

**EVALUATION OF HERBICIDES FOR WEED CONTROL
IN TRANSPLANTED CHILLI (*Capsicum annuum* L.)**

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1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important commercial crop grown on a wide range of soil at altitudes varying from sea level 800 to 2000 m above mean sea level, both for the internal consumption and for export. It is an indispensable spice essentially used in every Indian cuisine, due to its pungency, taste, colour and aroma. Chilli fruits are rich sources of vit C, A and E. Pungency of chilli is due to crystalline volatile alkaloid called capsaicin present in the placenta of fruit, which has diverse prophylactic and therapeutic uses in allopathic and ayurvedic medicine. It is also a good source of oleoresin, which has varied uses in processed food and beverage industries.

The world's chilli area accounts for 1.5 million hectares and production around seven million tonnes. India is the largest producer of chillies in the world, accounting for 11.53 lakh tonnes in 2005-2006 followed by China (4 lakh tonnes), Mexico (3 lakh tonnes) and Pakistan (3 lakh tonnes) (Anon., 2008).

Major chilli producing states in India are Andhra Pradesh, Karnataka, Maharashtra, Orissa, Rajasthan and Tamil Nadu which contribute to around 86 per cent of total area of chilli crop cultivation in the country and 90 per cent of the total production. The important chilli growing districts in Karnataka are Haveri, Gadag, Dharwad, Koppal, Belgaum, Bellary and Raichur of which Haveri and Dharwad districts accounts for 72 and 60 per cent of total area and production, respectively (Anon., 2008).

Chilli exports in the country exceeded the target set for the commodity in 2007-08 and reached an all-time high, both by quantity and value. India exported 1.69 lakh tonnes of chilli in April-February 2007-2008. The value of the exports was Rs 906.44 crore (Anon., 2008). Exports comprised chilli powder, dried chillies, pickled chillies and chilli oleoresins.

Weeds emerge fast and grow rapidly competing with the crop severally for growth resources viz., nutrients, moisture, sunlight and space during entire vegetative and early reproductive stages of chilli. They also transpire lot of valuable conserved moisture and absorb large quantities of nutrients from the soil. Further, wide space provided to the chilli, allows fast growth of variety of weed species causing a considerable reduction in yield by affecting the growth and yield components. Presence of weeds reduces the photosynthetic efficiency, dry matter production and its distribution to economical parts and there by reduces sink capacity of crop resulting in poor fruit yield. Thus, the extent of reduction in fruit yield of chilli has been reported to be in the range of 60 to 70 per cent depending on the intensity and persistence of weed density in standing crop (Patel *et al.*, 2004). It is well established that 30 to 60 DAT is the most critical period for crop-weed competition in chilli. Hence, managing weeds during this period is most critical for higher yields. But, the competing weeds pose problem greatly and need effective management to realize higher yields. Clean and weed free cultivation is pre-requisite for successful crop production.

The choice of any weed control measures therefore, depends largely on its effectiveness and economics. Because of increased cost and non availability of manual labour in required quantity for hand weeding, herbicides not only control the weeds timely and effectively but also offer a great scope for minimizing the cost of weed control irrespective of situation. Use of pre-emergent and post-emergent herbicides would make the herbicidal weed control more acceptable to farmers, which will not change the existing agronomic practices but will allow for complete control of weeds. Usage of pre-emergence herbicides assumes greater importance in the view of their effectiveness from initial stages. The recent studies conducted by Narasalagi (1999) and Rajkumar (2009) in onion + chilli intercropping system clearly demonstrated usefulness of pre-emergence application of herbicides. But such information on the use of pre-emergence / post-emergence herbicides under transplanted condition is meagre. Hence, study on evaluation of herbicides for weed control in transplanted chilli was planned to ascertain the effect of different herbicides on weed control and growth and yield of chilli at Main Agriculture Research Station, UAS, Dharwad under rainfed conditions with the following objectives:

1. To evaluate different pre-emergent and post-emergent herbicides for weed control in transplanted chilli,

2. To find out effect of pre-emergent and post-emergent herbicides on growth and yield of chilli and
3. To work out the economics.

2. REVIEW OF LITERATURE

Chilli is a slow growing crop in the early stage of crop growth during this period weed because of their high competitive ability, affect chilli fruit yield. Hence, the productivity of chilli largely depends on a weed free condition. The study on chemical weed control assumes a greater importance in the cultivation of chilli in view of scarcity and in efficiency of labour. The literature on crop-weed competition and its effect on growth, yield components and yield and weed control through the use herbicides are reviewed in this chapter. The literature on the effect of diclosulam and haloxyfop is not available in chilli. Hence the literature on other crops is reviewed and presented.

2.1 Weed spectrum associated with chilli

To evolve a satisfactory weed control strategy, identification and understanding of weeds associated with chilli crop is pre- requisite. The weed flora in chilli field differs widely according to varied soil and climatic conditions. Krishnashastry (1957) has given the details of about 203 weed species which are commonly found in cultivated fields of Karnataka.

Rajagopal *et al.* (1976) reported that weeds associated with chilli crop in Tamil Nadu were *Trianthema portulacastrum* L., *Gynandropsis pentaphylla* L., *Cynodon dactylon* L. pers, and *Cyperus rotundus* L. In Punjab, *Cyprus rotundus* L., *Tribulus terrestris* L. *Celosia argentea* L., *Digera arvensis* Forsk., *Digitaria sanguinalis* L. Scop, *Eragrostis spp.*, *Eleusine aegyptium* Desf., and *Eleusine indica* L. Gaertn.were observed in chilli field (Saimbhi and Randhawa, 1976).

Bullock *et al.* (1984) observed *Digitaria sanguinalis* L. Scop, *Panicum dichotomiflorum* Michx., *Eleusine indica* L. Gaerth, *Amaranthus retroflexus* L. and *Galinsoga spp.*, in transplanted pepper plots.

Sharma *et al.* (1988) reported that *Cyperus rotundus* L., *Cynodon dactylon* (L.,) Pers., *Commelina nudiflora* L., *Digitaria sanguinalis* L. Scop., *Echinochloa colonum* L., *Setaria glauca* Beauv, *Eleusine indica* L. Gaertn, *Chenopodium album* L., and *Ageratum conyzoides* L., were associated with chilli.

The predominant weed species observed in capsicum plots by Masiunas (1989) were *Digitaria spp.*, *Panicum dichotomiflorum* michx., *Eleusine indica* L Gaertn., *Chenopodium album* L., *Amaranthus spp.* and *Portulaca oleracea* L., whereas Dangol *et al.* (1988) observed *Digitaria spp.*, *Amaranthus viridis* L., *Eleusine indica* L. Gaertn., and *Cynodon dactylon* L. Pers. Lankroo *et al.* (1990) observed *Cyperus rotundus* L., *Cynodon dactylon* L. *Commelina nudiflora* L., *Digitaria sanguinalis* L. Scop., *Echinochloa colonum* L. Link., *Setaria glauca* Beauv, *Eleusine indica* L. Gaertn, *Chenopodium album* L.

Hosmani (1993) observed the most predominant weed species in chilli field were *Cynodon dactylon* L Pers, *Cyperus rotundus* L., *Convolvulus arvensis* L., *Digitaria mrginata* Link., *Dactyloctenium ageyptium* Beauv., *Dinebra retroflexa* (Vahl) Panz., *Panicum isache* Roth., *Commelina benghalensis* L., *Cynotis cristata*, *Phyllanthus niruri* L. *Sida spp.*, *Celosia argentea* L., *Acanthospermum hispidum* DC., *Trianthema portulacastrum* L., *Ageratum conyzoides* L., *Cuscuta spp.*, and *Orobanche spp.* Schroeder (1992) reported that most common weed in chilli (*Capsicum annum* L.) field were *Physailis wrightit*, *Amaranthus blitoides* and *Datura quercifolia* L. According to Singh *et al.* (1993a) *Amaranthus viridis* L., *Trianthema portulacastrum* L., *Digitaria spp* and *Dactyloctenium aegyptium* Beauv were predominated weeds in chilli.

Lanini and Strange (1994) observed *Echinochloa crus-galli* L. Beauv, *Amaranthus retroflexus* L., *Chenopodium Album* L., *Portulaca oleracea* L. and *Solanum nigrum* L. in pepper (*Capsicum annum* L.) fields. The dominant weeds species observed in capsicum plots by Singh *et al.* (1995) were *Amaranthus viridis* L., *Trianthema portulacastrum* L., *Phyllanthus niruri* L., *Digitaria ciliaris* (Retz.) *Dactyloctenium aegyptium* L.

Biradar (1999) observed that during *kharif* season *Cynodon dactylon* L Pers, *Cyperus rotundus* L., *Dinebra retroflexa* (Vahl) Panz., *Echinochloa crus-galli*, *Eleusine indica* L., *Setaria italica* L., *Commelina benghalensis* L., *Acanthospermum hispidum* Dc., *Ageratum conyzoides*, *Amaranthus viridis* L., *Convolvulus arvensis* L., *Digera arvensis*, *Euphorbia spp.*,

Parthenium hysterophorus L., *Phyllanthus niruri* L., *Portulaca oleracea* L. and *Tridax procumbens* L. were predominant weeds at Dharwad.

Narasalagi (1999) reported that most common weeds in chilli (*Capsicum annum* L.) field were *Acalypha indica* L., *Ageratum conyzoides*, *Amaranthus viridis* L., *Argemone mexicana*, *Chenopodium album* L., *Convolvulus arvensis* L., *Commelina benghalensis* L., *Cynodon dactylon* Pers., *Cyperus rotundus* L., *Digera arvensis* L., *Euphorbia geniculata*., *Lactuca rancinata* Dc., *Legusca mollis* Cav. *Portulaca oleracea* L., *Phyllanthus niruri* L., *Solanum nigrum* L., and *Setaria italica* L.

Ved Prakash *et al.* (1999) observed *Ageratum conyzoides*, *Commelina benghalensis* L., *Celosia argentea* L., *Cyperus rotundus* L., *Cynodon dactylon* Pers., *Digitaria sanguinalis*, *Digera arvensis*, *Echinochloa colonum*, *Galinsoga parviflora* Cav., *Oxalis latifolia* and *Panicum spp.* in transplanted chilli plots.

Yadav (2001) observed that most dominant weed flora of the chilli (*Capsicum annum* L.) field were *Amaranthus viridis* L., *Trianthema portulacastrum* L., *Digitaria ciliaris* Retz., *Dactyloctenium aegyptium* L. Rajput *et al.* (2003) observed that *Cyperus rotundus* L., *Argemona mexicana* L., *Celosia argentea* L., *Digera arvensis* L., *Euphorbia hitra*, *Launea splinifolia*, *Cynodon dactylon*. In Uttaranchal, *Galinsoga parviflora* Cav., *Oxalis latifolia*, *Echinochloa colonum*, *Digera arvensis*, *Digitaria sanguinalis*, *Ageratum conyzoides*, *Commelina benghalensis* L., *Celosia argentea* L., *Cyperus rotundus* L., *Cynodon dactylon* Pers., *Digitaria sanguinalis* are pre dominated weeds (Ved Prakash *et al.*, 2003).

Shaikh (2005) observed that dominant weeds were *Brachiaria eruciformis*, *Cynodon dactylon*, *Dinebra retroflexa*, *Cyperus rotundus*, *Parthenium hysterophorus*, *Digera arvensis*, *Merremia emarginata*, *Acalypha indica*, *Chrozophora rottleri*, *Euphorbia hirta*, *Convolvulus arvensis*, *Corchorus acutangulus*, *Lagasca mollis* Cav. and *Physalis minima* L.

The literature clearly indicates that the weed flora of chilli comprises of a large number of species of grassy and broad leaf weeds and perennial sedges. The most common monocot weeds noticed in chilli are *Cynodon dactylon* L. Pers., *Cyperus rotundus* L. Pers., *Panicum isachne* Roth., *Dactyloctenium aegyptium* Beauv., *Commelina benghalensis* L., *Digitaria sanguinalis* L. Scop., *Setaria spp.*, *Panicum spp.* and dicot weeds are *Gynandropsis pentaphylla* L., *Trianthema portulacastrum* L., *Digera arvensis*, Forsk., *Amaranthus viridis* L. and *Phyllanthus niruri* L.

2.2 Nature of crop-weeds competition

Chilli being a widely spaced crop, the wider spacing facilitates severe competition by weeds particularly in the early stages. Crop plants vary greatly in their ability to compete with associate weeds. The problem of crop-weed competition in field depends upon the relative merits of weed species, crop varieties, seasonal and annual cycles, tillage and rotational practices.

Under rainfed conditions, moisture is the sole limiting factor in crop production. Arakeri *et al.* (1962) observed that an increase of yield by 10 to 15 per cent by avoiding transpiration through weeds by means of clean cultivation.

Moolani and Sachan (1966) opined that weeds are adapted to rapid multiplication and better dissemination. The weeds compete at every stage of crop for nutrient, moisture, carbon dioxide and space, thus reducing the quality and quantity of yield. There is a great variation in competitive ability of crop plants with a quick start and better establishment.

Dense vegetation canopy effectively suppress the weed growth, whereas slower growing ones tends to become infested with weeds (Sweet *et al.*, 1974).

Nanjappa (1980) defined crop-weed competition as a natural force, where in crop plants and weeds tends to attain a maximum combined growth and yield with the development of each species, being to some extent at the expense of other. This occurs when the demand of both the species for moisture, nutrients, light and possibly carbon dioxide exceed the available supply.

Pandey (2000) reported that weeds depleted crops environment of nutrients, water and light thus, yields of chilli was reduced considerably. In addition, weeds cause spread of several diseases and pests. The quality of produce is also reduced by weed infestation.

Khokhar *et al.* (2006) reported that pendimethalin and oxadiazon at 0.825 and 0.240 kg a.i. ha⁻¹, respectively were applied one week before and two days after transplanting and their efficacy alone and in combination with one manual weeding was reduced weed competition and its effects on fruit yield.

2.3 Losses caused by weeds

Weeds in chilli crop cause a considerable reduction in fruit yield by suppressing the growth of chilli due to slow growth habit and short stature of the later. Weeds are the potential competitors with crop plants as a result of which they cause marked reduction in the chilli fruit yield. The losses depend upon the density of weeds, duration of weeds, types of weed species and crop competing ability.

Bhalla and Nakhatore (1980) observed that the losses in yield in rainfed chilli due to weeds to an extent of 60 to 70 per cent while, Adigun *et al.* (1991) reported that the seasonal long competition by weeds causes yield reduction in chilli ranging from 40 to 90 per cent.

Torner *et al.* (1993) reported that presence of one black night shade (*Solanum nigrum*) weed with every 50 cms in the crop rows of transplanted pepper resulted in yield loss of 48 per cent.

Ved Prakash *et al.* (2003) reported that weed infestation is the major limiting factor in realizing potential yield of *Capsicum*, resulting in heavy reduction in the yield as high as 78 per cent.

Patel *et al.* (2004) reported that chilli fruit yield losses ranges between 60 to 70 per cent depending upon the weed flora and intensity of weeds.

Khokhar *et al.* (2006) reported that compared to weed free condition, weed-crop competition caused 30.1 and 46.4 per cent reduction in the fruit yield during the first and second year.

2.4 Critical period of crop-weed competition

The critical period of weed competition is period of time during which weeds must be controlled to prevent statistically significant yield losses.

Eshel *et al.* (1973) reported that pepper yields were reduced by 70 percent when weeds invaded during the first month after direct seeding.

Labrada and Paredesh (1983) asserted that the critical period of weed interference in pepper lies between 20 to 40 days after transplanting. Tei (1986) reported that critical period of interference by *Echinochloa crus-galli* (L.) Beauv in pepper was from 25 to 30 days after transplanting.

Frank *et al.* (1988) observed that the weed interference period is approximately 40 to 60 days reducing both the pepper fruit number and weight. Also during this period crop-weed competition was maximum.

Singh *et al.* (1993a) reported that most critical period for crop weed competition was from 30 to 45 days after planting and weeds must be removed during this period.

Gonzalez *et al.* (1995) reported that pepper fruit yield was reduced, whenever (*Solanum nigrum*) weed reached a greater height than the crop plants.

In a field experiment at Kanpur in transplanted chilli, keeping the field free of weeds between 15 and 60 days after transplanting appeared to be optimum for obtaining economic yield (Anon., 1996^a).

Weeding after 60 days of transplanting could not increase the fruit yield significantly. A weed free period of 60 days after transplanting is required for optimum yield of chilli. (Anon., 1996^c). Keeping the plots weedy throughout the season reduced the dry chilli yield by 75.86 per cent (Anon., 1997).

Amador-Ramírez (2002) observed that maximum weed-infested period ranged between 0.7 and 3.2 weeks after transplanting (WAT) at a five per cent yield loss level. To prevent losses in total and marketable yields, weeds should be removed 2.1 or 0.9 WAT, respectively. The end of the critical period decreased as the predetermined yield loss level

increased from 2.5 per cent to 10 per cent. The minimum weed-free period ranged between 6.7 and 15.3 WAT at a five per cent yield loss level depending on crop yield category. The chilli pepper crop required an average of 12.2 weeks of weed-free maintenance to avoid losses above 5 per cent. Using a five per cent yield loss level, the duration of the critical period of weed control was 14 weeks. Weeds must be controlled during the first half of the crop's growing season in order to prevent yield losses.

Ved Parkash *et al.* (2003) reported that Seasonal-long crop-weed competition reduced the average fruit yield by 98.1 per cent compared to frequent weeding.

2.5 Effect of weed competition

Weeds are most universal of all pests, proliferating in varying number each year on every farm. Because of their universal presence, there is a tendency to regard weeds as an unavoidable problem in farming.

2.5.1 Effect on growth and yield parameters of chilli

Klingmen (1961) reported that crop was suppressed by the vigorous growth of weeds. Many workers have emphasised that effect of weeds on the growth and yield components ultimately decides the yield. The reduction may occur as a result of competition between the crop and weed for nutrients, water, space and light.

Singh *et al.* (1985) reported that effective weed control by different weed management treatments increased the growth and yield of chillies.

Tei (1986) reported that weed competition in transplanted pepper decreased leaf area index, shoot dry weight, plant height and branches. Yield reduction was observed mainly due to a decrease in the number of fruits per plant.

Adigun *et al.* (1987) reported that unchecked weed growth throughout the crop life cycle resulted in an 86-90 per cent reduction in potential chilli pepper fruit yield.

Frank *et al.* (1988) studied the addition effects of weed cover and insects on pepper production. Weeds covered less than 10 percent of test plots; the natural insects' population reduced the marketable fruit yield of bell pepper 32 percent in 1983 & 22 percent in 1994. When weeds covered 72 or 94 per cent of the plots, foliage damage due to insects was from 5.8 to 12.1 per cent, respectively. The high percent weed cover and insects reduced yield by 99 per cent. The average fresh weight of pepper foliage approached zero as weed cover reached maximum. Foliar levels of iron and aluminium reduced greatly in peppers grown in competition with a 100 per cent weed cover. The level of boron, copper, phosphorus and potassium in pepper foliage decreased as per cent weed cover increased.

Sharma *et al.* (1988) reported that due to crop-weed competition, the number of fruits per plant, seed numbers per fruit and fruit weight decreased in weedy check plot. Under weed free conditions, there was 35.8 per cent increased in the fruit yield over weedy check.

Medina and Zaragoza (1992) opined that sweet pepper growth was severally affected by *Datura stramonium* after 30-45 days competition. The extent of chilli yield reduction differed with the type and the number of weeds.

Schroeder (1992) reported that *Physalis wrightii* and *Amaranthus blitoides* reduced chilli pepper yield by 33 per cent, *Flaveria trinervia* by 19 per cent and *Physalis wrightii*, *Amaranthus palmeri*, *Chenopodium album* by 61 to 76 per cent in untreated plots.

Lanini and Strange (1994) opined that when the weed-free condition was maintained for the entire season, bell pepper yield was 4 to 18 per cent higher than in other treatments.

The study conducted at APAU, Hyderabad (Anon., 1995) revealed that unweeded check recorded significantly the lowest yield of chilli due to the more competition from weed. The study conducted at Kanpur (Anon., 1996) revealed that competition with five and 10 plants/m² of *Commelina benghalensis* caused 21.73 per cent and 26.73 per cent reduction in fruit yield.

Gonzalez *et al.* (1995) reported that pepper fruit yield was reduced, whenever *Solanum nigrum* weed reached a greater height than the crop plants.

Adigun (2001) opined that unchecked weed growth throughout the crop life cycle resulted in an 81–90 per cent reduction in potential chilli pepper fruit yields.

Amador-Ramírez *et al.* (2007) reported that internodes length, stem diameter and plant height were always higher under weed free conditions with an increased period without weed interference when compared to weed interference. Internode length, stem diameter and plant height started decreasing after eight or more weeks of weed interference. At least four tonnes weed dry matter ha⁻¹ was recorded for treatments with increasing periods of weed interference. This was enough to decrease crop yield up to 67 per cent.

2.6 Methods of weed control and their effects on weed growth, yield attributes and yield

Timely weed control in chilli crop is one of the important agronomic practices for increased productivity. In a tropical country like India, availability of abundant sunshine and adequate fertilisers applied to the crop after transplanting trigger growth of weeds in the chilli fields.

2.6.1 Chemical method of weed control

Where labour is scarce and expensive, use of herbicides hold a good promise for timely, effective and efficient weed control. Since most weeds emerge either before or along with the crop, the use of pre-sowing incorporation and pre-emergence herbicides is a better management practices.

The choice of herbicides for a particular situation will depend upon the climate, soil type, prevalent weed species, crop cultivar and method of propagation and management.

2.6.1.1 Butachlor

The study conducted at Hyderabad (Anon., 1995) reveled that pre-emergence application of butachlor @1.0 kg ha⁻¹ followed by one intercultivation at 30 DAS significantly reduced the weed dry weight and increased the crop growth and chilli fruit yield.

At Dharwad, Narasalagi (1999) reported that pre-emergence application of butachlor @ 1.0 kg ha⁻¹ followed by one hand weeding at 45 DAS significantly reveled lower weed dry weight and increased the crop growth and yield in directed seeded chilli + onion intercropping study.

2.6.1.2 Alachlor

The study conducted by Rajagopal *et al.* (1976) on chilli revealed that alachlor 1.5, 2.0 & 2.5 kg ha⁻¹ resulted in early weed control of annual weeds. But higher yield was recorded in pre-emergence application of alachlor 1.5 kg ha⁻¹ + one hand weeding at 30 DAT compared to pendimethalin application alone.

Bhalla and Nakhatore (1980) reported that pre-plant application of alachlor @ 2.0 kg ha⁻¹ + one HW recorded the lowest dry weight of weeds, increased the yield and maximum weed control efficiency as compared to control in chilli.

Joshi *et al.* (1995) reported that application of alachlor @ 1.25 kg a.i.ha⁻¹ or pendimethalin @ 0.75 kg a.i.ha⁻¹ as pre-emergence suppressed the weeds significantly and also recorded higher chilli yield.

Ved Prakash *et al.* (1999) reported that alachlor 3.0 kg ha⁻¹ + hand weeding at 45 DAT resulted in excellent control of weeds closely followed by alachlor 2.0 kg ha⁻¹ + HW at 45 DAT. Pendimethalin was effective against grassy as well as broad leaf weeds, whereas fluchloralin was effective against broad-leaf weeds in chilli.

Narasalagi (1999) reported that alachlor 1.5 kg ha⁻¹ and fluchloralin 1.0 kg ha⁻¹ were effective in controlling *Commelina benghalensis*, *Amaranthus viridis* and *Physalis minima* in directed seeded chilli crop.

Rajput *et al.* (2003) opined that alachlor 3.0 kg ha⁻¹ + hand weeding 45 DAT significantly reduced the weed population and dry-matter accumulation. Alachlor 2.0 kg ha⁻¹ + hand weeding 45 DAT was equally effective in reducing the dry weight of weeds compared to its higher concentration.

2.6.1.3 Pendimethalin

Singh *et al.* (1985) reported that pendimethalin, fluchloralin and oxadiazon at 1.0 kg ha⁻¹ controlled the weed effectively and increased the growth and yield of chilli.

Singh *et al.* (1992) opined that highest yield was obtained when pendimethalin (1.0 kg ha⁻¹) plus oxyfluorfen (0.15 kg ha⁻¹) when applied as pre-emergence (one day before transplanting) and it increased 77.6 and 41.4 per cent fruit yield over the weedy check and hand weeding done at 20 and 40 days after transplanting, respectively. Weed control efficacy increased with increasing levels of herbicides.

Ajaykumar and Thakral (1993) opined that pre-emergence application of pendimethalin @ 1.25 kg a.i.ha⁻¹ recorded minimum weed dry weight (2352 kg ha⁻¹) which was significantly lower than oxyfluorfen @ 0.25 kg a.i.ha⁻¹ with or without hoeing or hand weeding twice 30 and 60 DAT (3248 kg ha⁻¹ and 3555 kg ha⁻¹, respectively). Dry weight of weeds had significant negative co-relation with yield. Pre-emergence application of pendimethalin at 1.25 kg ha⁻¹ + one hoeing 45 DAT resulted in maximum number of branches (7.96 plant⁻¹), plant spread (2412.3 cm² plant⁻¹) and fruits per plant (182.30) recorded at 60 DAT as compared to control (2.60 plant⁻¹, 535.2 cm² plant⁻¹ and 43.40 plant⁻¹, respectively). They attributed that with increase in plant spread, light interception by the crop might have increased, resulting in more availability of assimilates which in turn increased the growth and yield attributes and thus total yield increase. Plant spread had a significant positive co-relation with fruit yield.

Muthusankaranarayanan *et al.* (1997) opined that pre-emergence application of pendimethalin @ 1.0 kg ha⁻¹ was found effective in lowering the weed density and weed dry matter in chilli + coriander inter cropping system than chilli + onion system and sole chilli at Kovilpatti.

