

**EFFECT OF CYHALOFOP BUTYL ON
Echinochloa spp IN DIRECT SEEDED
PUDDLED PADDY (*Oryza sativa* L.)**

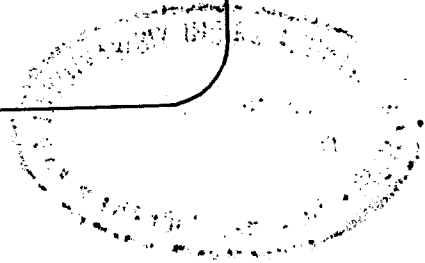
**A
Thesis
Submitted to the
Bidhan Chandra Krishi Viswavidyalaya
for the award of degree of Doctor of Philosophy
in
AGRICULTURE (AGRONOMY)**

**By
*Binod Kumar Singh, M. Sc. (Ag.)***



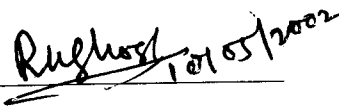
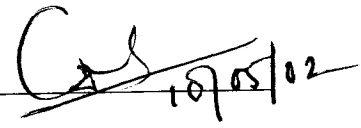
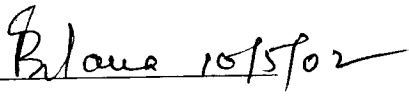
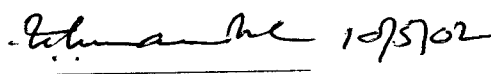
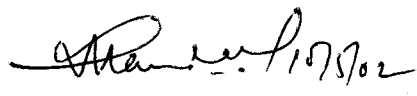
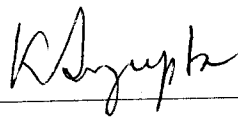
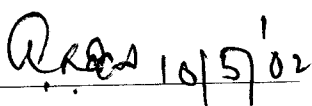
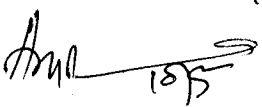
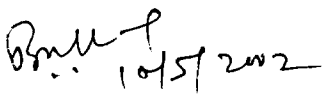
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2001**

Dedicated
To My
Beloved
Parents



**APPROVAL OF EXAMINERS
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DEGREE OF DOCTOR OF PHILOSOPHY
IN
AGRICULTURE (AGRONOMY)**

We, the undersigned, having been satisfied with the performance of Sri Binod Kumar Singh in the Viva-voce examination, conducted today, the 10/05/2002, recommended that the thesis be accepted for the award of degree of Doctor of Philosophy in Agriculture (Agronomy).

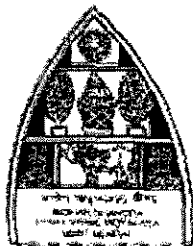
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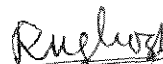
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This is certify that the work recorded in this thesis entitled. "EFFECT OF CYHALOFOP BUTYL ON *Echinochloa spp* IN DIRECT SEEDED PUDDLED PADDY (*Oryza sativa* L.)" submitted by Sri Binod Kumar Singh for the award of degree of Doctor of Philosophy in Agriculture (Agronomy) of Bidhan Chandra Krishi Viswavidyalaya, is a faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other degree or diploma. The assistance and help availed during the course of investigation from various sources have been duly acknowledged.


(R.K. Ghosh) 27.03.2002

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Dated. Mohanpur

The 27th march, 2002

BK Singh.
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List of abbreviations

@	:	at the rate of
a.i.	:	active ingredient
AICRP	:	All India Co-ordinated Research Project
°C	:	Degree Celcius
cm	:	Centimeter
DAA	:	Days after application
DAS	:	Days after sowing
EC	:	Emulsifiable concentrate
Fig	:	Figure
g	:	Gram
g m ⁻²	:	Gram per square metre
ha	:	hectare
G : S	:	Grain straw ratio
HI	:	Harvest Index
HW	:	Hand weeding
Kg	:	Kilogram
Kg ha ⁻¹	:	Kilogram per hectare
m	:	Metre
m ha	:	million hectare
MT	:	Metric tonne
No.	:	Number
NS	:	Non significant
pH	:	Negative logarithum of hydrogen ion concentration
(%) cent ⁻¹	:	Percentage
SEm±	:	Mean standard error
t	:	Tonne
t ha ⁻¹	:	Tonne per hectarre
T	:	Treatment
WCE	:	Weed control efficiency
WI	:	Weed index

ABSTRACT

To study the bioefficacy of the herbicide Cyhalofop butyl on management of the dominant grassy rice weed *Echinochloa spp* in direct seeded puddled rice culture in the Gangetic alluvial plains of West Bengal, field experiment was carried out in sandy clay loam soil during *kharif* and *boro* seasons of 1997 - 98 and 1998 - 99 at the Viswavidyalaya farm, Kalyani under irrigated condition. Five different doses of Cyhalofop butyl (0.04, 0.06, 0.08, 0.16 and 0.32 kg ha⁻¹ applied at 10 and 20 DAS during *kharif* and *boro* season, respectively), hand weeding at 20 and 40 DAS and integration of one hand weeding at 40 DAS with 0.06 and 0.08 kg ha⁻¹ Cyhalofop butyl along with weedy check were tried in this experiment in a randomised block design with three replications.

The investigation indicated that the dominant weed *Echinochloa spp* and other grassy weeds recorded 24.2 and 35.0 cent⁻¹ more population and 20.9 and 17.9 cent⁻¹ higher dry weights at *kharif* in comparison to *boro* season, respectively. The reverse trends of variation were obtained in case of sedges and broadleaved weeds (26.6 and 127 cent⁻¹ population and 21.7 and 21.8 cent⁻¹ dry weight, respectively). Post emergence application of Cyhalofop butyl 0.08 kg ha⁻¹ in combination with hand weeding at 40 DAS showed **maximum control** of *Echinochloa spp* in all the dates of observation. At harvest **this treatment** recorded 19 and 17 cent⁻¹ lower dry weight of *Echinochloa spp* during *kharif* and *boro* season, respectively in comparison to twice HW, **which, along with** maximum dose of Cyhalofop butyl treatment (0.32 kg ha⁻¹) **showed statistically** at par in all the dates of observation excepting at 30 DAS, **indicating the effectiveness** of integrated approach over the HW twice or sole application of Cyhalofop butyl. This may be due to the reduction of

chlorophyll content in leaves, its root length and fresh weight of *Echinochloa spp.*

The population and dry weight of other grasses, sedges and broad leaved weeds did not show any significant variations among the HW at 20 and 40 DAS and combination treatment of hand weeding at 40 DAS with Cyhalofop butyl 0.08 kg ha⁻¹ in all the dates of observation excepting at 30 DAS during *kharif* and *boro* season, respectively. Higher doses of Cyhalofop butyl only can able to manage the *Echinochloa spp* effectively in comparison to its lower doses but fail to control not only the other grassy weeds but also sedges and broadleaved weeds.

All the treatments recorded significantly higher grain yield over weedy check due to better management of weeds. Higher doses of Cyhalofop butyl (0.16 and 0.32 kg ha⁻¹) showed phytotoxic effect as wilting and leaf injury on surface and tip on rice plant and thus, did not produce higher grain yield of rice as that obtained from the other treatments. The treatment Cyhalofop butyl 0.08 kg ha⁻¹ combining with one HW at 40 DAS appreciably increased the grain yield by 91.9 and 85.5 cent⁻¹ over weedy check during *kharif* and *boro* season, respectively. Hand weeding twice also produced 94.8 and 89.1 cent⁻¹ higher grain yield over the control treatment during *kharif* and *boro* season, respectively but did not show significant variations with the former treatment. Both these treatments registered higher number of tillers, number of panicles, number of spikelet panicle⁻¹, panicle length, panicle weight and cent⁻¹ filled grain than all the other treatments may be due to better control of *Echinochloa spp* and other weeds, by reducing the crop – weed competition in the initial growth stage.

The weed index and weed control efficiency data showed the superiority of integrated approach over the application of chemical alone. Considering the gradual increase in labour wages, the integrated approach in direct seeded puddled rice is, therefore the most effective and remunerative method of weed management.

CHAPTER – 1

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop in the world. One-third of the world's population depends on rice for nearly two-third of its food (Labrada, 1996). Far East Asia is the leading rice producing region with 91 cent⁻¹ of world production (FAO, 1993a). Global output of rice is projected to increase at an annual rate of just under 2 cent⁻¹ to 409 million tonnes (milled terms) by the year 2000. This growth is driven mainly by continued improvements in yields through advances in plant technology as well as improvements in the application of inputs and irrigation (Yap, 1994).

India with 2.4 cent⁻¹ of the total area of the world is sustaining more than 16 cent⁻¹ global population. With a potential development of irrigation 80 million ha, the second largest in the world. India can boost present food production 200 MT to more than 260 MT by the year 2030 to keep pace with burgeoning population. New crop production technology, productivity per unit of land can be build up, must be cope up with this challenge in relation to inputs of farm challenge in relation to inputs of farm productivity. Weed management is one of the significantly inputs in this situation.

India has a 45.96 million hectares rice growing area with total production of 131.00 million tonnes of grain. Inspite of occupying the first position in respect of total world's area under rice culture, India ranks second in respect of production, which mainly due to its low productivity (2.85 t ha⁻¹) as compared to world average of 3.73 t ha⁻¹ (FAO Production Year Book, 1999). According to Economic Survey, 1999 the farm productivity of most of the important crops is very low in India in their world ranking. In our country rice is mostly grown in the States of West Bengal, Andhra Pradesh, Assam, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Tamil Nadu and Kerala. Nearly 67 cent⁻¹ of rice area in India is confined to the Eastern region.

Of the various reasons put forward to explain this low productivity, weed infestation is considered to be one of the most important constraints. The presence of weeds in rice poses a continuous threat to sustainable rice cropping in all the major rice agro - ecosystems of Asia. Given a conservative estimate of yield loss due to weeds at approximately 20 cent⁻¹, in excess of 100 million tons of rice production is lost annually due to weed competition (Crop Focus, Feb 2, 2001). In India weed management takes 30 – 50 cent⁻¹ share of total cost of plant production (Bhan, 1997). This illustrates the importance of weed control in minimizing the yield losses and stepping up the crop productivity. Weeds interfere with rice growth in different ways -

- They interfere the rice growth by competing for one or more growth limiting resources such as light, nutrients and water.
- Weeds also act as host of other pests, diseases and insects and indirectly limit production by serving as hosts for organism that adversely affect rice yields.
- Weeds require high labour costs to be kept under control (30 cent⁻¹ of the required labour) and huge crop losses may take place in rice fields with high weed infestations, which prevent normal harvesting.
- Some weeds also secrete root exudates which depress the normal growth of rice plants.

Thus weeds without any doubt are considered as a major pest and as a constraint in increasing rice production (Labrada, 1996).

Of the total annual loss of agricultural produce from various pests amounting to Rs. 6,000/- crores in India, weeds alone account for 33 cent⁻¹, plant diseases (pathogens) 26 cent⁻¹, insects 20 cent⁻¹, miscellaneous pests 8 cent⁻¹, storage pest 7 cent⁻¹ and rodents 6 cent⁻¹ (Kulshreshta and Parmar, 1992). The extent of yield loss due to weeds alone is around 18-20 cent⁻¹ for transplanted rice, 30-35 cent⁻¹ for direct sown puddled rice and more than 50 cent⁻¹ for direct seeded upland rice (Balasubramanian and Duraisamy, 1996).

Besides reduction in yield, weeds remove 30-40, 10-15 and 20-40 kg ha⁻¹ of nitrogen, phosphorus and potassium respectively (Alagh, 1988).

Direct seeding under puddled soil has become an acceptable alternative to transplanting as labour cost has increased, less expensive herbicides are become available and irrigated area has also increased. This practice reduced the cost of labour and cost of cultivation in respect to transplanted rice under good management condition (De Datta, 1981) and is more remunerative if the crop is managed properly (Chaudhary *et al*, 1996). Puddled seeding is recommended when water is received late in *Kharif* season. In this culture the field is leveled after puddling and pre-germinated seeds are broadcasted or drilled on the puddled soil with little or no standing water. The water level is increased gradually as the rice grows, because the field cannot be flooded until seedlings are established. After establishment of rice, the water level should be raised as rapidly as possible without damaging the young rice seedlings, then uniform and continuous depth of water is maintained. Due to increasing transplanting costs, labour scarcity and declining profitability of rice production, direct seeding of sprouted seeds on puddled field is gaining importance over transplanting method of stand establishment. But in this method weed problem is more intense (Moody, 1993) and causes 45 cent⁻¹ reduction in grain yield (Subramanian *et al*, 1991).

This practice of rice culture has become an increasingly important rice – crop establishment method in South East Asia. It is mainly practised in some parts of India, Bangladesh and Sri Lanka. (De Datta and Flinn ,1986).

Weed infestation is the major problem in direct seeded puddled rice due to alternate wetting and drying practised during initial growth of seedling (Reddy *et al*, 1995). The culture requires shallow flooding which results in more exposed soil area and aerobic condition, which induces a number of weeds. Because rice and weed germinate and emerge together, it results in more intense competition than transplanted rice.

The genus *Echinochloa* that includes about 50 weed species includes some of the most important rice weeds. The most common are *Echinochloa crusgalli*, *Echinochloa glabrescens* and *Echinochloa colona*.

Echinochloa crusgalli grows widely in both temperate and tropical regions. Its distribution ranges from 50° N to 40° S latitudes. *Echinochloa colona* occurs in tropical and sub-tropical regions. *Echinochloa crusgalli* prefers moist conditions and continues to grow when submerged whereas *Echinochloa colona* ceases to grow when submerged. *Echinochloa glabrescens* is found in the Indian subcontinent, South East Asia, China and Southern Japan.

Rice yield losses due to long competition with *Echinochloa spp* can be as high as 90 cent¹. *Echinochloa spp* germinate earlier than direct seeded rice and resemble like rice plant. During the first 3 weeks of weed growth, profuse emergence of new leaves and vegetative growth of tillers and adventitious roots occur. Therefore rice growth and development are drastically suppressed due to these weeds. It indirectly limits production by serving as a hosts for a number of organisms that adversely affect rice yields; provide food, shelter and reproduction sites for insects, nematodes, pathogens and rodents [Ou (1985) and IRRI (1988a)].

Murakami *et al* (1978) reported that the influence of barnyard grass on rice productivity was greater in the early maturing variety than in the late maturing one. Nishi (1981) showed that annual fluctuation in the dry weight of rice and *Echinochloa crusgalli* followed a similar pattern but the extent of the changes was more pronounced in case of weed. Under cool summer condition (25.7° Celcius) dry matter production of *Echinochloa crusgalli* was inferior to that of rice while the reverse was true at temperatures of 25.7° to 27° Celcius. Lestrangle (1983) opined that rice yield declined as densities of *Echinochloa crusgalli* increased. Senanayake *et al* (1986) reported that rice was sensitive to the presence of *Echinochloa crusgalli* causing depression of panicle and spikelet numbers in particular. A highly significant negative correlation

was established between weed dry weight and grain yield. The threshold density of *Echinochloa crusgalli* for season long competition was 5 plant m⁻² at which level grain yield losses were 8 to 17 cent⁻¹ in transplanted paddy. Devendra *et al* (1987) reported that *Echinochloa spp* were more competitive than rice in terms of light, moisture and CO₂ utilisation. The alternate drying and wetting caused an aggressive flush of both terrestrial and aquatic weeds to come up in early growth stage of the crop resulting in 28 to 48 cent⁻¹ yield reduction under midland transplanted condition (Singh and Bhan, 1989).

Hill *et al* (1990) observed that *Echinochloa spp* were more competitive in direct sown rice than transplanted rice and revealed that yield reductions of 20 cent⁻¹ being caused by 3 and 66 *Echinochloa spp* in direct seeded condition in comparison to transplanted flooded condition. Examination of the effects of rice density showed that the response to *Echinochloa* density of 300 direct sown rice plants m⁻² was equivalent in terms of yield produced to that of only 25 transplanted plants.

Herbicides are accounted for US \$1.06 billion in crop protection sales in 1999, 39 cent⁻¹ of rice crop production market (Crop Focus, Feb 2, 2001). Out of 160 million hectares of gross cultivated area of India only about 15 million hectares are currently treated with herbicides. Therefore, more exists further exploitation of herbicide use in our agricultural sector (Aditya Chaudhury *et al*, 1997). The first 6-weeks after seeding is the critical period of weed competition in direct seeded puddled rice. 2 to 3 HW at such early stage is necessary to prevent yield loss. Because HW is difficult and not economical to farmer in direct seeded puddled rice, chemical method combined with HW or mechanical method is an alternative that can be practised to reduce weed competition, crop losses and labour costs. Use of herbicides is one of the most labour saving innovations that has been introduced in rice farming. The reduction in yield can be reduced to a great extent by the use of herbicides

(Pandey and Shukla, 1991). Therefore, combined application of chemical and mechanical methods are cheaper and effective than HW. Two or more of these methods are more suitable for crop and weed situation to control weeds more effectively and economically (Ali and Bhanumurthy, 1985). With a view to the above ideas to manage *Echinochloa spp* and also other weed flora by applying Cyhalofop butyl (Clincher) the present investigation was carried out at 'C' Block Farm, BCKV, Kalyani, Nadia, West Bengal during the *Kharif* (wet) and *boro* (dry) seasons of 1997-98 and 1998-99 with the following objectives-

- To evaluate the efficacy of Cyhalofop butyl against *Echinochloa spp* and also on other weed flora in direct seeded puddled rice.
- To find out the effective dose of Cyhalofop butyl against *Echinochloa spp* in direct seeded puddled condition.
- To determine the integrated efficacy of Cyhalofop butyl with HW in controlling various weed flora including *Echinochloa spp* and
- To evaluate the phytotoxicity of Cyhalofop butyl on rice.

CHAPTER – 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In this chapter, emphasis has been made to critically review the available information on different methods of weed control to manage *Echinochloa spp* and other weeds in combination with herbicides or sole in direct seeded puddled condition. One major emphasis has been laid on a new herbicide Cyhalofop butyl to control *Echinochloa spp* and other weeds in direct seeded puddled rice. Some other related works were also taken for consideration whenever found necessary to support the findings of present investigation.

2.1 Weed problem in rice under direct seeded puddled condition

The prevalent weeds in rice field is often legacies of previous years crop seeds, rhizomes, tubers and bulbs surviving in the soil. The weed flora in rice field is greatly influenced by rice culture practiced. Continuous rice with unchanged cultural system encourage the build up of particular weeds adopted to that system.

Weed problem in direct seeded puddled condition is more severe in comparison to transplanted rice because it requires little or no standing water during initial period for proper emergence of pre-germinated seeds which are broadcast or drilled onto the puddled soil. The water level is increased gradually as the rice grows, because the field cannot be flooded until seedlings are established. After establishment of rice, the level of water should be raised as rapidly as possible without damaging the young rice seedling, then kept uniform and continuous water. This culture requires shallow flooding which results in more exposed soil area and aerobic condition which induces a number of weeds germinate and emerge together with rice seedlings. This results in more intense competition for nutrients, light,

moisture and other growth limiting resources. This competition becomes more severe when one of the growth limiting resources fall short of the combined requirement of both. (Reddy *et al*, 1995).

The weed problem is different from the main warm wet (*kharif*) season in rice cultivation. Thus, like in *kharif* season when grasses are predominant weeds in *boro* season rice fields, sedge weeds (Cyperaceae family) are predominant and some broadleaved weeds of semi-aquatic in nature are prevalent. *Boro* rice or summer rice is cultivated in a season when there is a spell of winter covering almost 60 cent¹ of its growing period. Due to cold weather and pre-germinated seeds are broadcasted in puddled condition, the weed problem is different from the main warm wet (*Kharif*) season of rice cultivation (Moody and Mukhoadhyay, 1982).

The extent of yield reduction as evidenced from the data collected over a number of seasons at many locations in India in the multilocal testing programme under the All India co-ordinated rice improvement project due to weeds alone in India has been estimated to be around 15 to 20 cent¹ for transplanted rice, 30 to 35 cent¹ for direct seeded rice under puddled condition and over 50 cent¹ for upland rice (Mukhoadhyay, 1974; Rao and Pillai, 1974). The loss in yield caused by weeds in rice has been estimated to be 9 and 51 cent¹ in case of irrigated rice depending upon the agroclimatic condition and the methods of cultivation, respectively (Mahapatra and Yaduraju, 1981).

Yield reduction due to uncontrolled weed growth generally ranges from 20 to 25 cent¹ for transplanted rice and 40 to 50 cent¹ for broadcast seeded rice in puddled soil (Moody, 1980).

2.2 Weed flora in direct seeded puddled paddy

2.2.1. Common weed flora prevalent in direct seeded puddled paddy

The most common weeds associated with rice under direct seeded puddled condition are *Echinochloa crusgalli*, *Echinochloa glabrescens*, *Echinochloa colonum*, *Leptochloa chinensis*, *Paspalum distichum*, *Bracharia mutica*, *Ischacum rugosum*, *Fimbristylis littoralis*, *Cyperus iria*, *Cyperus difformis*, *Scripus maritimus*, *Eclipta alba* (Annual report of IRRI 1972 to 1987). Ali *et al* (1981) reported that *Echinochloa crusgalli* and *Echinochloa colonum* were the predominant weeds in the monsoon and summer seasons of 1975 - 77 under puddled and non-puddled condition, respectively. Among sedges, *Cyperus difformis* was the predominant and its competition was severe in early stages under puddled condition. *Eclipta alba* was dominant dicot under both conditions. *Cyperus iria* was the most predominant weed in non-puddled rice. In puddled rice *Ammania baccifera* and *Marsilea quadrifolia* were the predominant weeds.

Sreedevi *et al* (1993) conducted a field trial at Kerala Agricultural University during 1992 and found the most problematic weeds were certain sedges *Cyperus iria*, *Cyperus difformis*, *Cyperus haspan*, *Fimbristylis miliaceae* and *Schoenoplectus lateriflorus* and broadleaved weeds (*Ludwigia perennis*, *Sphenoclea zeylanica*, *Dapotrium junceum* and *Ammania baccifera*). Prakash *et al* (1995) found that the following dominant weeds *Echinochloa colonum*, *Echinochloa crusgalli*, *Panicum repens*, *Leptochloa chinensis*, *Ludwigia adscendens*, *Marsilea quadrifolia*, *Cyperus difformis* and *Cyperus iria* during kharif season at Hebbal (Bangalore).

The most dominant weed species as *Echinochoa colonum* and *Cyperus iria* were found at Palampur during kharif 1988-89 and 1989-90. Whereas *Setaria glauca*, *Panicum repens* and *Commelina bengalensis* were present only in 1988-89 (Nandal *et al*, 1995). Subash *et al* (1996) observed the predominant weed species as *Echinochloa colonum*, *Echinochloa crusgalli* and *Leptochloa chinensis* and

dicot weeds as *Eclipta alba* and *Commelina bengalensis* under direct seeded puddled condition as well in transplanted rice plots at IARI, New Delhi.

It has been reported by Choi *et al* (1998) that the major weeds were *Echinochloa crusgalli* and *Digitaria sanguinalis* in early sown rice (10 to 25 May) whereas *Cyperus difformis* dominated by later sown crops (10 June). *Echinochloa crusgalli* gained in dominance as the rice crop developed. Angiras *et al* (1998) found that the major weeds were *Echinochloa crusgalli*, *Echinochloa colona*, *Ammania baccifera*, *Cyperus iria*, *Cyperus difformis*, *Cyperus esculentus*, *Aeschynomene indica*, *Monocharia vaginalis*, *Commelina forsakalli* and *Scripus spp*.

The most problematic weeds found in direct seeded puddled paddy during *kharif* 1994 and 1995 at Palampur were *Echinochloa crusgalli* and *Echinochloa colonum* constituting 23.24 cent⁻¹ of total weed flora and accumulating 71.1 cent⁻¹ of total weed dry weight. *Ammania baccifera* (31.64 cent⁻¹), *Scripus spp* (21.35 cent⁻¹), *Cyperus iria* (5.84 cent⁻¹) and *Cyperus difformis* (5.44 cent⁻¹) were the other dominating weed species (Rana *et al*, 1997). Suresh *et al* (1998) found the major weeds were *Echinochloa colonum*, *Cyperus iria* and *Trianthema monogyna* in direct seeded puddled rice. Mutanal *et al* (1997) observed the following weeds at maland tract of Karnataka such as *Eichhornia crassipes*, *Echinochloa crusgalli*, *Echinochloa colonum*, *Cyperus spp*, *Fimbristylis spp*, *Eclipta prostrata*, *Paspalum spp*, *Panicum spp* and *Commelina spp* under direct seeded puddled rice plot.

2.2.2 Shifting of weed flora in direct seeded paddy

Herbicides are widely used in the developed countries because of increasing cost of manual labour. Unfortunately, due to inherent selectivity of the herbicides, a shift in weed flora from annuals to perennials which are often difficult to control have been widely reported in many countries (Kim, 1983) as a result of repeated use of herbicides.

In Korea, repeated application of Butachlor, Thiobencarb and 2, 4 - D to rice have resulted in the predominance of perennial sedges, such as *Cyperus serotimus* and *Eleocharis kurogawi* (Ahn *et al* 1975). In Philippines, a long term annual herbicide applications have resulted in *Echinochloa crusgalli* and *Monocharia Vaginalis* becoming minor weeds and *Scripus maritimus*, a perennial sedge becoming increasingly dominant (De Datta, 1977). In Japan, long term application of many rice herbicides have caused a shift to perennial weeds (Ueki, 1983). Janiya and Moody (1987) observed that when the plots were hand weeded, *Monocharia vaginalis* and annual broadleaved weed to dominate and continuous application of herbicide caused population shift from annuals to perennials with a build-up of *Paspalum distichum*, a perennial grass. Ho and Zuki (1988) reported the changes in the weed flora of rice in Muda area of Malaysia since the adoption of double cropping and more rapidly growing cultivars. Grasses such as *Echinochloa crusgalli* and *Leptochloa chinensis* have large replaced the previously dominated broad leaved weeds and sedges. In Coimbatore, continuous application of Butachlor and 2, 4 - D caused a shift from dicot to monocot *Leptochloa chinensis* as dominant weed (Kandasamy and Sankaran, 1995). Repeated use of same herbicide year after year in the same area leads to shift in rice weed for a from *Echinochloa spp* to *Cyperus iria*, *Fimbristylis milliaceae*, and *Sphenoclea zeylanica* (Mukhopadhyay, 1997).

2.3 Critical period of weed competition in direct seeded puddled paddy

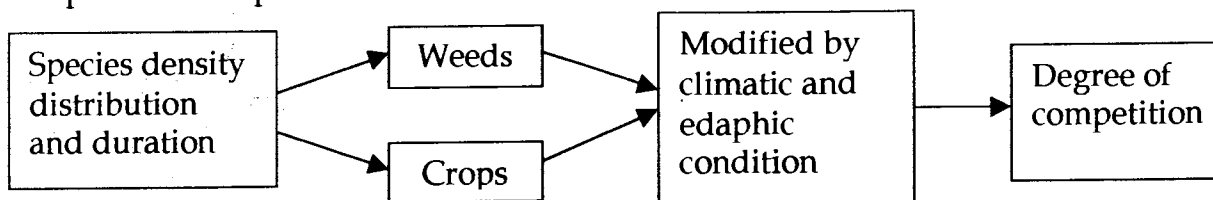
The critical period is the span of time between the time period after seeding or emergence when weed competition does not reduce crop yield and the time period after which weed competition will no longer reduce crop yield (Balasubramaniam and Ravichandran, 1996). Often this period is approximately the first one fourth to one third of crop life (Kandasamy, 1996).

The first 6 weeks after seeding is the critical period of weed competition in direct seeded puddled rice. 2-3 HW at such early stage is very necessary to prevent yield loss. Uncontrolled weeds in direct seeded puddled rice can reduce yield about 53 cent¹ (Rao and Pillai, 1974). Due to introduction of fertilizer responsive early maturing semi dwarf rice cv has made early and timely weed control highly critical for good yields (De Dutta and Herdt, 1983). It was found that yield reduction caused by weeds is more severe at the early stage of growth (Pande and Rao, 1965). Bhan *et al* (1980) observed that weed free maintenance upto 30 DAS gave highest paddy yield in direct sown rice; increasing the duration of weed-free period upto 45-60 days gave no significant further increase in yield. When rice was allowed to compete with weeds upto 50-60 DAS, the crop tolerated weed competition upto 30 DAS without much reduction in yield; further delay in HW decreased the yield. Yields with two HW at 15 and 45 or 30 and 45 DAS were similar to obtained under weed free conditions throughout the growth. Singh and Tandon (1982) opined that in case of direct sown rice 4 successive weedings for 40 days were needed before yields improved from 1.4 to 2.2 t ha⁻¹.

Singh and Ram (1982) reported that there was no significant variation in yield of direct seeded rice where plots were kept weed free initially for 25, 35, 45 or 55 days or throughout the crop period. Maintaining weed free condition during the first 15 DAS was not effective as weeds reappeared. For reducing weed competition and obtaining higher yields, weed free conditions for initial 25 DAS were essential. In the 2nd set of treatments weed infestation upto 45 DAS reduced the yield significantly. It was concluded that the period of first 45 DAS was the most crucial for weed removal for obtaining optimum yield in direct seeded paddy. Locket (1983) reported that weed competition in the first 15 to 30 days from germination caused greatest yield reduction.

2.4 Nature of rice-weed competition

Crop-weed competition is a function of



(Balasubramaniam and Ravi Chandran, 1996)

Competition of rice and weeds begin when they grow in close proximity and the supply of any necessary growth factor fall short of the combined requirements of both. In theory, the amount of these resources in a given rice environment is fixed – whatever is used by one plant species is not available for another. This means that resources taken by weeds are lost to rice and vice-versa. In general, rice dry matter yield will be reduced by 1 kg for every kilogram of weeds produced in the same area (Ampong – Nyarko and De Datta, 1991). The overall effect of crop-weed competition not only causes reduction in the biomass of rice but also in grain yield. Competition is maximum between plants which are similar in growth habits like root growth and foliage characteristics, as they have the same demands of the environment. Those species which utilize the best environmental growth factors dominate when population levels are similar. Competition for light occurs whenever plants are grown close together and one plant shades another to the point the intensity and quality of the light received by the shaded plants are less than that necessary for optimum growth. Plants vary greatly in their requirement for water. Competition for water and mineral nutrients is more important because it begins before competition for light. Competition for water is greater when roots of crop and weed are closely intermingled and obtain their water from the same volume of soil. In competing for nutrients, weeds absorb as much or more than the crop plant. Competition between weed and crop for space and CO₂ is generally not critical.

Borema (1962) observed that *Echinochloa crusgalli* (barnyard grass) took up nitrogen and phosphorus in enormous amount from the soil. This weed took up nitrogen more than 6 times as compared to the rice crop and removed 60 to 85 cent¹ of the total nitrogen in a severely infested crop (French and Gay, 1963). Barnyard grass offered a great degree of competition with rice for solar energy (IRRI Annual Report, 1967). Smith (1968) reported that barnyard grass competed more with thin rice stands than with thick rice stands. Rice panicle sq ft⁻¹, height of mature rice, weight of rice straw, filled grains panicle⁻¹ and weight of 1000 grains decreased as the barnyard grass (*Echinochloa crusgalli*) population increased in a fixed rice stand. Murakami *et al.* (1978) reported that the influence of barnyard grass on rice productivity was greater in the early maturing variety than in the late maturing one.

Ali and Sankaran (1981) reported that *Echinochloa crusgalli* and *Echinochloa colonum* were the predominant grassy weeds under puddled and non-puddled conditions, respectively; they competed with rice at all stages. Turner (1983) opined that weed control is an essential part of rice husbandry and *Echinochloa crusgalli* is the most ubiquitous rice weed, 9 plant m⁻² reduced yields of low density rice by 57 cent¹. Singh *et al.* (1985) studied competition from barnyard grass in rice hills at different N levels, rice and barnyard grass seedlings were transplanted in different proportions, viz - 5 rice + no barnyard seedlings, 4 rice + one barnyard grass and 3 rice + 2 barnyard grass seedlings per hill. N rates were 60, 120 and 180 kg ha⁻¹. Barnyard grass, irrespective of number decreased the number of tillers (23.9 cent¹) and dry weight (23.2 cent¹) of rice at 70 DAT compared to rice in pure stand. There was 20.2 and 37.5 cent¹ reduction in grain yield of rice with one and two barnyard grass seedlings per hill, respectively. Madhu and Nanjappa (1996) found that first 20 to 50 DAS was more critical period for crop-weed competition for nutrients.

2.5 Weed control methods in direct seeded puddled paddy

In the recent past the farmers realised the need of herbicide usage for successful farming. A fundamental reason for the wide spread use of chemical herbicides in modern agriculture is their ability to control selectively and immediately a wide spectrum of weeds in a variety of crops and in some situations where all other method fail or cannot be adopted (Mukhopadhyay, 1992). Also the hike in labour costs has laid to increased use of herbicides. Again HW in rice is a problem during early growth stage, since least difference between a grass and a rice seedling. Thus it has been a coming observation that in recent years the farmers on their own have started adopting chemical weed control themselves (Mukhopadhyay, 1995).

However, each control method have same advantage and disadvantage. Continuous use of same methods lead to build up tolerant weeds and shifting of weed flora. It is, therefore, necessary to combine or change the method of weed control for better management of weeds. The combined application of chemical and mechanical weed control practices are cheap and more effective than HW (Ali and Bhanumurthy, 1985; Ghosh, 1998).

There are several weed control measures followed in our country to control paddy weeds *viz.* Cultural, mechanical, biological, chemical and latest integrated weed management (IWM). Amongst these, chemical method of weed control is becoming more popular in most of the countries, though in India IWM (a combination of chemical at initial followed by one HW) is the best method. Now-a-days herbicides mixture with low doses with safer herbicides is coming up very rapidly to weed control science. In paddy for example Ethoxysulfuron combined with Fenoxaprop are used for controlling weeds (Kolhe, 1999). These are the following methods which are used to

control weeds as single or combined with other methods in direct seeded puddled rice.

2.5.1 Cultural Methods of Weed Control

A basic principle of cultural method is to increase competitive ability of rice and enable it to suppress the weed growth. Cultural methods include prevention of weed introduction, land preparation, crop rotation, plant population, fertilization and water management. A tall varieties with broader droopy leaves of rice by nature of their growth and height enable them to compete with weeds but dwarf varieties did not have the competitive ability (Mujik, 1979). Appropriate water management is important for controlling weeds, as many weeds do not germinate under flooded condition. Kandaswamy (1996) conducted a field experiment at Tamil Nadu and revealed that continuous submergence and field saturation condition in all the three seasons Kuruvai, Thaladi and Samba; weed density m^{-2} and weed dry weight was lowest (82, 47, 81) and (311, 179, 140 $kg\ ha^{-1}$), respectively of continuous submergence in all the three seasons whereas in alternate submergence plot (94, 54, 93) and (314, 188, 167 $kg\ ha^{-1}$), respectively which is lower than field saturation plot (130, 77, 133 m^{-2}) and (395, 260, 216 $kg\ ha^{-1}$), respectively.

2.5.2 Manual method of weed control

Manual methods of weed control includes burning, hand pulling hand trempling and mechanical HW. Hand weeding should be done at the early stage, although it may be difficult to distinguish grassy weed seedlings from rice seedlings at such early stage. Traditionally 2 to 3 HW are necessary to prevent yield losses due to weeds (Singh *et al*, 1985). However HW is more labour intensive oldest method and it is not economical to farmer. Early weeding is necessary in direct seeded rice, but often the time of manual weeding is dependent upon visual evidence of weed growth. By then, it is

probably too late, the weeds have already competed with the crop and caused yield reduction (Moody and Mian, 1979).

Moody (1980) reported that HW is by far the most common method, but it cannot be practised when weeds are very young as they are too tiny to handle. Thus, HW is invariably done later than the stage of which, weeds should be destroyed. He also reported that a single HW may be required 1000 man hours per hectare for dry seeded rice and 100 man hours per hectare in transplanted rice. Nandal *et al*, (1995) observed during *kharif* 1989 and 1990 with 3 doses of Anilophos, 3 timings of application, 3 herbicide checks (0.5 kg Oxadiazon, 1.0 kg Butachlor and 0.75 kg Pretilachlor) and 3 mechanical checks (HW twice, weed free and unweeded) and revealed that HW was significantly superior to rest of treatments except weed free plot in reducing weed count and weed dry weight.

Dhiman *et al* (1996) observed that weed free gave highest grain yield (5625 kg ha⁻¹) and this was followed by two HW (20 and 40 DAS). Muthukrishnan *et al* (1996) also reported that weed free check plot gave highest yield (3.8 t ha⁻¹) and this is significantly at par with two HW (3.7 t ha⁻¹) followed by Butachlor 1 kg ha⁻¹ with one HW (3.6 t ha⁻¹). Similarly weed control efficiency is also highest in weed free check (74 cent⁻¹) and followed by two HWs (68 cent⁻¹) and Anilofos + 2, 4 - DEE followed by HW (65 cent⁻¹). Madhu and Nanjappa (1996) found that weed free upto 50, 60, 70 and 80 DAS and weeding upto 20, 30 and 40 DAS gave higher grain and straw yield and lower dry weight of weeds during summer and wet season.

2.5.3 Chemical method of weed control

Herbicides development came into picture when the world agriculture was entering an era of increased mechanisation and intensive cropping programmes to increase yield with a reduction in production costs. Since, then herbicides have played a very vital role in augmenting these efforts. The

credit for introducing 2, 4 - D as herbicide goes to Marth and Mitch all of USA who in 1944 reported selective weed control by 2, 4 - D successfully in field of weed control. At present there are few weed problems where herbicides cannot solve (Rao, 1988). With the advent of chemical weed killers, a revolutionary effect was brought about in the method of weed control in rice because of their easy and rapid application and more effectiveness for controlling weeds over cultural and mechanical methods in many weed problem situation in different rice cultures (Bhardwaj and Verma, 1969; De Datta, 1972 and 1974 and Ray, 1973). Herbicides are accounted for US \$ 1.06 billion in crop protection sales in 1999, 39 cent¹ of rice production market. The major products and sales are Bensulfuron US \$ 220 million, Butachlor - US \$ 200, Pyrazosulfuron ethyl - US \$ 65 and Molinate US \$ 65 million (Crop Focus Feb 2, 2001).

Use of herbicides is one of the most labour saving innovations that have been introduced in rice farming. Many new herbicides has become available for every type of weed problems. In many instances, they offer the most practical, effective and economical means to control weeds. They are also adopted in large areas in short time, making them suitable for large farms. Herbicides applied before the rice germinates provide good weed control during the early growth stages when rice is most susceptible to weed competition. Pre-emergence and early post-emergence applications are most effective because the weeds are most susceptible at seedling stage. Weed resistance to herbicide increases with age. Several herbicides can selectivity control *Echinochloa spp* are Butachlor, Oxadiazon, Oxyflurofen, Pendimethalin, Thiobencarb, Molinate, Propanil, Pretilachlor and Quinclorac. The reduction in yield can be reduced to a great extent by use of herbicides (Pandey and Sukla, 1991). The range of herbicides that can be used safely is also limited, because the rice and weeds remain at the same developmental stage. The herbicides that can be safely in tropics are Butachlor, Thiobencarb,

2, 4 - D and Propanil effectively control weeds and have been widely tested in direct seeded puddled paddy.

2.5.3.1 Effect of Cyhalofop butyl in controlling weeds

Cyhalofop butyl is a new aryloxy - phenoxy propionate herbicide which offers good selectivity to rice together with high post-emergence activity across all European biotypes of *Echinochloa*. It possesses a favourable technological and environmental profile as well as rotational crop selectivity. It can be used in drained or flooded conditions, as well as by aerial or terrestrial applications (Buendia *et al*, 1998).

