EFFICIENCY OF DIFFERENT HERBICIDES FOR WEED CONTROL IN CAULIFLOWER

(Brassica oleracea var. botrytis L.)

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THESIS

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CERTIFICATE-I

This is to certify that the thesis entitled "**Efficiency of different herbicides for weed control in cauliflower (*Brassica oleracea* var. botrytis L.")** submitted in partial fulfilment to the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (Olericulture)** to the **Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, J&K Jammu,** is a record ***bona fide*** research carried out by **Mr. A.A. Mir** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that such helps or information received during the course of investigation have been duly acknowledged.

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CERTIFICATE - II

We, the members of **Advisory Committee** of **Mr. A.A. MIR**, a candidate for the degree of **MASTER OF SCIENCE IN AGRICULTURE (Olericulture)** have gone through the manuscript of thesis entitled, **"Efficiency of different herbicides for weed control in cauliflower (*Brassica oleracea* var. botrytis L.")** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the degree.

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DEDICATED TO

THE RESPECTFUL MEMORY OF

MY FATHER

THE LATE GULAM RASOOL MIR

Thesis Abstract of A.A. MIR, student of M.Sc Agriculture (Olericulture)

Registration No.:- 98/A/496/M

Thesis Title:- "Efficiency of different herbicides for weed control in cauliflower *Brassica oleracea var botrytis L.*"

ABSTRACT

The present investigation was carried out under the sub-tropical conditions of Jammu in the experimental plots of Vegetable Research, Farm, Ponichak, Division of Olericulture and Floriculture, SKUAST, F.O.A Udheywalla, J&K Jammu, during the crop season of 1999-2000. The Experiment was conducted to ascertain pre-plant and post-emergence herbicides for effective and selective weed control in cauliflower.

All the herbicidal treatment significantly decreased the weed population and increased the yield as compared to unweeded control except metribuzin at 0.35 and 0.17 kg a.i ha^{-1} applied as pre-plant and post-emergence which proved phytotoxic to crop and showed complete mortality of the seedlings.

Herbicidal treatment studied under reference were significantly at par with each other for weed control in cauliflower and also proved to be the most effective, selective and economical as compared to unweeded control. Whereas, higher doses proved superior than the lower doses of all the herbicides applied during the study. However, Weeded control with four hoeings gave the maximum yield of cauliflower as compared to all the herbicidal treatment, but this method was laborious and tedious.

No residual effects were observed with any of the herbicides applied to cauliflower crop on the succeeding crops of beans, okra, cucumber and muskmelon.

On the perusal of the results, the present studies advocated that for getting maximum yield in cauliflower, these herbicidal treatment viz. fluchloralin, trifluralin, pendimethalin and oxyfluorfen can be recommended for effective, selective and economical weed control.

INTRODUCTION

Chapter - I

INTRODUCTION

Cauliflower (*Brassica oleracea var. botrytis* L.) commonly known as phool gobhi is an important member of the cole crops belongs to the family cruciferae. It is one of the most important vegetable crop grown throughout the world. Among the cole crops, it is next to cabbage in importance with regard to area and production in the world covering an area of 345 thousand hectares with a production of 4555 thousand tonnes (Bose and Som, 1990).

India and Italy are the main countries accounting for 25 per cent of the total area under this crop. In India, however, cauliflower is more widely grown as compared to cabbage in an area of about 90 thousand hectares with a production of about 560 thousand tonnes (Bose and Som, 1990). In Jammu district, it is grown in an area of 1250 hectares with a production of 25 thousand tonnes, whereas, Jammu district contributes 74 per cent and 79 per cent of the total area and production respectively (Anonymous, 1997).

Amongst the vegetables grown in India cauliflower has its own importance because this is the only vegetable, the seed of which is still imported. In Kashmir valley and higher reaches of Jammu region, cauliflower is mainly grown as an off season vegetable because of favourable agro-climatic conditions in the region, whereas, in plain areas of Jammu it is considered to be the queen of winter vegetables. The cultivation of cauliflower is gaining ground in view of its attractive appearance, good taste, high nutritive and market value. However, bringing more area under this crop has a limited scope but there is a potential to increase productivity per unit area by rational and optimum use of inputs and better management practices.

Among the problems encountered in the cultivation of cauliflower, control of weeds is of utmost importance. Weeds are unwanted and undesirable plants that interfere with the utilizations of land, water resources and thus adversely affect crop production and human welfare. Reduction in crop yield has a direct correlation with weed competition. Generally, an increase in one kilogram of weed growth corresponds to reduction in one kilogram of crop growth. Weeds remove plant nutrients more efficiently than crop plants. Effects of weeds are greatest on agriculture as weeds compete with crop plants for nutrients, soil moisture, space and sunlight thereby seriously reducing the productive capacity of agricultural lands.

There is no reliable study of worldwide damage due to weeds.

However, it is widely known that the losses caused by weeds exceed the losses from any other category of agricultural pests like insects, nematodes, diseases, rodents etc. Of the total annual losses of agricultural produce from various pests in India, weeds account for 45 per cent, Insects 30 per cent, diseases 20 per cent and other pests 5 per cent (Subramanian *et al*, 1995).

The quality of leafy and other vegetable crops also suffers on account of weeds. Due to this competition the cauliflower crop remains unhealthy and perhaps this is the biggest factor in the reduction of its yield and quality (Singh *et al*, 1974).

Cauliflower compete poorly with weeds in the early growing stage. This is made worse due to the frequent irrigations and application of liberal quantities of organic and inorganic manures which encourages the rapid growth of weeds. Traditionally, the crop is hand weeded but this process is uneconomical, laborious and tedious because the farmers have to face numerous problems for arranging labour for about four hoeings required for raising a healthy crop and not available at time when it is needed. It may also cause mechanical damage to the cauliflower crop.

In recent years the chemicalization of agriculture has offered a wide spectrum of herbicides which can accomplish weed control at much lower cost than mechanical and hand weeding. In addition to it, the herbicides are commonly used as a means of over coming the labour pressure (Hasewell, 1972 and Parker, 1974) and various possible benefits of herbicides tend to improve yield due to more effective weed control

especially early in crops life when the critical period of weed competition occurs (Shetty *et al*, 1977).

So far very little work have been done in India on chemical weed control in vegetable crops and least so in cole crops especially in cauliflower. Therefore, there is great need for controlling noxious weeds with herbicides in cauliflower however, use of different herbicides required very careful considerations on account of their narrow range between effective dose and toxicity limit.

Chemical weed control in vegetables has a greater scope even in India because it is more economical and suppresses germination and growth of weeds at the early stage of plant growth which is the most critical period for crop weed competition. Considering the importance of weed control in the region and lack of any published scientific informations, the present investigation is aimed to generate base line data regarding to weed control by herbicides in cauliflower. The data thus generated may be useful in drawing the effective management strategy.

Keeping in view the losses due to the weed infestations and highest cost of manual labour, the present investigation has been taken and planned with the following broad objectives.

1. To screen out the effective herbicides in cauliflower for the control of weeds.

2. To study the efficiency and selectivity of various pre-plant and post-emergence herbicides.

3. To find out the effect of herbicides on growth and yield of cauliflower.

4. To study the residual effect of various herbicides on succeeding crop.

5. To work out the relative economics.

REVIEW OF LITERATURE

Chapter - II

REVIEW OF LITERATURE

Man discriminated between useful and unwanted plants even when he was primitive about a million years ago and were undoubtedly recognized as a problem from the beginning (Hay, 1974). Weeds from a serious negative factor in crop production and are responsible for market losses in crop yields. It has been experimentally concluded that the fields cropped to vegetables have more weeds than soil where general farm crops are grown (Mani and Singh, 1977).

Chemical weed control have a great scope in India because, it is more economical and suppresses germination and growth of weeds at the early stage of plant growth which is the most critical period for weed competition (Bhutani *et al*, 1978). However, very little information is available on chemical weed control in cauliflower, hence a brief review of literature has been done in relation to cauliflower and other related vegetable crops under the following headings.

2.1. Crop weed competition and losses caused by weeds.

2.2. Chemical weed control.

2.3. Residual effect of herbicides on succeeding crops.

2.1 Crop weed competition and losses caused by weeds.

It is quite evident that by competing for nutrients, water and light, the weeds effect the vegetables adversely which lead to significant reduction in yield and quality (Roberts, 1976). The findings of the previous works also showed that the total losses due to weeds are more than the combined losses due to all agricultural pest and diseases (knake, 1962 and Furtick, 1967).

The competition of weeds with the cauliflower and other vegetable crops have been reported by various workers. Shadbolt and Holm, (1956) found that weed competition during early part of the season caused many adverse effect on the vegetable crops. It was noted that weed competition significantly reduced the yield of cauliflower (Finlayson *et al*, 1975). Lowest yield of cauliflower was recorded from the weedy check plots which was mainly due to higher weed population (Bhutani *et al*, 1978). Significant reduction in yield of cauliflower was noticed when the weeds were not removed throughout the crop life (Singh *et al*, 1974). They further recorded yield of 259.66 q/ha from the weeded plot as compared to 176.66 q/ha from the unweeded plot.

In competition studies between *Stellaria media* and transplanted spring cabbage, Lawson and Wiseman, (1972) concluded that there was 50

per cent reduction in total crop weight and 66 per cent in weight of marketable heads due to competition offered by *Stellaria media* during the entire crop season.

The yield and quality of cabbage was reduced to a great extent by heavy infestation of *Chenopodium album* and *Urtiea urena* (Roberts and Bond, 1975), while studying the effect of five weedicides at various concentrations along with weedy check by (Bhutani *et al*, 1978), found that all the weedicides controlled broad leaved weeds effectively whereas, *Cyperus rotundus* was not controlled by any one. Tenoran 50 W.P. @ 1 kg a.i/ha was most effective weedicide in controlling weeds and increasing the curd yield (144.37 q/ha) followed by 2 kg Tenoran 50 W.P. Lowest yield of cauliflower (98.88 q/ha) was recorded from the weedy check.

Similarly (Brathwaite, 1979) also observed that there was a 51 per cent reduction of yield and 14 per cent less head weight of cabbage in the presence of weeds. He further reported that only 50 per cent marketable heads were obtained from unweeded control as compared to 90 per cent from clean control treatments. Weed competition studies in other vegetable crops also revealed that there was 25.8 per cent reduction of yield in peas (Saimbhi, *et al*, 1970), 20 per cent in dwarf beans *(Phaseolus vulgaris* L,) 25 per cent to 100 per cent in summer cabbage *(Brassica oleracea* L) and runner beans *(Phaseolus multiflorus)* (Roberts, 1976), Saimbhi and Randhawa (1974) noted that maximum weed crop competition 83:1 was recorded in the unweeded control and caused 99.6 per cent decrease in

fruit yield of tomato as compared to weed free plots.

Randhawa and Bhalla, (1976) found that unweeded control showed significantly 65 per cent lower yield than weeded plots of onion. There was 80.66 per cent reduction in seed yield of onion due to the intense competition of weeds in unweeded check, (Sandhu and Randhawa, 1980).

Singh and Tripathi, (1982) found that weed competition during early part of the season causes many adversal affect on the cauliflower crop. The weed density was sufficient during early stages of crop growth to cause competition with crop and resulting poor net curd. They further observed that increase in curd yield was associated with the reduction in weed competition as evinced by decreased population and dry matter production of weeds. However, weed free condition proved significantly superior over all the treatments. Thus the crop need weed free condition for at least 30 days after transplanting. The magnitude of reduction in the curd yield of cauliflower due to weeds during 60 days after transplanting was more as compared to early to late stages.

Porwal and Singh, (1993) reported that there was non significant increase in the curd yield due to increase in the weed free condition beyond 60 days after transplanting, suggesting thereby the cauliflower crop should be kept weed free for first 60 days of transplanting. Similarly during the weed competition studies, three year data indicated that there was a significant reduction in the yield of onion, when the weeds were not removed throughout the crop life.

Singh, (1996), he also recorded that yield of 156.48 q/ha from the weeded plots as compared to 43.14 q/ha from the unweeded plots. Singh *et al*, (1997) recorded that lowest yield of brinjal (60.94 q/ha) from the weeded check plots as compared to the yield of (298.14 q/ha) obtained from weed free check plots. They further advocated that the lowest yield from the weedy check plots was mainly due to the higher weed populations.

In another experiment conducted by Singh *et al* (1997) observed a significant reduction and obtained a yield of onion (41.24 q/ha) in the plots where the weeds were not removed throughout the crop life. However, highest yield of (275.32 q/ha) was obtained from weed free check plots.

2.2 Chemical weed control.

In chemical weed control studies, alachlor was found to be a good pre-emergence herbicide against annual grasses and broad leaf weed (Bhan and Singh, 1972). They observed that alachlor normally degrades in the soil approximately 45 to 50 days after application, as such there was neither any build up of the chemical nor its residual toxicity in the soil that may effect the following crops. However, Singh *et al*, (1973) found that alachlor 1.5-2.0 kg a.i/ha applied in cole crops and turnip controlled *Chenopodium album*, *Amaranthus* spp, *Portulaca oleracea* and *Launea pinnatifida* very effectively but gave poor control of perenial *convolvulus arvensis*, *Cyperus rotundus* and *Cynodon dactylon*. Zohan *et al*, (1971) in their studies with chemical weed control in cole crops found alachlor (1-3 kg a.i/ha) effective in controlling weeds.

Best yield of cabbage was obtained with pre-emergence application of alachlor at 2.27 lit/ha (Noll, 1971). In a research report published by Canada Department of Agriculture, it has been concluded that alachlor at 2.5 lit/ha caused a slight growth of cabbage but, was very effective against *Solanum nigrum* (Anonymous, 1973). Scudder, (1975) reported that a mixture of alachlor at 2.27 lit/ha and sulfallat at 2.27 lit/ha was the best treatment when applied after transplanting cabbage. Pre-emergence application of alachlor at 1.13 lit/ha gave excellent control of *Galinsoga ciliata* and *Amaranthus reteroflexus* with minimum injury to cabbage crop (Stillwell and Sweet, 1975, Shelleck and Sanok, 1976).

Singh and Sharma (1968) reported that nitrofen was a promising herbicide for potato, turnip, radish, carrot and onion. It controlled all weeds except *Cyperus rotundus* and *Fumaria paraviflora.* They also concluded that nitrofen at 0.9 - 1.8 kg a.i/ha was highly effective and economical in controlling weeds in cauliflower. Bhutani *et al*, (1978) also found that nitrofen at 3 kg a.i/ha applied two weeks after planting the cauliflower, gave the highest yield and was found effective for controlling broad leaved weeds but proved to be ineffective for controlling *Cyperus rotundus.* They also stated that the higher yield with nitrofen could be due to its stimulating or growth regulatory effects.

