorily and grain yield was practically nil.

The content of N, P and K in green manures was also higher in sunhemp, which ranged from 113.09 to 120.96 kg N ha^{-1}, 26.21 to 28.27 kg P ha^{-1} and

Table 14. Effect of treatments on weed index

Treatments	Weed index (%)
T_1 - Absolute control (unweeding)	45.30[a]
T_2 - Complete weed control	-
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	12.70[cd]
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	18.86[c]
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	19.94[bc]
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	23.42[bc]
T_7 - Blackgram incorporation at 45 DAP.	21.00[bc]
T_8 - Blackgram bhusa incorporation.	22.87[bc]
T_9 - Daincha incorporation at 45 DAP.	21.51[bc]
T_{10} - Sunhemp incorporation at 45 DAP.	5.05[d]
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	33.57[b]
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	21.18[bc]

DAP – Days after planting PE = Pre-emergence
fb = followed by

Table 15. Effect of treatments on wet weight, dry weight and nutrient content of intercrops

Treatments	Wet weight (t ha^{-1})	Dry weight (t ha^{-1})	NPK content (kg ha^{-1})		
			N	P	K
T_7 - Blackgram incorporation at 45 DAP.	2.72	0.95	19.95	3.42	23.66
T_8 - Blackgram bhusa.	1.65	0.45	7.42	1.71	11.30
T_9 - Daincha incorporation at 45 DAP.	5.20	2.59	49.99	11.40	62.68
T_{10} - Sunhemp incorporation at 45 DAP.	10.79	5.04	120.96	26.21	125.50
T_{11} - Daincha desiccation by 2,4-D @ 1kg a.i. ha^{-1} at 45 DAP.	5.17	2.53	47.05	10.88	60.21
T_{12} - Sunhemp desiccation by 2,4-D @ 1kg a.i. ha^{-1} at 45 DAP.	10.73	4.96	113.09	28.27	121.02

DAP = Days after planting

121.02 to 125.50 kg K ha^{-1}. The content of N, P and K in daincha was about half to that of sunhemp and that in blackgram.

4.6 NUTRIENT REMOVAL BY WEEDS

4.6.1 Nitrogen (N)

The nitrogen removal by weeds is presented in Table 16.

At 45 DAP, N removed by weeds ranged from 0.93 to 30.70 kg ha^{-1}, which were significantly different among treatments. In general, the N removal was lower in PE herbicides compared to intercropping treatments. Application of oxyfluorfen 0.20 kg ha^{-1} (T_4) removed the lowest N (0.93 kg ha^{-1}) at 45 DAP followed by ametryn 2 kg ha^{-1} (T_5). The highest N removed by unweeded control (T_1) was significantly above all other treatments. Among intercrops, sunhemp incorporation (T_{10}) removed least nitrogen.

At 60 DAP, the N removal ranged from 1.38 to 35.42 kg ha^{-1}. The highest nutrient removed was observed in unweeded control (T_1) followed by blackgram intercropping (T_8 and T_7) and glyphosate spray (T_6).

At 90 DAP, N removal ranged from 1.94 to 43.91 kg ha^{-1}. After the unweeded control, the highest N removal was in blackgram bhusa incorporation (T_8) and black gram incorporation at 45 DAP (T_7), whereas lowest value recorded by oxyfluorfen 0.20 kg ha^{-1} (T_4) followed by atrazine 2 kg ha^{-1} (T_3).

4.6.2 Phosphorus (P)

From the data in Table 17, it is clear that at 45 and 60 DAP, P removed by weeds ranged from 0.06 to 5.86 and 0.09 to 4.70 kg ha^{-1}, respectively. Herbicides or intercrops significantly reduced P removal by weeds over unweeded control. Among the treatments, highest P removal by weeds was recorded by intercropping blackgram for grain (T_8) whereas lowest removal was in oxyfluorfen 2 kg ha^{-1} (T_4) followed by atrazine 2 kg ha^{-1} (T_3) and ametryn 2 kg

Table 16. Effect of treatments on N removal by weeds

Treatments	Nitrogen removal in (kg ha^{-1})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	30.70^a	35.42^a	43.91^a
T_2 - Complete weed control	2.32^h	3.91^h	5.76^i
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	1.58^i	2.36^i	3.74^k
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2,4-D 1kg ha^{-1} at 60 DAP.	0.93^k	1.38^j	1.94^l
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2,4-D 1kg ha^{-1} at 60 DAP.	1.33^j	2.81^h	4.96^j
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2,4-D 1kg ha^{-1} at 60 DAP.	6.42^e	12.08^d	13.49^d
T_7 - Blackgram incorporation at 45 DAP.	8.73^c	13.14^c	16.25^c
T_8 - Blackgram bhusa incorporation.	10.42^b	17.38^b	16.75^b
T_9 - Daincha incorporation at 45 DAP.	7.92^d	9.98^e	11.22^f
T_{10} - Sunhemp incorporation at 45 DAP.	3.92^g	7.32^g	8.31^h
T_{11} - Daincha desiccation by 2,4-D 1kg ha^{-1} at 45 DAP.	5.76^f	9.90^f	9.00^g
T_{12} - Sunhemp desiccation by 2,4-D 1kg ha^{-1} at 45 DAP.	6.59^e	9.68^e	12.77^e

DAP = Days after planting PE = Pre-emergence
fb = followed by

Table 17. Effect of treatments on P removal by weeds

Treatments	Phosphorus removal in (kg ha^{-1})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	5.86^{a}	4.70^{a}	10.24^{a}
T_2 - Complete weed control	0.20^{i}	0.28^{j}	1.22
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.09^{k}	1.77^{d}	0.71^{j}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.06^{l}	0.09^{l}	0.18^{l}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.15^{j}	0.21^{k}	0.38^{k}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.79^{g}	1.56^{e}	5.08^{b}
T_7 - Blackgram incorporation at 45 DAP.	1.63^{c}	2.54^{c}	3.42^{c}
T_8 - Blackgram bhusa incorporation.	1.95^{b}	2.58^{b}	4.54^{c}
T_9 - Daincha incorporation at 45 DAP.	1.68^{c}	1.34^{f}	3.48^{d}
T_{10} - Sunhemp incorporation at 45 DAP.	0.65^{h}	0.78^{i}	1.67^{h}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.12^{f}	1.18^{g}	2.29^{g}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.21^{e}	0.90^{h}	2.66^{f}

DAP = Days after planting PE = Pre-emergence
fb = followed by

ha^{-1} (T_5). Among intercrops, sunhemp incorporation (T_{10}) recorded lowest removal at 60 DAP. At 90 DAP, oxyfluorfen 0.20 kg ha^{-1} (T4) recorded lowest P removal, whereas highest value was in glyphosate spray (T_6).

4.6.3 Potassium (K)

Potassium removal by weeds by treatments got significantly reduced over unweeded control at all stages. The data in Table 18 reveals that at 45 and 60 DAP, K removed by weeds ranged from 1.19 to 27.0 and 1.67 to 37.6 kg ha^{-1}, respectively. The K removal in herbicide plots was less than that in intercropped plots. At 60 DAP, highest K removal observed in intercropping blackgram for grain (T_8) followed by intercropping sunhemp (T_{12}), whereas the lowest K was removed in oxyfluorfen 0.2 kg ha^{-1}, followed by atrazine 2 kg ha^{-1} .Among intercrops, sunhemp incorporation (T_{10}) and daincha desiccation by 2,4-D (T_{11}) recorded lower K removal at 45 and 60 DAP.

At 90 DAP, K removal ranged from 2.77 to 59.20 kg ha^{-1}. The highest K removal was by weeds in intercropping sunhemp (T_{12}) followed by blackgram for grain (T_8), whereas lowest K recorded in oxyfluorfen 0.20 kg ha^{-1}.

Intercropping treatments permitted more uptake of N by weeds than PE herbicides and it was lowest in daincha desiccation by 2,4-D (T_{11}). Although the intercrops permitted more nutrient removal than herbicide it was recycled into the soil, which could increase soil fertility.

4.7. SOIL ORGANIC CARBON (OC) AND NPK

4.7.1 Soil Organic Carbon and NPK at 120 DAP

Soil organic carbon (OC%) and NPK (kg ha^{-1}) at 120 DAP are given in Table 19. The highest organic carbon (1.02%) obtained in the case of sunhemp desiccation by 2,4-D (T_{12}) and it was superior to T_5, T_6 and T_{11} and was on par with other treatments except ametryn (T_5) and glyphosate spray (T_6).

Table 18. Effect of treatments on K removal by weeds

Treatments	Potassium removal in (kg ha^{-1})		
	45 DAP	60 DAP	90 DAP
T_1 - Absolute control (unweeding)	27.00^{a}	37.60^{a}	59.20^{a}
T_2 - Complete weed control	2.47^{j}	4.15^{h}	6.35^{h}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	1.65^{k}	2.72^{i}	4.08^{i}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.19^{l}	1.67^{k}	2.77^{j}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.79^{j}	2.92^{i}	4.16^{h}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	6.44^{g}	11.21^{f}	21.04^{c}
T_7 - Blackgram incorporation at 45 DAP.	7.07^{f}	12.80^{e}	25.01^{c}
T_8 - Blackgram bhusa incorporation.	8.63^{b}	18.12^{b}	26.16^{c}
T_9 - Daincha incorporation at 45 DAP.	7.98^{d}	13.15^{d}	20.89^{d}
T_{10} - Sunhemp incorporation at 45 DAP.	4.84^{h}	9.34^{g}	20.18^{d}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	7.18^{e}	9.20^{g}	16.95^{f}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	9.50^{c}	15.30^{c}	28.99^{b}

DAP = Days after planting PE = Pre-emergence
fb = followed by

Table 19. Effect of treatments on soil organic carbon and NPK at 120 DAP

Treatments	Soil fertility status at 120 DAP			
	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K(kg ha^{-1})
T_1 - Absolute control (unweeding)	0.91^{ab}	225.10^{a}	23.84^{ab}	303.81^{a}
T_2 - Complete weed control	0.88^{ab}	229.10^{a}	23.41^{abc}	303.92^{a}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.91^{ab}	230.11^{a}	23.28^{abc}	309.31^{a}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.92^{ab}	222.52^{a}	22.71^{bc}	304.27^{a}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.86^{b}	223.43^{a}	22.40^{bc}	307.54^{a}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.86^{b}	222.70^{a}	23.07^{abc}	304.41^{a}
T_7 - Blackgram incorporation at 45 DAP.	0.91^{ab}	222.51^{a}	23.67^{abc}	311.42^{a}
T_8 - Blackgram bhusa incorporation.	0.88^{ab}	233.41^{a}	22.26^{bc}	308.12^{a}
T_9 - Daincha incorporation at 45 DAP.	0.92^{ab}	223.52^{a}	23.39^{abc}	317.56^{a}
T_{10} - Sunhemp incorporation at 45 DAP.	0.95^{ab}	233.00^{a}	24.71^{a}	313.12^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	0.82^{b}	223.41^{a}	21.94^{c}	310.94^{a}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.02^{a}	232.00^{a}	22.93^{bc}	310.46^{a}

DAP - Days after planting PE = Pre-emergence
fb – followed by

Soil N at 120 DAP was not influenced by various weed control treatments. The soil N ranged from 222.51 to 233.41 kg ha^{-1}.

The soil P ranged from 21.94 to 24.71 kg ha^{-1}. The highest soil P was observed in sunhemp incorporation (T_{10}). The spectacular increase on P content by intercropping was not seen, except that intercropping sunhemp (T_{10}) was superior to oxyfluorfen 0.20 kg ha^{-1} (T_4), ametryn 2 kg ha^{-1} (T_5), intercropping blackgram for grain (T_8), daincha (T_{11}) and sunhemp (T_{12}) desiccation by 2,4-D.

Soil K at 120 DAP was not significantly influenced by weed control treatments. The soil K at 120 DAP ranged from 303.81 to 317.56 kg ha^{-1}. Highest soil K was registered in daincha intercropping (T_9) and it was lowest in unweeded control (T_1).

4.7.2 Soil Organic Carbon and NPK at Harvest

The soil organic carbon (OC%) and NPK (kg ha^{-1}) are given in Table 20.

The soil organic carbon (OC%) after harvest ranged from 0.78 to 0.98 percent. Highest soil organic carbon was noticed in sunhemp desiccation by 2,4-D (T_{12}) and lowest in oxyfluorfen (T_4) plot. Between other intercrop treatments there was no difference. Similarly, between herbicide plots also there was no difference.

The soil N at harvest ranged from 224.61 to 241.56 kg ha^{-1}. Any definite advantage of intercropping systems in increasing soil N content over herbicide treatments was not evident in the experiment. Among the intercropping treatments the highest soil N was obtained by sunhemp desiccation by 2,4-D (T_{12}) followed by sunhemp (T_{10}) and daincha incorporation (T_9). The lowest value was observed in daincha desiccation by 2,4-D (T_{11}).

Soil P was not influenced by various treatments. The soil P ranged from 18.44 to 21.96 kg ha^{-1}. The highest value obtained in intercropping sunhemp (T_{10}) whereas it was lowest in ametryn 2 kg ha^{-1} (T_5).

Table 20. Effect of treatments on soil organic carbon and NPK at post harvest

Treatments	Soil fertility status at post harvest stage			
	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K(kg ha^{-1})
T_1 - Absolute control (unweeding)	0.86^{ab}	227.42^{bc}	20.41^{a}	302.84^{a}
T_2 - Complete weed control	0.83^{b}	228.63^{abc}	19.38^{a}	305.23^{a}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	0.88^{ab}	229.81^{abc}	18.94^{a}	307.56^{a}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.78^{b}	226.84^{bc}	18.98^{a}	304.52^{a}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.82^{b}	232.94^{abc}	18.44^{a}	309.23^{a}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	0.89^{ab}	225.58^{bc}	19.75^{a}	307.51^{a}
T_7 - Blackgram incorporation at 45 DAP.	0.78^{b}	234.26^{abc}	21.46^{a}	312.80^{a}
T_8 - Blackgram bhusa incorporation.	0.84^{b}	225.91^{bc}	18.97^{a}	306.82^{a}
T_9 - Daincha incorporation at 45 DAP.	0.85^{b}	238.32^{abc}	21.27^{a}	310.43^{a}
T_{10} - Sunhemp incorporation at 45 DAP.	0.80^{b}	238.92^{ab}	21.96^{a}	312.24^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	0.83^{b}	224.61^{c}	19.06^{a}	307.19^{a}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	0.98^{a}	241.56^{a}	19.04^{a}	301.92^{a}

DAP = Days after planting PE = Pre-emergence
fb = followed by

Soil K was not influenced by various weed control treatments. The soil K ranged from 301.92 to 312.80 kg ha^{-1}. The highest value obtained in case of intercropping blackgram (T7) whereas it was lowest in sunhemp desiccation by 2,4-D (T_{12}).