An experiment was conducted at Korea to determine the selective mechanism of Cyhalofop butyl ester (Butyl (R) - 2 - [4 - cyano - 2 - fluorophenoxy] phenoxy] Propionate) on *Echinochloa crusgalli* growing with rice. Cyhalofop butyl ester applied at 100 ppm inhibited *Echinochloa crusgalli* seedling growth by 90 cent¹ when applied at 3-leaf stage. Complete inhibition was observed when applied 180 ppm at the 4-leaf stage. Cyhalofop butyl ester applied through the stem at 10 and 50 ppm moved rapidly to the meristem and resulted in a greater reduction of height, root length and fresh weight of *Echinochloa crusgalli*, compared with root or leaf applications. Seedlings of *Echinochloa crusgalli* at 3 to 4-leaf stage were dipped in 180 ppm Cyhalofop butyl ester solution for one minute and removed immediately, it was found that regrowth of *Echinochloa crusgalli* was inhibited by 41.7 cent¹ of the untreated control (Park *et al*, 1994).

Kondo *et al* (1996) reported from Japan that Cyhalofop butyl is a selective rice graminicide which can control *Echinochloa crusgalli* upto the 5 to 6 leaf stage by foliar application. Different commercial ester products on KCI crore granules of this herbicide was also evaluated for improved bio-efficacy in green house and in field trials. Among them, di-tridecyl phthalate showed enhanced efficiency significantly above that of Cyhalofop butyl EC

formulation. Use of di-tridecyl phthalate contributed to the high concentration of the graminicide on the water surface, prolonged its half life on hydrolysis and enhanced its uptake into plants. These results suggested that Cyhalofop butyl granules containing di-tridecyl phthalate would be an effective way to maximize bioefficacy of this herbicide. Kondo *et al* (1997) also observed the herbicidal activity of Cyhalofop butyl EW formulation equals that of Cyhalofop butyl EC (Emulsifiable concentrate) formulation and can control 5 to 6 leaf stage of *Echinochloa crusgalli* when applied at 240 g ha⁻¹. To obtain a sustained level of control a 500 - 1000 litre ha⁻¹ spray solution of Cyhalofop butyl EW is recommended. The results suggested that Cyhalofop butyl EW is a promising rice herbicide for the control of late leaf stage of *Echinochloa crusgalli*, in terms of its high biological activity and crop safety.

Choi *et al* (1998) observed that *Echinochloa crusgalli* and *Digitaria sanguinalis* were the major weeds found in early sown rice, whereas *Cyperus difformis* dominated later sown crop. When herbicides (Pendimethalin + Molinate, Glyphosate ammonium, Cyhalofop butyl + Bentazone and Pyrazosulfuron ethyl + Molinate) were applied before 15 DAS weeds were effectively controlled only upto 35 DAS. Hence, the application of systemic herbicide once at 0 to 10 DAS and then again just after flooding is recommended for direct sown rice.

Kondo *et al* (1998) also reported from a green house trials and observed several core granules systems and solvent systems to develop an efficacious extruded granule of Cyhalofop butyl. Among them, the employment of malefic acid polymer type surfactants for the extruded core granule system and di-tridecyl phthalate + isoparaffin as solvent showed the best control efficacy against the 3-leaf stage of *Echinochloa crusgalli* than did the KCl of Cyhalofop butyl. Granules excluded by this system also showed a high release rate of graminicide in the upper layer of the water.

Wu *et al* (1998) conducted an experiment at Korea to develop a foliar applied herbicide for a wide spectrum weeds in dry direct sown rice. Uniform precision control composite design (UPCCD) was employed to evaluate the effects of herbicide mixtures including Cyhalofop butyl, Bispyribenzoxim (Bispyribac) and Pyrazosulfuron ethyl, and to determine the best application rates of these three herbicides. A partial additive effect was observed with a mixture of Bispyribenzoxim and Pyrazosulfuron against *Cyperus serotinus* and in *Aneilem keisak*. Cyhalofop butyl has no effect on these weeds. The most appropriate rate for a mixture of Cyhalofop butyl with Bispyribenzoxim and Pyrazosulfuron was found to be 100 : 12 : 10 g ha⁻¹.

Im *et al* (1999) reported that a single application of Imazosulfuron + Pretilachlor + Cyhalofop butyl or Bensulfuron methyl + Pretilachlor + Cyhalofop butyl at 26 DAS (1 day after flooding) was effective for suppression of annual and perennial weeds in dry, direct seeded rice fields. Two systematic applications of herbicides, Butachlor + Paraquet, Thiobencarb + Propanil or Molinate + Propanil at 10, 15 and 20 DAS followed by a second application of Imazosulfuron + Pretilachlor + Cyhalofop butyl at 26 DAS (1 day after flooding) were the best treatments for dry direct seeded rice field dominated by annual weeds such as *Echinochloa crusgalli*. Sumiyoshi and Kawana (1999) observed a wide range of herbicides and herbicide mixtures were compared for control of *Echinochloa colonum*. Control of both plant number and plant dry weight were effective with all herbicides tested. In some cases control was less if the herbicide was applied at the 1 - leaf stage than if applied before emergence. Similarly same mixtures were less effective if applied at the 2 to 5 - leaf stage than if applied either before emergence or at 1 to 2 - leaf stage. Cyhalofop butyl or Cyhalofop butyl with bentazone gave complete control even when applied at the 5 - leaf stage.

2.5.3.2 Effect of Cyhalofop butyl on rice plants

Park *et al* (1994) observed the selective mechanism of Cyhalofop butyl ester between rice and *Echinochloa crusgalli*. The results revealed that *Echinochloa crusgalli* seedlings growth was completely inhibited when applied at 180 ppm at the 4 - leaf stage. Rice was not inhibited by Cyhalofop butyl ester at 230 ppm regardless of its growth stage (3 -, 4 -, 5 - or 6 - leaf stages). Seedlings of rice and *Echinochloa crusgalli* at the 3 to 4 - leaf stage were dipped in 180 ppm Cyhalofop butyl ester solution for 1 minute and above ground parts of both species were removed immediately after. It was found that regrowth of *Echinochloa crusgalli* was inhibited by 41.7 cent⁻¹, but no inhibition was observed in rice. Chlorophyll content of *Echinochloa crusgalli* was also reduced to 18.7 cent⁻¹ of the untreated control, but no effect on chlorophyll content of rice was observed. Kim and Park (1997) reported that uptake and translocation of ¹⁴C Cyhalofop butyl ester was greater in *Echinochloa crusgalli* than rice following shoot treatment. ¹⁴C uptake by the roots of *Echinochloa crusgalli* increased reapidly at 30 minutes after treatments and maximum at 12 hours after treatment remaining stable thereafter. The pattern of uptake in rice roots was not significantly affected by the duration of herbicide treatment. In *Echinochloa crusgalli* the absorbed ¹⁴C Cyhalofop butyl ester was rapidly metabolized into the free acid and the amount of changed free acid was greater than that found in rice.

2.5.3.3 Effect of different chemical methods on weed population and dry matter accumulation in direct seeded puddled paddy

Rohm and Hass (1961) reported that *Echinochloa colonum*, *Echinochloa crusgalli* and *Digitaria spp* were controlled effectively with Propanil when applied at 4 - leaf stage. It was observed that 3 kg ha⁻¹ of Propanil applied at 2 to 4 - leaf stage of grass weeds, effectively controlled the weeds but when

the same amount was applied on the older grass, there was almost no effects on weeds.

Borulkar and Shelke (1980) opined that post emergence application of propanil at 2 kg ha⁻¹ at 21 DAS gave significantly higher yield than unweeded control. Pre-emergence applications of Butachlor + either 2, 4 - D or Propanil (3 kg ha⁻¹), followed by either 2, 4-D at 0.8 kg ha⁻¹ or Bentazone at 1.25 kg ha⁻¹ as POE controlled broadleaved weeds much better than Butachlor alone (Imperial, 1980). Sharma *et al* (1981) revealed that Butachlor 1 - 2 kg ha⁻¹, Propanil 2 kg ha⁻¹ and Thiobencarb 2 kg ha⁻¹ were the most effective herbicides in checking weed growth and nutrient depletion and produced yields comparable to the hand weeded treatment.

Ali *et al* (1981) observed that *Echinochloa crusgalli* and *Echinochloa colonum* were the predominant grass weeds under puddled and non puddled conditions, respectively. Weed free period required was upto 50 days in monsoon season and upto 130 days in the summer season for higher yield in puddled rice. Strachan (1985) reported that 0.15 lb whip (Fenoxaprop ethyl + Bentazon) applied to rice at 3 to 4 - leaf stage gave 87 cent⁻¹ control of *Echinochloa crusgalli*. Bas 514 - H (Quinclorac) a promising herbicide gave excellent control of *Echinochloa crusgalli* in rice with good crop tolerance (Pearson and Carte, 1986 and Reeves *et al*, 1986).

Pendimethalin granule 1.0 kg ha⁻¹ gave the most effective control of *Echinochloa crusgalli* in transplanted rice and increased panicle number m⁻² and panicle weight which was equally effective as Thiobencarb (1.0 - 1.5 kg ha⁻¹) and 2, 4 - D 1.0 kg ha⁻¹ (Tomar, 1987). Mishra *et al* (1987) found that among the different control treatments *viz.* Thiobencarb 1.5 kg ha⁻¹, Thiobencarb 1.0 ha⁻¹, Oxyfluorfen 0.5 kg ha⁻¹, Oxyfluorfen 0.1 kg ha⁻¹, HW twice (20 and 40 DAS), 2, 4 - D 0.8 kg ha⁻¹, Butachlor 1.5 kg ha⁻¹ as granules, Butachlor 1.5 kg ha⁻¹ as emulsion, Anilofos 0.3 kg ha⁻¹, 2, 4 - D 1.0 kg ha⁻¹, weed free and weed control plots weed dry weight was 42.5, 77.5, 62.5, 67.5,

93.8, 87.5, 84.3, 77.5, 99.0, 81.3, 107.5, 82.5, 10.8 and 217.5 g m⁻², respectively and yields were 1.99, 1.95, 1.93, 1.88, 1.86, 1.69, 1.66, 1.55, 1.53, 1.46, 1.41, 1.41, 1.96 and 0.96 t ha⁻¹, respectively.

Vijayaraghavan *et al* (1988) found that Butachlor 1.0 kg ha⁻¹ + one HW provided the best weed control (78 cent⁻¹) followed by Oxyfluorfen 1 kg ha⁻¹ and Piperophos 1 kg ha⁻¹ (76 cent⁻¹), HW (20 and 40 DAS) and Butachlor 1 kg ha⁻¹ (75 cent⁻¹) and Fluchloralin 0.5 kg ha⁻¹ (74 cent⁻¹). 2, 4 - D 0.8 kg ha⁻¹ and Oxadiazon 0.5 kg ha⁻¹ gave only 71 cent⁻¹ and 63 cent⁻¹ weed control, respectively. The application of Cinmethylin (Argold) indicates that it was best applied at the 2 - leaf stage of crop at the doses ranging from 10 to 100 g ha⁻¹ provided effective control of *Echinochloa spp*, *Cyperus spp* and *Monocharia vaginalis* (Jones, 1989).

Moussavi *et al* (1989) reported that Molinate incorporated pre sowing or post emergence at the 2 - leaf stage of *Echinochloa crusgalli* gave good weed control and crop tolerance was good, but it was essential that the field was kept flooded and that water remained undisturbed for 3 - 4 days. Thiobencarb applied 3 - 5 days before sowing or post emergence at the 2 - leaf stage of *Echinochloa crusgalli* was effective and the crop damage and stand reduction resulting was acceptable. Rathore (1991) observed that the conventional local method of weed control was by ploughing across the sowing direction in a 25 day old crop under shallow water, followed by planting uprooted seedlings in gaps. Weed biomass was lowest with 3 HWs, while net economic return was highest using Thiobencarb 1.5 kg ha⁻¹.

Gogoi and Kalita (1991) found that application of Bensulfuron methyl (0.04 kg), Butachlor (1.00 kg), Quinclorac (0.2 kg), Thiobencarb (0.7 kg), Pretilachlor (0.45 kg), Piperophos (0.3 kg), Pendimethalin (90.75 kg), 2, 4 - D (0.5 kg) or Butachlor (0.5 kg) followed by manual weeding at 35 DAS were assessed for weed control in direct seeded late sown flooded rice during late *kharif* season of 1998 and revealed that Butachlor + manual weeding gave the

greatest reduction in weed population and dry weights (112 m^{-2} and 44 g m^{-2}) compared with control plots (312 m^{-2} and 114 g m^{-2}). This treatment also gave the highest rice population and grain yield (207 m^{-2} and 1.82 t ha^{-1} , compared with 140 m^{-2} and 0.8 t ha^{-1} in controls).

Singh and Pillai (1993) opined that weed control efficiency in the Butachlor 1.5 kg ha^{-1} , Thiobencarb 1.5 kg ha^{-1} , Anilofos 1.5 kg ha^{-1} and HW control treatments was 69.3, 67.6, 71.2 and 91.6 cent⁻¹, respectively. Dry weight of weeds treated with herbicides at 3, 6 and 9 DAS (irrespective of herbicide used) was significantly lower than in plots treated 12 DAS. Sreedevi and Thomas (1993) also observed that HW resulted in the lowest weed populations in 1992 (6 plants) compared to untreated control values of 16 and 22 plants, respectively. Angadi *et al* (1993) reported that application of Butachlor 1.0 kg ha^{-1} was found effective as weed free check when combined with HW in controlling weeds. Nandal and Singh (1994) conducted a field trials at Palampur during *kharif* 1989 – 90 and the results indicated that weed dry weight was lowest in HW (30 and 60 DAS) treatment in 1989, compared with Oxadiazon 0.5 kg ha^{-1} , Butachlor 1.0 kg ha^{-1} , Pretilachlor 0.75 kg ha^{-1} with Anilofos 0.3 kg ha^{-1} and 0.6 kg ha^{-1} applied at 5 and 15 days after planting combined with them. Weed free control plots out performed than HW in both years.

A field experiment was conducted during *kharif* 1989 and 1990 with three rates of Anilofos (0.30 , 0.45 and 0.60 kg ha^{-1}), 3 timings of application (5, 10 and 15 DAS), 3 herbicide checks (0.5 kg Oxadiazon, 1.0 kg Butachlor and 0.75 kg Pretilachlor) and 3 mechanical checks (HW twice, weed free and unweeded) were evaluated. HW was significantly superior to the rest of treatments, except weed free plot in reducing weed count and weed dry weight and increasing grain yield during 1st year, while in the 2nd year it was found statistically alike to herbicide checks, 0.45 kg Anilofos (5 and 10 DAS) and 0.60 kg Anilofos (10 DAS) in respect of weed count and weed dry weight.

Imposition of weed control treatments decreased the nutrient loss by weeds. The highest uptake of nutrients by crops was noticed in weed free plots and the lowest in the weedy check. Nutrient uptake followed a similar trend for yield in the 2nd year (Nandal and Singh, 1995). Prakash *et al* (1995) opined that application of Oxyfluorfen 0.25 kg ha⁻¹ + Safener 1.0 kg ha⁻¹ (63.3 cent⁻¹), Anilofos 1.0 kg ha⁻¹ was least effective in controlling weeds (25.3 cent⁻¹), weed control efficiency, resulting in the lowest grain yield (2900 kg ha⁻¹). N uptake by weeds was significantly reduced in all weed control treatments (3.0 to 11.5 kg ha⁻¹) as compared to the weedy check (16.6 kg ha⁻¹).

Bisht *et al* (1996) reported that application of pretilachlor 0.6 kg ha⁻¹ + safener 0.6 kg ha⁻¹ applied at 3 days after planting were best treatment in controlling weeds and yield was not significantly different from that of weed free plots. It was also found that weed population were lower in the high density plots.

Butachlor 1.5 kg ha⁻¹ with or without Safener 0.6 kg ha⁻¹; Anilofos 0.5 kg ha⁻¹; Pretilachlor 1.0 kg ha⁻¹ applied 3 or 1 days before sowing or 1 DAS, weed dry weight at harvest was slightly lower with Anilofos than the other herbicides (Jayadeva and Nanjappa, 1996). Mahalle (1996) observed the effects of 4 methods of rice sowing (broadcast, drilling, rahu where pre-germinated seed were broadcasted on prepared rice field and dibbling) and 4 methods of weed control (HW twice at 15 and 30 DAS, Butachlor 1.5 kg ha⁻¹, Anilofos 0.5 kg ha⁻¹ and spreading of rice straw on weed dry matter accumulation). All weed control treatments decreased weed dry matter. HW resulted in the least weed dry matter accumulation. Similarly all weed control treatments increased rice grain yield compared with untreated control. HW + rahu sowing produced the highest grain yield (3.04 t ha⁻¹) and highest net return.

Subash *et al* (1996) observed that the effect of weed control (N - 120 kg ha⁻¹, manual weed control or herbicide application of Butachlor 1.0 kg ha⁻¹, Anilofos 0.5 kg ha⁻¹ and Chlorimuron ethyl 0.012 kg ha⁻¹) in transplanted

and in direct seeded rice. Transplanted rice plots exhibited low weed populations and low weed dry weight were significantly compared to direct seeded puddled rice. The application of 120 kg N ha⁻¹ significantly increased the weed populations compared with 60 kg N ha⁻¹. Manual weeding resulted in maximum decrease in weed population and weed dry weight. Among herbicide treatments, Anilofos gave the best overall weed control and highest grain yield. Chlorimuron ethyl was most effective against broadleaved weeds. Jayadeva (1997) opined that Anilofos 0.5 kg ha⁻¹ applied 1 days before sowing resulted in lowest weed population, but it was phytotoxic to crop and so gave a reduced grain yield. Pretilachlor 1.0 kg ha⁻¹ applied 3 DAS were found to be effective in controlling weeds and higher grain yields and greater net returns. Mutanal *et al* (1997) reported that weed dry weight was significantly lower after application of Anilofos 1, 3, 5 and 7 days after broadcasting sprouted seeds. However mortality of sprouted seeds was higher after application of Anilofos 1, 3 and 5 days after broadcasting sprouted seeds. weed control efficiency decreased from 8 days after broadcasting sprouted seeds.

Rana *et al* (1997) revealed that *Echinochloa crusgalli* and *Echinochloa colonum* were the most problematic weeds constituting 23.24 cent⁻¹ of total weed flora and accumulating 71.1 cent⁻¹ of total weed dry weight. Butachlor 2.0 kg ha⁻¹ + Safener 0.188 kg ha⁻¹ applied at 7 DAS controlled the weeds effectively (98 cent⁻¹ WCE), and increased grain yield. This treatment gave comparable results to applications of Butachlor 1.50 kg ha⁻¹ + Safener 0.188 kg ha⁻¹ at 2 and 7 DAS and two manual weed control treatments. The high labour cost of manual weed control brought down the net returns and net profit of this method compared with Butachlor 1.50 kg ha⁻¹ and 2 kg ha⁻¹ + Safener 0.094 and 0.188 kg ha⁻¹. Butachlor 2 kg ha⁻¹ + Safener 0.188 kg ha⁻¹ applied at 7 DAS was the most effective combination for controlling weeds in direct seeded puddled rice. (Angiras and Rana, 1998).

Jayadeva *et al* (1998) observed that Butachlor + Safener (1.5 kg ha^{-1}) and Pretilachlor 1.0 kg ha^{-1} applied 3 DAS is the best treatment in controlling weeds with crop safety point of view. Suresh *et al* (1998) opined that manual weeding at 25 and 40 DAS recorded lowest weed density of 3 species (*Echinochloa colonum*, *Cyperus iria* and *Trianthema portulacastrum*) total weed dry weight and greatest weed control efficiency (93.9 cent^{-1}), Oxadiazon 0.8 kg ha^{-1} , Butachlor 2 kg ha^{-1} and Thiobencarb 2 kg ha^{-1} provided 80.5, 78.3 and 35.1 cent^{-1} weed control efficiency. Thus, manual weeding was the best method of weed control and Oxadiazon was the most effective herbicide treatment. Kolhe (1999) revealed that reductions in weed dry matter were comparable between the post emergence application of Fenoxaprop ethyl (0.06 kg ha^{-1}) + Ethoxy sulfuron (15 g ha^{-1}) at 15 DAS and HW twice treatments. Higher weed control efficiency (74.2 to 89.6 cent^{-1}) were recorded with combined application of Fenoxaprop and Ethoxysulfuron, compared to single application of these herbicides.

2.5.3.4 Effect of different chemical methods on yield component and yield of rice in direct seeded puddled condition

Imperial (1980) reported that application of Butachlor 0.375 kg ha^{-1} and 0.75 kg ha^{-1} did not differ significantly in yield from those treated with Butachlor in combination with other herbicides. Yields from a plot treated with a sequential application of Butachlor 0.75 kg ha^{-1} at 6 DAS and 2, 4 - D 0.5 kg ha^{-1} at 30 DAS were significantly higher than those from a tank mixture of the two components. Ali and Sankran (1981) observed that weed free required was upto 30 days in the summer season for higher yield in direct sown puddled rice. Mixture of Thiobencarb 1 kg ha^{-1} + Propanil 2 kg ha^{-1} gave higher yield than individual herbicides in both seasons under puddled condition. Sharma *et al* (1981) conducted a field experiment and revealed that highest paddy yield was given by transplanted rice followed by direct sown

puddled rice and a significantly lower yield was given by direct sown rice under dry conditions owing to corresponding uptake of nutrients by the crop. Propanil 2 kg ha^{-1} and Thiobencarb 2 kg ha^{-1} produced comparable yields to the hand weeded treatment.

A field trial conducted at Pantnagar in 1984 and observed that application of Oxyfluorfen 0.15 kg ha^{-1} or Thiobencarb 1.0 kg ha^{-1} gave grain yields of 3.96 and 3.89 t ha^{-1} , respectively compared with 1.86 t ha^{-1} without weed control. Butachlor 1.5 kg ha^{-1} , Anilofos 0.3 kg ha^{-1} and 2, 4 - D ethyl ester 0.8 kg ha^{-1} gave yield more than 3 t ha^{-1} . All herbicide treatments increased the number of panicles m^{-2} and filled grain panicle $^{-1}$ compared with the control. HW at 30 and 50 DAS gave higher yields (4.18 t ha^{-1}) than any of the herbicide treatments (Kumar *et al* 1986). Vijayaraghavan *et al* (1988) found that HW at 20 and 40 DAS and Butachlor 1 kg ha^{-1} + one HW provided the highest yields (0.7 t ha^{-1}), 20 cent $^{-1}$ higher than unweeded control in direct sown puddled rice. Molinate incorporated pre sowing or post emergence at the 2-leaf stage of *Echinochloa crusgalli* gave good weed control and crop tolerance was good and subsequently give good yield, but it was essential that the field was kept flooded and that water remained undisturbed for 3 - 4 days (Moussavi *et al*, 1989).

Rathore *et al* (1991) reported that grain yield was increased by all weed control treatments and was highest using Butachlor 1.5 kg ha^{-1} as pre emergence or Thiobencarb 1.5 kg ha^{-1} or 3 HWs, or the conventional method + 2 HWs. Mukhopadhyay and Banerjee (1993) observed that Thiobencarb 1.0 kg ha^{-1} + 2, 4 - D 0.5 kg ha^{-1} resulted in the greatest grain yield (4190 kg ha^{-1}), followed by Butachlor 0.75 kg ha^{-1} + 2, 4 - D 0.5 kg ha^{-1} (3925 kg ha^{-1}) and Bensulfuron methyl 0.05 kg ha^{-1} (3900 kg ha^{-1}). Yield losses of upto 22.7 cent $^{-1}$ were observed in unweeded control direct seeded flooded rice (3238 kg ha^{-1}) when compared to rice treated with Thiobencarb 1.0 kg ha^{-1} + 2, 4 - D 0.5 kg ha^{-1} . Singh *et al* (1993) found that Butachlor 1.5 kg ha^{-1} , Benthocarb 1.5 kg ha^{-1}

and Anilofos 0.4 kg ha^{-1} and unweeded control were recorded reductions in grain yield (6.1, 3.1, 2.4 and 41.7 cent⁻¹, respectively) compared to the HW control. Grain yield reductions were 0.6, 0.4, 3.4 and 11.0 cent⁻¹ when herbicides were applied at 3, 6, 9 and 12 DAS compared to the HW control.

Mutanal *et al* (1997) revealed that Anilofos was applied 1, 3, 5, 7, 9, 11 and 13 days after broadcasting sprouted seeds (DABS), significantly higher rice grain yields (4.24 and 3.99 t ha^{-1}) were obtained after application of Anilofos 7 and 9 DABS, respectively, when compared to the weedy standard (2.71 t ha^{-1}). Radhamani *et al* (1997) observed that application of Anilofos 0.3 kg ha^{-1} + 2, 4 - D 0.4 kg ha^{-1} , respectively at 10 DAS resulted in higher grain yield and benefit cost ratio than those resulting from HW twice in direct seeded puddled rice. Butachlor 2 kg ha^{-1} + Safener 0.188 kg ha^{-1} applied 7 DAS was the most effective combination for yield and weed control in direct seeded puddled rice (Angiras and Rana, 1998). Jayadeva *et al* (1998) also found that Butachlor 1.5 kg ha^{-1} + Safener and Sofit 1.0 kg ha^{-1} applied 3 DAS was given highest yield and crop safety.

Suresh *et al* (1998) conducted a field trial at Kanpur and observed that manual weeding at 25 and 40 DAS was the best treatment in controlling weeds (93.9 cent⁻¹ WCE) and grain yield (3365 kg ha^{-1}) and yield increase over the weedy control (27.9 cent⁻¹). He also reported that one weeding at 25 DAS and 2 weedings at 25 and 40 DAS, produced grain yield of 3240 kg ha^{-1} and 3365 kg ha^{-1} which were on a par with that from the Oxadiazon 0.8 kg ha^{-1} (3141 kg ha^{-1}). The highest return was obtained with twice HW treatment (net income Rs. 1004.90 ha^{-1} greater than untreated control), followed by Oxadiazon 0.8 kg ha^{-1} treatment (Rs 999.10 ha^{-1}). The benefit cost ratio was highest in the Oxadiazon 0.8 kg ha^{-1} treatment. Butachlor 2.0 kg ha^{-1} and Thiobencarb 2.0 kg ha^{-1} were effective, but uneconomical.

2.5.4 Integrated weed management in direct seeded puddled paddy

The resilience of weed population under intensive herbicide use, build up to weed species tolerant of the control methods used and increasingly public concern about indiscriminate pesticide use and its effects on the environment and human health have led to wide spread appreciation of the Integrated weed management (IWM) Concept (Fryer and Matsunaka, 1997; Fryer, 1983). Thus, a sound weed management system in paddy includes both cultivation and herbicides in addition to good crop husbandry practices.

Herbicides especially in combination with one HW markedly decreased the N depletion by weeds (Singh and Singh, 1985; Srinivasan and Pothiraj, 1989). The cultural control measures which can be integrated with chemical control include rotation, stubble management, primary cultivation (including ploughing and tillage), the sowing date, row width, N rate and mechanical weed control. It was suggested that integrating cultural methods reduce the level of herbicides required.

Presently the modern trend in the field of weed control is to promote integrated weed management (IWM) so that chemical for weed control is to be used as minimum as possible and as a last resort (Mukhopadhyay, 1995).

In this culture, weed flora may not be controlled by herbicides alone as flushes of weeds come up at different stages. Application of herbicides with HW at 35-40 DAS given better results to control weeds in direct sown puddled rice. De Datta and Ampong-Nyarko (1988) observed that combination of Butachlor with 0.5 kg ha^{-1} + HW is more economical than only herbicides Butachlor 1.0 kg ha^{-1} or HW. They observed that Butachlor with one HW gave 4.2 t ha^{-1} grain yield and marginal benefit cost ratio (2.5) whereas only Butachlor gave 2.7 t ha^{-1} grain yield and marginal benefit cost ratio (5.7).

Ghosh (1998) working at alluvial plains of West Bengal, revealed that in transplanted paddy out of four chemicals (Butachlor, Pretilachlor, Cyhalofop butyl and Oxadiazon), Pretilachlor applied through Refit 800 ml ha⁻¹ at 3 DAT when integrated with one HW at 40 DAT showed the maximum (4.4 t ha⁻¹) and 45.1 cent⁻¹ higher grain yield over the unweeded control (3.1 t ha⁻¹) plot. The other chemicals Butachlor applied at 5 DAT through Machete @ 4 kg ha⁻¹, Cyhalofop butyl through Clincher 800 ml ha⁻¹ integrated with one HW at 40 DAT also showed 40.7, 34.8 and 40.2 cent⁻¹, respectively, higher paddy grain yields over unweeded control. HW at 20 and 40 DAT recorded the maximum grain yield of paddy.

Nandal *et al* (1998) also observed that conjunction of one HW (35 DAS) with Pretilachlor 1 kg ha⁻¹ gave highest yield (4142 kg ha⁻¹ and 4917 kg ha⁻¹) in both the year 1995 and 1996 and this was followed by Butachlor 1.5 kg ha⁻¹ + HW at 35 DAS (4087 kg ha⁻¹ and 4833 kg ha⁻¹). Both the herbicides Pretilachlor and Butachlor along with one HW gave significantly higher yield than only herbicidal treatment. Similarly, total weed count and dry weight was also lowest than two HW (20 and 40 DAS) plot and other treatments. Net return due to weed management was also highest (Rs. 14165 ha⁻¹) in Pretilachlor 1 kg ha⁻¹ + HW (35 DAS) and this was followed by Butachlor 1.5 kg ha⁻¹ + HW (35 DAS). Kolhe *et al* (1998) reported that pre-emergence application of Anilofos and Thiobencarb each supplemented by one HW at 35 DAS were found comparable to two HW in reducing dry matter of weeds and enhancing grain yield in direct seeded puddled rice. Among the herbicide combination, pre-emergence application of Anilofos or Thiobencarb followed by post-emergence application of Cyhalofop butyl was found more effective than 2, 4 - D in direct seeded rice.

2.6 Phytotoxic effect of herbicides in direct seeded puddled paddy

Imperial *et al* (1980) found that Butachlor 0.75 kg ha^{-1} with 2, 4 - D 0.50 kg ha^{-1} applied during the early stages of crop growth caused moderate injury to rice. Thiobencarb 1.25 kg ha^{-1} + Propanil 2 kg ha^{-1} and Thiobencarb 0.75 kg ha^{-1} on 8th days after planting showed no herbicide residue adverse effect on germination and dry matter production on the following crops of cotton, finger millet and black gram in both *kharif* and summer seasons (Ali and Sankaran, 1981).

Propanil, Molinate, Thiobencarb, Butachlor, 2, 4 - D, Bentazone or 2, 4 - D + MCPA when applied at various rates and dates either alone or as tank mixtures Moussavi *et al* (1989) found that Propanil was unsuitable because of application problems and the persistence of *Echinochloa crusgalli* was best applied in a mixture or followed by a residual soil applied herbicide such as Molinate or Thiobencarb. Molinate incorporated pre-sowing or post emergence at 2-leaf stage of *Echinochloa crusgalli* gave good weed control and crop tolerance was good but it was essential that the field was kept flooded and that water remained undisturbed for 3-4 days. Thiobencarb applied 3-5 leaf stage of *Echinochloa crusgalli* was effective and crop damage and stand reduction resulting was acceptable. Butachlor 2.4 kg ha^{-1} gave severe crop damage and prevented germination of a large proportion of the rice seeds. Prakash *et al* (1995) revealed that Anilofos 1.0 kg ha^{-1} was also highly phytotoxic to rice, as was Pendimethalin 1.0 kg ha^{-1} as pre-emergence.

Bisht *et al* (1996) reported the efficacy of Pretilachlor 0.4 kg ha^{-1} + 0.6 kg ha^{-1} Safener, Butachlor 1.0 kg ha^{-1} + Safener 1.5 kg ha^{-1} , Thiobencarb 1.0 kg ha^{-1} and 1.5 kg ha^{-1} applied 3 or 6 days after planting, respectively. Results indicated that no phytotoxic symptoms were observed with the treatments that included Safeners and weed are adequately controlled by these treatments in both years. Jayadeva *et al* (1997) observed that Anilofos 0.5 kg

ha⁻¹ when applied 1 DAS was phytotoxic to the crop and so gave a reduced grain yield, whereas Pretilachlor and Butachlor + Safener applied 3 DAS were found to be effective and resulted in higher grain yields and greater net returns.

Radhamani *et al* (1997) opined that application of Anilofos + 2, 4 - D mixture (0.3 kg ha⁻¹ + 0.4 kg ha⁻¹, , respectively) at 10 DAS resulted in best yield and high benefit cost ratio than two HW. Higher doses of these herbicides mixtures caused phytotoxicity to the seedlings at earlier applications. Delayed application (12 DAS) recorded less phytotoxic, but also lower weed control efficiency. The same scientists also found that application of 0.4 kg Anilofos resulted persistence in the soil for upto 56 days after treatment. Residues after two successive rice crops were below the level of detection. At higher doses, both Anilofos and 2, 4 - D residues were recorded in rice grain and straw, but the residue level were for below the minimum residue limit.

Angiras and Rana (1998) conducted a field experiment during 1994 and 1995 wet seasons at Palampur to determine the effect of Butachlor + Safener combinations with different doses and found that Butachlor + Safener combinations also caused acute toxicity symptoms, but rice plants were able to recover. Butachlor 2 kg ha⁻¹ + Safener 0.188 kg ha⁻¹ applied 7 DAS was the most effective combination for yield and weed control.

CHAPTER – 3

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation was conducted during the *boro* (dry) and *kharif* (wet) seasons of 1997-98 and 1998-99 to study the effect of Cyhalofop butyl on *Echinochloa spp* under direct seeded puddled rice at 'C' Block farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal. The details of the materials used and methods adopted during the course of investigation have been given in this chapter.

3.1 Experimental site

The experimental site was situated at 22°5' N latitude and 89°E longitude with an altitude of 9.75 metres above the mean sea level and topographically the land was medium in slope from west to east.

3.2 Experimental soil

The soil of the experimental field was a typical Gangetic alluvium (Entisol) with sandy clay loam texture, good water holding capacity and moderate soil fertility status. The soil samples were collected according to method described by Jackson (1973). The samples were collected from different spots of the plot upto a depth of 15 cm and were mixed thoroughly. A composite sample from this mixture was taken and subjected to chemical analysis to assess its reaction and fertility status. The soil was also subjected to mechanical analysis by International Pipette Method to estimate percentage of sand, silt and clay in the experimental field.

3.3 Climatic condition

The experimental area was under 'subtropical humid climate' and was situated just south of the tropic of cancer. The crop was grown during *kharif*

and *boro* seasons of 1997-98 and 1998-99. In the growing season of *kharif* 1997-98 the average maximum temperature was observed in the month of July

The physico-chemical properties of the experimental soil after analysis have been summarised in Table 1.

Table 1 Physico-chemical properties of the experimental soil

Physico-chemical properties (0-15 cm depth of soil)		
<u>Particulars</u>	<u>Results</u>	<u>Analytical methods Employed</u>
A. Mechanical composition of the soil		
a) Coarse sand (cent ⁻¹)	3.3	International Pipette method
b) Fine sand (cent ⁻¹)	42.5	(Piper, 1966)
c) Silt (cent ⁻¹)	18.7	
d) Clay (cent ⁻¹)	35.5	
B. Chemical composition of the soil		
a) Soil pH (1:2.5 soil water suspension)	6.8	pH meter method (Jackson, 1973)
b) Organic carbon (cent ⁻¹)	0.71	Walkey – Black method (Jackson, 1973)
c) Total nitrogen (cent ⁻¹)	0.069	Modified kjeldahl method (Jackson, 1973)
d) Available P ₂ O ₅ (kg ha ⁻¹)	18.96	Bray and Kurtz method (1945)
e) Available K ₂ O (Kg ha ⁻¹)	202.80	Flame photometer method (Muhr <i>et al</i> 1965)

(33.2^o Celsius) and the lowest mean temperature was in October 1997 (21.7^o Celsius). The rainfall ranged from 19.1 to 399.8 mm (total - 958.7 mm) and the relative humidity was maximum in the month of July (98 cent⁻¹) while the minimum was in the month of October 1997 (61.4 cent⁻¹).

During *boro* 1998-99 the rainfall ranged between 39.2 and 199.6 mm (total - 467.1 mm) and the relative humidity was maximum in the month of January 1998 (98.3 cent⁻¹) and minimum in the month of March 1998 (49.2 cent⁻¹). The average maximum temperature was higher in the month of May

1998 (35.6⁰ Celsius) and the lowest average temperature was in the month of January 1998 (11.2⁰ Celsius).

It is also observed that the average maximum temperature was found in the month of June 1998 (36.2⁰ Celsius) while the lowest mean temperature was in October 1998 (24.4⁰ Celsius). The rainfall ranged from 119.2 to 273.4 mm (Total - 933.8 mm) during the experimental period of *kharif* 1998-99 and the relative humidity was maximum in September 1998 (97.56 cent⁻¹) while the minimum in the month of June 1998 (66.22 cent⁻¹).

During the growing season of *boro* paddy in the same year the mean lowest temperature was found in January 1999 (9.9⁰ Celsius) and the average maximum temperature was in April 1999 (37.3⁰ Celsius). The rainfall ranged from 0 to 277.5 mm (total - 433.1 mm) and the relative humidity was found maximum in the month of January 1999 (99 cent⁻¹) and in March 1999 (36.9 cent⁻¹) the minimum was recorded.

The details of different meteorological parameters pertaining to the period of experimentation along with corresponding average for preceeding 20 years have been presented in Table 2 and illustrated in Figure 1.