Narasalagi (1999) reported that most of the weeds except *Cynodon dactylon*, *Cyperus rotundus*, *Ageratum conyzoides*, *Commelina benghalensis* and *Cynotis cristata* were found susceptible to pendimethalin 1.5 kg ha⁻¹.

Adigun (2001) opined that selective weed control with consequent high chilli pepper fruit yields were comparable to the hoe-weeded control with pre-emergence application of oxadiazon + prometryn; metolachlor + CGA and pendimethalin + terbutryn each at 1.5 + 1.0 kg a.i. ha⁻¹ in wet season.

Ved Prakash *et al.* (2003) opined that weed- control efficiency ranged from 7.6 to 88.0, being maximum under repeated weeding (88.0) and minimum in pendimethalin alone (7.6). Weed index varied from 16.2 to 98.1, being the lowest and highest under alachlor 3.0 kg ha⁻¹ along with hand-weeding (HW) at 45 days after transplanting (DAT) and unweeded check, respectively. In herbicidal treatments, alachlor at 3.0 kg ha⁻¹, followed by HW at 45 days after transplanting (DAT) recorded the highest weed- control efficiency (WCE) (70.1-74.9) and minimum weed index (15.8-16.2), closely followed by alachlor 2.0 kg ha⁻¹ HW 45 DAT. Significant improvement in plant height, number of fruits and fruit weight plant⁻¹ was registered due to all weed- control measures except pendimethalin alone at 1.0 kg ha⁻¹ and fluchloralin alone at 1.0 or 2.0 kg ha⁻¹ in both the years. The highest plant height (71 cm), fruits plant⁻¹ (12.4) and fruit weight plant⁻¹ (551) were recorded under repeated weeding, followed by alachlor 3.0 kg ha⁻¹ + HW 45 DAT.

Frost and Hingston (2004) reported that most effective herbicides were pendimethalin, clomazone and oxadiargyl, which gave best results when applied pre-crop transplanting. All the herbicides provided effective pre-emergent control of a range of common broadleaf and grass weeds across a number of sites.

Patel *et al.* (2004) reported that dry weed weight recorded at 45 days after transplanting was significantly lower in three HW and was at par with three hand weeding and hand hoeing and application of pendimethalin at 1.0 kg ha⁻¹ as pre – transplant supplemented with HW at 45 DAT. Weed control efficiency was between 89.4 to 97.3 per cent in these treatments among herbicidal treatments; significantly lower weed dry weight was recorded in pre-transplant application of pendimethalin, which was at par with all the herbicidal treatments except pre-transplant or post- transplant application of metolachlor due to non control of *Boerhavia diffusa*.

Shaikh (2005) reported that weed control efficiency (>80%) was recorded in hand weeding, oxyfluorfen at 0.10 kg ha⁻¹ and pendimethalin at 0.75 kg ha⁻¹ supplemented with hand weeding at 45 DAT. The mean chilli yield was higher in pendimethalin (9.62 t ha⁻¹) @ 0.75 kg ha⁻¹ fb weeding at 45 DAT and oxyfluorfen 0.10 kg ha⁻¹.

Drill sown chilli yield was higher (298.30 kg ha⁻¹) with pendimethalin 1.0 kg ha⁻¹ as pre emergence spray + hand weeding and was on par with oxadiargyl 0.09 kg ha⁻¹ + hand weeding (Agasimani and Channappagoudar, 2005).

Gulshan-Marajan *et al.* (2006) reported that black polyethylene mulch along with pendimethalin 1.0 kg ha⁻¹ provided good control over weeds and resulted in the highest yield (241.9 q ha⁻¹) followed by sole plastic mulching treatment (219.4 q ha⁻¹). The unweeded control treatment registered only 30.2 q ha⁻¹ red chilli yield.

2.6.1.4 Oxyfluorfen

Semidey *et al.* (1989) reported that pre-plant application of oxyfluorfen at 0.14 kg ha⁻¹ alone or combined with metolachlor at 2.24 kg ha⁻¹ and pendimethalin at 1.65 kg ha⁻¹ gave excellent control of broad leaved weeds during first 3 week. Oxyfluorfen at 0.40 kg ha⁻¹ supplemented with one HW six weeks after transplanting registered highest chilli yield.

Singh *et al.* (1991) studied the economics of herbicides in bell pepper at Solan (H.P) and they reported that application of pendimethalin (1.0 kg ha⁻¹) + oxyfluorfen (0.15 kg ha⁻¹) proved distinctly superior in terms of additional yield and net profit followed by application fluchloralin (1.0 kg ha⁻¹) + pendimethalin (1.0 kg ha⁻¹) + oxyfluorfen (1.15 kg ha⁻¹)

Singh *et al.* (1992) reported that combined application of fluchloralin at 1.0 kg ha⁻¹ plus pendimethalin at 0.15 kg ha⁻¹ plus oxyfluorfen at 1.0 kg ha⁻¹ reduced the population and weed dry weight on an average by 41 and five and 76 and 30 per cent compared to weedy check and hand weeding done at 20 and 40 days after transplanting.

Singh *et al.* (1995) reported that oxyfluorfen @ 0.3 kg ha⁻¹ significantly reduced the weed density compared with fluchloralin @ 1.0 kg ha⁻¹, oxyfluorfen @ 0.1 kg ha⁻¹ and metolachlor @ 0.5 and 0.75 kg ha⁻¹. Oxyfluorfen, pendimethalin and fluchloralin at all the levels controlled the wild amaranth and horse purslane significantly compared with the weedy control. The lowest number of these weeds was recorded by oxyfluorfen @ 0.3kg ha⁻¹, thus showing 98.9 and 99.0 per cent control, respectively. It was followed by oxyfluorfen @ 0.2kg ha⁻¹. Application of oxyfluorfen at all levels was found effective in controlling fly roost leaf flower recording 1.3 weeds m² at 0.3 kg ha⁻¹ compared with 22.6 m² recorded under the weedy control. Other herbicides could not control this weed significantly. Thus, oxyfluorfen @ 0.3 kg ha⁻¹ was found the most effective against all the weeds (95.2%), recording the lowest number of total weeds (10.3 m⁻²), followed by oxyfluorfen @ 0.2 kg ha⁻¹ (86.8%). Oxyfluorfen @ 0.1 kg ha⁻¹ and pendimethalin @ 1.0 kg ha⁻¹ also showed effective control of total weeds (77%).

Narasalgi (1999) at Dharwad evaluated herbicides in directed seeded onion + chilli intercropping system. He reported that among dicots, lowest density of *Commelina benghalensis* (1.90%) and *Ageratum conyzoides* (1.90%) were noticed with oxyfluorfen 0.15 kg ha⁻¹ + one hand weeding.

Yadav (2001) opined that oxyfluorfen (0.2 kg ha⁻¹) combined with two hoeing at 30 and 60 DAT significantly reduced the dry weight of both grassy and broad-leaf weeds compared to oxyflourfen (0.2 or 0.3 kg ha⁻¹) with one hoeing. Pendimethalin (1.0 kg ha⁻¹) + one hoeing controlled grassy weeds as effectively as the oxyflourfen at 0.2 or 0.3 kg ha⁻¹ with two hoeing but oxyflourfen (0.3 kg ha⁻¹) + one hoeing was more effective on broad-leaved weeds compared to pendimethalin.

At Ludhiana, green chilli fruit yield was significantly higher in oxyfluorfen than other herbicides. The yield ranged from 142.4 q ha⁻¹ to 170.2 q ha⁻¹ (Anon., 2005^c).

2.6.1.5 Diclosulam

Scott *et al.* (2001) reported that dimethenamid plus diclosulam or flumioxazin pre-emergence controlled common lambsquarters, *Eclipta*, and prickly sida at least 91 per cent in peanut. Diclosulam and flumioxazin provided variable control of three *Ipomoea* species (59 to

91%) and bentazon plus acifluorfen post-emergence provided > 90 per cent control. Only diclosulam systems controlled yellow nutsedge 90% late season.

Andrew and John (2002) reported that diclosulam pre-emergence alone or dimethenamid plus diclosulam pre-emergence controlled yellow nut sedge by 65 to 100 and dimethenamid pre-emergence controlled common ragweed by 82 per cent in peanut, whereas diclosulam pre-emergence or dimethenamid plus diclosulam pre-emergence controlled common ragweed by 99 per cent.

Grichar *et al.* (2004) reported that diclosulam alone or in combination with ethalfluralin-applied preplant incorporated, pre-emergence or post-emergence at 0.009 to 0.024 kg a.i.ha⁻¹ provided at least 93 per cent season-long *Eclipta* control in peanut. Ethalfluralin, in combination with diclosulam-applied pre-plant incorporation at 0.016 or 0.024 kg a.i.ha⁻¹ controlled *Cyperus esculentus* at least 82 per cent season-long.

2.6.1.6 Haloxypop

Abdullahi *et al.* (2000) reported that haloxypop and fluazifop-p applied at high rates reduced *Cynodon dactylon* shoot dry weight by 80, and 59 per cent, respectively and reduced grass shoot dry weight by 77 and 86 per cent, respectively in sunflower crop.

Suresh Kumar *et al.* (2008) reported that haloxypop at 0.100 kg ha⁻¹ (72%) and acetachlor 1.50 kg ha⁻¹ (73.3%) resulted in highest weed control efficiency among post-emergent and pre-emergent herbicides, respectively tried in soybean. Haloxypop at 0.100 kg ha⁻¹ and quizalofop at 0.625 kg ha⁻¹ were effective against grassy weeds (*Panicum*, *Echinochloa* and *Digitaria*). Acetachlor was most effective against grassy as well as broad-leaved weeds (*Ageratum conyzoides*, *Polygonum alatum* and *Commelina benghalensis*). Haloxypop at 0.100 and 0.125 kg ha⁻¹, quizalofop 0.0625 kg ha⁻¹, acetachlor 1.50 kg ha⁻¹ and trifluralin 1.50 kg ha⁻¹ resulted in significantly higher plant dry weight, branches plant⁻¹, pods plant⁻¹, seed/plod, 1000-seed weight and seed yield of soybean.

2.6.2 Mechanical and cultural methods

Mechanical and cultural methods of weed control are most common methods. Although herbicides are fast replacing the traditional methods, mechanical and cultural methods are still practiced in India.

Whenever possible it would be better to prevent the outgrowth of weeds rather than to control them after their establishment (Krishnashastry, 1957). Optimum planting date and spacing have been recognized as important agronomic measures to control weeds (Phillip, 1960). In addition to these practices, Asalam *et al.* (1989) have emphasized the use of certified seeds, removal of source of infestation, use of well decomposed manure, clean cultivation, proper crop rotations, proper maintenance of water channel and bunds, as some of the preventive methods of weed control.

Rangaswami (1984) reported that tractor ploughing followed by harrowing reduced weed weight (44.00 g plot⁻¹), increased root weight (11.98 g plot⁻¹) and yield (11.10 q ha⁻¹) of chilli, as compared to no tillage (9.00 q ha⁻¹).

Lanini and Strange (1994) reported that weed cover in hand weeding at 2, 4, 6 and 8 week after transplanting was significantly lower (74.5%, 36.0%, 30.5% and 11.5%, respectively) than other treatments and it was on par with the 2, 4 and 6 WAT. The green chilli yield produced in hand weeding at 2, 4, 6 and 8 WAT was maximum (17915 kg ha⁻¹) but it was on par with 2, 4 and 6 WAT.

Narasalagi (1999) at Dharwad, the reported lowest weed dry weight and the highest weed control efficiency was in weed free check followed by butachlor 1.0 kg ha⁻¹ coupled with HW at 45 DAS and farmers practice. Drill sown chilli fruit was highest in weed free check.

Patil (1999) reported significantly higher dry chilli (transplanted) yield from the plots which were kept weed-free throughout the crop growth period.

Patel *et al.* (2004) while studying the effect of cultural and chemical methods on weeds in transplanted chilli. They reported significantly higher green chilli fruits yield from three hand weeding + three hand hoeing.

Amador- Ramirez *et al.* (2006) reported that weeds are mainly controlled by mechanical means such as cultivation and hand hoeing increasing production costs.

2.7 Phytotoxicity of herbicides

Krishnamurthy (1971) studied the percentage establishment of chilli seedlings under different herbicidal treatments. He found that at three week after spray establishment was better and it was 93 per cent in tok- granular 5 kg ha^{-1} , 92 per cent in Pentachlorophenol (P.C.P) 2.5 lit ha^{-1} , 91 per cent in diuron 1.25 kg ha^{-1} , 90 per cent in captam 2.5 l ha^{-1} and 84 per cent in Stam F-34 2.5 lit ha^{-1} . These compared favourable with the control plot ($1000 \text{ lit water ha}^{-1}$), which gave 95 per cent establishment. The result showed that the triazine compounds like simazine 1.25 kg ha^{-1} and atrazine 1.25 kg ha^{-1} were toxic to chilli crop, perhaps through their longer persistence in the soil.

Saimbhi and Randhawa (1976) stated that pre-plant application (one day before planting) of linuron $0.30 \text{ kg a.i. ha}^{-1}$ showed adverse effect on seedling setting and thus a high percentage of seedling mortality was recorded in chilli, particularly when these were combined with pre-plant application of EPTC @ 3.75 kg ha^{-1} .

The study conducted at Anand (Gujarat) (Anon., 1996c) revealed that oxyfluorfen 0.24 kg ha^{-1} was phytotoxic to chilli plants of evidenced by drying of growing plants after transplanting.

Oxyfluorfen showed mild initial toxicity to the chilli crop and this recovered in due course of time at PAU, Ludhiana (Anonymous, 2005c).

Narasalagi (1999) reported that application of pendimethalin 1.50 kg ha^{-1} caused severe injury to the direct seeded chilli crop and some stand loss at 15 days after sowing. Injury was more pronounced with oxyfluorfen 0.15 kg ha^{-1} during the initial stages but not persistent at subsequent stages. In butachlor, 1.0 kg ha^{-1} treated plots though slight stunting and injury was noticed the crop recovered soon. Pendimethalin 1.50 kg ha^{-1} maintained its phytotoxicity on chilli even up to 90 DAS. At 60 DAS and thereafter, phytotoxicity of all herbicides disappeared except pendimethalin 1.5 kg ha^{-1} .

Patel *et al.* (2004) reported that post-emergent application of linuron (0.25 kg ha^{-1}) was phytotoxic when chilli crop was 6-8 true leaf stage while, ethalfuralin and rimsulfuron (0.83 kg ha^{-1} and 8 g ha^{-1} , respectively) produced the temporary symptoms of phytotoxicity. Post-transplant application of oxadiazon, oxyfluorfen and metolachlor caused phytotoxicity to chilli crop. Metolachlor applied even as pre-plant showed toxicity on chilli. Crop growth was also severely affected under black polyethylene mulch treatment due to higher soil temperature as compared to no mulch ($37.0 \text{ }^\circ\text{C}$), which restricted root growth of chilli at early stage.

2.8 Economics of weeds control

Sharma *et al.* (1988) reported that highest net returns of Rs. $13,000 \text{ ha}^{-1}$, when fluchloralin applied as pre-plant application @ $0.48 \text{ kg a.i. ha}^{-1}$ and one hoeing 25 DAT in chilli. Fluchloralin @ $1.44 \text{ kg a.i. ha}^{-1}$ and fluchloralin @ $0.96 \text{ kg a.i. ha}^{-1}$ + one hoeing were next in order. Nitofen was also economical in checking weeds, when it was used as pre-plant incorporation spray and one hoeing but 2,4 D in general showed poor performance because of its phytotoxic effect on plant. The minimum weed index was also found with fluchloralin @ $0.48 \text{ kg a.i. ha}^{-1}$ + one hoeing in transplanted chilli.

Singh *et al.* (1991) reported that herbicides either alone (at varied rate) or in combination with hand weeding gave higher profit in transplanted chilli compared to weedy check. The higher net profit of Rs. 18379 ha^{-1} were obtained from pre- emergence application of pendimethalin @ $1.0 \text{ kg a.i. ha}^{-1}$ + oxyfluorfen @ $0.15 \text{ kg a.i. ha}^{-1}$ which was on par with fluchloralin @ $1.0 \text{ kg a.i. ha}^{-1}$ + pendimethalin @ $1.0 \text{ kg a.i. ha}^{-1}$ and oxyfluorfen @ $0.15 \text{ kg a.i. ha}^{-1}$ (Rs. 16536 ha^{-1}).

Biradar (1999) reported higher net income in weed free check followed by glufosinate ammonium @ 0.90 kg ha^{-1} and alachlor @ 2.0 kg ha^{-1} , both in combination with intercultivation at 40 and 60 DAT + HW at 45 and 75 DAT in transplanted chilli.

Narasalagi (1999) observed higher net returns were with weed free check and butachlor 1.0 kg ha⁻¹ + HW at 45 DAS, but the latter treatment recorded the highest benefit: cost ratio in direct seeded chilli.

Yadav (2001) observed that higher net return was obtained in oxyflourfen at 0.3 kg ha⁻¹ + two hoeing (Rs 24,992 ha⁻¹), closely followed by lower dose of oxyflourfen (0.2 kg ha⁻¹) with two hoeing (Rs. 24,515 ha⁻¹). However, higher benefit: cost ratio was obtained in lower dose of oxyflourfen (0.2 kg ha⁻¹) with two hoeing closely followed by oxyflourfen at 0.3 kg ha⁻¹ + two hoeing in transplanted chilli.

Ved Prakash *et al.* (2003) observed that repeated weeding treatment recorded the higher net return (Rs79, 890 ha⁻¹), followed by alachlor 3.0 kg ha⁻¹ + HW 45 DAT (Rs. 73,326 ha⁻¹) however, later treatment provided more net profit rupee⁻¹ invested (Rs. 8.2) than former treatment (Rs.4.2). Application of alachlor 2.0 kg ha⁻¹ alone proved the best from net profit rupee⁻¹ investment point of view (Rs.12.1) in transplanted chilli.

Patel *et al.* (2004) reported that three hand weeding and hoeing gave highest net profit (Rs. 65253 ha⁻¹) and benefit: cost ratio (2.68) followed by three hand weeding (Rs. 63053ha⁻¹) and pre-transplant application of pendimethalin supplemented with hand weeding at 45 DAT (Rs. 60080 ha⁻¹) in transplanted chilli.

Shaikh (2005) reported higher net monetary returns (Rs.55.70 thousand ha⁻¹ in pendimethalin at 0.75 kg ha⁻¹ fb hand weeding at 45 DAT over weedy check and fluchloralin at 1.35 kg ha⁻¹.

Agasimani and Channappagoudar (2005) in onion + chilli intercropping system, reported higher net return (Rs. 44,075 ha⁻¹) and B: C ratio (9.52) with pendimethalin + hand weeding at 40 DAS.

Khokhar *et al.* (2006) reported that application of oxadiazon one week before transplanting of chilli in combination with one hand weeding at 45 DAT was found more effective in enhancing fruit yield and recorded the highest net returns than other treatments.

3. MATERIAL AND METHODS

The study on the evaluation of herbicides for weed control in transplanted chilli (*Capsicum annuum* L.) was undertaken during *kharif* 2008, at the Main Agriculture Research Station, University of Agricultural Sciences, Dharwad (Karnataka) under rainfed condition. The details of the materials used and the techniques adopted during the course of investigation are presented in this chapter.

3.1 Experimental site (Location)

The experiment was conducted at Main Agriculture Research Station (MARS), University of Agriculture Sciences, Dharwad in plot number 130 of E block. Dharwad is located at 15° 26' N latitude, 75° 07' E longitude and on an altitude of 678 m above mean sea level. The research station comes under Northern Transition Zone (Zone-8) of Karnataka which lies between the Western Hilly Zone (Zone-9) and Northern Dry Zone (Zone-3).

3.2 Soil characteristics of the experiment site

The experiment was laid out on black clay soil. Composite soil samples were collected from experimental site at a depth of 0 to 30 cm before transplanting of chilli and were analysed for various physical and chemical characteristics. The data of soil analysis along with method employed are furnished in Table 1.

3.3 Weather and Climate

The data on weather parameters such as rainfall (mm), mean maximum and minimum temperature (°C) and relative humidity (%) recorded at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during the experimental year and the mean of the last 58 years (1950-2008) are presented in Table 2 and Fig 1.

The normal annual rainfall for the past 58 years was 768.4 mm. The maximum normal rainfall was received in the month of July (152.4 mm) followed by October (126.9 mm). The total annual rainfall during 2008-09 was 844.4 mm. Maximum monthly rainfall of 213.2 mm, was received in August, followed by 162.4 mm in September, 72.2 mm November and 60.4 mm in October. The rainfall during cropping season was 37.4 per cent higher than normal. The mean maximum temperature ranged from 35.1 (May) to 26.9°C (August) during year 2008. April, May and June months were hottest. The mean maximum temperature during past 58 years indicated that, it was maximum in April (37.3°C) followed by May (33.7°C). The minimum temperature ranged from 13.0° (January) to 21.0°C (June) during the 2008-09. The average of last 58 years indicated that the mean minimum temperature was maximum during June (22.4°C) and minimum during December (12.5°C). The relative humidity ranged from 57.5 (February) to 91.8 per cent (June) during 2008-09, while it ranged from 51.5 per cent (February) to 87.1 per cent (July) during the last 58 year.

3.4 Previous cropping history of experiment plot

During *kharif* the land was used for general chilli production and it was kept fallow during the *rabi* and summer seasons of 2007-08.

3.5 Experimental details

3.5.1 Treatment details

T₁ -Butachlor (Machete 50 % EC) @ 1.0 kg a.i. ha⁻¹ (Pre-emergence-PE)

T₂ .Alachlor (Lasso 50 % EC) @ 2.0 kg a.i. ha⁻¹ (Pre-emergence-PE)

T₃ .Pendimethalin (Stomp 30 % EC) @ 1.0 kg a.i. ha⁻¹ (Pre-emergence-PE)

T₄ .Oxyfluorfen (Goal 23.5 % EC) @ 0.3 kg a.i ha⁻¹ (Pre-emergence-PE)

T₅ . Diclosulam (Strongarm 84% WDG) @ 22 g a.i. ha⁻¹ (Pre-emergence-PE)

T₆ . Haloxypop (Verdict 10% EC) @ 75 g a.i. ha⁻¹ (Post-emergence-POE, 15-21 DAT)

Table 1. Physical and chemical properties of soil at the experimental field

Particulars	Value observed	Method Used
Physical properties		
Particle size analysis		International pipette method (Piper, 1966)
Coarse sand (%)	6.18	
Fine sand (%)	12.84	
Silt (%)	27.4	
Clay (%)	53.60	
Textural class	Clay	
Field capacity (%)	31.5	Field method (Dastane, 1967)
Bulk density (Mg m^{-3})	1.27	Coarse sampler method (Dastane, 1967)
Chemical properties		
Available N (kg ha^{-1})	285.61	Alkaline permanganate method (Subbiah and Asija, 1966)
Available P_2O_5 (kg ha^{-1})	40.37	Olsen's method (Jackson, 1973)
Available K_2O (kg ha^{-1})	384.23	Flame photometer (Jackson, 1973)
Organic carbon (g kg^{-1})	4.9	Wet oxidation method (Jackson, 1973)
pH (1:2.5 Soil : water)	7.7	Buckman's pH meter (Piper, 1966)
EC (dSm^{-1})	0.2	Conductometry (Jackson, 1973)

Table 2. Monthly meteorological data during crop growth period (2008-09) and the average of 58 years (1950-2008) at Main Agricultural Research Station, UAS, Dharwad

Months	Rainfall (mm)		Temperature (°C)				Mean relative humidity (%)	
	2008-09	1950-2008	Mean maximum		Mean minimum		2008-09	1950-2008
			2008-09	1950-2008	2008-09	1950-2008		
April	28.8	49.3	34.7	37.3	20.4	19.8	80.4	75.6
May	55.8	80.2	35.1	33.7	20.6	21.3	85.1	66.2
June	101.6	114.2	28.7	28.8	21.0	22.4	91.8	81.1
July	121.0	152.4	28.2	29.1	20.7	21.0	91.3	87.1
August	213.2	98.5	26.9	26.9	20.1	20.0	91.5	86.0
September	162.4	104.9	27.8	28.5	20.0	19.9	91.4	82.1
October	60.4	126.9	30.3	30.0	18.9	18.4	83.5	75.8
November	72.2	33.0	29.3	30.1	15.9	15.9	79.4	68.0
December	0.0	5.2	28.6	29.3	13.8	12.5	75.4	63.2
January	0.0	0.1	29.8	29.6	13.3	14.6	66.6	63.1
February	0.0	1.1	33.2	31.2	16.8	16.3	57.5	51.5
March	29.0	2.3	35.0	32.4	19.9	19.5	73.0	56.0
Total	844.4	768.4						

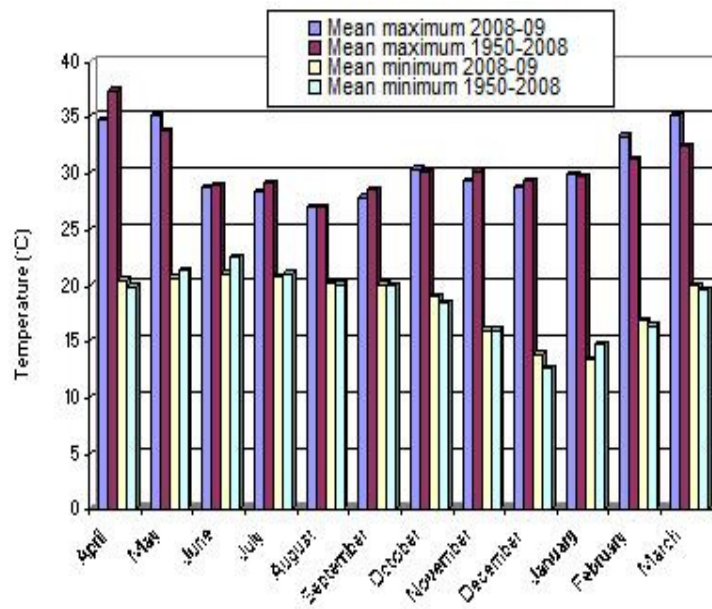
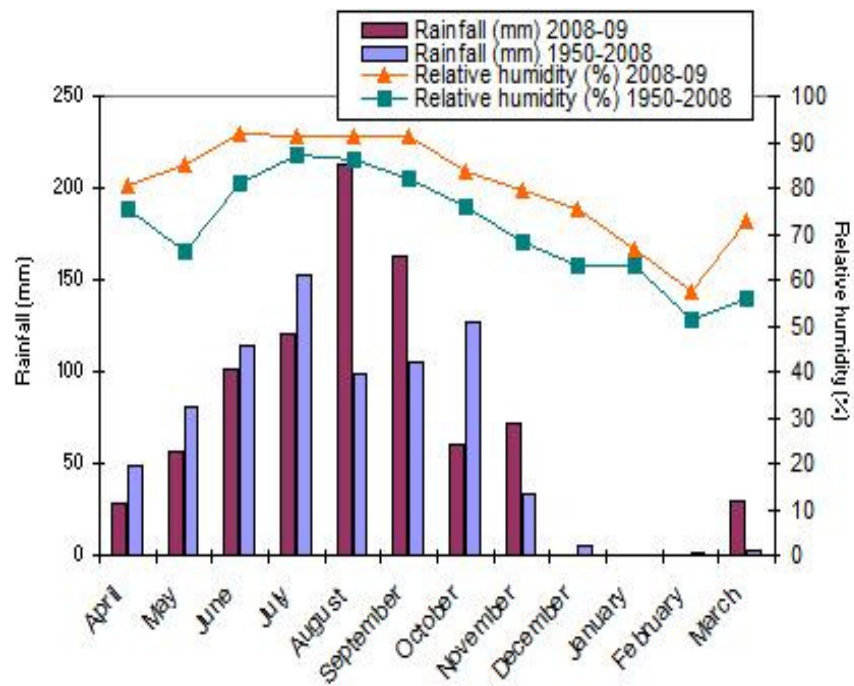


Fig.1. Monthly meteorological data during crop growth period (2008-09) and the average of 58 years (1950-2008) at Main Agricultural Research Station, UAS Dharwad

T₇ - Weed free

T₈-Weedy check

Note: Treatment 1-6 received two intercultivations at 40 and 75 days after transplanting (DAT) and one hand weeding 45 days after transplanting (DAT).

