"WEED CONTROL STUDIES IN CARROT (*Daucus carota* L.)"

M.Sc. (Ag.) THESIS

by

MANNU RAM NETAM

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
INDIRA GANDHI AGRICULTURAL UNIVERSITY
RAIPUR (C.G.)

2005

“WEED CONTROL STUDIES IN CARROT (*Daucus carota* L.)”

Thesis

Submitted to the

Indira Gandhi Agricultural University, Raipur

by

MANNU RAM NETAM

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science

***I**n*

Agriculture
(HORTICULTURE)

ROLL NO. 2902 **ID NO. AG/ 97/48**

DECEMBER, 2005

CERTIFICATE – I

This is to certify that the thesis entitled **"WEED CONTROL STUDIES IN CARROT (*Daucus carota* L.)"** submitted in partial fulfilment of the requirements for the degree of **"Master of Science in Agriculture"** of the Indira Gandhi Agricultural University, Raipur, is a record of the bonafide research work carried out by **MANNU RAM NETAM** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date:

Chairman
Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman : Dr. D. A. Sarnaik ________________________

Member : Dr. S. S. Kolhe ________________________

Member : Dr. M.C. Bhambri ________________________

Member : Dr. Jitendra Singh ________________________

Member : Dr. Ravi R. Saxena ________________________

CERTIFICATE - II

This is to certify that the thesis entitled **"WEED CONTROL STUDIES IN CARROT (*Daucus carota* L.)"** submitted by **MANNU RAM NETAM** to the Indira Gandhi Agricultural University, Raipur in partial fulfilment of the requirements for the degree of **M.Sc. (Ag.)** in the **Department of Horticulture** has been approved by the Student's Advisory Committee after an oral examination in collaboration with the external examiner.

Date: **EXTERNAL EXAMINER**

Major Advisor __________________

Head of the Department __________________

Director of Instructions __________________

ACKNOWLEDGEMENT

I feel pleasure in expressing my sincere thanks and deep sense of gratitude to **Dr. D.A. Sarnaik,** Professor and Head, Department of Horticulture and Chairman of my Advisory Committee for his valuable guidance and constant encouragement throughout the course of investigation.

I am deeply obliged to all the members of my Advisory Committee, Dr. S.S. Kolhe, Professor (Agronomy), Dr. Jitendra Singh, Assoc. Professor (Horticulture), Dr. M.C. Bhambri, Assoc. Professor (Agronomy), Dr. Ravi R. Saxena, Assistant Professor (Agricultural Statistics) for their valuable guidance and suggestions in completion of this thesis work.

I wish to record my sincere thanks to Dr. C.R. Hazra, Hon'ble Vice Chancellor, Dr. A.S.R.A.S. Sastri, Director Research Services and Dean, College of Agriculture, Raipur, Dr. R.B. Sharma, Director Extension Services and Dr. Sunil Puri, Director of Instruction, IGAU, Raipur for providing me necessary facilities during the period of my investigation.

I profusely thanks to Dr. N. Mehta, Shri P. Dubey, Dr. Prabhakar Singh, Dr. H.G. Sharma, Dr. N. Shukla, Dr. C.P. Khare, Shri T. Tirkey, Shri Jitendra Trivedi, Dr. Shailendra Agrawal, Shri R.K. Sonkar, Shri Satish Verma and Dr. R.N. Sharma, Dept. of Horticulture, who were always ready to give their valuable kind guidance when ever required.

I have immense pleasure in expressing my whole hearted sense of gratitude to Dr. (Capt.) G.K. Shrivastava, Senior Scientist, for the encouragement, timely help and advice given during the thesis work.

My special thanks goes to Shri Jeevan Lal Nag, Narayan Singh, Shri Deo Shankar Ram and Kailash Singh Paikra (Horticulture), Shri Santosh Nag, Shri S.S. Porte (Soil Science), Shri Manoj Dhruv, Shri S.R. Netam (Plant Physiology) and Shri S.S. Netam Engineer for their ever remembering co-operation, cordial dealing and immense help during the study period and preparation of manuscript.