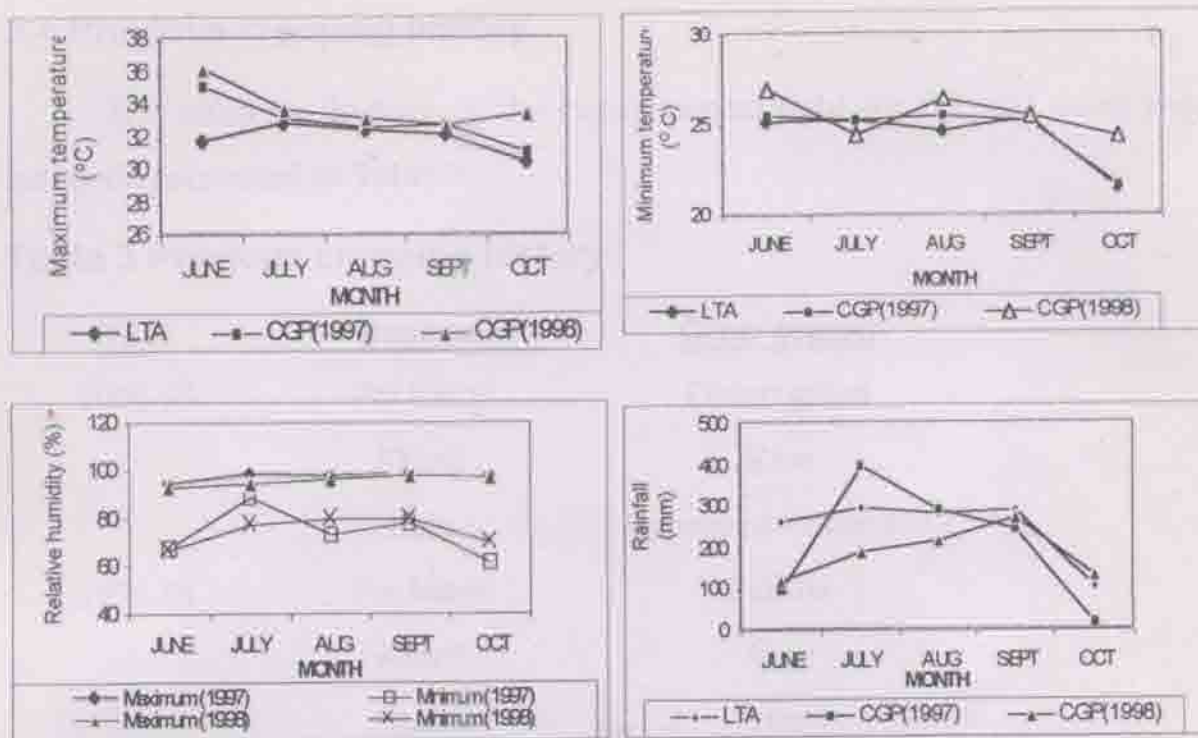
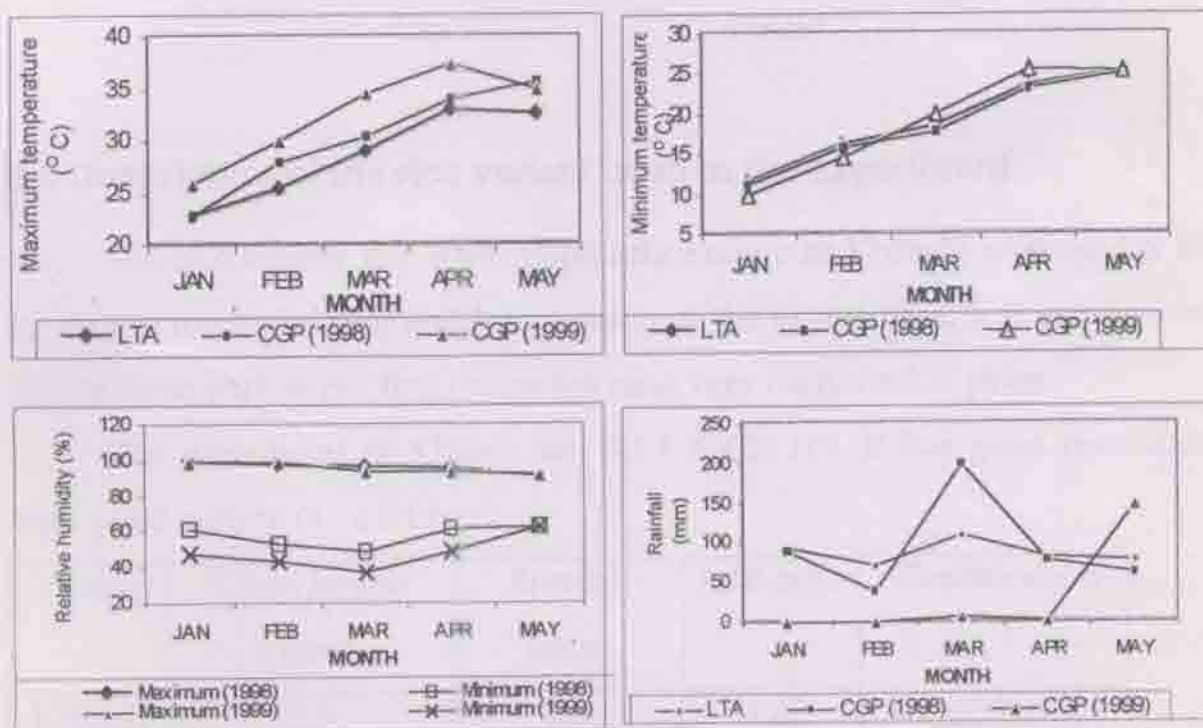
Table 2 Meteorological data during the period of experimentation

Months	Temperature ($^{\circ}$ Celsius)				Rainfall (mm)		Relative humidity (Cent ⁻¹)	
	Maximum		Minimum		LTA	CGP	Maximum	Minimum
	LTA	CGP	LTA	CGP				
Jul 97	32.80	33.20	25.20	25.30	296.5	399.8	98.00	89.00
Aug 97	32.30	32.60	24.60	25.50	283.2	293.5	97.00	73.00
Sept 97	32.10	32.80	25.30	25.20	292.4	246.3	98.00	78.00
Oct 97	30.40	31.12	21.50	21.70	108.6	19.1	97.10	61.40
Jan 98	22.60	22.80	11.40	11.20	94.8	89.9	98.30	61.10
Feb 98	25.30	27.90	16.10	15.90	70.6	39.2	96.80	52.70
Mar 98	28.80	30.40	18.30	17.80	109.3	199.6	95.03	49.20
Apr 98	32.90	34.03	23.30	23.22	83.70	76.9	94.40	62.00
May 99	32.40	35.60	25.20	25.10	78.4	61.5	89.96	62.40
Jun 98	35.10	36.20	25.40	27.02	108.5	119.20	92.87	66.22
Jul 98	32.20	33.70	25.00	24.50	280.2	190.8	94.54	77.03
Aug 98	32.60	33.20	25.90	26.50	276.4	217.3	96.29	79.67
Sep 98	32.40	32.70	24.80	25.50	296.6	273.4	97.56	79.30
Oct 98	31.60	33.40	24.10	24.40	115.1	133.1	97.06	69.61
Jan 99	23.20	25.90	11.30	9.90	92.5	nil	99.00	47.50
Feb 99	25.70	30.00	15.90	14.50	68.4	nil	98.30	43.70
Mar 99	29.30	34.60	18.20	20.01	116.8	6.2	93.90	36.90
Apr 99	33.10	37.30	23.40	25.50	81.20	1.4	93.10	49.10
May 99	32.50	34.98	25.30	25.31	83.6	158.0	91.77	62.35
Jun 99	33.60	34.22	25.50	25.79	146.6	277.5	93.53	74.53

LTA - Long term average, representing monthly mean of preceeding 20 years.

CGP - Crop growth period during *kharif* and *boro* seasons of 1997-98 and 1998-99.

Source - Department of Agro-meteorology, Faculty of Agriculture,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia,
West Bengal.

Kharif season 1997-98**Boro season 1998-99**

LTA = Long term average, representing monthly mean of preceding 20 years
 CGP = Crop growth period during kharif and boro season of 1997-98 and 1998-99.

Figure : 1. Meteorological data pertaining to period of experimentation.

3.4 Previous cropping history

The cropping history of the experimental field for the last three years has been presented in Table 3.

Table 3 Previous cropping history

<u>Year</u>	<u>Season</u>	<u>Crop grown</u>
1994-95	<i>Pre kharif</i>	Green gram
	<i>Kharif</i>	Rice
	<i>Rabi</i>	Rapeseed - mustard
1995-96	<i>Pre kharif</i>	Fallow
	<i>Kharif</i>	Rice
	<i>Rabi</i>	Wheat
1996-97	<i>Pre kharif</i>	Sesame
	<i>Kharif</i>	Rice
	<i>Rabi</i>	Potato

3.5 Description of the rice variety used in the experiment

The rice variety IET 4094 (Popularly known as Khitish) was used @ 100 kg ha⁻¹ in the both *kharif* and *boro* season of the experiment. It is non-scented rice cultivar with super fine grains fetching very high market price.

The parentages of Khitish are BU 1 X CR 115. It has good potentially high yield variety (4 - 4.5 t ha⁻¹)

Variety	Grain length (mm)	Breadth (mm)	L/B ratio	Classification
Khitish	8.5	2.6	3.27	Long slender

3.6 Plan of work

3.6.1 Details of the experiment

Crop growing Season: *Kharif* 1997 and *Boro* 1998

And *Kharif* 1998 and *Boro* 1999.

Design of experiment: Randomised Block Design (R BD)

Number of treatments: 9

Number of Replications: 3 Total Number of Plots: 27

Plot Size

a) Gross experimental area: 680 m²

b) Net plot Size: 4 x 4 m²

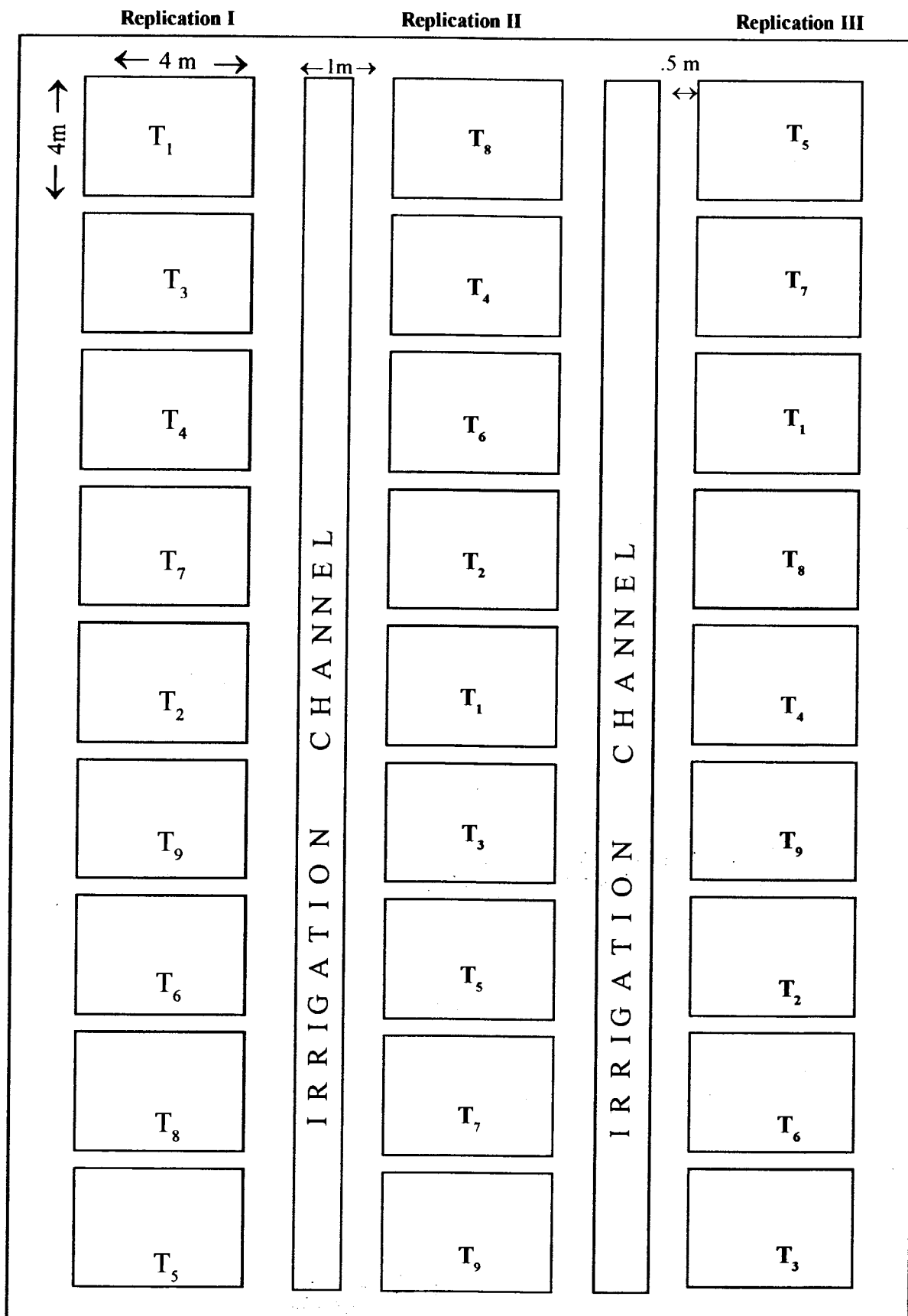
The lay-out plan for the experiment has been presented in Figure 2.

3.6.2 Details of the treatments concerned to the experiment

The details of the treatments concerned to the experiment have been given in Table 4.

Table 4 Treatment details for control of weeds in direct seeded puddled rice

Treatment No	Treatment	Concentration cent ⁻¹	Dosage (kg ha ⁻¹)	Time of application (DAS)
T ₁	Cyhalofop butyl	10EC	0.04	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₂	Cyhalofop butyl	10EC	0.06	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₃	Cyhalofop butyl	10EC	0.08	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₄	Cyhalofop butyl	10EC	0.16	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₅	Cyhalofop butyl	10EC	0.32	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₆	Hand weeding (Twice)	—	—	20 and 40
T ₇	Cyhalofop butyl + Hand weeding (40 DAS)	10EC	0.06	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₈	Cyhalofop butyl + Hand weeding (40 DAS)	10EC	0.08	10 (<i>Kharif</i>) and 20 (<i>Boro</i>)
T ₉	Weedy check	—	—	—



Design = Randomised Block design, Replication = 3, Treatment = 9

Figure 2 Plan of layout for the experiment

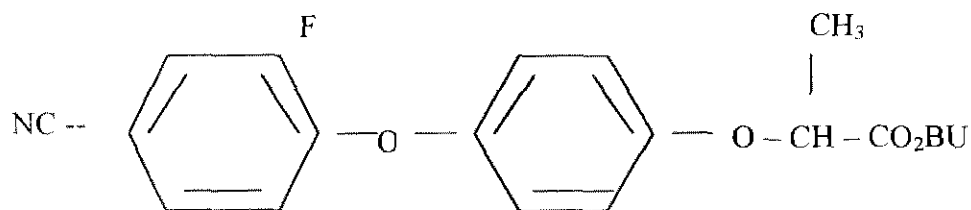
3.7 Details of herbicides used in the experiment

The specification of Cyhalofop butyl used in this experiment has been given here --

Commercial name - Clincher 10 EC

Chemical name - Butyl - R-2-4-(4-Cyano-fluorophenoxy) - Propionate

Structural Formula:-



Empirical Formula: $C_{20}H_{20}FNO_4$

Molecular Weight : 357.39

Formulation type :Emulsifiable/ Concentrate

Appearance, Colour, state and order : Amber Clear liquid, no odour.

Statement of Ingredient

<u>Ingredient</u>	<u>W/W cent⁻¹</u>
Clincher 10 EC NB ₄ Tech (Purity 97.4 cent ⁻¹)	10.4
Anionic / Non-ionic surfactant blend	8.0
Ployglycol 26-2	50.0
Oleic acid	2.5
Aromatic solvent	9.1
Total	100

Activity : It is used as post-emergence to control grasses such as *Echinochloa crusgalli*, *Echinochloa colonum* and *Echinochloa glabrescens*. It has no pre-emergence activity and a very short residuality of 2-3 days. It has no activity on broadleaved weeds or sedges.

3.8 Used equations for calculating the amount of different chemicals required in the experiment

- a) Fertilizer - The amount of fertilizer required to apply to a given area was calculated by using the following formula

$$\text{Amount (kg)} = \frac{\text{Amount of element desired (kg)} \times \text{area (ha)} \times 100}{\text{cent}^{-1} \text{ of element in fertilizer}}$$

$$\text{Amount (g)} = \frac{\text{Amount of element desired (kg)} \times \text{area (m}^2\text{)} \times 10}{\text{cent}^{-1} \text{ element of fertilizer}}$$

- b) Herbicide - The amount of herbicide (commercial formation) required to apply to a given area was calculated on the basis of the following formula

$$\text{Amount (kg or l)} = \frac{\text{Rate desired (kg a.i.ha}^{-1}\text{)} \times \text{area (ha)} \times 100}{\text{cent}^{-1} \text{ of herbicide concentration}}$$

$$\text{Amount (g or ml)} = \frac{\text{Rate desired (kg a.i.ha}^{-1}\text{)} \times \text{area (m}^2\text{)} \times 10}{\text{cent}^{-1} \text{ of herbicide concentration}}$$

The calculated amount of insecticide required to apply to a given area was calculated using the following formula.

$$\text{Amount (kg or l)} = \frac{\text{Rate desired (kg a.i.ha}^{-1}\text{)} \times \text{area (ha)} \times 100}{\text{cent}^{-1} \text{ concentration of insecticide}}$$

$$\text{Amount (g or ml)} = \frac{\text{Rate desired (kg a.i.ha}^{-1}\text{)} \times \text{area (m}^2\text{)} \times 10}{\text{cent}^{-1} \text{ concentration of insecticide}}$$

3.9 Agronomic operations followed in the experiment

Proper care was taken for management of all the experimental plots from the beginning of sowing of seeds upto harvest. The details of various agronomic practices are given in Table 5.

Table 5 Schedule of agronomic operations followed in the experiment

Sl. No.	Operation	Date	Details of operation
1	Land preparation		
	(a) Preparatory tillage		
	(i) Initial	(<i>Khariif</i>) 2/7/97 25/6/98 (<i>Boro</i>) 14/1/98 21/1/99	The experimental field was initially ploughed for three times crosswise in standing water with power tiller to make the land well puddled
	(ii) Final	(<i>Khariif</i>) 9/7/97 1/7/98 (<i>Boro</i>) 21/1/98 28/1/99	Final land was prepared with the help of country plough crosswise for two times followed by ladder to obtain uniform surface.
	b. Lay out	(<i>Khariif</i>) 10/7/97 2/7/98 (<i>Boro</i>) 22/1/98 29/1/99	The experimental field was divided into 3 blocks and each block was subdivided into 9 plots. The plots under each replication were demarketed by bunds, each of 25 cm high all round. One irrigation cum drainage channel was given between 1 st and 2 nd block and similar type of another channel was given between 2 nd and 3 rd block. The bunds and irrigation channels were 0.5 m and 1.0 m wide, respectively.
2	Preparation of seeds for sowing		
	(i) Seed treatment	(<i>Khariif</i>) 7/7/97 29/6/98 (<i>Boro</i>) 16/1/98 23/1/99	The seeds of paddy used @100 kg ha ⁻¹ and <i>Echinochloa crusgalli</i> were mixed in 1:200 ratio in weight basis and soaked in water for 24 hours for wetting. Then in 1 kg seed mixture 2 g Diathane M - 45 was used for seed treatment (before that the excess water was removed)

		(ii) Sprouting of seed		(<i>Kharif</i>) 8/7/97 30/7/98 (<i>Boro</i>) 17/1/98 24/1/99	from the mixture of rice and weed seed after wetting). The treated seed mixture was dried in shade and kept on banana leaves mixing with compost. The mixture of compost and treated seed was binded gently in gunny bag to keep for sprouting for 2 days in <i>kharif</i> and 4 days in <i>boro</i> season.
		(iii) Sowing of seed		(<i>Kharif</i>) 11/7/97 3/7/98 (<i>Boro</i>) 23/1/98 30/1/99	After removing the sprouted seeds from gunny bag these were uniformly placed in line with 20 cm spacing of east-west direction. Before that draining of excess water was done from the experimental plots.
3	Fertilizer Management			(<i>Kharif</i>) 9/7/97 1/7/98 (<i>Boro</i>) 21/1/98 28/1/99 (<i>Kharif</i>) 10/8/97 2/8/98 (<i>Boro</i>) 22/3/98 28/3/99 (<i>Kharif</i>) 5/9/97 30/8/98 (<i>Boro</i>) 20/4/98 25/4/99	The recommended fertilizer doses of 60 Kg N, 30 Kg P ₂ O ₅ and 30 Kg K ₂ O in <i>Kharif</i> and 100 Kg N, 50 Kg P ₂ O ₅ and 50 Kg K ₂ O were applied in <i>boro</i> season. 25 cent ⁻¹ of nitrogen and full doses of phosphate and potash were incorporated in the soil at the time of final land preparation as basal, 50 cent ⁻¹ nitrogen was applied at active tillering and rest 25 cent ⁻¹ nitrogen was applied at panicle initiation stage. Urea, Single Super Phosphate and Muriate of Potash were used as the source of Nitrogen, Phosphate and Potash respectively in the experimental field in both years.

4 Water management

During the sowing of sprouted seed mixture, for uniform germination the excess water was drained out from the each plot and was kept only to saturate the soil. After germination of rice seedlings uniform and continuous water was maintained and level of water was then increased with the development of rice seedlings. 3-5 cm of water tried to maintain upto dough stage in each plot. In all the plots water was drained out before top dressings of fertilizer. Water was drained out 7 and 10 days before harvesting during *kharif* and *boro* season, respectively in each year.

5 Application of treatment

(a) Herbicide application
(*Kharif*) 21/7/97
13/7/98
(T₁, T₂, T₃, T₄,
T₅, T₇ and T₈)
(*Boro*) 12/1/98
20/1/99
(T₁, T₂, T₃, T₄,
T₅, T₇ and T₈)

The required quantity of commercial formulation of herbicide was accurately measured with the help of a injection syringe and was applied with high volume knapsack sprayer fitted with flat pan nozzle with 500 litre water ha⁻¹ volume of spray. Proper care was taken to ensure uniformity in herbicide application.

(b) Hand weeding
(i) 20 DAS
(*Kharif*) 1/8/97
23/7/98
(*Boro*) 13/2/98
20/2/99
(ii) 40 DAS
(*Kharif*) 21/8/97
13/8/98
(*Boro*) 3/3/98
10/3/99

Hand weeding was done in T₆ plot with the help of "Khurpi" and small spade to remove weeds only in T₆ plot.

Hand weeding was done in T₆, T₇ and T₈ plots following same procedure.

6	Observation on population and dry weight of weeds		
(i)	30 DAS	(Kharif) 11/8/97 3/8/98 (Boro) 23/2/98 20/3/99	The Quadrant (50 cm x 50 cm) was placed at randomly 4 times in each plot for counting of <i>Echinochloa spp.</i> , other grasses, sedges and broadleaved weeds and pegs were inserted at the corner to demarcate for next counting of weeds. The same quadrant was placed at random at two places outside the net plot area but inside the border rows and weeds were pulled out of the soil, washed thoroughly with clean water, labeled properly, kept in the oven dried weeds were weighted in an electrical balance and dry weights were recorded.
(ii)	45 DAS	(Kharif) 26/8/97 18/9/98 (Boro) 10/3/98 17/3/99	
(iii)	60 DAS	(Kharif) 11/9/97 3/9/98 (Boro) 23/3/98 2/4/99	
(iv)	At harvest	(Kharif) 23/10/97 20/10/98 (Boro) 5/6/98 10/6/99	
7	Plant protection measures	(Kharif) 11/9/97 3/9/98 (Boro) 23/3/98 2/4/99 (Kharif) 26/9/97 18/9/98 (Boro) 8/4/98 17/4/99	Foliar spraying of Demicron (1.2 ml litre ⁻¹) was done at 60 DAS and at 75 DAS to protect the crop against rice insects.
8	Harvesting	(Kharif) 23/10/97 20/10/98 (Boro) 5/6/98 10/6/99	

			previously for tiller count. Ten panicles were taken at random for panicle length, weight of panicle and for number of spikelet panicle ⁻¹ and cent ⁻¹ filled grain panicle ⁻¹ calculation. Then the harvested crop was left as such in field for 2 days for sundrying.
9 Threshing	(Kharif)	26/10/97	The sundried rice plants were taken to the threshing floor and threshed separately for each plot with the help of pedal-thresher. The straw and grain to each individual plot were dried separately under sun. After proper cleaning and drying grains and straws of each net plot were weighed and yields were recorded.
		23/10/98	
	(Boro)	10/6/98	
		15/6/99	

3.10 Experimental observations

3.10.1 Observations on weeds

Regular observations were taken to identify different weed species prevalent in the experimental plots. Weed flora in each plot of the entire experimental field were studied in respect of their population and dry matter accumulation by them.

3.10.1.1 Weed count

Weed population (m⁻²) was calculated at 30, 45 and 60 DAS and at harvest of the crop in all the plots as mentioned earlier in schedule of agronomic operation.

3.10.1.2 Dry matter accumulation or weed dry weight

The dry weight of weeds were recorded separately at 30, 45 and 60 DAS and at harvest as mentioned earlier in schedule of agronomic operation.

3.10.1.3 Weed control efficiency

It denotes the efficiency of the applied herbicide or a herbicidal treatment for comparison purpose. Weed control efficiency of different treatments was computed on the basis of weed dry weight of *Echinochloa spp* and total weeds as below

$$\text{WCE (Cent}^{-1}\text{)} = \frac{\text{WDC} - \text{WDT}}{\text{WDC}} \times 100$$

WDC = Weed dry weight in control plot

WDT = Weed dry weight in treated plot

3.10.2 Observations on rice crop

3.10.2.1 Number of tillers

Tiller counting was made from net plot area randomly by placing quadrant at 3 different places before harvest and marked for other yield component and then converted into number of tiller m⁻² area.

3.10.2.2 Number of panicles

The number of ear bearing tillers was counted at harvest from the samples already selected and marked previously for tiller count in each plot and was expressed as the number of effective tillers or panicle m⁻².

3.10.2.3 Length of panicle

Ten panicles (ear heads) were taken at random from each plot. Then the panicle length was measured from its basal node to the tip of the top most grain and finally the average length for each treatment was calculated and was recorded.

3.10.2.4 Weight of panicle

Ten panicles were taken at random from each plot and weighed separately to get an average panicle weight of each treatment.

3.10.2.5 Number of spikelet panicle⁻¹

Spikelet number includes filled, partially filled and unfertilized spikelets. Samples collected for panicle observation from each individual plot were threshed, spikelets were counted and then the average number of spikelets panicle⁻¹ for each plot were calculated and recorded.

3.10.2.6 Cent⁻¹ filled grains

The filled grain cent⁻¹ is a ratio of number of filled grain to the total number of spikelets. This was calculated and recorded for each individual plot.

3.10.2.7 Test weight of grains

One thousand filled grains were taken at random from the harvested bulk samples of each treatment, dried in the sun and their weights (at 14 cent⁻¹ moisture) were recorded separately for each plot.

3.10.2.8 Yield of grain and straw

Plants from net plot area of each plot excluding the border rows were harvested at ground level. These were then threshed, winnowed and sundried separately for each treatment (plot wise) and the grain yields were computed at 14 cent⁻¹ moisture basis and converted in to kg ha⁻¹.

$$Y = \frac{\text{Plot yield (g)}}{1,000} \times \frac{10,000 \text{ m}^2}{\text{plot sample area (m}^2\text{)}}$$

Y = Grain yield in kg ha⁻¹.

After threshing the straw bundles were allowed to dry for 2 to 3 days and then yield of straw was recorded for each plot. It was also converted in terms of kg ha⁻¹.

3.10.2.9 Harvest index (HI)

Relationship between total dry matter (biological yield) and economically useful component (grain yield) was given by harvest index. HI is defined as a ratio of economical yield to biological yield.

$$\text{HI (cent}^{-1}\text{)} = \frac{\text{Economic (grain) yield}}{\text{Biological (grain + straw) yield}} \times 100$$

3.10.2.10 Grain : Straw ratio (G:S)

It is the ratio of dry grain yield and straw yield and it is represented by the following formula

$$\text{Grain : Straw} = \frac{\text{Dry grain yield}}{\text{Dry straw yield}}$$

3.10.2.11 Weed index (WI)

It is an index expressing the reduction in yield due to the presence of weeds in comparison with weed free situation. This was computed by using the formula as suggested by USDA / ICAR - NRCWC (1988) :

$$\text{WI (Cent}^{-1}\text{)} = \frac{X - Y}{X} \times 100$$

where, X = Grain yield from weed free (HW) treatment and

Y = Grain yield from treatment for which weed index is to be worked out

3.10.2.12 Observation on Phytotoxicity

Visual assessment of crop response was rated at 3, 7 and 30 days after spraying of Cyhalofop butyl at different rates and were recorded at cent⁻¹ basis of injury as shown in Table 6. The herbicide toxicity was observed by visual scoring scale (1 - 10) with number of plants in respect of leaf injury on surface, leaf injury on tip and wilting of plants.

Table 6 Quantitative description of phytotoxic effects on crop

Scale (cent⁻¹)	Grade
0-10	1
11-20	2
21-30	3
31-40	4
41-50	5
51-60	6
61-70	7
71-80	8
81-90	9
91-100	10

3.10.3 Soil analysis

Composite samples were taken from the experimental field at a depth of 0-15 cm before land preparation for analysis of physico-chemical properties.

3.10.3.1 Mechanical analysis of soil

Mechanical analysis of soil particularly the contents of fine sand, coarse sand, clay and silt was done by International pipette method (Piper, 1966).

3.10.3.2 Chemical analysis of soil

3.10.3.2.1 Soil pH

The pH was determined by using electronic digital pH meter with glass electrode, calmol reference electrode and salt bridge at soil : water ratio of 1 : 2.5 stirred till reading (at 20°C) was recorded (Jackson, 1973).

3.10.3.2.2 Organic carbon content of soil

Organic carbon was determined in cent⁻¹ according to the Walkley and Black (1934) method as stated by Jackson (1973), taking 2 g soil using Diphenyl amine as indicator.

3.10.3.2.3 Total nitrogen content in soil

Total nitrogen content of soil was determined in cent⁻¹, according to Modified Kjeldahl method as described by Jackson (1973).

3.10.3.2.4 Available phosphate (P₂ O₅) content in soil

Available phosphate in kg ha⁻¹ was determined by Bray and Kurtz (1945) method, as described by Jackson (1973).

3.10.3.2.5 Available potash (K₂O) content in soil

Available potash in kg ha⁻¹ was determined from 5g of soil by Flame photometer method (Muhr *et al*, 1965).

3.11 Statistical analysis and interpretation of results

The data collected from field experiment was subjected to statistical analysis appropriate to the design (Gomez and Gomez, 1984). The statistical analysis and interpretation of results were obtained by subjecting the data to the analysis of variance technique (Cochran and Cox, 1955 and Panse and Sukhatme, 1967). The significance of different sources of variation was tested by Fisher and Snedecor's 'F' test at probability level of 0.05. In the table of results the standard error mean (SEm±) and the value of critical difference (CD) have been provided to compare the differences between treatment means. For determination of critical difference (CD) at 5 cent⁻¹ level of significance the statistical tables formulated by Fisher and Yates (1979) were consulted.

The data of number of weed count are transformed by square root transformation method. The most appropriate transformation is $\sqrt{x}$ where x is actual count. But some of the counts are very small or zero, the appropriate transformation variate will be $\sqrt{x + 0.5}$.

CHAPTER – 4

RESULTS

RESULTS

Observations recorded in course of investigation in the present experiment were analysed and have been presented below in brief.

4.1 Studies on weeds

4.1.1 Weed flora present in the experimental field

Survey on weed flora was made regularly to identify different weed species intercepted in the experimental field starting from growing period to harvest. Sequence of emergence and special characteristics of some dominant weed flora were also noted. Details of the survey of these weeds have been presented in Table 7.

Table 7 Weed flora present in the experimental field throughout the crop growing season

Sl. no.	Botanical name	Family	English Name (Local Name)	Special characteristics
A Grasses				
1	<i>Echinochloa crusgalli</i> (L.) Beauv	Gramineae	Barnyard grass (Shyama ghash)	Annual grass that can grow as tall as 150 cm, leaves are narrow, flat, linear, sessile and attached to a smooth sheath which encircles the stem in the absence of ligule, fibrous root, spreading and rigid. Stem is stout, glabrous and ends in 10 - 20 cm. long inflorescence, with a slender spike like panicle, green or purplish in colour, propagates by seeds, which may remain dormant 3-4 months.
2	<i>Echinochloa colonum</i> (L.) Gaertn	Gramineae	(Jungle rice)	Annual grass, 50-70 cm high simple or branched at lower part, leaves 12-22 cm linear, smooth, erect panicle, 7-15 cm

				linear, smooth, erect panicle, 7-15 cm long, fibrous root, reproduce by seed and sucker.
3	<i>Eleusine indica</i> (L.) Gaertn	Gramineae	Goose grass (Kodai / Mal - ankura)	A hardly tufted grass, culm about 15 to 50 cm high, flattened, decumbent at base, braches arising from the base which form a set of rosette, leaf linear 8 to 20 cm long. Spikes 3 to 5, fibrous root system, covered with rootlets, root quite deep and spreading, difficult to pull off, propagates by seed, sometimes grows from old roots.
4	<i>Leersia hexandra</i> (Sw)	Gramineae	Rice cutgrass (Kara ghash)	Aquatic perennial creeping grass that can grow as tall as 100 cm. propagates by seeds, rhizomes and stolons.
5	<i>Paspalum</i> <i>scorbiculatum</i> Linn.	Gramineae	Kodo Millet (Myna)	An annual grass, culm erect, shortly decumbent at the base, 20 to 80 cm high, tufted, lower base often rooting, leaves almost erect, smooth, linear about 12 to 25 cm long. A panicle with 2 to 4 spikes, erect or spreading 4 to 10 cm long, spikelets adnate to the rachis, Fibrous and spreading root system, propagates by seed but may grows from old root stock and suckers.
6	<i>Paspalum</i> <i>conjugatum</i> Berg.	Gramineae	Sour grass (Kodo dhan)	Annual prostrate grass, culm 20-30 cm high, 5-7 cm long smooth leaves, two digitate spikes, fibrous shallow roots are formed in the nodes that touch the soil, propagates by seed and from runners.

- | | | | | |
|---|---|-----------|--------------------------------|---|
| 7 | <i>Paspalum distichum</i> L.
[Syn. <i>Paspalum paspaloides</i>] | Gramineae | Knot grass | Perennial grass that can grow as tall as 30-60 cm, propagates mainly by creeping stolons and to some extent by seeds |
| 8 | <i>Axonopus compressus</i> (Sw) Beauv | Gramineae | Carpet grass or Savannah grass | A perennial grass, leaves linear, about 10 to 15 cm long and 1.5 cm. broad, folded at base, sheath flat or compressed and cover the stem, culm about 20 to 25 cm long. 3 to 5 spikes, 5 to 7 cm long, erect or slightly digitate, fibrous roots producing from nodes of the stem which creeps along the ground. Propagates by seed and creeping stem. |
| 9 | <i>Brachiaria mutica</i> (L.) | Gramineae | Para grass | An annual grass leaves linear, culm erect, fibrous root, propagates by seed and root stock. |

B. Sedges

- | | | | | |
|----|--|------------|--|---|
| 10 | <i>Cyperus difformis</i> L. | Cyperaceae | Umbrella sedge
(Motha) | Annual sedge that can grow as tall as 75 cm, normally propagates by seeds. |
| 11 | <i>Cyperus iria</i> L. | Cyperaceae | Flat sedge or yellow nut sedge
(Jalmotha or morphula) | Annual sedge that grow as tall as 60 cm, erect herb with triangular stem, hairy underground stem, with chains or nut like tubers, leaves look like grasses, propagates by seeds, which may be dormant but can germinate about 75 days after shedding. |
| 12 | <i>Fimbristylis littoralis</i> Gaud
(Syn. <i>Fimbristylis miliacea</i> (L.) | Cyperaceae | Hoorah grass or globe fingerush
(Bindi | Annual sedge that grows as tall as 60 cm, flexous stem, narrow flat leaves, spikelets light brown in colour, nut yellow brown, propagates by seeds, large proportion of seeds have no dormancy and can germinate immediate |

	Vahl		Motha)	after reaching maturity.
13	<i>Kyllinga</i> <i>brevifolia</i> Rottb <i>Cyperus</i> <i>aromaticus</i> (Rid-M&K).	Cyperaceae	Greater Kyllinga (Nirbishi/ Bindi muthi)	Annual 20 cm high, leaves linear, globose head, fibrous root system propagates by underground runners and seed.

C Broadleaved

14	<i>Ammania</i> <i>baccifera</i> (L)	Lathyaceae	Dadmari	Annual weed, leaves opposite, stem erect, greenish-red flower, fruits formed during cold season, propagates by seeds.
15	<i>Commelina</i> <i>benghalensis</i> L.	Commelin aceae	Day flower (Kansira or Kankaua)	Creeping annual or perennial broadleaf that grows as tall as 40 cm. Leaves are alternate, simple, parallel-veined, and ovate, with an entire margin contracted at the base into a narrow, stalk-like portion and a sheath enclosing the stem, flowers blue in colour, propagates by seeds and stolons.
16	<i>Eclipta alba</i> (L) <i>Hassak</i>	Asteraceae	Eclipta (Keshuti)	Annual or perennial broadleaf weed that can go as tall as 90 cm small herb with leaves opposite, bracts in one or two series, small capitulum flower with white ligule, propagates by seeds, which show no dormancy, seeds germinate throughout the year in the tropics.
17	<i>Ludwigia</i> <i>parviflora</i> Roxb.	Onagra ceae	Water purslane (Labanga Phool)	Annual aquatic broadleaf weed that can grow as tall as 100 cm. Leaves petioled, stem semisculant propagates by seeds, some of which will germinate immediately in wet or flooded soils.
18	<i>Marsilea</i> <i>quadrifolia</i> L.	Marsilea ceae	Water fern (Shushru)	Leaves quadrifoliate, propagates vegetatively.

Of these, other weeds were often looked as *Echinochloa glabrescens*, *Brachiaria platyphylla*, *Cyperus cephalotus*, *Monochoria vaginalis*, *Oldenlandia corymbosa* and *Jussiaea suffruticosa*.

4.1.2 Effect of treatments on weed population

4.1.2.1 Effect of treatments on population of *Echinochloa spp*

Number of *Echinochloa spp* was recorded at 30, 45, 60 DAS and at harvest in both the seasons of 1997-98 and 1998-99 (Table 8 and 9) and graphically plotted in Figure 3 and 4. In both seasons, higher doses of Cyhalofop butyl showed a gradual reduction in number of *Echinochloa spp*.

At 30 DAS of both years 1997 and 1998 during *kharif* season maximum number of *Echinochloa spp* (28.7 and 26.3 m⁻², respectively) was observed in unweeded control (T₉) and the minimum (1.0 and 1.0 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) which recorded significantly lower number of *Echinochloa spp* amongst all the treatments. The number of *Echinochloa spp* (1.64 and 1.33 m⁻², respectively) recorded in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) was statistically at par with T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1.32 and 1.0 m⁻², respectively) and T₃ Cyhalofop butyl 0.08 kg ha⁻¹ (2.00 and 1.64 m⁻², respectively). The treatments comprising of different doses of Cyhalofop butyl and its combination with HW reduced the *Echinochloa spp* population significantly in comparison to weedy check (T₉).