3.5.2 Design and layout

The experiment was laid out in Randomized Block Design with four replications. The plan of layout of the experiment is depicted in Fig.2.

3.5.3 Plot size

Gross size: 6.0 m x 5.40 m

Net plot: 3.6 m x 4.2 m

3.5.4 Spacing: 60 cm x 60 cm

3.5.5 Fertilizer doses: 100: 50: 50: N: P₂O₅: K₂O (kg ha⁻¹)

3.5.6 Variety

Byadagi dabbi

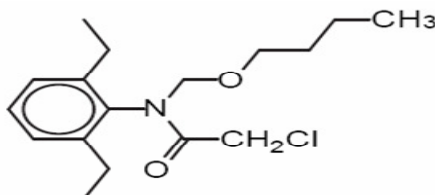
The plant grows up to a height of one meter with canopy spread of 40 to 50 cm, leaves are thick and dark green in colour. It is medium branching type. Fruit attained deep red colour on maturity and develop wrinkles on the surface. Matured fruits are 8-10 cm long with less pungency. The green and dry chilli yield potential 60 to 80 and 12- 15 q ha⁻¹, respectively.

3.6 Herbicide description

Different herbicides used in the experiment were described as given by Anon. (1983) and Anon. (1987).

3.6.1 Butachlor (C₁₇H₂₆ClNO₂)

Structural formula



Chemical name

2-chloro-2-(2,4,6-triethylphenyl)-N-(butoxy)methylacetanilide.

Introduced by Monsanto company

Trade name: Machete

Properties

It is liquid (Amber oil) in physical state having molecular weight of 311.86 with specific gravity 1.65 at 25 °C, its solubility in water is 4 ppm.

Mode of action

It is absorbed mainly by germinating shoots rather than by roots and inhibiting the germinating seedlings.

Uses

It is generally used as pre-emergence herbicides to control broad leaved weeds and grasses in rice, barley and vegetable crops.

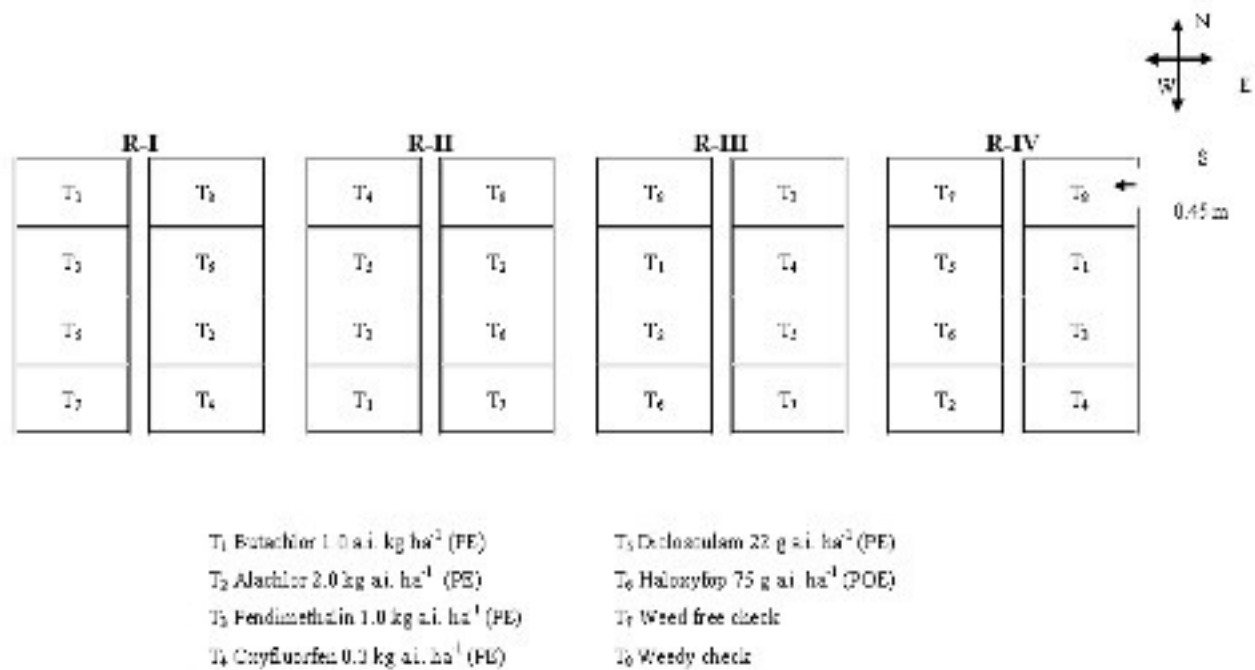


Fig. 2 Plan of layout

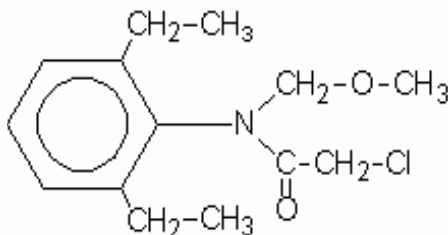
Fig.2. Plan of layout

Formulation

Emulsifiable concentration (50 % EC) and granular

3.6.2 Alachlor ($C_{14}H_{20}ClNO_2$)

Structural formula



Chemical name

2-chloro-2,6-diethyl-N-(methoxymethyl)-acetanilide

Introduced by Monsanto company (1960's)

Trade name: Lasso

Properties

Pure alachlor is a cream coloured solid having melting point at 39.5 to 41.5°C, solubility (25°C) with 242 mg/1 water, soluble in acetone, benzene, ethanol, ethyl acetate but sparingly soluble in heptane, hydrolysed under strong acid or alkaline conditions.

Mode of action

It is absorbed primarily between seed and first node of germinating seedling. It inhibits seedling emergence and root and shoots growth.

Uses

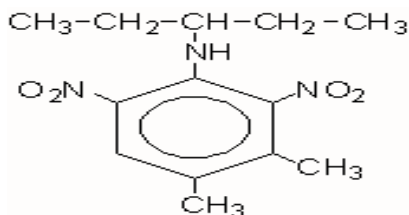
Alachlor is selective pre-emergent or early post emergent herbicide used at 1.68 to 4.48 kg ha⁻¹ to control annual grasses and many broad leaved weeds in chilli, Brassica, maize, oil rape seed, peanuts, raddish, soybean and sugarcane.

Formulation

Emulsifiable concentration (50 % EC)

3.6.3 Pendimethalin ($C_{13}H_{19}N_3O_4$)

Structural formula



Chemical name

N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitro benzenamine

Trade name: Stomp

Properties

Pendimethalin has an orange yellow colour with odourless crystals and high solubility. It is also reported to be stable to acids and alkalis and slowly decomposed by light.

Mode of action

It is selective soil applied herbicide, predominantly used for pre-emergence treatment. Inhibits the seedling or destroys the seedling.

Uses

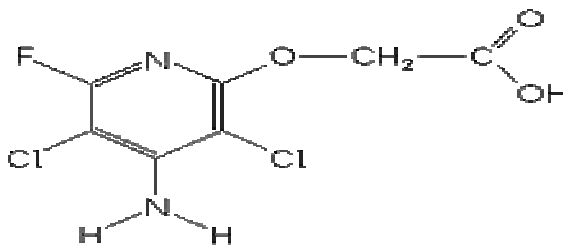
Used for pre-emergence control of annual broad leaved weeds, annual meadow grass and black grass in winter barley, wheat and rye; pre or post-emergence control of weeds in sorghum and rice; pre-plant incorporation for control in cotton, peanut, soybean, sunflower and tobacco. It controls germinating annual weeds in strawberries.

Formulation

Emulsifiable concentration (30 % EC)

3.6.4 Oxyfluorfen ($C_{15}H_{11}ClF_3NO_4$)

Structural formula



Chemical name

2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene

Introduced by Rohm and Hass Company

Trade name: Goal

Properties

It is dark brown liquid with melting point 84-85°C. It is soluble in most of the organic solvents and in water less than 1 ppm at 25°C. It is orange crystalline solid at room temperature.

Mode of action

It is used as pre and post-emergence herbicide.

Uses

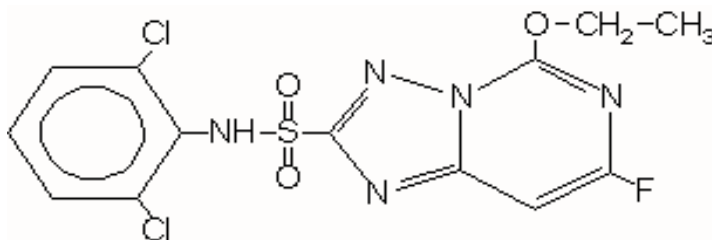
Selective herbicide for pre-emergence and/or post-emergence control of certain annual broad leaf and grassy weeds. Registered for use in artichokes, avocados, broccoli, cabbage, cauliflower, citrus, coffee, conifers, corn, cotton, mint, nut crops, olives, onion and tree fruits (Stone fruit, pome fruit).

Formulation

Emulsifiable concentration (23.5 % EC)

3.6.5 Diclosulam ($C_{13}H_{10}Cl_2FN_5O_3S$)

Structural formula



Chemical name: N-(2, 6-dichlorophenyl) -5-ethoxy-7-fluoro-

Trade name: Strongarm 84% WDG

Properties

It is dark brown granule with melting point 218-221 °C (l). Soluble in most of the water molecular substances are often soluble in organic solvents-which are themselves molecular.

Mode of action

It is selective soil applied herbicide, predominantly used for pre-emergence treatment. Inhibits the seed or destroys the seedling

Uses

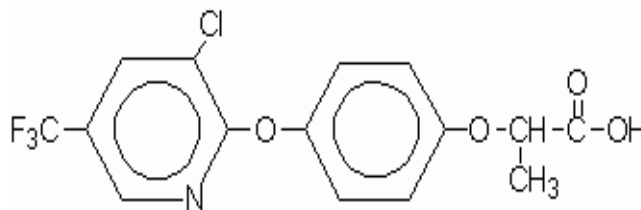
Selective herbicide for pre-emergence and or post-emergence control of certain annual broad leaf and grassy weeds.

Formulation

Emulsifiable concentration (84%WDG)

3.6.6 Haloxyfop

Structural formula



Chemical name 2-(4-(3-chloro-5-(trifluoromethyl)-2-pyridinyl) oxy) phenoxy-methyl ester

Trade name: Verdict

Properties Haloxyfop (acid) is a white crystal with an offensive odor. Haloxyfop- ethoxyethyl is a colourless crystal which is hydrolyzed to haloxyfop under acidic and alkaline conditions. The rate of hydrolysis increases with temperature. Haloxyfop-methyl is amber to straw yellow solid with a mild aromatic odor. It is stable to UV light and in high temperatures. There is no decomposition after 88 hours at 200 °C.

Mode of action

It is used as pre- and post-emergence selective herbicides.

Uses

It used as pre- and post-emergence selective herbicides. They control annual and perennial grasses in sugar beet, oilseed, potatoes, leaf vegetables, onions, sunflowers, strawberries, and other crops. Absorbed into the plant and inhibit growth.

Formulation

Emulsifiable concentration (10 % EC)

3.7 Cultural operations

3.7.1 Land preparation

The land was ploughed once with mould board plough and harrowed twice to bring the soil to a fine tilth. Stubbles and weeds were collected and disposed off. Plots were laid out as per the plan before transplanting.

3.7.2 Transplanting

The experimental plots were demarcated as per the plan of layout during the second fortnight of July (29.07 08). In each plot, with the help of marker, marking was done at a

Table 2a. Calendar of cultural operations

Sl.No.	Particular	Date of operation	Sl.No.	Particular	Date of operation
1	Land preparation			Second weeding	14.08.2008
	First ploughing (tractor)	03.06.2008		Third weeding	21.08.2008
	Second ploughing (tractor)	15.06.2008		Fourth weeding	28.08.2008
	Harrowing (bullock pair)	26.07.2008		Fifth weeding	04.09.2008
2	Plan of layout	29. 07. 2008		Sixth weeding	11.09.2008
3	Transplanting	01. 08. 2008		Seventh weeding	18.09.2008
4	Fertilizer application			Eight weeding	25.09.2008
	Basal	01.08.2008		Nine weeding	02.10.2008
	Topdressing	02.09.2008, 25.09.2008		Ten weeding	09.10.2008
5	Spraying of herbicides			Eleven weeding	16.10.2008
	Pre-emergent herbicide	03. 08. 2008		Twelve weeding	23.10.2008
	Post-emergent herbicides	18. 08. 2008		Thirteen weeding	30.10.2008
6	Plant protection			Fourteen weeding	06.11.2008
	First spraying	15..09.2008		Fifteen weeding	13.11.2008
	Second spraying	30.09.2008		Sixteen weeding	20.11.2008
	Third spraying	10.10.2008		Seventeen weeding	27.11.2008
	Fourth spraying	20.10.2008		Eighteen weeding	04.12.2008
	Fifth spraying	30.10.2008		Nineteen weeding	11.12.2008
	Sixth spraying	10.11.2008		Twenty weeding	18.12.2008
	Seventh spraying	20.11.2008		Twenty-one weeding	25.12.2008
	Eight spraying	30.11.2008	10	Picking of fruits	
7	Intercultivation			First picking	21.10.2008
	First	10. 09. 2008		Second picking	01.11.2008
	Second	10.10.2008		Third picking	18. 11. 2008
8	Hand weeding 45DAT	10. 09. 2008		Fourth picking	29. 11. 2008
9	Hand weeding (weed free plot)			Fifth picking	15. 12. 2008
	First weeding	07.08.2008	11	Harvesting	07. 01. 2009

spacing of 60 cm from row to row and plant to plant. Two healthy seedlings (6 weeks old) of chilli cultivar Byadagi dabbi were transplanted at each spot on 01.08.2008.

3.7.3 Fertilizer application

Nitrogen, phosphorus and potassium were applied in the form of urea, diammonium phosphate and muriate of potash, respectively. The entire quantity of P_2O_5 (50 kg ha^{-1}) and K_2O (50 kg ha^{-1}) and half doses of N (50 kg ha^{-1}) were applied at the time of transplanting by ring method 5 cm away from the plant. The remaining half dose of N (50 kg ha^{-1}) in the form of urea was top dressed six weeks after transplanting by ring method 5 cm away from the plant.

3.7.4 Gap filling

Gap filling was made after 10 to 12 days after transplanting to ensure uniform plant population.

3.8 Imposition of treatments

3.8.1 Pre-emergence application of herbicides

The pre-emergence application was made by spraying the herbicides on the soil surface uniformly two days after transplanting (03.08.09) of chilli seedlings with minimum trampling. A spray solution 750 l ha^{-1} was used knapsack sprayer. While applying the pre-emergent herbicides, care was taken to ensure that the herbicide drift dose not reaches to chilli plant.

3.8.2 Post-emergence application of herbicides

The post-emergence spray of haloxyfop was made by spraying the herbicide (directed spray) on the growing weeds up to 2 to 4 leaf stages using a protective shield at the nozzle of sprayer to avoid herbicide drift reaching to the crop. This operation was done on 18.08.2008.

3.8.3 Intercultivation and hand weeding

All the herbicide treatments received two interculture operations at 45 and 75 DAT. Hand weeding was carried out once in all the herbicides treatments immediately after first intercultivation (45DAT). In weed free check (T_7) treatment, the weeding was done once in a week to keep the plot free from weeds from transplanting to till harvesting.

3.8.4 Plant protection measures

The schedule of different plant protection measures taken up during the period of investigation was as follows:

Sl. No.	Chemical used	Concentration (%)	Interval of spray (Days after transplanting)	Pest control
1	Endosulfun (35% EC)	2.0 ml/ l	45, 60, 90	Cut worms
2	Monocrotophos (36% EC) + Dicofol	2.5 ml/ l	60, 80, 100, 120	Thrips, mite and aphids
3	Monocrotophos + Abamectin 1.9% EC (W/W)	2.5 ml+0.2 ml/l	45, 70, 90, 110	Thrips, mite and aphids

3.8.5 Harvesting

Green chilli fruits from the whole plot area were picked at marketable maturity. Totally five pickings were carried out starting from 80 days after transplanting. The first picking was done on 21st Oct., second on 1st Nov., third on 18th Nov., fourth on 29th Nov. and fifth on 15th Dec. 2008. Firstly, chilli fruits in the border plants around each net plot were harvested separately. After that in each treatment, fruits from the net plot were harvested and weighed separately. The green chilli fruit weight was recorded in kilograms per hectare.



Plate.1. General view of experiment at the time of transplanting



Plate.2. General view of experimental plot at 60 DAT

Observations on weeds

3.9.1 Weed control and crop toxicity rating

Visual rating (Table 3) were made at weekly interval up to 45 DAT to know the extent of weed control and the extent of toxicity caused by different herbicides on crop as given by Rao (1986 a).

3.9.2 Weed population count

The number of weeds present in each treatment in 1.0 m² area selected at random each time were counted at 30, 60, 90, 120 DAT and at harvest. They are further classified into grasses, sedges, and broad leaved weeds.

3.9.3 Dry weight of weeds (g/1.0 m²)

Dry weight of weeds was recorded at periodical intervals i.e., 30, 60, 90, 120 DAT and at harvest. The weeds were uprooted from the 1.0 m² area selected at random each time and were oven dried to a constant weight at 65 °C. The dry weight of weeds was expressed as g per 1.0 m².

3.9.4 Weed control efficiency (%)

It denotes the efficiency of the applied herbicides or herbicidal treatments for comparison purpose. It was worked out by using the formula suggested by Mani *et al.* (1973) and expressed in percentage.

$$\text{WCE (\%)} = \frac{\text{Dry weight of weeds in weedy plot} - \text{Dry weight of weeds in treatment plot}}{\text{Dry weight of weeds in weedy plot}} \times 100$$

3.9.5 Weed index (%)

Weed index is the reduction in crop yield due to the presence of weeds in comparison with weed free plot expressed as percentage. In other words weed index expresses the competition offered by weeds measured by per cent reduction in yield owing to their presence in the field (Gill and Vijayakumar, 1969).

$$\text{Weed index (\%)} = \frac{x - y}{x} \times 100$$

Where,

x = total yield from the weed free plot

y = total yield from the treatment for which weed index has to be calculated

3.10 Observations of chilli crop

3.10.1 Observations on growth parameters

For recording various biometric observations, five plants were selected at random from sample area and were tagged. From these tagged plants the following observations were recorded at 30, 60, 90, 120 DAT and at harvest.

3.10.1.1 Plant height (cm)

The plant height of chilli was measured from the base of stem to the growing tip of the plant and the mean of five plants was expressed as plant height in centimetres.

3.10.1.2 Number of branches per plant

Number of branches produced by chilli plants was counted and the average of five plants was expressed as number of branches per plant.

Table 3. Qualitative description of treatment effects on weeds and crop in the visual scoring Scale of 0 to 10

Effect	Rating	Weed	Description crop
None	0	No control	No injury , normal
Slight	1	Very poor control	Slight stunting, injury or discolouration
	2	Poor control	Some stand loss, stunting or discolouration
	3	Poor to deficient control	Injury more pronounced but not persistent
Moderate	4	Deficient control	Moderate injury, recovery possible
	5	Deficient to moderate control	Injury more persistent, recovery doubtful
	6	Moderate control	Near severe injury no recovery possible
Severe	7	Satisfactory control	Severe injury stand loss
	8	Good control	Almost destroyed a few plants surviving
	9	Good to excellent control	Very few plants alive
Complete	10	Complete control	Complete destruction

Rao (1986^a)

3.10.2 Dry matter production and its accumulation in different plant parts (g plant⁻¹)

Dry matter accumulation was studied for only above ground portion of the plant. From each plot randomly three plants were uprooted from the sample rows. They were separated into stem, leaf and fruiting parts. The partitioned samples were first air dried. Then oven dried at 65°C till a constant weight was recorded and was expressed in grammes.

3.11 Yield and yield components

During each picking, the green chilli fruits were picked separately from tagged plant for recording observations on various yield parameters.

3.11.1 Number of green chilli fruits per plant

Total number of green chilli fruits was counted from five tagged plants at different picking and the average was considered as number of fruit per plant.

3.11.2 Green fruit weight per plant

The harvested green chilli fruits were weighed. The average of this was considered as the yield per plant and expressed as grams plant⁻¹.

3.11.3 Green chilli fruit yield per hectare

Green chilli fruits picked from the plants in the net plot area and weighed. The yield obtained from five observation plants at harvest was added to this. The yield per hectare was worked out based on net plot yield all picking expressed in kg per hectare (ha⁻¹).

3.11.4 Stalk yield per hectare

Stalk was harvested separately in net plot area was sun dried up to fragile stage. The stalk weight was recorded in kilograms and converted in per hectare (ha⁻¹).

3.12 Economics

The market price of the produce at the time when produce was ready for sale was obtained from Agriculture Produce Marketing. Economics was worked out by using cost of cultivation, gross income and net income. The prices of the input that were prevailed at the time of the use were considered to work out the cost of cultivations which is given Rs. ha⁻¹ (Appendix I & II). The net income Rs. ha⁻¹ was calculated by deducting cost of cultivation from the gross income.

The B: C ratio works out as under:

$$\text{Benefit: cost ratio} = \frac{\text{Gross income (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.13 Transformation

Data on weed count have showed high degree of variation. A linear relationship between the means and variance was observed and therefore, the data on weed count was subjected to $(x+1)^{1/2}$ transformation to make analysis of variance valid as suggested by Bartlett (1947).

3.14 Statistical analysis and interpretation of data

The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Panse and Sukhatme (1967). Statistical analysis was carried out based on mean values obtained. The level of significance used in 'F' and 'T' test was P= 0.05. Critical difference values were calculated wherever 'F' test was significant.

4. EXPERIMENTAL RESULTS

The present investigation was conducted to study the bio-efficacy of pre-emergent and post-emergent herbicides behaviour in transplanted chilli. Results obtained in studying different aspects of weed control and their effect on chilli growth, yield and yield attributes are presented in this chapter.

4.1 WEED FLORA OBSERVED IN EXPERIMENTAL SITE

The important weeds belonging to grasses, sedges and broad-leaved groups observed in experimental area are given in Table 4.

4.2 WEED POPULATION

The data on weed population (grasses, sedges, broad-leaved weeds and total) recorded at 30, 60, 90, 120 DAT and at harvest was significantly influenced by different herbicides at all the above stages (Table 5-8).

4.2.1 Grasses (1.0 m⁻²)

Grassy weeds differed significantly due to different herbicides at all the stages of crop growth (Table 5).

At 30 DAT, weed free check recorded lower number of weeds (1.49) when compared all the other treatments. However, butachlor 1.0 kg ha⁻¹ (1.64), alachlor 2.0 kg ha⁻¹ (1.93), oxyfluorfen 0.3 kg ha⁻¹ (1.93) and pendimethalin 1.0 kg ha⁻¹ (1.99) found on par with weed free check. Haloxyfop 0.75 kg ha⁻¹ (2.17) and diclosulam 22 g ha⁻¹ (2.53) were next in order. Significantly higher grasses were recorded in weedy check.

At 60 DAT, weed free check (1.41) again recorded lower numbers of grassy weeds than weedy check. The number of grassy weeds in all the herbicides treatment was on par with weed free check.

At 90 DAT, weed free check (1.99) recorded significantly lower number of grassy weeds, which was on par with butachlor 1.0 kg ha⁻¹ (2.05). Alachlor 2.0 kg ha⁻¹ (2.83), oxyfluorfen 0.3 kg ha⁻¹ (3.16) and pendimethalin 1.0 kg ha⁻¹ (3.20) were next in order. Weedy check registered higher number of grassy weeds.