My most heartfelt thanks goes to my friends Ganga, Ganesh, Suresh, Morish, Lakesh, DSP, Mahipal, Mohan Singh, Santosh, Usendi brothers, Netam brothers, Rajendra, SSP Goyal, Vikram, Ramlal, Suklu Ram Salam, Ugresh, M.P., Tanwar brothers, Niranjan, Markam and loving juniors Ranjit, Joshi, Bhupendra, Bhuarya brothers for their love and co-operation during post graduation.

Sincere thanks are also due to Mr. Ajay Kaushik for their tireless effort and dedication showing during formatting of this thesis.

My literal power is too less to express my gratitude to my grandmother Late Shri Pati Ram and elder brother Late Shri Chandan Singh Netam for their continuous blessing upon me.

My cordial thanks to all my family, relatives for their continuous blessings and encouragement during my study.

From the core of my heart, I express my heart full gratitude to my beloved father Late Shri J.R. Netam and mother Smt. Keshari Bai, cousins Pradeep, Mahendra Mandavi.

Diction is not enough to my heartfelt gratitude to my beloved elder brothers Shri Chandra Bhan Netam and Bhabhiji Smt.l Janki Netam and my sister Smt. Hemlata Kawde, Tiloka, Rekha, Nephew Gomti, Babu, Bhanjee Monika whose blessing, affection and encouragement have always been the most vital source of inspiration and motivation in my life.

I wish to express my grateful thanks to all teachers, friends and well wishers who have directly or indirectly helped me to reach up to this level in my life.

I have no words adequate to convey by name, but each of them know that he has my cordial thanks

Place : **(Mannu Ram Netam)**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
@	At the rate of
^{0}C	Degree Celsius
CD	Critical difference
cm	Centimetre
DAS	Days after sowing
Fig.	Figure
g	Gram
HW	Hand weeding
ha	Hectare
m	Metre
mg	Milligram
N	Nitrogen
P	Phosphorus
K	Potassium
PE	Pre-emergence
PPI	Pre-planting incorporation
PE	Post emergence
NS	Non significant
q	Quintal
SEm	Standard error of mean
T	Tonne

CHAPTER-I

INTRODUCTION

Vegetables are rich source of essential nutrients and play significant role in improving the nutritional status, particularly of malnourished people and also provide nutritional security to the nation. Vegetables are so common in human diet that a meal without vegetable is supposed to be in-complete. They supply essential minerals, vitamins and roughage, which most food materials rarely provide. It has been pointed out that the protein yield per acre of the leaf green vegetable far exceeded from other sources. They also play an important role in neutralizing the acid during digestion of meal. Hence, the role of the vegetable in the applied nutrition programme is well realized.

Vegetable cultivation in India is mostly adopted by small and marginal farmers. These farmers grow vegetables to generate an additional income from their backyards or small portion of their scarce land holding, which is comparatively well endowed in terms of soil and irrigation. The farm sector is changing throughout the World. Cereal farmers are adding vegetables to their crop rotations in response to increased consumer demand. Assuming a 3.6 and 5.5 per cent GDP growth rate in India, the projected demand for vegetables in the year 2030 for India alone is 151 and 193 million tonnes. Without increasing the area to achieve this target, the yield increase should be around 190 to 200 per cent. India continues to be the second largest producer of vegetables in world with 80.26 million tonnes (second only to China) and accounts for about 9.3 per cent of the world's vegetable production (Anonymous, 2005).

Carrot (*Daucus carota* L.) locally known as *Gajar* belonging to family Umbelliferae is an important root crop. It is consumed as raw as well as in cooked form and its juice is a rich source of carotene. A delicious dish "*Gajar ka halwa*" is also prepared from carrot root in which milk and sugar both are added. Black carrot is used for preparation of a beverage called "*Kanji*" considered to be a good appetizer. An orange coloured carrot is rich in carotene, which is precursor of Vitamin A (3,150 I.U.) and contains appreciable quantity of thiamine (0.04 mg/100 g) and riboflavin (0.02 mg/100g). Choudhary (1990) reported that carrot leaves are highly nutritive, rich in protein (0.9 m/ 100g), minerals (1.1 gm/100g) and vitamin C (3.0 mg/100g) which are used as fodder and also to prepare poultry feed.. In India, carrot is grown in about 24,000 hectares with the production of 35,0000 tonnes (FAO, 2001-04) and Uttar Pradesh, Assam, Karnataka, Andhra Pradesh, Punjab and Haryana are the main carrot growing state of the country.