4.8. CROP GROWTH AND YIELD

The germination percentage and shoot count at 90 and 180 DAP are given in Table 21.

4.8.1 Germination

Germination percentage ranged from 72.00 to 84.99. The germination percent was highest in oxyfluorfen applied plot (T_4). However, it was significantly lower in glyphosate spray (T_6). In between other treatments appreciable variation in germination rate could not be observed. The data suggest that herbicides except glyphosate sprayed plot did not affect germination of sugarcane.

4.8.2 Shoot Count

At 90 DAP, shoot count ranged from 86.79 to 119.90 ('000ha^{-1}). The number of shoots was lowest in unweeded control (T_1) followed by glyphosate spray (T_6). The shoot count was highest in oxyfluorfen (T_4) followed by atrazine (T_3) and ametryn (T_5) which was on par with incorporation of sunhemp (T_{10}) and were on par with complete weed control (T_2) and definitely superior to unweeded control (T_1).

At 180 DAP, shoot count ranged from 99.99 to 133 ('000) ha^{-1}. The highest shoot count was observed in intercropping blackgram (T_7), which was on par with complete weed control (T_2), oxyfluorfen 0.20kg ha^{-1} (T_4), daincha incorporation (T_9), sunhemp incorporation (T_{10}) and sunhemp desiccation by 2,4-D (T_{12}). Among pre-emergence herbicides, ametryn 2 kg ha^{-1} (T_5) gave poor performance.

Table 21. Effect of treatments on germination and shoot count

Treatments	Germination (%)	Shoot count ('000 ha^{-1})	
		90 DAP	180 DAP
T_1 - Absolute control (unweeding)	78.90^{a}	86.79^{h}	99.99^{e}
T_2 - Complete weed control	81.60^{a}	118.44^{ab}	129.40^{c}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	81.65^{a}	118.50^{ab}	120.80^{c}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	84.99^{a}	119.90^{a}	132.80^{a}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	82.80^{a}	99.90^{g}	113.20^{c}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	72.00^{b}	100.70^{g}	107.30^{d}
T_7 - Blackgram incorporation at 45 DAP.	82.80^{a}	117.50^{bc}	133.00^{a}
T_8 - Blackgram bhusa incorporation.	82.35^{a}	109.90^{e}	122.10^{b}
T_9 - Daincha incorporation at 45 DAP.	82.80^{a}	114.20^{d}	133.00^{a}
T_{10} - Sunhemp incorporation at 45 DAP.	82.08^{a}	119.40^{a}	133.00^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	81.63^{a}	107.60^{f}	123.10^{b}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	81.45^{a}	116.20^{c}	130.40^{c}

DAP = Days after planting PE = Pre-emergence
fb = followed by

4.8.3 Plant height

Data on plant height at 90, 150 and 210 DAP and at harvest are presented in Table 22.

At 90 DAP, plant height ranged from 154 to 196 cm. The plants were highest in intercropping sunhemp (T_{10}) followed by complete weed control (T_2) whereas lowest value was recorded for glyphosate spray (T_6). Between other treatments there was no spectacular difference in plant height. Complete weed control (T_2) also gave increased plant height but on par with unweeded control (T_1), atrazine @ 2 kg ai ha^{-1} (T_3), oxyfluorfen @ 0.20 kg ai ha^{-1} (T_4) and ametryn @ 2 kg ai ha^{-1} (T_5). Among intercropping systems, black gram for bhusa incorporation (T_8) recorded lowest plant height.

At 150 DAP, plant height ranged from 229 to 286 cm. The highest plant height recorded in atrazine 2 kg ha^{-1} (T_3), followed by oxyfluorfen 0.2 kg ha^{-1} (T_4), intercropping sunhemp (T_{10}) and sunhemp desiccation by 2,4-D (T_{12}) were on par with all other treatments except control plot (T_1) and glyphosate spray (T_6), whereas lowest plant height recorded in unweeded control (T_1).

At 210 DAP, plant height ranged from 295 to 350 cm. The highest plant height at 210 DAP recorded by intercropping blackgram for grain (T_8) and intercropping daincha (T_9) followed by intercropping blackgram (T_7) were on par with all other treatments except unweeded control (T_1), glyphosate spray (T_6) and sunhemp desiccation by 2,4-D (T_{12}).

At the time of harvest, plant height ranged from 351 cm (unweeded control- T_1) to 392 cm (incorporation of sunhemp-T_4). Highest plant height was observed in incorporation of sunhemp (T_{10}) followed by incorporation of daincha (T_9) and atrazine (T_3) oxyfluorfen 0.20 kg ha^{-1} (T_4) and sunhemp desiccation by 2,4-D (T_{12})

Table 22. Effect of treatments on plant height

Treatments	Plant height (cm)			
	90 DAP	150 DAP	210 DAP	Harvest
T_1 - Absolute control (unweeding)	180^{ab}	229^{c}	295^{b}	351^{c}
T_2 - Complete weed control	195^{ab}	271^{ab}	318^{ab}	389^{ab}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	193^{ab}	286^{a}	325^{ab}	389^{ab}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	193^{ab}	285^{a}	328^{ab}	390^{ab}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	190^{ab}	277^{ab}	317^{ab}	379^{abc}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	154^{c}	242^{bc}	305^{b}	375^{abd}
T_7 - Blackgram incorporation at 45 DAP.	191^{ab}	275^{ab}	344^{a}	373^{abcd}
T_8 - Blackgram bhusa incorporation.	172^{bc}	278^{ab}	350^{a}	388^{ab}
T_9 - Daincha incorporation at 45 DAP.	184^{ab}	275^{ab}	350^{a}	390^{a}
T_{10} - Sunhemp incorporation at 45 DAP.	196^{a}	282^{a}	324^{ab}	394^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	175^{ab}	275^{ab}	324^{ab}	367^{abcd}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	185^{ab}	282^{a}	305^{b}	363^{bcd}

DAP = Days after planting PE = Pre-emergence
fb = followed by

4.8.4 Cane Length

Cane length, cane girth and internodal length are given in Table 23.

The highest cane length was observed in intercropping sunhemp (T_{10}), whereas it was lowest in unweeded control (T_1). Complete hand weeding was on par with atrazine 2 kg ha^{-1} (T_3), oxyfluorfen 0.2 kg ha^{-1} (T_4) and ametryn 2 kg ha^{-1} (T_5) and intercropping sunhemp (T_{10}). All pre-emergence herbicides gave higher cane length. Among intercrops, highest cane length of 2.75 m was recorded in intercropping sunhemp (T_{10}), while lowest of 2.10 m was noticed in daincha desiccation by 2,4-D (T_{11}).

4.8.5 Cane Girth

The cane girth (Table 23) was highest (9.66 cm) in intercropping blackgram for grain (T8) was by intercropping sunhemp (T10) (9.63 cm) and were on par with all treatments except unweeded control (T1) and glyphosate spray (T6). All pre-emergence herbicides and intercrops gave higher cane girth than unweeded control. Daincha desiccation by 2,4-D 1.0 kg ha^{-1} at 45 DAP (T_{11}) recorded lower cane girth compared to other intercropping treatments.

4.8.6 Internodal Length

The internodal length (Table 23) ranged from 12.3 cm to 18.05 cm. The highest internodal length recorded by complete hand weeding (T_2) was followed by incorporation of sunhemp (T_{10}) oxyfluorfen (T_4) and atrazine (T_3) and they were on par, whereas lowest internodal length was recorded from unweeded control (T_1) followed by blackgram for grain (T_8) and intercropping blackgram (T_7). All pre-emergence herbicides treated plots (T_3, T_4 and T_5) recorded an average length of 16.5 cm and were on par. Intercropping daincha and incorporation at 45 DAP (T_9) also showed similar internodal length.

Table 23. Effect of treatments on cane length, cane girth and internodal length

Treatments	Cane length (m)	Cane girth (cm)	Internodal length (cm)
T_1 - Absolute control (unweeding)	1.65^{f}	7.06^{c}	12.93^{d}
T_2 - Complete weed control	2.68^{a}	9.40^{ab}	18.05^{a}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	2.60^{ab}	9.37^{ab}	16.79^{b}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.67^{a}	9.55^{ab}	16.88^{ab}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.71^{a}	9.11^{ab}	15.94^{b}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	2.22^{de}	8.55^{b}	14.69^{c}
T_7 - Blackgram incorporation at 45 DAP.	2.34^{cd}	8.89^{ab}	13.78^{cd}
T_8 - Blackgram bhusa incorporation.	2.34^{de}	9.66^{a}	12.94^{d}
T_9 - Daincha incorporation at 45 DAP.	2.45^{bc}	9.22^{ab}	16.37^{b}
T_{10} - Sunhemp incorporation at 45 DAP.	2.75^{a}	9.63^{a}	18.04^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	2.10^{e}	8.66^{ab}	14.22^{c}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	2.22^{de}	9.00^{ab}	14.73^{c}

DAP = Days after planting   PE = Pre-emergence
fb = followed by

4.8.7 Single Cane Weight

Table 24 shows that the single cane weight (kg $cane^{-1}$) ranged from 0.82 in control (T_1) to 1.50 kg in hoeing (T_2). The cane weight in unweeded control (T_1) was significantly poor than other treatments followed by daincha desiccation (T_{11}). The highest single cane weight recorded from complete hand weeding (T_2) followed by oxyfluorfen 0.20 kg ha^{-1} (T_4) and sunhemp incorporation at 45 DAP (T_{10}) were on par with atrazine (T_3) .

4.8.8 Millable Cane Count

The millable cane count at harvest (Table 24) was influenced by different weed control treatments in sugarcane.

The millable cane population ranged from 57.04 to 68.60 ('000) ha^{-1} from unweeded control (T_1) to complete weed control (T_2), respectively. Among intercropping treatments, sunhemp incorporation (T_{10}), daincha incorporation (T_9) and sunhemp desiccation (T_{12}) gave higher values. Among PE herbicides oxyfluorfen 0.20 kg ha^{-1} (T_4) recorded 67.52 ('000) ha^{-1}, which was on par with ametryn (T_5) and atrazine (T_3). All pre-emergence herbicide treated plots gave higher millable cane count. Lower millable cane population was registered by glyphosate spray (T^6), incorporation of black gram bhusa (T_8) and daincha desiccation by 2,4-D (T_{11}), which were on par.

4.8.9 Cane Yield

The data on cane yield are presented in Table 24.

Cane yield was significantly influenced by different weed control treatments. Among pre-emergence herbicide, oxyfluorfen (T_4) was found the best one followed by atrazine (T_3) and ametryn (T_5). Among intercrops, sunhemp incorporation (T_{10}) was the best, followed by sunhemp desiccation (T_{12}). Cane yield (102.50 t ha^{-1}) was highest in complete hand weeding (T_2), which was on par with oxyfluorfen 0.20 kg ha^{-1} (T_4). Sunhemp incorporation (T_{10}) and atrazine

Table 24. Effect of treatments on single cane weight, millable cane count, cane yield and sugar yield

Treatments	Single cane weight (kg cane^{-1})	Millable cane count ('000 ha^{-1})	Cane yield (t ha^{-1})	Sugar yield (t ha^{-1})
T_1 - Absolute control (unweeding)	0.82^{e}	57.04^{d}	47.11^{e}	3.88^{e}
T_2 - Complete weed control	1.50^{a}	68.60^{a}	102.90^{a}	8.73^{abc}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	1.40^{ab}	64.09^{bc}	90.04^{bc}	7.14^{cd}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.48^{ab}	67.52^{ab}	100.00^{ab}	9.40^{ab}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.26^{c}	65.19^{abc}	82.43^{c}	7.24^{cd}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	1.23^{c}	63.58^{c}	78.77^{cd}	7.53^{bcd}
T_7 - Blackgram incorporation at 45 DAP.	1.26^{c}	64.20^{bc}	81.30^{c}	7.34^{bcd}
T_8 - Blackgram bhusa incorporation.	1.24^{c}	63.46^{c}	79.02^{cd}	7.5[illegible]^{bcd}
T_9 - Daincha incorporation at 45 DAP.	1.23^{c}	65.68^{abc}	80.79^{cd}	7.86^{abcd}
T_{10} - Sunhemp incorporation at 45 DAP.	1.44^{ab}	67.56^{ab}	97.77^{b}	9.86^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.11^{d}	63.19^{c}	68.42^{d}	6.36^{d}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	1.36^{bc}	65.31^{abc}	87.75^{bc}	8.19^{abcd}

kg ha^{-1} (T_3) were on par. Lowest cane yield (47.11 t ha^{-1}) was accounted in unweeded control (T_1) followed by daincha desiccation by 2,4-D (T_{11}).

4.8.10 Sugar Yield

Sugar yield in various treatments (Table 24) ranged from 3.88 in unweeded control (T1) to 9.86 t ha^{-1} in sunhemp incorporation(T_{10}). Unweeded control (T_1) was the poorest one followed by daincha desiccation by 2,4-D (T_{11}). Among the pre-emergence herbicide, oxyfluorfen 0.20 kg ha^{-1} gave higher sugar yield whereas in other treatments it was significantly less. Among the intercrops, sunhemp incorporation (T_{10}) gave highest sugar yield followed by sunhemp desiccation (T_{12}) on parity with complete weed control (T_2). Complete weeding (T_2) was on par with atrazine 2.0 kg ha^{-1} (T_4), intercropping daincha (T_9), intercropping sunhemp (T_{10}) and sunhemp desiccation by 2,4-D (T_{12}). Among intercropping treatments, daincha desiccation by 2,4-D (T_{11}) performed significantly poor, whereas between other treatments there was no much variation except that intercropping sunhemp (T_{10}) which performed significantly better.

4.9 JUICE QUALITY

The CCS percent, juice recovery, SMT Brix, sucrose and purity are presented in Table 25.

4.9.1 Commercial Cane Sugar (CCS)

The CCS percent ranged from 7.94 to 10.09 and this quality parameter was not influenced by various weed control treatments.