Similar trends of variation were also observed in *boro* seasons of 1998 and 1999. At 30 DAS, maximum number of *Echinochloa spp* (26.3 and 24.7 m⁻², respectively) was recorded in weedy check (T₉) in both years and the minimum (0.33 and 0.34 m⁻², respectively) in Cyhalofop butyl 0.32 kg ha⁻¹ (T₅) which was significantly lower than all the treatments except T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (0.67 and 0.66 m⁻², respectively). T₂ Cyhalofop butyl 0.06 kg ha⁻¹ (2.6 and 2.3 m⁻², respectively) T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40

Table 8 Effect of treatments on population of *Echinochloa* spp during *kharif* 1997 and 1998

Treatments	Number of <i>Echinochloa</i> spp m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	5.65 (2.38)	4.33 (2.08)	4.99	6.32 (2.61)	5.67 (2.48)	5.99	7.68 (2.86)	6.00 (2.55)	6.84 (2.89)	7.65 (2.76)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	4.30 (2.07)	3.65 (1.91)	3.97	5.68 (2.48)	3.68 (2.04)	4.68	6.00 (2.55)	4.34 (2.20)	5.17 (2.51)	5.66 (2.38)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	2.00 (1.41)	1.64 (1.28)	1.82	2.34 (1.68)	2.00 (1.58)	2.17	2.66 (1.78)	2.32 (1.68)	2.49 (1.63)	2.34 (1.53)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	1.32 (1.15)	1.00 (1.00)	1.16	1.34 (1.36)	1.33 (1.35)	1.33	1.67 (1.47)	1.33 (1.35)	1.50 (1.28)	1.65 (1.29)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	1.00 (1.00)	1.00 (1.00)	1.00	1.00 (1.22)	0.67 (1.08)	0.83	1.33 (1.35)	1.00 (1.22)	1.16 (1.29)	1.33 (1.15)
T ₆ HW at 20 and 40 DAS	3.32 (1.82)	2.67 (1.63)	2.99	0.67 (1.08)	0.66 (1.08)	0.66	1.33 (1.35)	1.00 (1.22)	1.16 (1.15)	1.33 (1.15)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	4.64 (2.15)	3.00 (1.73)	3.82	0.66 (1.08)	0.67 (1.08)	0.66	1.00 (1.22)	0.68 (1.09)	0.84 (1.29)	1.67 (1.28)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	1.64 (1.28)	1.33 (1.15)	1.48	0.35 (0.91)	0.33 (0.91)	0.34	0.66 (1.08)	0.66 (1.08)	0.66 (1.15)	1.33 (1.15)
T ₉ Weedy check	28.68 (5.35)	26.33 (5.13)	27.50	33.00 (5.79)	31.67 (5.67)	32.33	33.33 (5.82)	32.00 (5.70)	32.66 (5.80)	32.30 (5.68)
Mean	5.84	4.99		5.71	5.26		6.18	5.48		6.14
SEm±	0.05	0.09		0.12	0.11		0.08	0.09		0.10
CD at 5%	0.15	0.27		0.36	0.33		0.24	0.27		0.29

* Data given in parentheses are square root transformed of original value. SEm(±) and CD of transformed value

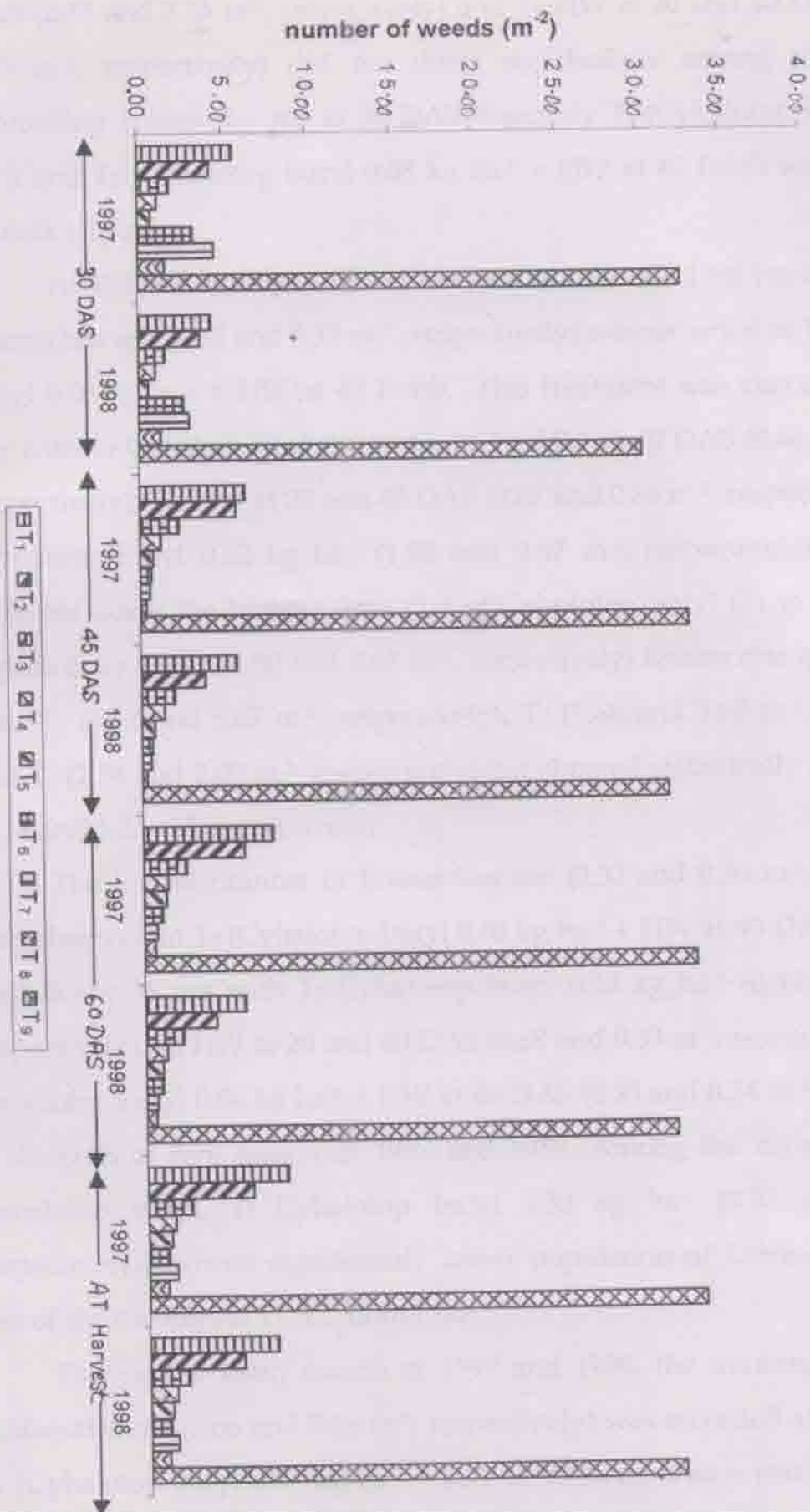


Figure 3 Effect of treatments on population of *Echinochloa* spp. in Kharif 1997 and 1998

DAS (2.33 and 2.35 m⁻², respectively) and T₆ HW at 20 and 40 DAS (2.32 and 2.25 m⁻², respectively) did not differ significantly among themselves in controlling *Echinochloa spp* at 30 DAS. Similarly T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) was also found statistically alike.

At 45 DAS, during the *kharif* seasons of 1997 and 1998 lowest number of *Echinochloa spp* (0.35 and 0.33 m⁻², respectively) was recorded in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS). This treatment was also statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.66 and 0.67 m⁻², respectively), T₆ HW at 20 and 40 DAS (0.67 and 0.66 m⁻², respectively) and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (1.00 and 0.67 m⁻², respectively). Among the different doses the highest dose (T₅) of Cyhalofop butyl (T₁ to T₅), recorded significantly lower (1.00 and 0.67 m⁻², respectively) *Echinochloa spp* population than T₁ (6.32 and 5.67 m⁻², respectively), T₂ (5.68 and 3.68 m⁻², respectively) and T₃ (2.34 and 2.00 m⁻², respectively) but showed statistically at par with T₄ (1.34 and 1.33 m⁻², respectively).

The lowest number of *Echinochloa spp* (0.32 and 0.30 m⁻², respectively) was observed in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) which was statistically at par with T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (0.33 and 0.34 m⁻², respectively), T₆ HW at 20 and 40 DAS (0.68 and 0.33 m⁻², respectively) and T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.33 and 0.34 m⁻², respectively) at 45 DAS of *boro* season of 1997 and 1998. Among the different doses of Cyhalofop butyl, T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (0.33 and 0.34 m⁻², respectively) showed significantly lower population of *Echinochloa spp* than rest of the treatments T₁, T₂, T₃ and T₄.

During the *kharif* season of 1997 and 1998, the minimum number of *Echinochloa spp* (0.66 and 0.66 m⁻², respectively) was recorded at 60 DAS from T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.00 and 0.68 m⁻²,

Table 9 Effect of treatments on population of *Echinochloa spp* during boro 1998 and 1999

Treatments	Num ber of <i>Echinochloa spp</i> m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	4.30 (2.19)	3.36 (1.96)	3.83	5.34 (2.42)	3.68 (2.04)	4.51	5.66 (2.48)	3.65 (2.04)	4.65	4.00 (2.12)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	2.60 (1.76)	2.30 (1.67)	2.45	3.33 (1.95)	2.67 (1.78)	3.00	3.62 (2.03)	2.64 (1.77)	3.13	3.36 (1.96)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	1.33 (1.35)	1.00 (1.22)	1.16	1.65 (1.47)	1.33 (1.35)	1.49	2.30 (1.67)	1.60 (1.45)	1.95	2.00 (1.58)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	0.67 (1.08)	0.66 (1.08)	0.66	1.30 (1.34)	0.66 (1.08)	0.98	1.66 (1.47)	1.35 (1.36)	1.50	1.36 (1.36)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	0.33 (0.91)	0.34 (0.92)	0.33	0.33 (0.91)	0.34 (0.92)	0.33	0.64 (1.07)	0.35 (0.92)	0.49	0.66 (1.08)
T ₆ HW at 20 and 40 DAS	2.32 (1.68)	2.35 (1.69)	2.33	0.68 (1.09)	0.33 (0.91)	0.50	1.00 (1.22)	0.62 (1.06)	0.81	1.00 (1.22)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	2.33 (1.68)	2.35 (1.69)	2.34	0.33 (0.91)	0.34 (0.92)	0.33	1.33 (1.35)	1.00 (1.22)	1.16	1.32 (1.35)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	1.66 (1.47)	1.34 (1.36)	1.50	0.32 (0.90)	0.30 (0.89)	0.31	0.64 (1.07)	0.32 (0.90)	0.48	0.34 (0.92)
T ₉ Weedy check	26.30 (5.18)	24.70 (5.02)	25.50	30.67 (5.83)	27.32 (5.27)	28.99	30.67 (5.58)	27.70 (5.31)	29.18	28.35 (5.37)
Mean	4.65	4.27		4.88	4.11		5.28	4.36		4.67
SEm±	0.10	0.10		0.10	0.11		0.09	0.12		0.11
CD at 5%	0.29	0.30		0.30	0.32		0.27	0.35		0.32

* Data given in parentheses are square root transformed of original value SEm(±) and CD of transformed value

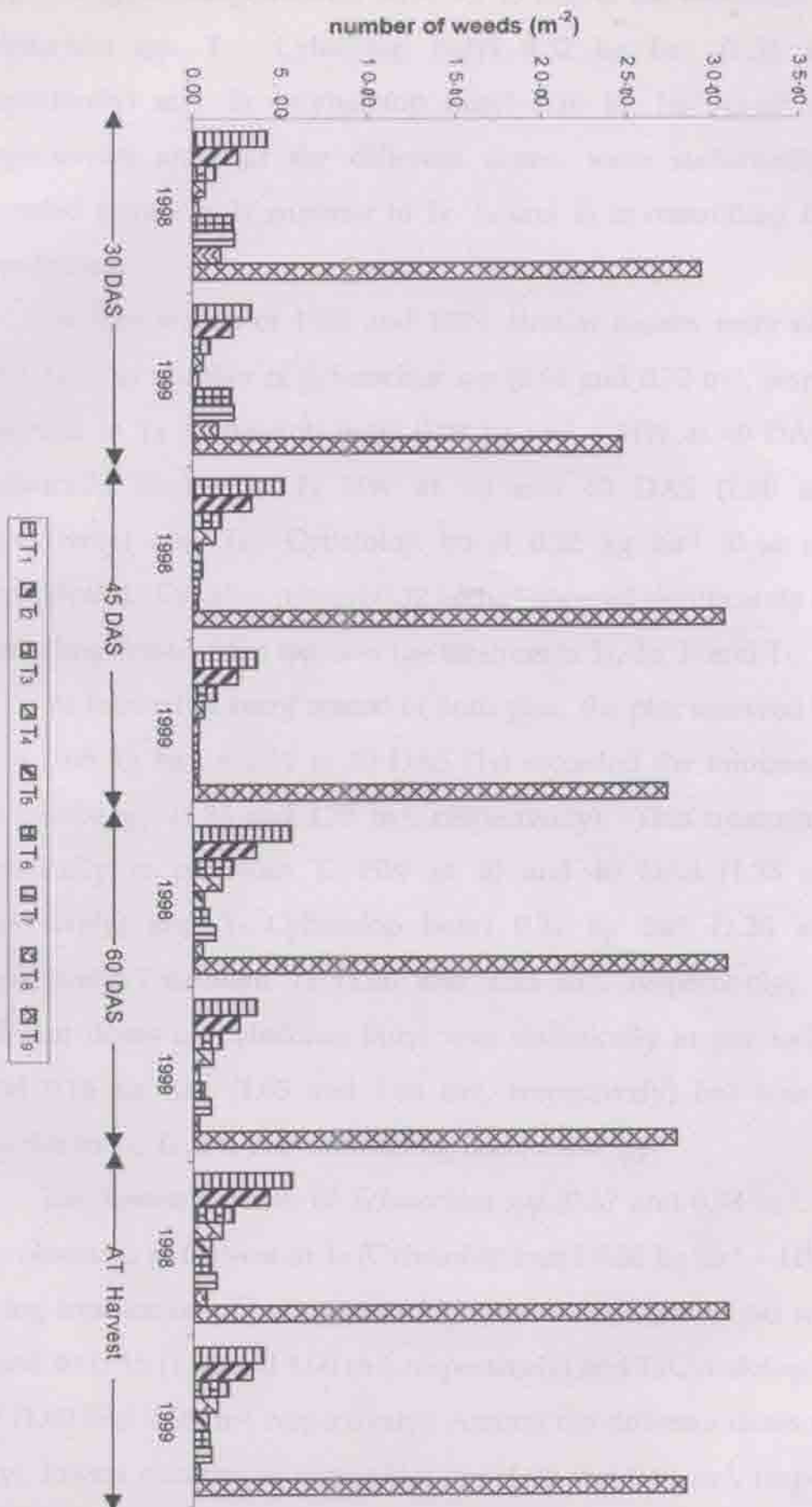


Figure 4 Effect of treatments on population of *Echinochola* spp. in boro 1998 and 1999

respectively) and significantly superior to rest of the treatment in controlling *Echinochloa spp.* T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (1.33 and 1.00 m⁻², respectively) and T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1.67 and 1.33 m⁻², respectively) amongst the different doses, were statistically at par but recorded significantly superior to T₁, T₂ and T₃ in controlling *Echinochloa spp* populations.

In *boro* season of 1998 and 1999, similar results were observed at 60 DAS. Lowest number of *Echinochloa spp* (0.64 and 0.32 m⁻², respectively) was observed in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) which was statistically similar to T₆ HW at 20 and 40 DAS (1.00 and 0.62 m⁻², respectively) and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (0.64 and 0.35 m⁻², respectively). Cyhalofop butyl 0.32 kg ha⁻¹ showed significantly superiority in controlling *Echinochloa spp* over the treatments T₁, T₂, T₃ and T₄.

At harvest of *kharif* season of both year, the plot received by Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (T₈) recorded the minimum number of *Echinochloa spp* (1.33 and 1.33 m⁻², respectively). This treatment which was statistically at par with T₆ HW at 20 and 40 DAS (1.33 and 1.33 m⁻², respectively) and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (1.33 and 1.33 m⁻², respectively). Treatment T₅ (1.66 and 1.33 m⁻², respectively) amongst the different doses of Cyhalofop butyl was statistically at par to T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1.65 and 1.66 m⁻², respectively) but was significantly superior to T₁, T₂ and T₃ in controlling *Echinochloa spp*.

The lowest number of *Echinochloa spp* (0.67 and 0.34 m⁻², respectively) was observed at harvest in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) during *boro* season of both years which was statistically at par with T₆ HW at 20 and 40 DAS (1.00 and 1.00 m⁻², respectively) and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (1.00 and 0.66 m⁻², respectively). Among the different doses of Cyhalofop butyl, lowest number of *Echinochloa spp* (1.00 and 0.66 m⁻², respectively) was recorded in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) which was statistically at par

with T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1.68 and 1.36 m⁻², respectively) and significantly superior in controlling *Echinochloa spp* over the T₁, T₂ and T₃.

4.1.2.2 Effect of treatments on population of other grasses

Data on other grasses as recorded at 30, 45, 60 DAS and at harvest have been presented in Table 10 (*kharif* season) and Table 11 (*boro* season) and graphically plotted in Figure 5 and 6.

Hand weeding at 20 and 40 DAS during the *kharif* and *boro* seasons of year 1997-98 and 1998-99 gave significantly lower population of other grasses in all the observations. Hand weeding in combination with Cyhalofop butyl also registered lower weed population of other grasses at 45 DAS, 60 DAS and at harvest.

The observations recorded at 30 DAS in *kharif* season of both the years showed the lowest (1.32 and 1.00 m⁻², respectively) number of other grasses with HW at 20 and 40 DAS (T₆) which was statistically superior to rest of the treatments. In case of the sole application of herbicide T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (46.0 and 48.3 m⁻², respectively) registered the lowest and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (73.65 and 76.00 m⁻², respectively) recorded maximum number of other grasses which was again statistically at par with T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (71.00 and 73.64 m⁻², respectively).

During the *boro* season of both year in same date of observation, population of other grasses (1.67 and 2.32 m⁻², respectively) was lowest in HW at 20 and 40 DAS (T₆) and this was significantly lower than rest of the treatments. When applied as sole (T₁ – T₅) lowest number of other grasses (40.31 and 42.65 m⁻², respectively) was recorded in Cyhalofop butyl 0.04 kg ha⁻¹ and the highest (62.35 and 64.34 m⁻², respectively) was recorded in Cyhalofop butyl 0.32 kg ha⁻¹ (T₅).

At 45 DAS during *kharif* season of 1997 and 1998, lowest number of other grasses (0.35 and 0.32 m⁻², respectively) was observed in T₆ (HW at 20

Table 10 Effect of treatments on population of other grasses during *kharif* 1997 and 1998

Treatments	Number of other grasses m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	46.00 (6.78)	48.30 (6.95)	47.15	64.00 (8.03)	66.00 (8.15)	65.00	68.68 (8.29)	76.00 (8.72)	72.34	92.35 (9.61)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	58.33 (7.64)	60.34 (7.77)	59.33	68.65 (8.32)	71.30 (8.47)	69.97	71.33 (8.44)	80.65 (8.98)	75.99	96.65 (9.83)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	62.34 (7.89)	65.67 (8.10)	64.00	72.35 (8.53)	73.34 (8.59)	72.84	75.34 (8.68)	83.38 (9.13)	79.36	100.68 (10.03)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	71.00 (8.43)	73.64 (8.58)	72.32	81.66 (9.06)	84.32 (9.21)	82.99	85.35 (9.24)	90.30 (9.50)	87.82	104.30 (10.21)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	73.65 (8.58)	76.00 (8.72)	74.82	85.34 (9.26)	89.35 (9.48)	87.34	93.34 (9.66)	96.32 (9.81)	94.83	106.32 (10.31)
T ₆ HW at 20 and 40 DAS	132 (1.15)	1.00 (1.00)	1.16	0.35 (0.92)	0.32 (0.90)	0.33	1.68 (1.29)	1.35 (1.16)	1.51	2.65 (1.63)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	57.00 (7.55)	59.30 (7.70)	58.15	0.65 (1.07)	0.65 (1.07)	0.65	2.36 (1.4)	1.67 (1.29)	2.01	5.35 (2.31)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	61.67 (7.85)	64.66 (8.04)	63.16	0.67 (1.08)	0.66 (1.08)	0.66	2.33 (1.53)	1.66 (1.29)	2.00	6.00 (2.45)
T ₉ Weedy check	78.30 (8.85)	80.00 (8.94)	79.15	98.70 (9.96)	101.35 (10.09)	100.02	105.67 (10.28)	110.00 (10.49)	107.83	122.30 (11.06)
Mean	56.62	58.77		52.48	54.14		56.23	60.15		70.73
SE _{mt}	0.07	0.10		0.08	0.11		0.08	0.11		0.09
CD at 5%	0.21	0.30		0.23	0.32		0.24	0.34		0.28

* Data given in parentheses are square root transformed of original value SE_{mt}(±) and CD of transformed value.

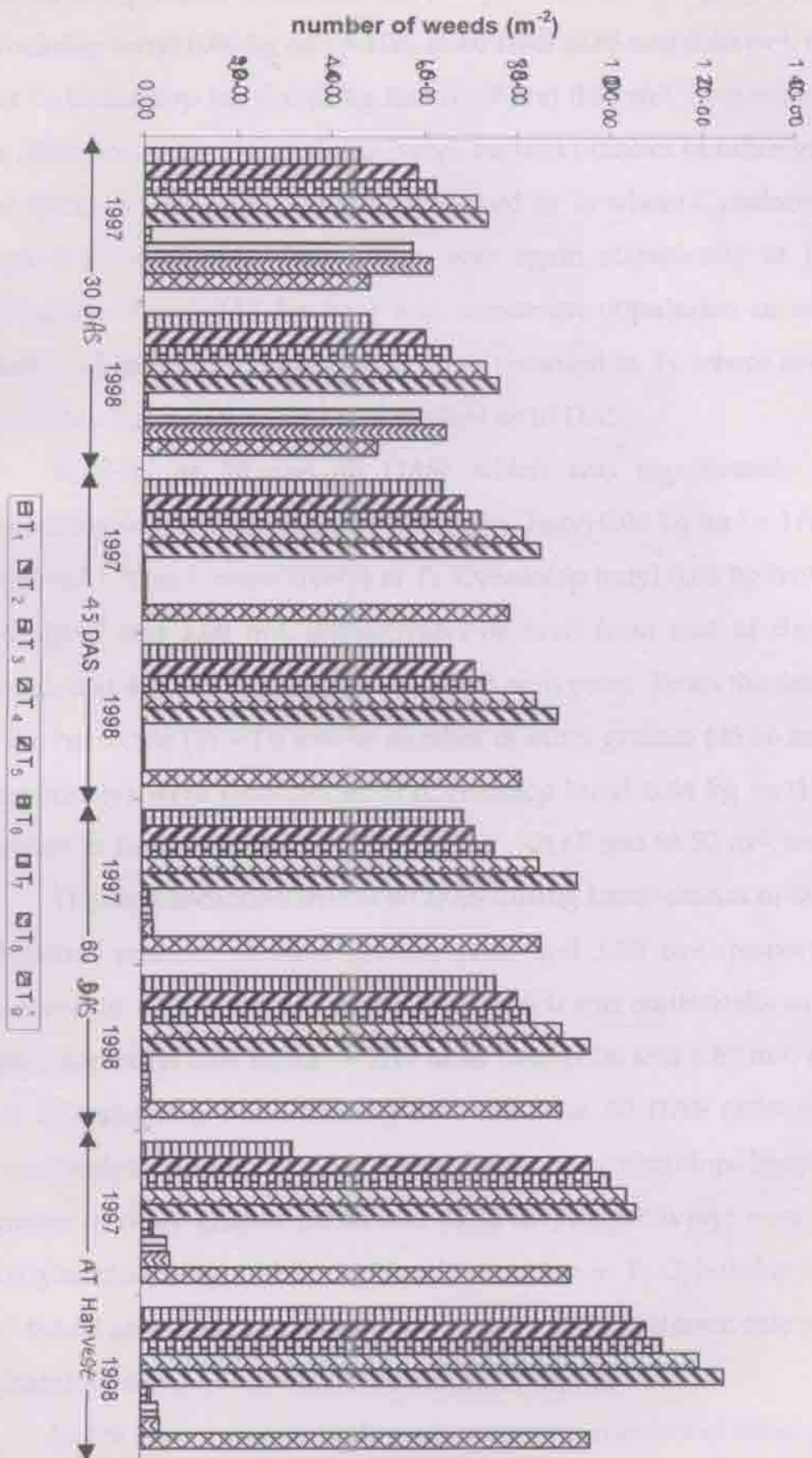


Figure 5 Effect of treatments on population of other grasses in Kharif 1997 and 1998

and 40 DAS) which was statistically at par with the integrated treatments T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.65 and 0.65 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ (0.67 and 0.66 m⁻², respectively). Among the different doses of Cyhalofop butyl, highest number of other grasses (85.34 and 89.35 m⁻², respectively) were observed in T₅ where Cyhalofop butyl was applied in maximum dose. This was again statistically at par with T₄ (Cyhalofop butyl 0.16 kg ha⁻¹) and minimum population of other grasses (64.00 and 66.00 m⁻², respectively) were recorded in T₁ where lowest dose of Cyhalofop butyl 0.04 kg ha⁻¹ was applied at 10 DAS.

T₆ (HW at 20 and 40 DAS) which was significantly superior in controlling weeds than either T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.66 and 1.30 m⁻², respectively) or T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (0.67 and 1.00 m⁻², respectively) or even from rest of the treatments, recorded at 45 DAS during *boro* season of both years. From the sole treatments of the herbicide (T₁ – T₅) lowest number of other grasses (46.66 and 48.35 m⁻², respectively) were recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and highest number in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (64.65 and 68.32 m⁻², respectively).

The data indicated that at 60 DAS during *kharif* season of 1997 and 1998 minimum number of other grasses (1.68 and 1.35 m⁻², respectively) were observed in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (2.36 and 1.67 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2.38 and 1.66 m⁻², respectively). Among the different doses of Cyhalofop butyl maximum number of other grasses (93.54 and 96.32 m⁻², respectively) were observed in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and minimum in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (68.68 and 76.00 m⁻², respectively) amongst the different sole treatments of Cyhalofop butyl.

In the *boro* season of both years minimum number of other grasses (1.00 and 1.32 m⁻², respectively) at 60 DAS was observed with the weed free

Table 11 Effect of treatments on population of other grasses during *boro* 1998 and 1999

Treatments	Number of other grasses m ⁻²											
	30 DAS			45 DAS			60 DAS			At harvest		
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	40.31 (6.35)	42.65 (6.53)	41.48	46.66 (6.87)	48.35 (6.99)	47.50	50.36 (7.10)	52.66 (7.26)	51.51	74.00 (8.60)	76.67 (8.76)	75.33
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	44.66 (6.68)	48.32 (6.95)	46.49	48.00 (6.64)	50.67 (7.1)	49.33	54.34 (7.37)	62.67 (7.92)	58.60	76.36 (8.74)	78.66 (8.87)	77.51
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	52.64 (7.25)	54.65 (7.39)	53.64	54.34 (7.40)	56.35 (7.54)	55.34	58.67 (7.66)	63.32 (7.96)	60.99	80.32 (8.96)	82.67 (9.09)	81.49
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	58.65 (7.66)	56.32 (7.50)	57.48	59.00 (7.71)	60.65 (7.82)	59.82	62.70 (7.92)	65.65 (8.10)	64.17	83.00 (9.11)	84.33 (9.18)	83.66
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	62.35 (7.90)	64.34 (8.02)	63.34	64.65 (8.07)	68.32 (8.29)	66.48	66.34 (8.14)	72.67 (8.52)	69.50	86.65 (9.31)	90.70 (9.52)	88.67
T ₆ HW at 20 and 40 DAS	1.67 (1.29)	2.32 (1.52)	1.99	0.32 (0.90)	0.34 (0.92)	0.33	1.00 (1.00)	1.32 (1.15)	1.16	2.00 (1.41)	2.34 (1.53)	2.17
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	45.65 (6.76)	46.65 (6.83)	46.15	0.66 (1.08)	1.30 (1.34)	0.98	1.34 (1.15)	2.00 (1.41)	1.67	2.30 (1.52)	3.30 (1.82)	2.80
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	51.35 (7.16)	52.66 (7.26)	52.00	0.67 (1.08)	1.00 (1.22)	0.83	1.67 (1.29)	1.67 (1.29)	1.67	2.34 (1.53)	2.34 (1.53)	2.34
T ₉ Woody check	70.35 (8.39)	72.67 (8.52)	71.51	74.65 (8.67)	76.67 (8.78)	75.66	79.32 (8.91)	80.00 (8.94)	79.66	91.34 (9.56)	92.66 (9.61)	92.00

* Data given in parentheses are square root transformed of original value Stim(t) and CD of transformed value

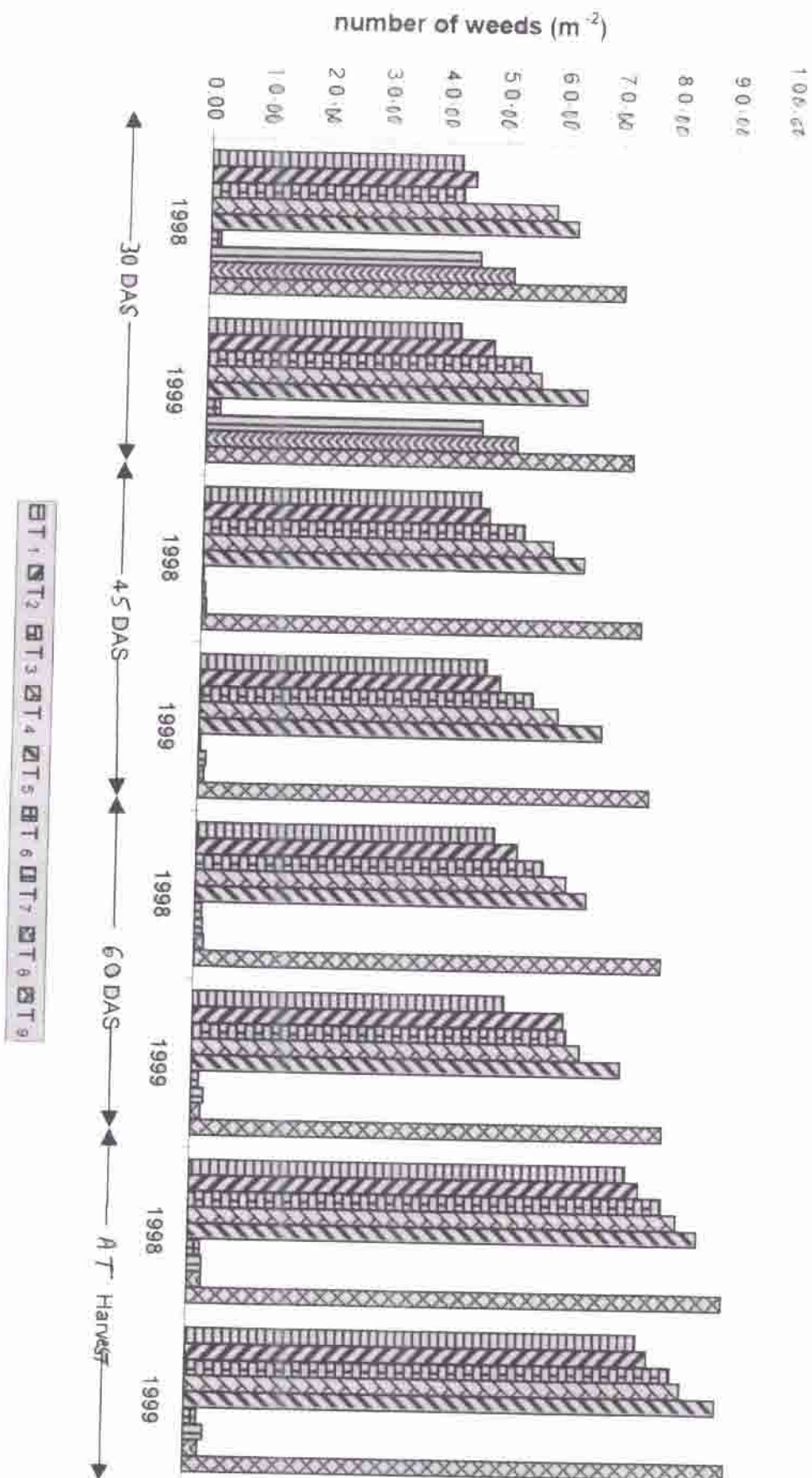


Figure 6 Effect of treatments on population of other grasses inboro 1998 and 1999

treatment T₆ (HW at 20 and 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.34 and 2.00 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.67 and 1.67 m⁻², respectively). The plots received different doses of Cyhalofop butyl, lowest number of other grasses (50.36 and 52.66 m⁻², respectively) was recorded when Cyhalofop butyl was applied 0.04 kg ha⁻¹ while the maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (66.34 and 72.67 m⁻², respectively) was observed.

At harvest the weedy check recorded the maximum number of other grasses during the *kharif* season of 1997 and 1998. The lowest number of other grasses (2.65 and 2.32 m⁻², respectively) was seen in T₆ (HW at 20 and 40 DAS) which was significantly lower to the integrated treatments T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (5.35 and 3.65 m⁻², respectively) or T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (6.00 and 4.00 m⁻², respectively). This treatment also showed significantly lower population of other grasses than rest of the treatments. Lowest number of other grasses (92.35 and 105.32 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.32 kg ha⁻¹) and the highest number in treatment T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (106.32 and 125.66 m⁻², respectively) amongst the different doses of this herbicide (T₁ – T₅).

T₆ (HW at 20 and 40 DAS) during *boro* seasons of 1998 and 1999 recorded the lowest number of other grasses (2.00 and 2.34 m⁻², respectively) at harvest which was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2.34 and 2.34 m⁻², respectively) and significantly superior in controlling other grasses to rest of the treatments. Among the different doses of the chemical Cyhalofop butyl (T₁ – T₅), lowest number of other grasses (74.00 and 76.67 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and highest number of other grasses (86.65 and 90.70 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

4.1.2.3 Effect of treatments on population of sedges

The data presented in Table 12 and 13 and Figure 8 and 9 indicate the presence of more number of sedges m^{-2} than that of *Echinochloa spp* and other grasses but less broadleaved weeds in all the treatments. It is also evident that weed free treatments resulted in lowest sedge weed population and there is a very negligible effect of Cyhalofop butyl. However, significant difference is observed in some plots only due to competitive effect of *Echinochloa spp* with other weeds.

During the *kharif* season of 1997 and 1998 in the first observation date at 30 DAS the minimum number of sedges (6.64 and 8.35 m^{-2} , respectively) was recorded in weed free treatment T_6 (HW at 20 and 40 DAS) which was significantly lower than rest of the treatments. Lower number of sedges (53.35 and 64.00 m^{-2} , respectively) was recorded in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) amongst the treatments where different doses of Cyhalofop butyl were applied and higher number of sedges (74.65 and 74.64 m^{-2}) was observed in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}).

In the same date of observation of *boro* 1998 and 1999, the lowest number of sedges (4.66 and 6.66 m^{-2} , respectively) was again recorded in same treatment weed free which was significantly superior to rest of the treatments in controlling sedges. Among the different doses of Cyhalofop butyl, minimum number of sedges (90.65 and 105.00 m^{-2} , respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and the maximum in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (110.68 and 112.34 m^{-2} , respectively). This treatment was statistically at par with T_3 (Cyhalofop butyl 0.08 kg ha^{-1}) and T_4 (Cyhalofop butyl 0.16 kg ha^{-1}).

In the *kharif* season of same year, T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (1.33 and 2.65 m^{-2} , respectively) and showed statistically at par number of sedges with T_6 which recorded lowest number of sedges (1.34 and

Table – 12 Effect of treatments on population of sedge weeds during *kharif* 1997 and 1998

Treatments	Number of sedge weeds m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	53.35 (7.30)	64.00 (8.00)	58.67	70.30 (8.38)	72.65 (8.52)	71.47	74.35 (8.62)	90.66 (9.52)	82.50	94.65 (9.73)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	64.00 (8.00)	65.32 (8.08)	64.66	74.34 (8.62)	74.67 (8.64)	74.50	80.00 (8.94)	94.65 (9.73)	87.32	98.30 (9.91)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	69.32 (8.32)	69.34 (8.32)	69.33	76.30 (8.73)	80.00 (8.94)	78.15	85.00 (9.22)	101.00 (10.05)	93.00	102.66 (10.13)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	70.67 (8.41)	71.67 (8.46)	71.17	80.00 (8.94)	83.36 (9.13)	81.68	89.34 (9.45)	101.65 (10.08)	95.49	105.65 (10.28)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	74.65 (8.64)	74.64 (8.64)	74.64	84.66 (9.20)	85.33 (9.24)	84.99	99.33 (9.97)	106.67 (10.33)	103.00	110.67 (10.52)
T ₆ HW at 20 and 40 DAS	6.64 (2.58)	8.35 (2.89)	7.49	1.34 (1.16)	2.35 (1.53)	1.84	6.00 (2.45)	10.34 (3.21)	8.17	15.33 (3.91)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ + HW at 40 DAS	58.65 (7.66)	64.00 (8.00)	61.32	1.33 (1.15)	2.65 (1.63)	1.99	12.66 (3.56)	16.34 (4.04)	14.50	18.67 (4.32)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ + HW at 40 DAS	64.32 (8.02)	70.30 (8.38)	67.31	1.67 (1.29)	2.64 (1.62)	2.1	10.32 (3.15)	15.00 (3.87)	12.66	16.68 (4.08)
T ₉ Weedy check	79.30 (8.90)	83.32 (9.13)	81.31	95.33 (9.76)	95.66 (9.78)	95.49	110.65 (10.52)	116.00 (10.77)	113.32	128.33 (11.33)
Mean	60.10	63.44		53.92	55.48		62.07	72.48		76.77
SEM	0.08	0.10		0.07	0.08		0.07	0.10		0.08
CD at 5%	0.25	0.31		0.21	0.24		0.21	0.29		0.24

* Data given in parentheses are square root transformed of original value. SEM(±) and CD of transformed value

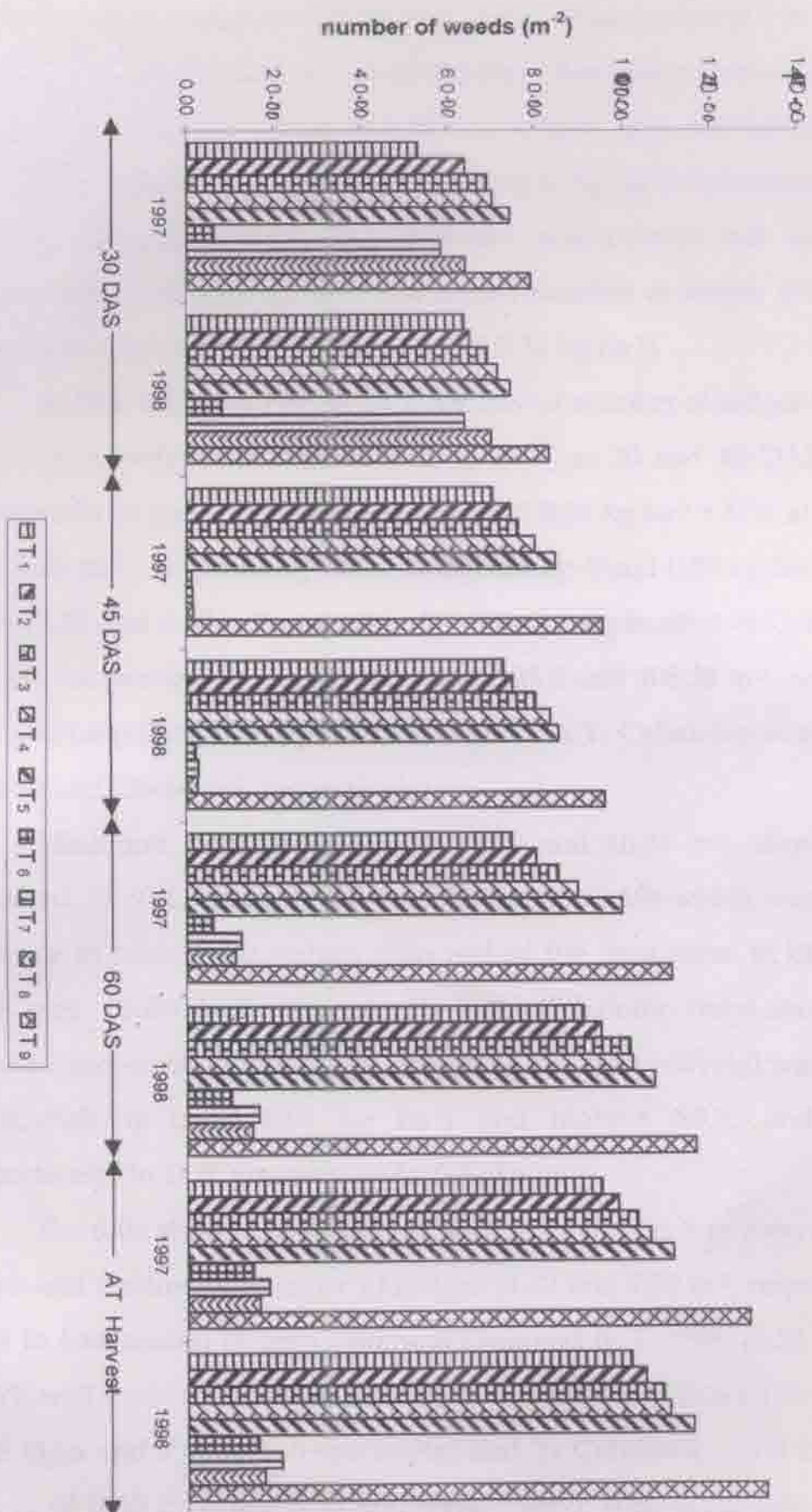


Figure 7 Effect of treatments on population of sedge weeds in kharif 1997 and 1998

2.35 m⁻², respectively) at 45 DAS with in T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.68 and 2.64 m⁻², respectively). Both these treatments (T₇ and T₈) showed significantly lower number of sedges than rest of the treatments. When applied in different doses (0.04 to 0.32 kg ha⁻¹) Cyhalofop butyl, lower number of sedges (70.30 and 72.65 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and higher number of sedges (84.66 and 85.33 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

In *boro* 1998 and 1999 at 45 DAS, lowest number of sedges (3.24 and 4.33 m⁻², respectively) was observed in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (3.33 and 4.65 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (3.32 and 4.67 m⁻², respectively). In sole application of Cyhalofop butyl, the lowest number of sedges recorded (105.0 and 108.34 m⁻², respectively) in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and highest in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (121.32 and 135.34 m⁻², respectively).