Avall, (1972) while studying the chemical weed control also reported that nitrofen at 2.27 kg/ha applied at the cotyledon stage of sown cauliflower or 2-4 weeks after planting could be recommended for the

control of broad leaved weeds in the cauliflower. Similar effects of nitrofen at 0.90 kg/ha have also been observed by Singh *et al*, (1974). They found that it was effective in kholrabi, turnip and cauliflower which significantly increased the yield of these crops.

Finlayson *et al*, (1975) noticed that nitrofen alone is not so effective against all the weeds in cauliflower. They got an excellent weed control which led to high yield with nitrofen 2.2 kg/ha + propachlor 2.2 kg/ha as pre-emergence application. Similar studies were also done by (Anonymous, 1968). They also observed that nitrofen at 3.62 kg/ha was only effective when it was applied along with chloroprophan at 3.1 kg/ha.

Pre-emergence application of nitrofen at 4.54 kg/ha gave excellent control of *Digitaria sanguinalis* and *portulace oleracea* without harming the cabbage crop (Shelleck and Sanok, 1978). Other workers also reported that nitrofen at 2-3 kg/ha gave an effective weed control in cabbage (Mani *et al*, 1975), kholrabi (Fiveland, 1975), swedes, kale, and oil seed rape (Fiveland, 1976).

Fluchloralin a selective herbicide at 0.68 -1.81 lit/ha gave an excellent range of efficacy against *Brachiaria platiphylla, Digitaria* spp, *Echinochloa colonum, Eragrostis crusgalli, Eleusine indica, Lolium multiflorum, Panicum texanum, Phalaris arundinacea, Poa annua, Setaria faberi, Setaria lutescens, Setaria viridus, Sorghum halepense, Amaranthus spp, Polygonum spp, Chenopodium album, Chenopodium morale, Kochia acorparia, Mullugo verticillate, Portulace oleracea,*

Richardia scabra and Tribulus terrestris (Ertl, 1974). Similarly, an effective weed control both in terms of dry weight and population of weeds like *Cynodon dactylon, Cyperus rotundus, Eleusine indica, Eragrostis spp, Chenopodium album* and *Trianthema monogyna* was obtained with fluchloralin in sunflower (Sankar *et al,* 1976) .

Fluchloralin applied at 0.90 lit/ha before transplanting cabbage had gave a good efficiency against most of the weeds and significantly increased the yield. Flouchloralin persisted well in the soil and prevented any weed growth even in the relay onion crop till the maturity and substantial improvement in onion bulb production appeared to have resulted from the long duration weed control with this herbicide (Mani *et al*, 1975). Fluchloralin incorporated lightly in the soil at 3 lit/ha gave the best weed control and resulted in 98 per cent increase in yield of peas as compared to control which was weeded once in a month after sowing (Singh *et al*, 1974). Superiority of fluchloralin had also been indicated even at the lower concentrations of 0.98 lit/ha as compared with other treatments in brinjal. Weed control was excellent up to 65 days followed by clear cut yield increases over hand weeded plots (Leela, 1976). In patato, fluchloralin applied at 0.5 lit/ha as pre-plant application substantially enhanced the tuber production and did not showed any residual effect on wheat raised as relay crop (Mani *et al*, 1977).

Work done in farm crops also revealed that fluchloralin was a selective and effective herbicides which resulted in higher yields of cotton

(Chowdappan, 1972) and maize fodder (Gill *et al*, 1978). An appreciable reduction in the number of curds was obtained with post planting application of simazine at 0.82 kg/ha (Allott, 1966). Verlaat, (1966) observed that simazine at 1.5 kg/ha when applied one weak after planting the cauliflower gave best early control of weeds but it caused chlorosis leading to mortality of the crop. Similarly, Cassidy, (1966) in field experiments concluded that simazine at 0.54-1.3 kg/ha gave an excellent weed control for entire season, but both the level of doses reduced the yield and number of curds as compared to hand weeded control.

In chemical weed control studies chloroxuron at 1 kg a.i/ha was the most effective weedicide in controlling the weeds and increasing the yield of cauliflower over repeated weedings (Bhutani *et al*, 1978). Chloroxuron at 2 kg/ha as pre-emergence application gave a significant increase in bulb weight and yield of onion over unweeded plot (Saghir *et al*, 1970). Whereas, Saimbhi *et al*, (1976) observed that a severe injury was caused to brinjal with chloroxuron at the rate of 0.50 kg a.i/ha and lorox at 0.25 kg a.i/ha and found that these herbicides were not effective in controlling weeds and stepping up yield.

Pre-plant application of trifluralin to cauliflower at 1.13 to 2.26 lit/ha had been found to be selective and showed good activity against most of the weeds (Woodford, 1968, Whitewell and Senior, 1968, Curvale, 1971, Uprichard, 1971). Whereas, Roberts, (1972) found that trifluralin alone was not so satisfactory for excellent weed control in cauliflower especially

against weeds like *Trifolium repens and Senecio vulgaris*. He got the best control of annual weeds and highest yield of cauliflower with a combinations of trifluralin 6 kg/ha incorporated during seed bed preparation followed by propachlor 4.4 kg/ha applied after drilling. Propachlor at 8-10 kg/ha was found to be selective and effective against most of the weeds (Verlaat, 1967, Anonymous, 1975).

In three years trials of chemical weed control studies (Gushcha, 1978) concluded that propachlor at 6-8 kg/ha gave 72-84 per cent control of weeds and had no adverse effect on cabbage yield and quality. Similarly Dolot, (1976) reported that propachlor at 6 kg/ha when incorporated before transplanting the cabbage gave 87-96 per cent control of annual weeds and also some broad leaved species.

Desmetryne at 1.5 kg/ha gave good control of weeds when applied 2 weeks after planting the cauliflower without adversely effecting the yield and quality of crop (Anonymous, 1965). Bugiani and Brandazza, (1966) also found that pre-emergence application of desmetryme at 1 kg/ha can be recommended for weed control in all *Brassica oleracea* cultivars, but post-emergence application is possible only in cabbage, kale and head cabbage but not in cauliflower. Desmetryne at 0.3-0.5 kg/ha gave 60-90 per cent control of weeds without reducing the yield of cabbage (Dolot, 1976). Similarly, Gautm *et al*, (1976) found that desmetryne at 0.5 kg/ha applied after transplanting cabbage but before weed emergence gave good control of annual weeds, increase in yield and hastened the maturity of the crop.

Mass (1974), in his study reported that desmetryne was bound strongly to the organic matter complex of the soil therefore, its rates had to be increased with increased soil humus to maintain the weed control. Pre-sowing incorporation of paraquat at 0.25 to 1 kg/ha gave excellent control of the *Digitaria sanguinalis* and *Portulaca oleracea* but imparted Phytotoxic effect on cabbage and cauliflower (Shelleck and Sanok, 1978).

Sandhu *et al*, (1982) studied the chemical weed control in cauliflower *cv Giant*-35 and found that fluchloralin at 1.20 kg a.i/ha, alachlor at 2.50 kg and 1.50 kg a.i/ha and chloroxuron at 1.50 kg a.i/ha controlled the weeds effectively and selectively whereas, methabenzthiazuron at 1.20 kg and 1.40 kg a.i/ha and metribuzin at 1/20 kg and 1.40 kg a.i/ha imparted sever phytotoxic effect to the cauliflower plants and showed complete mortality of the seedling.

Weed control studies in cauliflower were undertaken by Bhayan *et al*, (1985). They found all the six herbicides reduced weed population and dry matter accumulation by weeds significantly. Metribuzin at both the level of doses was injurious to cauliflower and curd formation did not took place, whereas, this herbicides was sprayed. They further observed that all the remaining treatment increased yield over weeding check. Weed free check gave the maximum yield of 218 q/ha whereas, among the herbicidal treatment pendimethalin at 1.50 kg a.i/ha gave the highest yield.

Singh and Tripathi, (1988) studied the relative efficiency of herbicides for weed control in cauliflower and found that post-emergence

application of sethoxydim at 1.5 kg/ha in combination with one manual weeding 45 days after transplanting followed by alachlor at 0.75 lit/ha pre-emergence with hand weeding 45 days after transplanting proved to be the most effective in controlling weeds whereas, uncontrolled weeds reduced the curd yield of cauliflower by 61.4 per cent.

James *et al*, (1989) tested the efficiency of herbicides at three different locations for the control of weeds in cauliflower. Applications of 4.5 kg a.i/ha diethatyl and tank mixes of oxyfluorfen controlled the weeds, best plant stand ,curd yield and curd size of cauliflower were not affected by the treatment for any of the varieties used at any of these locations. The best weed control consistently was obtained with 4.5 kg/ha diethatyl and tank mix of 1.1 kg/ha and oxyfluorfen alone or combined with 1.3 kg/ha cinmethylin.

Porwal and Singh, (1993) while studying the efficacy of herbicides for weed control in cauliflower found that the pre-plant incorporation of fluchloralin at 1 to 1.5 lit/ha followed by hand weeding 45 days after transplanting provided completely weed free environment and maximum curd yield. They further observed that fluchloralin at 1 lit/ha (PPi) and oxyfluorfen 0.1 lit/ha pre-emergence was the most economical and feasible method of controlling weeds in cauliflower.

Mark and Howard, (1995) while studying the effect of post-transplanting herbicides (oxyfluorfen) on different cultivars of broccoli, cabbage and cauliflower, found that the cultivars were different in tolerance

to oxyfluorfen at the rates above 0.25 kg a.i/ha, whereas, broccoli cultivars possess sufficient tolerance to oxyfluorfen applied as post-transplanting on weed control as compared to other cultivars of crop under study.

Singh, (1996) studied the relative efficacy of fluchloralin, methabenzthiazuron and oxyfluorfen with combination of one hand weeding at 45 days after transplanting on weed control in onion and found that a fluchloralin and oxyfluorfen at higher rates reduced the weed population but the size index of onion bulb and bulb yield (178.89 q/ha) was recorded highest at the lower rates of fluchloralin at 1 lit/ha + one weeding at 45 days after transplanting.

Singh *et al*, (1997) studied different chemical herbicides for the control of weeds in onion and observed pronounced effect of all the herbicides applied and mulching in controlling weeds and increasing the yield of onion. Among the different treatment combinations pendimethalin at 1 kg a.i/ha + one hand weeding at 60 days after transplanting proved to be the most economical as it gave the highest cost benefit ratio and suggested that control of weeds through chemical and mulching were superior than the mechanical hand weeding in onion crop.

In another experiment Singh *et al*, (1997) found that the treatment combinations of pendimethalin at 1 kg a.i/ha + one weeding at 30 days after transplanting proved to be the most economical as it gave the highest cost benefit ratio in brinjal crop.

Giri *et al*, (1998) while studying the performance of cultural, chemical and integrated methods of weed control in sunflower found that integrated method of weed control either with fluchloralin 1 kg/ha or oxyfluorfen 0.1 kg/ha each supplemented with one hoeing at 6 weeks after sowing proved to be economical.

Tewari *et al*, (1998) studied the different herbicides in potato intercropped with Indian mustard and reviewed the oxyfluorfen at 0.15 lit/ha, pendimethalin at 1.0 lit/ha and isoproturon at 0.75 kg/ha satisfactorily controlled the weeds leading to 79%, 51% and 54% weed control efficiency respectively. They further reported that oxyfluorfen and pendimethalin produced 33.45% and 26.17% more yield than that of unweeded control. Whereas, metribuzin at 0.70 kg/ha was highly toxic to Indian mustard.

Chaudhary, (2000) used four herbicides supplemented with hand weeding for the weed management in coriander. All the weed control measures significantly increased the number of umbels per plant and seed yield.

2.3 Residual effect of herbicides on succeeding crop

It has been suggested that if the treatment are applied in accordance with the recommendations and the crops are harvested at the normal time, residues of the herbicides in the soil should not effect succeeding crops (Woodford and Evans, 1965). It is being recognised that some persistence is a necessary property of all herbicides, with

no persistence soil applied herbicides would not control weeds (Ashtom and Crafts, 1973). Some herbicides may disappear completely over the course of a week or so, whereas, others may be still detectable in toxic concentrations after periods of two or more years. Although for one and the same chemical the degree of this persistence varies very considerably with soil conditions (Audus, 1964).

There may be two possible sources of crop damage firstly the repeated annual applications of herbicides resulted in a build up of residues in the soil, thus may be proving phytotoxic or reduce yield. Secondly, the residues from single or repeated applications might be a hazard to the succeeding crop (Davison and Clay, 1972).

Applications of linuron and monolinuron at 1 kg/ha and metobromuron at 1.25 kg/ha to potato did not effect its yield or of the following crop of cauliflowers sown 9-13 weeks after spraying (Granqvist, 1970). Residues from triflurolin at 1-2 lit/ha, fluchloralin at 2 lit/ha and nitrofen at 2 kg/ha, applied to cabbage did not adversely effect onion sown in the standing crop of cabbage and prevented weed growth almost its maturity gave a substantial increase in onion bulb production (Mani *et al*, 1975).

Fluchloralin applied to potato crop, did not show any residual phytotoxic effect on the succeeding wheat and barley crops (Gill *et al*, 1977). In a herbicidal trial no residual or phytotoxic effect of fluchloralin 1.25 lit/ha, alachlor 2 lit/ha was observed on the following crops of ragi, sorghum,

cowpeas and lablab, when these herbicides were applied to cotton crop (Balasubramanian and Sankaran, 1977).

The herbicides like nitrofen 2 kg a.i/ha, alachlor 2.50 kg a.i/ha, propanil 1.36 kg and 1.02 kg a.i/ha, fluchloralin 1.90 kg and 1.20 kg a.i/ha, chloroxuron 1.50 kg, 2 kg and 3 kg a.i/ha, pre-emergence, nitrofen 2 kg a.i/ha post-emergence, fluchloralin 1.20 kg a.i/ha pre-plant + propanil 0.68 kg a.i/ha post- emergence and fluchloralin 1.20 kg a.i/ha pre-plant + chloroxuron 1.50 kg a.i/ha post-emergence, did not show any deleterious residual effect in the soil which could proved toxic to succeeding crops i.e. okra, bottlegourd, squashmelon and muskmelon when these herbicides were applied to onion (Sandhu and Randhawa, 1980).

Hira, (1980) found no residual effect by herbicidal treatment applied to cauliflower crops on the succeeding crops. The herbicides are alachlor, fluchloralin, chloroxuron, nitrofen, methabenzthiaxuron, metribuzin, propanil, simazin as pre-plant, pre-emergence and post emergence stages did not show any residual effect on the succeeding crops of watermelon, muskmelon, bottlegourd and okra.