4.9.2 Juice Recovery

The juice recovery ranged from 51.37 to 66.07 percent, and it was not much influenced by weed control treatments. The juice recovery was highest (66.07%) in sunhemp incorporation (T_{10}) followed by daincha incorporation (T_9)

Table 25. Effect of treatments on commercial cane sugar, juice recovery, SMT Brix, sucrose content and purity

Treatments	Commercial cane sugar (%)	Juice recovery (%)	SMT Brix (%)	Sucrose percent (%)	Purity (%)
T_1 - Absolute control (unweeding)	8.23^{a}	51.37^{b}	16.16^{b}	12.67^{ab}	78.45^{a}
T_2 - Complete weed control	8.49^{a}	61.92^{ab}	17.80^{ab}	13.39^{ab}	75.77^{a}
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	7.94^{a}	60.78^{ab}	18.42^{a}	1303^{ab}	70.81^{a}
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	9.42^{a}	61.30^{ab}	17.64^{ab}	14.26^{ab}	80.97^{a}
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	8.80^{a}	52.72^{b}	16.89^{ab}	12.46^{b}	79.57^{a}
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	9.51^{a}	59.05^{ab}	16.78^{ab}	14.11^{ab}	84.68^{a}
T_7 - Blackgram incorporation at 45 DAP.	9.05^{a}	61.52^{ab}	17.86^{ab}	13.73^{ab}	80.24^{a}
T_8 - Blackgram bhusa incorporation.	9.61^{a}	60.97^{ab}	16.97^{ab}	14.25^{ab}	83.24^{a}
T_9 - Daincha incorporation at 45 DAP.	9.68	65.19^{a}	17.23^{ab}	14.43^{ab}	83.84^{a}
T_{10} - Sunhemp incorporation at 45 DAP.	10.09^{a}	66.07^{a}	17.30^{ab}	14.81^{a}	85.61^{a}
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	8.94^{a}	55.06^{ab}	16.51^{ab}	13.30^{ab}	81.01^{a}
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	9.22^{a}	55.40^{ab}	17.47^{ab}	14.15^{ab}	81.78^{a}

and were on par with all treatments except unwedded control (T_1) and ametryn (T_5).

4.9.3 SMT Brix

The data on SMT Brix reveals that it was not significantly influenced by treatments, except atrazine (T_3) which was significantly superior to unweeded control (T_1). The SMT Brix values ranged from 16.16 to 18.42 percent.

4.9.4 Sucrose

The sucrose content ranged from 12.46 to 14.81 percent. The highest sucrose content was observed in sunhemp incorporation (T_{10}). It was on par with all treatments except ametryn 2 kg ha^{-1} (T_5) which recorded lowest sucrose content.

4.9.5 Purity

The different weed control treatments did not influence significantly the purity of juice. The juice purity ranged from 70.81 to 85.61 percent. The highest value was recorded in sunhemp incorporation (T_{10}) and it was lowest in unweeded control (T_1).

4.10 CORRELATION STUDIES

4.10.1 Correlation between Cane Yield and Yield Contributing Characters

The correlation coefficients between cane yield and yield factors (Table 26) reveals significant positive correlation between cane yield and plant height at 150 DAP, cane girth, cane length, internodal length, single cane weight, number of shoots at 90 and 180 DAP and millable cane count. Plant height at 90 DAP and at harvest was correlated to cane yield at lower level (5%) of significance only. It was also observed that there was no correlation between cane yield and plant height at 210 DAP.

Table 26. Correlation between cane yield and yield characters.

Sl. No.	Yield parameters	'r'
1	Plant height at 90 DAP	0.35*
2	Plant height at 150 DAP	0.53**
3	Plant height at 210 DAP	0.21
4	Plant height at harvest	0.41*
5	Cane girth	0.67**
6	Cane length	0.79**
7	Internodal length	0.69**
8	Single cane weight	0.96**
9	Shoot count at 90 DAP	0.78**
10	Shoot count at 180 DAP	0.57**
11	Millable cane count	0.85**

* significant at 5% level
** significant at 1% level

4.10.2 Correlation between sugar yield and quality characters

Highly significant positive correlation (Table 27) between sugar yield and single cane weight, millable cane count, commercial cane sugar, juice percent, polarity, sucrose percent and juice purity could be observed. It was also found that there was no correlation between sugar yield and Brix.

Table 27. Correlation between sugar yield and quality characters

Sl. No.	Quality parameters	'r'
1	Single cane weight	0.80**
2	Millable cane count	0.80**
3	Commercial cane sugar	0.65**
4	Juice per cent	0.45**
5	Polarity per cent	0.74**
6	Brix	0.13
7	Sucrose	0.68**
8	Purity	0.51**

** Significant 1% level
NS - Non significant

Discussion

Chapter V

DISCUSSION

Study to understand the effect of different weed management techniques i.e. hoeing, herbicides and intercropping systems on weed control, yield and quality of sugarcane was conducted at Anjamile, K.K. Patty Post, Chittur taluk, Palakkad district during 2002-03. The results obtained in the study are discussed in this chapter.

5.1 WEED POPULATION

Four major weed species observed in the experimental field were *Portulaca oleracea, Mollugo pentaphylla, Trianthema portulacastrum* and *Ageratum conyzoides*. Other weeds such as *Euphorbia hirta, Corchorus olitorius, Solanum nigrum, Commelina benghalensis, Panicum repens, Amaranthus viridis, Parthenium hysterophorus, Cynodon dactylon* and *Tridax procumbens* were also noted in the experimental plots in lesser number. Sugarcane requires weed free environment for about 100 days before it started rapid growth (Hunsigi *et al*, 1976). One of the major weeds, *Portulaca oleracea* was effectively controlled by oxyfluorfen fb 2,4-D (T_4), atrazine fb hoeing (T_3) and ametryn fb 2,4-D (T_5) up to 90 DAP which was as good as hoeing treatments (T_2). The population of *Portulaca* sp. was quite low by growing sunhemp or daincha as intercrop and its incorporation at 45 DAP (T_{10} or T_9).

Results revealed that the weed menace of *Portulaca* sp. in sugarcane could be effectively controlled by any one of the pre-emergence herbicides viz; oxyfluorfen (T_4), atrazine fb hoeing (T_3) or ametryn (T_5) followed by 2,4-D at 45 DAP. However, growing daincha or sunhemp and their incorporation at 45 DAP would be more eco-safe.

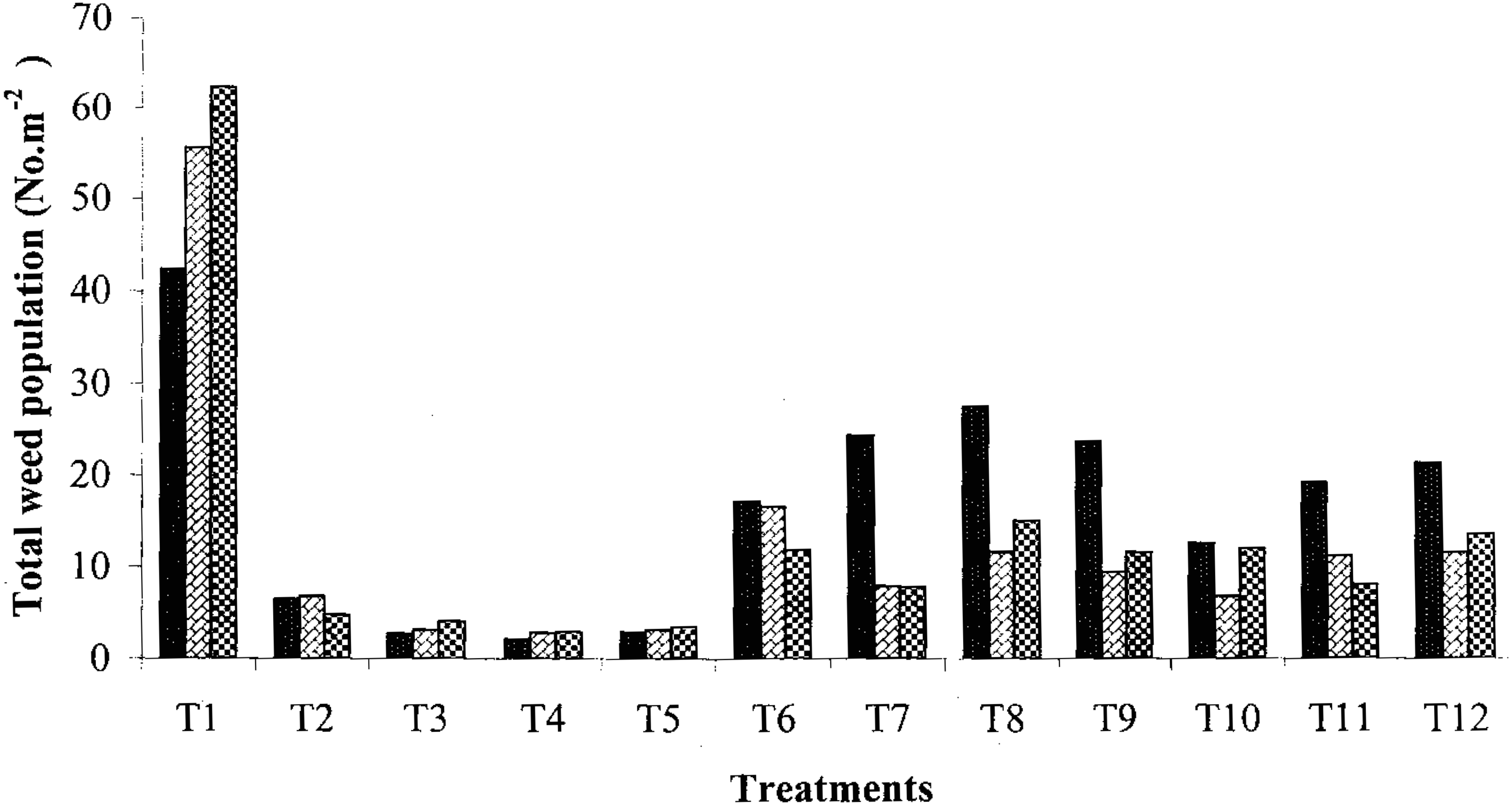


Fig.3. Effect of different weed control treatments on total weed population (No. m^{-2})

The pre-emergence herbicide fb 2,4-D application could control other major weed species viz; *Mollugo pentaphylla, Trianthema portulacastrum* and *Ageratum conyzoides* during the initial 90 days of sugarcane growth. Among the intercropping systems in general, growing sunhemp or daincha and their incorporation at 45 DAP (T_{10} or T_9) or their desiccation by 2,4-D at 45 DAP (T_{12} or T_{11}) registered less population of weeds especially after 45 DAP. The smothering effect of intercrops in weed control is well accepted (Rao and Shetty, 1977; Baumann *et al.*, 2000 and Srivastava and Chauhan, 2002). Green manuring crops interferes with life cycle of weeds and restricts the weed growth. In the present study, growth of sunhemp and daincha was quite satisfactory and thereby less growth of weeds. The growth of blackgram in the experiment (T_7 and T_8) was very poor and possibly this may be the reason for comparatively higher weed population in this plots.

The pre-emergence herbicides fb 2,4-D could effectively reduce the total weed population (Fig.3) including minor weeds during the early growth stages of sugarcane. Among the intercrops, sunhemp incorporation registered lowest weed population at 45 DAP and 60 DAP, however, there was slight increase at 90 DAP. At 90 DAP; the treatments of blackgram incorporation (T_7) and daincha incorporation (T_{11}) gave the lowest weed count. In general, it can be concluded that intercropping daincha or sunhemp and their incorporation at 45 DAP maintains weed population at lower pressure especially during the initial growth stages. Among these intercrops, sunhemp was found better in terms of biomass production also. The performance of glyphosate in weed control was very poor compared to other pre-emergence herbicides. Pre-emergence herbicides might have arrested weed germination. This may be the reason for low weed population in this treatment. And post-emergence application of 2,4-D in these treatments have killed the existing weeds at 45 DAP and maintained very low weed count up to 90 DAP.

Singh *et al.* (1998) reported that atrazine 2.0 kg ha^{-1} gave satisfactory control of *Triantaema portulacastrum*. Liu (2002) proved that pre-emergence application of atrazine or diuron was more effective in controlling weeds. Rao and Veeranna (1996) have reported that atrazine 2.5 kg ha^{-1} and 2,4-D 2.5 kg ha^{-1} were equally effective as hand weeding, resulting in lower dry weight of weeds. The effect of oxyfluorfen as pre-emergence application in reducing weed population in sugarcane + mustard system have been documented by Singh *et al.*, (1997). The herbicide 2,4-D is proved to be an effective post-emergent weedicide against broad leaved weeds and its effect on weed control in sugarcane have been earlier reported by Rao and Veeranna (1996); Mahadevaswamy *et al.* (1994) and Honyal and Yandagoudar (1999). The pre-emergence effect of atrazine, oxyfluorfen or ametryn and post emergence effect of 2,4-D have resulted in effective weed control in the present study.

Relatively better cover of sunhemp and daincha has resulted in the reduction of weed population as suggested earlier by Baumann *et al.* (2000) and Krishna and Reddy (2001). Comparatively more weed population in blackgram intercropped plot is possibly due to poor growth of blackgram. Kannappan and Ramaswamy (1995) reported observed that the nature of intercrop and their spatial arrangement decides the weed population.