At 120 DAT and at harvest, butachlor 1.0 kg ha⁻¹ recorded lower number of grasses (2.33 & 2.64, respectively) when compared with all other treatments except weed free check.

Alachlor 2.0 kg ha⁻¹ (3.04 & 3.24, respectively) and pendimethalin 1.0 kg ha⁻¹ (3.38 & 3.63, respectively) was next in order in terms of number of grassy weeds. As usual weedy check registered higher number of grassy weeds (9.46 & 9.92, respectively).

4.2.2 Sedges (1.0 m⁻²)

Number of sedges differed significantly due to different herbicides at all the stages of crop growth (Table 6).

At 30 DAT, weed free check recorded lower number of sedges (2.05) when compared all the other treatments. However, butachlor 1.0 kg ha⁻¹ (2.10), alachlor 2.0 kg ha⁻¹ (2.33), and pendimethalin 1.0 kg ha⁻¹ (2.44) were found on par with weed free check. Diclosulam 22 g ha⁻¹ (2.49), oxyfluorfen 0.3 kg ha⁻¹ (2.68) and haloxyfop 0.75 kg ha⁻¹ (2.69) were next in order. Significantly higher sedges were recorded in weedy check.

At 60 DAT, weed free check (1.72) registered significantly the lower sedges which were on par with butachlor 1.0 kg ha⁻¹ (1.99). Alachlor 2.0 kg ha⁻¹ (2.23) and pendimethalin 1.0 kg ha⁻¹ (2.28) were next in order in sedges. Weedy check registered higher number of sedge (4.29).

At 90 DAT, weed free check (1.72) recorded significantly lower sedges. Butachlor 1.0 kg ha⁻¹ (2.33), alachlor 2.0 kg ha⁻¹ (3.20) and haloxyfop 75 kg ha⁻¹ (3.67) treatments were next in order in sedges. Significantly higher number of sedges was recorded in weedy check (4.74).

Table 4. Weed flora of the experimental field

	Weed species	Common name	Family
A	Grasses		
	<i>Cynodon dactylon</i>	Bermuda grass	Poaceae
	<i>Dinebra retroflexa</i> Panz.	Wild foxtail	Poaceae
	<i>Eleusine indica</i>	Goosegrass	Poaceae
	<i>Setaria italica</i>		Poaceae
B	Sedges		
	<i>Cyperus rotundus</i> L.	Nut sedge	Cyperaceae
C	Broad leave weeds (BLW)		
	<i>Abutilon indicum</i> G. Don.		Malvaceae
	<i>Acanthospermum hispidum</i> Dc.	Starbur	Asteraceae
	<i>Ageratum conyzoides</i> L.	Bill goat weed	Asteraceae
	<i>Alternanthera sessilis</i> L.		Amaranthaceae
	<i>Amaranthus viridis</i> L.	Pigweed	Amaranthaceae
	<i>Borreria sp.</i>		Nyctaginaceae
	<i>Cynotis cristata</i> L.		Commelinaceae
	<i>Convolvulus arvensis</i> L.	Field bind weed	Convolvulaceae
	<i>Commelina benghalensis</i> L.	Tropical spider wort	Commelinaceae
	<i>Desmodium diffusum</i> Dc.	Telegraphic plant	Leguminosae
	<i>Digera arvensis</i> L.		Amaranthaceae
	<i>Euphorbia hirta</i> L.	Milky weed	Euphorbiaceae
	<i>Lactuca rancinata</i> Dc.	Wild lettuce	Asteraceae
	<i>Lagasca mollis</i> Cav.		Asteraceae
	<i>Mollugo disticha</i> Ser.,	Carpet weed	Aizoaceae
	<i>Parthenium hysterophorus</i> L.	Carrot weed	Asteraceae
	<i>Phyllanthus niruri</i> L.		Euphorbiaceae
	<i>Physalis minima</i> L.	Ground cherry	Solanaceae
	<i>Portulaca oleracea</i> L.	Purslane	Portulacaceae

Table 5. Number of grassy weeds (1.0 m²) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	1.75 (1.64) ^{ab}	1.25 (1.49) ^{ab}	3.25 (2.05) ^{ab}	4.00 (2.23) ^a	6.00 (2.64) ^a
Alachlor @ 2.0 kg a.i/ha (PE)	2.75 (1.93) ^{abc}	2.00 (1.72) ^{abc}	7.00 (2.83) ^c	8.25 (3.04) ^c	9.50 (3.24) ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	3.00 (1.99) ^{abcde}	2.25 (1.77) ^{abcde}	9.25 (3.20) ^{de}	10.50 (3.38) ^{cd}	12.25 (3.63) ^{cd}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	2.75 (1.93) ^{abcd}	2.50 (1.83) ^{abcdef}	9.00 (3.16) ^d	11.25 (3.49) ^{def}	13.50 (3.80) ^{def}
Diclosulam @ 22g a.i/ha (PE)	5.50 (2.53) ^{fg}	2.75 (1.87) ^{abcdefg}	12.75 (3.71) ^g	15.00 (4.00) ^g	18.50 (4.41) ^g
Haloxypop @ 75g a.i/ha (Post E)	3.75 (2.17) ^{cdf}	2.00 (1.72) ^{abcd}	10.00 (3.31) ^{def}	11.25 (3.48) ^{de}	12.75 (3.69) ^{de}
Weed free	1.25 (1.49) ^a	1.00 (1.41) ^a	3.00 (1.99) ^a	5.75 (2.59) ^{ab}	6.50 (2.73) ^{ab}
Weedy check	60.00 (7.79) ^h	54.75 (7.46) ^h	75.50 (8.75) ^h	88.50 (9.46) ^h	97.50 (9.92) ^h
SEm±	(0.17)	(0.17)	(0.10)	(0.12)	(0.13)
CD at 5%	(0.50)	(0.51)	(0.30)	(0.36)	(0.39)

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

At 120 DAT, weed free check (2.45) registered significantly lower sedges. Next best treatment was butachlor 1.0 kg ha⁻¹ (3.04) and alachlor 2.0 kg ha⁻¹ (3.67). Weedy check registered higher number of sedge.

At harvest, weed free check (2.91) registered significantly lower number of sedges which was on par with butachlor 1.0 kg ha⁻¹ (3.16). Alachlor 2.0 kg ha⁻¹ (3.93) and oxyfluorfen 0.3 kg ha⁻¹ (4.35) treatments were next in order in sedges. Significantly higher sedges were recorded in weedy check (6.04).

4.2.3 Broad-leaved weeds (1.0 m⁻²)

Number of broad-leaved weeds (BLW) differed significantly due to different herbicides at all the stages of crop growth (Table 7).

At 30 DAT, weed free check (1.57) recorded significantly lower number of BLW. Butachlor 1.0 kg ha⁻¹ (1.99), alachlor 2.0 kg ha⁻¹ (2.23) and diclosulam 22 g ha⁻¹ (2.23) treatments were next in terms of BLW count. Weedy check registered higher broad-leaved weed.

At 60 DAT, weed free check (1.31) recorded significantly lower number of BLW, which was on par with butachlor 1.0 kg ha⁻¹ (1.72). Alachlor 2.0 kg ha⁻¹ (2.09), oxyfluorfen 0.3 kg ha⁻¹ (2.10), haloxyfop 75 g ha⁻¹ (2.15) and diclosulam 22 g ha⁻¹ (2.22) herbicides were next in order in lower number of BLW. However, all the treatments were on par with each other. Significantly higher number of BLW registered in weedy check (3.71).

At 90 DAT, weed free check (1.72) recorded significantly lower number of BLW which was on par with diclosulam 22 g ha⁻¹ (2.05). Butachlor 1.0 kg ha⁻¹ (2.12), alachlor 2.0 kg ha⁻¹ (2.29), pendimethalin 1.0 kg ha⁻¹ (2.23), oxyfluorfen 0.3 kg ha⁻¹ (2.23) and haloxyfop 75 g ha⁻¹ (2.33) were next in order in lower number of BLW. Weedy check registered higher number of BLW.

At 120 DAT and at harvest, diclosulam 22 g ha⁻¹ recorded lower number of BLW (2.17 & 2.45, respectively) when compared with all other treatments. However, butachlor 1.0 kg ha⁻¹ (2.33 & 2.64, respectively), weedy free check (2.49 & 2.73, respectively), alachlor 2.0 kg ha⁻¹ (2.39 & 2.64, respectively) and haloxyfop 75 g ha⁻¹ (2.49 & 2.73, respectively) were found on par with diclosulam 22 g ha⁻¹. Significantly higher number of BLW was recorded in weedy check (4.24 & 4.52, respectively).

4.3 Total number of weeds (1.0 m⁻²)

Total number of weeds differed significantly due to different herbicides (Table 8).

At 30 DAT, weedy free check (2.64) recorded significantly lower total number of weeds which was on par with the butachlor 1.0 kg ha⁻¹ (3.02). Alachlor 2.0 kg ha⁻¹ (3.49), oxyfluorfen 0.3 kg ha⁻¹ (3.83), pendimethalin 1.0 kg ha⁻¹ (3.90) and diclosulam 22 g ha⁻¹ (3.96) were next in order and these treatments in turn were on par with each other. Significantly higher total number of weeds recorded in weedy check (9.89).

At 60 and 90 DAT, weed free check (2.17 & 2.82, respectively) recorded significantly lower total number of weeds. Butachlor 1.0 kg ha⁻¹ (2.68 & 3.49, respectively) was next in order. As usual weedy check registered higher total number of weeds (9.27 & 10.59, respectively).

At 120 DAT and at harvest, weed free check (4.03 & 4.55, respectively) recorded significantly lower total number of weeds which was on par with butachlor 1.0 kg ha⁻¹ (4.21 & 4.69, respectively). Alachlor 2.0 kg ha⁻¹ (5.14 & 5.57, respectively) was next in order. Weedy check recorded higher total number of weeds (11.81 & 12.39, respectively).

4.4 STUDIES ON WEED CONTROL RATING AND CROP TOXICITY RATING

4.4.1 Weed control ratings

Visual observations on weed control ratings were recorded at 1st, 2nd, 3rd, 4th, 5th, 6th week after transplanting (Table 9).

Table 6. Number of sedges (1.0 m²) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	3.50 (2.10) ^{ab}	3.00 (1.99) ^{ab}	4.50 (2.33) ^b	8.25 (3.04) ^b	9.00 (3.16) ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	4.50 (2.33) ^{abc}	4.00 (2.23) ^{bc}	9.25 (3.20) ^c	12.50 (3.67) ^c	14.50(3.93) ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	5.00 (2.44) ^{abcd}	4.25 (2.28) ^{bcd}	21.00 (4.69) ^{fgh}	23.00 (4.90) ^g	24.75 (5.07) ^{fg}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	6.25 (2.68) ^{cdef}	5.75 (2.58) ^{cdefg}	14.00 (3.87) ^{de}	16.25 (4.15) ^d	18.00 (4.35) ^d
Diclosulam @ 22g a.i/ha (PE)	5.25 (2.49) ^{bcde}	4.25 (2.28) ^{bcde}	18.75 (4.44) ^{fgh}	19.75 (4.55) ^{ef}	21.75 (4.77) ^f
Haloxypop @ 75g a.i/ha (Post E)	6.25 (2.69) ^{cdefg}	4.75 (2.39) ^{cdef}	12.50 (3.67) ^d	18.25 (4.38) ^{de}	18.25 (4.38) ^{de}
Weed free	3.25 (2.05) ^a	2.00 (1.72) ^a	2.00 (1.72) ^a	5.00 (2.45) ^a	7.50 (2.91) ^a
Weedy check	19.75 (4.55) ^h	17.50 (4.29) ^h	21.50 (4.74) ^{fgh}	33.00 (5.82) ^h	35.50 (6.04) ^h
SEm±	(0.14)	(0.13)	(0.12)	(0.15)	(0.11)
CD at 5%	(0.41)	(0.38)	(0.37)	(0.45)	(0.32)

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 7. Number of broad leaved weeds (1.0 m⁻²) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	3.00 (1.99) ^b	2.00 (1.72) ^{ab}	3.50 (2.12) ^{bc}	4.50 (2.33) ^{ab}	6.00 (2.64) ^{abc}
Alachlor @ 2.0 kg a.i/ha (PE)	4.00 (2.23) ^{bc}	3.50 (2.09) ^{bc}	4.25 (2.29) ^{bcdef}	4.75 (2.39) ^{abcd}	6.00 (2.64) ^{abcd}
Pendemethalin @ 1.0 kg a.i/ha (PE)	6.25 (2.69) ^{defg}	3.75 (2.17) ^{cde}	4.00 (2.23) ^{bcd}	4.75 (2.39) ^{abcde}	7.25 (2.87) ^{bcefg}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	4.75 (2.39) ^{cde}	3.50 (2.10) ^{bcd}	4.00 (2.23) ^{bcde}	4.75 (2.39) ^{abcdef}	6.75 (2.78) ^{bcddef}
Diclosulam @ 22g a.i/ha (PE)	4.00 (2.23) ^{bcd}	4.00 (2.22) ^{bcdefg}	3.25 (2.05) ^{ab}	3.75 (2.17) ^a	5.00 (2.45) ^a
Haloxypop @ 75g a.i/ha (Post E)	4.75 (2.39) ^{cdef}	3.75 (2.15) ^{bcdef}	4.50 (2.33) ^{bcdefg}	5.25 (2.49) ^{abcdefg}	6.50 (2.73) ^{abcde}
Weed free	1.50 (1.57) ^a	0.75 (1.31) ^a	2.00 (1.72) ^a	4.50 (2.33) ^{abc}	5.75 (2.59) ^{ab}
Weedy check	17.25 (4.26) ^h	12.75 (3.71) ^h	14.25 (3.90) ^h	17.00 (4.24) ^h	19.50 (4.52) ^h
SEm±	(0.11)	(0.15)	(0.14)	(0.13)	(0.10)
CD at 5%	(0.33)	(0.44)	(0.41)	(0.39)	(0.0.30)

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

At 1st week after transplanting (WAT), weed free check recorded complete control of weeds (10.00). Among the herbicides, butachlor 1.0 kg ha⁻¹ (9.00) gave good to excellent control of weeds than alachlor 2.0 kg ha⁻¹ (8.75) and oxyfluorfen 0.3 kg ha⁻¹ (8.75). The latter two herbicides gave good control of weeds. Pendimethalin 1.0 kg ha⁻¹ (7.50) and diclosulam 22 ha⁻¹ (7.50) gave satisfactory control of weeds. The similar trend was noticed in 2nd WAT.

At 3rd WAT, weed free check (9.75) and butachlor 1.0 kg ha⁻¹ (8.75) recorded good to excellent control of weeds. Alachlor 2.0 kg ha⁻¹ (8.25), haloxyfop 75 g ha⁻¹ (8.00) and pendimethalin 1.0 kg ha⁻¹ (7.75) gave good to satisfactory control of weeds. Diclosulam 22 g ha⁻¹ (6.25) gave moderate control of weeds.

At 4th, 5th and 6th WAT, as usual weed free check (9.50, 9.25 & 8.50, respectively) recorded good to excellent control of weeds. Butachlor 1.0 kg ha⁻¹ (8.50, 8.50 & 8.25, respectively) treatment was comparable to that of weed free check in term of control of weeds. Alachlor 2.0 kg ha⁻¹ (8.00, 8.00 & 7.00, respectively) gave satisfactory to good control of weeds. The other herbicides gave moderate control of weeds.

4.4.2 Crop toxicity ratings

Visual observations on crop toxicity ratings were recorded at 1st, 2nd, 3rd, 4th, 5th, 6th week after transplanting (Table 10).

At 1st week after transplanting (WAT) slight discoloration was observed with the application of butachlor 1.0 kg ha⁻¹ (1.0) and alachlor 2.0 kg ha⁻¹ (1.25) while some stand loss was observed pendimethalin 1.0 kg ha⁻¹ (2.0) and haloxyfop 75 g ha⁻¹ (2.0). In case of oxyfluorfen 0.3 kg ha⁻¹ (3.25) was injury more pronounced whereas in diclosulam 22 g ha⁻¹ (4.50) the injury of moderate. The similar trend in phytotoxicity rating was observed at 2nd, 3rd, and 4th WAT.

At 5th and 6th WAT, butachlor 1.0 kg ha⁻¹ (0.00 & 0.00, respectively) and alachlor 2.0 kg ha⁻¹ (0.00 & 0.00, respectively) treatments recorded no injury and plant grew normally. In case of pendimethalin 1.0 kg ha⁻¹ (0.25 & 0.25, respectively), oxyfluorfen 0.3 kg ha⁻¹ (0.50 & 0.25, respectively) and haloxyfop 75 g ha⁻¹ (0.50 & 0.25, respectively) slight stunting injury was noticed whereas in diclosulam 22 g ha⁻¹ (5.75 & 5.00, respectively) injury was more persistent and recovery was doubtful.

4.5 Total dry weight of weeds (g m⁻²)

Total dry weight of weeds differed significantly due to different herbicides at different stages of crop growth (Table 11).

At 30 days after transplanting (DAT), weed free check (2.77) recorded significantly lower total weed dry weight than other treatments. Application of butachlor 1.0 kg ha⁻¹ (3.81) and alachlor 2.0 kg ha⁻¹ (5.19) recorded lower total weed dry weight and was comparable to that of weed free check. Oxyfluorfen 0.3 kg ha⁻¹ (6.35) and pendimethalin 1.0 kg ha⁻¹ (6.58) followed by diclosulam 22 g ha⁻¹ (6.81) and haloxyfop 75 g ha⁻¹ (6.81) were next in order in total weed dry weight. The highest weed dry weight noticed in weedy check (44.76).

At 60 DAT, weed free check (1.73) recorded significantly lower total weed dry weight which was on par with application of butachlor 1.0 kg ha⁻¹ (2.88). All the remaining herbicides were next in order and were on par with each other. Significantly highest dry weight was recorded in weedy check (39.23).

At 90 DAT, weed free check (3.23) recorded significantly lower total weed dry weight than all other herbicides. Butachlor 1.0 kg ha⁻¹ (5.19) followed by alachlor 2.0 kg ha⁻¹ (9.46) were next best treatments in term of lower total weed dry weight. Diclosulam 22 g ha⁻¹ (16.04) registered higher weed dry weight among the herbicides while weedy check (51.34) as usual recorded significantly the highest total weed dry weight.

At 120 DAT and at harvest, weed free check recorded significantly lower total weed dry weight (7.04 & 9.11, respectively). However, butachlor 1.0 kg ha⁻¹ (7.73 & 9.69, respectively) was on par with that of weed free check. Alachlor 2.0 kg ha⁻¹ (11.77 & 13.84, respectively) followed by oxyfluorfen 0.3 kg ha⁻¹ (14.88 & 17.65, respectively) and haloxyfop 75 g ha⁻¹ (16.04 & 17.31, respectively) was next in order in total weed dry weight. Pendimethalin 1.0 kg ha⁻¹ (17.65 & 20.42, respectively) and diclosulam 22 g ha⁻¹ (17.77 &

Table 8. Total number of weeds (1.0 m²) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	8.25 (3.02) ^{ab}	6.25 (2.68) ^b	11.25 (3.49) ^b	16.75 (4.21) ^{ab}	21.00 (4.69) ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	11.25 (3.49) ^c	9.50 (3.22) ^c	20.50 (4.63) ^c	25.50 (5.14) ^c	30.00 (5.57) ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	14.25 (3.90) ^{cde}	10.00 (3.31) ^{cd}	34.25 (5.94) ^f	38.25 (6.26) ^f	44.25 (6.73) ^f
Oxyfluorfen @ 0.3kg a.i/ha (PE)	13.75 (3.83) ^{cd}	11.75 (3.56) ^{cedefg}	27.00 (5.29) ^e	32.25 (5.77) ^{de}	38.25 (6.26) ^{de}
Diclosulam @ 22g a.i/ha (PE)	14.75 (3.96) ^{cdef}	10.50 (3.38) ^{cde}	34.75 (5.98) ^{fg}	38.50 (6.28) ^{fg}	45.25 (6.80) ^{fg}
Haloxypop @ 75g a.i/ha (Post E)	14.75 (3.96) ^{cdefg}	11.00 (3.46) ^{cdef}	27.00 (5.29) ^{cd}	34.75 (5.97) ^d	37.50 (6.20) ^d
Weed free	6.00 (2.64) ^a	3.75 (2.17) ^a	7.00 (2.82) ^a	15.25 (4.03) ^a	19.75 (4.55) ^a
Weedy check	97.00 (9.89) ^h	85.00 (9.27) ^h	111.25 (10.59) ^h	138.50 (11.81) ^h	152.50 (12.39) ^h
SEm±	(0.17)	(0.14)	(0.09)	(0.10)	(0.09)
CD at 5%	(0.49)	(0.42)	(0.26)	(0.30)	(0.27)

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 9. Weed control rating (0-10 scale) as influenced by different herbicides in transplanted chilli

Treatment	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Butachlor @ 1.0 kg a.i/ha (PE)	9.00 ^{ab}	9.00 ^{ab}	8.75 ^{ab}	8.50 ^{ab}	8.50 ^{ab}	8.25 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	8.75 ^{bc}	8.25 ^{bcde}	8.25 ^{bc}	8.00 ^{bc}	8.00 ^{bc}	7.00 ^{bcd}
Pendemethalin @ 1.0 kg a.i /ha (PE)	7.50 ^{ef}	7.50 ^{ef}	7.75 ^{bcde}	7.00 ^{cdef}	6.75 ^{def}	6.75 ^{cdef}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	8.75 ^{bcd}	8.75 ^{bc}	7.25 ^{cdef}	7.25 ^{cde}	7.50 ^{bcde}	7.75 ^{abc}
Diclosulam @ 22g a.i/ha (PE)	7.50 ^{efg}	7.50 ^{efg}	6.25 ^{fg}	6.00 ^{fg}	6.75 ^{defg}	6.50 ^{cdefg}
Haloxyfop @ 75g a.i/ha (Post E)	8.25 ^{b^{cde}}	8.75 ^{bcd}	8.00 ^{bcd}	7.75 ^{bcd}	7.75 ^{bcd}	7.00 ^{bcde}
Weed free	10.00 ^a	10.00 ^a	9.75 ^a	9.50 ^a	9.25 ^a	8.50 ^a
Weedy check	0.00 ^h	0.00 ^h	0.00 ^h	0.00 ^h	0.00 ^h	0.00 ^h
SEm±	0.40	0.38	0.35	0.37	0.41	0.42
CD at 5%	1.19	1.11	1.03	1.08	1.22	1.25

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 10. Phytotoxicity ratings (0-10 scale) as influenced by different herbicides in transplanted chilli

Treatment	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Butachlor @ 1.0 kg a.i/ha (PE)	1.00 ^a	1.00 ^a	1.00 ^a	0.50 ^a	0.00	0.00
Alachlor @ 2.0 kg a.i/ha (PE)	1.25 ^a ^b	1.25 ^{ab}	1.25 ^{ab}	1.25 ^{ab}	00.0	0.00
Pendemethalin @ 1.0 kg a.i /ha (PE)	2.00 ^{abc}	2.00 ^{abcd}	2.00 ^{abcd}	1.25 ^{abc}	0.25 ^a	0.25 ^{ab}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	3.25 ^e	3.00 ^e	3.75 ^e	1.75 ^e	0.50 ^{abc}	0.25 ^{abc}
Diclosulam @ 22g a.i/ha (PE)	4.50 ^f	5.00 ^f	5.25 ^f	5.00 ^f	5.75 ^f	5.00 ^d
Haloxyfop @ 75g a.i/ha (Post E)	2.00 ^{abcd}	1.75 ^{abcd}	1.75 ^{abc}	1.50 ^{abcd}	0.50 ^{ab}	0.25 ^a
Weed free	0.00	0.00	0.00	0.00	0.00	0.00
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00
SEm±	0.34	0.37	0.35	0.37	0.19	0.20
CD at 5%	1.00	1.08	1.04	1.10	0.56	0.59

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , Figures in the parentheses indicate $(x+1)^{1/2}$ transformed data, DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 11. Total dry weight weeds (g m⁻²) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	3.81 ^{ab}	2.88 ^{ab}	5.19 ^b	7.73 ^{ab}	9.69 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	5.19 ^{abc}	4.38 ^c	9.46 ^c	11.77 ^c	13.84 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	6.58 ^{bcd}	4.73 ^{cd}	15.81 ^f	17.65 ^{ef}	20.42 ^f
Oxyfluorfen @ 0.3kg a.i/ha (PE)	6.35 ^{bcd}	5.42 ^{cdefg}	12.46 ^e	14.88 ^d	17.65 ^{de}
Diclosulam @ 22g a.i/ha (PE)	6.81 ^{cdef}	4.85 ^{cde}	16.04 ^{fg}	17.77 ^{fg}	20.88 ^{fg}
Haloxypop @ 75g a.i/ha (Post E)	6.81 ^{cdefg}	4.85 ^{cdef}	12.46 ^{cde}	16.04 ^{de}	17.31 ^d
Weed free	2.77 ^a	1.73 ^a	3.23 ^a	7.04 ^a	9.11 ^a
Weedy check	44.76 ^h	39.23 ^h	51.34 ^h	63.92 ^h	70.38 ^h
SEm±	0.97	0.45	0.40	0.55	0.67
CD at 5%	2.86	1.49	1.28	1.70	1.78

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

20.88, respectively) reregistered significantly higher total weed dry weight among the herbicides treatments. Weedy check recorded significantly the highest dry weight (63.92 & 70.38, respectively).

4.6 Weed control efficiency (%)

Weed control efficiency (%) differed significantly due to herbicides (Table12).

At 30 DAT, weed free check (93.81) recorded higher weed control efficiency, which was on par with butachlor 1.0 kg ha⁻¹ (91.48). Alachlor 2.0 kg ha⁻¹ (88.13), oxyfluorfen 0.3 kg ha⁻¹ (85.81), diclosulam 22 g ha⁻¹ (84.78), pendimethalin 1.0 kg ha⁻¹ (85.21) and haloxyfop 75 g ha⁻¹ (84.78) treatments were next in order and found on par with each other.