There are several constraints, which are responsible for low yield of carrot per unit area. Weeds are the foremost biotic barrier in enhancing yield of carrot. It is observed that, carrot yield can shrink 30 to 60 per cent under severe crop weed competition. Although, it has capacity to recover from competition when weeds are removed at an early stage. Looking to the severity of reduction in carrot yield due to weeds and unavailability of labourers in time due to industrialization and emigration, use of herbicide is an alternative of weed management. The work on this aspect for vegetables in India is very meagre as well as inadequate and Chhattisgarh is not exemption to it.

Keeping above points in view, a field experiment entitled **"Weed control studies in carrot (*Daucus carota* L.)"** with Pendimethalin, Oxyfluorfen, Fluchloralin, Metribuzin alone as well as in combination with one hand weeding was planned and carried out during winter season of 2004-05 with following objectives:

1. **Documentation of weeds prevailing in carrot crop under agro-climatic condition of Chhattisgarh plains,**
2. **To study the effect of weed management practices on crop growth and yield attributing characters of carrot,**
3. **To evaluate the efficiency of selected herbicides against the weed population and its impact on carrot yield, and**
4. **To work out the economics of weed management practices in carrot.**

CHAPTER -II

REVIEW OF LITERATURE

Weeds are a serious problem in carrot crop. The problem of controlling weeds has been taken by studying various cultural and chemical methods to the extent of different degrees of success by the workers all over the world.

In this chapter brief review of various experimental finding of weed control such as weed density, composition of weed flora, losses caused by weeds, use of chemical control as well as effect on yield is given below:

2.1 Effect of weed management practices on carrot

2.1.1 Weed dynamics in carrot

2.1.2 Yield attributes and yield of carrot

2.2 Weed control efficiency

2.3 Economics

2.1 Effect of weed management practices on carrot

2.1.1 Weed dynamics in carrot

Weed dynamics in carrot field has been found to vary from place to place and even at the same place from year to year depending upon the agro-climatic condition, method of sowing, situation of field, preparation of fields etc.

Roberts and Bond (1982) observed that *Solanum nigrum*, *Chenopodium album*, *Laminum amplexicaule* and *Laminum purpureum, Veronica persica* and *Capsella bursa-pastosis* were the most dominant weeds in carrot crop. Benoit *et al.* (1995) recorded 23 weed species in carrot, of which the most abundant were *Taraxacum officinale*, *Chenopodium glaucum*, *Portulaca oleracea* and *Amaranthus retroflexus*.

Bellinder *et al.* (1997) reported that red root pigweed (*Amaranthus retroflexus)* and common lambsquarter (*Chenopodium album*) were the major weeds in carrot at Ithaca (USA). Malidza *et al.* (1997) found *Galinsoga parviflora, Sinapsis arvensis*, *Chenopodium album*, *Amaranthus retroflexus* and *Datura stramonium* as major weeds in carrot crop.

Fogelberg (1999) reported that the major weeds flora in carrot consisted of *Galinsoga parviflora*, *Vertica urens*, *Sinapsis arvensis*, *Chenopodium album*, *Stellaria media*, *Senecio vulgaris* and *Capsella bursa-pastoris*. Marenco and Lustosa (2000) found that the major weeds spp. in carrot crop were *Cyperus* spp., *Chamaecrista nictans* var. paraguariensis, *Marsypionthes chamaedrys*, *Mitracarpus* spp., *Mollugo verticillata* L., *Sebastiania corniculata* and *Spigelia anthelmia*.

Sandhu *et al.* (2001) reported that the seed crop of carrot was highly infested with weed spp. of both the winter and summer season.