5.2 WEED DRY MATTER PRODUCTION

As in the case of population of weeds, dry matter production of major weed species as well as total weeds including minor weed species could be maintained at lower levels up to 90 DAP by pre-emergent application of atrazine fb hoeing (T_3), oxyfluorfen (T_4) or ametryn (T_5) fb 2,4-D spraying. The total weed dry matter production in pre-emergence herbicide plots ranged from 2.29 to 3.12, 4.78 to 6.73 and 8.81 to 13.52 g m^{-2} at 45, 60 and 90 DAP, respectively, which was only 4 to 11 percent of weed dry matter observed in unweeded control plot. Any favourable effect of glyphosate in weed control was not evident. The reduction of weed population and dry matter by pre-emergence herbicides have

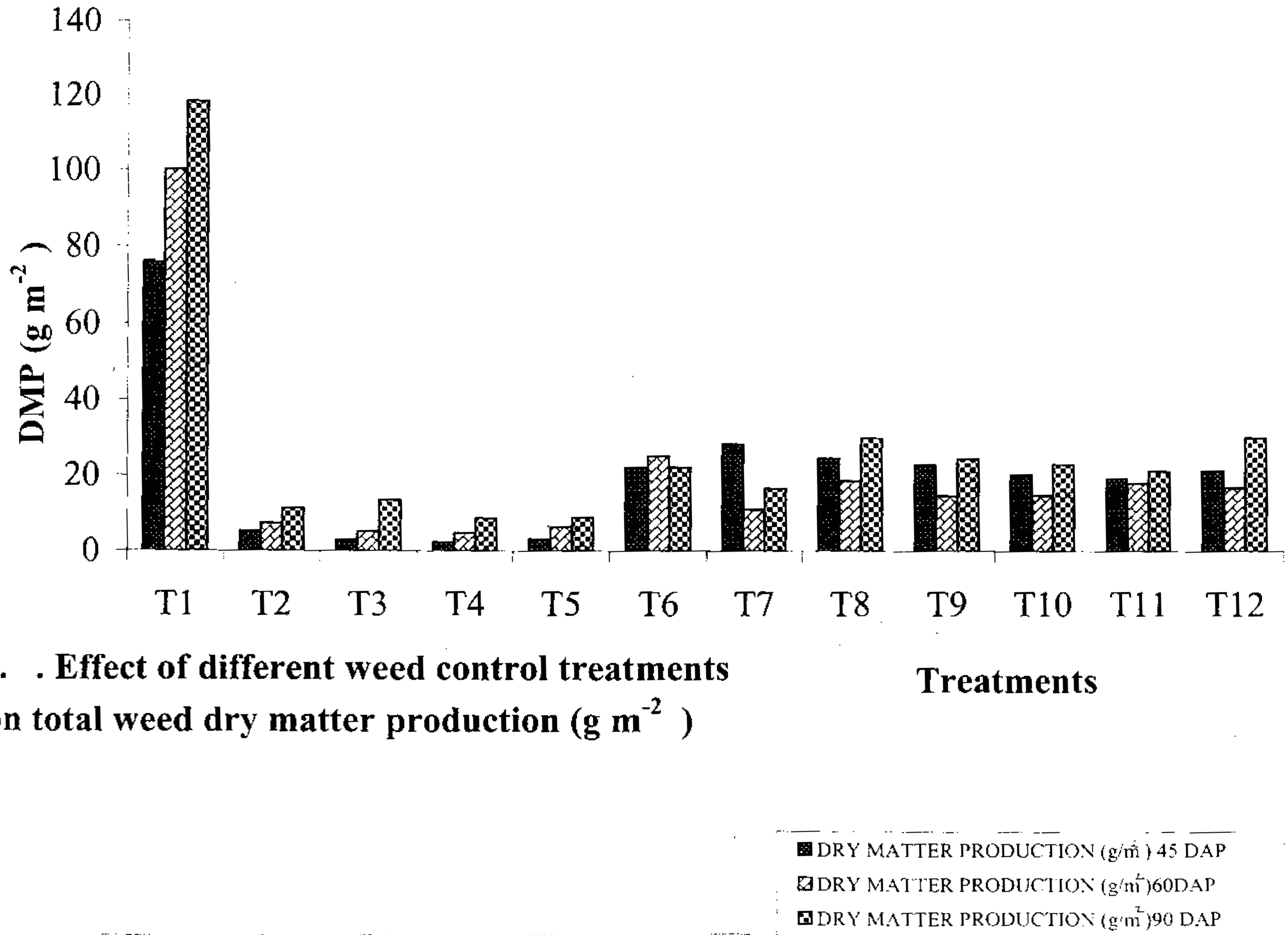


Fig. . Effect of different weed control treatments on total weed dry matter production (g m^{-2})

been earlier reported by Rao *et al.* (1982), Chauhan and Das (1990) and Mishra *et al.* (2003).

In the present study weed population at all stages in pre-emergence herbicide treated plot was lowest and predictably lower dry matter also. Though there was no definite appreciable difference between intercropping treatments, incorporation of daincha (T_9) or sunhemp (T_{10}) were found better in reduction of dry matter of weeds during 60 DAP. This was possibly due to the low weed pressure in these treatments.

In blackgram intercropped (T_7 and T_8) plots, dry matter production in early stage was more but it got reduced in blackgram incorporation (T_7) where incorporation was done at 45 DAP. The low weed dry matter production in this plot is possibly due to digging at the time of incorporation. The desiccation effect of 2,4-D was less in sunhemp and associated weeds, hence more dry matter weights in this plot was recorded (T_{12}) at 90 DAP. The results corroborate with the findings of Baumann *et al.* (2000) who reported that the relative cover of weeds that emerged was reduced by 41 percent in the intercrop and the weed dry matter weight got reduced.

For sugarcane to control weed population as well as weed dry matter production, the techniques of pre-emergent application of atrazine 2 kg ha^{-1} fb hoeing (T_3), oxyfluorfen 0.20 kg ha^{-1} (T_4) or ametryn (T_5) fb 2,4-D 1.0 kg ha^{-1} could be used. Growing daincha (T_9) or sunhemp (T_{10}) as intercrops and their incorporation at 45 DAP was also found effective.

5.3 WEED CONTROL EFFICIENCY (WCE) AND WEED INDEX(WI)

The effect of pre-emergence herbicide fb 2,4-D has been well reflected in the case of weed control efficiency also (Fig.5). The WCE in these plots were always higher at all stages of observations, either better or equal to complete weed control (T_2) treatments. The results clearly indicate the beneficial effect of pre-emergent herbicides viz; atrazine fb hoeing (T_3), oxyfluorfen (T_4) or ametryn

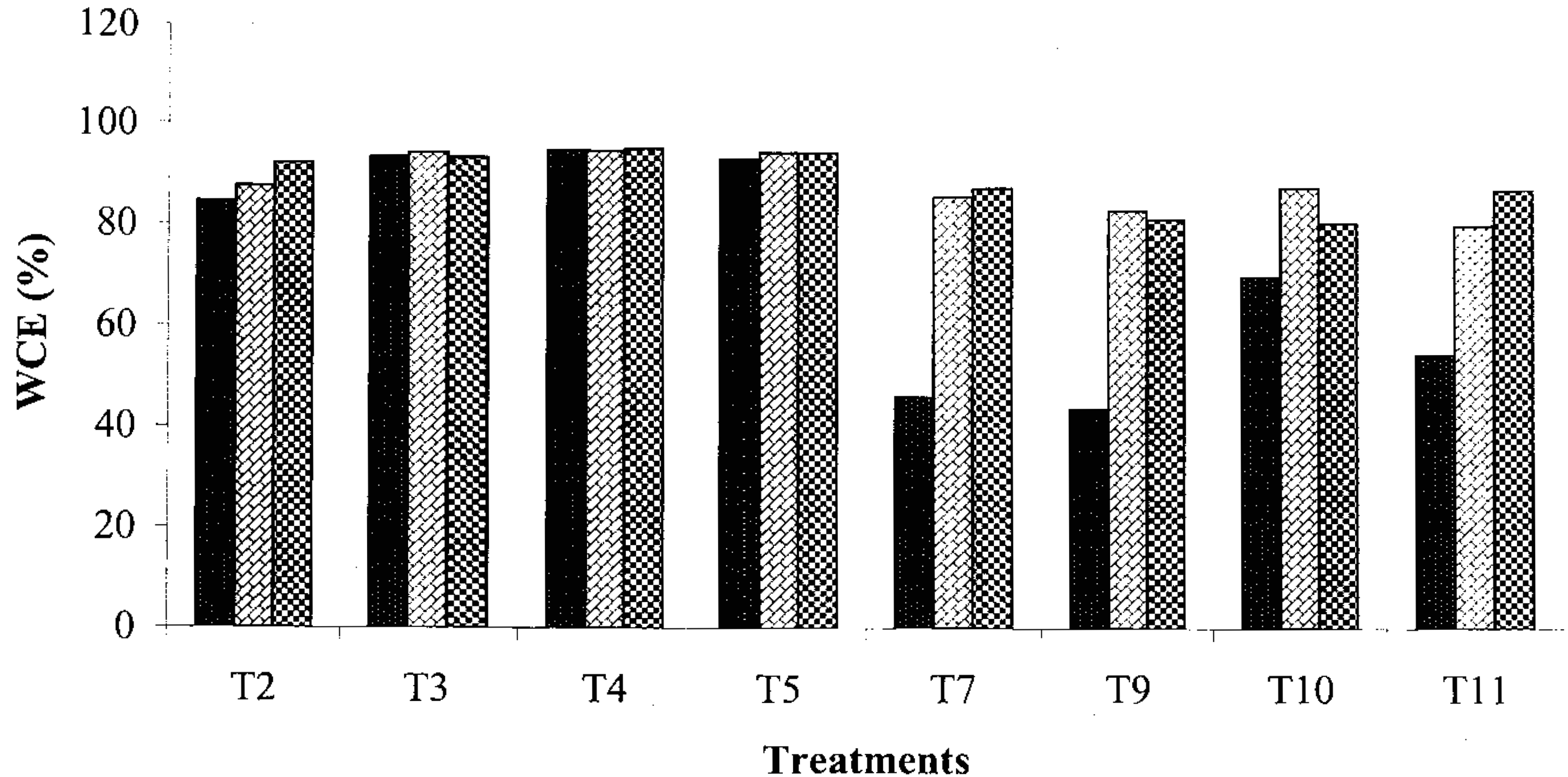


Fig. 5 . Effect of different weed control treatments on weed control efficiency (%)

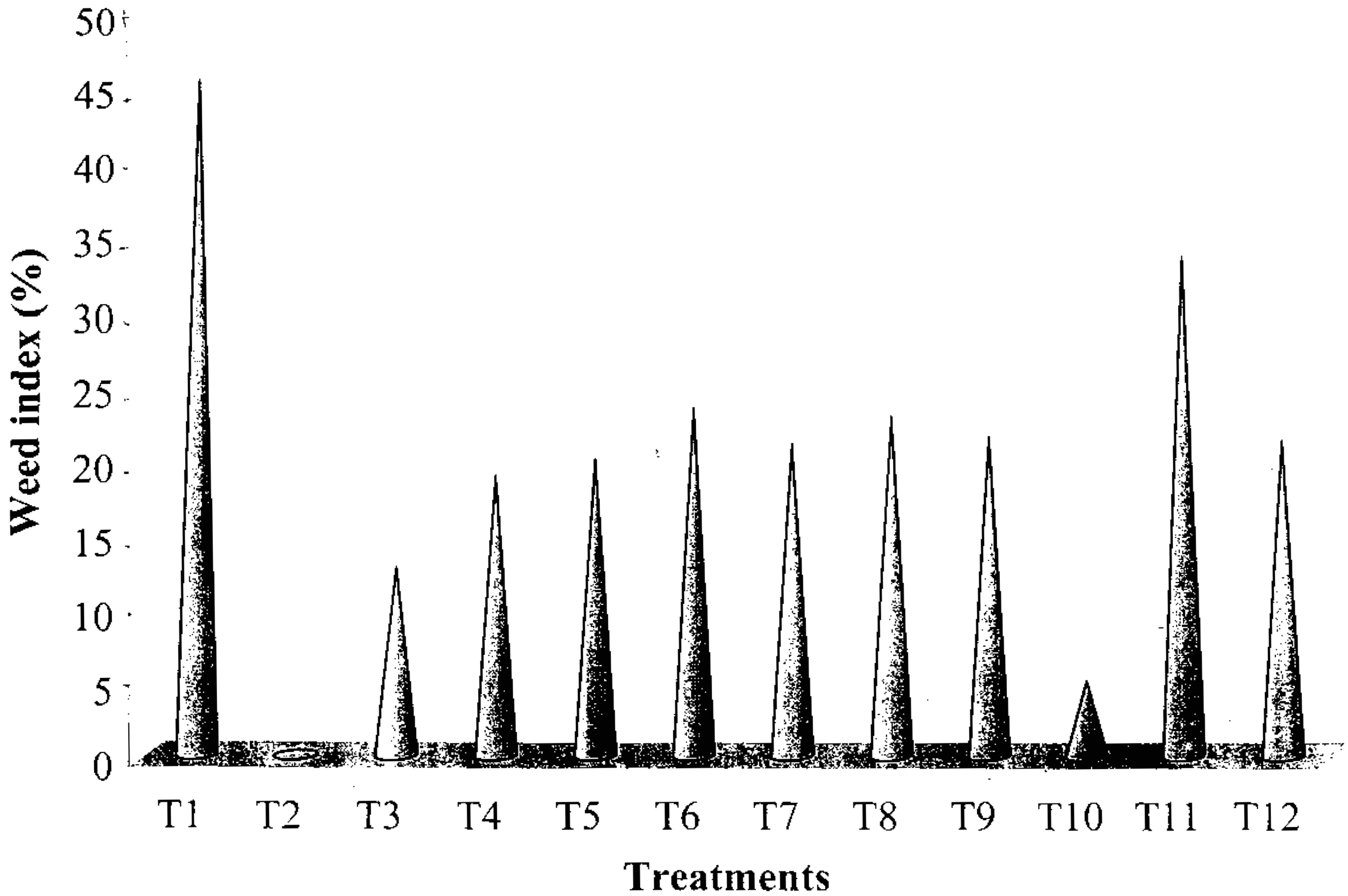


Fig 6. Effect of different weed control treatments on weed index (%)

(T_5) followed by 2,4-D in the reduction of weed population and thereby increased WCE. Similar results have been reported by Singh *et al.* (2002); Kathiresan and Manoharan (1994); Sankpal *et al.* (1997) and Nagaraju *et al.* (2000).

Among the intercrops, blackgram (T_7), daincha (T_9) and sunhemp incorporation (T_{10}) and daincha desiccation (T_{11}) gave higher WCE almost steadily after 45 DAP. This is possibly due to better weed control effect by incorporation of green manures. The effect of green manures on control of weeds in sugarcane has been reported by Srivastava and Chauhan (2002).

Weed index (Fig.6) indicates the reduction in yield due to weeds in a treatment, compared to hand weeded plot. In the present study, weed index was (45.30) highest in unweeded control (T_1) followed by daincha desiccation by 2,4-D (T_{11}). The reduction in yield was lowest in intercropping sunhemp and incorporation at 45 DAP (T_{10}). Pre-emergence application of atrazine fb hoeing, oxyfluorfen or ametryn fb 2,4-D gave lower indices compared to intercropping treatments (except T_{10}). The results indicate the best performance of growing sunhemp as intercrop and its incorporation at 45 DAP (T_{10}) in improving the yield of sugarcane. Although pre-emergence herbicides gave less reduction in yield, sunhemp incorporation was found better. The benefits of pre-emergence herbicides in decreasing weed index have been earlier reported by Thakur *et al.*(1995). The growth of sunhemp was excellent, which reduced the weed population and might have provided a better condition for the growth of sugarcane and thus increased yield. The lowest weed index in this treatment can be attributed to highest yield.

5.4 REMOVAL OF NPK BY WEEDS

The results revealed that the removal of NPK was highest in unweeded control (T_1). The removal of NPK at all stages of observation was very low in treatments of pre-emergence herbicides fb 2,4-D. The lower weed population and dry matter of weeds observed in these treatments can be attributed as the reason for this.