At 60 DAT, weed free check (95.59) recorded higher weed control efficiency followed by butachlor 1.0 kg ha⁻¹ (92.65). All the other herbicides were next to butachlor and remained on par with each other.

At 90 DAT, weed free check (93.70) recorded significantly higher weed control efficiency. Butachlor 1.0 kg ha⁻¹ (89.89) was next in order. Pendimethalin 1.0 kg ha⁻¹ (69.20) and diclosulam 22 g ha⁻¹ (68.75) registered the lower weed control efficiency and remained on par with each other.

At 120 DAT and at harvest, weed free check recorded higher weed control efficiency (88.98 & 87.05, respectively). Butachlor 1.0 kg ha⁻¹ (87.90 & 86.23, respectively) was comparable to that of weed free check. Alachlor 2.0 kg ha⁻¹ (81.54 & 80.34, respectively) was next in order. Significantly lower weed control efficiency recorded diclosulam 22 g ha⁻¹ (72.19 & 70.33, respectively) and pendimethalin 1.0 kg ha⁻¹ (72.38 & 70.98, respectively).

4.7.1 Growth and growth attributes of chilli

4.7.2 Plant height (cm)

The data pertaining to effect of different weed control treatments on plant height of chilli recorded at 30, 60, 90, 120 DAT and at harvest are presented in Table 13.

At 30 DAT, plant height did not differ significantly by various herbicides treatments.

At 60, 90 and 120 DAT, weed free check (47.20, 66.05 & 72.70, respectively) recorded significantly higher plant height. Butachlor 1.0 kg ha⁻¹ (45.10, 62.20 & 72.30, respectively), alachlor 2.0 kg ha⁻¹ (41.25, 61.70 & 69.35, respectively), oxyfluorfen 0.3 kg ha⁻¹ (43.60, 62.00 & 68.90, respectively) and pendimethalin 1.0 kg ha⁻¹ (42.95, 60.15 & 65.50, respectively) produced taller plants but comparable to that of weed free check. Significantly lower plant height was recorded in, diclosulam 22 g ha⁻¹ (26.37, 33.30 & 42.75, respectively) followed by weedy check (29.00, 44.25 & 52.00, respectively).

At harvest, weed free check (99.33) and butachlor 1.0 kg ha⁻¹ (91.15) recorded significantly higher plant height. Alachlor 2.0 kg ha⁻¹ (86.35), haloxyfop 75 g ha⁻¹ (84.70), pendimethalin 1.0 kg ha⁻¹ (84.65) and oxyfluorfen 0.3 kg ha⁻¹ (84.28) treatments were next in order in plant height but remained on par with each other. Significantly lower plant height was recorded in diclosulam 22 g ha⁻¹ (55.08) and weedy check (62.28).

4.7.3 Number of branches per plant

Number of branches plant⁻¹ differed significantly due to different herbicides at all the stages of crop growth except at 30 DAT (Table14).

At 60 DAT, weed free check (7.05) recorded significantly higher number of branches plant⁻¹ which was on par with butachlor 1.0 kg ha⁻¹ (6.35). Next best treatment was alachlor 2.0 kg ha⁻¹ (3.85) followed by oxyfluorfen 0.3 kg ha⁻¹ (2.95), pendimethalin 1.0 kg ha⁻¹ (2.70) and haloxyfop 75 g ha⁻¹ (2.65). The latter three herbicides were on par with each other. Significantly lower number of branches plant⁻¹ was recorded in diclosulam 22 g ha⁻¹ (1.25) and weedy check (1.55).

At 90, 120 DAT and at harvest, weed free check (11.80, 12.45 & 13.35, respectively) recorded significantly higher number of branches plant⁻¹ which was on par with butachlor 1.0 kg ha⁻¹ (11.25, 12.00 & 12.90, respectively). Alachlor 2.0 kg ha⁻¹ (8.10, 9.05 & 10.00, respectively) and oxyfluorfen 0.3 kg ha⁻¹ (7.30, 8.35 & 9.55, respectively) treatments were

Table 12. Weed control efficiency (%) as influenced by different herbicides in transplanted chilli

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i./ha (PE)	91.48 ^{ab}	92.65 ^b	89.89 ^b	87.90 ^{ab}	86.23 ^{ab}
Alachlor @ 2.0 kg a.i./ha (PE)	88.13 ^{bc}	88.24 ^c	81.51 ^c	81.54 ^c	80.34 ^c
Pendemethalin @ 1.0 kg a.i./ha (PE)	85.21 ^{cde}	87.94 ^{cd}	69.20 ^f	72.38 ^f	70.98 ^f
Oxyfluorfen @ 0.3kg a.i./ha (PE)	85.81 ^{cd}	86.18 ^{cdefg}	75.73 ^e	76.72 ^d	74.92 ^e
Diclosulam @ 22g a.i./ha (PE)	84.78 ^{cdef}	87.63 ^{cde}	68.75 ^{fg}	72.19 ^{fg}	70.33 ^{fg}
Haloxypop @ 75g a.i./ha (Post E)	84.78 ^{cdefg}	87.63 ^{cdef}	75.74 ^d	74.94 ^{de}	75.38 ^d
Weed free	93.81 ^a	95.59 ^a	93.70 ^a	88.98 ^a	87.05 ^a
Weedy check	-	-	-	-	-
SEm±	1.12	1.03	0.63	0.74	0.73
CD at 5%	3.30	3.02	1.86	2.18	2.13

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 13. Plant height (cm) of chilli at different growth stages as influenced by different herbicides

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	27.58	45.10 ^{ab}	62.20 ^{ab}	72.30 ^{ab}	91.15 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	27.20	41.25 ^{abcde}	61.7 ^{abcd}	69.35 ^{abc}	86.35 ^{bc}
Pendemethalin @ 1.0 kg a.i /ha (PE)	26.60	42.95 ^{abcd}	60.15 ^{abcde}	65.50 ^{abcdef}	84.65 ^{bcde}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	27.23	43.60 ^{abc}	62.00 ^{abc}	68.90 ^{abcd}	84.28 ^{bcdef}
Diclosulam @ 22g a.i/ha (PE)	25.10	26.37 ^h	33.30 ^h	42.75 ^h	55.08 ^{gh}
Haloxyfop @ 75g a.i/ha (Post E)	26.38	40.40 ^{bcdef}	60.15 ^{abcdef}	66.95 ^{abcde}	84.70 ^{bcd}
Weed free	27.98	47.20 ^a	66.05 ^a	72.70 ^a	99.33 ^a
Weedy check	24.60	29.00 ^g	44.25 ^g	52.0 ^g	62.28 ^g
SEm±	1.49	2.24	2.84	3.05	3.40
CD at 5%	NS	6.60	8.36	8.96	10.01

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 14. Number of branches plant⁻¹ at different growth stages of Chilli as influenced by different herbicides

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	1.30	6.35 ^{ab}	11.25 ^{ab}	12.00 ^{ab}	12.90 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	1.15	3.85 ^c	8.10 ^c	9.05 ^c	10.00 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	1.15	2.70 ^{de}	7.05 ^{cde}	7.80 ^{def}	8.75 ^{df}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	1.05	2.95 ^d	7.30 ^{cd}	8.35 ^{cd}	9.55 ^{cd}
Diclosulam @ 22g a.i/ha (PE)	1.00	1.25 ^{gh}	2.80 ^{gh}	3.00 ^{gh}	3.45 ^{gh}
Haloxypop @ 75g a.i/ha (Post E)	1.10	2.65 ^{def}	6.85 ^{cdef}	7.85 ^{de}	8.95 ^{cde}
Weed free	1.45	7.05 ^a	11.80 ^a	12.45 ^a	13.35 ^a
Weedy check	1.20	1.55 ^g	3.55 ^g	4.10 ^g	4.80 ^g
SEm±	0.10	0.24	0.43	0.37	0.37
CD at 5%	NS	0.70	1.27	1.08	1.07

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

next in order in number of branches plant⁻¹. Significantly lower number of branches plant⁻¹ was recorded in diclosulam 22 g ha⁻¹ (2.80, 3.00 & 3.45, respectively) and weedy check (3.55, 4.10 & 4.80, respectively).

4.7.4 Total dry matter production (g plant⁻¹)

The data on total dry matter production (TDMP) per plant of chilli as influenced by various weed control treatments at 30, 60, 90, 120 DAT and at harvest are presented in Table 15.

At 30 DAT, total dry matter production (TDMP) plant⁻¹ did not differ significantly by various herbicides treatments.

At 60 DAT, weed free check (28.25) recorded significantly higher TDMP plant⁻¹ which was on par with butachlor 1.0 kg ha⁻¹ (26.08). Alachlor 2.0 kg ha⁻¹ (17.95), pendimethalin 1.0 kg ha⁻¹ (16.23), haloxyfop 75 g ha⁻¹ (16.03) and oxyfluorfen 0.3 kg ha⁻¹ (15.58) treatments were next in order in TDMP plant⁻¹. However, all the latter herbicides were comparable with each other. Significantly lower TDMP plant⁻¹ was recorded in diclosulam 22 g ha⁻¹ (7.78) and weedy check (9.43).

At 90 DAT, weed free check (97.38) recorded significantly higher TDMP plant⁻¹. Next best treatment was butachlor 1.0 kg ha⁻¹ (86.53). Alachlor 2.0 kg ha⁻¹ (61.53), haloxyfop 75 g ha⁻¹ (58.00), pendimethalin 1.0 kg ha⁻¹ (55.23) and oxyfluorfen 0.3 kg ha⁻¹ (54.28) treatments were next in order in TDMP plant⁻¹. Significantly lower TDMP plant⁻¹ was recorded in diclosulam 22 g ha⁻¹ (20.75) and weedy check (30.25).

At 120 DAT and at harvest, significant differences were observed in TDMP plant⁻¹. Weed free check (100.23 & 93.35, respectively) registered significantly higher TDMP plant⁻¹ than all other herbicides except butachlor. Butachlor 1.0 kg ha⁻¹ (91.45 & 88.81, respectively) however, was comparable to that of weed free check. TDMP recorded in alachlor (71.40 & 58.25, respectively) pendimethalin 1.0 kg ha⁻¹ (64.15 & 50.85, respectively), oxyfluorfen 0.3 kg ha⁻¹ (60.68 & 48.10, respectively) and haloxyfop 75 g ha⁻¹ (59.70 & 49.68, respectively) were moderate and they were on par with each other. Diclosulam 22 g ha⁻¹ herbicides registered significantly the lowest TDMP plant⁻¹ (23.05 & 19.40, respectively).

4.7.4.1 Dry matter accumulation in stem (g plant⁻¹)

The data on the dry matter accumulation in stem as influenced by various weed control treatments at 30, 60, 90, 120 DAT and at harvest are presented in Table 16.

At 30 DAT, dry matter accumulation in stem did not differ significantly due to various herbicides treatments.

At 60 DAT, weed free check (15.50) recorded significantly higher dry matter accumulation in stem which was on par with butachlor 1.0 kg ha⁻¹ (14.45). Alachlor 2.0 kg ha⁻¹ (11.20), pendimethalin 1.0 kg ha⁻¹ (10.20), haloxyfop 75 g ha⁻¹ (9.94) and oxyfluorfen 0.3 kg ha⁻¹ (9.91) treatments were next in order however, all the herbicides on par with each other. Significantly lower dry matter accumulation in stem was recorded in diclosulam 22 g ha⁻¹ (4.51) and weedy check (5.50).

At 90, 120 DAT and at harvest, weed free check (47.85, 54.68 & 54.28, respectively) recorded significantly higher dry matter accumulation in stem. Butachlor 1.0 kg ha⁻¹ (43.58, 51.54 & 50.64, respectively) followed by alachlor 2.0 kg ha⁻¹ (31.43, 39.87 & 28.89, respectively) treatment was next in order in dry matter accumulation in stem. Significantly lower dry matter accumulation in stem was recorded in diclosulam 22 g ha⁻¹ (11.03, 11.12 & 9.94, respectively) followed by weedy check (14.12, 14.56 & 12.18, respectively).

4.7.4.2 Dry matter accumulation in leaves (g plant⁻¹)

The data on the dry matter accumulation in leaves showed significant differences at all stages except at 30 DAT (Table 17)

At 60 DAT, weed free check (11.20) recorded significantly higher dry matter accumulation in leaves which was on par with butachlor 1.0 kg ha⁻¹ (10.14). Alachlor 2.0 kg ha⁻¹ (5.40), haloxyfop 75 g ha⁻¹ (5.20), pendimethalin 1.0 kg ha⁻¹ (5.00) and oxyfluorfen 0.3 kg ha⁻¹ (4.86) treatments were next in order in dry matter accumulation in leaves and remained

Table 15. Total dry matter production (g plant⁻¹) at different growth stages of Chilli as influenced by different herbicides

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	4.90	26.08 ^{ab}	86.53 ^b	91.45 ^{ab}	88.18 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	4.80	17.95 ^c	61.53 ^c	71.40 ^c	58.25 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	4.30	16.23 ^{cd}	55.23 ^{cde}	64.15 ^{cd}	50.85 ^{cd}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	4.43	15.58 ^{cdef}	54.28 ^{cdef}	60.68 ^{cde}	48.10 ^{def}
Diclosulam @ 22g a.i/ha (PE)	3.85	7.78 ^{gh}	20.75 ^h	23.05 ^h	19.40 ^h
Haloxyfop @ 75g a.i/ha (Post E)	4.58	16.03 ^{cde}	58.00 ^{cd}	59.70 ^{cdef}	49.68 ^{de}
Weed free	5.13	28.25 ^a	97.38 ^a	100.23 ^a	93.35 ^a
Weedy check	4.20	9.43 ^g	30.25 ^g	36.45 ^g	30.78 ^g
SEm±	0.31	0.91	2.86	4.10	2.79
CD at 5%	NS	2.66	8.43	12.07	8.20

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 16. Dry matter accumulation (g plant⁻¹) in stem at different growth stages of chilli as influenced by different herbicides

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	2.00	14.45 ^{ab}	43.58 ^b	51.54 ^b	50.64 ^b
Alachlor @ 2.0 kg a.i/ha (PE)	1.98	11.20 ^c	31.43 ^c	39.87 ^c	28.89 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	1.75	10.20 ^{cd}	28.11 ^e	36.37 ^d	24.68 ^d
Oxyfluorfen @ 0.3kg a.i/ha (PE)	1.89	9.91 ^{cdef}	27.89 ^{ef}	31.12 ^e	23.64 ^{def}
Diclosulam @ 22g a.i/ha (PE)	1.44	4.51 ^{gh}	11.03 ^h	11.12 ^h	9.94 ^{gh}
Haloxypop @ 75g a.i/ha (Post E)	1.90	9.94 ^{cde}	29.87 ^{cd}	29.96 ^{ef}	23.86 ^{de}
Weed free	2.13	15.50 ^a	47.85 ^a	54.68 ^a	54.24 ^a
Weedy check	1.67	5.50 ^g	14.12 ^g	14.56 ^g	12.18 ^g
SEm±	0.14	0.87	1.01	0.90	0.86
CD at 5%	NS	2.57	2.98	2.63	2.54

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 17. Dry matter accumulation (g plant⁻¹) in leaves at different growth stages of chilli as influenced by different herbicides

Treatment	30 DAT	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	2.90	10.14 ^{ab}	28.58 ^b	18.87 ^b	18.12 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	2.82	5.40 ^c	19.11 ^c	14.75 ^c	14.24 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	2.55	5.00 ^{cde}	17.09 ^{cde}	13.22 ^{cdef}	12.53 ^{cd}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	2.54	4.86 ^{cdef}	16.54 ^{def}	14.14 ^{cde}	11.32 ^{ef}
Diclosulam @ 22g a.i/ha (PE)	2.40	3.10 ^{gh}	5.83 ^{gh}	5.76 ^h	4.10 ^h
Haloxypop @ 75g a.i/ha (Post E)	2.68	5.20 ^{cd}	18.17 ^{cd}	14.51 ^{cd}	12.04 ^{cde}
Weed free	3.00	11.20 ^a	33.39 ^a	22.24 ^a	18.54 ^a
Weedy check	2.54	3.85 ^{cdefg}	8.45 ^g	10.06 ^g	8.92 ^g
SEm±	0.16	0.61	0.90	0.78	0.82
CD at 5%	NS	1.81	2.64	2.30	2.41

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

on par with each others. Significantly lower dry matter accumulation in leaves was recorded in diclosulam 22 g ha⁻¹ (3.10) and weedy check (3.85).

At 90 DAT, weed free check (33.39) recorded significantly higher dry matter accumulation in leaves. Next best treatments were butachlor 1.0 kg ha⁻¹ (28.58) and alachlor 2.0 kg ha⁻¹ (19.11). Significantly lower dry matter accumulation in leaves was recorded in diclosulam 22 g ha⁻¹ (5.83) and weedy check (8.45).

At 120 DAT, weed free check (22.24) recorded significantly higher dry matter accumulation in leaves. Next best treatment was butachlor 1.0 kg ha⁻¹ (18.87) followed by alachlor 2.0 kg ha⁻¹ (14.75). Significantly lower dry matter accumulation in leaves was recorded in diclosulam 22 g ha⁻¹ (5.76) followed by weedy check (10.06).

At harvest, weed free check (18.54) recorded significantly higher dry matter accumulation in leaves which in turn of found on par with butachlor 1.0 kg ha⁻¹ (18.12). Alachlor 2.0 kg ha⁻¹ (14.24), pendimethalin 1.0 kg ha⁻¹ (12.53) and haloxyfop 75 g ha⁻¹ (12.04) were next best treatments. Significantly lower dry matter accumulation in leaves was recorded in diclosulam 22 g ha⁻¹ (4.10) followed by weedy check (8.92).

4.7.4.3 Dry matter accumulation in reproductive parts (g plant⁻¹)

The data on the dry matter accumulation of chilli in reproductive parts as influenced by various weed control treatments are presented (Table 18).

At 60 DAT, weed free check (1.58) recorded significantly higher dry matter accumulation in reproductive parts but remained on par with butachlor 1.0 kg ha⁻¹ (1.49) and alachlor 2.0 kg ha⁻¹ (1.35). Significantly lower dry matter accumulation in reproductive parts was recorded in diclosulam 22 g ha⁻¹ (0.17) and weedy check (0.48). Pendimethalin 1.0 kg ha⁻¹ (1.03) was intermediate.

At 90 and 120 DAT, weed free check (16.14 & 23.31, respectively) recorded significantly higher dry matter accumulation in reproductive parts. Butachlor 1.0 kg ha⁻¹ (14.37 & 21.04, respectively) and alachlor 2.0 kg ha⁻¹ (10.99 & 16.78, respectively) were next in order. Significantly lower dry matter accumulation in reproductive parts was recorded in diclosulam 22 g ha⁻¹ (3.89 & 6.17, respectively) followed by weedy check (7.68 & 11.83, respectively).

At harvest, weed free check (20.57) recorded significantly higher dry matter accumulation in reproductive parts, which was on par with butachlor 1.0 kg ha⁻¹ (19.42). Alachlor 2.0 kg ha⁻¹ (15.12), haloxyfop 75 g ha⁻¹ (13.78), pendimethalin 1.0 kg ha⁻¹ (13.64) and oxyfluorfen 0.3 kg ha⁻¹ (13.14) treatments were next in order in dry matter accumulation in leaves. Significantly lower dry matter accumulation in reproductive parts was recorded in diclosulam 22 g ha⁻¹ (5.36) followed by weedy check (9.68).

4.8 Yield and yield components of green chilli

4.8.1 Number of green chilli fruits per plant

Number of fruits per plant chilli differed significantly due to different herbicides (Table 19).

During 1st picking weed free check (7.45) and butachlor 1.0 kg ha⁻¹ (7.30) recorded significantly higher fruit number of chilli fruit plant⁻¹ than all other treatments. Alachlor 2.0 kg ha⁻¹ (5.50) and haloxyfop 75 g ha⁻¹ (5.40) were next in order. Diclosulam 22 g ha⁻¹ (0.55) recorded significantly the lower number of green chilli fruits followed by weedy checks (2.05). The similar trend was observed during 2nd picking.

During 3rd picking weed free check (16.20), butachlor 1.0 kg ha⁻¹ (15.00) and alachlor 2.0 kg ha⁻¹ (14.25) recorded higher number of chilli fruits (on par with each other) than rest of the treatments. Pendimethalin 1.0 kg ha⁻¹ (13.15) and oxyfluorfen 0.3 kg ha⁻¹ (10.55) were next in order. Diclosulam 22 g ha⁻¹ (2.45) registered the lowest number of chilli fruits followed by weedy check (6.00).

During 4th and 5th picking weed free check (7.80 & 3.80, respectively) and butachlor 1.0 kg ha⁻¹ (7.25 & 3.35, respectively) showed superiority in number of chilli fruits plant⁻¹ than other treatments. Alachlor 2.0 kg ha⁻¹ (5.55 & 3.00, respectively), oxyfluorfen 0.3 kg ha⁻¹ (5.15

Table 18. Dry matter accumulation (g plant⁻¹) in reproductive parts at different growth stages of chilli as influenced by different herbicides

Treatment	60 DAT	90DAT	120DAT	At harvest
Butachlor @ 1.0 kg a.i/ha (PE)	1.49 ^{ab}	14.37 ^b	21.04 ^b	19.42 ^{ab}
Alachlor @ 2.0 kg a.i/ha (PE)	1.35 ^{abc}	10.99 ^c	16.78 ^c	15.12 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	1.03 ^{cd}	10.03 ^{cd}	14.56 ^{cdef}	13.64 ^{cde}
Oxyfluorfen @ 0.3kg a.i/ha (PE)	0.81 ^{def}	9.85 ^{cdef}	15.42 ^{cd}	13.14 ^{cdef}
Diclosulam @ 22g a.i/ha (PE)	0.17 ^{gh}	3.89 ^h	6.17 ^h	5.36 ^h
Haloxypop @ 75g a.i/ha (Post E)	0.89 ^{de}	9.96 ^{cde}	15.23 ^{cde}	13.78 ^{cd}
Weed free	1.58 ^a	16.14 ^a	23.31 ^a	20.57 ^a
Weedy check	0.48 ^{fg}	7.68 ^g	11.83 ^g	9.68 ^g
SEm±	0.14	0.57	0.66	0.68
CD at 5%	0.40	1.69	1.95	1.99

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 19. Number of green chilli fruits plant⁻¹ as influenced by different herbicides

Treatment	1 st Pick	2 nd Pick	3 th Pick	4 th Pick	5 th Pick	Total
Butachlor @ 1.0 kg a.i/ha (PE)	7.30 ^{ab}	4.45 ^{ab}	15.00 ^{ab}	7.25 ^{ab}	3.35 ^{ab}	37.35 ^b
Alachlor @ 2.0 kg a.i/ha (PE)	5.50 ^c	3.80 ^{cd}	14.25 ^{abc}	5.55 ^{cd}	3.00 ^{bc}	32.10 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	4.55 ^e	4.05 ^c	13.15 ^{bcd}	4.20 ^{ef}	2.50 ^{de}	28.45 ^d
Oxyfluorfen @ 0.3kg a.i/ha (PE)	3.90 ^{ef}	3.30 ^f	10.55 ^e	5.15 ^{cde}	2.55 ^d	25.45 ^{ef}
Diclosulam @ 22g a.i/ha (PE)	0.55 ^h	0.65 ^h	2.45 ^h	2.40 ^{gh}	1.00 ^h	7.05 ^h
Haloxyfop @ 75g a.i/ha (Post E)	5.40 ^{cd}	3.65 ^{cde}	10.20 ^{ef}	6.10 ^c	2.30 ^{def}	27.65 ^{de}
Weed free	7.45 ^a	4.85 ^a	16.20 ^a	7.80 ^a	3.80 ^a	40.10 ^a
Weedy check	2.05 ^g	1.95 ^g	6.00 ^g	3.35 ^{efg}	1.65 ^g	15.00 ^g
SEm±	0.29	0.21	0.67	0.33	0.18	0.71
CD at 5%	0.84	0.62	1.98	0.97	0.52	2.08

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

& 2.55, respectively) and pendimethalin 1.0 kg ha⁻¹ (4.20 & 2.50, respectively) were next in order. Diclosulam 22 g ha⁻¹ (2.40 & 1.00, respectively) recorded the lowest number of fruits plant⁻¹ followed by weedy check (3.35 & 1.65, respectively).

The total number of green chilli fruits plant⁻¹ was significantly higher in weed free check (40.10) than the other treatments. Among the herbicides butachlor 1.0 kg ha⁻¹ (37.35) registered significantly higher number of fruits followed by alachlor 2.0 kg ha⁻¹ (32.10), pendimethalin 1.0 kg ha⁻¹ (28.45) and haloxyfop 75 g ha⁻¹ (27.65). Oxyfluorfen 0.3 kg ha⁻¹ (25.45) was next in that order. Diclosulam 22 g ha⁻¹ (7.05) recorded significantly lower number fruits followed by weedy check (15.00).

4.8.2 Green chilli fruit weight per plant

Significant differences were observed with respect to green chilli fruit weight plant⁻¹ at deferent pickings and also total fruit weight plant⁻¹ (Table 20).

During 1st picking weed free check (51.05) and butachlor 1.0 kg ha⁻¹ (47.75) registered significantly higher fruit weight plant⁻¹ than rest of the treatments. Haloxyfop 75 g ha⁻¹ (33.85), alachlor 2.0 kg ha⁻¹ (32.75) and pendimethalin 1.0 kg ha⁻¹ (30.25) recorded next higher chilli fruit weight plant⁻¹. Diclosulam 22 g ha⁻¹ (5.25) recorded the lowest fruit weight plant⁻¹. The similar trends were also observed during 2nd, 3rd and 5th pickings.