The predominant weeds were *Poa annua*, *Chenopodium album*, *Anagallis arvensis*, *Setaria media*, *Lapidium sativum* and *Madicago* spp. in witner and *Triagonella polyceratia*, *Cyperus rotundus*, *Amaranthus* spp and *Tribulus terrestris* in summer.

2.1.2 Yield attributes and yield of carrot

While working in Italy, Rapparini and Ballasso (1977) observed that spring sown carrot crop grown in medium textured soil was heavily infested with *Chenopodium* spp., *Linasia spuria, Polygonum convolvulus, P. persicarica* and *Anagallis arvensis* and application of metribuzin (35%) at 2 kg product ha^{-1} post emergence controlled these weeds most effectively but caused significant crop thinning. Sharma and Bhagchandani (1979) stated that manual weeding is tedious and time consuming. They also noted that herbicide applications as pre-emergence was more effective than post-emergence stage. The pre-emergence method has also been observed better than post-emergence by Quaglitti and Tosi (1968), Fiveland (1972) and Leal *et al*. (1973).

Yogaratnam *et al.* (1982) from Sri lanka, reported that application of 0.5 kg metribuzin gave good weed control when applied pre-emergence and root yields of carrot cv Cape market was 24.33-25.59 t ha^{-1} compared with 7.33 and 29.99 t ha^{-1} for weedy and hand weeded control, respectively. Post-emergence application of metribuzin gave poor weed control. Leela (1982) noticed the pronounced effect of herbicide application in controlling the weeds and increasing the yield of horticultural crops.

At Hissar, Singh and Malik (1983) studied on carrot crop with herbicides like fluchloralin @ 0.76-1.12 kg ha^{-1}, oxyfluorfen @ 0.12-0.25 kg ha^{-1}, pendimethalin @1.5-2.0 kg ha^{-1}, and metribuzin @ 0.5-1.5 kg ha^{-1} and their lower rates were combined with one hand weeding to determine their effects on weed dry matter production and carrot seed yield. The noticed that oxadiazon, metribuzin, pendimethalin and oxyfluorfen resulted in better weed control and gave higher yields than control. Iskenderov and Volvodin (1983) reported that the application of pendimethalin at 1.5 kg pre-emergence +1.0 kg post emergence ha^{-1} gave effective control of weeds, markedly increased the seed yield and improved the sowing quality of the seeds.

Singh (1994) found that the herbicide at recommended rates or combination with hand weeding at 45 DAT gave yield as compared to weedy check. The herbicide pendimethalin at 1.0 kg ha^{-1} (PE) +one hand weeding at DAT gave highest fruit yield (214.42 q ha^{-1}) and net profit (Rs.12,372.00 ha^{-1}) with cost benefit ratio 2.36. Singh *et al.* (1996) noted that in brinjal crop, the pendimethalin at 0.5 kg a.i.ha^{-1} + hand weeding and oxyfluorfen at 0.1kg ha^{-1} +one hand weeding gave best weed control and highest fruit yield followed by oxyfluorfen at 0.18 kg a.i.ha^{-1}, fluchloralin at 0.8kg a.i. ha^{-1} + one weeding, metolachlor at 1.25 kg a.i. ha^{-1} and 0.94 kg a.i. ha^{-1} + one weeding, oxyfluorfen at 0.18 kg and 0.12 kg a.i.ha^{-1} + one weeding.

Working in Saudi Arabia, Tag *et al.* (1997) investigated the effect of metribuzin (350 gha^{-1}) alone and in combination pendimethalin (750 gha^{-1}) on carrot (cv. Nantes). They found that metribuzin was less effective than their mixture in weed control and carrot yield. Results showed that pendimethalin mixture improved weed control without causing phytotoxity to carrot. Pendimethalin mixture increased the growth of leaves, root yield and quality, marketable roots and ascorbic acid contents in roots. Bell *et al.* (2000) compared the application of linuron with hand weeding and an untreated control for weed control in carrots cv. Caropak. Linuron @ 1.12 kg ha^{-1} applied pre or post emergence was slightly less effective than the 100 per cent weed control obtained by hand weeding. Carrot yields were similar for all treatments and were at least six times as great as in the control.