Minimum number of sedges (6.00 and 10.34 m⁻², respectively) was observed at 60 DAS in T₆ (HW at 20 and 40 DAS) which was significantly superior in controlling sedges than rest of the treatments in *kharif* season of both year. Sole application of (T₁ – T₅) Cyhalofop butyl showed that the lowest number of sedges (74.35 and 90.66 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and highest (99.33 and 106.67 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

The data showed that highest number of sedges was observed in weedy check and the lowest number of sedges (4.32 and 7.00 m⁻², respectively) at 60 DAS in *boro* season of both year was observed in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (4.66 and 7.66 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (5.00 and 8.35 m⁻², respectively). Among the different doses of Cyhalofop butyl, lowest number of sedges (114.00 and 115.66 m⁻²,

Table 13 Effect of treatments on population of sedge weeds during *boro* 1998 and 1999

Treatments	Number of sedge weeds m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	90.65 (9.52)	105.00 (10.25)	97.82	105.00 (10.25)	108.34 (10.41)	106.67	114.00 (10.68)	115.66 (10.75)	114.83 (11.50)	132.35 (11.55)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	102.00 (10.10)	106.32 (10.31)	104.16	110.35 (10.50)	112.33 (10.60)	111.34	121.00 (11.00)	125.00 (11.18)	123.00 (11.60)	135.65 (11.65)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	106.64 (10.33)	107.33 (10.36)	106.98	115.64 (10.75)	116.67 (10.80)	116.15	125.35 (11.19)	130.33 (11.42)	127.84 (11.83)	140.30 (11.84)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	108.32 (10.41)	110.00 (10.49)	109.16	118.66 (10.89)	121.35 (11.01)	120.00	130.66 (11.43)	133.65 (11.56)	132.15 (12.07)	145.65 (12.21)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	110.68 (10.52)	112.34 (10.60)	111.51	121.32 (11.01)	135.34 (11.63)	128.33	135.34 (11.63)	145.32 (12.05)	140.33 (12.30)	151.35 (12.66)
T ₆ HW at 20 and 40 DAS	4.66 (2.16)	6.66 (2.58)	5.66	3.24 (1.80)	4.33 (2.08)	3.78	4.32 (2.08)	7.00 (2.64)	5.66 (3.06)	9.35 (3.42)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	104.30 (10.21)	105.32 (10.26)	104.81	3.33 (1.82)	4.65 (2.16)	3.99	4.66 (2.16)	7.66 (2.77)	6.16 (3.26)	10.66 (3.51)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	104.65 (10.23)	108.64 (10.42)	106.64	3.32 (1.82)	4.67 (2.16)	3.99	5.00 (2.24)	8.35 (2.89)	6.67 (3.11)	9.65 (3.69)
T ₉ Weedy check	121.30 (11.01)	122.65 (11.07)	121.97	134.65 (11.60)	142.35 (11.93)	138.50	149.35 (12.22)	158.66 (12.60)	170.33 (13.05)	181.32 (13.46)
Mean	94.80	98.25		79.50	83.34		87.74	92.40	100.44	104.17
SEm±	0.08	0.09		0.09	0.12		0.09	0.10	0.09	0.11
CD at 5%	0.23	0.26		0.28	0.35		0.28	0.30	0.27	0.32

* Data given in parentheses are square root transformed of original value SEm(±) and CD of transformed value.

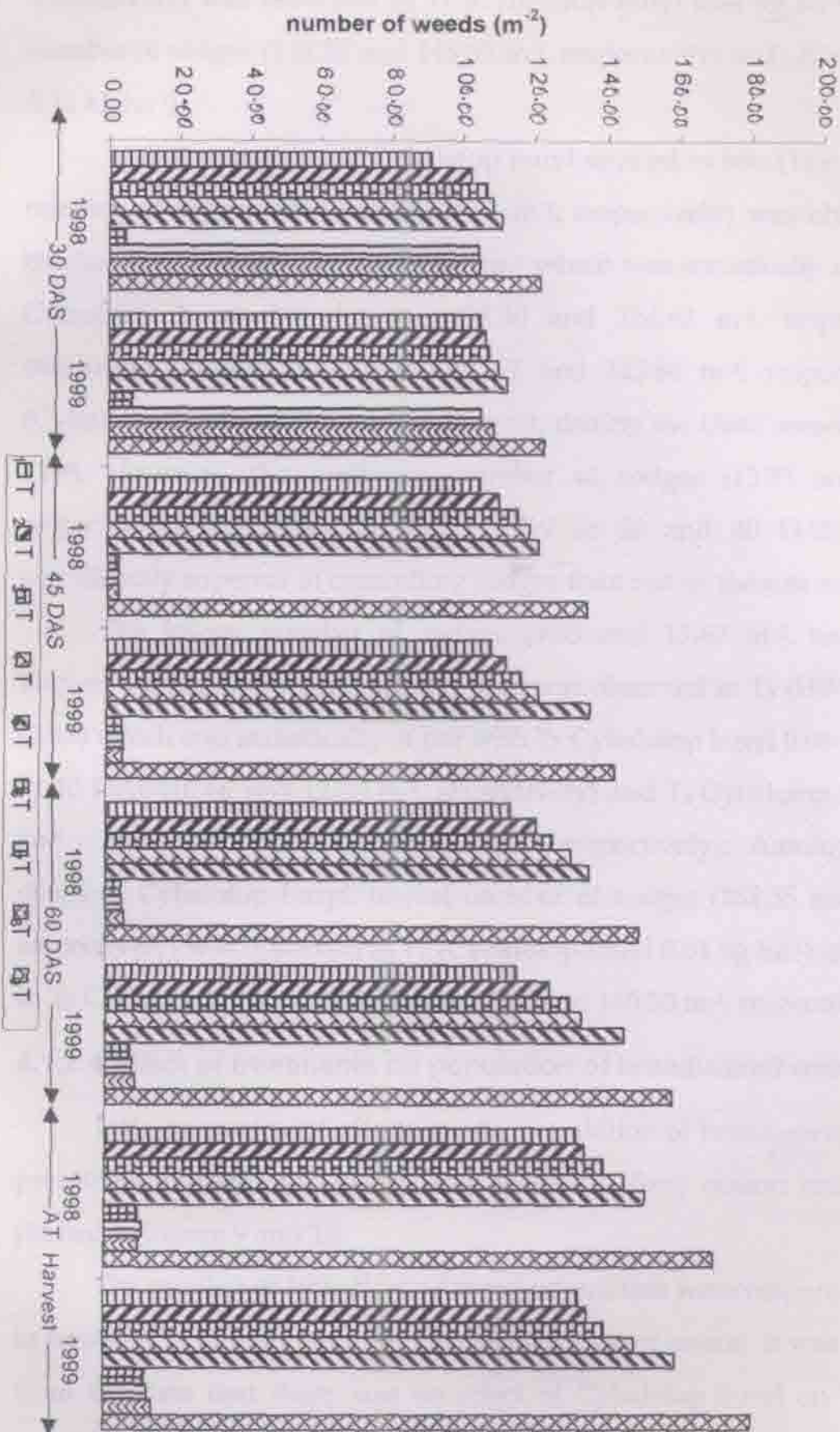


Figure 8 Effect of treatments on population of sedge weeds in boro 1998 and 1999

respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and highest number of sedges (135.34 and 145.32 m^{-2} , respectively) in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}).

In different doses of Cyhalofop butyl applied as sole ($T_1 - T_5$) minimum number of sedges (94.65 and 101.32 m^{-2} , respectively) was observed in the treatment Cyhalofop butyl 0.04 kg ha^{-1} which was statistically at par with T_2 Cyhalofop butyl 0.06 kg ha^{-1} (98.30 and 104.62 m^{-2} , respectively) and maximum number of sedges (110.67 and 115.64 m^{-2} , respectively) in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}) at harvest, during the *kharif* season of 1997 and 1998, However, the minimum number of sedges (15.33 and 16.34 m^{-2} , respectively) was observed in T_6 (HW at 20 and 40 DAS) which was significantly superior in controlling sedges than rest of the treatments.

The lowest number of sedges (9.35 and 11.67 m^{-2} , respectively) at harvest during *boro* season of both year was observed in T_6 (HW at 20 and 40 DAS) which was statistically at par with T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (10.66 and 12.30 m^{-2} , respectively) and T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (9.65 and 13.65 m^{-2} , respectively). Among the different doses of Cyhalofop butyl, lowest number of sedges (132.35 and 133.34 m^{-2} , respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and maximum in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (151.35 and 160.30 m^{-2} , respectively).

4.1.2.4 Effect of treatments on population of broadleaved weeds

Data on treatment effects on the population of broadleaved weeds was presented in Table 14 (*Kharif*) and Table 15 (*Boro*) season and graphically plotted in Figure 9 and 10.

The number of broadleaved weed population was comparatively higher in *boro* season of both years in comparison to *kharif* season. It was also evident from the data that there was no effect of Cyhalofop butyl on broadleaved weeds in both season of 1997-98 and 1998 -99.

In the *kharif* season of 1997 and 1998 at 30 DAS, lowest number of broad leaved weeds (5.32 and 11.33 m⁻², respectively) weed free plot was observed in plot T₆ which was significantly superior in controlling weeds than rest of treatments. Among the different doses of Cyhalofop butyl, maximum number of broadleaved weeds (86.00 and 86.66 m⁻², respectively) was observed in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and minimum number of broad leaved weeds (64.35 and 68.66 m⁻², respectively) in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹).

Maximum number of broadleaved weeds (165.00 and 199.33 m⁻², respectively) was observed in T₉ weedy check at 30 DAS in *boro* 1998 and 1999. Whereas in sole application of Cyhalofop butyl (T₁ – T₅), minimum number of broadleaved weeds (119.35 and 121.30 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ (150.64 and 188.0 m⁻², respectively). Minimum number of broadleaved weeds (6.30 and 8.00 m⁻², respectively) was recorded in T₆ (HW at 20 and 40 DAS) hich was significantly lower than rest of the treatments.

Similar trend of variation was also observed in *kharif* seasons of both years at 45 DAS, minimum number of broadleaved weeds (1.66 and 2.33 m⁻², respectively) was observed in T₆ HW at 20 and 40 DAS which was statistically at par with the T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (2.00 and 2.68 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.67 and 2.32 m⁻², respectively). Lowest number of broadleaved weeds (74.65 and 76.00 m⁻², respectively) was recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and highest number of broadleaved weeds in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (90.00 and 94.23 m⁻², respectively) among the different doses of this chemical (T₁ – T₅).

The observation recorded at 45 DAS in the *boro* season indicated the lowest number of broadleaved weed (1.33 and 1.35 m⁻², respectively) in twice HW at 20 and 40 DAS. The two integrated treatents T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.32 and 1.66 m⁻², respectively) and T₈ Cyhalofop

Table 14 Effect of treatments on population of broadleaved weeds during *kharif* 1997 and 1998

Treatments	Number of broadleaved weeds m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	64.35 (8.02)	68.66 (8.29)	66.50	74.65 (8.64)	76.00 (8.72)	75.32	80.34 (8.96)	82.34 (9.07)	81.34	85.66 (9.25)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	69.33 (8.33)	70.00 (8.37)	69.66	80.32 (8.96)	80.67 (8.98)	80.49	84.65 (9.20)	85.35 (9.24)	85.00	92.32 (9.61)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	74.67 (8.64)	74.67 (8.64)	74.67	81.33 (9.02)	81.66 (9.04)	81.49	85.35 (9.24)	88.34 (9.40)	86.84	93.65 (9.68)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	76.00 (8.72)	80.32 (8.96)	78.16	84.35 (9.18)	84.67 (9.20)	84.51	88.34 (9.40)	90.65 (9.52)	89.49	98.30 (9.91)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	86.00 (9.27)	86.66 (9.31)	86.33	90.00 (9.49)	94.38 (9.71)	92.19	94.65 (9.73)	98.32 (9.91)	96.48	102.32 (10.11)
T ₆ HW at 20 and 40 DAS	5.32 (2.31)	11.33 (3.37)	8.32	1.66 (1.29)	2.33 (1.53)	1.99	2.00 (1.41)	3.32 (1.80)	2.66	6.65 (2.58)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	69.68 (8.35)	70.65 (8.40)	70.16	2.00 (1.41)	2.68 (1.64)	2.34	2.34 (1.53)	3.33 (1.82)	2.83	7.32 (2.70)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	72.34 (8.50)	72.66 (8.52)	72.50	1.67 (1.29)	2.32 (1.52)	1.99	2.34 (1.53)	3.67 (1.91)	3.00	6.67 (2.58)
T ₉ Weedy check	96.32 (9.81)	105.32 (10.26)	100.82	100.00 (10.00)	110.32 (10.50)	105.16	102.30 (10.11)	114.65 (10.71)	108.47	128.35 (11.33)
Mean	68.22	71.14		57.33	59.40		60.26	63.33		69.03
Stim t	0.06	0.08		0.07	0.10		0.08	0.09		0.08
CID at 5%	0.17	0.23		0.22	0.29		0.26	0.28		0.25

* Data given in parentheses are square root transformed of original value Stim(t) and CID of transformed value.

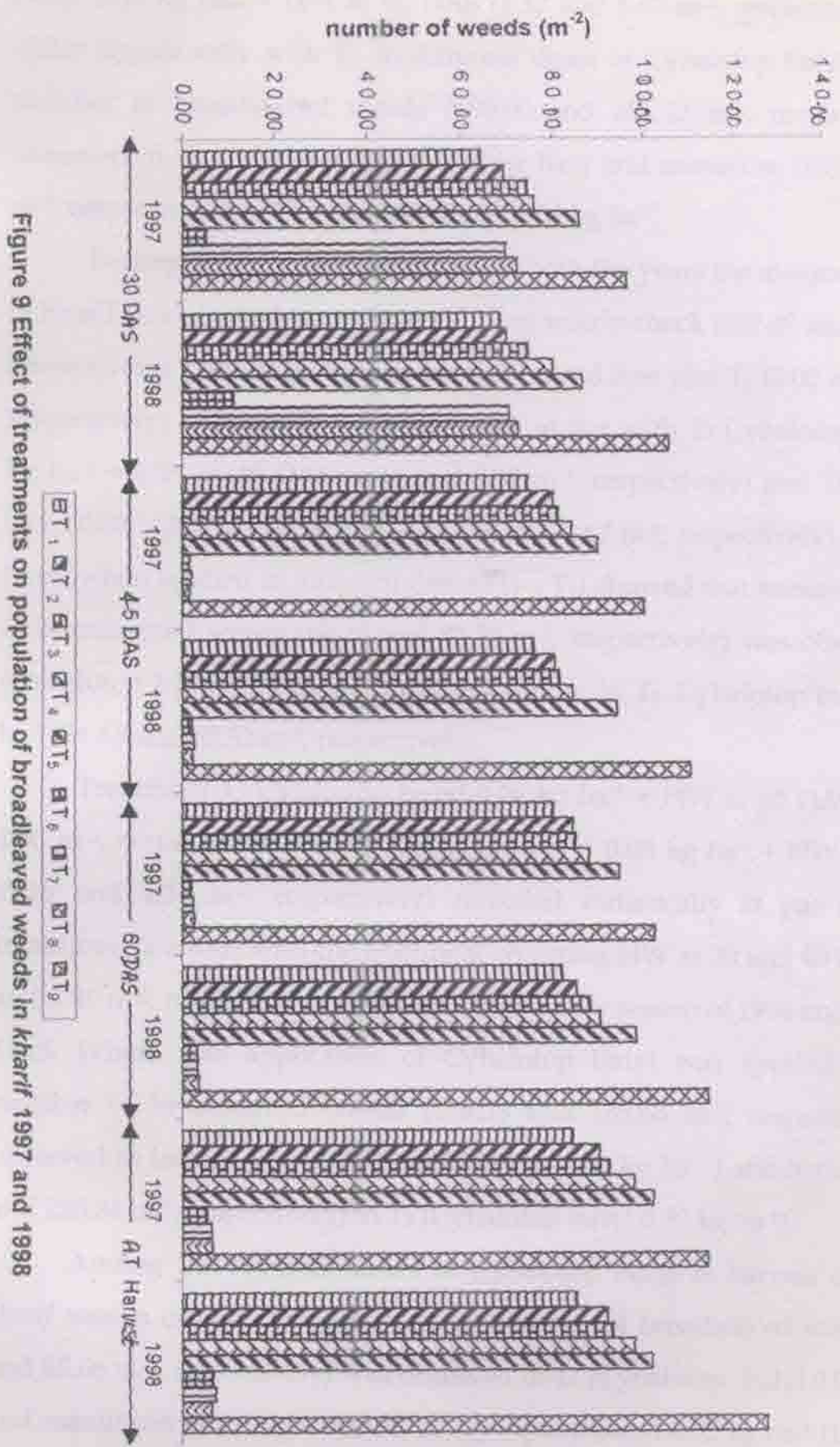


Figure 9 Effect of treatments on population of broadleaved weeds in kharif 1997 and 1998

butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.32 and 1.67 m⁻², respectively) did not differ significantly with T₆. In different doses of Cyhalofop butyl, maximum number of broadleaved weeds (193.00 and 204.32 m⁻², respectively) was observed in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and minimum (133.0 and 140.0 m⁻², respectively) in T₁ Cyhalofop butyl 0.04 kg ha⁻¹.

During *kharif* season at 60 DAS of both the years the maximum number of broad leaved weeds was obtained from weedy check (102.30 and 114.65 m⁻², respectively) and the minimum from the weed free plot T₆ (2.00 and 3.32 m⁻², respectively) . The later was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (2.34 and 3.33 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2.34 and 3.67 m⁻², respectively). Cyhalofop butyl when applied in different doses (T₁ – T₅) showed that minimum number of broadleaved weeds (80.34 and 82.34 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (94.65 and 98.32 m⁻², respectively).

Treatment T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (4.00 and 4.00 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (3.66 and 4.34 m⁻², respectively) recorded statistically at par number of broadleaved weeds with the treatment receiving HW at 20 and 40 DAS, (3.32 and 3.45 m⁻², respectively) the lowest during *boro* season of 1998 and 1999 at 60 DAS. Where sole application of Cyhalofop butyl was applied minimum number of broadleaved weeds (176.33 and 185.66 m⁻², respectively) was observed in lowest dose of (Cyhalofop butyl 0.04 kg ha⁻¹) and highest (198.32 and 220.34 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

Among the different doses of Cyhalofop butyl at harvest during the *kharif* season of both the years, lowest number of broadleaved weeds (84.64 and 85.66 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum with highest dose of Cyhalofop butyl 0.32 kg ha⁻¹ (102.32 and 102.33 m⁻², respectively). Lowest number of broadleaved weeds (5.34 and 6.65

Table 15 Effect of treatments on population of broadleaved weeds during *boro* 1998 and 1999

Treatments	Number of broadleaved weeds m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T₁ Cyhalofop butyl 0.04 kg ha ⁻¹	119.35 (10.92)	121.30 (11.01)	120.32	133.00 (11.53)	140.00 (11.83)	136.50	176.33 (13.27)	185.66 (13.62)	180.99	201.98 205.30 (14.33)
T₂ Cyhalofop butyl 0.06 kg ha ⁻¹	125.34 (11.19)	140.32 (11.84)	132.83	142.66 (11.94)	162.00 (12.73)	152.33	182.67 (13.51)	196.32 (14.01)	189.49	211.67 (14.55)
T₃ Cyhalofop butyl 0.08 kg ha ⁻¹	141.33 (11.89)	161.33 (12.70)	151.33	153.34 (12.38)	170.33 (13.05)	161.83	190.32 (13.79)	204.35 (14.29)	197.33	225.33 (15.01)
T₄ Cyhalofop butyl 0.16 kg ha ⁻¹	146.65 (12.11)	173.65 (13.18)	160.15	182.33 (13.50)	192.34 (13.87)	187.33	194.66 (13.95)	208.67 (14.44)	201.66	232.35 (15.24)
T₅ Cyhalofop butyl 0.32 kg ha ⁻¹	150.64 (12.27)	188.00 (13.71)	169.32	193.00 (13.89)	204.32 (14.29)	198.66	198.32 (14.08)	220.34 (14.84)	209.33	241.67 (15.54)
T₆ HW at 20 and 40 DAS	6.30 (2.51)	8.00 (2.83)	7.15	1.33 (1.15)	1.35 (1.16)	1.34	3.32 (1.82)	3.45 (1.86)	3.38	8.64 (2.94)
T₇ Cyhalofop butyl 0.06 kg ha ⁻¹ + HW at 40 DAS	123.34 (11.10)	140.00 (11.83)	131.67	1.32 (1.15)	1.66 (1.29)	1.49	4.00 (2.00)	4.00 (2.00)	4.00	12.66 (3.56)
T₈ Cyhalofop butyl 0.08 kg ha ⁻¹ + HW at 40 DAS	142.67 (11.94)	160.67 (12.67)	151.67	1.32 (1.15)	1.67 (1.29)	1.49	3.66 (1.91)	4.34 (2.08)	4.00	12.35 (3.51)
T₉ Weedy check	165.00 (12.84)	199.33 (14.11)	182.16	202.34 (14.22)	223.34 (14.94)	212.84	212.34 (14.57)	234.66 (15.31)	223.50	254.34 (15.94)
Mean	124.51	143.62		112.29	121.89		120.51	140.19		156.04
SE(m)	0.10	0.11		0.12	0.15		0.16	0.17		0.20
CD at 5%	0.30	0.32		0.36	0.45		0.4	0.50		0.60

* Data given in parentheses are square root transformed of original value SE(m) and (CD) of transformed value.

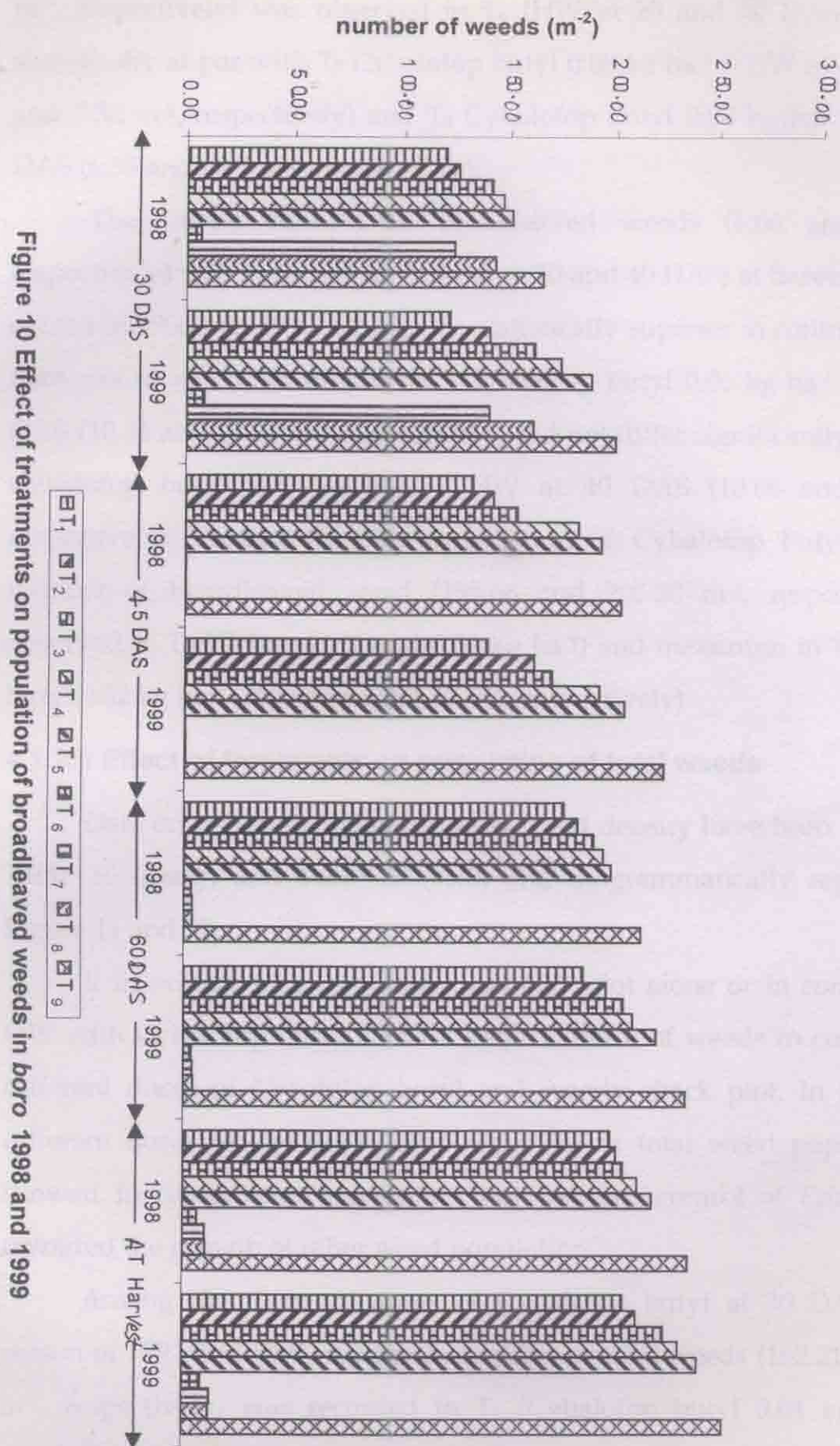


Figure 10 Effect of treatments on population of broadleaved weeds in boro 1998 and 1999

m^{-2} , respectively) was observed in T_6 (HW at 20 and 40 DAS) which was statistically at par with T_7 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (6.30 and 7.32 m^{-2} , respectively) and T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (6.35 and 6.67 m^{-2} , respectively).

The lowest number of broadleaved weeds (6.66 and 8.67 m^{-2} , respectively) was observed in T_6 (HW at 20 and 40 DAS) at harvest in the *boro* season of 1998 and 1999, which was statistically superior in controlling weeds than rest of all other treatments. Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (10.34 and 12.66 m^{-2} , respectively) did not differ significantly with the T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (10.66 and 12.35 m^{-2} , respectively). Among the sole application of Cyhalofop butyl, minimum number of broadleaved weed (198.66 and 205.30 m^{-2} , respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and maximum in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (218.64 and 241.67 m^{-2} , respectively).

4.1.2.5 Effect of treatments on population of total weeds

Data on treatment effects on total weed density have been presented in Table 16 (*kharif*) and Table 17 (*boro*) and diagrammatically represented in Figure 11 and 12.

It is evident from the Table that HW plot alone or in combination of HW with Cyhalofop butyl showed better control of weeds in comparison to different doses of Cyhalofop butyl and weedy check plot. In the plots of different doses of Cyhalofop butyl even lower total weed population was showed in comparison to weedy check but the control of *Echinochloa spp* favoured the growth of other weed population.

Among the different doses of Cyhalofop butyl at 30 DAS in *kharif* season of 1997 and 1998, minimum number of total weeds (162.21 and 178.63 m^{-2} , respectively) was recorded in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and maximum number (223.20 and 226.00 m^{-2} , respectively) in T_5 (Cyhalofop butyl

0.32 kg ha⁻¹). However, lowest number of total weeds (18.55 and 21.82 m⁻², respectively) was observed in HW at 20 and 40 DAS (T₆) which was significantly superior in controlling weeds to the rest of the treatments.

During the *boro* season of both the years at 30 DAS, minimum number of total weed population (16.21 and 17.30 m⁻², respectively) was again recorded in weed free plot (T₆) and among the plots received different doses of Cyhalofop butyl, lowest number of total weeds (261.65 and 275.15 m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum (340.20 and 371.93 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

At 45 DAS, during *kharif* season of both years the highest number of total weeds was recorded from weedy check (289.48 and 300.76, respectively) and the lowest (4.33 and 4.37 m⁻², respectively) was observed in HW at 20 and 40 DAS. This treatment (T₆) was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (5.28 and 5.74 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (4.95 and 5.14 m⁻², respectively). In sole of application of Cyhalofop butyl, lowest number of total weeds (196.74 and 200.87 m⁻², respectively) was observed in the plot which received Cyhalofop butyl 0.04 kg ha⁻¹ and the maximum (239.55 and 248.21 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

The results showed that at 45 DAS in the *boro* season of both years, minimum number (4.16 and 5.90 m⁻², respectively) of total weeds observed in twice HW plot (T₆) which was statistically at par with the integrated treatments T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (4.92 and 6.47 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (4.89 and 6.03 m⁻² respectively). The lowest number of total weeds (309.70 and 318.63 m⁻², respectively) was observed in the plot which received Cyhalofop butyl 0.04 kg ha⁻¹ and the maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (411.60 and 419.75 m⁻², respectively amongst the sole treatments of this chemical (T₁ – T₅).

Table 16 Effect of treatments on population of total weeds during *kharif* 1997 and 1998

Treatments	Number of total weeds m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	162.21 (12.74)	178.63 (13.36)	170.42	196.74 (14.03)	200.87 (14.17)	198.80	210.86 (14.52)	229.00 (15.14)	219.93	269.32 (16.41)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	180.98 (13.45)	185.56 (13.62)	183.27	206.24 (14.36)	208.74 (14.45)	207.49	230.04 (15.17)	237.89 (15.42)	233.96	277.87 (16.67)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	197.54 (14.05)	200.15 (14.15)	198.84	215.41 (14.68)	219.28 (14.81)	217.34	230.59 (15.18)	255.02 (15.97)	242.80	286.31 (16.92)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	205.73 (14.34)	209.07 (14.46)	207.40	224.41 (14.98)	229.56 (15.15)	226.98	240.93 (15.52)	259.40 (16.10)	250.16	294.33 (17.15)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	223.20 (14.94)	226.00 (15.03)	224.60	239.55 (15.48)	248.21 (15.75)	243.88	260.50 (16.14)	278.32 (16.68)	269.41	309.54 (17.79)
T ₆ HW at 20 and 40 DAS	18.55 (4.31)	21.82 (4.67)	20.18	4.33 (2.08)	4.37 (2.09)	4.35	16.02 (4.00)	17.06 (4.13)	16.54	24.92 (4.99)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ + HW at 40 DAS	177.26 (13.31)	182.54 (13.51)	179.90	5.28 (2.30)	5.74 (2.39)	5.51	18.26 (4.27)	21.03 (4.58)	19.64	36.66 (6.05)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ + HW at 40 DAS	190.01 (13.78)	194.71 (13.95)	192.36	4.95 (2.22)	5.14 (2.27)	5.04	16.80 (4.10)	19.22 (4.38)	18.01	27.14 (5.21)
T ₉ Weedy check	263.04 (16.22)	278.54 (16.69)	270.79	289.48 (17.01)	300.76 (17.34)	295.12	298.57 (17.28)	305.36 (17.47)	300.39	344.31 (18.99)
Mean	180.83	186.33		154.04	158.07		169.17	180.25		200.92
SEM	0.14	0.16		0.10	0.13		0.13	0.15		0.17
CV at 5%	0.41	0.49		0.30	0.39		0.40	0.46		0.52

* Data given in parentheses are square root transformed of original value S.E.(m) and C.V. of transformed value

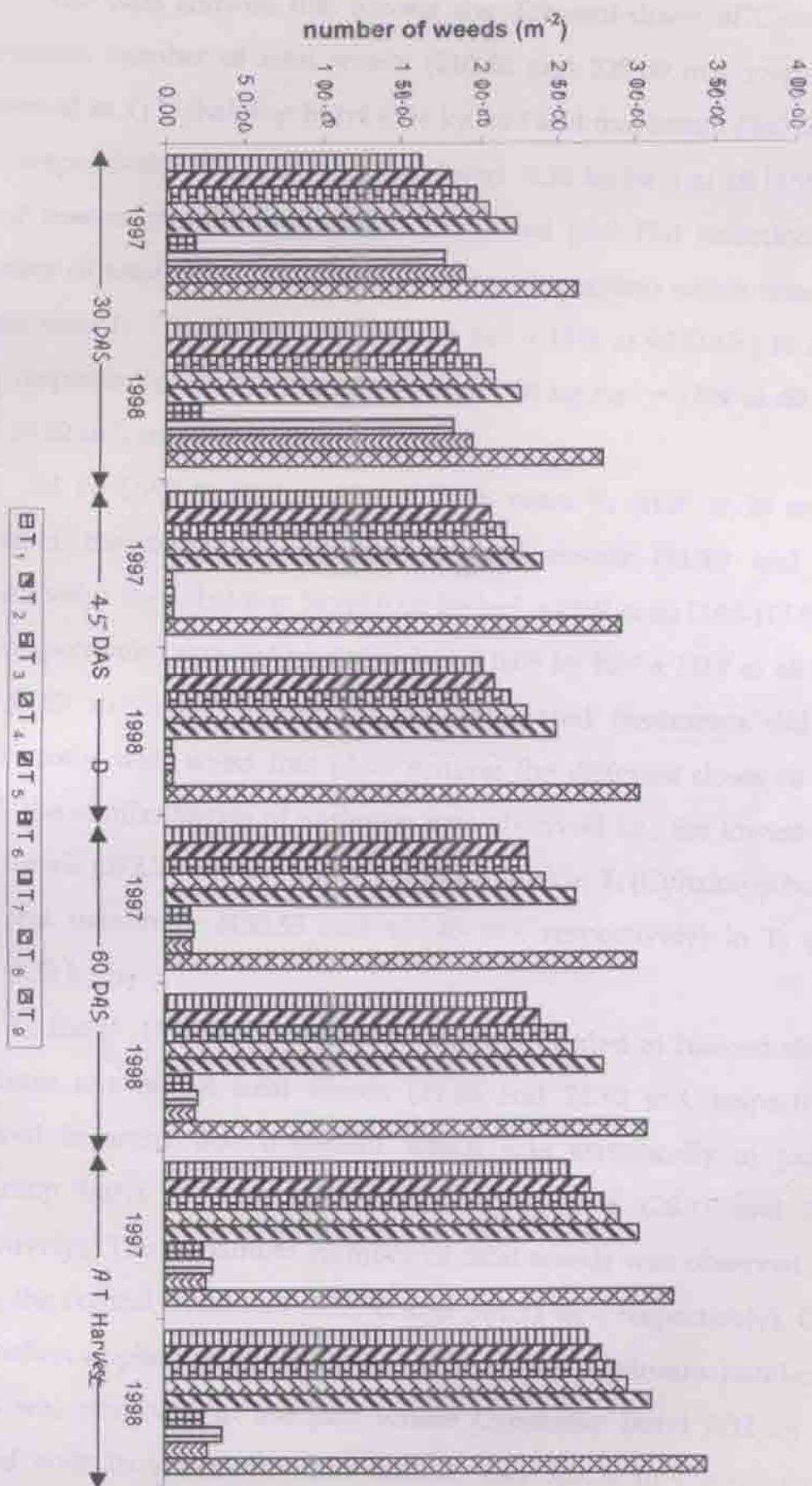


Figure 11 Effect of treatments on population of total weeds during kharif 1997 and 1998

The data showed that among the different doses of Cyhalofop butyl, minimum number of total weeds (210.86 and 229.00 m⁻², respectively) was observed in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and maximum (260.50 and 278.32 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) at 60 DAS during the *kharif* season of 1997 and 1998. The weed plot (T₆) recorded the lowest number of total weed (16.02 and 17.06 m⁻² respective) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (18.26 and 21.03 m⁻², respectively) or T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (16.80 and 19.22 m⁻², respectively).

At 60 DAS in *boro* season of both years T₆ (HW at 20 and 40 DAS) recorded the minimum number of total weeds (11.19 and 13.33 m⁻², respectively) T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (12.58 and 15.38 m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (12.22 and 14.83 m⁻², respectively) the two integrated treatments did not differ significantly with weed free plot. Among the different doses of Cyhalofop butyl, the similar trends of variation was observed i.e., the lowest number of total weeds (372.23 and 377.79 m⁻², respectively) in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum (450.55 and 453.45 m⁻², respectively) in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

In *kharif* 1997 and 1998 observations recorded at harvest showed that minimum number of total weeds (24.66 and 24.92 m⁻², respectively) was observed in weed free treatment which was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (26.17 and 27.14 m⁻², respectively). The maximum number of total weeds was observed in weedy check, the control treatment (322.60 and 344.31 m⁻², respectively). Cyhalofop butyl when applied in different doses (T₁ - T₅) maximum number of total weeds was observed in the plot where Cyhalofop butyl 0.32 kg ha⁻¹ was sprayed with its maximum dose (300.70 and 309.70 m⁻², respectively) and

Table 17 Effect of treatments on population of total weeds during *boro* 1998 and 1999

Treatments	Number of total weeds m ⁻²										
	30 DAS			45 DAS			60 DAS			At harvest	
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	1998	1999
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	261.65 (16.17)	279.15 (16.71)	270.40	309.70 (17.60)	318.63 (17.85)	314.16	372.23 (19.29)	377.79 (19.44)	375.01	336.30 (18.34)	415.86 (20.39)
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	291.27 (17.07)	309.38 (17.59)	300.32	329.55 (18.15)	346.68 (18.62)	338.11	392.53 (19.81)	394.54 (19.86)	393.53	444.15 (21.07)	452.08 (21.26)
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	312.62 (17.68)	389.99 (19.75)	351.30	343.44 (18.53)	360.46 (18.98)	351.45	406.31 (20.16)	421.79 (20.54)	414.05	461.89 (21.49)	468.83 (21.65)
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	331.57 (18.21)	354.12 (18.82)	342.84	389.82 (19.74)	393.87 (19.85)	391.84	420.16 (20.50)	435.92 (20.88)	428.04	480.33 (21.92)	487.38 (22.08)
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	340.20 (18.44)	371.93 (19.28)	356.06	411.60 (20.29)	419.75 (20.49)	415.67	450.55 (21.23)	453.45 (21.29)	452.00	500.11 (22.36)	505.92 (22.49)
T ₆ HW at 20 and 40 DAS	16.21 (4.03)	17.30 (4.16)	16.75	4.16 (2.04)	5.90 (2.43)	5.03	11.19 (3.34)	13.33 (3.65)	12.26	21.42 (4.63)	24.17 (4.92)
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	281.88 (16.79)	300.72 (17.34)	291.30	4.92 (2.22)	6.47 (2.54)	5.69	12.58 (3.55)	15.38 (3.92)	13.98	28.91 (5.38)	30.92 (5.56)
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	299.48 (17.30)	322.96 (17.97)	311.22	4.89 (2.21)	6.03 (2.45)	5.46	12.22 (3.49)	14.83 (3.85)	13.52	26.42 (5.14)	29.97 (5.47)
T ₉ Weedy check	387.12 (19.67)	393.46 (19.83)	390.29	425.21 (20.62)	443.27 (21.05)	434.29	468.26 (21.64)	477.86 (21.86)	473.06	510.85 (22.60)	516.96 (22.74)
Mean	280.34	304.41		247.13	255.67		282.89	289.43		312.27	329.02
SEm±	0.16	0.17		0.17	0.18		0.18	0.18		0.19	0.20
CD at 5%	0.49	0.51		0.52	0.53		0.54	0.55		0.58	0.60

* Data given in parentheses are square root transformed of original value SEm(±) and CD of transformed value.