During 4th picking weed free check (36.40) recorded significantly higher fruit weight plant⁻¹ than other treatments. Butachlor 1.0 kg ha⁻¹ (31.90) and alachlor 2.0 kg ha⁻¹ (31.90) were next best herbicides followed by haloxyfop (27.10). Oxyfluorfen 0.3 kg ha⁻¹ (25.75) and pendimethalin 1.0 kg ha⁻¹ (20.80) were intermediate in fruit weight plant⁻¹. Significantly lower fruit weight plant⁻¹ was recorded in diclosulam 22 g ha⁻¹ (11.00) followed by weedy check (15.65).

The total fruit weight plant⁻¹ also followed the trend observed during 4th picking. Weed free check registered significantly higher fruit weight (245.10) plant⁻¹ than rest of the treatments. Among the herbicides and significant reduction in fruit weight per plant was in order of butachlor 1.0 kg ha⁻¹ (231.20) > alachlor 2.0 kg ha⁻¹ (206.35) > pendimethalin 1.0 kg ha⁻¹ (181.50) > haloxyfop 75 g ha⁻¹ (163.30) > oxyfluorfen 0.3 kg ha⁻¹ (157.00). Diclosulam 22 g ha⁻¹ (47.05) recorded significantly lower fruit weight plant⁻¹ followed by weedy check (91.40).

4.8.3 Green chilli fruit yield (kg ha⁻¹)

Chilli fruit yield per hectare (ha⁻¹) was significantly influenced by various weed control treatments (Table 21)

During 1st picking weed free check (546) recorded significantly higher chilli fruit yield than other treatments. Among the herbicides, butachlor 1.0 kg ha⁻¹ (489) recorded higher chilli yield than other herbicides differed also significantly in the order of alachlor 2.0 kg ha⁻¹ (409) > pendimethalin 1.0 kg ha⁻¹ (289) and haloxyfop 75 g ha⁻¹ (269) > oxyfluorfen 0.3 kg ha⁻¹ (157). Diclosulam 22 g ha⁻¹ (38) recorded the lowest chilli fruit yield followed by weedy check (94). Similar trend was observed during 2nd picking.

During 3rd, 4th and 5th pickings, weed free check (1968, 926 & 547, respectively) registered significantly higher chilli fruit yield than rest of the treatments. Butachlor 1.0 kg ha⁻¹ (1769, 847 & 520, respectively) however was comparable to that of weed free check. Diclosulam 22 g ha⁻¹ (107, 124 & 87, respectively) recorded significantly the lowest fruit yield ha⁻¹. Other herbicides viz., alachlor 2.0 kg ha⁻¹ (1571, 761 & 413, respectively), pendimethalin 1.0 kg ha⁻¹ (1405, 752 & 347, respectively), oxyfluorfen 0.3 kg ha⁻¹ (1571, 620 & 442, respectively) and haloxyfop 75 g ha⁻¹ (1339, 612 & 347, respectively) were intermediate chilli fruit yield ha⁻¹.

The total chilli yield ha⁻¹ followed the trend that was observed during 1st and 2nd picking. Weed free check (4393) recorded significantly the highest chilli fruit yield. Butachlor 1.0 kg ha⁻¹ (3948) was the next best treatments followed by alachlor 2.0 kg ha⁻¹ (3456). The significantly the lowest chilli fruit yield ha⁻¹ was observed in diclosulam 22 g ha⁻¹ (403). Pendimethalin 1.0 kg ha⁻¹ (3051), oxyfluorfen 0.3 kg ha⁻¹ (3039) and haloxyfop 75 g ha⁻¹ (2827) did not differ significantly in chilli yield ha⁻¹ but they were next to alachlor.

Table 20. Green chilli fruit weight (g plant⁻¹) as influenced by different herbicides

Treatment	1 st Pick	2 nd Pick	3 th Pick	4 th Pick	5 th Pick	Total
Butachlor @ 1.0 kg a.i/ha (PE)	47.75 ^{ab}	30.85 ^{ab}	104.50 ^{ab}	31.90 ^b	16.20 ^{ab}	231.20 ^b
Alachlor @ 2.0 kg a.i/ha (PE)	32.75 ^{cd}	26.50 ^{cd}	102.50 ^{bc}	31.90 ^{bc}	12.70 ^c	206.35 ^c
Pendemethalin @ 1.0 kg a.i /ha (PE)	30.25 ^{cde}	26.35 ^{cde}	92.90 ^d	20.80 ^f	11.20 ^{cde}	181.50 ^d
Oxyfluorfen @ 0.3kg a.i/ha (PE)	25.90 ^f	17.75 ^f	75.75 ^e	25.75 ^e	11.85 ^{cd}	157.00 ^f
Diclosulam @ 22g a.i/ha (PE)	5.25 ^h	6.00 ^h	15.10 ^h	11.00 ^h	4.70 ^h	47.05 ^h
Haloxypop @ 75g a.i/ha (Post E)	33.85 ^c	26.75 ^c	65.25 ^f	27.10 ^d	10.35 ^{def}	163.30 ^e
Weed free	51.05 ^a	32.50 ^a	107.50 ^a	36.40 ^a	17.65 ^a	245.10 ^a
Weedy check	14.30 ^g	10.75 ^g	43.50 ^g	15.65 ^g	7.20 ^g	91.40 ^g
SEm±	1.39	1.36	1.70	1.39	0.67	1.98
CD at 5%	4.10	3.99	4.99	4.08	1.97	5.83

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 21. Green chilli fruit yield (kg ha⁻¹) and weed index (%) as influenced by different herbicides

Treatment	1 st Pick	2 nd Pick	3 th Pick	4 th Pick	5 th Pick	Total	Weed index	Stalk yield (kg ha ⁻¹)
Butachlor 1.0 kg a.i/ha (PE)	489 ^b	322 ^b	1769 ^{ab}	847 ^{ab}	520 ^{ab}	3948 ^b	10.12 ^a	1883 ^{ab}
Alachlor- 2.0 kg a.i/ha (PE)	409 ^c	302 ^{bc}	1571 ^{bc}	760 ^{bc}	413 ^{cd}	3456 ^c	21.33 ^b	1559 ^c
Pendemethalin-1.0 kg a.i /ha (PE)	289 ^d	256 ^{de}	1405 ^{cde}	752 ^{bcd}	347 ^e	3051 ^d	30.56 ^c	1238 ^d
Oxyfluorfen-0.3kg a.i/ha (PE)	157 ^f	249 ^{def}	1571 ^{bcd}	620 ^e	442 ^c	3039 ^{de}	30.82 ^{cd}	1222 ^{de}
Diclosulam-22g a.i/ha (PE)	38 ^h	46 ^h	107 ^h	124 ^h	87 ^{gh}	403 ^h	90.83 ^g	394 ^h
Haloxypop-75g a.i/ha (Post E)	269 ^{de}	260 ^d	1339 ^{cdef}	612 ^{ef}	347 ^{ef}	2827 ^{def}	35.64 ^{cde}	1215 ^{def}
Weed free	546 ^a	407 ^a	1968 ^a	926 ^a	547 ^a	4393 ^a	-	1914 ^a
Weedy check	94 ^g	86 ^g	657 ^g	256 ^g	124 ^g	1218 ^g	72.28 ^f	930 ^g
SEm±	17	15	82	38	20	99	2.31	90
CD at 5%	51	45	241	111	59	290	6.87	265

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence and POE- post-emergence.

Table 22. Economics of weed control practices

Treatment	Gross income (Rs. ha ⁻¹)	Total cost of cultivation (Rs. ha ⁻¹)	Net income (Rs. ha ⁻¹)	B:C ratio
Butachlor 1.0 kg a.i/ha (PE)	51329 ^b	15325	36004 ^a	3.35 ^a
Alachlor- 2.0 kg a.i/ha (PE)	44923 ^c	15525	29399 ^{bc}	2.89 ^b
Pendemethalin-1.0 kg a.i /ha (PE)	39657 ^d	15365	24293 ^{cd}	2.58 ^{cd}
Oxyfluorfen-0.3kg a.i/ha (PE)	39507 ^{de}	15044	24463 ^{cde}	2.63 ^c
Diclosulam-22g a.i/ha (PE)	5233 ^h	15016	-9782 ^h	0.35 ^h
Haloxyfop-75g a.i/ha (Post E)	36755 ^{def}	15374	21382 ^{cdef}	2.39 ^{cde}
Weed free	57111 ^a	25365	31746 ^b	2.25 ^{ef}
Weedy check	15830 ^g	13505	2326 ^g	1.17 ^g
SEm±	1281		1281	0.08
C.D at 5%	3768		3768	0.24

All herbicides treatments received two inter cultivations at 40 and 75 DAT and one common hand weeding at 40 DAT , DAT – days after transplanting, PE- Pre-emergence, POE- post-emergence and green chilli price Rs. 13 kg⁻¹

4.8.4 Weed index (%)

Significant differences were observed in weed index due to various weed control treatments (Table 21).

Butachlor 1.0 kg ha⁻¹ showed its superiority among the herbicides and recorded significantly lower weed index (10.12) than other herbicides tried. Alachlor 2.0 kg ha⁻¹ (21.33) was next best treatment. Haloxyfop 75 g ha⁻¹ (35.64), oxyfluorfen 0.3 kg ha⁻¹ (30.82) and pendimethalin 1.0 kg ha⁻¹ (30.56) were intermediate and they were on par with each other. Diclosulam 22 g ha⁻¹ (90.83) recorded significantly higher weed index followed by weedy check (72.28).

4.9 Stalk yield (kg ha⁻¹)

Different weed control treatments have a considerable influence on the stalk yield of chilli (Table 21)

Weed free check (1914) recorded significantly higher stalk yield which was in turn on par with that of butachlor 1.0 kg ha⁻¹ (1883). Alachlor 2.0 kg ha⁻¹ (1559) was next best treatment. Pendimethalin 1.0 kg ha⁻¹ (1238), oxyfluorfen 0.3 kg ha⁻¹ (1222) and haloxyfop 75 g ha⁻¹ (1215) were intermediate and were on par with each other. The Significantly lower stalk yield was recorded in diclosulam 22 g ha⁻¹ (394), followed by weedy check (930).

4.10. ECONOMICS OF WEED CONTROL

Significant differences were observed in gross return, net return and benefit: cost ratio due to different weed control treatments (Table 22).

The gross income was significantly higher in weed free check (Rs.57111 ha⁻¹) than rest of the weed control treatments. Among the herbicides, butachlor 1.0 kg ha⁻¹ (Rs. 51329 ha⁻¹) recorded significantly higher gross return than other herbicides. Alachlor 2.0 kg ha⁻¹ (Rs. 44923 ha⁻¹) was next to butachlor. Pendimethalin 1.0 kg ha⁻¹ (Rs. 39657 ha⁻¹), oxyfluorfen 0.3 kg ha⁻¹ (Rs. 39507 ha⁻¹) and haloxyfop 75 g ha⁻¹ (Rs.36755 ha⁻¹) were intermediate in gross returns and were on par with each other. Diclosulam 22 g ha⁻¹ (Rs. 5233 ha⁻¹) registered significantly lowest gross return followed by weedy check (Rs.15830 ha⁻¹).

In contrast to gross income, net income showed different trend. Butachlor 1.0 kg ha⁻¹ (Rs.36004 ha⁻¹) recorded significantly higher net income than rest of the weed control treatments. Weed free check (Rs. 31746 ha⁻¹) and alachlor 2.0 kg ha⁻¹(Rs.29399) were on par with each other. However, alachlor 2.0 kg ha⁻¹ was also found to be on par with pendimethalin 1.0 kg ha⁻¹ (Rs. 24293 ha⁻¹), oxyfluorfen 0.3 kg ha⁻¹ (Rs. 24463 ha⁻¹) and haloxyfop 75 g ha⁻¹ (Rs. 21382 ha⁻¹) were next to alachlor treatment and these treatments were on par with each other. Significantly lower net income was recorded in diclosulam 22 g ha⁻¹ (Rs. -9782 ha⁻¹) followed by weedy check (Rs. 2326 ha⁻¹).

Benefit: cost ratio also differed significantly due to weed control treatments and followed the trend that was observed in net income ha⁻¹. Butachlor 1.0 kg ha⁻¹ (3.35) recorded significantly highest benefit: cost ratio than other weed control treatments. Alachlor 2.0 kg ha⁻¹ (2.89) was next best treatment. Significantly lower benefit: cost ratio was recorded in diclosulam 22 g ha⁻¹ (0.35) followed by weedy check (1.17).

4.11. CORRELATION STUDIES

Significant and positive correlation was observed between chilli yield and growth parameters (Table 23) such as plant height (+0.986), number of branches plant⁻¹ (+0.970), total dry matter production (+ 0.954) and yield attributing characters like number of fruits plant⁻¹ (+ 0.992).

Chilli yield showed negatively correlation with weed dry weight (- 0.599), weed index (-1.00) and weed number per quadrat (-0.599).

Weed number per quadrat and weed dry weight per quadrat gave positively correlation (+ 0.990), but it was negatively co-relation weed control efficiency to weed number (- 0.990) and weed dry weight (-1.00).

Table 23. Correlations studies in transplanted chilli

	Weed number/quadrat	Weed dry weight/quadrat	Weed control efficiency	Plant height of chilli	Number of branches per Plant	Plant dry weight	Number of chilli fruit per plant	Fruit weight per plant	Weed index	Yield kg/ha
Weed number/quadrat	1	0.990(**)	-0.990(**)	-0.653	-0.711(*)	-0.673	-0.644	-0.641	0.671	-0.671
Weed dry weight/quadrat		1	-1.000(**)	-0.597	-0.623	-0.575	-0.563	-0.563	0.599	-0.599
Weed control efficiency			1	0.597	0.623	0.575	0.563	0.563	-0.599	0.599
Plant height of chill				1	0.932(**)	0.903(**)	0.966(**)	0.963(**)	-0.986(**)	0.986(**)
Number of branches/Plant					1	0.990(**)	0.969(**)	0.962(**)	-0.970(**)	0.970(**)
#TDMP						1	0.969(**)	0.960(**)	-0.954(**)	0.954(**)
Number of chilli fruit per plant							1	0.998(**)	-0.992(**)	0.992(**)
Fruit weight per plant								1	-0.991(**)	0.991(**)
Weed index									1	-1.000(**)
Yield kg/ha										1

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed), # TDMP: total dry matter production

5. DISCUSSION

The results of the field experiment on “Evaluation of different herbicides for weed control in transplanted chilli” conducted at College of Agriculture, University of Agricultural Sciences, Dharwad during *kharif* 2008 under rainfed condition are discussed in this chapter. The results obtained in the experiment are discussed by making an attempt to reason out as to the differential behaviour of chemical weed control vis-à-vis the unweeded check and the relationship with yield performance of the crop.

5.1 Weather and climate on crop growth

Crop growth is mainly depends on an environmental factors. Fluctuations in weather condition greatly influence the growth, development and their by yielding ability of crop. Chilli being medium to long duration crop, the availability of water in adequate quantity over the ontogeny of crop is most essential for successful crop production and that too under rain fed condition where the water is a limiting factor. Thus, the adequate quantity and uniform distribution of rainfall forms an important factor in periodical replenishment of soil moisture to sustain crop growth.

The annual rainfall received during year i.e. (2008-09) was 844.4 mm (Table 2 and Fig.1) which was 76.0 mm higher than average rainfall of 58 years (1952-2008). The rainfall during cropping period was 508.2 mm as against the normal of 369.7 mm which was well distributed during crop growth period. The chilli crop was transplanted on 01-08- 2008 with sufficient stored soil moisture conditions. The rainfall received in the month of June (101.6 mm) and July (121.1 mm) ensured adequate stored moisture condition before transplanting of chilli. Further, adequate quantity and uniform distribution rainfall received during August (114.2 mm) ensured proper establishment of chilli seedling. The subsequent crop growth and development was not affected as rainfall was fairly well distributed in the months of September, October and November and the rainfall was considerably higher than average of 58 years (except October 2008). The excess rainfall received (114.7 mm) in August month also encouraged the vigorous growth of weeds. To sum up, the rainfall received during crop growing season was much higher than normal and was well distributed as a result chilli crop did not suffer due to moisture stress throughout its life cycle.

The mean maximum temperature recorded during year of experimentation was in the range from 26.9 (August) to 33.2 °C (February), while minimum temperature ranged from 13.3 (January) - 20.1 °C (August). Both maximum and minimum temperatures were favourable for normal growth and development of chilli and the temperature did not deviate from the average of 58 years.

The relative humidity (RH) during entire crop season ranged between 57.5(February) and 91.5 (August) per cent as against the average RH (51.5 to 86.0) of 58 years. Relative humidity recorded during the year of experimentation was relatively higher. As a result there was an incident of murda complex and cut worm on chilli crop which was controlled effectively by spraying (Endosulfun @ 2.0 ml/ l, Monocrotophos + Dicofol 2.5 ml/ l and Monocrotophos + Abamectin @ 2.5+ 0.2 ml/ l) each three time at interval 15 to 20 days.

5.2 Weed flora

The weed flora noticed in the experimental site consisted of grasses, sedges and broad leaved weed category (Table 4). The important grassy weeds observed are *Cynodon dactylon*, *Dinebra retroflexa*, *Eleusine indica* and *Setaria italica*. *Cyperus rotundus* was lone weed under sedge category. This weed was more dominated than other weeds in entire experimental area because of the excess (114.7 mm) rainfall received in the August 2008 when compared with average of 58 years. Kalyanamurthy (2002) and Manjunatha (2005) reported that *Cyperus* occurrence was more prominent weed under irrigated condition. Good numbers of weeds were observed under broad leaved weeds (BLW) category. They are *Abutilon indicum* G. Don, *Acanthospermum hispidum* Dc, *Ageratum conyzoides* L. *Alternanthera sessilis* L., *Amaranthus viridis* L., *Borreria sp*, *Cynotis cristata* L., *Convolvulus arvensis* L., *Commelina benghalensis* L., *Desmodium diffusum* Dc., *Digera arvensis* L., *Euphorbia spp.* L., *Lactuca rancinata* Dc., *Lagasca mollis* Cav., *Mollugo disticha* Ser., *Parthenium hysterophorus* L., *Phyllanthus niruri* L., *Physalis minima* L. and *Portulaca oleracea* L. The similar weed flora was observed by Narasalagi (1999) in drilled onion + chilli,

Biradar (1999) in transplanted chilli, Patil (1999) in chilli + cotton and Rajkumara (2009) in onion – chilli – cotton relay inter cropping. Among the above BLW, *Ageratum conyzoides* L., *Convolvulus arvensis* L., *Parthenium hysterophorus* L., *Phyllanthus niruri* L., *Portulaca oleracea* L. and *Physalis minima* L. were most dominant weeds.

5.3 Weed control rating

Visual observations on weed control rating showed marked differences among the different weed control treatments (Table 9). In the initial stages (I and II week after transplanting-WAT), butachlor 1.0 kg ha⁻¹ gave good to excellent weed control (rating of 9) while, alachlor 2.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹ and haloxyfop 75 g ha⁻¹ gave good control of weeds (rating of 8). Pendimethalin 1.0 kg ha⁻¹ and diclosulam 22 g ha⁻¹ gave satisfactory control (rating of 7). At later stages (III, IV, V and VI WAT), also butachlor 1.0 kg ha⁻¹ and alachlor 2.0 kg ha⁻¹ gave good control (rating of 8). Other herbicides namely pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹ and haloxyfop 75 g ha⁻¹ gave satisfactory to deficient control compared to the weed free treatment. Diclosulam 22 g ha⁻¹ gave moderate control of weeds (rating of 6). The results are in conformity with the findings of Narasalagi (1999) in onion + chilli intercropping.

5.4 Crop toxicity rating as influenced by different weed control

The toxicity rating recorded on crop from first week of spray to sixth week of spray revealed (Table 10) that butachlor 1.0 kg ha⁻¹ and alachlor 2.0 kg ha⁻¹ herbicides showed slight stunting injury or discoloration up to fourth week of spray and later on the chilli plants grew normally. Pendimethalin 1.0 kg ha⁻¹ and haloxyfop 75 g ha⁻¹ showed stunting or discoloration up to third week of spray and later on plant recovered from early injury. In case of oxyfluorfen 0.3 kg ha⁻¹, chilli plants showed pronounced injury in the early stage (1st, 2nd and 3rd week) and later on (4th, 5th and 6th) plants recovered gradually. The results are in conformity findings of Narasalagi (1999) in onion + chilli intercropping. Pre-emergence spray of diclosulam 22 g ha⁻¹ adversely affected the chilli plants and injury was more persistent till sixth week of spray. Further, the plant did not recover from the initial injury even at later stages. William *et al.* (2000) reported that diclosulam herbicide injury up to three week after planting regardless of cultivar in pea nut.

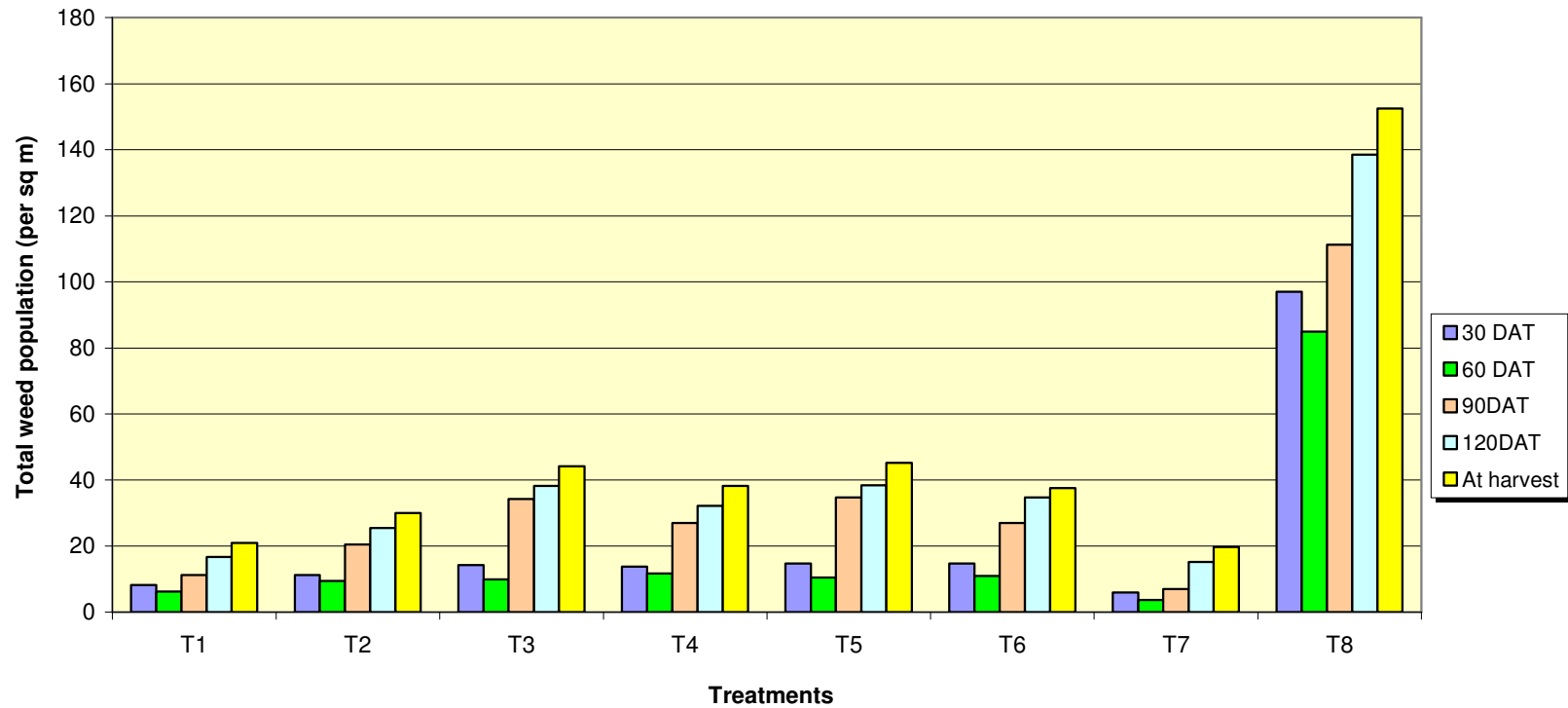
5.5 Effect on weed control treatments on weeds

The weed population of grasses, sedges, broad leaved weeds (BLW), total weed population (Table 5, 6, 7 & 8 and Fig. 3), total weed dry weight (Table 11 and Fig. 4), weed control efficiency (Table 12 and Fig. 5) differed significantly among various weed control treatments at all stages of crop growth.

Significantly higher total weed dry weight at harvest (70.38) was recorded in weedy check than rest of the treatments. It was mainly due to higher density of grasses, sedges, BLW and total weed population (9.92, 6.04, 4.52 & 12.39, respectively) and also non-control of weeds. Non-interference for weed growth and maximum utilization of moisture, nutrient, light and space also led to significantly higher weed dry weight. In contrast to this, significantly lower total weed dry weight was noticed in weed free check (2.77, 1.73, 3.23, 7.04 & 9.11, respectively). It was mainly on account of complete elimination of weeds as a no weed allowed to grow throughout the crop growth period. Singh *et al.* (1992) in transplanted bell pepper, Narasalagi (1999) in onion + chilli intercropping and Biradar (1999) in transplanted chilli also reported similar trend.