At Hissar, Kumar *et al.* (2001) studied on carrot cv. Hissar Garlic with twelve herbicidal treatments comprising of trifluralin, pendimethalin and linuron all applied at 0.75, 1.00 and 1.25 kg ha^{-1} and at 0.75 kg ha^{-1} with hand weeding, were compared with three hand weeding at 20, 40 and 60 DAS and season long weed free and unweeded condition. They reported that all treatments significantly increased the root and shoot length of carrot compared with weedy control, except for pendimethalin and linuron 0.75 kg ha^{-1}. Integration of lower doses (0.75 kg ha^{-1}) each of trifluralin, pendimethalin and linuron with one hand weeding at 40 DAS produced longer roots and shoots with higher diameter of root and root weight. All the treatments produced significantly higher yield of marketable roots per hectare compared with the weedy check. Pendimethalin at 0.75 kg ha^{-1} supplemented with one hand weeding at 40 DAS produced marketable yield at par with the weed free plot.

At Ludhiana, Sandhu *et al.* (2001) evaluated pendimethalin and fluchloralin both applied at 2.50, 1.87 and 1.25 litres ha^{-1}, one hoeing at 60 days of transplanting + the lower doses of both herbicides, a weeded control (4 hoeings) and unweeded control (no hoeing). They found that the seed crop of carrot was highly infested with seed spp. of both the winter and summer season. Weed population was significantly reduced by the herbicide treatment, with or without hoeing. Application of pendimethalin and fluchloralin at 1.87 litre ha^{-1} coupled with one hoeing at 60 DAT gave good weed control and high weed control efficiency of 83 per cent. Increased seed yield was noted under the treatment of pendimethalin at 2.5 litres ha^{-1} and 1.87 litres ha^{-1} with or without hoeing. Seed yields under weedy control were lowest due to high crop weed competition.

Jadhao *et al.* (2001) reported that the efficacy of fluchloralin (1.0 and 1.5 kg ha^{-1}), trifluralin (1.0 and 1.5 kg ha^{-1}), metolachlor (1.5

and 2.0 kg ha^{-1}), pendimethalin (1.0 and 1.5 kg ha^{-1}), butachlor (1.5 and 2.0 kg ha^{-1}) and benthiocarb (1.5 and 2.0 kg ha^{-1}) to control weeds of radish. cv. Pusachetki. All herbicides, irrespective of rate, significantly controlled weed count and weed dry matter accumulation. In general, higher application rate were more effective than lower ones. The pre-emergence application of butachlor (2.0 kg ha^{-1}) caused the highest reduction in weed dry matter at 30 and 60 DAS. The treatment produced the tallest plants (146.8 cm) with the highest number of branches (15.9) and pods (581.3), heaviest seed weight per plant (8.87 g) and highest yield (13.18 q ha^{-1}).

2.2 Weed control efficiency

Zagonel *et al.* (1999) studied that the efficiency and selectivity of propaquizofop on weed control in carrot crop. They observed that propaquizofop at 100, 125 and 150 g a.i ha^{-1} efficiently controlled all three weed species namely *Brachiaria plantagea*, *Digitaria horizontalis* and *Eleusine indica*. The yield resulting from the chemically treated plots was comparable with that of manually weeded control. Yield loss due to the weed competition were 76.4 per cent. Carrot plant did not show any visual symptoms of damage attributed to herbicide application.

Popov (2000) studied on weed infestation and their control with herbicides in the Astrakhan region of Southern Russia. He provided recommendations for weed control in onion, carrot and tomato under sprinkler irrigation conditions with pendimethalin 33 per cent, metribuzin 70 per cent, quizalofop 5 per cent and ioxynil 22.5 per cent, for better efficiency. Weed control should be started in the autumn using Roundup (Glyphosate).

2.3 Economics

Yogaratnam *et al.* (1982) while working in Sri Lanka noted that out of 3 herbicides (linuron, metribuzin and nitralin) evaluated for use in carrot cv. Cap Market, application of nitralin @ 1.0 kg ha^{-1} pre-em. gave the highest benefit : cost (70.67) due to weed control although hand weeding gave the highest profit (Rs.37953 ha^{-1}).