With regard to intercrops, removal of NPK were higher than the pre-emergence herbicide treated plots and complete weed control, but quite lower than unweeded control. Among the intercrops, the weeds in blackgram plots (T_7 and T_8) removed more N at all stages. This is possibly due to higher weed growth in these plots. Almost a similar trend was observed in case of P removal as well. However, in the case of K such a definite variation was not observed, possibly due to variation in the K content of the weeds. The removal of higher amount of NPK from weed-infested plots have been reported by Sathyavelu (1990) and Chauhan (1992).

Among the intercrops, sunhemp incorporation at 45 DAP (T_{10}) facilitate the lowest removal of NPK in general, possibly due to lower weed growth. The higher removal of NPK in blackgram incorporation (T_7) and (T_8) is clear from higher weed growth in these plots.

5.5 CROP GROWTH

Germination of sugarcane was not much influenced by pre-emergent herbicides or intercropping treatments. But it was much reduced by glyphosate application (T_6). This is in line with Biradar *et al.* (1995) who stated that intercrop did not affect the germination significantly. Also Nagaraju *et al.* (2000) reported that germination was not influenced by various herbicides and cultural practices.

At 90 DAP, atrazine 2 kg ha^{-1} (T_3), oxyfluorfen 0.20 kg ha^{-1} (T_4) and sunhemp incorporation (T_{10}) gave higher shoot count. At 180 DAP, oxyfluorfen 0.20 kg ha^{-1} (T_4), blackgram incorporation (T_7) and sunhemp or daincha incorporation (T_{10} or T_9) gave higher shoot count. Reduction in tiller production due to weed infestation has been earlier reported by Sathyavelu (1990). In

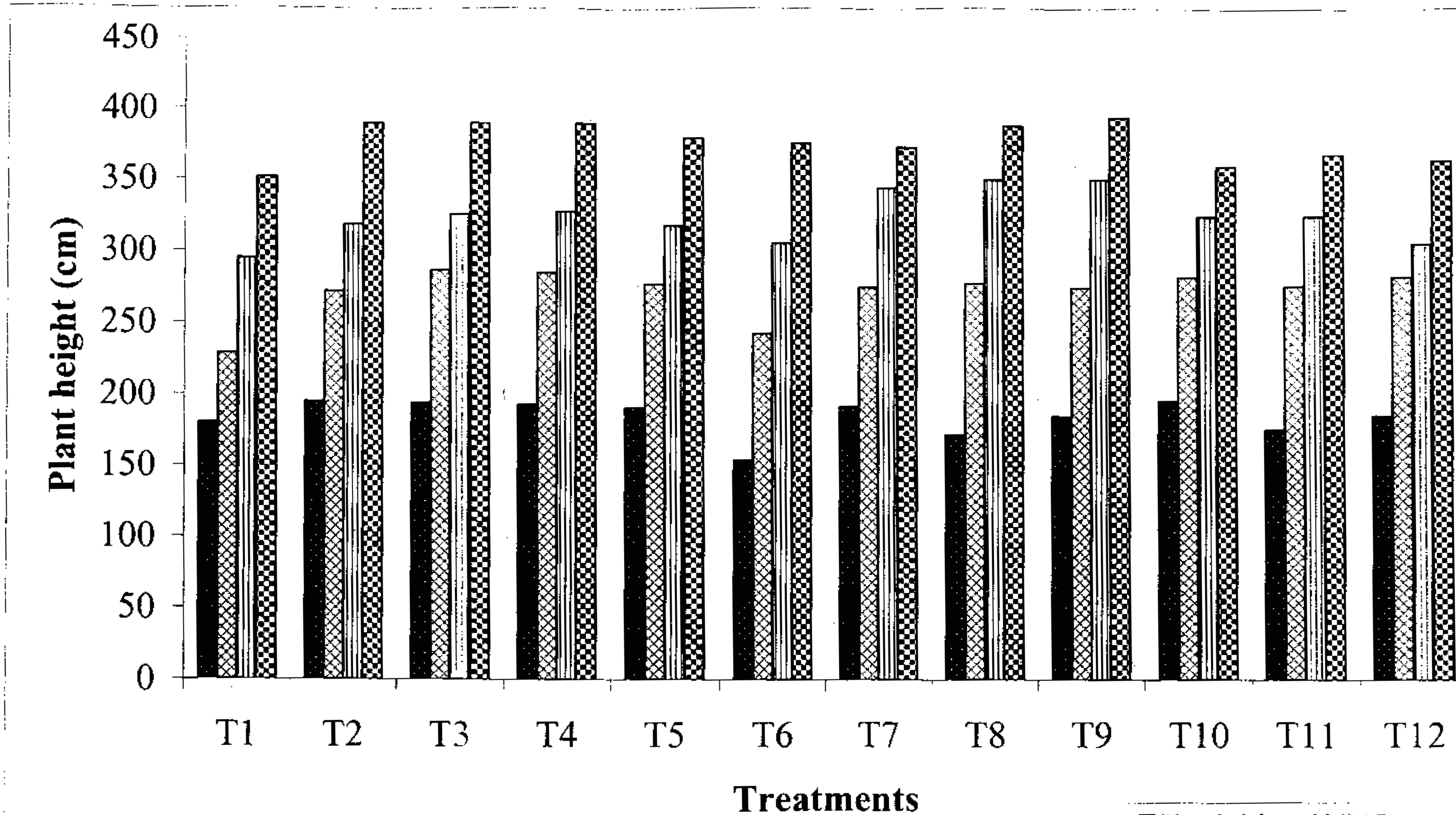


Fig. 7. Effect of different weed control treatments on height (cm) of sugarcane

general, the pre-emergence herbicide treated plots and intercropping treatments gave higher shoot count, possibly due to less weed infestation.

At 90 DAP, there was no appreciable difference between treatments on plant height (Fig. 7) except in glyphosate sprayed (T_6) plots, where plant height was very less. A similar trend was observed at 150 DAP as well. But at this stage, the height of unweeded control (T_1) was also lower. At 210 DAP, the height of plants in glyphosate (T_6) plots, sunhemp desiccation by 2,4-D (T_{12}) and unweeded control (T_1) were lower. At maturity the plants in pre-emergence herbicide plots (T_3, T_4 and T_5) and intercropped plots were taller than unweeded control (T_1) plots. This initial slow growth in glyphosate sprayed (T_6) plots is probably due to the harmful effect of herbicide on cane growth. However, it has recovered later and attained more height. Increasing growth in pre-emergence herbicide plots and intercropped plots (except daincha and sunhemp desiccation by 2,4-D) are possibly due to lesser weed growth and thereby favourable condition for cane growth. The desiccation effect of 2,4-D on sunhemp and daincha was less and thereby weeds as well as intercrops might have competed with sugarcane for resources and this may be the reason for lower cane height in this treatment.

Cane girth and cane length (Fig. 8 and 9) at harvest in PE herbicide applied plots and intercropped plots were significantly superior to unweeded plots. The PE herbicides were as good as complete control plots (T_2) in the case of cane girth and length. Among the intercropped plots, sunhemp incorporation (T_{10}) gave significantly better cane length than other intercropping plots. However, such a difference could not be noticed in the case of cane girth. The internodal length was similar in treatments of complete weed control (T_2) atrazine (T_3) and oxyfluorfen (T_4) plots which was closely followed by atrazine (T_3) and ametryn (T_5) Among intercrops, sunhemp incorporation (T_{10}) was found to be the best one followed by daincha incorporation (T_9). The better performance of the crop in pre-emergent herbicide plots and intercropped plots is due to better weed control. The effect of sunhemp or daincha incorporation (T_{10} or T_9) is clearly

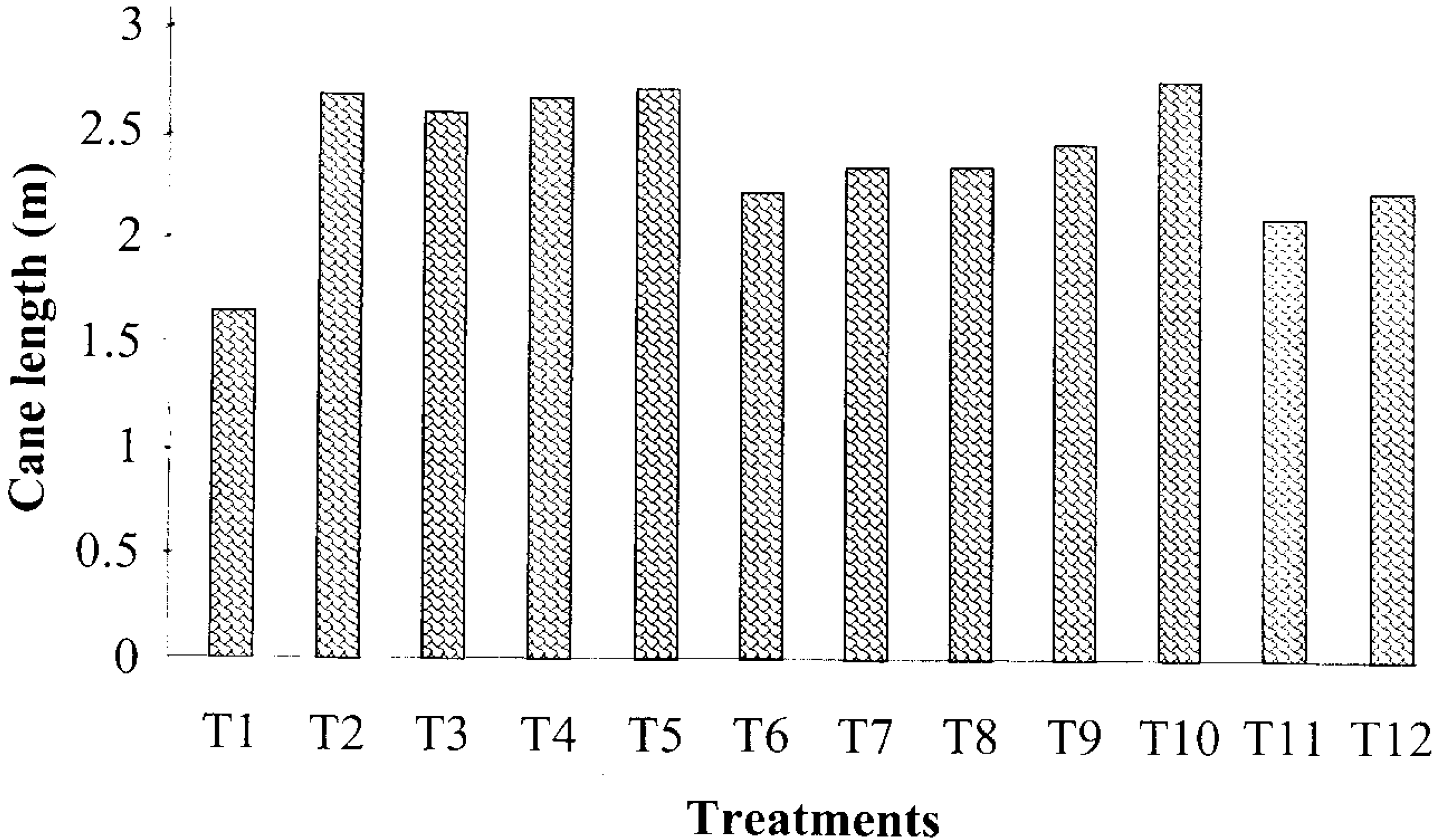


Fig 8 . Effect of various weed control treatments on cane length (m)

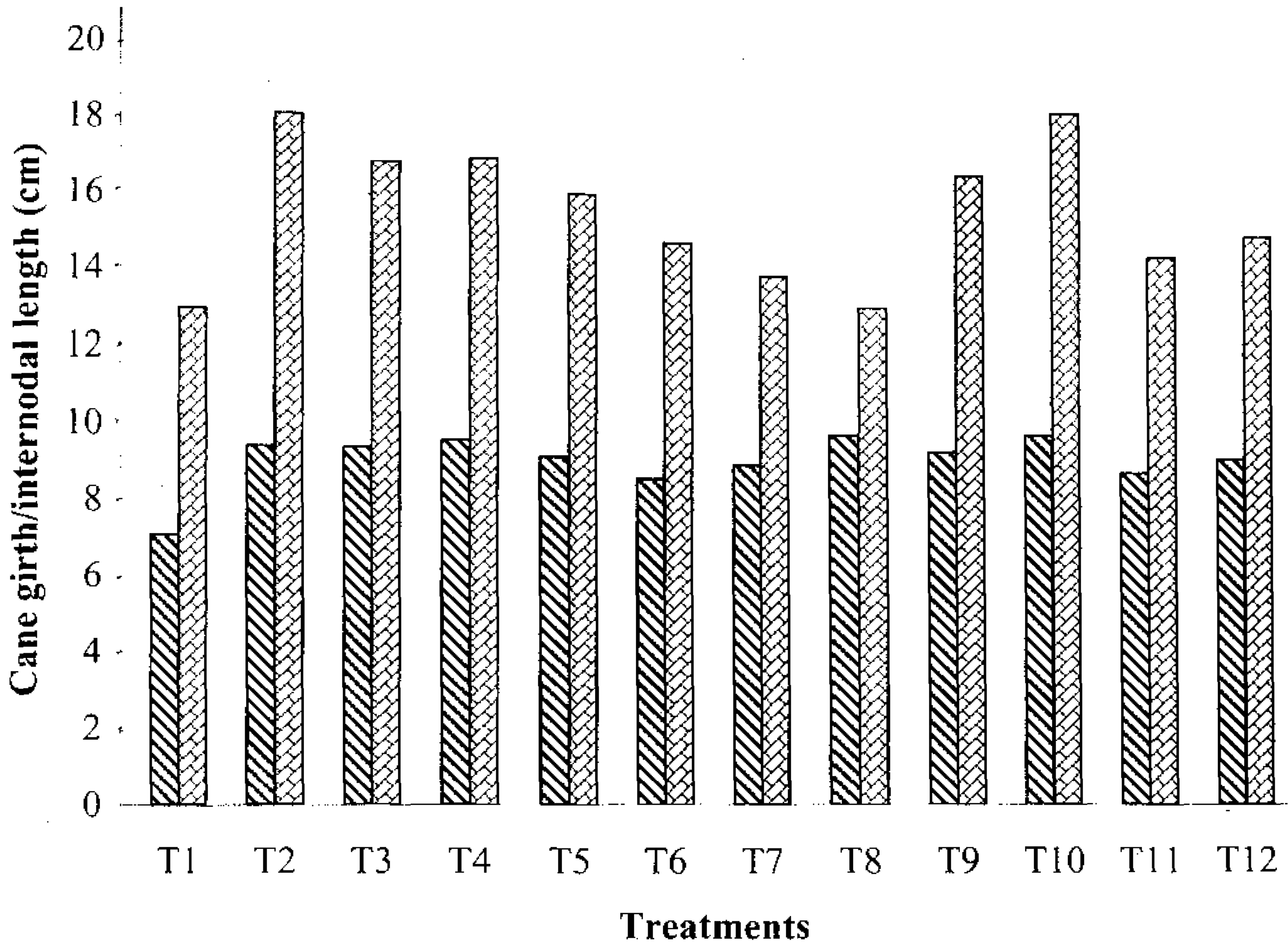


Fig 9 . Effect of different weed control treatments on cane girth (cm) and internodal length (cm)

evident from higher cane growth parameters. The results in the present study corroborates with the earlier findings of Sathyavelu (1990), Mathew *et al.* (2002), Ponnuswamy *et al.* (1996[a]) and Umaratha (1997).