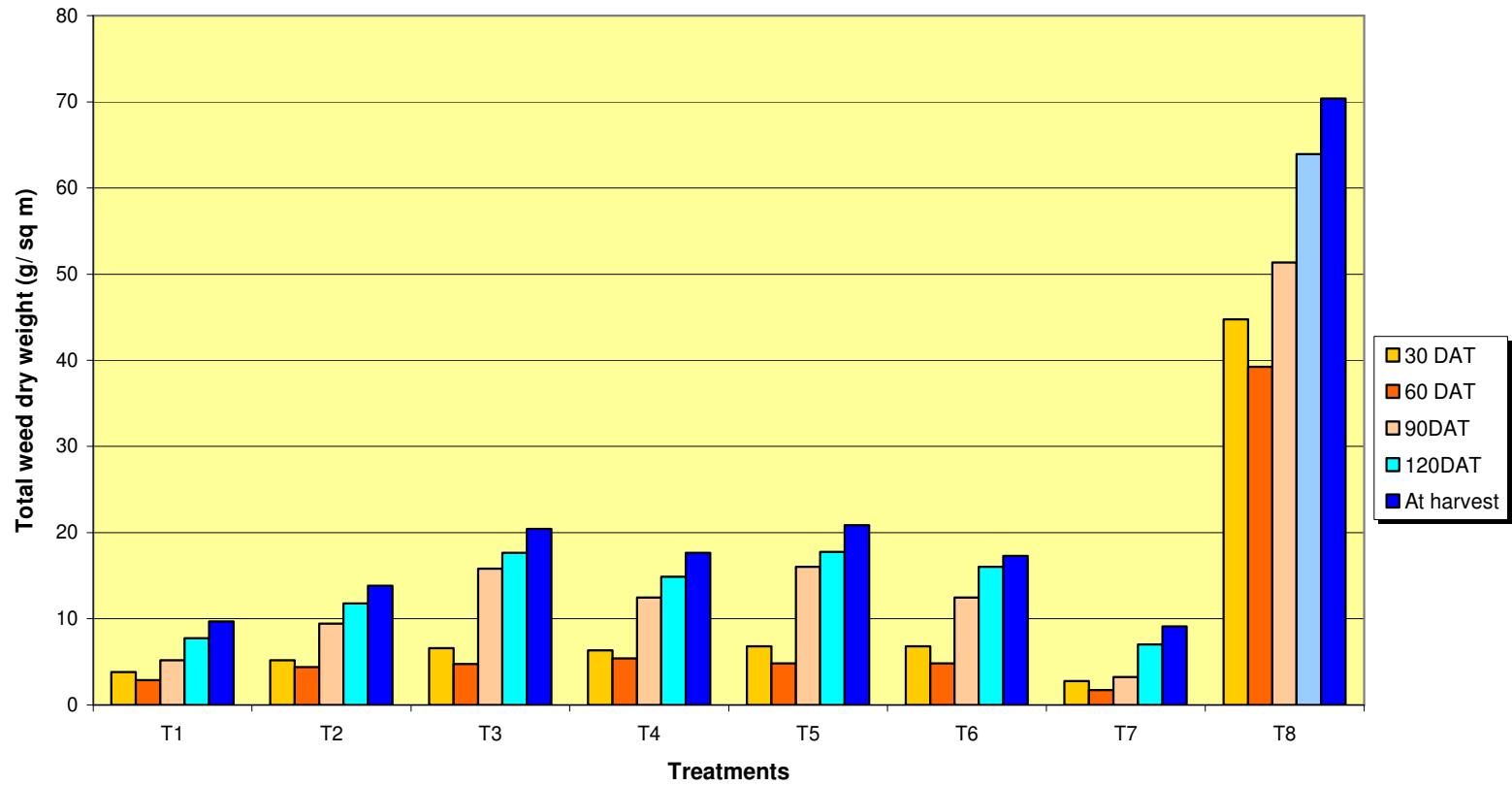
All the herbicide treatments recorded significantly lower weed dry weight at all growth stages and at harvest compared to unweeded check which was mainly attributed to lower weed population, lower weed dry weight and higher weed control efficiency. In general, weed dry weight and weed population increased from 30 DAT to at harvest (except at 60 DAT). This clearly indicates that there was continuous emergence of weeds. Similar results were reported by Narasalagi (1999) in onion + chilli intercropping.

Among the herbicides, butachlor 1.0 kg ha⁻¹ recorded significantly lower total weed dry weight at 30, 60, 90, 120 DAT and at harvest (3.81, 2.88, 5.19, 7.73 & 9.69, respectively) followed by alachlor 2.0 kg ha⁻¹ (5.19, 4.38, 9.46, 11.77 & 13.84, respectively). The significant reduction in total weed dry weight in butachlor 1.0 kg ha⁻¹ was mainly due to significantly



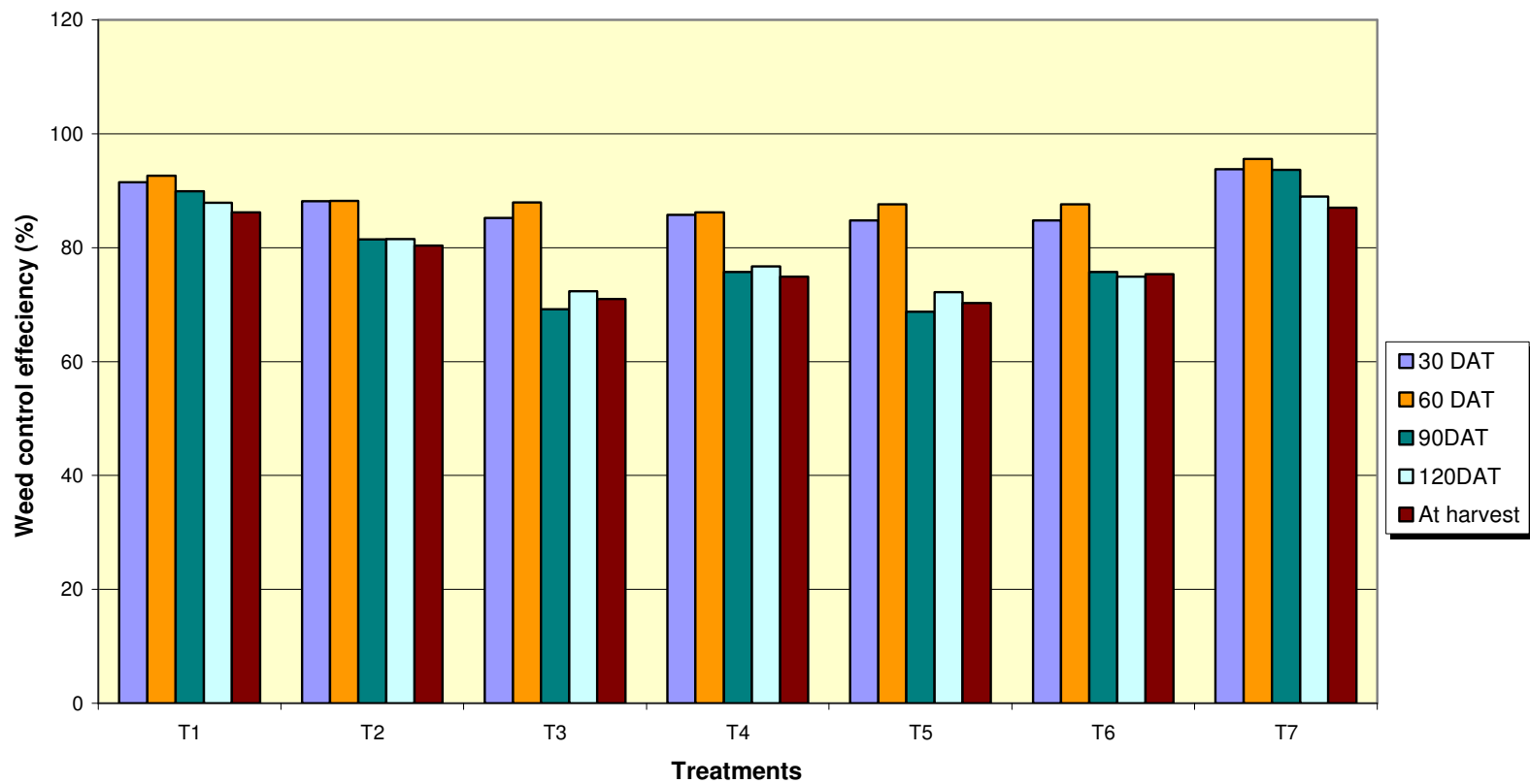
T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ -Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i. ha⁻¹ (PE), T₅ -Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈ -Weedy check

Fig.3. Total weed population (per sq m) as influenced by different herbicides



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxypop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈-Weedy check

Fig.4. Total weed dry weight (g/sq m) as influenced by different herbicides



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ .Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ .Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ .Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ . Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ . Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈-Weedy check

Fig.5. Weed control efficiency as influenced by different herbicides

lower density of grasses (1.64, 1.49, 2.05, 2.23 & 2.64, respectively), sedges (210, 1.99, 2.33, 3.04 & 3.16, respectively), BLW (1.99, 1.72, 2.12, 2.33 & 2.64, respectively) and total weed population (3.02, 2.68, 3.49, 4.21 & 4.69, respectively) at all stages as well as at harvest and significantly higher weed control efficiency (91.48, 92.65, 89.89, 87.90 & 86.23, respectively).

The similar trend was also observed in alachlor 2.0 kg ha⁻¹. The significant reduction in weed dry weight in butachlor 1.0 kg ha⁻¹ and alachlor 2.0 kg ha⁻¹ was due to higher inhibition of root and shoot growth, root elongation, early seedling growth, cell division and cell elongation, higher toxicity and persistence of herbicides in soil. The similar effects were earlier observed by Rajagopal *et al.* (1976), Joshi *et al.* (1995), Anonymous (1995), Narasalagi (1999) and Biradar (1999) in transplanted chilli. Further, the mode of action butachlor and alachlor clearly indicates that these herbicides are mainly absorbed by germinating shoots rather than roots and thus inhibiting the germinating seedlings (Anon., 1987)

The total weed dry weight recorded in haloxyfop 75 g ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹, pendimethalin 1.0 kg ha⁻¹ and diclosulam 22 g ha⁻¹ were significantly lower to that of butachlor and alachlor at all stages and at harvest. The higher weed dry weight in the former four herbicides in relation to latter two herbicides could be attributed to differences in variations observed in weed population of grasses, sedges, BLW and weed control efficiency. The weed control efficiency in haloxyfop 75 g ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹, pendimethalin 1.0 kg ha⁻¹ and diclosulam 22 g ha⁻¹ were in the range of 70.33 to 75.38 percentages at harvest. Narasalagi (1999) also reported that pendimethalin and oxyfluorfen were less effective in controlling weeds than butachlor. Biradar (1999) while the evaluating herbicides in chilli reported that alachlor was effective in controlling weeds but was next to glufosinate ammonium.

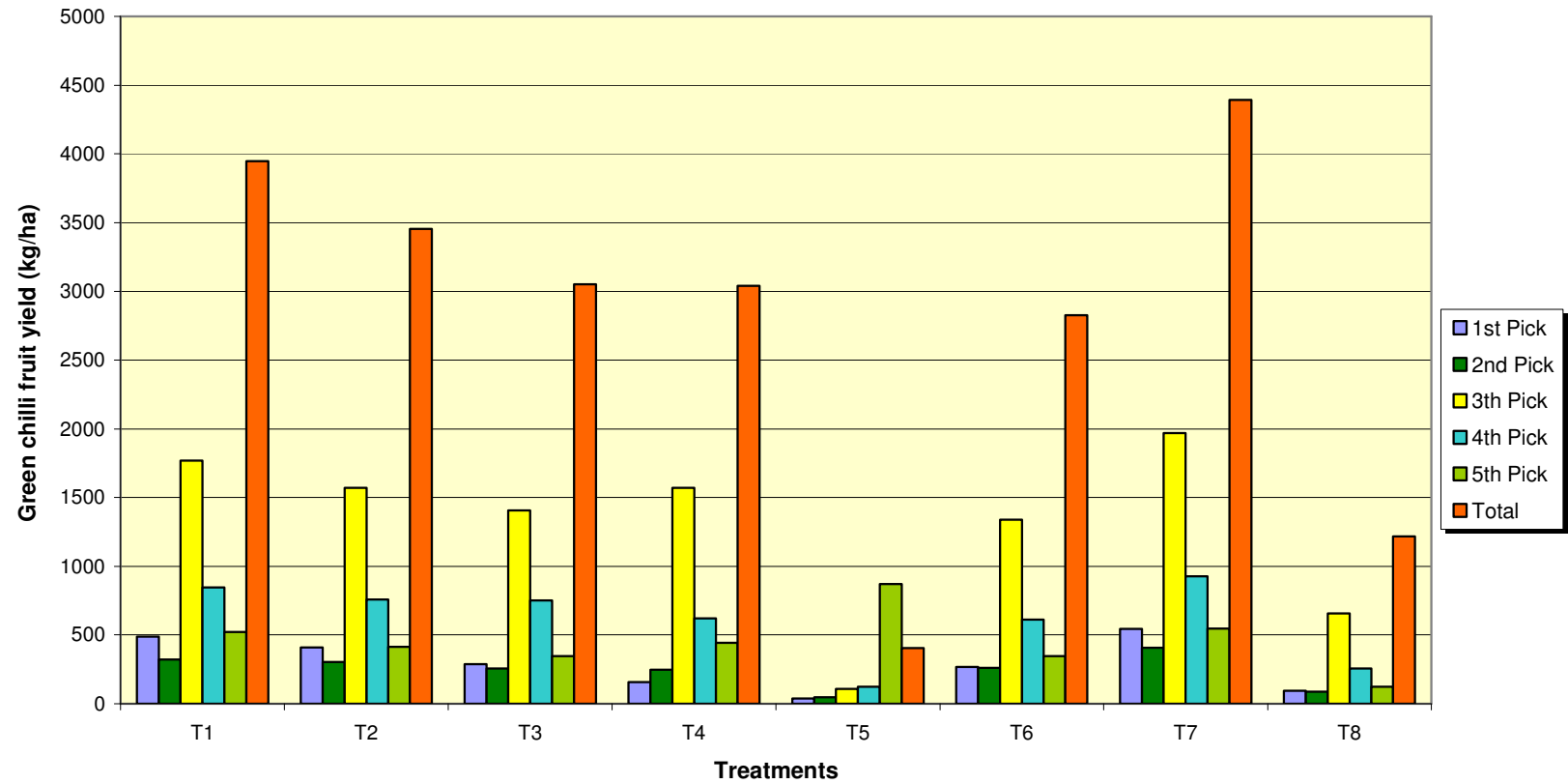
5.6 Effect of weed control of treatments on yield and yield component of chilli

Yield and yield components of chilli varied significantly among various weed control treatments (Table 21 and Fig. 6 & 7). All the weed control treatments produced higher green chilli yield than weedy check. However, none of them increased chilli yield to the level of weed free check. The results corroborate findings of Singh *et al.* (1992) and Yadav (2001).

Significantly the highest green chilli yield (4,393 kg ha⁻¹) was obtained with weed free check. The superlative performance of this treatment was mainly due to maintenance of weed free conditions by multiple hand weeding and intercultivation operations thus, enabling the crop for maximum utilization of available resources which ultimately had a favourable influence on growth and yield components. Lanini and Strange (1994) observed that when weed free conditions was maintained for entire season, chilli yield increased substantially 4-18 per cent than other treatments. Similarly, Narasalagi (1999), Biradar (1999), and Rajkumara (2009) also reported highest chilli yield in weed free check treatment.

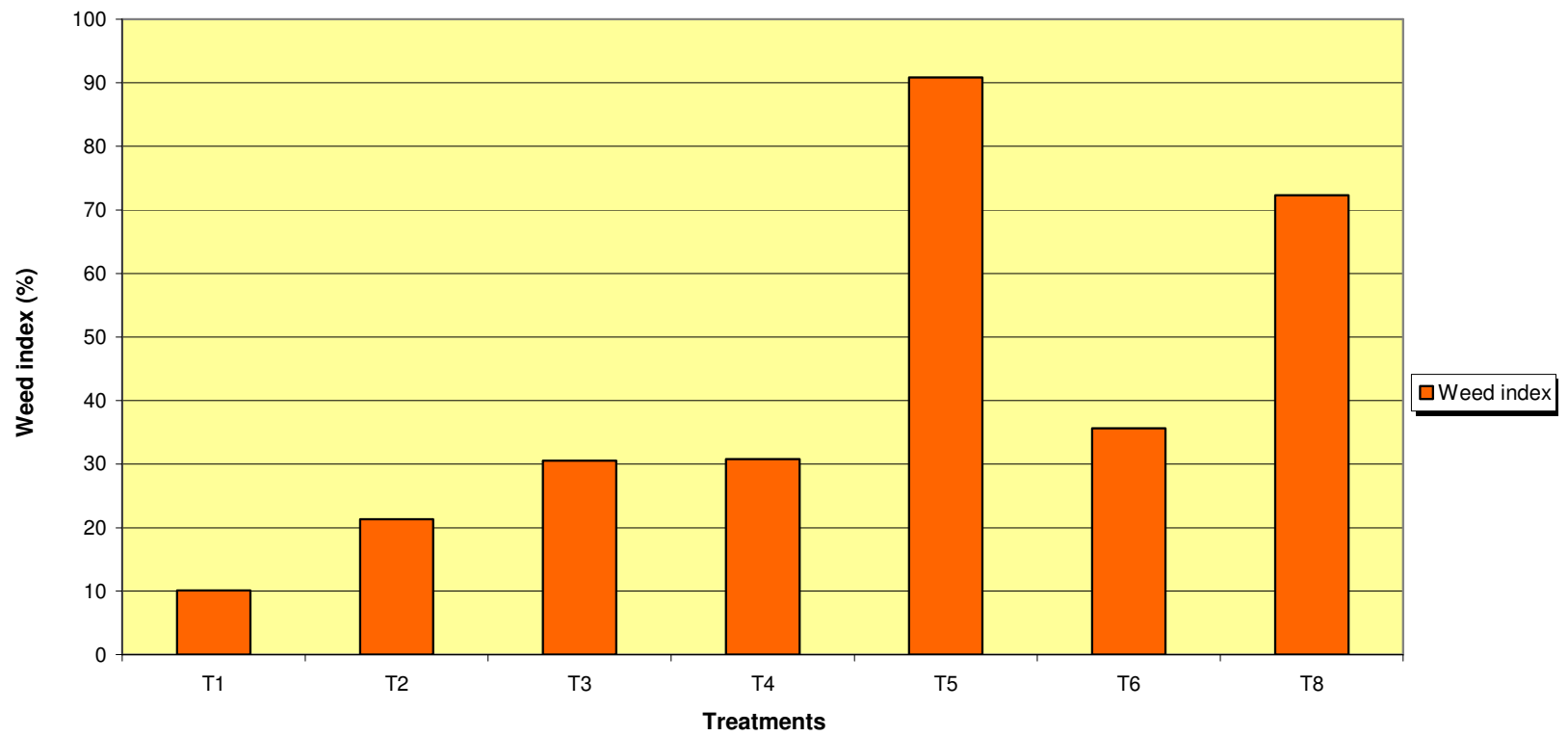
In contrast to weed free check, weedy check recorded significantly lower green chilli fruit yield (1,218 kg ha⁻¹) as a consequence of severe weed-competition, higher removal of moisture by weed and minimum uptake of nutrients by the crop resulting in poor development of fruiting bodies. Similar results were also reported by Kligman (1961), Sharma *et al.* (1988), Anonymous (1995) and Narasalagi (1999).

Butachlor 1.0 kg ha⁻¹ recorded higher green fruit yield (3,948 kg ha⁻¹) compared to other herbicides. This was mainly attributed to lower crop-weed competition, weed population and weed dry weight in the early stages enabling to crop establish and to grow well. This was clearly reflected in lower weed index (10.12%). As a result of effective weed control in initial stages, this treatment produced significantly higher dry matter plant⁻¹ (Table 15) which in turn might be due to increased water, nutrient uptake and photosynthesis. The dry matter production recorded in butachlor was comparable to that of weed free check, at all the growth stages except at 90 DAT. Alachlor was next to butachlor in recording green chilli fruit yield (3,456 kg ha⁻¹), followed by pendimethalin 1.0 kg ha⁻¹ (3,051 kg ha⁻¹), oxyfluorfen 0.3 kg ha⁻¹ (3,039 kg ha⁻¹) and haloxyfop 75 g ha⁻¹ (2,827 kg ha⁻¹). The variations in chilli yield in these treatments could be attributed to the variations observed in total dry matter production at all stages as well as at harvest Narasalagi (1999) and Biradar (1999) also reported similar findings in chilli.



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈-Weedy check

Fig.6. Green chilli fruit yield (Kg/ha) as influenced by different herbicides



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈ -Weedy check

Fig.7. Weed index (%) as influenced by different herbicides

Among the herbicides, diclosulam 22 g ha⁻¹ recorded significantly the lowest chilli yield (403 kg ha⁻¹). This was mainly due to phytotoxic effect of the herbicides on chilli crop plants and poor weed control to that of other herbicides tried. The weed index value was also higher (90.83%) when compared to other herbicides. William *et al.* (2000) reported that visible injury of diclosulam up to three weeks after planting and was less than 5 per cent regardless of cultivar in pea nut.

Variations in chilli yield could be attributed variations in growth and yield parameters such as number of green chilli fruits plant⁻¹ ($r = + 0.969$), green fruit weight plant⁻¹ ($r = + 0.998$). Narasalagi (1999), Biradar (1999) and Rajkumara (2009) reported that higher chilli yield obtained was due to significant and positive co-relation between yield and yield components and the negative correlation between weed dry weight and weed control efficiency.

Weed free check recorded significantly higher number of fruits plant⁻¹ and fruit weight plant⁻¹ (40.10 & 231.20, respectively) at harvest than rest of the treatments. Butachlor 1.0 kg ha⁻¹ was next to weed free check in terms of fruits number plant⁻¹ and fruit weight plant⁻¹ (37.35 & 206.35, respectively). The significant increase in fruit number and fruit weight in these treatments could be attributed to lower weed population, weed dry weight and higher weed control efficiency which ultimately resulted in better crop growth leading to higher dry matter production plant⁻¹. This inturn might have resulted in greater translocation of photosynthates resulting in increased fruit weight plant⁻¹. On the other hand, diclosulam recorded significantly the lowest fruits number and fruit weight plant⁻¹ (7.05 & 47.05, respectively) due to phytotoxic effect on crop.

The significantly lower fruits number plant⁻¹ and fruit weight plant⁻¹ in alachlor 2.0 kg ha⁻¹ (32.10 & 206.35, respectively), pendimethalin 1.0 kg ha⁻¹ (28.45 & 181.50, respectively), oxyfluorfen 0.3 kg ha⁻¹ (25.45 & 157.00, respectively) and haloxyfop 75 g ha⁻¹ (27.65 & 163.30, respectively) than butachlor and weed free check may be attributed to relatively higher weed population, weed dry weight and lower weed control efficiency. Narasalagi (1999), Biradar (1999) and Ved Prakash *et al.* (2003) they also reported similar findings in chilli.

The significant increase in number of fruit plant⁻¹ in weed control treatments could be attributed to relative improvement in dry matter production plant⁻¹ ($r = + 0.990$) which differed significantly in different weed control practices (Table 15). The total dry matter production (TDMP) showed significant increase between 30 and 90 DAT and was maximum at 120 DAT. At harvest, TDMP was reduced due to senescence of leaves (Table.15 and Fig. 8)

The TDMP of chilli was lowest in diclosulam 22 g ha⁻¹ at all stages of crop growth at 30, 60 90, 120 and at harvest (7.78, 20.75, 23.05 & 19.40, respectively). The significant reduction in TDMP was mainly due to phytotoxic effect of the herbicides. Weedy check recorded next lowest TDMP at all growth stages and was mainly attributed to severe competition from weeds and also due to profuse growth of weeds. Joshi *et al.* (1995), Narasalagi (1999) and Biradar (1999) also reported similar findings in chilli.

Weed free check and butachlor 1.0 kg ha⁻¹ treatments on other hand recoded significantly higher TDMP at 60, 90, 120 DAT and at harvest (28.25, 97.38, 100.23 & 93.35 and 26.08, 86.53, 91.45 & 88.18 g plant⁻¹, respectively) due to better utilization of resources as a result of lack of crop- weed competition. The herbicides such as alachlor 2.0 kg ha⁻¹ (17.95, 61.53, 71.40 & 58.25 g plant⁻¹, respectively), pendimethalin 1.0 kg ha⁻¹ (16.23, 55.23, 64.15 & 50.85 g plant⁻¹, respectively), oxyfluorfen 0.3 kg ha⁻¹ (15.58, 54.28, 60.68 & 48.10 g plant⁻¹, respectively) and haloxyfop 75 g ha⁻¹ (16.03, 58.00, 59.70 & 49.68 g plant⁻¹, respectively) recorded next higher values to butachlor. The TDMP recorded in these herbicides treatments did not differs themselves and but TDMP was significant higher when compared to diclosulam and weedy check. This could be attributed to the variations in selectivity of herbicides, lesser weed population, weed dry weight, lesser crop-weed competition and higher resources utilization by the chilli crop than that of diclosulam and weedy check. The results are in line with the findings reported earlier by Narasalagi (1999), Biradar (1999) and Rajkumara (2009) in chilli.