In California (USA), Bell *et al.* (2000) carried out experiment to compare linuron (1.12 kg ha^{-1} pre em., 1.12 kg ha^{-1} post em. and 0.56 kg ha^{-1} pre-em. followed by 1.12 kg ha^{-1} post em.) with hand weeding and an untreated control for weed control in carrot cv. Carpak. They found that linuron treatment returned net profits ranging from $980 to $1887 per hectare, compared to $740 for hand weeding and -$2975 for the control.

CHAPTER-III

MATERIALS AND METHODS

The chapter deals with the concise description of the materials used and the techniques adopted during the course of investigation.

The present investigation was conducted at the Department of Horticulture, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh during the winter season (November, 2004 to January, 2005). The investigation was aimed at the "Weed control studies in carrot (*Daucus carota* L.)".

3.1 Climate and weather conditions

Geographically, Raipur is situated in the centre of Chhattisgarh and lies at 21°16′ N latitude and 81°36′E longitude at an altitude of 289.56 m above the mean sea level. Climatologically, Raipur is classified as slightly moist hot zone. The source of rainfall is South-western monsoon. It receives an average annual rainfall of 1325 mm (based on 80 year mean) mostly concentrated during the period from June to September. May and December months are the hottest and coolest months, respectively. The weekly maximum temperature raises up to 46°C during summer and minimum temperature reaches as low as to 6°C during winter season. The meteorological data namely, temperature, sunshine hours, relative humidity, wind velocity and evaporation during the crop period are depicted in Fig.3.1. During the course of investigation, the weekly maximum and minimum temperature were 42.3°C and 9.3°C, respectively (Appendix-I).

3.2 Experimental site

The experimental site was located at the Research Farm of the Department of Horticulture, College of Agriculture, Indira Gandhi Agricultural University, Raipur (C.G.) where, adequate facilities for irrigation and drainage existed.

3.3 Cropping history of experimental field

The cropping history of the experimental field for the past three years and during the year of experimentation is given in Table 3.1.

Table 3.1 : Cropping history of the experimental field

S.No.	Year	Crop	
		Kharif	Rabi
1.	2001-2002	Okra	Potato
2.	2002-2003	Okra	Potato
3.	2003-2004	-	Potato

3.4 Soil physical properties of experimental field

Representative soil samples were collected randomly from the experimental site upto 30 cm depth. A composite sample was drawn from mixed representative samples by divided repeatedly till the amount of representative samples remain about 250 g. The representative sample was then analysed for physico-chemical properties. The detailed physico-chemical properties of the experimental soil are presented in Table 3.2.

Table 3.2 : Physico-chemical properties of the experimental soil

Particulars	Analysis Values	Group class	Method used
A. Physical properties			
1. Sand (%)	32.59	Clay loam (Dorsa)	International Pipette method (Black, 1965)
2. Silt (%)	36.10		
3. Clay	31.34		
B. Chemical properties			
1. Organic carbon (%)	0.48	Low	Walkey & Blacks rapid titration method (Jackson, 1967)
2. Available N (kg ha^{-1})	218.00	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
3. Available P (kg ha^{-1})	11.50	Medium	Olsen's method (Olsen, 1954)
4. Available K (kg ha^{-1})	270.60	Medium	Flame photometric method (Jackson, 1967)
5. pH (1:2.5 soil:water)	6.80	Normal	Glass electrode pH meter (Piper, 1967)
6. EC (dsm^{-1} at 25^oC)	0.77	Medium	Solubridge conductivity method (Black, 1965)

3.5 Test crop

Carrot variety 'Pusa Kesar' was grown as test crop. This variety a selection from a cross of local Red and Nantes Half long, developed at IARI, New Delhi. The roots are scarlet in colour with sufficiently red coloured core unlike the local tropical cultivars wherein the core is yellow or white. The most desirable feature of this variety is that roots remain about a month longer in field than local red without bolting.

3.6 Experimental details

The experiment consisted of ten treatments, which comprised of ten weed management practices, details of which are given in Fig. 3.2. The experiment was laid out in randomized block design (RBD) and treatments were replicated thrice. The gross and net plot size were 24.3 m^2 and 19.35 m^2, respectively. Carrot crop was sown at a spacing of 45 cm row to row and 10 cm plant to plant.