In oxyfluorfen fb 2,4-D (T_4) and also in sunhemp incorporation plots (T_{10}) cane girth, cane length and internodal length were better, as good as complete weed control (T_2), and significantly superior to unweeded control (T_1). A similar pattern was observed in millable cane count also (Fig.11) in the case of pre-emergence herbicide treatment, whereas in the case of green manures millable cane count was higher in sunhemp (T_{10}) and daincha (T_9) incorporation plots. Better single cane weight (Fig.10) and millable cane count in pre-emergence herbicides fb 2, 4-D is possibly due to better weed control effect during the growth cycles of cane and thereby vigorous growth as suggested by Sathyavelu (1990), Ponnuswamy *et al.* (1996[b]) and Umaratha (1997). Although single cane weight was less in daincha incorporation plot, millable cane count was higher in both sunhemp and daincha incorporation plots. This is possibly due to higher shoot count in these plots at 180 DAP.

The better effect of sunhemp incorporation (T_{10}) is evident from higher single cane weight and millable cane count. Daincha incorporated plot (T_9) also performed equally good in case of millable cane count. This is probably due to less weed growth, better microclimate and increased soil fertility. The competitive ability of intercrops in reduction of weed growth have been earlier reported by Rao and Shetty (1977); Krishna and Reddy (2001) and Baumann *et al.* (2000).

5.6 CANE AND SUGAR YIELD

Cane yield is a reflection of several growth and yield parameters, such as plant height, cane girth, cane length, internodal length, single cane weight and millable cane count etc.

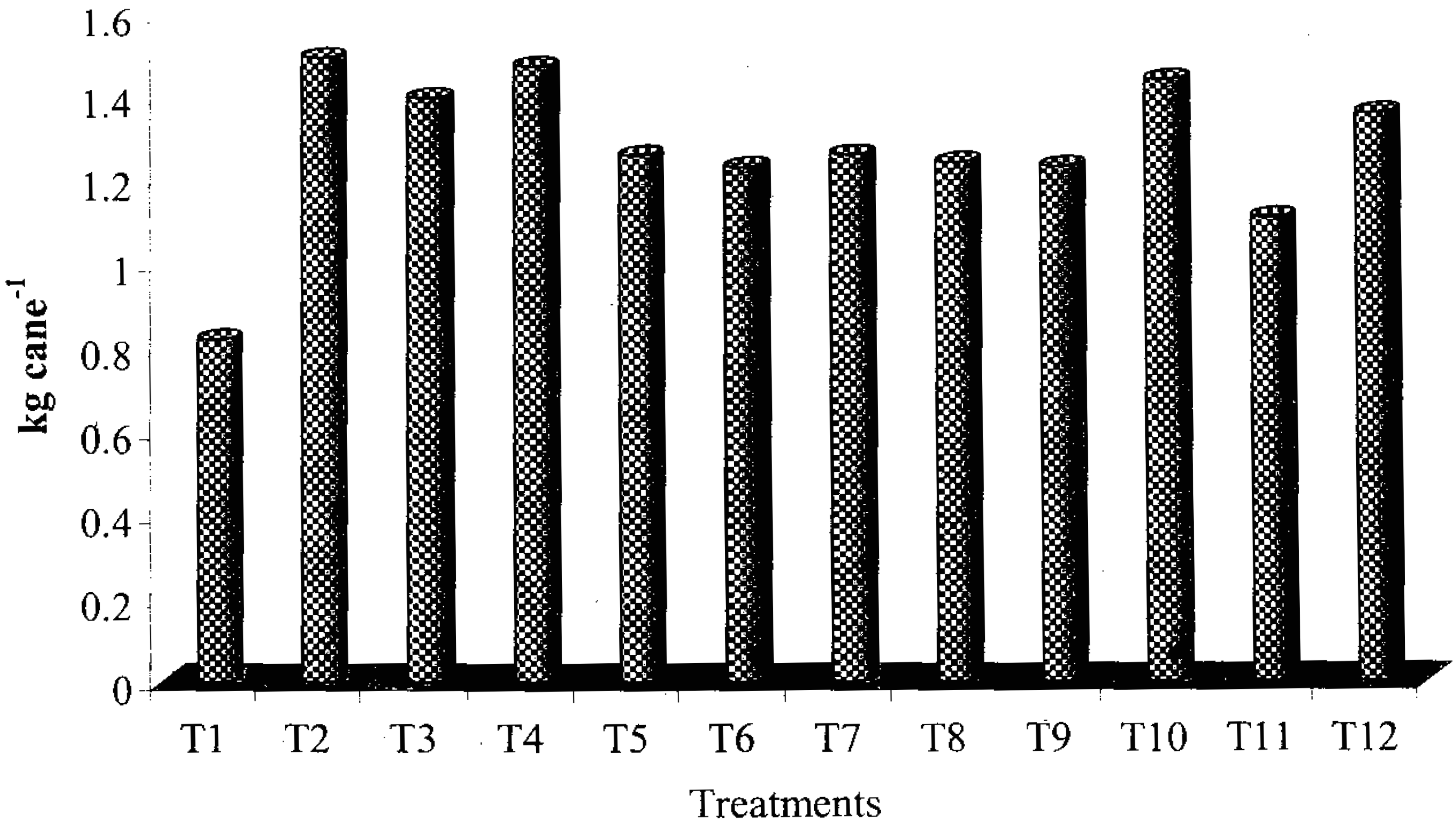


Fig.10 Effect of different weed control treatments on single cane weight (kg cane^{-1})

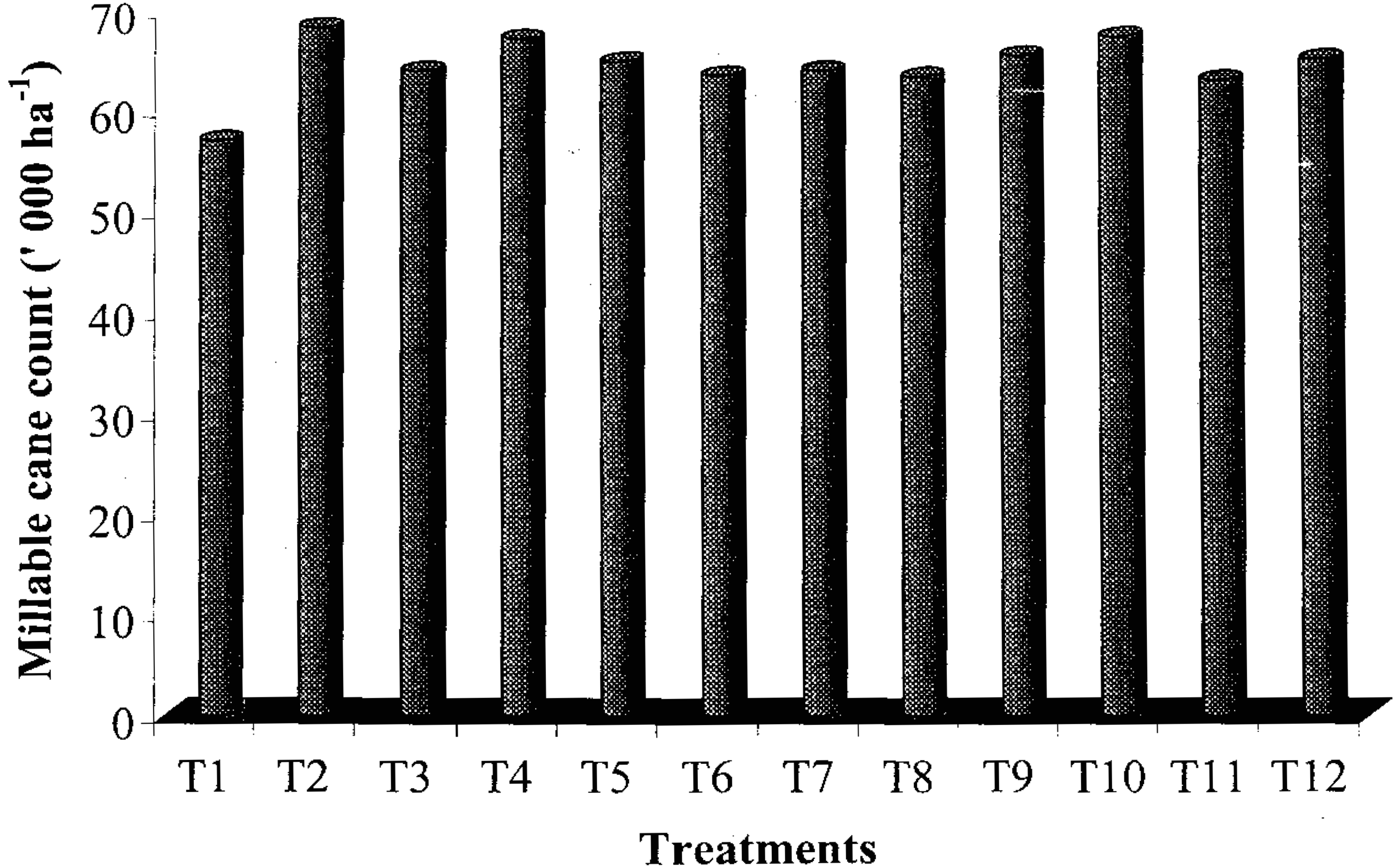


Fig. 11. Effect of different weed control treatments on millable cane count (' 000 ha^{-1})

In the present study, highest cane yield (Fig.12) was obtained in complete weed control treatment (T_2-102.9t ha^{-1}) i.e., 118 percent higher than unweeded control. The extent of damage by weeds in sugarcane yield has been reported by several workers (Sundara, 1998; Singh and Singh, 1996 and Srivastava, 2001). Even upto 75 per cent yield reduction have been reported by Singh and Moolani (1975). In the present experiment there was a reduction of 54 percent yield in unweeded plot (T_1) compared to complete weed control (T_2). Among, the herbicide treatments, oxyfluorfen fb 2,4-D (T_4) and atrazine fb hoeing (T_3) were found better in terms of cane yield. These treatments gave an additional yield of 52.89 t ha^{-1} and 42.93 t ha^{-1}, respectively over unweeded control. Ametryn application (T_5) could give an added advantage of 35.32 t ha^{-1} over unweeded control (T1). The effect of pre-emergent herbicide fb 2,4-D in improving the cane growth is clear in terms of yield factors such as height, cane girth, cane length etc, and all this factors have resulted in higher cane yield.

Among the herbicides, oxyfluorfen fb 2,4-D gave an yield equal to that of hand hoeing whereas in other treatments there was a reduction of upto 20.47 t ha^{-1} over hand hoeings. The efficiency of oxyfluorfen in weed control was evident in the study of Mathew *et al.* (2002). Increased cane yield in weed control by ametryn @ 2.0 kg ai ha^{-1} (T_5) have been reported by Chauhan *et al.* (1999) and that of atrazine by Mahadevaswamy and Kailasam (1994).

Among the intercrops, sunhemp incorporation at 45 DAP (T_{10}) was found the best in cane production which was on par with oxyfluorfen and atrazine treatments. There was an yield advantage of 108.0 percent over unweeded control (T_1). It was followed by sunhemp desiccation by 2,4-D (T12), which was on par with the above treatments. Better weed control and better growth and yield parameters have resulted in high yield as suggested by Durai *et al.* (2002); Mahendran *et al.* (1997) and Roodagi *et al.* (2000).

Sugar yield (Fig. 13) was highest in intercropping and incorporation of sunhemp (T_{10}) followed by oxyfluorfen 0.20 kg ha^{-1} (T_4) and complete weed

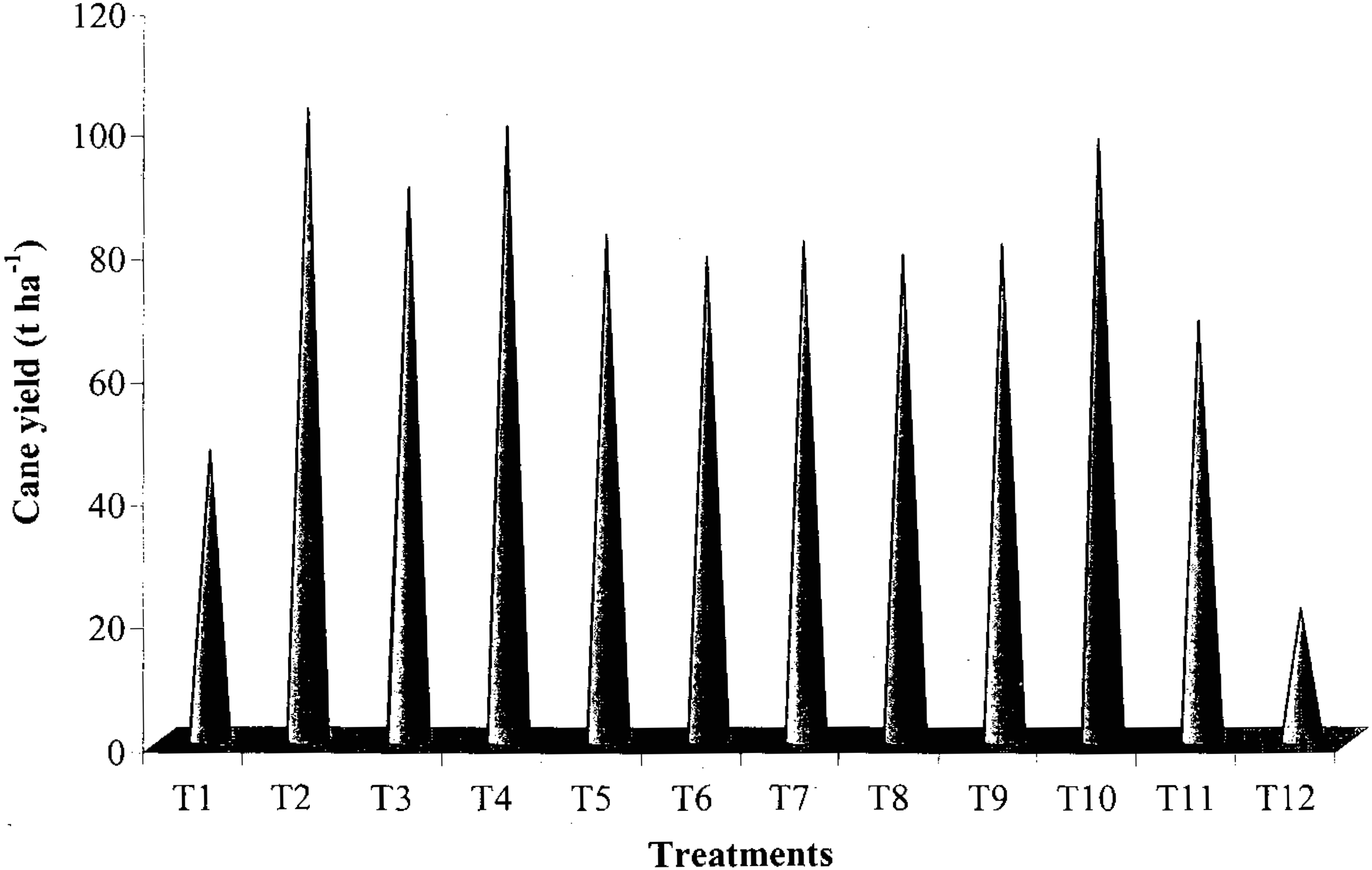


Fig.12. Effect of different weed control treatments on cane yield (t ha^{-1})