Nalayini and Sankaran, (1992) found no residual effects of any herbicides applied to the sunflower on the succeeding crops of sorghum, pearlmillet and cowpea. Similarly the effect of herbicides residues on a sensitive succeeding crop cucumber was also studied by Dhanapal and Bomme, (1996). They found that residue of oxyfluorfen and 2,4-D sodium salt adversely affected the germination, root length, shoot length and dry weight of the

seedling as compared to the residues of benethicarb, fluchloralin and oxyfluorfen, 2, 4-D sodium salt and preceding crops such as finger millet, sorghum, navane, cowpea, soybean, red gram, niger, castor and sunflower had reduced the germination, root length, shoot length and dry weight of cucumber whereas, these parameters on cucumber were not affected due to interaction of benthiocarb, fluchloralin, oxdiazon and the above mentioned crops.

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The present investigation was carried out at the vegetable Research Farm, Ponichak, Division of Olericulture and Floriculture, S.K. University of Agricultural Sciences and Technology, F.O.A Udheywalla, J&K Jammu, during the year 1999-2000. The site is at 295 metres above mean sea level altitude with location of 32^0 42'N latitude and 74^0 50 'E longitude.

3.1 Environmental condition

The climate in general is sub-tropical. May and June are the hottest months while December and January are the coldest. The annual precipitation ranges between 1000-1300 mm, of which about 70 per cent is received during monsoon season. Winter rains are also received during the month of Jannuary. The noteworthy features of the annual variations are, the rapid increase in temperature in the month of April and a similar fall in the month of January. The weather remained favourable throughout crop growth season during 1999-2000.

3.2 Soil characteristics

The soil of the experimental field was well drained and silty loam with neutral rection (6.8 to 7.00 pH). The levels of available nitrogen 262-263 kg/ha and phosphorus 18.00 to 19.14 kg/ha were relatively low but potassium content (144.00-145.63 kg/ha) was quite sufficient for the normal growth of the plants. The physio-chemical characteristics of the soil and meteorological date during the life span of the crop are give in appendix i , ii and depicted graphically in Fig. 1.

3.3 Experimental procedure

Selection - 4, a mid-season variety of cauliflower recently developed in the division of Olericulture and Floriculture S.K. University of Agriculrural Sciences and Technology, F.O.A Udheywalla, J&K Jammu, was used for this study. The experiment was laid out in the randomised block design comprising 12 herbicidal treatment, weeded control and unweeded control, in three replications (Table 1). The net plot size was 10 square meters (4 x 2½ m) in each case. The seedlings of cauliflower were transplanted on october,12 1999-2000. Each treatment consisted of 7 rows of 5 plants each set at a distance of 60 x 45 cm both between and within the rows respectively. Thus there were 35 plants in each plot.

The recommended dose of N,P and K were applied to raise a healthy crop. Half dose of nitrogen calculated was broadcast at the time of transplanting along with the whole P_2O_5 and K_2O. While second half dose

Fig. 1 Weekly climatalogical data recorded at Water Management Research Center for the period of crop under study with effict from 10th of Sep.99 to 25th of Feb. 2000

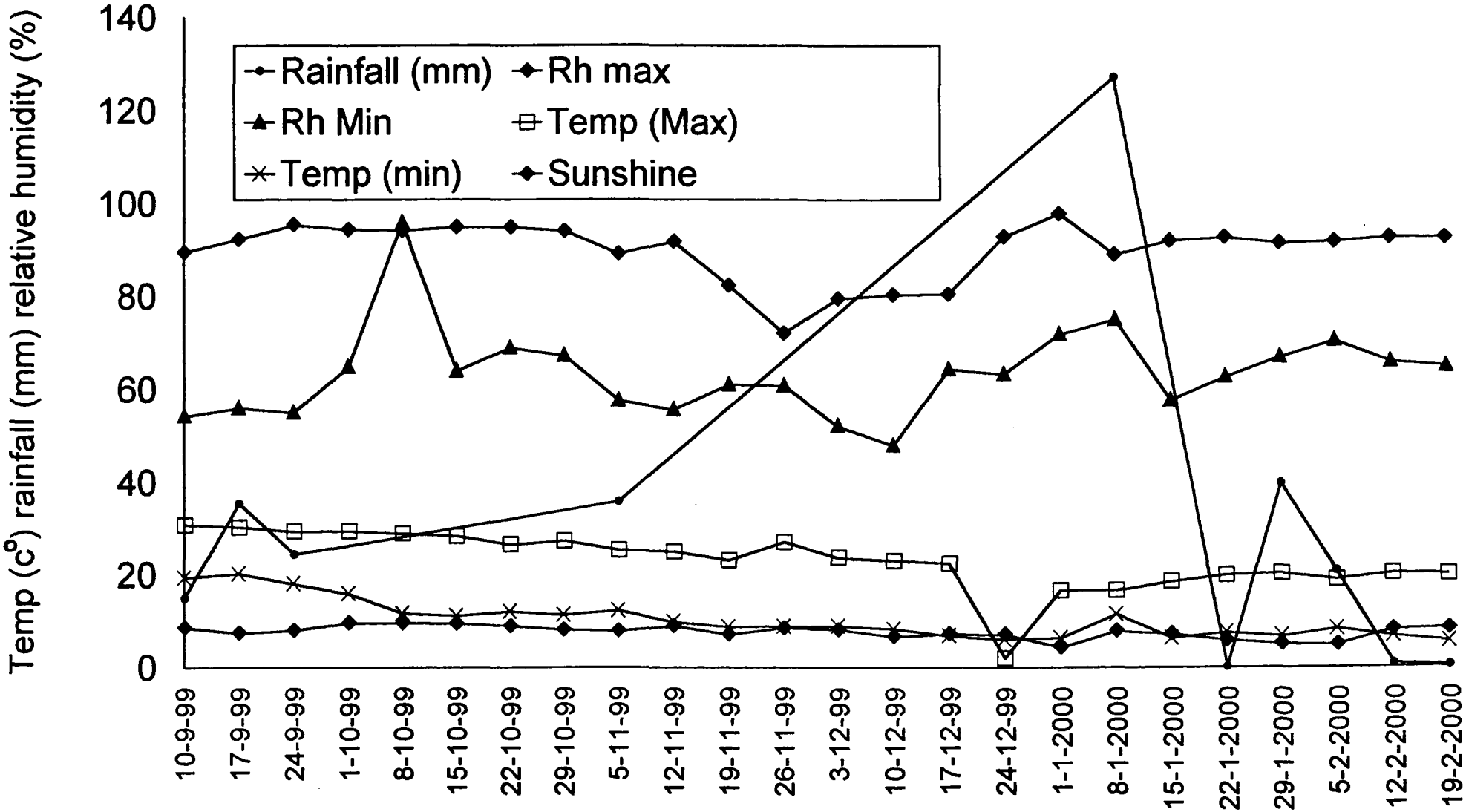


Table1 Details of herbicidal treatment

Treatment		Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}
Trade name	**Common name**			
Basalin	Fluchloralin	Pre-plant	2.50	1.12
Basalin	Fluchloralin	Pre-plant	1.50	0.67
Sencor	Metribuzin	Pre-plant	0.50	0.35
Sencor	Metribuzin	Pre-plant	0.25	0.17
Sencor	Metribuzin	Post-emergence	0.50	0.35
Sencor	Metribuzin	Post-emergence	0.25	0.17
Treflan	Trifluralin	Pre-plant	2.50	1.20
Treflan	Trifluralin	Pre-plant	1.50	0.72
Stomp	Pendimethalin	Pre-plant	6.00	1.80
Stomp	Pendimethalin	Pre-plant	4.00	1.20
Alto	Oxyfluorfen	Pre-plant	1.00	0.23
Alto	Oxyfluorfen	Pre-plant	0.50	0.11
Weeded control	Weeded control	-	4 hoeings	-
Unweeded control	Unweeded control	-	-	-

of nitrogen was applied after an interval of 35 days after transplanting. Irrigation was applied as needed.

3.4 Application of herbicides

The pre-plant application of hrbicides was done two days before transplanting and incorporated thoroghly in the soil by proper harrowing. The post-emergence herbicide was applied 15 days after transplanting when the weeds were emerged. The application of the herbicide was done with the help of a knap sack sprayer by using flat fan type nozel. In case of weed free treatment, four hoeing and weedings were done with the help of khurpa at an interval of 15, 30, 45 and 60 days after transplanting of crop respectively. The common name, trade name and chemical name of herbicides used are mentioned in the Appendix iii.

3.5 Observational procedures

Observations were recorded on the following characters from each treatment in each replication and their means worked out for statistical analysis.

1. Crop studies

i. Crop stand

To know the crop stand, the number of seedlings of cauliflower were counted under the different treatment in each plot after 30 days of transplanting and average mean were worked out.

ii. Phytotoxic effect

Phytotoxic effect under the influence of different herbicidal treatment during the growth period was noticed by visual observation from each plot.

iii. Height of the plants

Plant height after 45 days of transplanting and at the time of final harvest was measured in centimeter from the base of the plant to the tip of the upper leaf. Five plants were marked randomly in each plot and average height was calculated.

iv. Yield

The plants were harvested and the weight of the curd excluding stalk up to first leaf and leaves up to the line of curd harvested at the marketable maturity was recorded in each plot and average yield per hectar calculated in quintals.

2. Weed studies

i. Weed flora

The different weed species present in each plot under the influence of different treatment were recorded at 45 days after transplanting and at the time of harvest.

ii. Weed count

The total number of weeds present in each plot was counted at 45

days after transplanting and at the harvesting time under the influence of different treatment. Weed count was taken by putting 0.25 Sq.m quadrant at 3 random places within the plot at 45 days after the transplanting and at the time of harvesting of the crop. Average number of weeds present in each plot at 45 days and at the harvesting time were worked out.

iii. Fresh weight accumulation of weeds

The total fresh weight of weeds in each plot was recorded at the time of harvest and average fresh weight was calculated.

iv. Dry weight accumulation of weeds

The respresentative samples of fresh weeds were taken from each treatment and weight of the samples were recorded. These samples were sun-dried for 5 days and then were dried in oven at 55^0c till they became brittle and the average of dry weight was worked out.

v. Weed competition index

A reduction in yield due to the presence of weeds in comparasion with weed free plots was estimated with weed competition index by using the following formula proposed by (Gill and Kumar, 1966)

$$\text{Weed index (W.I)} = \frac{X - Y}{X} \times 100$$

Where X = yield from weed free plot

Y = Yield from the treatment for which (W.I) is to be calculated.

vi. Weed control efficiency

Mani *et al*, (1973) suggested a formula to work out the weed control efficiency of different treatment to know about the percentage of reduction of weeds under the influence of various herbicidal treatment.

$$\text{Weed efficiency (W.E)} = \frac{WPC - WPT}{WPC} \times 100$$

Where WPC = Weed population in control plot

WPT = Weed population in treated plot

3.6 Residual effect

The layout was not disturbed after harvesting the crop. Equal number of seeds of cucumber, french bean, okra and muskmelon were sown in each plot. These succeeding crops were kept in the field for a period of one and a half month to study the residual effect of herbicides applied in the preceding crop.

3.7 Relative economics

The relative economics of the different treatment and increase or decrease in returns over weeded and unweeded control was worked out. The details about the rates of herbicides and labour employed are given in Appendix IV

3.8 Statistical analysis

The data were subjected to statistical analysis according to

procedure outlined by (Cochran and Cox, 1967) for randomized block design and "F" test was applied to determine the significance of the results.

EXPERIMENTAL RESULTS

CHAPTER - IV

EXPERIMENTAL RESULTS

The observations recorded on the effect of different herbicides on weed flora, cauliflower crop and other factors are presented as under :-

4.1 Crop stand

The data presented in (Table 2) revealed that metribuzin at 0.35 kg and 0.17 kg a.i/ha applied pre-plant and post-emergence stage imparted severe phytotoxic effect to cauliflower crop and showed complete mortality causing hundred per cent reduction of cauliflower crop. All other herbicidal treatment showed no adverse effect on the crop stand and were statistically at par with each other.

4.2 Phytotoxic effect

Metribuzin at 0.35 kg and 0.17 kg a.i/ha applied pre-plant and post-emergence, imparted severe phytotoxic effect and showed complete mortality of cauliflower crop. Pre-plant applications of metribuzin caused severe yellowing, scorching and wilting of the plants which led to ultimate

Table 2 Crop stand (%) as influenced by different herbicidal treatment

Treatment	Time of application	Product Doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Crop Stand $10m^2$
Fluchloralin	Pre-plant	2.50	1.12	96.18
Fluchloralin	Pre-plant	1.50	0.67	96.18
#Metribuzin	Pre-plant	0.50	0.35	x
#Metribuzin	Pre-plant	0.25	0.17	x
#Metribuzin	Post-emergence	0.50	0.35	x
#Metribuzin	Post-emergence	0.25	0.17	x
Trifluralin	Pre-plant	2.50	1.20	96.18
Trifluralin	Pre-plant	1.50	0.72	96.18
Pendimethalin	Pre-plant	6.00	1.80	94.28
Pendimethalin	Pre-plant	4.00	1.20	94.28
Oxyfluorfen	Pre-plant	1.00	0.23	93.28
Oxyfluorfen	Pre-plant	0.50	0.11	93.28
Weeded control	-	-	-	97.14
Unweeded control	-	-	-	93.28
$CD_{(P=0.5\%)}$	-	-	-	N.S

There was complete mortality of cauliflower crop under the influence of these herbicides.

death up to 20 days after transplanting. Post-emergence application of metribuzin showed similar symptoms on the cauliflower crop which led to ultimate death of seedlings after 5-6 days of herbicidal spray, all other herbicides showed no visible phytotoxic effect on the crop.

4.3 Plant height

The plant height recorded at 45 days after transplanting and at harvesting time (Table 3, Fig.2 and Fig. 3) significantly increased the plant height by the application of all the herbicides as compared to unweeded control. Maximum height of the plant was observed in weeded control at 45 days (26.40 cm) and at harvest stage (53.16 cm), followed by fluchloralin which showed plant height of (24.76 and 25.63 cm) at 45 days after transplanting and at harvest (47.26 and 48.12 cm) respectively and the other herbicidal treatment were significantly at par with each other. However, unweeded control had the minimum plant height (15 and 26.16 cm) at 45 days and at harvest respectively.