3.7 Method of sowing and seed rate

Pure seed of carrot variety Pusa Kesar were manually sown by dibbling in ridges at the depth of 1 to 2 cm on 10^{th} November 2004. The seed rate used was 6 kg ha^{-1}.

3.8 Field preparation

The experimental field was prepared by giving three criss-cross tractor ploughings followed by harrowing. Later on, the field was levelled with a levelling plank. The experiment was laid out in field as per layout plan (Fig.3.2). Well rotten FYM @ 20 t ha^{-1} was applied uniformly before final land preparation.

3.9 Gap filling

In order to maintain the desired plant density, gap filling was done on 10^{th} day after sowing.

3.10 Irrigation

Carrot crop was irrigated frequently depending upon need. The schedule of irrigation is given in Table 3.4.

3.11 Fertilizer application

Carrot crop was given 75:50:75 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Whole quantity of P_2O_5 and K_2O was applied as basal, while N was applied in equal three splits *i.e*. basal, 20 and 40 DAS.

3.12 Application of herbicides and cultural operations

The spraying of different herbicides was done as per treatments. The brief information of herbicides used in experiment is given in Table 3.3. Spraying was done by hand operated Knapsack sprayer with flat fan nozzle using water as carrier @ 500 L ha^{-1}. The required quantity of herbicide was dissolved in measured quantity of water and sprayed uniformly over the plot. Pendimethalin, Oxyfluorfen and Fluchloralin, were sprayed as blanket spray, whereas, direct spray of Metribuzin was made as per treatment. Hand weeding was performed by *khurpi*.

3.13 Harvesting

Harvesting of carrot at proper maturity is an important operation to be considered in carrot cultivation otherwise the roots become unfit for consumption. Delay in harvest generally lead to more firmness of root as well as splitting. The roots attain marketable stage when their diameter is 2-4 inch at the upper end. A light irrigation was given before harvesting to facilitate the pulling of the root without any damage. The weight of roots recorded from each net plot was converted into t^{-1}. Roots of three plants were taken for observation of yield attributing characters from net plot area.

3.14 Cultural schedule

The details of the cultural operations adopted in the experiment plot from sowing to harvesting are given in Table 3.4.

Table 3.4: Cultural schedule performed in the experiment

S. No.	Cultural operations	Implement/ method used	Date
1.	Tillage twice	Tractor drawn cultivator	2-11-2004
2.	Rotavator twice	Tractor drawn rotavator	4-11-2004
3.	Levelling	Planker	4-11-2004
4.	Layout preparation	Steel tape & manual	8-11-2004
5.	Manuring	Manual	10-11-2004
6.	Date of sowing	Manual	10-11-2004
7.	Application of herbicide	Manual	10-11-2004
8.	Top dressing of nitrogen	Manual	10-11-2004
9.	Irrigation	Manual	11, 16, 22, 26 Nov., 2004
			2, 9, 16, 22, 28 Dec., 2004
			5, 11, 17, 20 Jan., 2005
10.	Harvesting	Manual	28-01-2005

3.15 Studies on crop

3.15.1 Pre-harvest studies

3.15.1.1 Plant height (cm)

The plant height of five marked plants from each plot was recorded at an interval of 30, 45, 60 DAS and at harvest. It was recorded from the ground level to tip of the plant with the help of metre scale. The average height was then worked out by dividing the summation with five.

3.15.1.2 Root length (cm)

Root length was taken at 30, 45, 60 DAS and at harvest. For root length, three randomly selected plants were taken in each plot. It was measured with the help of metre scale, at each observation. The average length of root was then worked out by dividing summation of length of roots with three.

3.15.1.3 Number of leaves plant^{-1}

Number of leaves per plant were counted from three randomly selected plants at 30, 45, 60 DAS and at harvest. The average number of leaves per plant was worked out by dividing summation of number of leaves with three.