The variations observed in TDMP in chilli due to different weed control treatments could inturn attributed to the variations in growth components. Growth components such as



Plate.3. Butachlor 1.0 Kg/ha at 60 DAT



Plate.4. Alachlor 2.0 Kg/ha at 60 DAT



Plate.5. Pendimethalin 1.0 Kg/ha at 60 DAT



Plate.6. Oxyfluorfen 0.3 Kg/ha at 60 DAT



Plate.7. Diclosulam 22g/ha at 60 DAT



Plate.8. Diclosulam 22g/ha at 90 DAT



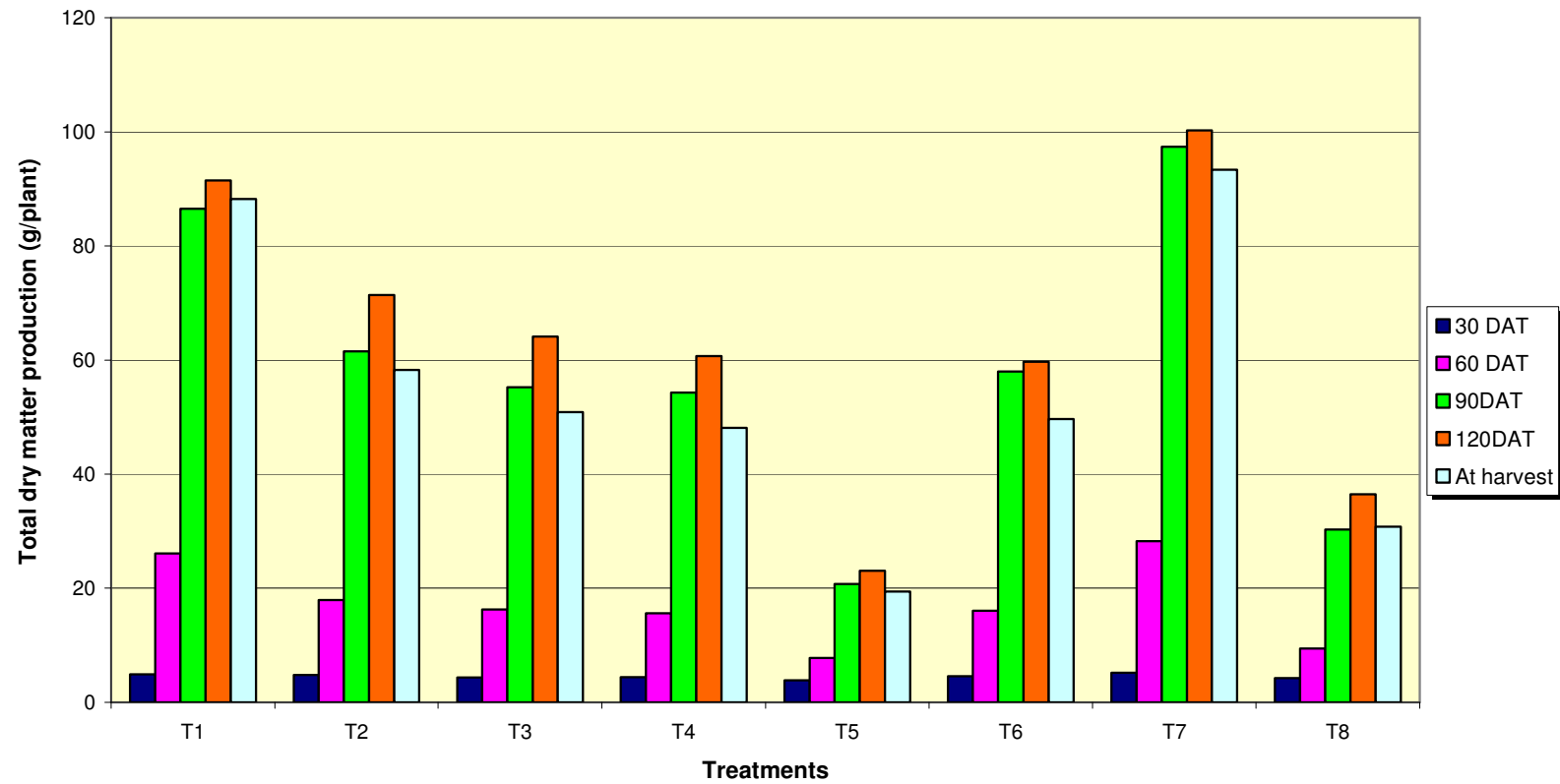
Plate.9. Haloxyfop 75g/ha at 60 DAT



Plate.10. Weed free check at 60 DAT

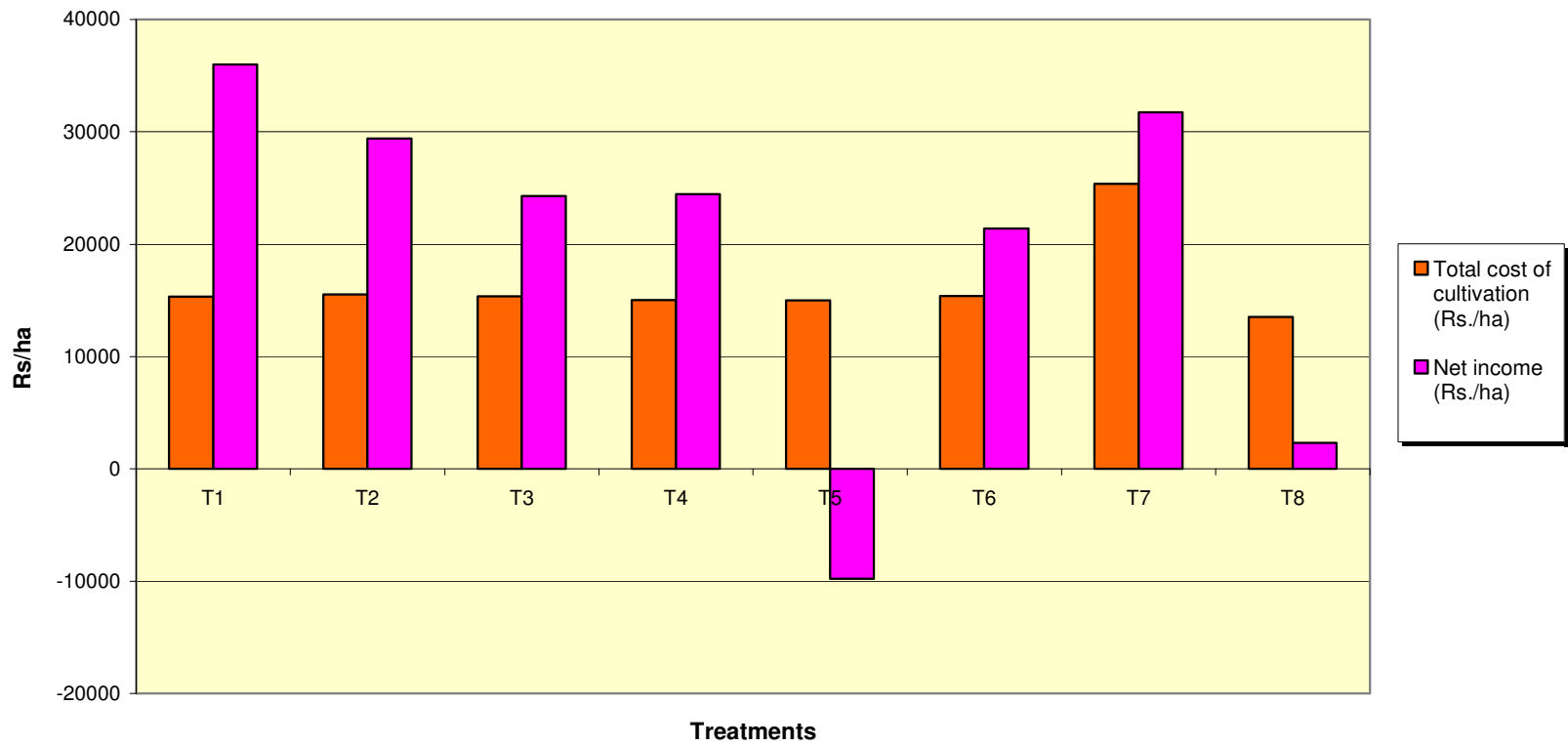


Plate.11 Weedy check at 60 DAT



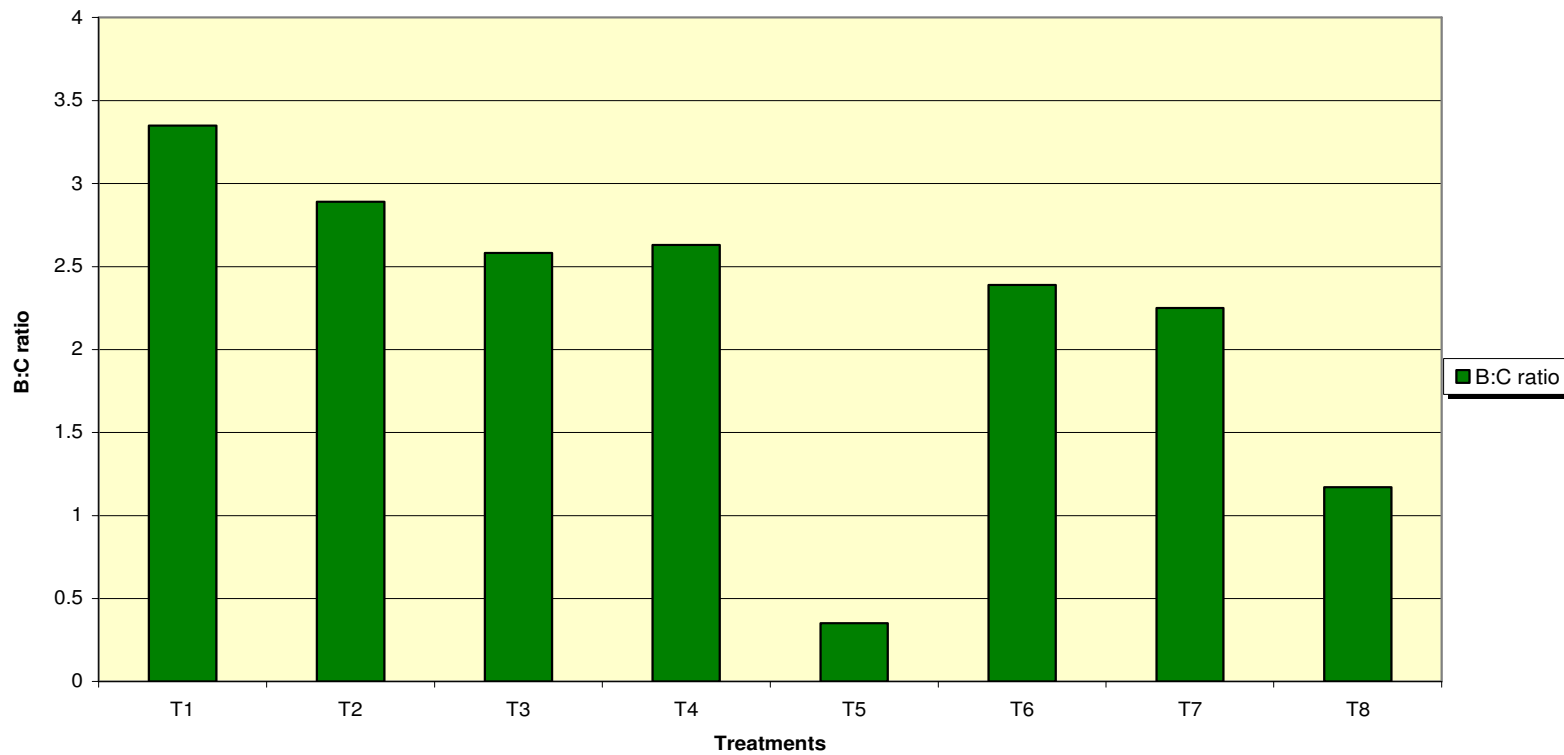
T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxypop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈ -Weedy check

Fig.8. Total dry matter production (g/plant) as influenced by different herbicides



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ .Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ .Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈-Weedy check

Fig.9. Total cost of cultivation and net income (Rs/ha) as influenced by different herbicides



T₁ -Butachlor @ 1.0 kg a.i. ha⁻¹ (PE), T₂ - Alachlor @ 2.0 kg a.i. ha⁻¹ (PE), T₃ -Pendimethalin @ 1.0 kg a.i. ha⁻¹ (PE), T₄ -Oxyfluorfen @ 0.3 kg a.i ha⁻¹ (PE), T₅ - Diclosulam @ 22 g a.i. ha⁻¹ (PE), T₆ - Haloxyfop @ 75 g a.i. ha⁻¹ (POE), T₇ - Weed free, T₈ -Weedy check

Fig.10. B:C ratio as influenced by different herbicides

plant height ($r = + 0.903$), number of branches ($r = + 0.990$) differed significantly due to different weed control treatments (Table 13 & 14).

Among the weed control treatments, weed free check and butachlor 1.0 kg ha⁻¹ recorded significantly taller plant and higher number of branches at harvest (99.33 & 91.15 and 13.35 & 12.90, respectively) followed by alachlor 2.0 kg ha⁻¹ (86.35 & 10.00, respectively), pendimethalin 1.0 kg ha⁻¹ (84.65 & 8.75, respectively), oxyfluorfen 0.3 kg ha⁻¹ (84.28 & 9.55, respectively) and haloxyfop 75 g ha⁻¹ (84.70 & 8.95, respectively). The latter four herbicides were however, on par with each other. Significantly shorter plant height and lesser number of branches observed in diclosulam 22 g ha⁻¹ followed by weedy check. The significant improvement in plant height and number of branches in weed free check and butachlor 1.0 kg ha⁻¹ treatments was due to efficient control of weeds and better utilization of the resources by the crop. On the other hand significantly higher weed competition and smothering effect of weeds on crop was noticed in weedy check which recorded shorter plant height (62.28 cm) and number of branches (4.80 cm) at harvest. The significant reduction in plant height (55.08 cm) and number of branches (3.45 cm) in diclosulam 22 g ha⁻¹ herbicide was mainly due to phytotoxicity of chemical on the chilli crop. Narasalagi (1999) reported that oxyfluorfen and pendimethalin herbicides were phytotoxic on chilli.

5.7 Economics of weed control treatments

The data on the economics (Table 22 and Fig. 9) of different weed control treatments showed significantly higher net income with butachlor 1.0 kg ha⁻¹ (Rs.36,004 ha⁻¹) followed by weed free check (Rs.31746 ha⁻¹). This was mainly due to higher green fruit yield of chilli. The other hand, significantly lower net income was recorded in diclosulam 22 g ha⁻¹ (Rs.-9,782 ha⁻¹) due to toxicity of the chemical and lower green fruit yield. In weedy check (Rs. 2,326 ha⁻¹) it was due to severe weed-crop competition as reflected in higher weed index (72.28 %). Narasalagi (1999) in chilli, Biradar (1999) in chilli and Lancaster *et al.* (2007) in peanut also reported similar such findings.

The data on benefit: cost ratio (B: C ratio) (Table 22 and Fig. 10) also revealed that butachlor 1.0 kg ha⁻¹ recorded significantly the highest value (3.35). This was mainly due to higher economic yield and net return and lower cost of cultivation. Alachlor 2.0 kg ha⁻¹ was next best treatment with B: C ratio of 2.89. The herbicides such as pendimethalin 1.0 kg ha⁻¹ (2.58), oxyfluorfen 0.3 kg ha⁻¹ (2.63) and haloxyfop 75 g ha⁻¹ (2.39) were next in order. Diclosulam 22 g ha⁻¹ (0.35) and weedy check (1.17) recorded significantly the lower B: C ratio on account of lower economic yield. Weedy free check through recorded maximum yield and gross income but the B: C ratio was comparable to that of pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹ and haloxyfop 75 g ha⁻¹. This was mainly due to higher cost of cultivation in maintaining weed free environment throughout the life cycle of the crop. Narasalagi (1999), Biradar (1999) and Rajkumara (2009) also reported similar such findings in chilli.

5.8 Practical application of the results

Based on the results of the investigation carried out on evaluation of herbicides for weed control in transplanted chilli under rainfed condition, pre-emergence application of butachlor 1.0 kg ha⁻¹ coupled with two inter cultivation at 40 & 75 and one hand weeding at 40 DAT can be suggested for effective weed control, higher yield and net returns.

5.9 Future line of work

1. Studies on diclosulam herbicide at lower doses as a pre-emergent and post-emergent.
2. Residual effect of herbicides on succeeding crop.
3. Effect of herbicides on soil micro flora and fauna.

6. SUMMARY AND CONCLUSION

A field experiment to study the Evaluation of different herbicides for weed control in transplanted chilli (*Capsicum annuum* L.) was carried out in medium deep black soil at College of Agriculture, Dharwad during *Kharif* 2008, under rainfed condition. The experiment was laid out in a randomized block design with four replications. Treatments consisted of five pre-emergent herbicides (butachlor 1.0 kg ha⁻¹, alachlor 2.0 kg ha⁻¹, pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹, diclosulam 22 g ha⁻¹) and one post-emergent herbicides (haloxyfop 75 g ha⁻¹) and two control treatments (weed free check and weedy check).

Weed flora

The weed flora noticed in the experimental site consisted of grasses, sedges and broad leaved weed category. The important grassy weeds observed are *Cynodon dactylon*, *Dinebra retroflexa*, *Eleusine indica* and *Setaria italica*. *Cyperus rotundus* was lone weed under sedge category and was more dominant than other weeds in entire experimental area. Among the broad leaved weeds, *Ageratum conyzoides* L., *Convolvulus arvensis* L., *Parthenium hysterophorus* L., *Phyllanthus niruri* L., *Portulaca oleraceae* L. and *Physalis minima* L. were most dominant weeds.

Weed control rating and crop toxicity rating

Weed control rating and crop toxicity rating showed marked differences among the different weed control treatments. Butachlor 1.0 kg ha⁻¹ gave good to excellent control while diclosulam 22 g ha⁻¹ gave moderate control of weeds (rating 6).

Application of diclosulam 22 g ha⁻¹ caused severe injury of chilli crop and some stand loss during entire crop season. Pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹ and haloxyfop 75 g ha⁻¹ gave slight toxic at later stage.

Effect on weed control treatments on weeds

The total weed dry weight, weed control efficiency and weed population of (grasses, sedges, broad leaved weeds) and total weed population differed significantly among various weed control treatments.

Significantly lower total weed dry weight was noticed in weed free check. Among the herbicides, butachlor 1.0 kg ha⁻¹ recorded significantly lower total weed dry weight at all the stages of crop growth. Significantly higher total weed dry weight was recorded in weedy check than rest of the treatments and other herbicides was intermediate in terms of weed dry weight.

Significantly lower total weed population was noticed in weed free check. Among the herbicides, butachlor 1.0 kg ha⁻¹ recorded significantly lower total weed population at all the stages of crop growth. Significantly higher total weed population was recorded in weedy check than rest of the treatments

Significantly higher weed control efficiency was recorded in butachlor 1.0 kg ha⁻¹ and followed by alachlor 2.0 kg ha⁻¹. Significantly lower weed control efficiency was recorded in weedy check.

Effect of weed control of treatments on yield and yield components of chilli

Yield and yield components of chilli varied significantly among various weed control treatments. Significantly the highest green chilli yield (4393 kg ha⁻¹) was obtained with weed free check. Butachlor 1.0 kg ha⁻¹ recorded higher green chilli yield (3948 kg ha⁻¹) and lower weed index (10.12 %) compared to other herbicides. The lower green chilli yields (403 & 1218 kg ha⁻¹, respectively) and lower and higher weed index (90.83 & 72.28 % respectively) was in diclosulam and weedy check treatments, respectively.

Weed free check recorded significantly higher number of fruits plant⁻¹ and fruit weight plant⁻¹ than rest of the treatments. Butachlor 1.0 kg ha⁻¹ was next to weed free check in terms of fruits number plant⁻¹ and fruit weight plant⁻¹. Diclosulam and weedy check treatments recorded significantly the lower fruits number and fruit weight plant⁻¹.

Dry matter production plant⁻¹ differed significantly among the treatments. Significantly higher total dry matter production (TDMP) was recorded in weed free check and butachlor 1.0

kg ha⁻¹ treatments. The TDMP of chilli was lower in diclosulam 22 g ha⁻¹ and weedy check treatments.

Weed free check and butachlor 1.0 kg ha⁻¹ treatments recorded significantly taller plant and higher number of branches than rest of the treatments. Significantly shorter plants height and lesser number of branches were observed in diclosulam 22 g ha⁻¹ followed by weedy check.

Economics

Economics of various weed control treatments indicated that significantly the highest net income (Rs. 36,004 ha⁻¹) was recorded in butachlor 1.0 kg ha⁻¹. Diclosulam recorded negative net return (Rs. -9,782 ha⁻¹) followed by weedy check (Rs. 2,326 ha⁻¹).

Benefit: cost ratio (B: C ratio) also revealed that butachlor 1.0 kg ha⁻¹ recorded significantly the highest value (3.35) while, significantly lower B: C ratio (0.35) was noticed in diclosulam 22 g ha⁻¹.

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APPENDIX I

Price list of inputs and outputs

Sl. No.	Particulars	Unit	Price (Rs.)
	A. Inputs		
1	Tractor charges (Ploughing)	ha	2000.00
	Seedling	Bed	100.00
3	Manures and fertilizers		
	Urea	kg	5.20
	DAP	kg	10.00
	MOP	kg	4.80
4	Herbicide/Weedicide		
	Butachlor 50%EC	l	200.00
	Alachlor50%EC	l	310.00
	Pendimethalin 30%EC	l	230.00
	Oxyfluorfen 23.5%EC	100ml	189.00
	Diclosulam84 WDG	kg	425.00
	Haloxypop 10%EC	l	625.00
5	Insecticide		
	Dicofol	l	240.00
	Endosulfan 35% EC	l	220.00
	Monocrotophos 36% EC	l	189.00
	Vertimac	100ml	900.00
6	Labour wages		
	Men for eight hours	Day	60.00
	Women for eight hours	Day	40.00
	Bullock pair with bullockman for eight hours	Day	350.00
	B. Output		
	Green chilli	kg	13.00

APPENDIX II

Details of cost of cultivation of chilli in different treatments (Rs. ha⁻¹)

Sl. No.	Particulars	T1	T2	T3	T4	T5	T6	T7	T8
I	Land preparation								
	Ploughing (tractor)	2000	2000	2000	2000	2000	2000	2000	2000
	Harrowing (bullock pair)	700	700	700	700	700	700	700	700
II	Transplanting								
	Seedlings	500	500	500	500	500	500	500	500
	Labour	1040	1040	1040	1040	1040	1040	1040	1040
III	fertilizers								
	DAP cost	1090	1090	1090	1090	1090	1090	1090	1090
	MOP cost	398	398	398	398	398	398	398	398
	Labour	260	260	260	260	260	260	260	260
	Urea cost	905	905	905	905	905	905	905	905
	Labour	180	180	180	180	180	180	180	180
IV	Weed control								
	Pre-emergent herbicide								
	Butachlor 50%EC	420							
	Alachlor 50%EC		620						
	Pendimethalin 30%EC			460					
	Oxyfluorfen 23.5%EC				139				
	Diclosulam84 WDG					111			
	Labour for spraying	100	100	100	100	100			
B	Post-emergent								
	Haloxypop 10%EC						469		
	Labour for spraying						100		
V	Plant protection								
	Dicofol	480	480	480	480	480	480	480	480
	Monocrotophos	378	378	378	378	378	378	378	378
	Labour for spraying	200	200	200	200	200	200	200	200
	Vertimac	144	144	144	144	144	144	144	144
	Monocrotophos	378	378	378	378	378	378	378	378
	Labour for spraying	200	200	200	200	200	200	200	200
	Endosulfan 35 EC	352	352	352	352	352	352	352	352
	Labour	200	200	200	200	200	200	200	200
	VI	Cultural practices							
Intercultivation (hoeing)		820	820	820	820	820	820	820	
Hand weeding (weekly)								11040	
Hand weeding 45 DAT		480	480	480	480	480	480		
VII	Harvesting (Picking)	2400	2400	2400	2400	2400	2400	2400	2400
	Miscellaneous (Land rent, implements, marketing costs, interest, layout, etc.,)	1700	1700	1700	1700	1700	1700	1700	1700
	TOTAL	15325	15525	15365	15044	15016	15374	25365	13505

T₁ Butachlor 1.0 kg ha⁻¹, T₂ Alachlor 2.0 kg ha⁻¹, T₃ Pendimethalin 1.0kg ha⁻¹, T₄- Oxyfluorfen 0.3 kg ha⁻¹,

T₅ Diclosulam 22 g ha⁻¹, T₆ Haloxypop 75 g ha⁻¹, T₇ Weed free check, T₈ Weedy check

EVALUATION OF HERBICIDES FOR WEED CONTROL IN TRANSPLANTED CHILLI (*Capsicum annuum* L.)

UMENDRA SINGH

2009

Dr. S. M. HIREMATH

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ABSTRACT

A field experiment to study the evaluation of different herbicides for weed control in transplanted chilli (*Capsicum annuum* L.) was carried out in medium deep black soil at College of Agriculture, Dharwad during *Kharif* 2008, under rainfed condition. There were eight treatments involving five pre-emergent herbicides (butachlor 1.0 kg ha⁻¹, alachlor 2.0 kg ha⁻¹, pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹, diclosulam 22 g ha⁻¹), one post-emergent herbicides (haloxyfop 75 g ha⁻¹) and two control treatments (weed free check and weedy check). The experiment was laid out in a randomized block design with four replications.

Weed control ratings and crop toxicity ratings showed marked differences among the different weed control treatments. Butachlor 1.0 kg ha⁻¹ gave good to excellent control followed by alachlor 2.0 kg ha⁻¹, while diclosulam 22 g ha⁻¹ gave moderate control of weeds. Application of diclosulam 22 g ha⁻¹ caused severe injury of chilli crop and some stand loss during crop season, while pendimethalin 1.0 kg ha⁻¹, oxyfluorfen 0.3 kg ha⁻¹ and haloxyfop 75 g ha⁻¹ gave slight toxic injury. Significantly lower weed population, weed dry weight and weed control efficiency (WCE) was noticed in weed free check and butachlor 1.0 kg ha⁻¹ at all the stages of crop growth. Significantly higher total weed dry weight was recorded in weedy check. Other herbicides were intermediate in terms of weed population, weed dry weight and WCE.

Green chilli fruit yields were significantly higher in weed free check (4,393 kg ha⁻¹). Butachlor 1.0 kg ha⁻¹ (3,948 kg ha⁻¹) and alachlor 2.0 kg ha⁻¹ (3,456 kg ha⁻¹) recorded next higher green chilli fruit yields. Chilli fruit number and fruit weight plant⁻¹ followed the trend of chilli fruit yield. Significantly higher net returns (Rs.36,004 ha⁻¹) and benefit: cost ratio (3.35) was recorded in butachlor 1.0 kg ha⁻¹ followed by weed free check (Rs.31,746) and alachlor 2.0 kg ha⁻¹ (2.89). Thus, it could be inferred that pre-emergence application of butachlor 1.0 kg ha⁻¹ + two Intercultivation + one Hand weeding was not only effective in controlling weeds but also found economical.