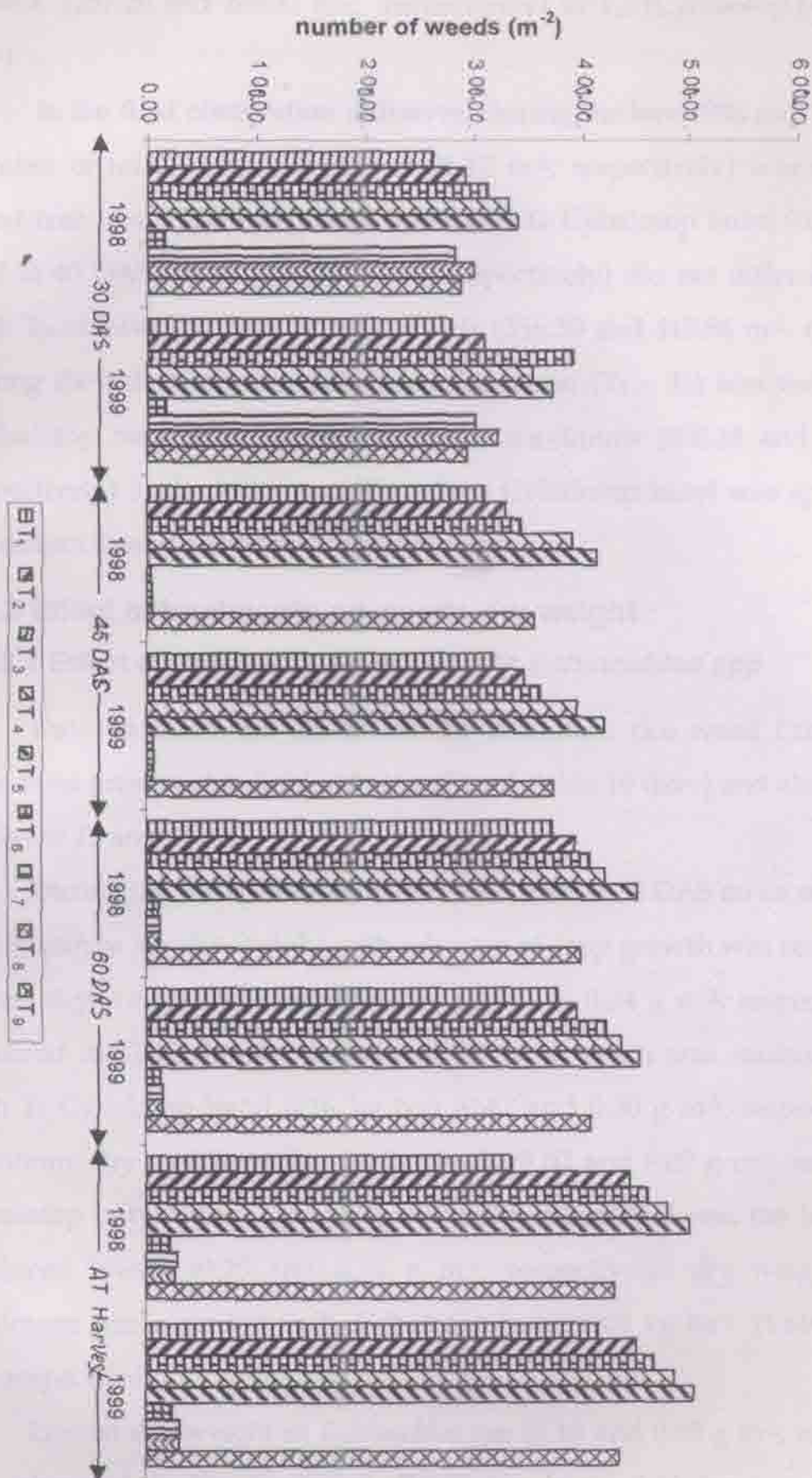


Figure 12 Effect of treatments on population of total weeds in boro 1998 and 1999

lowest (257.29 and 269.32 m^{-2} , respectively) in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}).

In the final observation at harvest during the *boro* 1998 and 1999, lowest number of total weeds (21.42 and 24.17 m^{-2} , respectively) was observed in weed free plot. The integrated treatment T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (26.42 and 29.97 m^{-2} , respectively) did not differ significantly with T_6 . Lowest number of total weeds (336.30 and 415.86 m^{-2} , respectively) among the sole application of Cyhalofop butyl (T_1 – T_5) was recorded in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and the maximum (500.11 and 505.92 m^{-2} , respectively) in the treatment (T_5) where Cyhalofop butyl was applied in its' maximum dose 0.32 kg ha^{-1} .

4.1.3 Effect of treatments on weeds dry weight

4.1.3.1 Effect of treatments on dry weight *Echinochloa spp*

Data on treatment effects on the dominant rice weed *Echinochloa spp* have been presented in Table 18 (*kharif*) and Table 19 (*boro*) and also illustrated in Figure 13 and 14.

During the *Kharif* season of 1997 and 1998 at 30 DAS an increasing trend of *Echinochloa spp* dry weight with advance of crop growth was recorded. The lowest dry weight of *Echinochloa spp* (0.25 and 0.24 g m^{-2} , respectively) was observed in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}) which was statistically at par with T_4 Cyhalofop butyl 0.16 kg ha^{-1} (0.41 and 0.30 g m^{-2} , respectively) and maximum dry weight in T_9 weedy check (9.80 and 9.07 g m^{-2} , respectively). Cyhalofop butyl when applied as sole with different doses, the highest dose produced lowest (0.25 and 0.24 g m^{-2} , respectively) dry weight and the maximum was recorded in T_1 Cyhalofop butyl 0.04 kg ha^{-1} (1.69 and 1.30 g m^{-2} , respectively).

Lowest dry weight of *Echinochloa spp* (0.10 and 0.09 g m^{-2} , respectively) was observed in the treatment Cyhalofop butyl 0.32 kg ha^{-1} which was

statistically at par with its next following dose 0.16 kg ha^{-1} (0.22 and 0.18 g m^{-2} , respectively) in boro 1998 and 1999 at same date of observation. The maximum weed dry weight was observed in weedy check (8.79 and 7.41 g m^{-2} , respectively) while the weed free treatment T_6 recorded 0.78 and 0.52 g m^{-2} , respectively. Among the integrated methods of weed control, lowest weed dry weight of *Echinochloa spp* (0.48 and 0.32 g m^{-2} , respectively) was observed in T_8 (Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS).

At 45 DAS in Kharif season of both years, minimum dry weight of *Echinochloa spp* (0.24 and 0.20 g m^{-2} , respectively) was observed in T_8 (Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS) which was statistically at par with T_5 Cyhalofop butyl 0.32 kg ha^{-1} (0.70 and 0.54 g m^{-2} , respectively). T_6 —twice HW at 20 and 40 DAS (0.49 and 0.46 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (0.70 and 0.04 kg m^{-2} , respectively). Weedy check recorded the maximum (23.10 and 22.17 g m^{-2} , respectively) and among the sole treatments of Cyhalofop butyl, lowest weed dry weight of *Echinochloa spp* (0.70 and 0.54 g m^{-2} , respectively) was observed in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}) and the maximum in T_1 Cyhalofop butyl 0.04 kg ha^{-1} (4.37 and 3.99 g m^{-2} , respectively).

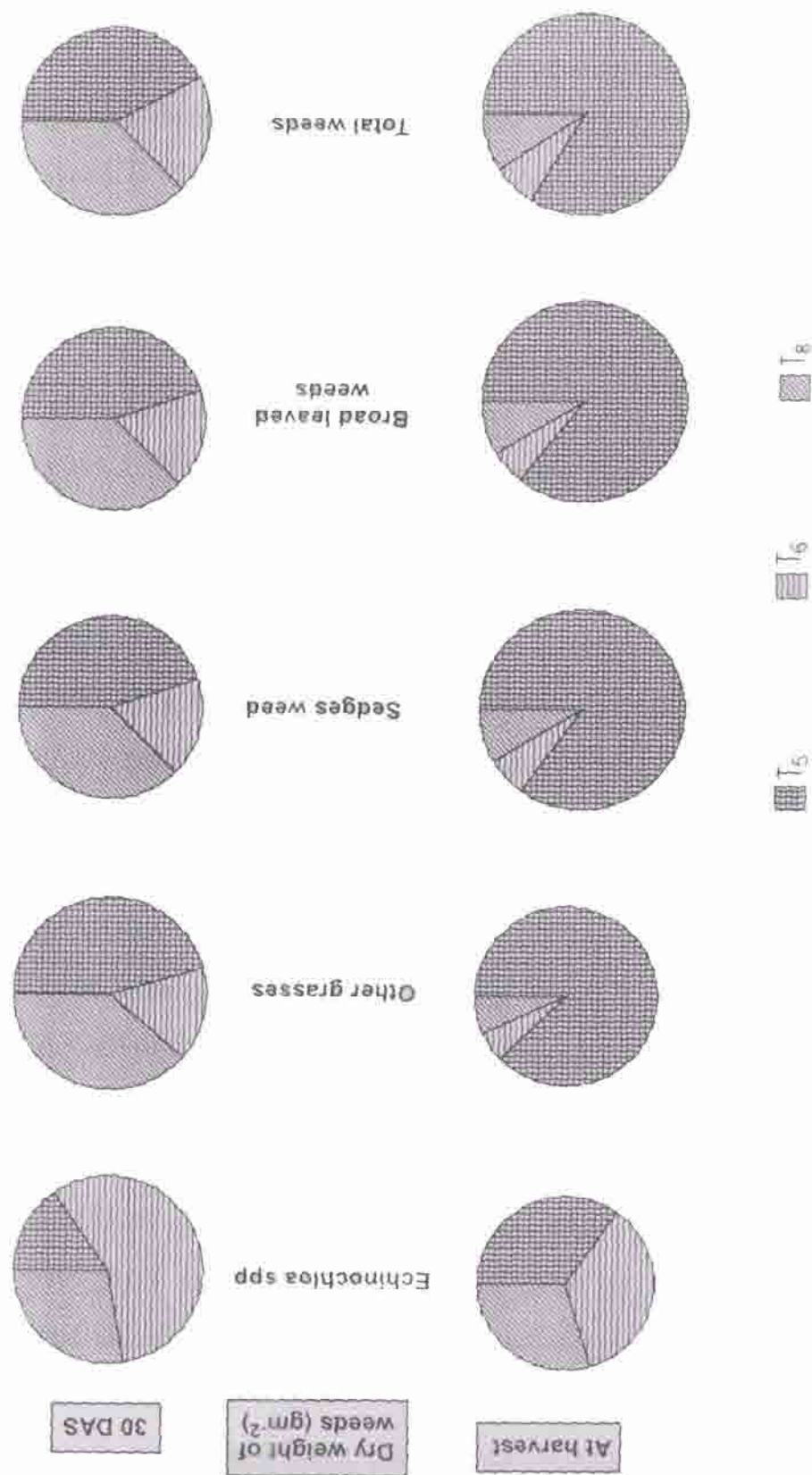
Cyhalofop butyl when applied as sole maximum dry weight of *Echinochloa spp* was found in its lowest dose 0.04 kg ha^{-1} (3.67 and 2.58 g m^{-2} , respectively) and minimum (0.44 and 0.24 g m^{-2} , respectively) in its maximum dose 0.32 kg ha^{-1} at 45 DAS of boro 1998 and 1999. Lowest weed dry weight of *Echinochloa spp* (0.21 and 0.20 g m^{-2} , respectively) was observed in T_8 (Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS) which was statistically at par with T_4 Cyhalofop butyl 0.16 kg ha^{-1} (0.61 and 0.46 g m^{-2} , respectively), T_5 Cyhalofop butyl 0.32 kg ha^{-1} (0.44 and 0.24 g m^{-2} , respectively), T_6 HW at 20 and 40 DAS (0.41 and 0.21 g m^{-2} , respectively).

The results showed that at 60 DAS during the Kharif season of 1997 and 1998, minimum weed dry weight of *Echinochloa spp* was observed in T_8

Table 18 Effect of treatments on dry weight of *Echinochloa spp* during *khari* 1997 and 1998

Treatments	Dry weight of <i>Echinochloa</i> spp g m ⁻²											
	30 DAS			45 DAS			60 DAS			At harvest		
	1997	1998		1997	1998		1997	1998		1997	1998	Mean
		Mean			Mean			Mean				
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1.69	1.30	1.49	4.37	3.99	4.18	7.65	6.00	6.82	10.43	9.56	9.99
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1.29	1.09	1.19	3.98	2.52	3.25	6.10	4.25	5.17	7.85	7.05	7.45
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	0.48	0.40	0.44	1.63	1.40	1.51	2.55	2.30	2.42	3.27	2.92	3.10
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	0.41	0.30	0.35	1.17	0.87	1.02	1.70	1.25	1.47	2.50	2.03	2.26
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	0.25	0.24	0.24	0.70	0.54	0.62	1.40	1.00	1.20	1.75	1.70	1.72
T ₆ HW at 20 and 40 DAS	1.00	0.80	0.90	0.49	0.46	0.47	2.00	1.30	1.65	1.87	1.65	1.76
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	1.36	1.20	1.28	0.70	0.40	0.55	1.30	0.60	0.95	2.50	2.06	2.28
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	0.50	0.38	0.44	0.24	0.20	0.22	1.00	0.55	0.77	1.68	1.25	1.46
T ₉ Weedy check	9.80	9.07	9.43	23.10	22.17	22.63	33.30	32.50	32.90	42.21	40.37	41.21
Mean	1.86	1.63		4.04	3.62		6.33	5.53		8.22	7.62	
SEm±	0.06	0.05		0.20	0.19		0.38	0.37		0.46	0.44	
CD at 5%	0.17	0.15		0.61	0.58		1.15	1.10		1.28	1.12	

Figure 13. Effect of treatments on dry weight of weeds during Kharif 1997 and 1998



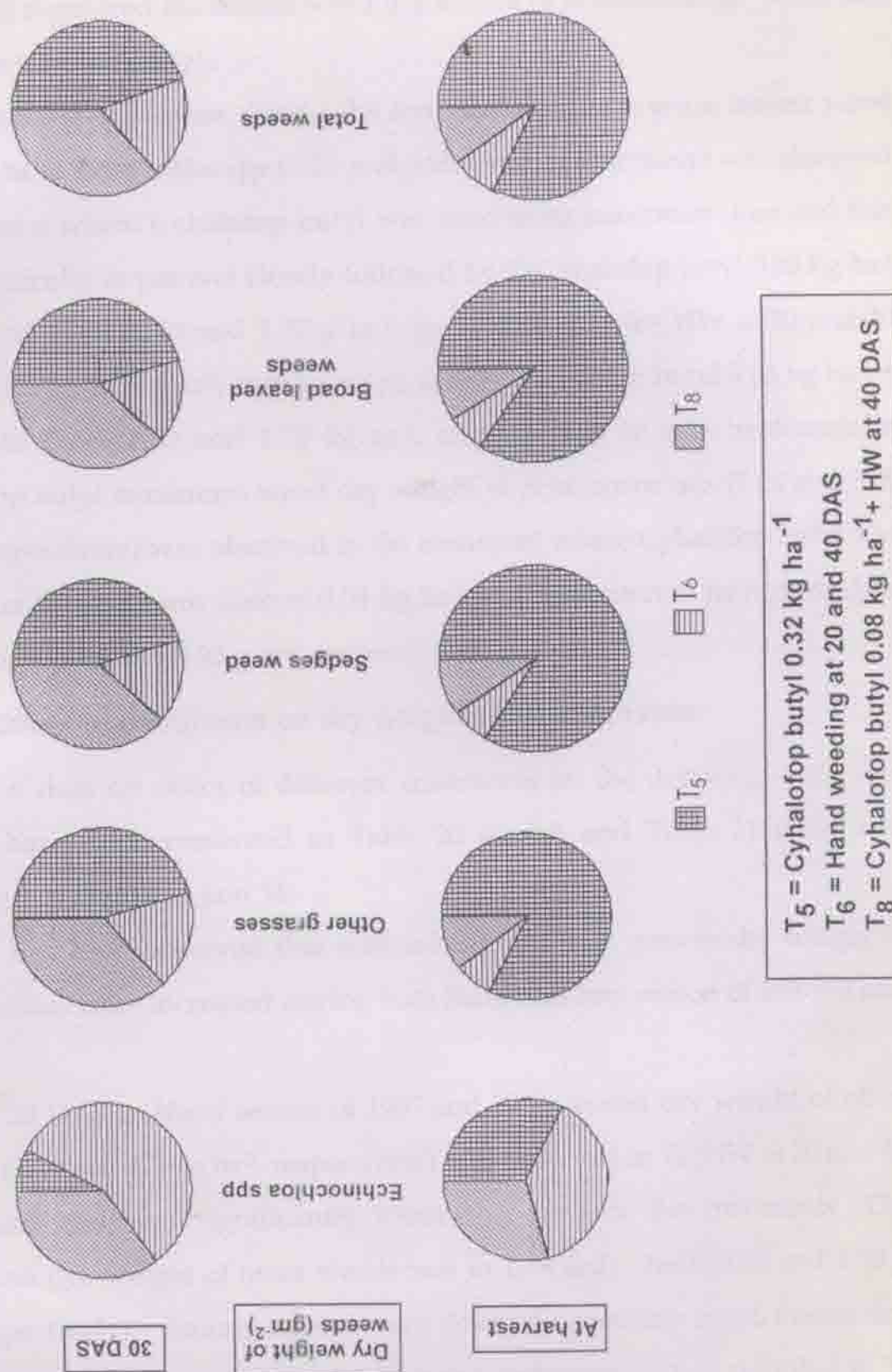
T₅ = Cyhalofop butyl 0.32 kg ha⁻¹
 T₆ = Hand weeding at 20 and 40 DAS
 T₈ = Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS

Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (1.00 and 0.55 g m^{-2} , respectively) which was statistically at par with T_4 Cyhalofop butyl 0.16 kg ha^{-1} (1.70 and 1.25 g m^{-2} , respectively), T_5 Cyhalofop butyl 0.32 kg ha^{-1} (1.40 and 1.00 g m^{-2} , respectively), T_6 HW at 20 and 40 DAS (2.00 and 1.30 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (1.30 and 0.06 g m^{-2} , respectively). Sole application of Cyhalofop butyl recorded maximum dry weight of *Echinochloa spp* (7.65 and 6.00 g m^{-2} , respectively) in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and minimum (1.40 and 1.00 g m^{-2} , respectively) in T_5 Cyhalofop butyl 0.32 kg ha^{-1} .

In the year 1998 and 1999 at 60 DAS during *boro* season the minimum weed dry weight of *Echinochloa spp* was observed in the integrated treatment T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (0.60 and 0.35 g m^{-2} , respectively), and it did not differ significantly with T_4 Cyhalofop butyl 0.16 kg ha^{-1} (1.60 and 0.65 g m^{-2} , respectively), T_5 Cyhalofop butyl 0.32 kg ha^{-1} (0.70 and 0.45 g m^{-2} , respectively), T_6 HW at 20 and 40 DAS (1.20 and 0.65 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (1.30 and 1.00 g m^{-2} , respectively). Whereas the sole application of Cyhalofop butyl (T_1 – T_5), maximum weed dry weight of *Echinochloa spp* (5.70 and 3.65 g m^{-2} , respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and the minimum in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (0.70 and 0.45 g m^{-2} , respectively).

The data obtained at harvest during *kharif* season of 1997 and 1998 showed lowest weed dry weight of *Echinochloa spp* in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (1.68 and 1.25 g m^{-2} , respectively) which was closely followed by T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (1.75 and 1.70 g m^{-2} , respectively) and statistically at par with T_6 HW at 20 and 40 DAS (1.87 and 1.65 g m^{-2} , respectively), T_4 Cyhalofop butyl 0.16 kg ha^{-1} (2.50 and 2.03 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (2.50 and 2.06 g m^{-2} , respectively). Among the different doses of Cyhalofop butyl, maximum dry weight of *Echinochloa spp* (10.43 and 9.56 g m^{-2} , respectively)

Figure 14. Effect of treatments on dry weight of weeds during boro 1998 and 1999



was observed in the lowest dose of Cyhalofop butyl (0.04 kg ha^{-1}). Weedy check plot registered maximum weed dry weight of *Echinochloa spp* (42.21 and 40.37 g m^{-2} , respectively).

Similarly at harvest during the *boro* season of both years, lowest weed dry weight of *Echinochloa spp* (1.25 and 0.95 g m^{-2} , respectively) was observed in treatment where Cyhalofop butyl was used in its maximum dose and this was statistically at par and closely followed by T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (1.40 and 1.02 g m^{-2} , respectively), twice HW at 20 and 40 DAS (1.67 and 1.25 g m^{-2} , respectively), and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (2.02 and 1.70 g m^{-2} , respectively). In sole treatments of Cyhalofop butyl maximum weed dry weight of *Echinochloa spp* (7.06 and 5.00 g m^{-2} , respectively) was observed in the treatment where Cyhalofop butyl was applied at its minimum dose of 0.04 kg ha^{-1} and minimum in its highest dose 0.32 kg ha^{-1} (1.25 and 0.95 g m^{-2} , respectively).

4.1.3.2 Effect of treatments on dry weight of other grasses

The data on effect of different treatments on the dry weight of other grasses have been presented in Table 20 (*kharif*) and Table 21 (*boro*) and illustrated in Figure 13 and 14.

It had been observed that with advance of crop growth dry weight of other grasses were increased during both *kharif* and *boro* season of 1997-98 and 1998-99.

At 30 DAS in *kharif* season of 1997 and 1998, lowest dry weight of other grasses (1.10 and 1.36 g m^{-2} , respectively) was observed in T_6 (HW at 20 and 40 DAS) and this was significantly lower than rest of the treatments. The maximum dry weight of other weeds was in T_9 weedy check (3.60 and 4.30 g m^{-2} , respectively). Among the different doses of Cyhalofop butyl, lowest dry weight of other grasses (2.52 and 3.01 g m^{-2} , respectively) was recorded in T_1

(Cyhalofop butyl 0.04 kg ha^{-1}) and maximum dry weight (3.44 and 4.08 g m^{-2} , respectively) in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}).

Similarly, in *boro* season of both years at same date of observation, lowest dry weight of other grasses (1.08 and 1.16 g m^{-2} , respectively) was observed in twice hand weeded plot and this was again significantly lower than rest of the treatments. Whereas in sole application of chemical Cyhalofop butyl ($T_1 - T_5$), lowest dry weight of other grasses (1.96 and 2.18 g m^{-2} , respectively) was observed in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and maximum dry weight (2.46 and 3.24 g m^{-2} , respectively) in T_5 (Cyhalofop butyl 0.32 kg ha^{-1}).

Weed free treatment (HW at 20 and 40 DAS) which did not vary significantly with T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (0.44 and 0.46 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (0.42 and 0.44 g m^{-2} , respectively) recorded the minimum dry weight of other grasses (0.36 and 0.40 g m^{-2} , respectively) at 45 DAS of kharif 1997 and 1998. The lowest dose of chemical T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) recorded lowest dry weight of other grasses (10.08 and 10.53 g m^{-2} , respectively) while the maximum dose, T_5 Cyhalofop butyl 0.32 kg ha^{-1} recorded the maximum (12.72 and 14.28 g m^{-2} , respectively) amongst the different doses of Cyhalofop butyl.

The results showed that at 45 DAS in *boro* seasons of both years, weedy check the control T_9 plot showed significantly higher dry weight of other grasses (10.88 and 11.64 , respectively) in treatment T_6 (HW at 20 and 40 DAS) showed minimum dry weight of other grasses (0.32 and 0.34 g m^{-2} , respectively) and was statistically at par with T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (0.36 and 0.38 g m^{-2} , respectively) and T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (0.33 and 0.36 g m^{-2} , respectively). The treatments received Cyhalofop butyl as sole ($T_1 - T_5$) showed lowest dry weight of other grasses (8.32 and 8.84 g m^{-2} , respectively) in T_1 (Cyhalofop butyl 0.04 kg ha^{-1}) and the maximum (9.40 and 10.20 g m^{-2} , respectively) in T_5 Cyhalofop butyl 0.32 kg ha^{-1} closely followed by T_4 (8.82 and 9.70 g m^{-2}).

Minimum dry weight of other grasses (1.33 and 1.60 g m⁻², respectively) was observed at 60 DAS in *kharif* season of both years twice hand weeding plot at 20 and 40 DAS T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.63 and 1.92 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.82 and 2.13 g m⁻², respectively) the two integrated treatments, did not vary significantly with the weed free treatment. In different doses of Cyhalofop butyl (T₁ - T₅), lowest dry weight of other grasses (19.72 and 22.00 g m⁻², respectively) was recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (25.61 and 29.84 g m⁻², respectively).

Similarly, at 60 DAS in *boro* season of 1998 and 1999, lowest dry weight of other grasses (1.23 and 1.48 g m⁻², respectively) was observed in T₆ (HW at 20 and 40 DAS) and this was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ HW at 40 DAS (1.33 and 1.63 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.29 and 1.79 g m⁻², respectively). Among the different doses of Cyhalofop butyl lowest dry weight of other grasses (17.18 and 18.47 g m⁻², respectively) was observed in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and highest dry weight (20.63 and 22.84 g m⁻², respectively) in T₅ Cyhalofop butyl 0.32 kg ha⁻¹.

At harvest during *kharif* season of 1997 and 1998 maximum dry weight of other grasses (52.30 and 56.45 g m⁻², respectively) was observed in T₉ (weedy check) and minimum dry weight of other grasses (2.29 and 2.34 g m⁻², respectively) in T₆ (HW at 20 and 40 DAS) which was significantly lower than rest of the treatments. Lowest dry weight of other grasses (30.92 and 33.73 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.32 kg ha⁻¹) among the different doses of Cyhalofop butyl, and highest dry weight (37.52 and 38.47 g m⁻², respectively) in T₅ Cyhalofop butyl 0.32 kg ha⁻¹.

Lowest dry weight of other grasses (2.48 and 2.76 g m⁻², respectively) was recorded in T₆ (HW at 20 and 40 DAS) which was significantly lower than rest

Table 21 Effect of treatments on dry weight of other grasses during *boro* 1998 and 1999

Treatments	Dry weight of other grasses g m ⁻²								
	30 DAS			45 DAS			60 DAS		
	1998		Mean	1998		Mean	1998		Mean
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1.96	2.18	2.07	8.32	8.84	8.58	17.18	18.47	17.82
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	2.04	2.42	2.23	8.46	9.30	8.88	18.33	19.15	18.74
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	2.14	2.56	2.35	8.64	9.56	9.10	19.61	20.03	19.82
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	2.28	2.92	2.60	8.82	9.70	9.26	20.03	21.20	20.61
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	2.46	3.24	2.85	9.40	10.20	9.80	20.63	22.84	21.74
T ₆ HW at 20 and 40 DAS	1.08	1.16	1.12	0.32	0.34	0.33	1.23	1.48	1.36
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹	2.10	2.48	2.29	0.33	0.36	0.34	1.33	1.63	1.48
+HW at 40 DAS									
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW	2.20	2.60	2.40	0.36	0.38	0.37	1.29	1.79	1.54
at 40 DAS									
T ₉ Weedy check	2.92	3.38	3.10	10.88	11.64	11.26	25.15	26.78	25.97
Mean	2.13	2.54		6.17	6.70		13.86	14.82	17.96
SEm±	0.02	0.04		0.15	0.15		0.26	0.28	0.61
CD at 5%	0.07	0.11		0.44	0.46		0.77	0.84	1.83
									19.61
									0.65
									1.95
									33.65
									32.76

of the treatments and highest in weedy check (31.88 and 33.65 g m⁻², respectively in *boro* season of 1998 and 1999 at harvest. In sole application of herbicide (T₁ - T₅), minimum dry weight of other grasses (21.68 and 23.21 g m⁻², respectively) was found in the plot where lowest dose of the chemical Cyhalofop butyl 0.04 kg ha⁻¹ was applied and the highest from the plot where maximum dose of Cyhalofop butyl 0.32 kg ha⁻¹ (28.13 and 30.79 g m⁻²) was applied.

4.1.3.3 Effect of treatments on dry weight of sedges

The data on effect of treatments on dry weight of sedges have been presented in Table 22 (*kharif*) and Table 23 (*boro*) and plotted in Figure 13 and 14.

A gradual increase in dry weight of sedges was observed in both *kharif* and *boro* seasons of 1997-98 and 1998-99 with advance of crop growth. All the treatments recorded significantly higher sedge weed dry weight over the weedy check in all dates of observation in both years.

Minimum dry weight of sedges (0.91 and 0.99 g m⁻², respectively) was observed in T₆ (HW at 20 and 40 DAS) while the same, (1.67 and 1.85 g m⁻², respectively) among the different doses of Cyhalofop butyl, was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (2.09 and 2.75 g m⁻², respectively) followed by T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1.94 and 2.48 g m⁻², respectively) during the *kharif* season of 1997 - 1998 at 30 DAS.

In *boro* season at same date of observation, weedy check recorded the maximum (3.21 and 3.55 g m⁻², respectively) weight of sedges while the lowest, (0.93 and 1.16 g m⁻², respectively) was recorded in (HW at 20 and 40 DAS). Applying the different doses of Cyhalofop butyl (T₁ - T₅), lowest dry weight of sedges (2.14 and 2.56 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ Cyhalofop butyl 0.32 kg

ha⁻¹ (2.92 and 3.47 g m⁻², respectively) followed by again the treatments T₄ and T₃.

Treatment T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.26 and 0.28 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (0.28 and 0.30 g m⁻², respectively) recorded lower weed dry weight though twice HW was again showed the minimum dry weight of sedge (0.26 and 0.28 g m⁻², respectively) at 45 DAS in *kharif* season of 1997 and 1998. In case of sole application of chemical herbicide (T₁ – T₅), minimum dry weight of sedge (6.66 and 7.07 g m⁻², respectively) was observed where lowest dose of (Cyhalofop butyl 0.04 kg ha⁻¹) was applied. Similarly the maximum sedge weed dry weight was observed in T₅ where maximum dose of Cyhalofop butyl 0.32 kg ha⁻¹ (7.52 and 8.16 g m⁻², respectively) was applied.

All the treatments recorded significantly higher dry weight of sedges than the control (T₉) at 45 DAS in *boro* season of both years. Lowest dry weight of sedges (0.29 and 0.32 g m⁻², respectively) was observed in weed free plot which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.34 and 0.35 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (0.35 and 0.36 g m⁻², respectively) the two integrated treatments. In sole application of Cyhalofop butyl maximum dry weight of sedges (10.18 and 11.42 g m⁻², respectively) was observed in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ and minimum dry weight of sedges (8.06 and 8.42 g m⁻², respectively) was found in T₁ Cyhalofop butyl 0.04 kg ha⁻¹.

Both the treatments showed statistically at par with twice HW (T₆) which recorded minimum dry weight of sedge (0.97 and 1.17 g m⁻², respectively). The results showed that at 60 DAS in *kharif* season of 1997 and 1998, T₇ where Cyhalofop butyl was applied 0.06 kg ha⁻¹ recorded dry weight of sedge weeds 1.05 and 1.29 g m⁻², respectively or the same 0.08 kg ha⁻¹ (T₈) 1.02 and 1.41 g m⁻², respectively along with one HW at 40 DAS. Among the different doses of Cyhalofop butyl, lowest dry weight of sedge (13.56 and

Table 22 Effect of treatments on dry weight of sedge weeds in *kharif* 1997 and 1998

Treatments	Dry weight of sedge weeds g m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1.67	1.85	1.76	6.66	7.07	6.86	13.56	14.58	14.07	21.38
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1.73	2.06	1.89	6.77	7.44	7.10	14.47	15.12	14.80	22.45
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	1.82	2.18	1.99	6.91	7.65	7.28	15.48	15.81	15.64	22.45
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	1.94	2.48	2.21	7.06	7.76	7.41	15.81	16.74	16.27	25.26
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	2.09	2.75	2.42	7.52	8.16	7.84	16.29	18.03	17.16	27.36
T ₆ HW at 20 and 40 DAS	0.91	0.99	0.95	0.26	0.27	0.26	0.97	1.17	1.07	2.04
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	1.78	2.11	1.94	0.26	0.28	0.27	1.05	1.29	1.17	2.53
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	1.87	2.21	2.04	0.28	0.30	0.29	1.02	1.41	1.21	2.90
T ₉ Weedy check	2.63	2.94	2.78	9.30	9.91	9.61	18.75	20.04	19.39	31.04
Mean	1.82	2.18		5.00	5.42		16.82	17.68		17.49
SEm±	0.02	0.03		0.12	0.12		0.20	0.22		0.33
CD at 5%	0.06	0.09		0.35	0.36		0.61	0.66		0.98

14.58 g m⁻², respectively) was recorded from lowest doses of Cyhalofop butyl 0.04 kg ha⁻¹ and the maximum from the highest dose of Cyhalofop butyl 0.32 kg ha⁻¹ (16.29 and 18.03 g m⁻², respectively).

Similarly, the data on dry weight of sedges at 60 DAS in *boro* season of 1998 and 1999 showed the lowest in T₆ HW at 20 and 40 DAS (1.05 and 1.26 g m⁻², respectively). This was again statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.29 and 1.51 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.44 and 1.68 g m⁻², respectively). In sole application of Cyhalofop butyl, lowest dry weight of sedge (15.57 and 17.37 g m⁻², respectively) was recorded in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and highest in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (20.22 and 23.56 g m⁻², respectively).

At harvest during *kharif* season of both years maximum dry weight of sedges (29.23 and 31.04 g m⁻², respectively) was observed from T₉ (weedy check) and minimum dry weight of sedges (1.83 and 2.04 g m⁻², respectively) was found in weed free treatment plot which was significantly lower than the rest of treatments. When applied in different doses as sole Cyhalofop butyl, lowest dry weight of sedge (19.97 and 21.38 g m⁻², respectively) was recorded in T₁ and the highest in T₅ (25.91 and 27.36 g m⁻², respectively).

Similar trend of variations were also observed during the *boro* season of 1998 and 1999 at harvest. Lowest dry weight of sedges (2.38 and 2.53 g m⁻², respectively) was observed in T₆ (HW at 20 and 40 DAS). This was significantly lower than all the other treatments including the weedy check (T₉). In sole application of Cyhalofop butyl (T₁ – T₅) recorded lowest dry weight of sedge (23.79 and 25.32 g m⁻², respectively) was recorded in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and maximum dry weight (30.15 and 33.73 g m⁻², respectively) in T₅ where Cyhalofop butyl was applied with its maximum dose of 0.32 kg ha⁻¹.

Table 23 Effect of treatments on dry weight of sedge weeds in *boro* 1998 and 1999

Treatments	Dry weight of sedge weeds g m ⁻²															
	30 DAS						45 DAS						60 DAS		At harvest	
	1998			1999			1998			1999			1998		1999	
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	2.14	2.56	2.35	8.06	8.42	8.24	15.57	17.37	16.47	23.79	25.32	24.55				
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	2.35	2.73	2.54	8.86	9.00	8.93	16.38	18.36	17.47	24.18	27.16	25.67				
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	2.58	2.96	2.77	9.10	9.74	9.42	17.25	20.10	19.57	26.62	28.49	27.55				
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	2.75	3.26	3.01	9.68	10.75	10.21	18.67	22.18	20.42	28.36	30.61	29.48				
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	2.92	3.47	3.20	10.18	11.42	10.80	20.22	23.56	21.89	30.15	33.73	31.94				
T ₆ HW at 20 and 40 DAS	0.93	1.16	1.11	0.29	0.32	0.30	1.05	1.26	1.15	2.38	2.53	2.45				
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	2.41	2.69	2.55	0.34	0.35	0.34	1.29	1.51	1.40	3.09	3.65	3.37				
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	2.53	2.91	2.72	0.35	0.36	0.35	1.44	1.68	1.56	3.35	3.96	3.65				
T ₉ Weedy check	3.21	3.55	3.38	12.98	15.24	14.11	21.07	23.39	22.23	34.30	37.77	36.03				
Mean	2.44	2.81		6.54	7.28		12.55	14.38		19.58	21.47					
SEm±	0.02	0.03		0.11	0.14		0.19	0.21		0.41	0.42					
CD at 5%	0.05	0.08		0.33	0.43		0.57	0.63		1.22	1.26					

4.1.3.4 Effect of treatments on dry weight of broadleaved weeds

The data on effect of treatments on broadleaved weed bio-mass have been presented in Table 24 (*kharif*) and 25 (*boro*) and illustrated in Figure 13 and 14.

It has been observed that with dry weight of broadleaved increased with advance of crop growth during both *kharif* and *boro* season of 1997-98 and 1998-99 and all the treatments recorded significantly lower dry weights than the weedy check (T_9).

Minimum dry weight of broadleaved weed (0.70 and 0.75 g m^{-2} , respectively) recorded in weed free (T_6) treatment during *kharif* season of 1997 and 1998 at 30 DAS. The integrated two treatments T_7 and T_8 where Cyhalofop butyl was applied 0.06 and 0.08 kg ha^{-1} , respectively recorded lower dry weight of broadleaved weeds than the weed free treatment (T_6) which showed T_3 and T_4 , among the different doses of Cyhalofop butyl recorded higher dry weight of broadleaved weeds than T_5 Cyhalofop butyl 0.32 kg ha^{-1} (1.60 and 2.11 g m^{-2} , respectively) but lower than T_1 (1.27 and 1.42 g m^{-2} , respectively).

Maximum dry weight of broadleaved weed at 30 DAS in *boro* season of both years recorded in weedy check T_9 (2.69 and 2.95 g m^{-2} , respectively) and the minimum (0.71 and 0.88 g m^{-2} , respectively) in weed free which was significantly lower than rest of treatments. Lowest dry weight of broadleaved weeds (1.64 and 1.95 g m^{-2} , respectively) was found in T_1 Cyhalofop butyl 0.04 kg ha^{-1} among the different doses of Cyhalofop butyl and highest in T_5 Cyhalofop butyl 0.32 kg ha^{-1} (2.23 and 2.65 g m^{-2} , respectively).

Treatment T_7 Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS (0.23 and 0.25 g m^{-2} , respectively) and T_8 Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS (0.23 and 0.25 g m^{-2} , respectively) at 45 DAS in *kharif* season of 1997 and 1998, recorded statistically at par dry weight of broadleaves weeds with that of

Table 24 Effect of treatments on dry weight of broadleaved weeds in *kharif* 1997 and 1998

Treatments	Dry weight of broadleaved weeds g m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1.27	1.42	1.34	5.82	6.19	6.01	14.46	15.55	15.01	25.96
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1.33	1.57	1.45	5.92	6.51	6.22	15.44	16.13	15.78	27.26
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	1.39	1.66	1.53	6.05	6.69	6.37	16.51	16.86	16.69	28.94
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	1.48	1.90	1.69	6.17	6.79	6.48	16.86	17.86	17.36	31.89
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	1.60	2.11	1.85	6.58	7.14	6.86	17.38	19.23	18.30	34.43
T ₆ HW at 20 and 40 DAS	0.70	0.75	0.73	0.22	0.24	0.23	1.04	1.25	1.14	2.47
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	1.36	1.61	1.49	0.23	0.25	0.24	1.12	1.38	1.25	3.07
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	1.43	1.69	1.56	0.25	0.26	0.25	1.09	1.50	1.30	3.47
T ₉ Weedy check	2.25	2.48	2.36	7.52	8.05	7.78	22.60	23.98	23.29	35.85
Mean	1.42	1.69		4.74	5.12		11.83	12.64		21.73
SEm±	0.01	0.02		0.10	0.11		0.22	0.24		0.35
CD at 5%	0.04	0.06		0.30	0.33		0.65	0.71		1.05

twice hand weeding in which minimum dry weight of broadleaved weed (0.22 and 0.24 g m⁻², respectively) was observed. In sole application of Cyhalofop butyl (T₁ – T₅), the minimum dry weight of broadleaved weeds (5.82 and 6.19 g m⁻², respectively) was again recorded in where lowest doses of T₁ Cyhalofop butyl 0.04 kg ha⁻¹ was applied and maximum in T₅ where the maximum dose of Cyhalofop butyl (6.58 and 7.14 g m⁻², respectively) was applied.

The lowest dry weight of broadleaved weeds (0.25 and 0.28 g m⁻², respectively) was, however, observed in (T₆) HW at 20 and 40 DAS and this was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (0.29 and 0.31 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (0.31 and 0.32 g m⁻², respectively). In the different doses of Cyhalofop butyl, lower dry weight of broadleaved weeds than the treatment which received highest dose of Cyhalofop butyl 0.32 kg ha⁻¹ (8.90 and 9.99 g m⁻², respectively), was recorded in T₃ (7.97 and 8.53 g m⁻², respectively) and T₄ (8.47 and 9.41 g m⁻², respectively). These two treatments also recorded higher dry weight of broadleaved weeds than T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (7.06 and 7.37 g m⁻², respectively) in *boro* season of 1998 and 1999 at 45 DAS.

The results showed at 60 DAS in *kharif* season of 1997 and 1998 the dry weight of broadleaved weeds varied from 1.04 and 1.25 g m⁻², the lowest (T₆) to the highest 22.60 and 23.98 g m⁻², respectively in weedy check plot. Treatment T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.12 and 1.38 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.09 and 1.50 g m⁻², respectively) did not differ significantly with the weed free plot. Lowest dry weight (14.46 and 15.55 g m⁻², respectively) of broadleaved weeds was found in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ amongst the different doses of Cyhalofop butyl and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (17.38 and 19.23 g m⁻², respectively).