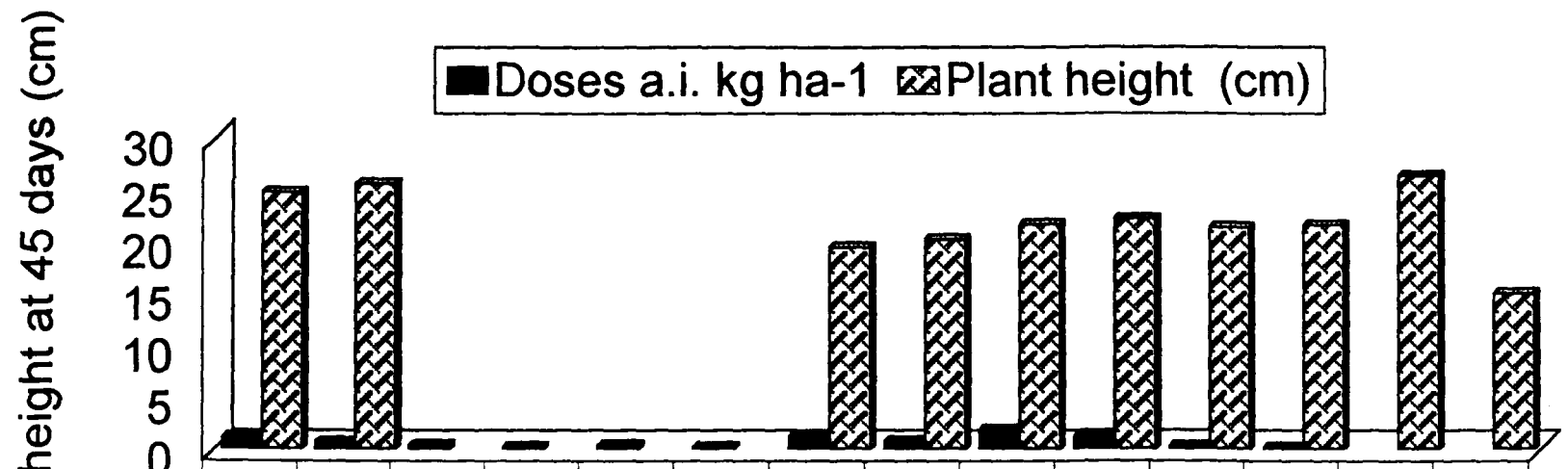
4.4 Yield

It was obvious from the data presented in (Table 4 and Fig. 4) that all the herbicidal treatment gave significantly higher yield than unweeded control except for metribuzin applied at 0.35 kg and 0.17 kg a.i/ha as pre-plant and post-emergence proved to be phytotoxic to the crop. Weeded control gave the highest yield of cauliflower (210 q/ha), which was significantly better than any of the herbicidal treatment applied for the study. However, all other herbicidal treatment like fluchloralin, trifluralin,

Table 3 Plant height (cm) as influenced by different herbicidal treatment

Treatment	Time of application	Product Doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Height	
				45 days	harvest
Fluchloralin	Pre-plant	2.50	1.12	24.76	47.26
Fluchloralin	Pre-plant	1.50	0.67	25.63	48.12
#Metribuzin	Pre-plant	0.50	0.35	x	x
#Metribuzin	Pre-plant	0.25	0.17	x	x
#Metribuzin	Post-emergence	0.50	0.35	x	x
#Metribuzin	Post-emergence	0.25	0.17	x	x
Trifluralin	Pre-plant	2.50	1.20	19.46	42.06
Trifluralin	Pre-plant	1.50	0.72	20.26	43.30
Pendimethalin	Pre-plant	6.00	1.80	21.70	44.06
Pendimethalin	Pre-plant	4.00	1.20	22.23	44.50
Oxyfluorfen	Pre-plant	1.00	0.23	21.40	43.30
Oxyfluorfen	Pre-plant	0.50	0.11	21.60	43.33
Weeded control	-	-	-	26.40	53.16
Unweeded control	-	-	-	15.00	26.16
SEm ±	-	-	-	0.2	0.5
CD $_{(P=0.5\%)}$	-	-	-	0.59	2.056

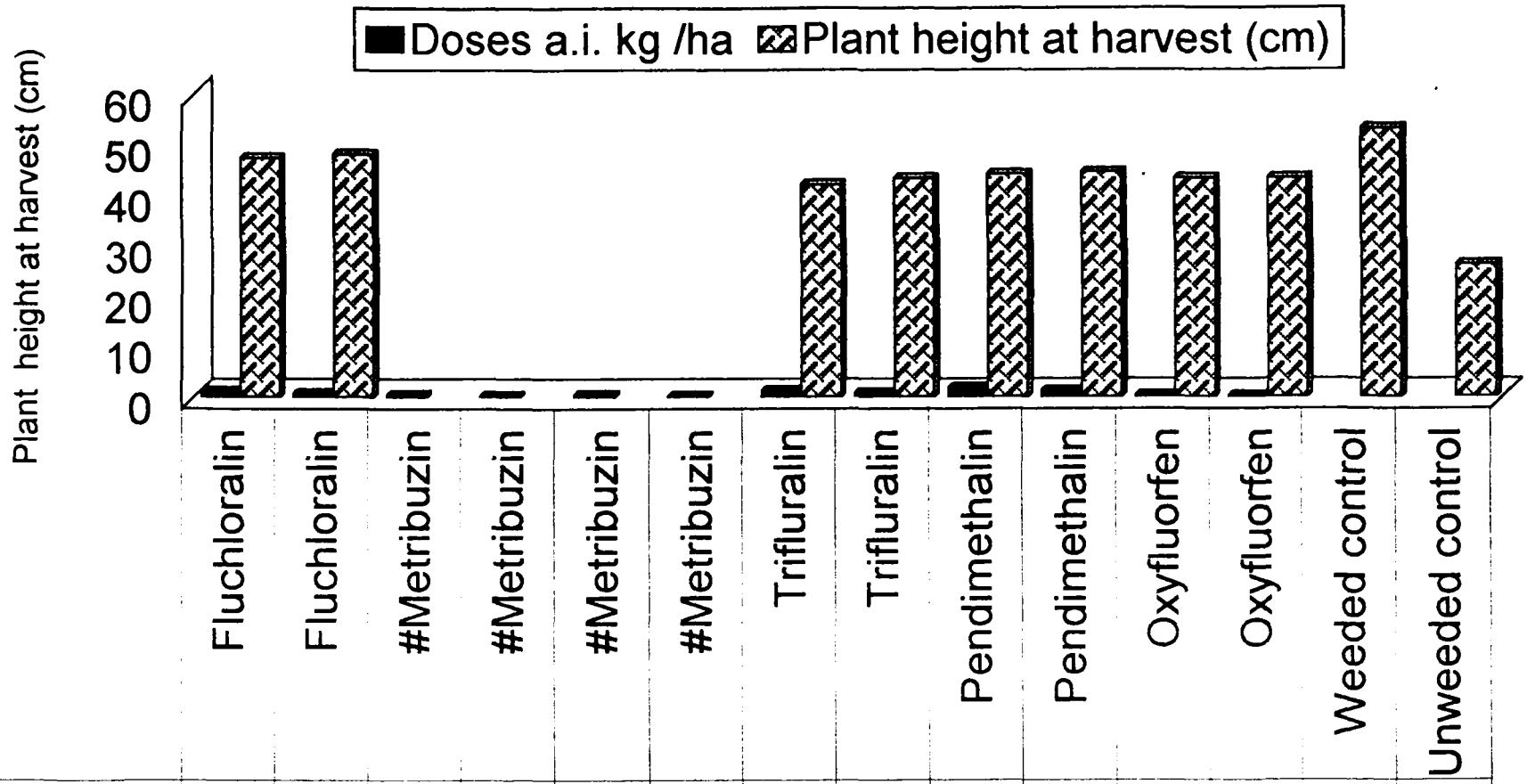
There was complete mortality of cauliflower crop under the influence of these herbicides.



Doses a.i. kg ha-1	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Plant height (cm)	24.76	25.63	–	–	–	–	19.46	20.26	21.7	22.23	21.4	21.6	26.4	15

#There was complete mortality of cauliflower crop under the influence of these herbicidal treatement

Fig. 2 Plant height at 45 days (cm) as influenced by different herbicidal treatement



Doses a.i. kg /ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Plant height at harvest (cm)	47.26	48.12					42.06	43.3	44.06	44.5	43.3	43.33	53.16	26.16

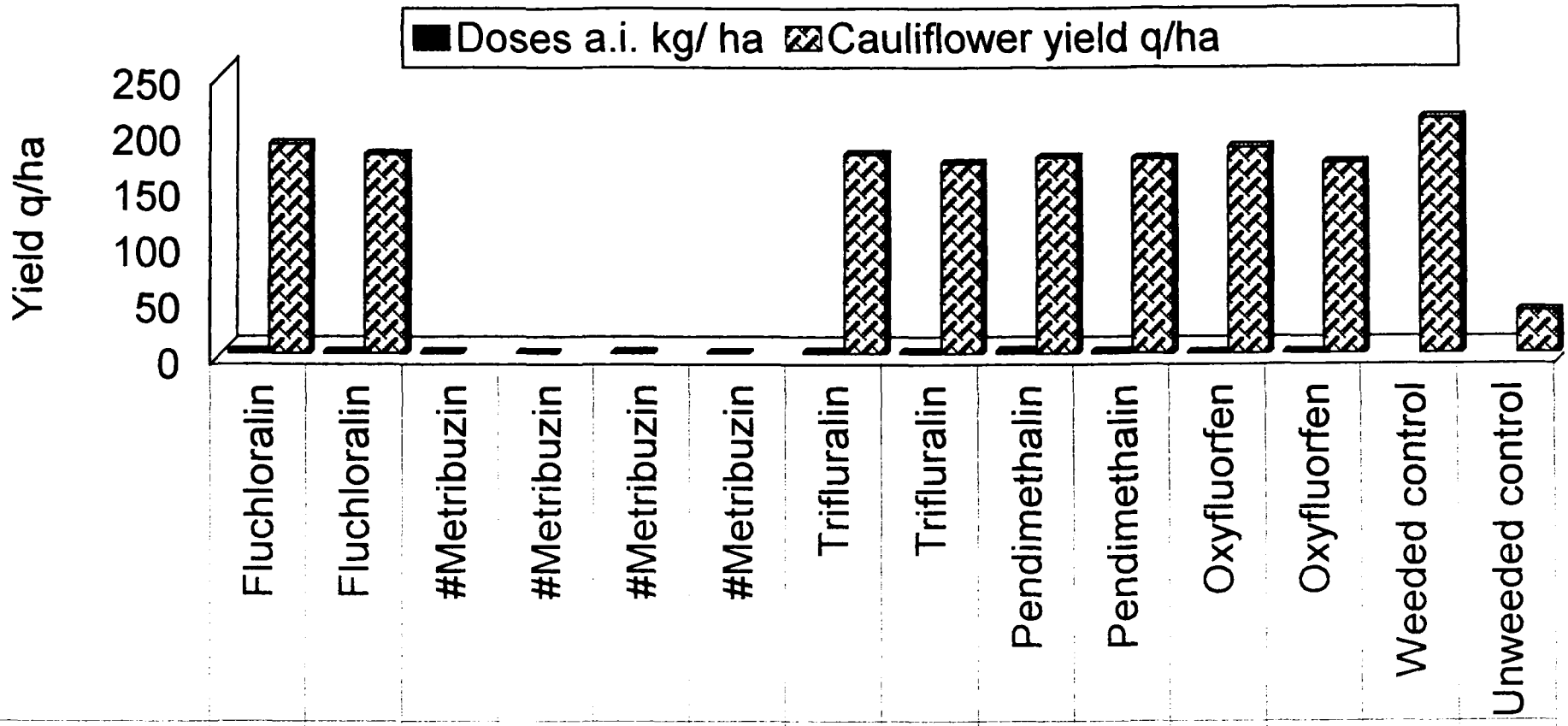
#There was complete mortality of cauliflower crop under the influence of these herbicidal treatement

Fig. 3 Plant height at harvest (cm) as influenced by different herbicidal treatement

Table 4 Cauliflower yield and Weed index as influenced by different herbicidal treatment

Treatment	Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Yield q ha^{-1}	Weed index
Fluchloralin	Pre-plant	2.50	1.12	187	-10.95
Fluchloralin	Pre-plant	1.50	0.67	178	-15.23
#Metribuzin	Pre-plant	0.50	0.35	x	x
#Metribuzin	Pre-plant	0.25	0.17	x	x
#Metribuzin	Post-emergence	0.50	0.35	x	x
#Metribuzin	Post-emergence	0.25	0.17	x	x
Trifluralin	Pre-plant	2.50	1.20	178	-15.23
Trifluralin	Pre-plant	1.50	0.72	170	-19.04
Pendimethalin	Pre-plant	6.00	1.80	175	-16.66
Pendimethalin	Pre-plant	4.00	1.20	174	-17.14
Oxyfluorfen	Pre-plant	1.00	0.23	184	-12.38
Oxyfluorfen	Pre-plant	0.50	0.11	170	-19.04
Weeded control	-	-	-	210	-
Unweeded control	-	-	-	37	-82.38
SEm ±	-	-	-	6.42	
$CD_{(P=0.5\%)}$	-	-	-	18.6	

There was complete mortality of cauliflower crop under the influence of these herbicides.
- denotes percent decrease in yield



Doses a.i. kg/ ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Cauliflower yield q/ha	187	178	–	–	–	–	178	170	175	174	184	170	210	37

#There was complete mortality of cauliflower crop under the influence of these herbicidal treatement

Fig. 4 Cauliflower yield as influenced by different herbicidal treatement

pendimethalin and oxyfluorfen were significantly at par each other.

The data pertaining to the weed competition index showed that all herbicidal treatment gave less yield than the weeded control and range of decrease varied from 10.95 to 19.04 per cent in case of fluchlorlin at 1.12 kg a.i/ha trifluralin at 0.72 kg a.i/ha and oxyfluorfen at 0.11 kg a.i/ha.