control (T_2) which gave an increase of 5.98, 5.52 and 4.85 t ha^{-1}, respectively over unweeded control (T_1). Sunhemp desiccation by 2,4-D (T_{12}) also gave higher sugar yield on par with these treatments. Sugar yield is the product of commercial cane sugar (CCS%) and cane yield. There was no variation in CCS percentage due to treatments. Naturally, the sugar yield in the present study was decided by the cane yield in various treatments. The treatments discussed above have higher cane yield and consequently higher sugar yield also. Increase in sugar yield by effective weed control by pre-emergence application of oxyfluorfen and atrazine have been earlier revealed by Mathew *et al.* (2002) and Mahadevaswamy and Kailasam (1994).

5.7 JUICE QUALITY

Any definite variation in juice quality parameters viz., CCS percent, juice recovery, SMT Brix, sucrose content and purity could not be observed between the treatments. That is, growth of weeds, herbicide treatments or intercrops did not influenced juice quality. Nagaraju *et al.* (2000) and Chauhan *et al.* (1999) have reported that herbicide treatments did not influence the juice quality. Mahendran *et al.* (1997) reported that juice quality got influenced by growing intercrops.

5.8 CORRELATION STUDIES

Correlation between cane yield and yield contributing characters showed that there was a positive correlation between cane yield and yield factors viz., Plant height (except plant height at 210 DAP), cane girth, cane length, internodal length, number of shoots and cane weight. Sugar yield was well correlated with quality characters viz; single cane weight, millable cane count, CCS per cent, juice recovery, sucrose content and purity.

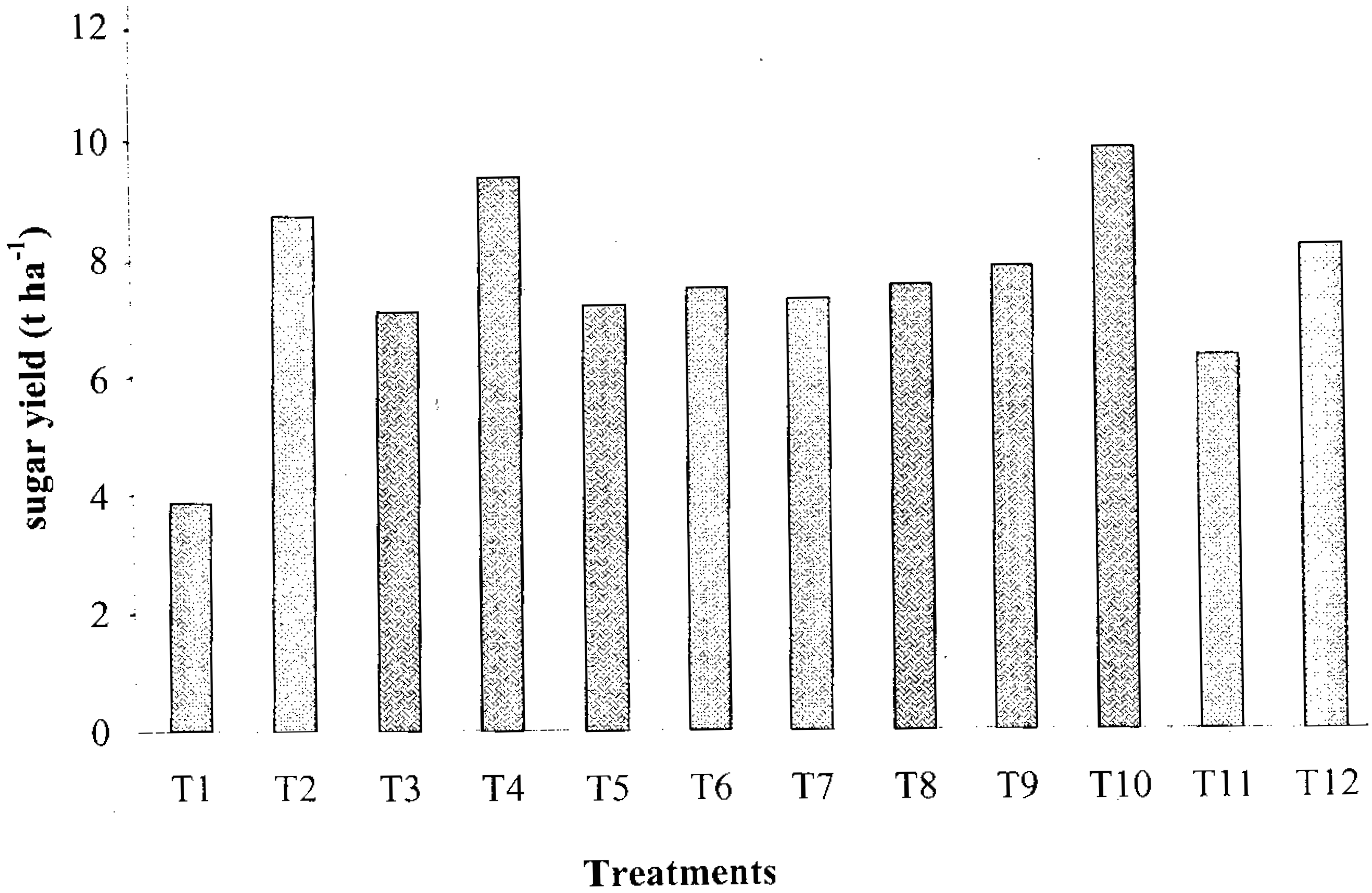


Fig13 Effect of different weed control treatments on sugar yield (t ha^{-1})

5.9 ECONOMIC ANALYSIS

The analysis of economic returns shows that gross return was highest in complete weed control plot, which gave an additional return of Rs.33474 ha^{-1} over unweeded control. It was closely followed by the treatment of oxyfluorfen fb 2,4-D (T_4), sunhemp incorporation (T_{10}), atrazine followed by hoeing (T_3) and sunhemp desiccation by 2,4-D (T_{12}) in which the gross income increased from Rs.24,384 to 31,734ha^{-1} over unweeded control (T_1). The trend was almost similar in net return also, except that in the treatment of atrazine followed by hoeing (T_3), where it got reduced compared to other promising treatments. The additional return due to weed control was highest in complete weed control (T_2- Rs.33474 ha^{-1}) and that in oxyfluorfen followed by 2,4-D (T4) and sunhemp incorporation (T_{10}) did not vary much (Rs.31734 and Rs.30396 ha^{-1}, respectively). Among other treatments, sunhemp desiccation by 2,4-D (T_{12}) followed by atrazine @ 2 kg ai ha^{-1} fb hoeing (T3) were found better.

The B:C ratio was highest in sunhemp incorporation (T_{10} 2.28) followed by oxyfluorfen fb 2,4-D (T_4 - 2.20) and complete weed control (T_2 - 2.13). The B:C ratio in sunhemp desiccation (T_{12}) as well as atrazine fb hoeing (T_4) stood almost equal to the former treatments. The results are in favour of growing sunhemp and its incorporation at 45 DAP. Among the herbicides, oxyflourfen fb 2,4-D would be better. However, in terms of eco-safety and other soil benefits sunhemp intercropping and incorporation would be more advisable.

Table 28. Economic analysis of weed control treatments in sugarcane

Treatments	Cost excluding weed control (Rs ha^{-1})	Cost of weed control (Rs ha^{-1})	Cost of green manure incorporation (Rs ha^{-1})	Total cost (Rs ha^{-1})	Cane yield (t ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Additional return due to weed control (Rs ha^{-1})	Benefit cost ratio
T_1 - Absolute control (unweeding)	24500	-	-	24500	47.11	28266	3766	-	1.15
T_2 - Complete weed control	24500	4550	-	29050	102.90	61740	32690	33474	2.13
T_3 - Atrazine 2 kg ha^{-1} as pre-emergent (PE) fb hoeing and earthing up at 90 DAP.	24500	1850	2000	28350	90.04	54000	25650	25734	1.90
T_4 - Oxyfluorfen 0.20kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	24500	2750	-	27250	100.00	60000	32750	31734	2.20
T_5 - Ametryn 2kg ha^{-1} (PE) fb 2.4-D 1kg ha^{-1} at 60 DAP.	24500	1750	-	26250	82.43	49458	23508	21192	1.88
T_6 - Glyphosate 1kg ha^{-1} at 20 DAP fb 2.4-D 1kg ha^{-1} at 60 DAP.	24500	1250	-	25750	78.77	47262	21512	18996	1.84
T_7 - Blackgram incorporation at 45 DAP.	24500	-	1200	25700	81.30	48780	23080	20514	1.89
T_8 - Blackgram bhusa incorporation.	24500	-	1200	25700	79.02	47412	21712	19146	1.84
T_9 - Daincha incorporation at 45 DAP.	24500	-	1200	25700	80.79	48474	22774	20208	1.88
T_{10} - Sunhemp incorporation at 45 DAP.	24500	-	1200	25700	97.77	58662	32962	30396	2.28
T_{11} - Daincha desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	24500	700	-	25200	68.42	41052	15852	12786	1.63
T_{12} - Sunhemp desiccation by 2.4-D 1kg ha^{-1} at 45 DAP.	24500	700	-	25200	87.75	52650	27450	24384	2.09

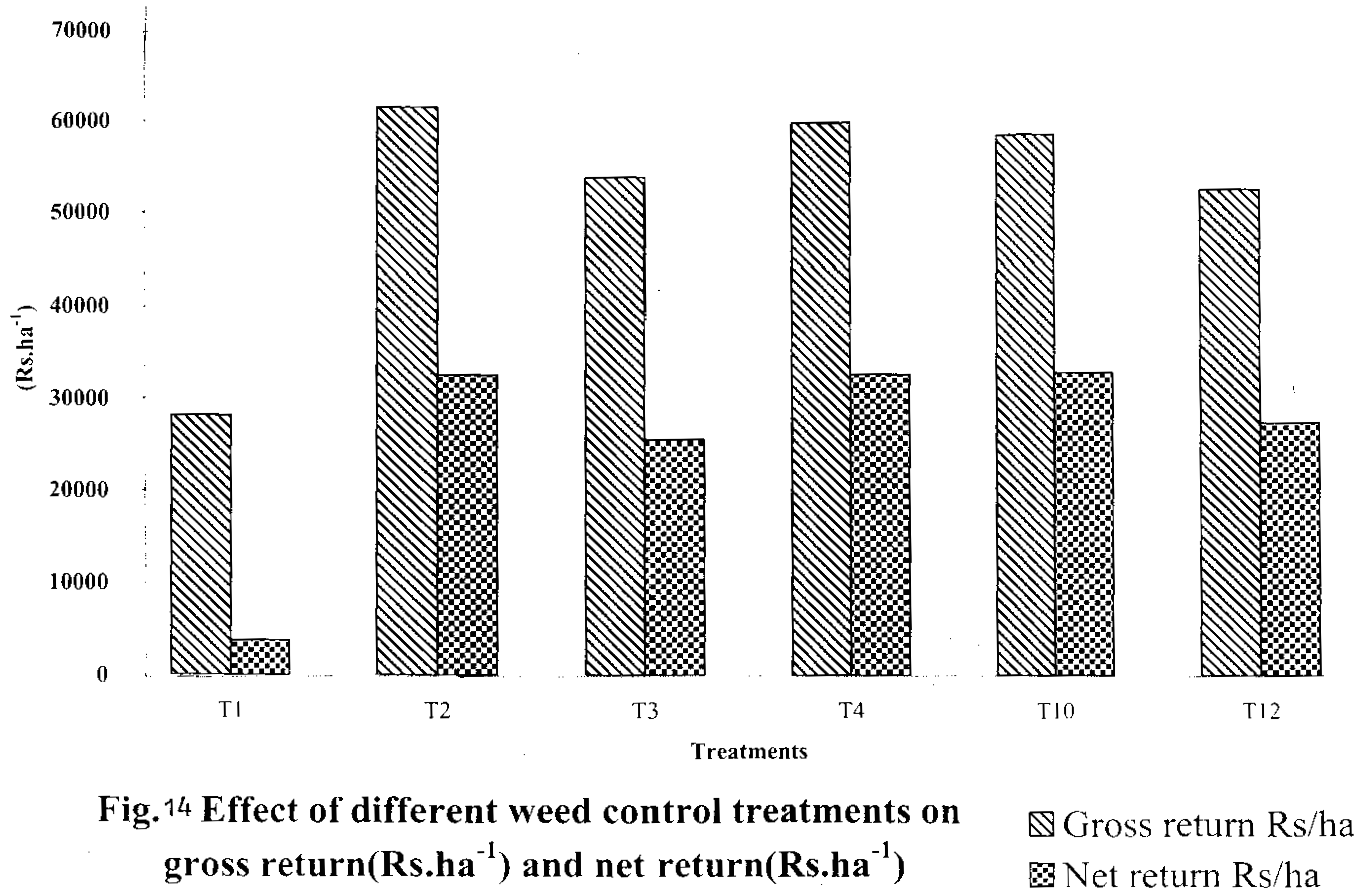
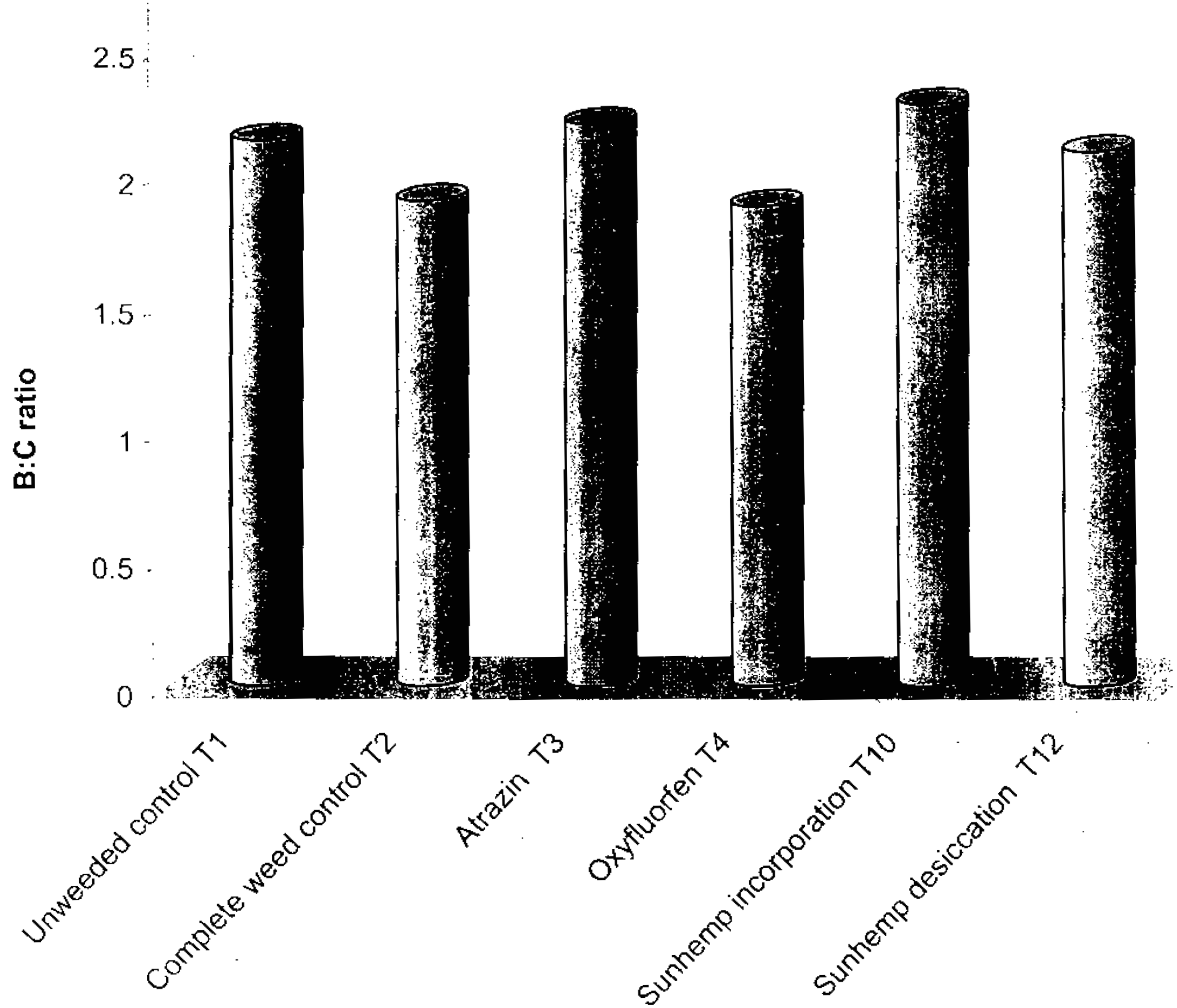