Table 25 Effect of treatments on dry weight of broadleaved weeds during *boro* 1998 and 1999

Treatments	Dry weight of broadleaved weeds g m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1.64	1.95	1.80	7.06	7.37	7.21	16.61	18.53	17.57	29.82
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1.79	2.09	1.94	7.76	7.88	7.82	17.47	19.58	18.64	31.78
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	1.98	2.26	2.12	7.97	8.53	8.25	18.40	21.44	20.88	34.67
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	2.11	2.50	2.30	8.47	9.41	8.94	19.92	23.65	21.78	37.63
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	2.23	2.65	2.44	8.90	9.99	9.45	21.57	25.13	23.35	40.00
T ₆ HW at 20 and 40 DAS	0.71	0.88	0.85	0.25	0.28	0.27	1.12	1.34	1.23	2.98
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	1.85	2.05	1.95	0.29	0.31	0.30	1.38	1.62	1.49	3.89
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	1.94	2.22	2.08	0.31	0.32	0.31	1.54	1.79	1.66	4.17
T ₉ Weedy check	2.69	2.95	2.82	9.24	11.21	10.22	23.81	26.29	25.05	43.05
Mean	2.10	2.39		5.58	6.14		13.53	15.48		27.16
SEm±	0.01	0.02		0.10	0.13		0.20	0.23		0.41
CD at 5%	0.03	0.06		0.30	0.38		0.60	0.68		1.23

Twice hand weeding recorded minimum dry weight of broadleaved weeds (1.12 and 1.34 g m⁻², respectively) at 60 DAS in *boro* season of 1998 and 1999. This was statistically at par with Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.38 and 1.62 g m⁻², respectively) or T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.54 and 1.79 g m⁻², respectively) of the two integrated treatments used in this experiment. Whereas in sole application of Cyhalofop butyl (T₁ – T₅) T₁ recorded the minimum dry weight of broadleaved weed (16.61 and 18.53 g m⁻², respectively) and T₅ Cyhalofop butyl 0.32 kg ha⁻¹ the maximum (21.57 and 25.13 g m⁻², respectively) closely followed by T₄ and T₃.

In last observation of *kharif* of 1997 and 1998 maximum dry weight of broadleaved weeds (35.85 and 38.05 g m⁻², respectively) recorded in T₉ (weedy check) and lowest dry weight of broadleaved weed (2.22 and 2.47 g m⁻², respectively) in weed free plot which was significantly lower than rest of the treatments. In the different doses of Cyhalofop butyl, minimum dry weight of broadleaved weed (24.25 and 25.96 g m⁻², respectively) was observed in T₁ Cyhalofop butyl 0.04 kg ha⁻¹ and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (31.46 and 34.43 g m⁻², respectively).

Similarly in *boro* season of 1998 and 1999 at harvest, the two integrated treatments (T₇ and T₈) recorded dry weight of broadleaved weeds (3.75 and 4.03 g m⁻² and 4.10 and 4.25 g m⁻², respectively) whereas in twice HW at 20 and 40 DAS recorded minimum dry weight of broadleaved weed (2.89 and 3.07 g m⁻², respectively). Cyhalofop butyl when applied in different doses (T₁ – T₅) lowest dry weight of broadleaved weeds was varied from T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (27.67 and 31.97 g m⁻², respectively) to T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (36.61 and 43.39 g m⁻², respectively).

4.1.3.5 Effect of treatments on dry weight of total weeds

Data on treatment effects on total dry weight of weeds have been presented in Table 26 and Table 27 and plotted down in Figure 13 and 14. In

the both year 1998 of *kharif* and 1999 of *boro* seasons higher total dry weight of weeds was recorded in comparison to that of 1997 and 1998 respectively.

Weedy check (T_9) recorded the maximum and significantly highest dry weight of total weeds than all the other treatments (12.21 and 14.59 g m⁻², respectively) during the *kharif* 1997 and 1998 at 30 DAS. Lowest total dry weight of weeds (3.22 and 3.68 g m⁻², respectively) were observed in T_6 (HW at 20 and 40 DAS). The treatments where different doses of Cyhalofop butyl, were applied recorded significantly higher dry weight of total weeds than the treatments weed free or integrated treatments (T_7 and T_8). Minimum total dry weight of weeds (5.91 and 6.74 g m⁻², respectively) in T_1 (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T_5 Cyhalofop butyl 0.32 kg ha⁻¹ (6.24 and 8.20 g m⁻², respectively) were recorded.

In the *boro* season of both years at the same date of observation the lowest dry weight of total weeds (3.55 and 4.08 g m⁻², respectively) was observed in T_6 (twice hand weeding) which was significantly superior in controlling weeds than rest of the treatments including the weedy check (15.57 and 17.30 g m⁻², respectively) which recorded maximum total dry weight of weeds. In sole application of Cyhalofop butyl, lowest total dry weight of weeds (7.99 and 8.82 g m⁻², respectively) were observed in T_1 (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum (8.90 and 10.38 g m⁻², respectively) in T_5 (Cyhalofop butyl 0.32 kg ha⁻¹) but all these treatments ($T_1 - T_5$) recorded significantly higher dry weight of total weeds than that of T_6 , T_7 or T_8 .

In the very next observation during the *kharif* season of both years T_7 Cyhalofop butyl 0.06 kg ha⁻¹ +HW at 40 DAS (1.08 and 1.35 g m⁻², respectively) and T_8 Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.14 and 1.21 g m⁻², respectively) recorded significantly at par dry weight of total weeds with the weed free treatment (T_6) which recorded the minimum dry weight of total weeds (1.06 and 1.11 g m⁻², respectively). The maximum and significantly higher dry weight was recorded in weedy check (38.82 and 43.02

Table 26 Effect of treatments on dry weight of total weeds during *kharif* 1997 and 1998

Treatments	Dry weight of total weeds g m ⁻²														
	30 DAS				45 DAS				60 DAS				At harvest		
	1997	1998	Mean		1997	1998	Mean		1997	1998	Mean		1997	1998	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	5.91	6.74	6.32		22.38	24.77	23.57		48.85	54.10	51.47		79.40	85.48	82.44
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	5.79	6.86	6.32		22.97	25.62	24.29		50.95	54.15	52.55		79.74	87.33	83.53
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	5.65	6.80	6.22		23.13	25.65	24.39		53.20	55.20	54.20		80.46	87.42	83.94
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	5.92	7.48	6.70		23.51	25.86	24.68		53.35	57.40	55.37		85.26	95.68	90.47
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	6.24	8.20	7.22		23.74	25.94	24.84		54.75	60.80	57.77		91.78	101.84	96.81
T ₆ HW at 20 and 40 DAS	3.22	3.68	3.45		1.06	1.11	1.09		4.45	4.55	4.50		8.26	8.62	8.44
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	6.07	6.97	6.52		1.08	1.35	1.21		4.50	5.60	5.05		9.84	10.55	10.19
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	5.82	6.98	6.40		1.14	1.21	1.18		4.75	5.30	5.02		10.27	10.63	10.45
T ₉ Weedy check	12.21	14.59	13.40		38.82	43.02	40.92		70.30	77.50	73.90		142.25	148.18	145.21
Mean	6.31	7.59			17.55	19.58			38.23	41.62			65.25	70.64	
SEm±	0.12	0.14			0.50	0.52			0.65	0.71			1.02	1.05	
CD at 5%	0.35	0.42			1.49	1.56			1.86	2.12			3.06	3.15	

respectively). In the different doses of Cyhalofop butyl, lowest dry weight of total weeds (22.38 and 24.77 g m⁻², respectively) in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (23.7 and 25.94 g m⁻², respectively) were observed.

At 45 DAS in *boro* season of 1998 and 1999 lowest dry weight of total weeds (1.25 and 1.39 g m⁻², respectively) was observed in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (1.45 and 1.08 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (1.30 and 1.39 g m⁻², respectively). The treatments where the chemical Cyhalofop butyl was applied in different doses (T₁ - T₅) minimum total dry weight of weeds (29.19 and 30.67 g m⁻² respectively) was observed in its lowest dose (Cyhalofop butyl 0.04 kg ha⁻¹) and maximum in its highest dose Cyhalofop butyl 0.32 kg ha⁻¹ (32.50 and 36.24 g m⁻², respectively). The control treatment recorded significantly higher dry weights of total weeds (40.87 and 48.85 g m⁻², respectively) than all the other treatments.

Minimum dry weight of total weeds (4.45 and 4.55 g m⁻², respectively) was observed in twice hand weeding at 60 DAS during *kharif* season of both years and this was statistically at par with the two integrated treatments T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (4.50 and 5.60 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (4.75 and 5.30 g m⁻², respectively). In sole application of Cyhalofop butyl, lowest dry weight of total weeds (48.65 and 54.10 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and the maximum in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹ (54.75 and 60.80 g m⁻², respectively).

Maximum dry weight of total weeds (89.40 and 94.95 g m⁻², respectively) in weedy check (T₉) and minimum (5.50 and 5.50 g m⁻², respectively) in T₆ (HW at 20 and 40 DAS) was observed in the same date of observation in *boro* season of 1998 and 1999. T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (5.60 and 5.65 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08

Table 27 Effect of treatments on dry weight of total weeds during *boro* 1998 and 1999

Treatments	Dry weight of total weeds g m ⁻²									
	30 DAS			45 DAS			60 DAS			At harvest
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	7.99	8.82	8.40	29.19	30.69	29.94	57.90	65.55	61.72	85.50
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	8.19	9.13	8.66	30.22	32.12	31.17	58.85	67.29	63.07	89.92
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	8.08	8.74	8.41	31.85	32.08	31.96	59.80	69.55	64.67	93.89
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	8.51	9.90	9.20	31.42	34.47	32.94	63.95	75.17	69.56	101.28
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	8.90	10.38	9.64	32.50	36.24	34.37	68.80	79.54	74.17	108.86
T ₆ HW at 20 and 40 DAS	3.55	4.80	4.17	1.26	1.39	1.33	5.50	5.50	5.50	9.62
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	7.50	8.96	8.23	1.45	1.80	1.62	5.60	5.65	5.62	12.81
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	7.59	8.29	7.94	1.30	1.39	1.34	5.80	6.15	5.97	12.90
T ₉ Weedy check	15.57	17.30	16.43	40.87	48.85	44.86	89.40	94.95	92.17	152.00
Mean	8.36	9.70		22.29	24.27		50.52	56.59		74.18
SEm±	0.17	0.15		0.54	0.59		0.65	0.74		1.10
CD at 5%	0.52	0.44		1.62	1.78		1.96	2.21		3.30

kg ha⁻¹ + HW at 40 DAS (5.80 and 6.15 g m⁻², respectively). Both treatments did not differ significantly with T₆. In comparison to T₃ and T₄ lower dry weight of total weeds (57.90 and 65.55 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) but higher dry weight of weeds (68.80 and 79.54 g m⁻², respectively) was recorded in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

The results showed that at harvest during the *kharif* season, the weed free treatments recorded significantly lower dry weight of total weeds (8.26 and 8.62 g m⁻², respectively) than that of all the treatments excepting the two integrated treatments T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (9.84 and 10.55 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (10.27 and 10.63 g m⁻², respectively). In sole application of Cyhalofop butyl (T₁ – T₅), minimum dry weight of total weeds (79.40 and 85.48 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and the maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (91.78 and 101.84 kg m⁻², respectively).

The data showed that minimum dry weight of total weeds (9.42 and 9.62 g m⁻², respectively) was observed at harvest during *boro* season of both year in T₆ (HW of at 20 and 40 DAS) which was significantly superior in controlling weeds than rest of the treatments and closely followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (11.84 and 12.81 g m⁻², respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (12.29 and 12.90 g m⁻², respectively). Lowest total dry weight of weeds (80.20 and 85.50 g m⁻², respectively) was observed in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) in sole application of Cyhalofop butyl and maximum in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (96.14 and 108.86 g m⁻², respectively).

4.1.4 Weed control efficiency of different treatments

Due to effect of different doses of Cyhalofop butyl alone or in combination with hand weeding the WCE of *Echinochloa spp* WCE (E) and total

weeds WCE (T) have been computed and presented in Table 28 (*kharif* and *boro*) season of 1997-98 and 1998-99.

The highest weed control efficiency on *Echinochloa spp* (96.02 and 96.90 cent⁻¹, respectively) during *kharif* season of 1997 and 1998 was offered by the integrated treatment T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) at harvest of rice crop. Among the different doses of Cyhalofop butyl, maximum WCE (E) (95.85 and 95.79 cent⁻¹, respectively) was recorded in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and lowest WCE (E) (75.29 and 76.32 cent⁻¹, respectively) was recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹). HW twice at 20 and 40 DAS (T₆) was offered higher WCE (E) (95.57 and 95.91 cent⁻¹, respectively) in comparison to T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (94.08 and 94.10 cent⁻¹, respectively) and T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (94.08 and 94.97 cent⁻¹, respectively).

In *boro* season, the highest WCE (E) (96.62 and 97.32 cent⁻¹, respectively) was observed in T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS). Lowest WCE (E) (80.92 and 85.89 cent⁻¹, respectively) was observed in T₁ (Cyhalorop butyl 0.04 kg ha⁻¹) and highest WCE (E) (96.22 and 97.12 cent⁻¹, respectively) was observed in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹). HW at 20 and 40 DAS (T₆) offered lower weed control efficiency (95.49 and 96.47 cent⁻¹, respectively) in comparison to T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (96.22 and 97.12 cent⁻¹, respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ (96.62 and 97.32 cent⁻¹, respectively).

In *kharif* season of 1997 and 1998 among the different doses of Cyhalofop butyl maximum weed control efficiency of total weeds WCE (T) was recorded in T₁ Cyhalofop butyl (44.18 and 42.31 cent⁻¹, respectively) and minimum WCE (T) in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (35.48 and 31.27 cent⁻¹, respectively). This was closely followed by T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (40.06 and 35.43 cent⁻¹, respectively). The highest WCE (T) were observed in twice hand weeding (94.19 and 94.18 cent⁻¹, respectively) which was closely

Table 28 Effect of treatments on weed control efficiency during *kharif* 1997-98 and *boro* 1998-99

Treatments	Weed control efficiency (%)										
	WCE during <i>kharif</i> season 1997-98					WCE during <i>boro</i> season 1998-99					
	WCE (E)			WCE (T)		WCE (E)			WCE (T)		
	1997	1998	Mean	1997	1998	Mean	1998	1999	Mean	1998	1999
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	75.29	76.32	75.80	44.18	42.31	43.24	80.92	85.89	83.40	44.35	43.75
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	81.40	82.54	81.97	43.94	41.06	42.50	85.35	88.14	86.74	43.56	40.84
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	92.25	92.77	92.51	43.44	41.00	42.22	92.24	92.94	92.59	41.02	38.23
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	94.08	94.97	94.52	40.06	35.43	37.74	95.51	96.25	95.88	37.59	33.37
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	95.85	95.79	95.82	35.48	31.27	33.37	96.22	97.12	96.67	33.29	28.38
T ₆ HW at 20 and 40 DAS	95.57	95.91	95.74	94.19	94.18	94.18	95.49	96.47	95.98	93.46	93.67
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	94.08	94.90	94.49	93.08	92.88	92.98	94.54	95.20	94.87	91.78	91.57
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	96.02	96.90	96.46	92.78	92.83	92.80	96.62	97.32	96.97	91.47	91.51
T ₉ Weedy check	-	-	-	-	-	-	-	-	-	-	-

followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (93.08 and 92.88 cent⁻¹, respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (92.78 and 92.83 cent⁻¹, respectively) the treatments where chemical herbicide was combined with mechanical hand weeding.

Total weed control efficiency was maximum during boro season of both years in weed free plot (93.46 and 93.67 cent⁻¹, respectively) which closely followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (91.78 and 91.57 cent⁻¹, respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (91.47 and 91.51 cent⁻¹, respectively). In sole application of Cyhalofop butyl when applied in different doses minimum WCE (T) was observed in T₅ Cyhalofop butyl 0.32 kg ha⁻¹ the maximum dose (33.29 and 28.38 cent⁻¹, respectively) closely followed by T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (37.59 and 33.77 cent⁻¹, respectively) and maximum in T₁ the lowest dose Cyhalofop butyl 0.04 kg ha⁻¹ (44.35 and 43.75 cent⁻¹, respectively).

4.2 Studies on rice crop

4.2.1 Effect of treatments on growth attribute (number of tillers)

The data on number of tillers m⁻² was summarised in Table 29 (*kharif*) and 30 (*boro*) season of 1997 and 1998. The results showed that highest number of tillers (216.9 and 209.4 m⁻², respectively) was produced in T₆ (HW at 20 and 40 DAS) in *kharif* season of both year and it was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (215.76 and 197.90 m⁻², respectively) and T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (215.06 and 196.16 m⁻², respectively). Lowest number of tillers (105.0 and 92.8 m⁻², respectively) was observed in weedy check plot (T₉). Where maximum dose of Cyhalofop butyl was applied it recorded the minimum (139.9 and 136.4 number of tillers m⁻², respectively) while maximum (145.58 and 138.50 m⁻²) was observed in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

Following similar trend in *boro* season of 1998 and 1999 lowest number of tillers (140.4 and 128.1 m⁻², respectively) was observed in weedy check and the maximum (259.2 and 252.3 m⁻², respectively) was observed in weed free plot. T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (251.6 and 242.4 m⁻², respectively) followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (241.9 and 235.4 m⁻², respectively) did not differ significantly with T₆ as like that of *kharif* season. Application of Cyhalofop butyl 0.08 kg ha⁻¹ without HW (T₃) recorded the maximum number of tillers 204.9 and 193.5 m⁻², respectively but the highest dose of this chemical (T₅) recorded the minimum (169.5 and 157.6 m⁻², respectively) amongst the sole treatments of Cyhalofop butyl (T₁ - T₅).

4.2.1 Effect of treatments on yield attributes

Data on treatment effects on different yield attributes of *kharif* and *boro* rice have been presented in Table 29 to 32. In determination of yield of paddy, yield attributing characters play significant role in different treatment and ultimately it influences grain yield of crop.

4.2.2.1 Effect of treatments on number of panicles

Hand weeding twice (T₆) recorded significantly higher number of panicles (187.0 and 180.5 m⁻² in *kharif* and 219.7 and 215.5 m⁻² in *boro* season of 1997-98 and 1998-99, respectively) over all other treatments excepting the treatments where the chemical Cyhalofop butyl 0.08 kg ha⁻¹ (T₈) or 0.06 kg ha⁻¹ (T₇) integrated with HW at 40 DAS. Among the plots received the different doses of sole application of Cyhalofop butyl (0.04 kg ha⁻¹ T₁ to 0.32 kg ha⁻¹ T₅), T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) recorded the maximum number of panicle m⁻² (135.3 and 132.2, in *kharif* and 173.7 and 164.0 during *boro*, respectively) and T₅ where the chemical was applied in its higher limit recorded the lowest (120.6 and 117.6 in *kharif* and 143.6 and 133.6 in *boro* season, respectively). The

Table 29 Effect of treatments on number of tillers, number of panicles, panicle length and panicle weight during *kharif* 1997 and 1998

Treatments	Number of tillers m ⁻²			Number of panicles m ⁻²			Panicle length (cm)			Panicle weight (g)		
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	149.99	144.54	147.26	129.30	124.60	126.95	16.83	16.50	16.66	1.65	1.52	1.59
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	150.80	148.71	149.76	130.00	128.20	129.10	17.14	17.06	17.10	1.82	1.76	1.79
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	156.95	153.35	155.15	135.30	132.20	133.75	17.34	17.25	17.30	1.97	1.86	1.92
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	145.58	138.50	142.04	125.50	119.40	122.45	16.98	16.75	16.86	1.80	1.72	1.76
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	139.90	136.42	138.16	120.60	117.60	119.10	16.85	16.60	16.72	1.70	1.61	1.65
T ₆ HW at 20 and 40 DAS	216.92	209.38	213.15	187.00	180.50	183.75	19.03	19.02	19.02	2.27	2.21	2.24
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	215.06	196.16	205.61	185.40	169.10	177.25	18.80	18.73	18.76	2.09	2.04	2.07
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	215.76	197.90	206.83	186.00	170.60	178.30	18.93	18.87	18.90	2.18	2.12	2.15
T ₉ Weedy check	104.98	92.80	98.89	90.50	80.00	85.25	15.22	15.10	15.16	1.27	1.26	1.27
Mean	165.81	157.92		142.94	136.14		17.44	17.33		1.79	1.73	
SEm±	2.74	3.83		2.36	3.30		0.07	0.06		0.04	0.03	
CD at 5%	8.22	11.50		7.08	9.89		0.20	0.18		0.11	0.10	

control plot (T₉) showed the minimum number of panicles m⁻² in both seasons of 1997 and 1998 (Table 29 and 30).

4.2.2.2 Effect of treatments on panicles length

The data as summarised in Table 29 (*Kharif*) for the *kharif* season of 1997 and 1998 showed that maximum length of panicle (19.0 cm in both years) was recorded in HW at 20 and 40 DAS (T₆) while the minimum (15.2 and 15.1 cm, respectively) was in control plot (T₉) which was significantly lower than the rest of the treatments. Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (T₈) recorded 18.9 cm panicle in both years showing significant superiority over the other treatments excepting HW at 20 and 40 DAS (T₆). When the same dose of Cyhalofop butyl was applied without HW (T₃) also recorded significantly higher panicle length of 17.3 cm in both years over the higher two doses of this chemical T₅ (16.9 and 16.6 cm, respectively) or T₄ (17.0 and 16.8 cm, respectively).

Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS recorded 22.0 cm panicle length during the boro season of 1998-99 (Table 39) showing statistically at par with twice HW (T₆), which recorded maximum panicle length of 22.2 and 22.1 cm, respectively. Lowest length of panicle (17.93 and 17.77 cm, respectively) was observed in weedy check (T₉) which recorded significantly lower panicle length than to rest of the treatments. Among the different doses of Cyhalofop butyl (T₁ - T₅) lowest panicle length (18.6 and 18.5 cm, respectively) was observed in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) which was statistically at par with T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (18.6 and 18.4 cm, respectively) and maximum panicle length (20.3 and 20.1 cm, respectively) was observed in treatment T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

4.2.2.3 Effect of treatments on panicle weight

The results observed during the *kharif* season of 1997 and 1998 (Table 29) showed that maximum panicle weight (2.3 and 2.2 g, respectively) in T₆

Table 30 Effect of treatments on number of tillers, number of panicles, panicle length and panicle weight during *boro* 1998 and 1999

Treatments	Number of tillers m ⁻²			Number of panicle m ⁻²			Panicle length (cm)			Panicle weight (g)		
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	182.13	172.28	177.20	154.35	146.00	150.17	18.38	18.26	18.32	1.65	1.58	1.62
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	186.91	179.71	183.31	158.40	152.30	155.35	19.58	19.43	19.50	1.72	1.68	1.70
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	204.93	193.52	199.22	173.67	164.00	168.83	20.33	20.12	20.22	1.90	1.82	1.86
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	175.05	160.01	167.52	148.35	135.60	141.97	18.72	18.62	18.67	1.85	1.73	1.79
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	169.51	157.65	163.57	143.65	133.60	138.62	18.56	18.44	18.50	1.70	1.66	1.68
T ₆ HW at 20 and 40 DAS	259.19	252.29	255.73	219.65	215.50	217.57	22.17	22.08	22.12	2.30	2.24	2.27
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	241.90	235.41	238.65	205.00	199.50	202.25	21.80	21.75	21.77	2.13	2.10	2.12
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	251.58	242.37	246.97	213.20	205.40	209.30	21.98	21.97	21.97	2.22	2.15	2.19
T ₉ Weedy check	140.42	128.15	134.28	119.00	108.60	113.80	17.93	17.77	17.85	1.42	1.35	1.39
Mean	199.55	193.22		169.11	163.75		20.03	19.96		1.78	1.81	
SEm±	3.79	3.36		3.21	2.85		0.08	0.07		0.04	0.04	
CD at 5%	11.37	10.08		9.64	8.56		0.24	0.21		0.12	0.11	

(HW at 20 and 40 DAS) which was statistically at par with treatment T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2.2 and 2.1 g, respectively). This was closely followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (2.1 and 2.0 g, respectively). Lowest panicle weight (1.3 in both years) was observed in T₉ (weedy check). Among the different doses of Cyhalofop butyl lowest panicle weight (1.7 and 1.5 g, respectively) was observed in the lowest dose of this chemical (Cyhalofop butyl 0.04 kg ha⁻¹) which was statistically at par with T₅ Cyhalofop butyl 0.32 kg ha⁻¹ where maximum dose of this chemical was applied (1.7 and 1.6 g, respectively). The maximum (2.0 and 1.9 g, respectively) panicle weight was observed in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

Maximum panicle weight (2.3 and 2.2g, respectively) was also observed in T₆ (HW at 20 and 40 DAS) in *boro* season of 1998 and 1999. This was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2.2 g in both years) and closely followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (2.1 in both years). The lowest panicle weight (1.4 g during both years) was observed in control (T₉). Cyhalofop butyl when applied in different doses as sole, lowest panicle weight (1.7 and 1.6 g, respectively) was recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) which was statistically at par with T₅ Cyhalofop butyl 0.32 kg ha⁻¹ (1.7 g in both years) and T₂ Cyhalofop butyl 0.06 kg ha⁻¹ (1.7 g in both 1997 and 1998). The maximum panicle weight (1.9 and 1.8 g, respectively) was observed in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

4.2.2.4 Effect of treatments on number of spikelets panicle⁻¹

The data on number of spikelet panicle⁻¹ was presented in Table 31 (*kharif*) and 32 (*boro*) for *kharif* 1997-98 and 1998-99 showed highest number of spikelet panicle⁻¹ (89.1 and 86.7, respectively) in twice hand weeding. this was statistically at par with T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (87.0 and 85.6, respectively) and T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS

Table 31 Effect of treatments on number of spikelet, filled grain cent⁻¹ and 1000 grain weight of paddy during *kharif* 1997 and 1998

Treatments	Number of spikelet panicle ⁻¹			Filled grain cent ⁻¹ panicle ⁻¹			1000-grain weight (g)		
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	64.25	64.16	64.20	51.40	51.33	51.36	20.45	20.42	20.43
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	67.50	67.06	67.27	54.00	53.65	53.82	20.80	20.70	20.75
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	70.31	69.70	70.00	56.25	55.76	56.00	20.82	20.78	20.80
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	69.06	68.75	68.90	55.25	55.00	55.12	20.52	20.43	20.47
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	67.50	67.00	67.25	54.00	53.60	53.80	20.38	20.35	20.36
T ₆ HW at 20 and 40 DAS	89.12	86.75	87.94	71.30	69.40	70.35	21.50	21.40	21.45
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	87.00	85.62	86.31	69.60	68.50	69.05	21.20	21.17	21.18
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	87.50	86.62	87.31	70.00	69.30	69.85	21.32	21.30	21.31
T ₉ Weedy check	60.87	60.25	60.56	48.70	48.20	48.45	20.22	20.15	20.18
Mean	73.02	73.02		58.42	58.42		20.76	20.78	
SEm±	1.05	1.11		0.84	0.89		--	--	
CD at 5%	3.14	3.33		2.51	2.67		NS	NS	

(87.5 and 86.6, respectively) and lowest number of spikelet panicle⁻¹ (60.87 and 60.25, respectively) in control plot (T₉). Among the different doses of Cyhalofop butyl, lowest number of spikelet panicle⁻¹ (64.3 and 64.2, respectively) was recorded in T₁ (Cyhalofop butyl 0.04 kg ha⁻¹) and highest in T₃ Cyhalofop butyl 0.08 kg ha⁻¹ (70.31 and 69.70, respectively).

During the *boro* season of 1998 and 1999 like the earlier season highest number of spikelet panicle⁻¹ (95.74 and 93.92) was observed in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (93.6 and 91.5, respectively) followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (92.6 and 91.5, respectively) and lowest in T₉ weedy check (65.9 and 64.1, respectively). Among the different doses of Cyhalofop butyl, highest number of spikelet panicle⁻¹ (75.8 and 68.9, respectively) was observed in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and lowest (68.9 and 67.2, respectively) in T₁ Cyhalofop butyl 0.04 kg ha⁻¹.

4.2.1.5 Effect of treatments on filled grain cent⁻¹

The data on cent⁻¹ filled grains during 1997-98 and 1998-99 presented in Table 31 (*kharif*) and Table 32 (*boro*) showed that weedy check (T₉) treatment recorded the lowest (48.7 and 48.2 - *kharif* and 50.3 and 49.4 - *boro*, respectively) and this was significantly lower than all the other treatments tried in the investigation. The highest filled grain cent⁻¹ (71.3 and 69.4 - *kharif* and 73.7 and 72.3 - *boro*, respectively) was recorded in HW at 20 and 40 DAS (T₆) which was statistically at par with T₈ Chyalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (70.0 and 69.3 - *kharif* 72.0 and 70.4 - *boro*, respectively) followed by T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS (69.6 and 68.5 - *kharif*, respectively). Among the different doses of Cyhalofop butyl, maximum (56.2 and 55.8 - *kharif* and 58.3 and 53.0 - *boro*, respectively) cent⁻¹ filled grains panicle⁻¹ was observed in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and minimum (51.4

Table 32 Effect of treatments on number of spikelet, filled grain cent⁻¹ and 1000 grain weight of paddy during *boro* 1998 and 1999

Treatments	Number of spikelet panicle ⁻¹			Filled grain cent ⁻¹ panicle ⁻¹			1000 grain weight (g)		
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	68.90	67.17	68.03	53.00	51.67	52.33	21.20	21.13	21.16
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	70.74	68.38	69.55	54.40	52.60	53.50	21.28	21.23	21.25
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	75.79	68.90	72.34	58.30	53.00	55.65	21.32	21.30	21.31
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	70.98	68.69	69.83	54.60	51.30	52.95	21.20	21.18	21.19
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	69.04	67.99	68.52	52.35	50.00	51.17	21.17	21.06	21.11
T ₆ HW at 20 and 40 DAS	95.74	93.92	94.83	73.65	72.25	72.95	21.90	21.80	21.85
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	92.60	91.48	92.04	72.00	69.60	70.80	21.40	21.39	21.39
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	93.60	91.52	92.56	72.00	70.40	71.20	21.48	21.40	21.44
T ₉ Weedy check	65.39	64.15	64.77	50.30	49.35	49.82	21.05	20.88	20.96
Mean	78.23	75.14		60.18	57.80		21.32	21.28	
SEm±	1.01	0.97		0.78	0.75		-	-	
CD at 5%	3.03	2.91		2.35	2.24		NS	NS	

and 51.4 – *kharif* in both years and 52.3 and 50.0 – *boro*, respectively) in T₁ during *kharif* and T₅ during *boro*, respectively.

4.2.2.6 Effect of treatments on test weight of grains

The data presented in Table 31 (*kharif*) and Table 32 (*boro*) clearly revealed that there was no significant variation in test weight of paddy in both seasons of 1997-98 and 1998-99. The maximum test weight (21.50 and 21.40 g – *kharif* and 21.90 and 21.80 g – *boro*, respectively) of paddy grains was observed in T₆ (HW at 20 and 40 DAS) and the lowest (20.22 and 20.15g – *kharif* and 21.05 and 20.88 g – *boro*, respectively) with weedy check (T₉). However when the different doses of Cyhalofop butyl (0.04 -0.32 kg ha⁻¹) was applied alone maximum test weight (20.82 and 20.78 g – *kharif* and 21.32 and 21.30 g – *boro*, respectively) was observed in T₃ Cyhalofop butyl 0.08 kg ha⁻¹.

4.2.3 Effect of treatments on grain and straw yields

The grain and straw yields data have been presented in Table 33 (*Kharif*) and Table 34 (*Boro*) during 1997-98 and 1998-99.

It appears from Table 33 during the *kharif* season of 1997 and 1998 that lowest grain yield (1082 and 1047 kg ha⁻¹, respectively) was obtained from the weedy check (T₉) which was significantly lower than any other treatments tried in this investigation. The highest grain yield (2122 and 2025 kg ha⁻¹, respectively) was recorded with HW at 20 and 40 DAS (T₆) having no significant difference with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2067 and 1958 kg ha⁻¹, respectively). Grain yield (1988 and 1887 kg ha⁻¹, respectively) obtained with T₇ (Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS) did not differ significantly with T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS). Among the different doses of Cyhalofop butyl, lowest grain yield (1180 and 1170 kg ha⁻¹, respectively) was recorded in T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and maximum grain yield (1467 and 1455 kg ha⁻¹, respectively) was obtained from T₃ (Cyhalofop butyl 0.08 kg ha⁻¹). The grain yield obtained from

Table 33 Effect of treatments on grain and straw yields during *kharif* 1997 and 1998

Treatments	Grain yield (Kg ha ⁻¹)			Cent ¹ increase over control		Straw yield (Kg ha ⁻¹)			Cent ¹ increase over control	
	1997		1998	Mean		1997		1998	Mean	
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1233.00	1175.00	1204.00	13.10	1446.00	1402.00	1424.00	4.32		
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1292.00	1265.00	1278.50	20.06	1588.00	1530.00	1559.00	14.21		
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	1467.00	1455.00	1461.00	37.25	1891.00	1811.00	1851.00	35.60		
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	1283.00	1213.00	1248.00	17.24	1601.00	1498.00	1549.50	13.52		
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	1188.00	1170.00	1179.00	10.76	1412.00	1365.00	1388.50	1.72		
T ₆ HW at 20 and 40 DAS	2122.00	2025.00	2073.50	94.78	2518.00	2409.00	2463.50	80.48		
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	1988.00	1887.00	1897.50	78.25	2384.00	2269.00	2326.50	70.44		
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	2067.00	1958.00	2042.50	91.87	2465.00	2344.00	2404.50	76.15		
T ₉ Weedy check	1082.00	1047.00	1064.50		1385.00	1345.00	1365.00			
Mean	1505.44	1485.33			1836.56	1792.67				
SEm±	26.99	24.80			37.49	34.59				
CD at 5%	80.90	74.36			112.40	103.70				

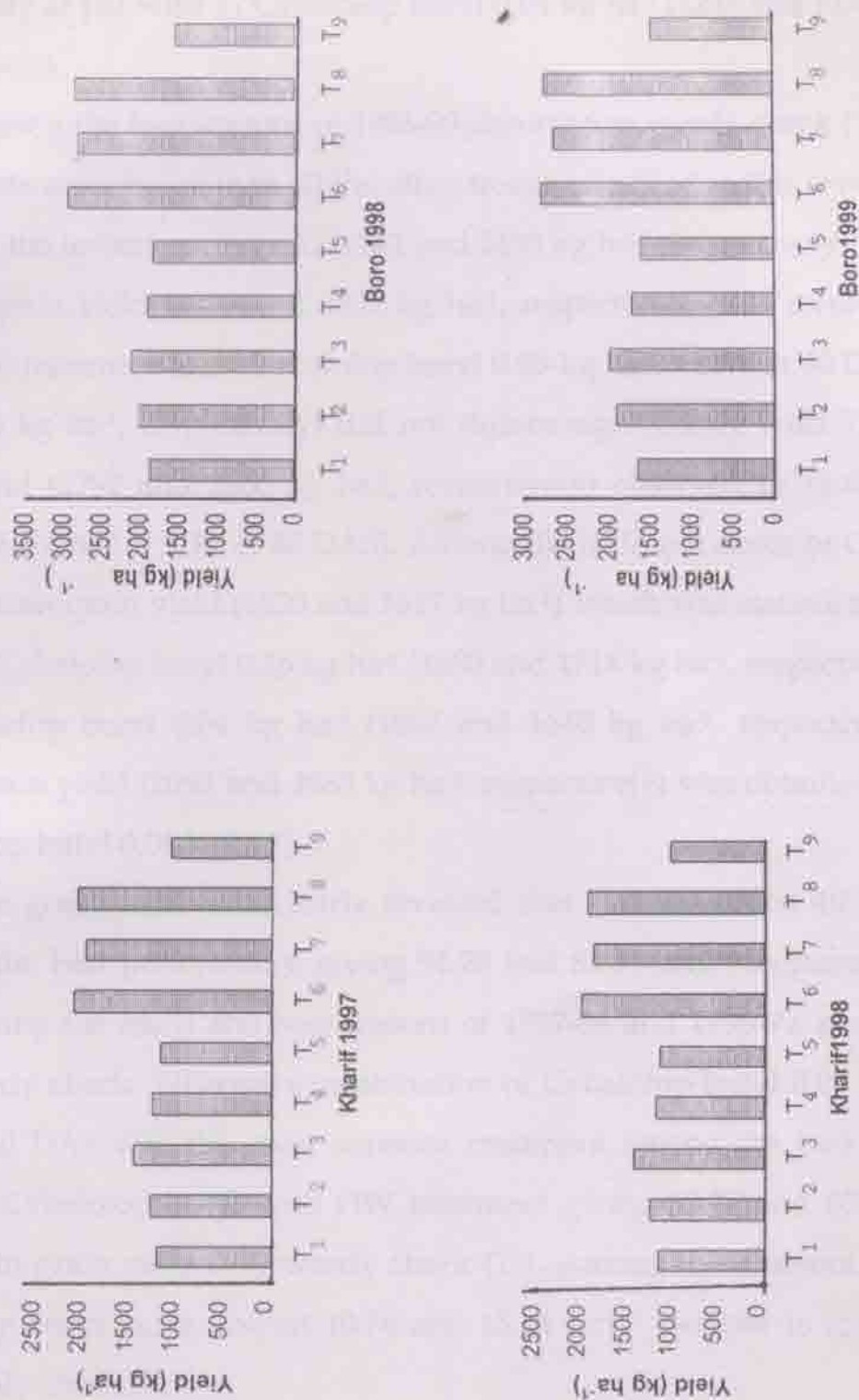


Figure 15. Effect of treatments on grain yield during Kharif and boro 1997-98 and 1998-99

T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1283 and 1213 kg ha⁻¹, respectively) recorded statistically at par with T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (1233 and 1175 kg ha⁻¹, respectively).

During the *boro* seasons of 1998-99 observation weedy check (T₉) which was significantly lower than all the other treatments tried in this investigation recorded the lowest grain yield (1542 and 1493 kg ha⁻¹, respectively) while the highest grain yield (2933 and 2807 kg ha⁻¹, respectively) was recorded with weed free treatment (T₆). Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2857 and 2773 kg ha⁻¹, respectively) did not differ significantly with T₆ and the grain yield (2792 and 2660 kg ha⁻¹, respectively) observed in T₇ Cyhalofop butyl 0.06 kg ha⁻¹ + HW at 40 DAS). Among the different doses of Cyhalofop butyl, lowest grain yield (1820 and 1617 kg ha⁻¹) which was statistically at par with T₄ Cyhalofop butyl 0.16 kg ha⁻¹ (1890 and 1716 kg ha⁻¹, respectively) and T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (1867 and 1640 kg ha⁻¹, respectively) and higher grain yield (2093 and 1983 kg ha⁻¹, respectively) was obtained from T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

The grain yield data clearly revealed that HW at 20 and 40 DAS (T₆) showed the best performance giving 94.78 and 89.13 cent⁻¹ increase in grain yield during the *kharif* and *boro* seasons of 1997-98 and 1998-99, respectively over weedy check. Whereas a combination of Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS was the most superior treatment among the two different doses of Cyhalofop butyl with HW treatment giving 91.87 and 85.50 cent⁻¹ increase in grain yield over weedy check (T₉). Among the different doses of Cyhalofop butyl alone, lowest 10.76 and 13.24 cent⁻¹ increase in grain yield over weedy check (T₉).