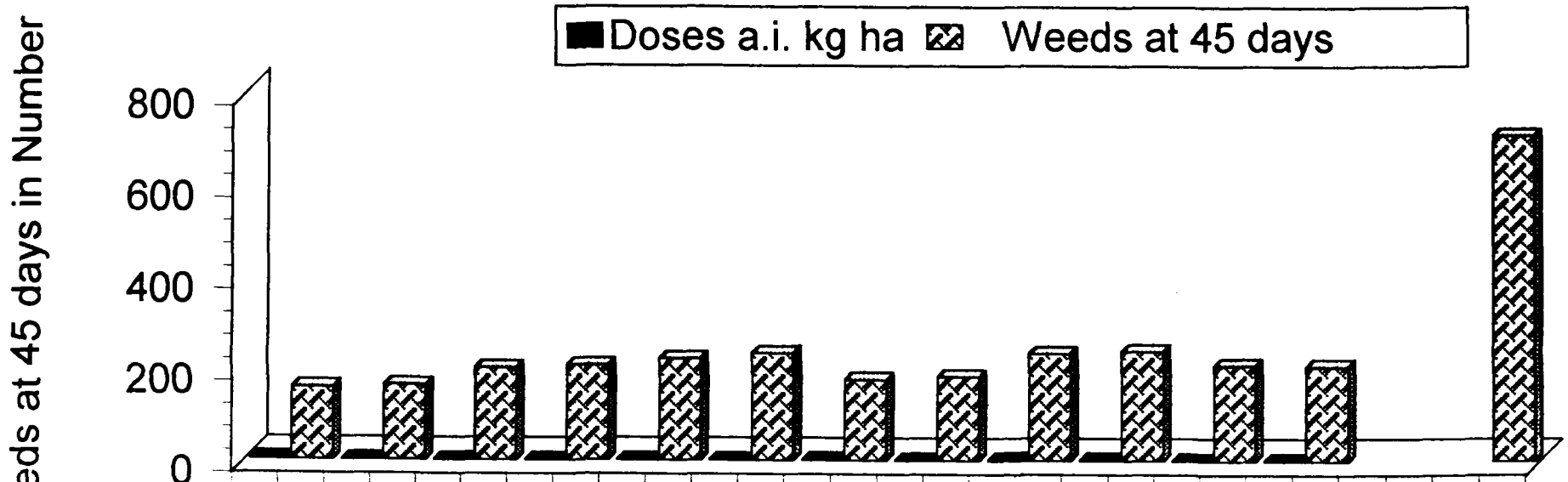
All the other treatment had intermediary values and varying percentages of decrease in yield than the weeded control were observed, where as unweeded control gave 82.35 per cent less yield than the weeded control due to heavy infestation of weeds. Metribuzin applied both pre-plant and post-emergence at 0.35 kg and 0.17 kg a.i/ha imparted severe phytotoxic effect to the cauliflower crop and the whole plant population was recorded as nil.

4.5 Weed population per plot and weed control efficiency.

The data presented in the (Table 5, Fig.5 and Fig. 6) revealed that all the herbicidal treatments gave significantly less weed population as compared to unweeded control at both the stages of observations after 45 days of transplanting and at harvesting time. Fluchloralin at 1.12 kg and 0.67 kg a.i/ha followed by trifluralin at 1.2 kg and 0.72 kg a.i/ha were proved to be superior in reducing the weed population at 45 days after transplanting than the remaining herbicidal treatment. However, all these herbicidal treatment except metribuzin proved to be significantly at par with each other for the weed population at the time of harvest. Metribuzin applied both pre-plant and post-emergence at 0.35 kg and 0.17 kg a.i/ha was found to be

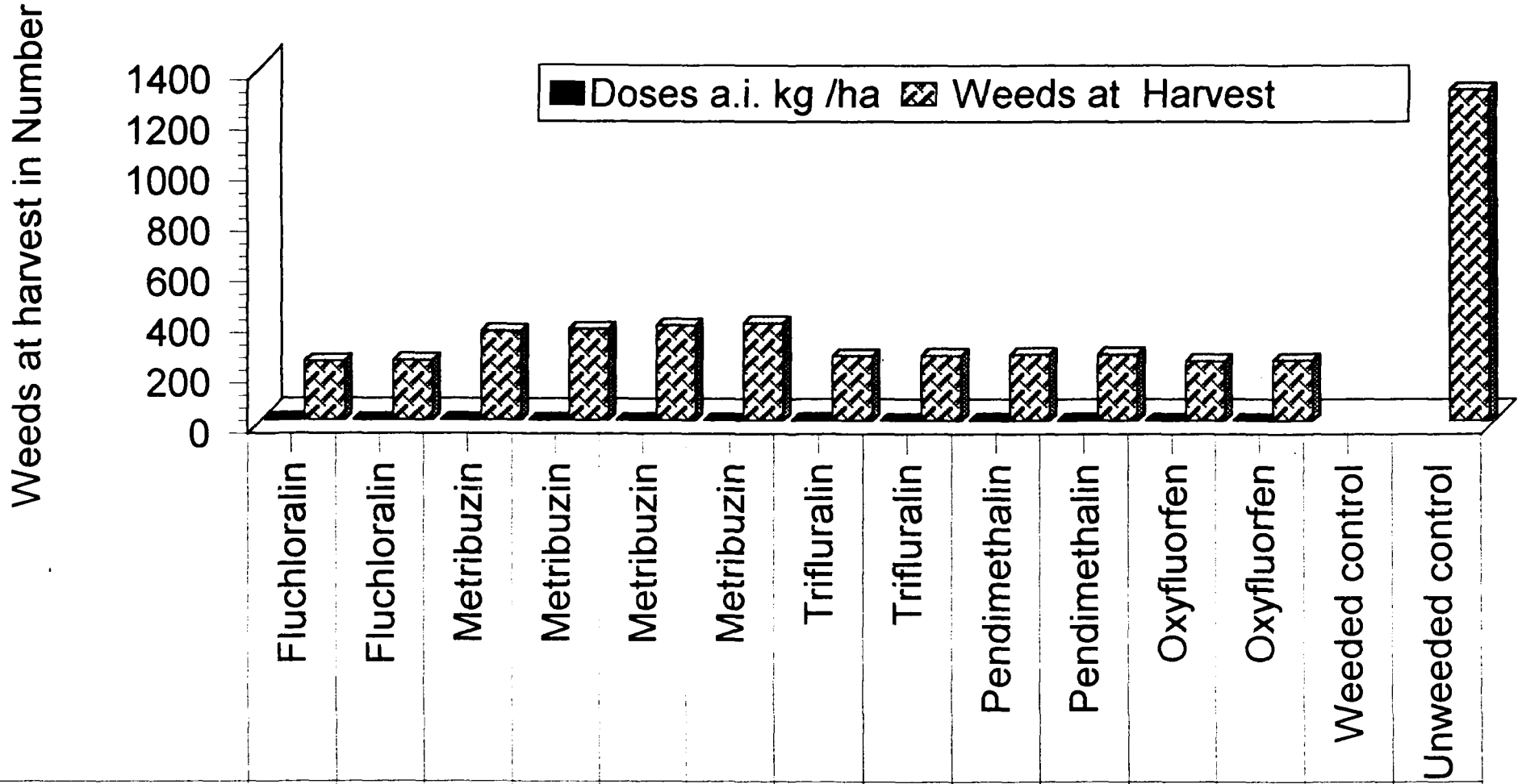
Table 5 Weed population and weed control efficiency as influenced by different herbicidal treatment

Treatment	Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Weeds 10m^2		Weed control efficiency (%)
				45 days	harvest	
Fluchloralin	Pre-plant	2.50	1.12	158	233	82.39
Fluchloralin	Pre-plant	1.50	0.67	163	236	82.01
Metribuzin	Pre-plant	0.50	0.35	201	352	73.17
Metribuzin	Pre-plant	0.25	0.17	207	362	72.40
Metribuzin	Post-emergence	0.50	0.35	221	376	69.05
Metribuzin	Post-emergence	0.25	0.17	233	385	63.56
Trifluralin	Pre-plant	2.50	1.20	176	256	80.71
Trifluralin	Pre-plant	1.50	0.72	183	259	79.57
Pendimethalin	Pre-plant	6.00	1.80	233	262	80.03
Pendimethalin	Pre-plant	4.00	1.20	238	263	79.19
Oxyfluorfen	Pre-plant	1.00	0.23	208	236	81.40
Oxyfluorfen	Pre-plant	0.50	0.11	206	239	80.56
Weeded control	-	-	-	-	-	-
Unweeded control	-	-	-	710	1312	-
SEm ±	-	-	-	15.62	12.09	
CD $_{(P=0.5\%)}$	-	-	-	45.43	35.17	



Doses a.i. kg ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Weeds at 45 days	158	163	201	207	221	233	176	183	233	238	208	206	–	710

Fig. 5 Weed population at 45 days as influenced by different herbicidal treatment



Doses a.i. kg /ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Weeds at Harvest	233	236	352	362	376	385	256	259	262	263	236	239	–	1312

Fig. 6 Weed population at harvest as influenced by different herbicidal treatment

inferior in reducing the weed population than the above mentioned treatment but better than unweeded control. Unweeded control was found mostly infested with weed population at both the stages i.e. 45 days after transplanting and at harvest.

The data recorded on the weed control efficiency showed that maximum reduction of weeds 82.39 and 82.01 per cent were caused under the influence of fluchloralin applied as pre-plant at 1.12 kg and 0.67 kg a.i/ha respectively. Minimum reduction of weeds 63.56 per cent was recorded in case of metribuzin at 0.17 kg a.i/ha applied as post-emergence application. All the other treatment had intermediary values and varying per centages of weed control efficiency.

4.6 Fresh weight accumulation by weeds.

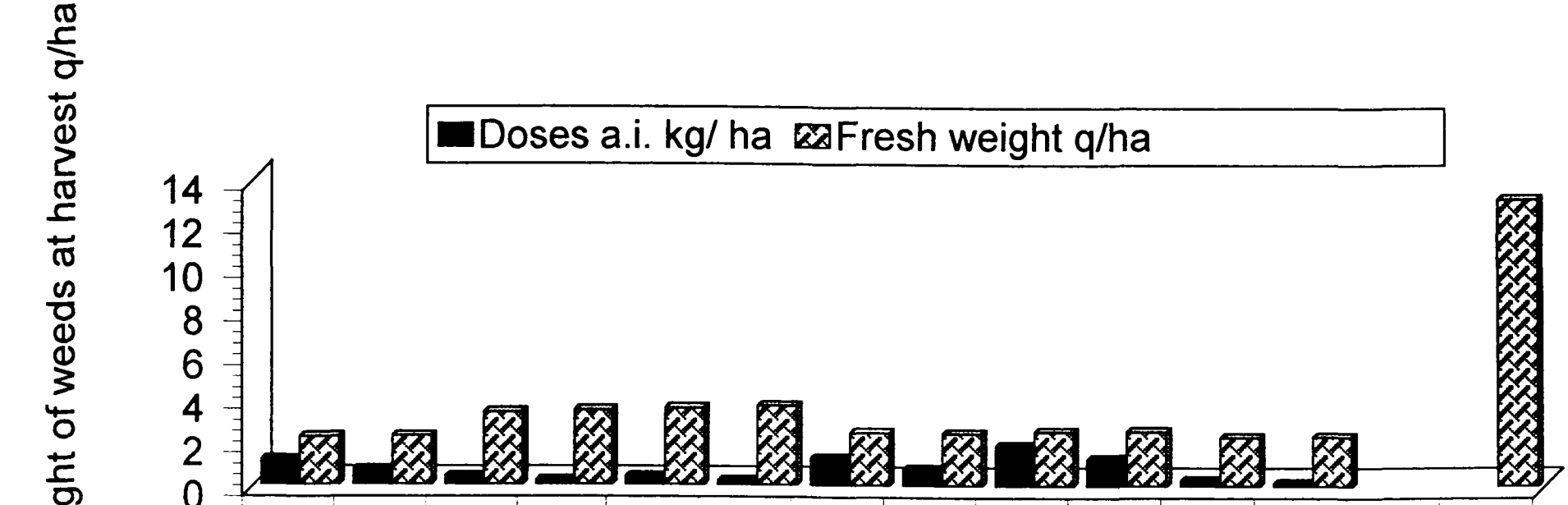
Data presented in (Table 6 and Fig.7) showed that during the study, all the herbicidal treatments significantly reduced the fresh weight accumulation of weeds as compared to unweeded control. Under the influence of fluchloralin at 1.12 kg a.i/ha (Pre-pant) the fresh weight of weeds was lowest, which was statistically at par with all other herbicidal treatment except metribuzin.

4.7 Dry matter accumulation by weeds

The data represented in the (Table 7 and Fig.8) showed that all the herbicidal treatment reduced dry matter accumulation drastically as compared to unweeded control. Fluchloralin at 1.12 kg a.i/ha was found to

Table 6 Fresh weight of weeds at harvest as influenced by different herbicidal treatment

Treatment	Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Fresh weight q ha^{-1}
Fluchloralin	Pre-plant	2.50	1.12	2.17
Fluchloralin	Pre-plant	1.50	0.67	2.21
Metribuzin	Pre-plant	0.50	0.35	3.30
Metribuzin	Pre-plant	0.25	0.17	3.40
Metribuzin	Post-emergence	0.50	0.35	3.50
Metribuzin	Post-emergence	0.25	0.17	3.61
Trifluralin	Pre-plant	2.50	1.20	2.39
Trifluralin	Pre-plant	1.50	0.72	2.36
Pendimethalin	Pre-plant	6.00	1.80	2.46
Pendimethalin	Pre-plant	4.00	1.20	2.47
Oxyfluorfen	Pre-plant	1.00	0.23	2.21
Oxyfluorfen	Pre-plant	0.50	0.11	2.24
Weeded control	-	-	-	-
Unweeded control	-	-	-	13.11
SEm ±	-	-	-	0.28
$CD_{(P=0.5\%)}$	-	-	-	0.82

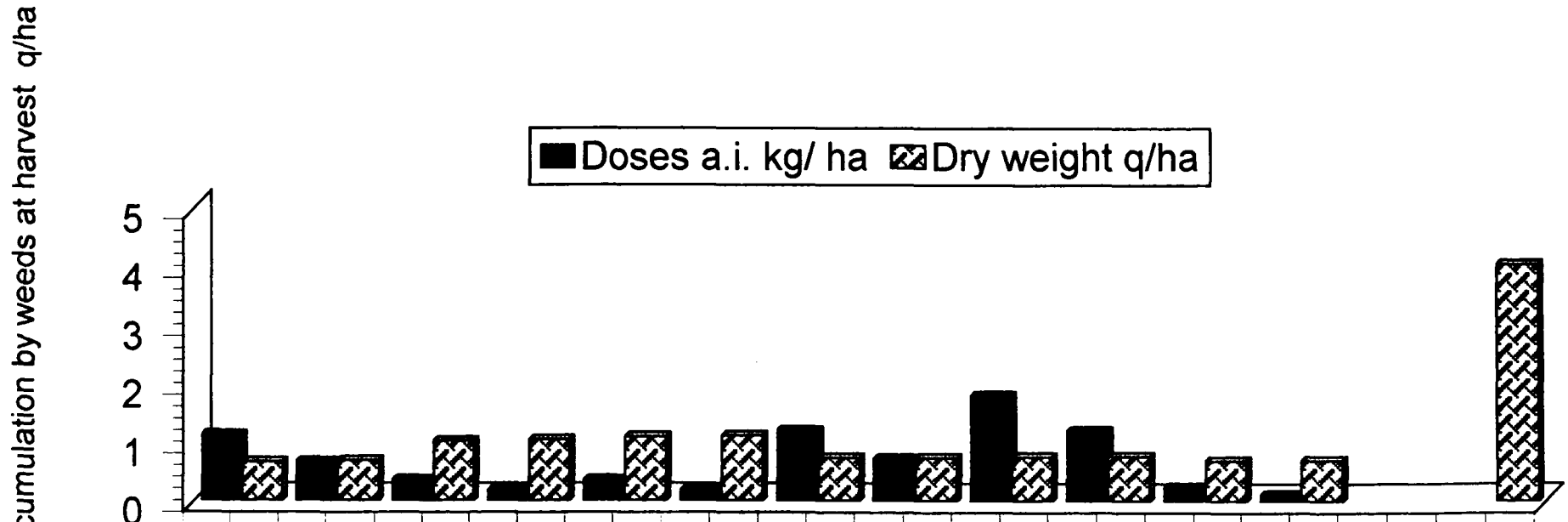


Doses a.i. kg/ ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11	
Fresh weight q/ha	2.17	2.21	3.3	3.4	3.5	3.61	2.39	2.36	2.46	2.47	2.21	2.24	13.11