Fig.14 Effect of different weed control treatments on gross return(Rs.ha^{-1}) and net return(Rs.ha^{-1})

Fig. 15 Effect of different weed control treatments on benefit cost ratio



Summary

Chapter VI

SUMMARY

The present study was conducted to understand the effect of different weed management techniques i.e., hoeing, herbicides and intercropping systems on weed control, yield and quality of sugarcane. The field experiment was conducted at Anjanile, K.K. Patty, Chittur taluk, Palakkad district during 2002-03. Herbicide treatments were atrazine 2 kg ha^{-1} as pre-emergence (PE) fb hoeing and earthing up at 90 DAP, oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (PE) fb 2,4-D, ametryn 2.0 kg ha^{-1} as PE fb 2,4-D and glyphosate 1 kg ha^{-1} at 20 DAP fb 2,4-D at 60 DAP. The intercropping treatments consisted of blackgram incorporation at 45 DAP, sunhemp incorporation at 45 DAP and it's bhusa incorporation, daincha desiccation by 2,4-D, and sunhemp desiccation by 2,4-D.

The dicot weeds dominated the weed flora. *Portulaca oleracea, Mollugo pentaphylla, Trianthema portulacastrum* and *Ageratum conyzoides* together constituted more than 80 percent of the weed flora. The other minor weed species included *Cyperus rotundus, Euphorbia hirta* and *Tridax procumbens* etc.

The pre-emergence herbicides atrazine fb hoeing, oxyfluorfen and ametryn fb 2,4-D were effective in controlling all the four major weed species. The number of weeds as well as dry matter weight was maintained at lower level by pre-emergence herbicides fb 2,4-D. Growing sunhemp or daincha as intercrops could also effectively control the growth of weeds.

In terms of weed control efficiency also, application of pre-emergence herbicides atrazine, oxyfluorfen or ametryn fb 2,4-D gave higher values as good as hoeing. Among the intercrops, incorporation of blackgram, daincha or sunhemp at 45 DAP gave higher weed control efficiency as good as hoeing. Reduction in yield was lowest in intercropping and incorporation of sunhemp as evident from the lowest weed index, whereas it was highest in unweeded control. The pre-emergence herbicides also gave lower weed indices. The results suggest

that growing sunhemp as intercrop and its incorporation or spraying pre-emergence herbicides fb 2,4-D gives effective control of weeds in sugarcane and decreases weed index. The removal of NPK by weeds was very low in treatments including pre-emergence herbicides or sunhemp incorporation.

Pre-emergence herbicides or intercropping treatments did not affect germination of sugarcane setts but glyphosate application reduced it. In general the pre-emergence herbicides and intercrops gave higher shoot count and millable cane count. Yield parameters such as cane girth, cane length and internodal length were also better in pre-emergence herbicides and in intercropping, especially sunhemp incorporation. Single cane weight was better in atrazine or oxyfluorfen fb 2,4-D and sunhemp incorporation as good as that in complete weed control.

The cane yield in unweeded control got reduced by 54 percent compared to complete weed control. Among the herbicides, oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (PE) fb 2,4-D at 45 DAP and atrazine 2 kg ha^{-1} as PE fb hoeing and earthing up at 90 DAP were found better for cane yield. Among intercrops, sunhemp incorporation at 45 DAP was found the best one. Sugar yield production also followed the same trend. Juice quality parameters were not influenced by weed control treatments. The correlation study revealed significant positive correlation between cane yield and yield factors viz., plant height, cane length, internodal length, shoot count, single cane weight and millable cane population etc. Complete weed control plot gave an economic advantage of about Rs.33,500 over unweeded control. In terms of B:C ratio, sunhemp incorporation gave the highest value fb oxyfluorfen and 2,4-D.

The overall results indicates that the weed problem in sugarcane could be effectively controlled by growing sunhemp as intercrop and incorporating it at 45 DAP or by spraying pre-emergence herbicides viz., oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (PE) fb 2,4-D. Growing sunhemp as intercrop and its incorporation at 45 DAP would facilitate eco-safe weed control as well as improvement of soil fertility.

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Appendices

Appendix – I

Monthly weather data during the crop period from November 2002 to September 2003

Month	Temperature (°C)		Relative humidity (%)		Wind speed (km/hr)	Total rainfall (mm)	Mean sunshine (h)	Number of rainy days	Evaporation (mm)
	Maximum	Minimum	Morning	Evening					
November	31.8	23.4	82	60	4.7	7.0	6.3	1	124.9
December	32.3	22.1	72	45	8.1	0	8.7	0	198.8
January	33.2	22.9	66	34	8.6	0	9.4	0	229.1
February	34.7	23.6	83	43	5.1	78.54	9.2	1	152.9
March	34.6	24.1	86	47	3.7	20.0	8.5	1	162.9
April	34.6	25.0	86	58	3.2	72.8	7.5	2	150.7
May	34.0	25.0	88	56	3.8	0	6.3	0	158.1
June	30.9	23.8	91	68	3.2	177.77	4.0	9	111.4
July	29.5	22.2	93	74	2.9	1111.8	2.5	15	99.5
August	30.0	23.4	93	73	3.1	320.8	4.2	12	115.2
September	31	22.7	91	66	3.3	216.65	7.3	3	138

Appendix II
Weed flora observed in experimental field

	Scientific name	Common name	Family
I.	MAJOR WEEDS		
A.	**Monocots**	Nil	
B.	**Dicots**		
1.	*Portulaca oleracea* L.	Indian purslane	Portulacaceae
2.	*Trianthema portulacastrum* L.	Giant pig weed	Aizoceae
3.	*Mollugo pentaphylla* L.	Parpadakapullu (M)	Mulluginaceae
4.	*Ageratum conyzoides* L.	Goat weed	Asteraceae
II.	MINOR WEEDS		
A.	**Monocots**		
1.	*Paspalum distichum* (L.)	Knot grass	Poaceae
2.	*Dactyloctenium aegyptium* (L.) Beauv.	Crowfoot grass	Poaceae
3.	*Panicum repens* L.	Torpedo grass	Asteraceae
4.	*Echinochloa colona* (L.) Link.	Jungle rice	Poaceae
5.	*Eleusine indica* (L.) Gaerth.	Goose grass	Poaceae
6.	*Cynodon dactylon* (L.) Pers.	Bermuda grass	Poaceae
7.	*Cyperus rotundus* L.	Purple nut sedge	Cyperaceae
B.	**Dicots**		
1.	*Euphorbia hirta* L.	--	Euphorbiaceae
2.	*Corchorus olitorius* L.	Wild safflower	Tiliaceae
3.	*Solanum nigrum* L.	--	Solanaceae
4.	*Commelina benghalensis* L.	Asiatic day flower	Commelinaceae
5.	*Tridax procumbens* L.	--	--
6.	*Euphorbia hirta* L.	Garden spurge	Euphorbiaceae
7.	*Amaranthus viridis* L.	Wild amaranth	Amaranthaceae
8.	*Parthenium hysterophorus* L.	Congress weed	Compositae
9.	*Phyllanthus niruri* Auct. Non. L.	Niruri	Euphorbiaceae

*M- Malayalam

Appendix - III

ABBREVIATIONS

'000 ha^{-1}	-	Thousand per hectare
°C	-	Degree Celsius
ai ha^{-1}	-	Active ingredient per hectare
B:C ratio	-	Benefit-cost ratio
CCS	-	Commercial cane sugar
cm	-	Centimeter
DAP	-	Days after planting
ds m^{-1}	-	Deci siemen per metre
fb	-	Followed by
g m^{-3}	-	Gram per metre cube
g	-	Gram
h.	-	Hours
K	-	Potassium
kg $cane^{-1}$	-	Kilogram per millable cane
km hr^{-1}	-	Kilometer per hour
l ha^{-1}	-	Litre per hectare
M	-	Malayalam
m	-	Metre
m^{-2}	-	Per square metre
m^{2}	-	Square metre
MCC	-	Millable cane count
mm day^{-1}	-	Millimeter per day
N	-	Nitrogen

No. m^{-2}	-	Number per square metre
OC	-	Organic carbon
P	-	Phosphorus
PE	-	Pre-emergence
Pol	-	Polarity
RH	-	Relative humidity
Rs. ha^{-1}	-	Rupees per hectare
r	-	Correlation coefficient
SMT	-	Small mill test
t ha^{-1}	-	Tonnes per hectare
WCE	-	Weed control efficiency
WI	-	Weed index
WP	-	Wettable powder
DMP	-	Dry matter production

WEED MANAGEMENT IN SUGARCANE (*Saccharum officinarum* L.) THROUGH HERBICIDES AND INTERCROPS

By
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ABSTRACT OF THE THESIS

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ABSTRACT

The present study was conducted to understand the effect of different weed management techniques i.e., hoeing, herbicides and intercropping systems on weed control, yield and quality of sugarcane. The field experiment was conducted at Anjanile, Chittur taluk of Palakkad district during 2002-03. Herbicide treatments were atrazine 2 kg ha^{-1} as pre-emergence (PE) fb hoeing and earthing up at 90 DAP, oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (PE) fb 2,4-D, ametryn 2.0 kg ha^{-1} as PE fb 2,4-D and glyphosate 1 kg ha^{-1} at 20 DAP fb 2,4-D at 60 DAP. The intercropping treatments consisted of blackgram incorporation at 45 DAP, sunhemp incorporation at 45 DAP and its bhusa incorporation, daincha desiccation by 2,4-D, and sunhemp desiccation by 2,4-D.

The major weed species in this experiment were *Portulaca oleracea, Mollugo pentaphylla, Trianthema portulacastrum* and *Ageratum conyzoides*. The population as well as dry matter production of weeds could be effectively controlled by the pre-emergence application of atrazine, oxyfluorfen or ametryn fb 2,4-D and also by growing sunhemp or daincha as intercrops. Higher weed control efficiency and lower weed indices could be observed for herbicides, the atrazine and oxyfloufen; and for incorporation of balackgram, daincha or sunhemp. Pre-emergence herbicides and sunhemp incorporation treatments gave better growth and yield parameters. In terms of cane production, oxyfluorfen 0.20 kg ha^{-1} as pre-emergence fb 2,4-D at 45 DAP and atrazine 2.0 kg ha^{-1} fb hoeing and earthing up at 90 DAP were found better.

The overall results indicates that the weed problem in sugarcane could be effectively controlled by growing sunhemp as intercrop and incorporating it at 45 DAP or by spraying pre-emergence herbicides viz., oxyfluorfen 0.20 kg ha^{-1} as pre-emergence (PE) fb 2,4-D. Among the intercrops, sunhemp incorporation at 45 DAP was found to be the best one. In terms of B:C ratio, sunhemp incorporation gave the highest value fb oxyfluorfen and 2,4-D. The results of

the study throws light on the effective and economic weed control in sugarcane by herbicides or intercrops, which could replace hand hoeing, which is a costly affair. Considering the green matter addition and eco-safe weed control, growing sunhemp would be more preferable.