Regarding the straw yield during the *kharif* season of 1997 and 1998, maximum straw yield (2518 and 2409 kg ha⁻¹, respectively) was found in T₆ (HW at 20 and 40 DAS) which was statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (2465 and 2344 kg ha⁻¹, respectively). Minimum

Table 34 Effect of treatments on grain and straw yields of paddy during *boro* 1998 and 1999

Treatments	Grain yield (Kg ha ⁻¹)		Cent ⁻¹ increase over control		Straw yield (Kg ha ⁻¹)		Cent ⁻¹ increase over control	
	1998	1999	Mean		1998	1999	Mean	
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	1867.00	1640.00	1753.50	15.55	2261.00	1998.00	2129.50	10.91
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	1995.00	1893.00	1944.00	28.10	2404.00	2295.00	2349.50	22.34
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	2093.00	1983.00	2038.00	34.30	2489.00	2365.00	2427.00	26.41
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	1890.00	1716.00	1803.00	18.81	2264.00	2146.00	2235.00	14.84
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	1820.00	1617.00	1718.50	13.24	2240.00	1992.00	2116.00	10.21
T ₆ HW at 20 and 40 DAS	2933.00	2807.00	2870.00	89.13	3417.00	3276.00	3346.50	74.27
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	2792.00	2660.00	2726.00	79.64	3310.00	3116.00	3213.00	67.34
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	2857.00	2773.00	2815.00	85.50	3360.00	3268.00	3314.00	72.60
T ₉ Weedy check	1542.00	1493.00	1517.00		1980.00	1860.00	1920.00	
Mean	2198.78	2064.67			2636.10	2479.60		
SEm±	46.30	41.80			40.46	36.22		
CD at 5%	138.80	125.30			121.30	108.60		

straw yield (1385 and 1345 kg ha⁻¹, respectively) was, however, obtained with weedy check (T₉). In sole application of Cyhalofop butyl, lower straw yield (1412 and 1365 kg ha⁻¹, respectively) was obtained with T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and maximum (1981 and 1811 kg ha⁻¹, respectively) in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

During the *boro* seasons of both years, minimum straw yield (1980 and 1860 kg ha⁻¹, respectively) was obtained from T₉ (weedy check) which was significantly lower than rest of the treatments and maximum straw yield (3417 and 3276 kg ha⁻¹, respectively) was obtained from the T₆ (HW at 20 and 40 DAS) which was again statistically at par with T₈ Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS (3360 and 3268 kg ha⁻¹, respectively). Cyhalofop butyl when applied in different doses (T₁ – T₅) lower straw yield (2240 and 1992 kg ha⁻¹, respectively) recorded in highest dose of Cyhalofop butyl 0.32 kg ha⁻¹. This was statistically at par with T₁ Cyhalofop butyl 0.04 kg ha⁻¹ (2261 and 1998 kg ha⁻¹, respectively). Maximum straw yield (2489 and 2365 kg ha⁻¹, respectively) was found in T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) which was statistically at par with T₂ Cyhalofop butyl 0.06 kg ha⁻¹ (2404 and 2295 kg ha⁻¹, respectively).

4.2.3.4 Effect of treatments on grain: straw ratio and harvest index

Regarding the grain: straw ratio during the *kharif* season of 1997 and 1998 (Table 35) it has been observed that this ratio was highest (0.8427 and 0.8406, respectively) with weed free and lowest with weedy check (0.7872 and 0.7784, respectively). A ratio of (0.8014 and 0.8011, respectively), the minimum was observed in sole application of Cyhalofop butyl with T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) while highest (0.8286 and 0.8200, respectively) ratio in the T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

In *boro* seasons of 1998 and 1999, (Table 36) highest grain: straw ratio (0.8583 and 0.8568, respectively) was obtained from the same T₆ (HW at 20 and 40 DAS) and the lowest (0.8084 and 0.8037) from weedy check (T₉) plot.

Table 35 Effect of treatments on grain : straw ratio, harvest index and weed index during *kharif* 1997 and 1998

Treatments	Grain : Straw ratio			Harvest index			Weed index		
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	0.8126	0.8081	0.8103	0.4488	0.4435	0.4461	44.63	44.05	44.34
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	0.8268	0.8136	0.8202	0.4526	0.4486	0.4506	40.39	36.20	38.29
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	0.8286	0.8200	0.8243	0.4531	0.4505	0.4518	26.67	26.15	26.41
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	0.8097	0.8013	0.8055	0.4487	0.4474	0.4480	42.84	36.64	39.74
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	0.8014	0.8011	0.8013	0.4483	0.4419	0.4451	46.27	45.80	46.03
T ₆ HW at 20 and 40 DAS	0.8427	0.8406	0.8416	0.4573	0.4567	0.4570	-	-	-
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	0.8339	0.8316	0.8327	0.4547	0.454	0.4543	6.81	6.31	6.56
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	0.8385	0.8353	0.8369	0.4561	0.4551	0.4556	3.31	2.59	2.95
T ₉ Weedy check	0.7872	0.7784	0.7828	0.4386	0.4377	0.4381	49.01	48.30	48.65

Minimum ratio (0.8125 and 0.8117, respectively) was from the T₅ (Cyhalofop butyl 0.32 kg ha⁻¹), the highest dose of Cyhalofop butyl among the different doses of Cyhalofop butyl was obtained and the highest ratio (0.8409 and 0.8385, respectively) was obtained from T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

So far as harvest index is concerned during the *kharif* season of 1997 and 1998 (Table 35) amongst the different doses of Cyhalofop butyl, maximum (0.4531 and 0.4531, respectively) was noticed from the T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and minimum (0.4483 and 0.4419, respectively) from T₅ (Cyhalofop butyl 0.32 kg ha⁻¹). T₆ (HW at 20 and 40 DAS) recorded highest harvest index (0.4573 and 0.4567, respectively) and lowest (0.4386 and 0.4377) with weedy check (T₉).

During the *boro* season of 1998 and 1999 (Table 36) highest harvest index (0.4619 and 0.4614, respectively) was noticed from the T₆ (HW at 20 and 40 DAS) and lowest (0.4470 and 0.4456, respectively) from the weedy check (T₉). In sole application of Cyhalofop butyl, lowest harvest index (0.4483 and 0.4480, respectively) was obtained from the treatment T₅ (Cyhalofop butyl 0.32 kg ha⁻¹) and highest harvest index (0.4568 and 0.4561, respectively) from T₃ (Cyhalofop butyl 0.08 kg ha⁻¹).

4.2.5 Weed index of different treatments

The calculated weed index of different treatments was presented in Table 35 (*Kharif*) and Table 36 (*boro*) of 1997-98 and 1998-99.

The data showed in *Kharif* 1997 and 1998 revealed that weedy check (T₉) recorded the highest weed index (49.01 and 48.30, respectively) where as T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ is POE + HW at 40 DAS) gave the lowest weed index (3.31 and 2.59, respectively). Among the different doses of Cyhalofop butyl, lowest weed index (26.67 and 26.15, respectively) was obtained from T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and highest (46.27 and 45.80, respectively) from T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

Table 36 Effect of treatments on grain : straw ratio, harvest index and weed index during *boro* 1998 and 1999

Treatments	Grain : Straw ratio			Harvest index			Weed index		
	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
T ₁ Cyhalofop butyl 0.04 kg ha ⁻¹	0.8257	0.8208	0.8232	0.4523	0.4508	0.4515	41.57	36.34	38.45
T ₂ Cyhalofop butyl 0.06 kg ha ⁻¹	0.8299	0.8248	0.8273	0.4535	0.4520	0.4527	32.56	31.98	32.27
T ₃ Cyhalofop butyl 0.08 kg ha ⁻¹	0.8409	0.8385	0.8397	0.4568	0.4561	0.4564	29.35	28.63	28.99
T ₄ Cyhalofop butyl 0.16 kg ha ⁻¹	0.8172	0.8155	0.8163	0.4497	0.4492	0.4494	37.65	36.92	37.28
T ₅ Cyhalofop butyl 0.32 kg ha ⁻¹	0.8125	0.8117	0.8121	0.4483	0.4480	0.4481	42.39	37.95	40.17
T ₆ HW at 20 and 40 DAS	0.8583	0.8568	0.8575	0.4619	0.4614	0.4616	-	-	-
T ₇ Cyhalofop butyl 0.06 kg ha ⁻¹ +HW at 40 DAS	0.8435	0.8408	0.8421	0.4575	0.4568	0.4571	6.67	4.81	5.74
T ₈ Cyhalofop butyl 0.08 kg ha ⁻¹ +HW at 40 DAS	0.8503	0.8485	0.8494	0.4595	0.4590	0.4592	4.77	2.59	3.68
T ₉ Weedy check	0.8084	0.8037	0.8060	0.4470	0.4456	0.4463	54.24	53.94	54.09

During the *boro* season of 1998 and 1999, it was found that lowest weed index (4.77 and 2.79, respectively) was obtained from T₈ (Cyhalofop butyl 0.08 kg ha⁻¹ + HW at 40 DAS) and highest (54.24 and 53.94, respectively) from weed check (T₉). Where as amongst sole application of Cyhalofop butyl (T₁ – T₅), lowest weed index (29.35 and 28.63, respectively) was obtained from the T₃ (Cyhalofop butyl 0.08 kg ha⁻¹) and highest weed index (42.39 and 37.95, respectively) from the T₅ (Cyhalofop butyl 0.32 kg ha⁻¹).

4.2.5. Effect of Cyhalofop butyl on Phytotoxicity in rice plant

The evaluation of Cyhalofop butyl (Clincher) for Phytotoxocity on direct seeded puddled paddy was done in both *kharif* and *boro* seasons during 1997-98 and 1998-99. The observations were recorded at 3, 7 and 30 days after application (DAA) of herbicide Clincher in both the seasons and year. The effect of herbicides on leaf injury on tips, leaf surface injury and wilting of rice plants were observed. The scale of phytotoxicity was summarised in previous chapter in Table 6.

The results as presented in Table 37 revealed that Cyhalofop butyl when applied 0.04 kg ha⁻¹ to 0.08 kg a.i. ha⁻¹ (T₁ – T₃) recorded neither wilting of plant nor leaf injury on tips or surface injury of paddy leaves in both seasons during both the years. Application of Cyhalofop butyl 0.16 kg ha⁻¹ (T₄) showed wilting of rice plants at 3 DAA (12 and 13 cent⁻¹ during 1998 and 1999, respectively) on *boro* paddy which recovered at 7 DAA during 1998, but took another 7 days more in the year 1999. The leaf injury on tip and surface injury on the leaves were also observed at 3 DAA on *boro* paddy during 1999 in the same dose of Cyhalofop butyl (11 cent⁻¹ leaf surface and 15 cent⁻¹ leaf tip). At 7 DAA, however like wilting, no injury symptoms were observed either on leaf surface or tips of the leaves.

The maximum leaf injury and wilting of direct seeded paddy plants were observed against the T₅ when Cyhalofop butyl was applied in its

Table 37 Effect of treatments of phytotoxicity on rice plants

Treatments	Leaf injury on surface (in phytotoxic grade)									Leaf injury on tip (in phytotoxic grade)									Wilting of plants (in phytotoxic grade)																	
	kharif									Boro									kharif									boro								
	7			30			3			7			30			3			7			30			3			7			30					
	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA	DAA							
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9				
	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9				
	7	8	7	8	7	8	9	8	9	7	8	7	8	9	8	9	7	8	9	7	8	7	8	7	8	9	8	9	8	9	8	9				
T ₁	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
T ₂	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
T ₃	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
T ₄	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1				
T ₅	2	2	1	1	2	2	2	2	1	1	2	1	2	1	1	2	2	2	1	1	2	2	2	2	1	2	2	2	2	1	1	1				
T ₆	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
T ₇	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
T ₈	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
T ₉	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			

*NOT APPLICABLE

maximum dose of 0.32 kg ha^{-1} in both seasons during 1997-98 and 1998-99. At 3 DAA, the data on leaf injury on surface of paddy leaves showed 16 cent⁻¹ and 19 cent⁻¹ leaf surface damage during kharif 1997 and 1998, respectively. Though rice leaves took 7 DAA during 1997 but additional 5 days was required to recover in 1998. In *boro* paddy 18 and 17 cent⁻¹ leaf surface damage were observed at 3 DAA which come down to 11 and 13 cent⁻¹, respectively at 7 DAA and 2 or 4 more days were required during 1998 and 1999, respectively to recover the same.

During the *kharif* season of 1997, no leaf injury on tips of rice leaves were observed while in 1998, 15 and 11 cent⁻¹ leaf tip injury were observed at 3 and 7 DAA, respectively. Only two more days had been found to recover the rice leaves. At both 3 and 7 DAA during *boro* season of 1998 and 1999, the tip injury of leaves recorded 18 and 19 cent⁻¹ (3 DAA) and 12 and 11 cent⁻¹ (7 DAA), respectively. However to recover the same in 5 and 3 more days were required during 1997 and 1998, respectively.

The wilting of rice plants as affected by treatment Cyhalofop butyl applied in its maximum dose of 0.32 kg ha^{-1} (T₅) showed no difference in between the seasons and years. Both at 3 and 7 DAA, the wilting of rice plants were observed. To recover the same during *kharif* season 2 and 1 days were less required than that of 12 and 13 days as required during *boro* season of 1998 and 1999, respectively.

From the above results, the phytotoxicity of the herbicide Cyhalofop butyl on rice plants may be declared as safe when the herbicide used 0.04 kg ha^{-1} to 0.08 kg ha^{-1} . For the higher dose of 0.16 kg ha^{-1} to 0.32 kg ha^{-1} showed some phytotoxicity on rice leaf injury and also on wilting of rice plants.

CHAPTER - 5

DISCUSSION

The findings of present investigation which have been presented in previous chapter in Table 8 to 37 are discussed below as follows in this chapter.

Studies on weed flora revealed that predominant weed flora in the experimental field were *Echinochloa crusgalli*, *Leersia hexandra*, *Paspalum scorbiculatum*, *Cyperus difformis*, *Cyperus iria*, *Fimbristylis littoralis*, *Ludwigia parviflora*, *Eclipta alba* and *Ammania baccifera*. Working on transplanted paddy at West Bengal, Mondal *et al* (1986), Mukhopadhyay (1995) and Ghosh (1998) recorded similar observation.

In this experiment it is observed that the grassy weeds were predominant in *kharif* season whereas the sedge and broadleaved weeds were found higher during *boro* season of both the years 1997-98 and 1998-99. The population of the dominant weed flora *Echinochloa spp* and other grassy weeds at harvest showed 24.2 and 35.0 cent⁻¹ higher, respectively during *kharif* in comparison to *boro* season. The corresponding figures for dry weight of same weeds were 20.9 and 17.9 cent⁻¹. On the contrast higher number of sedges (26.6 cent⁻¹) and broadleaved weeds (127 cent⁻¹) were recorded during *boro* season in comparison to *kharif* season. The corresponding figures for dry weights of sedges and broadleaved weeds were 21.7 and 21.8 cent⁻¹. Moody and Mukhopadhyay (1982), Ali and Sankaran (1984) expressed similar views of different weed flora in wet and dry seasons while working on transplanted paddy.

Among the different doses of Cyhalofop butyl sole application of Cyhalofop butyl showed that increasing the doses of chemical from 0.04 (lowest) to 0.32 kg (highest) reduced the population of *Echinochloa spp* by 4.3 and 3.5 m⁻² at 30 DAS and 5.19 and 3.97 m⁻² at 45 DAS during *kharif* and *boro*

season, respectively. The corresponding figures for 60 DAS and at harvest were 5.67 and 4.13 and 6.63 and 3.89 m^{-2} .

At 30 DAS, T_7 (Cyhalofop butyl 0.06 kg ha^{-1} + HW at 40 DAS) recorded higher number of *Echinochloa spp* in both the season than twice hand weeding (T_6). Treatment T_8 (Cyhalofop butyl 0.08 kg ha^{-1} + HW at 40 DAS) recorded 105 and 50 cent⁻¹ less *Echinochloa spp* than that of the HW twice (T_6) which recorded 14.7 and 11.4 cent⁻¹ at 45 DAS less *Echinochloa spp* during *kharif* and *boro*, respectively than even the treatment where maximum dose of Cyhalofop butyl was applied (T_5). The treatment T_8 where the chemical Cyhalofop butyl 0.08 kg was integrated with one HW showed 119 and 42 cent⁻¹ less *Echinochloa spp* at 45 DAS during *kharif* and *boro* season, respectively than that of twice HW plot (T_6). This integrated treatment (T_8) also recorded maximum control of *Echinochloa spp* in all the dates of observations. At harvest it also recorded an effective control of *Echinochloa spp* by showing 15.2 and 8.4 cent⁻¹ lower during *kharif* and *boro* season, respectively in comparison to HW treatment (Table 8 and 9 and Figure 3 and 4). Excepting at 30 DAS, HW (T_6) did not differ significantly in controlling *Echinochloa spp* with the treatments either where maximum dose of Cyhalofop butyl was applied or with T_8 where Cyhalofop butyl 0.08 kg applied with one HW at 40 DAS.

With the increasing the dose of Cyhalofop butyl from 0.04 to 0.32 kg, dry weight of *Echinochloa crusgalli* reduced significantly to the tune of 17.1 and 9.9 g m^{-2} at harvest during *kharif* and *boro* season, respectively. Similar trends of variations were also observed at 30 DAS (1.25 and 1.06 g m^{-2}), 45 DAS (3.56 and 2.78 g m^{-2}) and at 60 DAS (5.62 and 4.1 g m^{-2}). The treatment combination of Cyhalofop butyl 0.08 kg with HW at 40 DAS recorded 105 and 114 cent⁻¹ (30 DAS) and 63 and 48 cent⁻¹ (45 DAS) lower dry weight of *Echinochloa spp* than twice HW (T_6) during *kharif* and *boro* season, respectively. The corresponding figures were 53 and 49 cent⁻¹ (60 DAS) and 19 and 17 cent⁻¹ at harvest. This indicated the effectiveness of the integrated approach of controlling

Echinochloa spp over the twice HW or even the treatment where maximum dose of Cyhalofop butyl was applied though these three treatments T₈, T₆ and T₅ excepting at 30 DAS did not show significant variation in controlling the *Echinochloa spp*. Kondo et al (1997) working at Japan also reported that application of Cyhalofop butyl 0.04 kg ha⁻¹ showed promising in controlling of *Echinochloa crusgalli*. The effectiveness of Cyhalofop butyl against *Echinochloa spp* applied 0.08 kg or higher may be due to reduction of Chlorophyll content in *Echinochloa* leaf, its root length and fresh weight of *Echinochloa spp*. Additional HW at 40 DAS with Cyhalofop butyl 0.08 kg further reduced the population of *Echinochloa spp* showing better control of this weed in both seasons. Lower doses of Cyhalofop butyl below 0.08 kg (T₁ and T₂) did not effectively control the *Echinochloa spp* probably due to reason that it is comparatively less phytotoxic to *Echinochloa spp* in comparison to the doses of Cyhalofop butyl above 0.08 kg. Similar views were also expressed by Buendia et al (1998) and Park et al (1994).

The population and dry weight of other grasses (Table 10, 11, 20 and 21) showed that HW twice (T₆) recorded significantly lower dry weights than all the other treatments except T₇ and T₈ (integrated approach) in all the dates of observation. This is probably due to reason that the treatment received the weed free condition at 20 and 40 DAS. In addition, Cyhalofop butyl has very little effect in controlling the other grasses. The treatment where Cyhalofop butyl was applied either 0.06 or 0.08 kg along with one HW at 40 DAS recorded significantly at par dry weight of other grasses at 45 and 60 DAS. This is due to reason that all these three treatments (T₆, T₇ and T₈) received weed free condition at 40 DAS. Probably for the same reason these three treatments (T₆, T₇ and T₈) also recorded lower population and dry weight of other grasses than either weedy check (T₉) or the treatments where Cyhalofop butyl was applied as sole (T₁ – T₅). Similar trends of variations were also observed in case of sedges and broadleaved weeds.

Increasing the dose of Cyhalofop butyl from 0.04 kg to 0.32 kg the higher population of other grasses (17.1 and 13.3 m⁻²), sedges (15.6 and 17.3 cent⁻¹) and broadleaved weeds (20.1 and 14 cent⁻¹) during *kharif* and *boro* season, respectively were recorded at harvest, indicating the lesser phytotoxic effect of Cyhalofop butyl to all these weeds excepting the *Echinochloa spp.* While increasing the doses because of less competition from *Echinochloa spp.*, the other weeds may tap the resources fully and thus increasing the number and dry weight of these weeds. Working at Korea by Wu *et al* (1998) revealed that Cyhalofop butyl had no effect on the weeds like *Cyperus serotinus* or other broadleaved weeds. Whereas a mixture of Cyhalofop butyl with Bispyribenzoxim and Pyrazosulfuron at a ratio of 100 : 12 : 10 g ha⁻¹ was found to be good instead of this herbicide alone for controlling the different weed flora including *Echinochloa spp.* Choi *et al* (1998) also expressed similar views.

Therefore, HW twice or integration of Cyhalofop butyl 0.08 kg with one HW at 40 DAS seem better in controlling the *Echinochloa spp.* and also the other weeds prevalent in paddy field during 1997 and 1998. HW at 20 and 40 DAS recorded 7.1 and 187 cent⁻¹ (45 DAS), 139 and 35 cent⁻¹ (60 DAS), 131 and 81cent⁻¹ (at harvest) lower number of other grasses population during *kharif* and *boro* season, respectively in comparison to T₈ (Cyhalofop butyl 0.08 kg + HW at 40 DAS). The same for sedge population were 23 and 7 cent⁻¹ (45 DAS), 36 and 20 cent⁻¹ (60 DAS) and 9 and 11 cent⁻¹ (at harvest) and the population of broadleaved weeds were 4 and 42 cent⁻¹ (45 DAS), 7 and 19 cent⁻¹ (60 DAS), 6 and 19 cent⁻¹ (at harvest). The corresponding figures for total weed population were 16 and 9 cent⁻¹, 9 and 10 cent⁻¹ and 8 and 24 cent⁻¹ (Table 16 and 17 and Figure 11 and 12).

The better integrated approach for controlling the paddy weeds (T₈) also recorded 0.07 and 0.04 g (45 DAS), 0.52 and 0.18 g (60 DAS) and 16.7 and 10.39 g (at harvest), higher dry weight of other grasses during *kharif* and *boro* season, respectively in comparison to twice HW treatment (T₆). The

corresponding figures for the dry weights of sedge and broadleaved weeds were 14 and 17 cent⁻¹ - 9 and 15 cent⁻¹ (45 DAS), 14 and 36 cent⁻¹ - 14 and 35 cent⁻¹ (60 DAS) and 40 and 50 cent⁻¹ both for sedge and broadleaved weeds (at harvest). The same for the total weeds were 1 and 8 cent⁻¹ (45 DAS), 9 and 12 cent⁻¹ (60 DAS) and 44 and 36 cent⁻¹ (at harvest) during *kharif* and *boro* season, respectively. In spite of recording slightly higher population and dry weight of weeds by the integrated treatment T₈ over the HW twice (T₆) in most of the observations it did not vary significantly with twice HW. Considering the wages of labour the integrated approach (T₈) may, thus, be better to accept for final recommendation in rice weed control. Application of Cyhalofop butyl alone can able only to control the weed *Echinochloa spp* (efficacy increases with higher doses) but fail to control not only the other grassy weed but also the sedge and broadleaved weeds. (Table 8 to 15 and Figure 3 to 10). Addition of one HW at 40 DAS can solve the problem of controlling the other weeds to a greater extent.

Amongst the integrated treatments application of Cyhalofop butyl 0.08 kg and one HW at 40 DAS recorded lower population and dry weight of all weeds in all dates of observation and over Cyhalofop butyl 0.06 kg + HW at 40 DAS (T₇) proving the supermacy of the former (T₈) than that of the later (T₇). Working with rice by De Datta and Ampong - Nyarko (1988), Nandal and Om (1998), Kolhe and Tripathi (1998) and Ghosh (1998) revealed that integration of an initial chemical herbicide with one HW within the crop - weed competition stage was better than either the sole application of chemical herbicide or HW twice.

The different yield parameters *viz* number of panicles, number of spikelet panicle⁻¹, panicle length, panicle weight, percent filled grains varied significantly with different treatments in both seasons unlike the test weight of grains. HW twice (T₆) and integration of Cyhalofop butyl 0.08 kg along with one HW at 40 DAS (T₈) though did not vary significantly amongst

themselves in case of the important yield parameters but the former showed 2.9 and 4 cent⁻¹ (panicle number), 0.7 and 2.4 cent⁻¹ (spikelet number panicle⁻¹), 0.1 and 0.7 cent⁻¹ (panicle length), 4.2 and 3.6 cent⁻¹ (panicle weight) and 0.7 and 2.4 cent⁻¹ (filled grain cent⁻¹), higher during *kharif* and *boro* season, respectively as compared to the latter (T₈). This may be due to the reason that the treatment T₆ received an initial HW at the critical crop – weed competition stage (20 DAS), which helped the rice plant for better growth unlike T₈. Similar views was also expressed by Sreedevi *et al* (1993) and Dhiman and Nandal (1996).

Application of Cyhalofop butyl 0.08 kg only, among the different sole treatment of Cyhalofop butyl (T₁ – T₅) recorded 11.7 and 4.5 cent⁻¹ (panicle number), 4.75 and 0.7 cent⁻¹ (spikelet number panicle⁻¹), 3.5 and 9.3 cent⁻¹ (panicle length), 14.3 and 10.7 cent⁻¹ (panicle weight) and 4.1 and 8.8 cent⁻¹ (filled grains cent⁻¹) higher during *kharif* and *boro* season, respectively over T₅ where the maximum dose of 0.32 kg Cyhalofop butyl was applied. The maximum dose of Cyhalofop butyl in spite of inviting phytotoxicity to rice plant can effectively controlling the *Echinochloa spp* to maximum level but did not able to control the other weeds as that observed in case of T₃ and probably for this reason there was a less crop – weed competition in T₃ as compare to T₅. Application of Cyhalofop butyl 0.08 kg also recorded better yield parameters of rice as compared to that of T₁ where the minimum dose of Cyhalofop butyl 0.04 kg was used. 5.4 and 12.4 cent⁻¹ panicle number, 9.03 and 6.33 cent⁻¹ spikelet number panicle⁻¹, 3.8 and 10.3 cent⁻¹ panicle length, 20.7 and 14.8 cent⁻¹ panicle weight and 4.6 and 6.3 cent⁻¹ of higher percent filled grains were recorded in T₃ as compare to T₁. Existence of less crop – weed competition in T₃ in comparison to T₁ may be the reason for the same.

Treatment T₈ (Cyhalofop butyl 0.08 kg + HW at 40 DAS) recorded higher number of panicle m⁻² (33 and 18.1cent⁻¹), spikelet number panicle⁻¹ (24.73 and 27.95 cent⁻¹), panicle length (9.2 and 8.6 cent⁻¹), panicle weight (10.7 and 17.6

cent⁻¹), 1000 grain weight (2.4 and 0.6 cent⁻¹) and percent of filled grain (24.7 and 27.7 cent⁻¹) during *kharif* and *boro* season, respectively in comparison to treatment T₃ (Cyhalofop butyl 0.08 kg ha⁻¹). This may be due to better control of *Echinochloa spp* and other weeds in T₈ through additional one HW in comparison to T₃. The results were also confirmed by Nandal and Om (1998), Gogoi *et al* (1989) and Angadi *et al* (1993). However all the treatments where the chemical Cyhalofop butyl was applied either as sole or in combination with HW along with twice HW plot recorded better yield parameters comparatively to that of weedy check.

The grain and straw yield data as presented in Table 33 and 34 and Figure 15 showed that twice HW (T₆) recorded 95 and 85 cent⁻¹ and 89 and 74 cent⁻¹ higher grain and straw yields over the weedy check (T₉). This was closely followed by T₈ and T₇, the integrated treatments. The corresponding figures were 92 and 76 cent⁻¹ and 85 and 73 cent⁻¹ (T₈) and 78 and 70 cent⁻¹ and 80 and 67 cent⁻¹ (T₇) during *kharif* and *boro* season, respectively. The treatment twice HW (T₆) recorded 1.5 and 1.9 cent⁻¹ higher grain yield over the treatment T₈ where Cyhalofop butyl 0.08 kg combined with one HW at 40 DAS, the corresponding higher grain yield figure over T₇ where Cyhalofop butyl 0.06 kg with one HW at 40 DAS were 9.3 and 5.3 cent⁻¹ (higher grain yield in T₆ followed by T₈ and T₇ probably due to higher percent filled grain, panicle number, spikelet number, panicle weight and panicle length obtained through less crop – weed competition in comparison to that of the other treatments using in this experiment). Similar findings were also observed by Nandal and Om (1998), Dhiman and Nandal (1996) and Ghosh (1998).

Among the different treatments of sole application of Cyhalofop butyl (T₁ – T₅) application of Cyhalofop butyl 0.08 kg recorded (37.3 and 34.3 cent⁻¹ during *kharif* and *boro* season, respectively more than that of weedy check) higher yield over where maximum dose of Cyhalofop butyl was used 0.32 kg in T₅ (20.9 and 18.6 cent⁻¹) and T₁ where minimum dose of 0.04 kg of

Cyhalofop butyl was used (21.3 and 16.2 cent⁻¹) during *kharif* and *boro*, respectively. Probably because of comparatively lesser crop – weed competition amongst sole application of Cyhalofop butyl (T₁ – T₅). T₃ recorded better panicle number, spikelet number and filled grains cent⁻¹ and ultimately higher grain yield because of no phytotoxicity on rice as that obtained in T₅. Similar results were also found by Radhamani *et al* (1997).

The integrated approach preferably T₈ where Cyhalofop butyl applied 0.08 kg along with one HW at 40 DAS also recorded 40 and 38 cent⁻¹ higher grain yield during *kharif* and *boro* season, respectively over best yield performed sole treatment of Cyhalofop butyl (T₃). This may be due to the fact that additional one HW in integrated system helped the rice plant to yield better. Similar views were also expressed by Ghosh (1998), and Angadi *et al* (1993). The weedy check recorded the lowest grain yield amongst the all treatments. In general the grain yield of rice in all the treatments recorded higher in *boro* rice in comparison to *kharif* rice because of better utilisation of resources (Moody and Mukhopadhyay; 1982), the straw yield data also showed similar variations as that obtained in grain yield.

The grain and straw ratio and harvest index (Table 35 and 36) data revealed that the HW twice (T₆) recorded the maximum in both the season followed by treatment where integration of Cyhalofop butyl with one HW was practised. The treatment T₈ showed 0.0047 and 0.0083 lower grain straw ratio and 0.0014 and 0.0020 lower harvest index during *kharif* and *boro* season, respectively than that of twice HW (T₆). This also proved the supremacy of the weed free check over the other treatments including the recently recommended integrated system of weed management.

The data on weed index showed that amongst the different doses of Cyhalofop butyl applied either as sole or integrated with mechanical HW treatment T₈ (Cyhalofop butyl 0.08 kg + HW at 40 DAS) the lowest weed index of 2.95 and 3.68 during *kharif* and *boro* season, respectively was recorded and

this followed by the treatment T₇ (6.56 and 5.74 during *kharif* and *boro* season, respectively), the other treatments where integrated approach was followed. The similar trends were also observed when this herbicide was applied as sole (T₃ followed by T₂).

The herbicide Cyhalofop butyl 0.08 kg when applied in conjunction with one HW at 40 DAS recorded maximum WCE (E) followed by treatment T₅ where maximum dose of Cyhalofop butyl was applied (0.69 and 1.39 higher by T₈ over T₅) during *kharif* and *boro* season, respectively. This may be due to better control of *Echinochloa spp.* and other weeds. Similar views were also expressed by Park *et al* (1994).

Higher doses of Cyhalofop butyl 0.16 kg to 0.32 kg ha⁻¹ when applied in direct seeded puddled rice recorded phytotoxicity effect particularly on rice leaf tip and surface injury and wilting of rice plants varies from 11 – 20 cent⁻¹ and took at least two weeks after spraying to recover the rice plants and may reduce the root growth and tillering which ultimately affect the grain yield. (Table 37). Application of Butachlor 0.75 kg ha⁻¹ with 2, 4 – D 0.50 kg ha⁻¹ (Imperial *et al*, 1980) and Anilofos 1.0 kg ha⁻¹ or Pendimethalin 1.0 kg ha⁻¹ (Prakash *et al* 1995) also showed moderate injury to rice plant. Ghosh (1999) also reported moderate leaf injury of rice plants when Clomazone 15 EC was applied @ 200 g a.i. ha⁻¹ combined with Propanil 30 EC @ 400 g a.i. ha⁻¹ as POE (10 to 20 DAT).

CHAPTER – 6

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The *Echinochloa* spp. Viz. *Echinochloa crusgalli*, *Echinochloa Colonum* is the dominant grassy weed along with acting as host of pest and diseases in paddy field throughout the world. More number of weeds are observed in direct seeded paddy field than transplanted field. Direct seeded under puddled soil, reducing the cost of labours and also the cost of cultivation now becomes the most acceptable alternatives to transplanting for paddy growers of our country. Weed control is, thus, need to be taken more care in direct seeded puddled condition. Among the different control measures use of chemical herbicides showed best in controlling *Echinochloa* spp in both pre and post emergence and out of various chemicals tested Cyhalofop butyl showed an excellent capacity of controlling *Echinochloa* spp in post emergence condition.

An experiment entitled "Effect of Cyhalofop butyl on *Echinochloa* spp in direct seeded puddled paddy (*oryza sativa* L.)" was carried out at the Kalyani 'C'- Block Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during the wet (*Kharif*) and dry (*Boro*) season of 1997-98 and 1998-99 on sandy clay loam soil to study the efficacy of Cyhalofop butyl in controlling *Echinochloa* spp and the other weeds. The weed flora population and dry weight, weed control efficiency, growth and yield parameters were recorded along with the phytotoxic effect of Cyhalofop butyl on paddy.

The experiment was tried in a randomised block design where 9 treatments were replicated thrice in a plot size of 4m x 4m. Cyhalofop butyl was applied in 5 different doses (0.04, 0.06, 0.08, 0.16 and 0.32 kg ha⁻¹ as POE) along with HW twice at 20 and 40 DAS and integration of Cyhalofop butyl 0.06 kg and 0.08 kg ha⁻¹ with one HW at 40 DAS. The summary of these findings have been depicted in brief here under: -

There were 18 dominant species of weeds intercepted in the experimental field out of which 9 species were grasses, 4 species were sedges and 5 species were broadleaved weeds. These total number of weeds were highly competitive. The most predominant weeds were *Echinochloa crusgalli*, *Cyperus difformis*, *Cyperus iria*, *Fimbristylis littoralis*, *Ammania baccifera*, *Commelina bengalensis*, *Eclipta alba* and *Ludwigia parviflora*.

All the weed control treatments (Chemical and mechanical combined or alone) tried in this investigation resulted in significant decrease in density and biomass of *Echinochloa spp* over the weedy check treatment. The effects of treatments on other grasses, sedges and broadleaved weeds resulted significant decrease in weed density and dry weight over unweeded control treatment specially due to HW treatment. Very little or negligible effect of Cyhalofop butyl was observed on controlling other grasses, sedges and broad leaved weeds. Gradual increase in the doses of Cyhalofop butyl recorded higher control in both population and dry weight of *Echinochloa spp*.

So far as the effect of treatments of weed control is concerned HW twice at 20 and 40 DAS gave the best performance in reducing weed population and weed dry weight in both seasons of 1997-98 and 1998-99 at all the growth stage of rice crop which ultimately resulted in highest grain and straw yield (2073.50, 2463.50 kg ha⁻¹, respectively) during *kharif* and (2870.00 and 3346.50 kg ha⁻¹, respectively) during *boro* seasons. The reason behind the maximum yield in this treatment is that it gave very little scope to compete the weeds with crop preferably at the critical stages of crop – weed competition.

It has been found that during *boro* season on an average higher phytotoxicity in paddy crop was observed in comparison to *kharif* season. Higher concentration above 0.08 kg ha⁻¹ as POE of Cyhalofop butyl recorded more phytotoxicity in rice plants. Among the different phytotoxicity effect, wilting of plants showed higher in number in comparison to surface injury and tip injury of leaves.

Among the two different combination of Cyhalofop butyl with HW at 40 DAS Cyhalofop butyl 0.08 kg showed encouraging results by providing an efficient suppression of *Echinochloa spp* as a dominant weeds and other complex of weed flora under both seasons of year, 1997-98 and 1998-99 and finally this treatment combination of Cyhalofop butyl 0.08 kg ha⁻¹ as POE with HW at 40 DAS gave higher grain yield and straw yield (2042.50, 2404.50 kg ha⁻¹, respectively) during *kharif* and (2815.00, 3314.0 kg ha⁻¹, respectively) during *boro* seasons; exhibiting no phytotoxicity symptom to the crop plant. The performance of this herbicide with HW at 40 DAS was statistically at par with two HW at 20 and 40 DAS. Amongst the different chemicals the highest weed control efficiency of *Echinochloa* was also experienced with this combination with no phytotoxic symptom on crop and this might be due to its high soil adsorption, prolonged persistence of herbicidal action in soil and its selectivity, against *Echinochloa spp*.

Different doses of Cyhalofop butyl when applied as POE alone, the highest dose 0.32 kg ha⁻¹ was also found effective in controlling dominant weed *Echinochloa spp* of both *kharif* and *boro* seasons of 1997-98 and 1998-99, but phytotoxic effect was observed as wilting and leaf injury on surface and leaf injury on tip which were recovered after 12-15 days after spraying of herbicide and ultimately this phytotoxic effect in higher two doses of Cyhalotop butyl 0.16 kg ha⁻¹ and 0.32 kg ha⁻¹ caused a factor for reducing the grain yield (1461.00, 1248.00 kg ha⁻¹, respectively) during *kharif* season and (2038.0, 1803.0 kg ha⁻¹, respectively) during *boro* season.

Therefore, Cyhalofop butyl 0.08 kg ha⁻¹ as POE was found good and appropriate in controlling *Echinochloa spp* and its combination with one HW at 40 DAS showed most effective economic and an alternative method to HW at 20 and 40 DAS.

The maximum reduction in grain and straw yields was observed in weedy check plots where the competition between crop and weeds were keen

throughout the crop growth stages. On the other hand, HW at 20 and 40 DAS registered 94.78 and 80.48 cent⁻¹ increase in grain and straw yields, respectively over control during *kharif* seasons and 89.13 and 74.27 cent⁻¹ increase in grain and straw yields, respectively during *boro* seasons. Whereas Cyhalofop butyl applied with a dose of 0.08 kg ha⁻¹ as POE combining with one HW at 40 DAS appreciably increased grain and straw yields 91.87 and 76.15 cent⁻¹, respectively during *kharif* and 85.50 and 72.60 cent⁻¹ respectively, during *boro* seasons compared to unweeded control.

So from this experiment, it can be concluded that considering the gradual increase of labour cost and in an ecological area where *Echinochloa spp* is a predominant weeds, Cyhalofop butyl 0.08 kg ha⁻¹ either as sole or in combination with one HW at 40 DAS proved to be the best effective method of controlling *Echinochloa spp* and weed management in direct seeded puddled rice.

FUTURE SCOPE OF WORK

Echinochloa crusgalli, the Barnyard grass is the most predominant problematic weeds in paddy field. Because of its close resemble with rice in seedling stage often it is very difficult to most of the farmers to manage this weed. Continuous use of some chemical herbicides like propanil developed resistancy of this weed. Cyhalofop butyl the new aryloxy phenoxy propionate herbicide showed extremely good in managing this weed even at low rates. *Echinochloa spp* is more competitive in direct sown than in transplanted crops. Yield reductions of 20 cent⁻¹ being caused by 3 and 66 *Echinochloa* m⁻² in their respective systems. Examination of the effects of rice density showed that the response to *Echinochloa* density of 300 direct sown rice plant m⁻² was equivalent in terms of the yield produced to that of only 25 transplanted plants. Hence, the present investigation was carried out in direct sown puddled condition.

Results of the present investigation carried out during 1997-98 and 1998-99 in direct seeded puddled rice – rice crop sequence revealed that Cyhalofop butyl 0.08 kg combining with one HW at 40 DAS is sufficient for managing the Shama grass efficiently but there is a good field to work on this aspect for some more in depth work.

- To observe the effect of Cyhalofop butyl on the important growth factors of both *Echinochloa* and paddy particularly on different important enzymatic, protein synthesis, respiration, transpiration and other metabolic activities during crop – weed competition period.

- To find out the proper formulation of the herbicide Cyhalofop butyl along with the actual stage of *Echinochloa* for effective control of this weed in rice field.
- To observe its efficacy in controlling *Echinochloa* on transplanted rice culture.
- As Cyhalofop butyl is best effective for *Echinochloa* and less influenced on other weeds, herbicide mixture with Cyhalofop butyl will be more effective for controlling different weed flora of rice fields. Hence further studies are needed to find out the best combination of herbicide mixture with Cyhalofop butyl with their formulation, doses, method and time of application.
- To find out the selectivity of Cyhalofop butyl on upland rice culture and also on other than rice plant, particularly in the upland areas where *Echinochloa colonum* is a major problematic weed.
- To determine the efficacy of Cyhalofop butyl applied alone or in mixture with other herbicides in different land situation and on important cropping sequences in the different agroclimatic zones and
- To find out the effect of this herbicide or its suitable mixture on the soil microbes and enzymatic functions of both crops and weeds in different soil types and land situations.

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