Fig. 7 Fresh weight of weeds at harvest as influenced by different herbicidal treatement

Table 7 Dry matter accumulation by weeds at harvest as influenced by different herbicidal treatment

Treatment	Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Dry weight (q ha^{-1})
Fluchloralin	Pre-plant	2.50	1.12	0.66
Fluchloralin	Pre-plant	1.50	0.67	0.68
Metribuzin	Pre-plant	0.50	0.35	1.02
Metribuzin	Pre-plant	0.25	0.17	1.04
Metribuzin	Post-emergence	0.50	0.35	1.09
Metribuzin	Post-emergence	0.25	0.17	1.11
Trifluralin	Pre-plant	2.50	1.20	0.73
Trifluralin	Pre-plant	1.50	0.72	0.73
Pendimethalin	Pre-plant	6.00	1.80	0.75
Pendimethalin	Pre-plant	4.00	1.20	0.76
Oxyfluorfen	Pre-plant	1.00	0.23	0.68
Oxyfluorfen	Pre-plant	0.50	0.11	0.69
Weeded control	-	-	-	-
Unweeded control	-	-	-	4.04
SEm ±	-	-	-	0.05
$CD_{(P=0.5\%)}$	-	-	-	0.14



Doses a.i. kg/ ha	1.12	0.67	0.35	0.17	0.35	0.17	1.2	0.72	1.8	1.2	0.23	0.11		
Dry weight q/ha	0.66	0.68	1.02	1.04	1.09	1.11	0.73	0.73	0.75	0.76	0.68	0.69		4.04

Fig.8 Dry matter accumulation by weeds at harvest as influsened by different herbicidal treatement

be most effective treatment which was statistically at par with all other herbicidal treatment except metribuzin.

4.8 Residual effect

To find out the residual effect of different herbicides applied to the cauliflower crop. Equal number of seeds of beans, cucumber, muskmelon and okra were sown in each plot after harvesting of cauliflower crop. The seedlings were kept in the field for one and half month. The observation were recorded on emergence of these crop and visual phytotoxic effect (Table 8). There was no significant effect of any herbicidal treatments on emergence count in all the four vegetable crops. It clearly indicates that the applications of herbicides to the cauliflower crop leaves no residues that may effect the succeeding crops adversely. No phytotoxic effect was observed in any of the crop up to the period of one and a half month after sowing.

4.9 Weed flora

Data recorded on the presence of different weed species under different treatment are presented in (Table 9). The total number of different weed species at 45 days after transplanting and at harvest time during the study are presented in the (Table 10 and 10(a)).

4.10 Economics

Data on the economics of various treatments presented in (Table 11 and 11(a)) showed that all the herbicidal treatment gave considerable higher profits

Table 8 Residual effect of different herbicides on the germinability of succeeding summer vegetables

Treatment	Time of application	Doses lit/kg of product per hectare	Doses a.i kg ha^{-1}	Germination %			
				beans	okra	muskmelon	cucumber
Fluchloralin	Pre-plant	2.50	1.12	84.4	79.3	86.6	84.4
Fluchloralin	Pre-plant	1.50	0.67	86.6	73.3	84.4	84.4
Metribuzin	Pre-plant	0.50	0.35	84.4	80.0	84.4	84.4
Metribuzin	Pre-plant	0.25	0.17	84.4	75.5	86.6	84.4
Metribuzin	Post-emergence	0.50	0.35	84.4	73.3	84.4	86.6
Metribuzin	Post-emergence	0.25	0.17	84.4	73.3	84.4	86.6
Trifluralin	Pre-plant	2.50	1.20	84.4	77.7	84.4	84.4
Trifluralin	Pre-plant	1.50	0.72	86.6	77.7	84.4	86.6
Pendimethalin	Pre-plant	6.00	1.80	86.6	75.5	84.4	86.6
Pendimethalin	Pre-plant	4.00	1.20	86.6	79.9	84.4	84.4
Oxyfluorfen	Pre-plant	1.00	0.23	88.8	79.9	84.4	88.8
Oxyfluorfen	Pre-plant	0.50	0.11	86.6	79.9	86.6	88.8
Weeded control	-	-	-	86.6	80.0	84.4	88.8
Unweeded control	-	-	-	84.4	80.0	84.4	84.4
$CD_{(P=0.5\%)}$	-	-	-	NS	NS	NS	NS

Table 9 Efficiency of different herbicides for weed control

Treatment	Time of application	Product doses lit/kg ha^{-1}	Doses a.i kg ha^{-1}	Weed species	Remarks.
I	II	III	IV	V	VI
Fluchloralin	Pre-plant	2.50	1.12	*Cyperus rotundus*	This treatment was very effective against most of weeds and gave excellent weed control throughout the crop season. Only a small number of *Cyperus rotundus* appeared.
Fluchloralin	Pre-plant	1.50	0.67	*Cyperus rotundus*	This treatment was very effective against most of monocot and dicot weeds throughout the crop season and gave excellent weed control, but a small number of *Cyperus rotundus* appeared.
Metribuzin	Pre-plant	0.50	0.35	*Cyperus rotundus*	This treatment imparted severe phytotoxic effect to the crop and damaged all the cauliflower plants. But was very effective for the control of weeds except *Cyperus rotundus.*
Metribuzin	Pre-plant	0.25	0.17	*Cyperus rotundus*	This treatment also imparted severe phytotoxic effect to the cauliflower plants and caused total mortality of the plants. However, it gave good weed control through out the crop season and effective for the weed control except *Cyperus rotundus.*

I	II	III	IV	V	VI
Metribuzin	Post-emergence	0.50	0.35	*Cyperus rotundus*	This treatment imparted severe phytotoxic effect to cauliflower crop and caused total mortality of the crop. However, it gave good weed control throughout the crop season except *Cyperus rotundus.*
Metribuzin	Post-emergence	0.25	0.17	*Cyperus rotundus*	This treatment also imparted severe phytotoxic effect to cauliflower crop and caused total mortality of the crop, and gave good weed control throughout the crop season except *Cyperus rotundus*
Trifluralin	Pre-plant	2.50	1.20	*Cyperus rotundus*	This treatment was effective against most of weeds through out the crop season but only a small number of *Cyperus rotundus* appeared.
Trifluralin	Pre-plant	1.50	0.72	*Cyperus rotundus*	This treatment was also effective against most of the weeds throughout the crop season but only a small number of *Cyperus rotundus* appeared.
Pendimethalin	Pre-plant	6.00	1.80	*Cyperus rotundus*	This treatment was also effective against most of the weeds throughout the crop season but a small number of *Cyperus rotundus* appeared.
Pendimethalin	Pre-plant	4.00	1.20	*Cyperus rotundus*	This treatment was effective against most of the weeds throughout the crop season. A small number of *Cyperus rotundus* appeared.

I	II	III	IV	V	VI
Oxyfluorfen	Pre-plant	1.00	0.23	*Cyperus rotundus*	This treatment was also very effective against most the moncot and dicot weeds throughout the crop season. except *Cyperus rotundus.*
Oxyfluorfen	Pre-plant	0.50	0.11	*Cyperus rotundus*	This treatment was effective against most of the moncot and dicot weeds throughout the crop season. except *Cyperus rotundus*
Weeded control	-	-	-	-	------
Unweeded control	-	-	-	*Ageratum conyzoides* *Amaranthus reteroflexus* *Amaranthus viridis* *Chenopodium album* *Commelina benghalensis* *Convolvulus arvensis* *Cynodon dactylon* *Cyperus rotundus* *Daucus carota* *Euphorbia hirta* *Medicago denticulata* *Melilotus album* *Melilotus Indica* *Oxalis occidentalis* *Parthenium hysterophorus* *Portulaca oleraceae* *Rumex dentatus* *Solamum nigrum* *Sonchus oleraceus* *Stelliria spp* *Vicia hirsuta*	There was high infestation of most of the dicot weeds like *Chenopodium album, Medicago denticalate, Melilotus album, Melilotus Indica, Oxalis occidentalis, Portulace oleraccae, Amaranthus viridus, Amaranthus reteroflexus, Daucus carota, Ageratum conyzoides* and monot weeds like *Cyperus rotundus, Commelina benghalensis, and Cynodon dactylon,* other weeds appeared in a small number.

Table 10 Number of different weed species/10m^2 at 45 DAS as influenced by different herbicidal treatment

Weed species	Fluch-loralin 1.12 a.i kgha^{-1} pre-plant	Fluch-loralin 0.67 a.i kgha^{-1} pre-plant	Metri-buzin 0.35 a.i kgha^{-1} pre-plant	Metri-buzin 0.17 a.i kgha^{-1} pre-plant	Metri-buzin 0.35 a.i kgha^{-1} Post-emergence	Metri-buzin 0.17 a.i kgha^{-1} Post-emergence	Tri-fluralin 1.20 a.i kgha^{-1} Pre-plant	Tri-fluralin 0.72 a.i kgha^{-1} Pre-plant	Pendi-methalin 1.80 a.i kgha^{-1} Pre-plant	Pendi-methalin 1.20 a.i kgha^{-1} Pre-plant	Oxy-fluorfen 0.23 a.i kgha^{-1} Pre-plant	Oxy-fluorfen 0.11Kg a.i kgha^{-1} Pre-plant	Un-weeded control
Ageratum conyzoides	-	-	-	-	-	-	-	-	-	-	-	-	12
Amaranthus reteroflexus	-	-	-	-	-	-	-	-	-	-	-	-	16
Amaranthus viridis	-	-	-	-	-	-	-	-	-	-	-	-	17
Chenopodium album	-	-	-	-	-	-	-	-	-	-	-	-	34
Commelina benghalensis	-	-	-	-	-	-	-	-	-	-	-	-	7
Convolvulus arvensis	-	-	-	-	-	-	-	-	-	-	-	-	6
Cynodon dactylon	-	-	-	-	-	-	-	-	-	-	-	-	11
Cyperus rotundus	158	163	201	207	221	233	176	183	233	238	208	206	440
Daucus carota	-	-	-	-	-	-	-	-	-	-	-	-	19
Euphorbia hirta	-	-	-	-	-	-	-	-	-	-	-	-	7
Medicago denticulata	-	-	-	-	-	-	-	-	-	-	-	-	21
Melilotus album	-	-	-	-	-	-	-	-	-	-	-	-	19
Melilotus Indica	-	-	-	-	-	-	-	-	-	-	-	-	17
Oxalis occidentalis	-	-	-	-	-	-	-	-	-	-	-	-	13
Parthenium hysterophorus	-	-	-	-	-	-	-	-	-	-	-	-	9
Portulaca oleraceae	-	-	-	-	-	-	-	-	-	-	-	-	11
Rumex dentatus	-	-	-	-	-	-	-	-	-	-	-	-	8
Solamum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	12
Sonchus oleraceus	-	-	-	-	-	-	-	-	-	-	-	-	9
Stelliria spp.	-	-	-	-	-	-	-	-	-	-	-	-	15
Vicia hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	7

Table 10(a) Number of different weed species/10m^2 at harvest as influenced by different herbicidal treatment

Weed species	Fluch-loralin 1.12 a.i kgha^{-1} pre-plant	Fluch-loralin 0.67 a.i kgha^{-1} pre-plant	Metri-buzin 0.35 a.i kgha^{-1} pre-plant	Metri-buzin 0.17 a.i kgha^{-1} pre-plant	Metri-buzin 0.35 a.i kgha^{-1} Post-emergence	Metri-buzin 0.17 Kg a.i kgha^{-1} Post-emergence	Tri-fluralin 1.20 a.i kgha^{-1} Pre-plant	Tri-fluralin 0.72 a.i kgha^{-1} Pre-plant	Pendi-methalin 1.80 a.i kgha^{-1} Pre-plant	Pendi-methalin 1.20 a.i kgha^{-1} Pre-plant	Oxy-fluorfen 0.23 a.i kgha^{-1} Pre-plant	Oxy-fluorfen 0.11 a.i kgha^{-1} Pre-plant	Un-weeded control
Ageratum conyzoides	-	-	-	-	-	-	-	-	-	-	-	-	19
Amaranthus reteroflexus	-	-	-	-	-	-	-	-	-	-	-	-	27
Amaranthus viridis	-	-	-	-	-	-	-	-	-	-	-	-	31
Chenopodium album	-	-	-	-	-	-	-	-	-	-	-	-	64
Commelina benghalensis	-	-	-	-	-	-	-	-	-	-	-	-	11
Convolvulus arvensis	-	-	-	-	-	-	-	-	-	-	-	-	11
Cynodon dactylon	-	-	-	-	-	-	-	-	-	-	-	-	13
Cyperus rotundus	233	236	352	362	376	385	256	259	262	263	236	239	870
Daucus carota	-	-	-	-	-	-	-	-	-	-	-	-	24
Euphorbia hirta	-	-	-	-	-	-	-	-	-	-	-	-	11
Medicago denticulata	-	-	-	-	-	-	-	-	-	-	-	-	34
Melilotus album	-	-	-	-	-	-	-	-	-	-	-	-	31
Melilotus Indica	-	-	-	-	-	-	-	-	-	-	-	-	27
Oxalis occidentalis	-	-	-	-	-	-	-	-	-	-	-	-	21
Parthenium hysterophorus	-	-	-	-	-	-	-	-	-	-	-	-	13
Portulaca oleraceae	-	-	-	-	-	-	-	-	-	-	-	-	26
Rumex dentatus	-	-	-	-	-	-	-	-	-	-	-	-	13
Solamum nigrum	-	-	-	-	-	-	-	-	-	-	-	-	18
Sonchus oleraceus	-	-	-	-	-	-	-	-	-	-	-	-	14
Stelliria spp.	-	-	-	-	-	-	-	-	-	-	-	-	23
Vicia hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	11

Table 11 Economics of different herbicidal treatment

Treatment	Time of application	Doses lit/kg of product ha^{-1}	Doses kg a.i ha^{-1}	Cauliflower yield (q ha^{-1})	Yield increased over unweeded (q ha^{-1})	Value of increased yield (Rs ha^{-1})	Cost of treatments (Rs ha^{-1})	Return over unweded control (Rs ha^{-1})	Loss/Profit overweeded control (Rs ha^{-1})
Fluchloralin	Pre-plant	2.50	1.12	187	150	45,000	1485	43,515	-5585
Fluchloralin	Pre-plant	1.50	0.67	178	141	42,300	891	41,409	-7691
#Metribuzin	Pre-plant	0.50	0.35	x	x	x	x	x	x
#Metribuzin	Pre-plant	0.25	0.17	x	x	x	x	x	x
#Metribuzin	Post-emergence	0.50	0.35	x	x	x	x	x	x
#Metribuzin	Post-emergence	0.25	0.17	x	x	x	x	x	x
Trifluralin	Pre-plant	2.50	1.20	178	141	42,300	1490	40,810	-8290
Trifluralin	Pre-plant	1.50	0.72	170	133	39,900	894	39,006	-10,094
Pendimethalin	Pre-plant	6.00	1.80	175	138	41,400	3108	38,292	-10,808
Pendimethalin	Pre-plant	4.00	1.20	174	137	41,000	2072	38,928	-10,172
Oxyfluorfen	Pre-plant	1.00	0.23	184	147	44,100	2100	42,000	-7100
Oxyfluorfen	Pre-plant-	0.50	0.11	170	133	39,900	1050	38,850	-10250
Weeded control		-	-	210	173	51,900	2800	49,100	-
Unweeded control		-	-	37	-	-	-	-	-

There was complete mortality of the cauliflower crop under the influence of these herbicides.
The market sale rate of cauliflower was calculated at the rate of Rs. 300/q

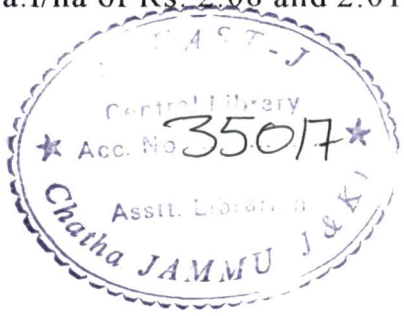
Table 11(a) Economics of different herbicidal treatments on return per rupee investment

Treatment	Time of application	Doses lit/kg ha^{-1}	Doses kg a.i ha^{-1}	Cauliflower yield (qha^{-1})	Cost of cultivations (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Return over unweeded check (Rs ha^{-1})	Return per rupee investe-ment
Fluchloralin	Pre-plant	2.50	1.12	187	14606.30	56100.00	41493.70	30393.70	2.08
Fluchloralin	Pre-plant	1.50	0.67	178	14012.30	53400.00	39387.70	28287.70	2.01
#Metribuzin	Pre-plant	0.50	0.35	x	x	x	x	x	x
#Metribuzin	Pre-plant	0.25	0.17	x	x	x	x	x	x
#Metribuzin	Post-emergence	0.50	0.35	x	x	x	x	x	x
#Metribuzin	Post-emergence	0.25	0.17	x	x	x	x	x	x
Trifluralin	Pre-plant	2.50	1.20	178	14611.30	53400.00	38788.70	27688.70	1.87
Trifluralin	Pre-plant	1.50	0.72	170	14015.30	51000.00	36984.70	25884.70	1.84
Pendimethalin	Pre-plant	6.00	1.80	175	16229.30	52,500.00	36270.00	25170.70	1.55
Pendimethalin	Pre-plant	4.00	1.20	174	15193.30	52,200.00	37006.70	25906.70	1.70
Oxyfluorfen	Pre-plant	1.00	0.23	184	15221.30	55200.00	39978.70	28878.70	1.89
Oxyfluorfen	Pre-plant	0.50	0.11	170	14171.30	51000.00	36828.70	25728.70	1.81
Weeded control	-	-	-	210	15921.30	63000.00	47078.70	35978.70	2.25
Unweeded control	-	-	-	37	13121.30	11000.00	-2021.30	-	-

There was complete mortality of the cauliflower crop under the influence of these herbicides.
The market sale rate of cauliflower was calculated at the rate of Rs 300/q.

than the unweeded control except metribuzin applied as pre-plant and post-emergence, which proved phytotoxic to the cauliflower crop. Among the herbicidal treatment highest profit of Rs 43515 was recorded in fluchloralin at 1.12 kg a.i/ha followed by oxyfluorfen at 0.23 kg a.i/ha (Rs 42,000) as compared to unweeded control. However, weeded control gave the highest return of Rs 49100 over unweeded control. All other herbicidal treatment had the intermediary values.

While calculating the cost benefit ratio, maximum return per rupee investment was recorded in the weeded control (Rs. 2.25) followed by fluchloralin at 1.12 and 0.67 kg a.i/ha of Rs. 2.08 and 2.01 respectively.



DISCUSSION

CHAPTER - V

DISCUSSION

The present investigation "Efficiency of different herbicides for weed control in cauliflower", (*Brassica oleracea var. botrytis L.)* was conducted during 1999-2000 and to screen out the promising herbicides to ascertain their effect on crop stand, plant growth, yield, weed population and to examine their residual effect on the succeeding crops.

The results of the present investigations are discussed under the following headings:-

5.1 Crop weed competition and losses

5.2 Chemical weed control

5.3 Residual effect of herbicides on the succeeding crop

5.1 Crop weed competition and losses.

It is quite evident that by competing for nutrients, water and light the weeds affect the vegetables adversely which lead to significant reduction in yield and

quality (Roberts, 1976). During the course of present investigations, it was noted that there was 82.38 per cent reduction in yield of cauliflower due to intense competition of heavy infestation of different species of weeds in unweeded control. Results obtained by previous works also showed that weeds posed a serious problems in cauliflower crop which led to significant reduction by its yield (Singh *et al*, 1974; Finlayson *et al*, 1975 ; Singh and Tripathi, 1982 and Porwal and Singh, 1993).

Similar losses due to weed infestations in vegetable crops were also observed by many workers as 62 per cent in okra, 89 per cent in garlic, 50 per cent in carrot, 53 per cent in tomato, 80 per cent in brinjal and 85 per cent in onion (Sandhu and Randhawa, 1980). From the above given statements, it was clear that weeds were great menace in cauliflower and other vegetable crops.

5.2 Chemical weed control.

In the studies different pre-plant and post-emergence herbicides were tried to find out some suitable, efficient and selective herbicides for providing season long weed control in cauliflower.

During the present investigations, fluchloralin at 1.12 kg a.i/ha (pre-plant) provided an effective and selective weed control and gave higher yield comparable to unweeded control and as well as other herbicidal treatments. Fluchloralin at 1.12 kg a.i/ha gave 10.95 per cent lesser yield than weeded control, by causing a reduction of 82.39 per cent of weeds as compared to unweeded check. Similarly a reduction of fresh weight accumulation and dry matter accumulation of weeds were caused by the application of this herbicide at 1.12 kg a.i/ha. However, fluchloralin at 0.67 kg a.i/ha was slightly less effective but significantly at par with higher dose of

fluchloralin 1.12 kg a.i/ha. Lower dose of fluchloralin at 0.67 kg a.i/ha also significantly reduced the weed population, fresh and dry matter accumulation of weeds which resulted in increase in yield as compared to unweeded control previous workers also noted the superiority of fluchlorain for excellent weed control of weeds and significant increase in yield of cauliflower crop (Sandhu *et al*, 1982 ; Bhayan *et al*, 1985 ; Porwal *and Singh*, 1993). Similar effects of fluchloralin have also been observed for excellent weed control which significantly increased the yield in other vegetables like cabbage, onion relay crop (Mani *et al*, 1975), okra (Sandhu and Randhawa, 1979), bell pepper (Singh *et al*, 1991), tomato (Singh , 1994, Ram *et al*, 1994), brinjal (Manoj , 1995, Singh *et al*, 1996, Singh *et al*, 1997), onion (Singh M.P. and Singh K.P., 1996, Singh, 1996, Singh *et al*, 1997) and coriander (Chaudhary, 2000).

Fluchloralin at 1.12 kg a.i/ha (Pre-plant) control most of the monocot and dicot weeds except *Cyperus rotundus.* Fluchloralin no doubt suppressed the growth of emerged *Cyperus rotundus* weeds but could not control it completely. The work done in the past also revealed that fluchloralin had an excellent range of efficacy against numerous dicot and monocot weeds in cauliflower crop (Sandhu *et al*, 1982, Bhayan *et al*, 1985, Porwal and Singh, 1993). From the outgoing discussion and reports, it was clear that fluchloralin was an efficient and selective herbicide in cauliflower. It gave season long control of both monocot and dicot weeds and increased the yield.

Oxyfluorfen was another promising herbicide for weed control in cauliflower (Olson and stall, 1983 ; James *et al*, 1989, Porwal and Singh, 1993 ; Mark and Howard, 1995) and also in other vegetable crops like cabbage

(Prasanta *et al*, 1986), bell pepper (Singh *et al*, 1991), tomato (Singh , 1994), potato (Tewari *et al*, 1998). During the present investigation, higher dose of oxyfluorfen at 0.23 kg a.i/ha (Pre-plant) also gave an effective and selective weed control during the year and gave comparable yield of cauliflower to the fluchloralin. It gave 81.40 per cent reduction in weeds whereas, oxyfluorfen at lower dose of 0.11 kg a.i/ha gave 80.56 per cent reduction in the weeds as compared to the unweeded control. Oxyfluorfen at 0.23 kg and at 0.11 kg a.i/ha gave significantly at par yield of 184 q and 170 q/ha respectively, the yield of which was comparable to the fluchloralin and weeded control. The work done by (Olson and Stall, 1983), James *et al*, 1989, Porwal and Singh, 1993, Mark and Howard, 1995) was also in line with the present investigation who obtained best yield of cauliflower crop with the (Pre-plant) application of oxyfluorfen.

Oxyfluorfen at 0.23 kg and 0.11 kg a.i/ha gave a promising control of all the dicot and monocot weeds which led to significant increase in yield, *Cyperus rotundus* though it was suppressed in the early stage but latter on again it was found emerging out in large number in the experimental plots. The investigation conducted in the past also showed that oxyfluorfen was selective and effective for a very good weed control in cauliflower, (Olson and Stall, 1983 ; Mark and Howard, 1995). They also noticed oxyfluorfen as a selective and effective herbicide for the control of most of the dicot and nonocot weeds except *Cyperus rotundus.*

Trifluralin another herbicide was found to be selective and efficient for controlling weeds which led to higher yield of cauliflower as compared to unweeded check, trifluralin at 1.2 kg a.i/ha applied as (pre-plant) gave comparable yield of

178 q/ha to weeded control. Fluchloralin at 1.12 kg and at 0.67 kg a.i/ha and oxyfluorfen at 0.23 kg a.i/ha gave 82.39, 82.01 and 81.40 per cent reduction of weeds respectively during the study. However, lower dose of trifluralin at 0.72 kg a.i/ha was no doubt produce less yield of 170 q/ha as compared with higher dose of trifluralin but it was significantly at par each other in controlling the weeds and increasing the yield..

It was further observed that trifluralin at both levels controlled most of the monocot and dicot weeds except *Cyperus rotundus,* which, no doubt were suppressed in growth in the early stage but latter on it increased in population gradually. The investigations conducted in the past also showed that trifluralin was very good selective and effective herbicide for cauliflower and other vegetable crops. In cauliflower (Dolot and Dzherul, 1976, Curvale *et al*, 1979; Stamm and Ashley, 1980; Hemery *et al*, 1981 ; Moens *et al*, 1985), *broccoli* and cauliflower (Porter, 1983, Gilreath and Gilreath, 1983, Johnson *et al*, 1992), cabbage and cauliflower (Romanowski *et al*, 1981) cabbage (Roberts and Bond , 1975 ; Brathwaite, 1979) also were in line with the present investigations. They also noticed that some of monocot and dicot weeds were controlled by the application of trifluralin.

Pendimathalin at 1.8 lit and 1.2 lit a.i/ha (pre-plant) gave significantly better yield than the unweeded control but it proved inferior as compared to weeded control. Pendimathalin at both levels reduced the weeds (80.3 and 79.19) per cent and gave a yield of 175 and 174 q/ha respectively. In the present study, the performance of pendimethalin was also in accordance with the findings of Bhayan *et al*, 1985, Porwal and Singh, 1993) in cauliflower crop. They also showed that pendimethalin

at the rate of 1.0 and 1.5 kg a.i/ha controlled the weeds and increased the availability of light, nutrients and moisture to the crop and there by increased the dry matter accumulation by leaves. The study further revealed that pendimethalin at both the levels controlled most of the monocot and dicot weeds except *Cyperus rotundus*.

It was observed that metribuzin at 0.35 kg and 0.17 kg a.i/ha (pre-plant) gave a very good weed control, but it also imparted severe phytotoxic effect to the cauliflower crop and caused hundred per cent mortality up to 20 days of transplanting. Treated plots remained almost weed free for 10 days but latter on *Cyperus rotundus* weeds emerged out in a small number, which increased in population gradually.

Metribuzin at 0.35 kg and 0.17 kg a.i/ha (post-emergence) also gave a very good weed control but caused severe phytotoxic effect to the standing cauliflower crop and showed complete mortality of plants. All the emerged weeds were completely destroyed but latter on *Cyperus rotundus* weeds emerged out from the experimental plots and gradually increased in population. The work done in the past by Sandhu *et al*, (1982) and Bhayal *et al*, (1985) showed that metribuzin at 0.70 kg and 1.12 kg a.i/ha gave an excellent weed control but imparted severe phytotoxic effect to the cauliflower crops and killed the whole plant population and in other vegetable crops like asparagus, metribuzin at 0.85 kg /ha also gave more than 95 per cent control of weeds, however, it significantly reduced the crop stand which resulted in poor yield (Anonymous, 1976). The results obtained during the present investigation are in close conformity with the above reports.

5.3 Residual effect of herbicides on succeeding crop.

It has been suggested that if the treatment are applied in accordance with

the recommendations and the crops were harvested at the normal time, residues of the herbicides in the soil should not affect succeeding crops (Woodford and Evans, 1965). During the present investigations, no residual effect of any herbicidal treatment applied to the cauliflower crop was observed on the succeeding crops of beans, okra, cucumber and muskmelon sown after its harvesting.

Sandhu and Randhewa, (1980) also indicated that there was no residual affect of nitrofen at 2.00 kg a.i/ha, alachlor at 2.50 kg a.i/ha, fluchloralin at 0.90 kg and 1.20kg a.i/ha, propanil at 1.36 kg and 1.02 kg a.i/ha, chloroxuron at 1.50, 2.00 and 3.00 kg a.i/ha, oxadiazon at 2.00 kg and 3.00 kg a.i/ha, nitrofen at 2.00 kg a.i/ha (pre-emergence), fluchloralin at 1.20 kg a.i/ha (pre-plant) + propanil at 1.20 kg a.i/ha (post-emergence) and fluchloralin at 1.20 kg a.i/ha (pre-plant) + chloroxuron at 1.50 kg a.i/ha (post-emergence) on the succeeding crops of okra, bottlegourd squashmelon and muskmelon when these herbicides were applied to preceding crops of onion.

Hira, (1980) residues from alachlor at 2.50 kg and 1.50 kg a.i/ha, nitrofen at 1.50 kg and 1.00 kg a.i/ha, fluchloralin at 1.20 kg and 0.72 kg a.i/ha, fluchloralin simazine at 0.72 kg and 0.12 kg a.i/ha, chloroxuron at 2.00 kg and 1.50 kg a.i/ha, propanil (post-emergence) at 1.02 kg, methabenzthizuron at 2.10 kg and 1.40 kg a.i/ha, metribuzin at 0.72 kg and 0.52 kg a.i/ha, did not adversely effect the succeeding crop of watermelon, muskmelon, bottlegourd, and okra. When these herbicides were applied to the preceding crop of cauliflower.

Similarly Nalayini and Sankaran (1992) did not found any residual effect of fluchloridone, pendimethalin and tank mixture of the two herbicides on the

succeeding crops of sorghum, pearlmillet and cowpea. However, they observed a marginal adversal effect on the crop, but the plant height and dry matter production of these crops were not affected.

Dhanapal and Gowda, (1996) found that the residue of oxyfluorfen and 2,4-D sodium salt diversely affected the germination, root length, shoot length and dry weight of the seedling as compared to the residues of benthiocarp, fluchloralin and oxadiazon. The interaction effect of oxyfluorfen, 2,4-D sodium salt and the preceding crops fingermillet, sorghum, navana, cowpea, soybean, redgram, niger costor and sunflower have reduced the germination, root length, shoot length and dry weight of cucumber. Whereas, these parameters on cucumber were not affected due to interaction of benthiocarp, fluchloralin oxdiazon and above mentioned crops.

The above mentioned reports indicated that there was no residual effect of these herbicides on the succeeding crops. The results obtained during the present studies were in confirmation with the results obtained by different workers.

In the end, it may be concluded that chemical weed control was playing an important role in the cultivation of cauliflower. During the present investigation, it was observed that fluchloralin at 1.12 litres a.i/ha and oxyfluorfen at 0.23 litres a.i/ ha gave an effective and selective weed control in cauliflower and gave the yield close to the weeded control. Trifluralin and pendimathlin were also found to be the effective and selective herbicides and these were at par with fluchloralin and oxyfluorfen. Metribuzin at 0.35 and 0.17 kg a.i/ha applied at pre-plant and post-emergence stage proved phytotoxic to cauliflower crop.

SUMMARY

CHAPTER - VI

SUMMARY

The present investigation was conducted on the, "efficiency of different herbicides for weed control in cauliflower" *(Brassica oleracea var. botrytis L.)* at the vegetable Research Farm, Poni chak, Division of Olericulture and Floriculture, S.K. University of Agricultural Sciences and technology, F.O.A Udheywalla, J&K Jammu during the year 1999-2000

The results of these investigation was summarised below.

1. During the investigation, metribuzin at 0.35 kg and 0.17 kg a.i/ha applied as pre-plant and post-emergence imparted severe phytotoxic effect to the cauliflower crop and showed complete mortality of the seedling within 5-6 days in case of post-emergence and 20 days in case of (pre-plant) after the transplanting of the crop.

2. All the herbicidal treatment reduced the fresh and dry matter accumulation of weeds significantly as compared to unweeded. Minimum being with fluchloralin at 1.12 kg and 0.67 kg a.i/ha followed by oxyfluorfen at 0.23 kg and 0.11 kg a.i/ha. All the herbicidal treatment

controlled most of the monocot and dicot weeds except *Cyperus rotundus* and subsequently these herbicidal treatment proved to be superior to unweeded control and were significantly at par with each other.

3. The highest yield of cauliflower was obtained with weeded control which, was significantly higher than any of the herbicidal treatment. Fluchloralin at 1.12 kg a.i/ha have the maximum yield of cauliflower among all the herbicidal treatment followed by higher dose of oxyfluorfen, trifluralin and pendimethalin and all these herbicidal treatment did not show any significant difference with each other.

4. No residual effect was observed of all the herbicidal treatment applied to the cauliflower crop, on the succeeding crops of beans, okra, cucumber and muskmelon. It may be concluded from the investigations conducted that all the herbicidal treatment caused a significant reduction in the weed populations, fresh weight and dry weight accumulation of weeds which led to significant increase in yield of cauliflower than the unweeded control. These treatment viz. fluchloralin, oxyfluorfen, trifluralin and pendimethalin may be recommended for effective, selective and economical weed control in cauliflower.

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* Original not seen

APPENDICES

APPENDIX - I

Physio-chemical characteristics of the soil

S.No.	Particulars	Values	Method employed
A	**Mechanical Analysis**		
I	Sand (%)	32	International pipette method (Piper, 1966)
II	Silt (%)	53	
III	Clay (%)	15	
IV	Texture	Silty loam	
B	**Chemical Analysis**		
1	Soil pH	6.8 - 7.00	Determined in 1:2:5 soil-water suspension using electrode pH meter.
2.	Available nitrogen (kg/ha)	262 - 263	Alkalin Potassium per magnate method (Subbiah and Asija, 1956)
3.	Available phosphorus (kg/ha)	18 - 19.14	Olsen's method (Jackson, 1973)
4.	Available potassium (kg/ha)	144 - 145.63	Morwin and Peach(1950)

APPENDIX - II

Weekly climatological data recorded at Water Management Research Centre for the period of crop under study with effect from 10th September 99 to 25th Feburary 2000.

Standard Week	Dates	Rain fall mm/Wk	Relative humidity		Temperature ^{0}C		Sunshine hrs/day
			Max.	Min.	Max.	Min.	
37	10-16 Sep.	15	89.5	54.3	30.9	19.5	8.7
38	17-23 Sep.	35.5	92.3	56.0	30.4	20.3	7.5
39	24-30 Sep.	24.5	95.4	55.0	29.4	18.1	8.1
40	01-07 Oct.	-	94.4	64.8	29.5	16.0	9.7
41	08-14 Oct.	-	94.2	95.9	29.0	11.7	9.7
42	15-21 Oct.	-	94.9	63.9	28.4	11.2	9.5
43	22-28 Oct.	-	94.9	68.9	27.6	12.1	9.0
44	29-04 Nov.	-	94.1	67.2	27.4	11.4	8.2
45	05-11 Nov.	35.9	89.2	57.6	25.4	12.3	7.9
46	12-18 Nov.	-	91.8	55.6	25.1	9.9	9.0
47	19-25 Nov.	-	82.4	61.0	23.2	8.8	7.2
48	26-02 Dec.	-	72.1	60.8	27.2	8.9	8.6
49	03-09 Dec.	-	79.6	52.1	23.8	9.0	8.3
50	10-16 Dec	-	80.4	47.9	23.1	8.4	6.8
51	17-23 Dec.	-	80.5	64.3	22.5	6.9	7.3
52	24-31 Dec.	-	92.8	63.3	2.04	6.1	7.2
1	01-07 Jan.	-	97.7	71.8	16.7	6.4	4.4
2	08-14 Jan.	127.1	88.9	74.9	16.7	11.5	7.9
3	15-21 Jan.	-	91.1	57.6	18.6	6.4	7.3
4	22-28 Jan.	0.2	92.6	62.6	20.0	7.6	5.9
5	29-04 Feb.	39.8	91.4	66.9	20.4	6.9	5.2
6	05-11 Feb.	20.9	91.7	70.4	19.1	8.4	5.0
7	12-18 Feb.	0.8	92.4	65.8	20.3	6.8	8.2
8	19-25 Feb.	0.4	92.3	64.7	20.1	5.6	8.4

Source:- Water Management Research Centre, Sher-e-Kashmir University of Agricultural Sciences and Technology, Ponichak, J&K Jammu.

APPENDIX-III

List of common name, trade name and chemical name of the herbicides used

S.No.	Common name	Trade name	Chemical name
1.	Fluchloralin	Basalin	N-(2-Chloroethyl) -2, 6 - dinitro-N-propyl-4-(trifluromethyl) aniline
2.	Metribuzin	Sencor	4-amino-6-tert-butyl -3-(methylthio)-as-triazin-5(4H)-one
3.	Oxyfluorfen	Alto	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluormethy)benzene
4.	Pendimethalin	Stom	N-(-1-ethylpropyl)3,4-dimethy l-2,6-dinitroaniline
5.	Trifluralin	Treflan	N-N-dipropyl-4-(trifluoromethyl)-2,6-dinitroaniline

APPENDIX -IV

Market price of herbicides and other details for working out economics.

Name of herbicide	Price in rupees kg/litre
Fluchloralin	594.00
Metribuzin	2100.00
Oxyfluorfen	2100.00
Pendimethalin	518.00
Trifluralin	596.00

Market sale rate of cauliflower 300.00 per quinntal

Labour employed

1. Labour employed for hoeing per hectare 20 man @ Rs. 35/per man

APPENDIX - V

Cost of cultivation of cauliflowre crop prodcution per hectare

1. Preparatory tillage

a) 3 ploughings @ Rs. 400/- per ploughing = Rs. 1200.00

b) 3 plankings @ Rs. 100/- per planking = Rs. 300.00

c) Preparation of beds, ridges and channals by 60 laboures @ Rs. 35 per labour = Rs. 2100.00

Total 1:- Rs. 3600.00

2. Transplanting of seedlings

a) Cost of 600 g seed @ 1600/ Kg = Rs. 960.00

b) Nursery management =Rs. 200.00

c) Transplanting of seedlings 40 labourers @ Rs. 35/- per labour per day = Rs. 1400.00

d) Irrigation and gap filling for 5 days 2 labours per day @ Rs. 35/- per labour per day = Rs. 350.00

Total 2:- Rs. 2910.00

3. Interculture

a) 4 hoeing and weeding 20 labours per hoeing and weeding @ Rs 35/- = Rs. 2800.00

b) Irrigation 5 times @ 2 laboures per irrigation @ Rs. 35/- per labour per day= Rs. 350.00

Total 3:- Rs. 3150.00

4. Plant protection (2 sprayings of Insecticide / weedicides).

a) Cost of Insecticides = Rs. 150.00

b) Spraying charges of 6 laboures @ Rs. 35/- per day per laboure of 3 laboures per spraying = Rs. 210.00

Total 4 Rs. 360.00

5. Manure and Fertilizers

a) FYM 10 tonnes @ Rs. 100/tonne = Rs. 1000.00

b) Cost of fertilizers = Rs. 2501.30

Total 5 = Rs. 3501.30

6. Harvesting of curd 4 times

@ 10 laboures per time

@ Rs. 35/- per day per labour = **Rs. 1400.00**

7. Miscellaneous charges

Land revenues, Interest on capital, depreciation etc. = **1000.00**

Total Expenditure:-

(1+2+3+4+5+6+7) = **15921.30**

APPENDIX - VI

Analysis of variance for crop stand (%)

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	26.72	13.36	3.12	
Treatment	9	58.89	6.54	1.53 $^{+}$	2.15
Error	18	76.89	4.27		
Total	**29**				

+ Non-significant

APPENDIX - VII

Analysis of variance for plant height (cm) at 45 days

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	0 .31	0 .16	1.2	
Treatment	9	297.3	33.02	254 *	2.15
Error	18	2.49	0.13		
Total	**29**				

* Significant at 5%

APPENDIX - VIII

Analysis of variance for plant height (cm) at harvest

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	6	3	2	
Treatment	9	1298.07	144.23	96.15 *	2.15
Error	18	27.03	1.5		
Total	**29**				

* Significant at 5%

APPENDIX - IX

Analysis of variance for cauliflower yield (q ha^{-1})

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	281.4	104.7	0.84	
Treatment	9	59418.3	6602.0	53 *	2.15
Error	18	2225.8	123.65		
Total	**29**				

* Significant at 5%

APPENDIX - X

Analysis of variance for weed population at 45 days

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	1439.29	719.64	0.98	
Treatment	13	900543.81	69272.6	94.63 *	2.15
Error	26	19054.05	732.8		
Total	**41**				

* Significant at 5%

APPENDIX - XI

Analysis of variance for weed population at harvest

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	1787.48	893.74	2.03	
Treatment	13	3400503.64	261577.20	595.65*	2.15
Error	26	11417.86	439.14		
Total	**41**				

* Significant at 5%

APPENDIX - XII

Analysis of variance for fresh weight of weeds at harvest q ha^{-1}

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	.0.19	0.095	0.39	
Treatment	13	345.27	26.55	110.62*	2.15
Error	26	6.38	0.24		
Total	**41**				

* Significant at 5%

APPENDIX - XIII

Analysis of variance for dry weigh of weeds at harvest

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	0.05	0.025	3.1	
Treatment	13	32.86	2.52	315.0*	2.15
Error	26	0.23	0.008		
Total	**41**				

* Significant at 5%

APPENDIX - XIV

Analysis of variance for residual effect on germinations (%) on beans

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	25.08	12.54	1.1	
Treatment	13	79.64	6.12	0.5 $^{+}$	2.15
Error	26	296.58	11.40		
Total	**41**				

$^{+}$ Non-Significant

APPENDIX - XV

Analysis of variance for residual effect on germinations (%) on okra

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	44.41	22.20	0.50	
Treatment	13	311.19	23.93	0.59^{+}	2.15
Error	26	1141.09	43.88		
Total	**41**				

\+ Non-Significant

APPENDIX - XVI

Analysis of variance for residual effect on germinations (%) on muskmelon

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	278.65	139.32	9.9	
Treatment	13	42.75	3.28	0.02^{+}	2.15
Error	26	365.54	14.05		
Total	**41**				

\+ Non-Significant

APPENDIX - XVII

Analysis of variance for residual effect on germinations (%) on cucumber

Source of variation	Degree of freedom	Sum of square	Mean sum of square	F Cal. Value	F Tab. Value 5%
Replication	2	64.97	32.48	3.70	
Treatment	13	130.32	10.02	1.14^{+}	2.15
Error	26	22.09	8.77		
Total	**41**				

\+ Non-Significant