3.15.1.4 Fresh weight of shoots plant^{-1}(g)

This observation was recorded on randomly selected three plants from each plot at 30, 45, 60 DAS and at harvest. Then portion of the shoot i.e. a part of the plant, which was above root, was separated from the plant with the help of knife and it was weighed and noted as fresh weight of shoots per plant. The average weight of shoot was then worked out by dividing summation of weight of shoots with number of sample plants i.e. three.

3.15.1.5 Fresh weight of roots plant^{-1} (g)

Fresh weight of roots per plant was recorded on randomly selected three plants taken from each plots at 30, 45, 60 DAS and at harvest. These plant were uprooted very carefully to avoid damage to root portion and they were washed carefully with water and then the roots were separated with the help of knife and then weighed. The average weight of roots was then worked out by dividing summation of weight of roots with three.

3.15.1.6 Dry weight of shoots and roots plant^{-1} (g)

Dry weight of shoots and roots was taken at 30, 45, 60 DAS and at harvest. For dry weight of shoots and roots per plant, three randomly selected plants taken for fresh weight of shoots and roots were considered. Plant materials were kept in verandah for natural drying till 2-3 days. The samples were kept in the hot air oven for 12 to 24 hours at 60°C till constant weight has been achieved and weighed on digital balance separately for shoots and roots weight**.** Afterwards, average was workout.

3.15.1.7 Root: shoot ratio

Root shoot ratio was calculated as follows:

$$\text{Root shoot ratio (\%)} = \frac{\text{Root fresh matter}}{\text{Shoot fresh matter}} \times 10$$

A total of three plants from each plots were considered for the root: shoot ratio. The root shoot ratio was obtained at four stages 30, 45, 60 DAS and at harvest. The root shoot ratio was expressed as per cent.

3.15.1.8 Root diameter (cm)

The root diameter was measured at 30, 45, 60 DAS and at harvest for the selected three plants taken for fresh weight of shoots. Root diameter in all the three plants were taken from three portion of root i.e. upper, middle and lower. Afterwards, the average diameter of root was worked out.

3.15.2 Post-harvest studies

3.15.2.1 Marketable, unmarketable and total root yield (t ha^{-1})

Roots from net plot were dug out and collected in separate gunny bags as per the treatments. Grading of harvested roots from net plot for each treatment was done in such a way that whole produce could be divided into two groups on the basis of size of roots. While making these groups, it has been decided that the roots having 20 g or more weight were considered as marketable root, which were weighed for each treatment and the data on marketable yield per plot was noted down. On the other hand, rest of the roots (below 20 g) were considered as unmarketable roots. Weight of these roots was also noted treatmentwise and the data on unmarketable root yield per plot was also recorded.

A total root yield (marketable + unmarketable) was also recorded in each net plot at the time of harvesting in kg and it was transformed into root yield in tonnes hectare^{-1} as per following formula:

$$\text{Root yield (t ha}^{-1}\text{)} = \frac{\text{Root yield (kg) net plot}^{-1}}{\text{Area of net plot, m}^2} \times 10$$

3.15.2.2 Shoot yield (t ha^{-1})

Shoot yield was recorded in each net plot at the time of harvesting in kg and it was transformed into shoot yield in tonnes hectare^{-1} as per the formula mentioned under root yield.

3.15.2.3 Harvest index

Harvest index was computed as the ratio of economic yield i.e. root yield to the total biomass i.e. biological yield (shoots and roots) from same area and expressed in per cent.

$$\text{HI, \%} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where, HI = Harvest index

3.16 Studies on weeds

Weed studies were made on weed density, dry matter of weeds, weed control efficiency. The techniques used are mentioned as follows.

3.16.1 Weed density

Weed associated with crop in the experimental area were recorded at 30, 45 and 60 DAS. Species wise weed count was made from randomly selected 5 units of quadrates of 50 cm x 50 cm (0.25^2) in each plot. The number of weeds was counted and the data were recorded m^2 for statistical analysis. Weed density of weeds was subjected to square root transformation i.e. $\sqrt{x+1}$ for the purpose of statistical analysis.

3.16.2 Dry matter of weeds

Dry matter of weeds was recorded at 30, 45 and 60 DAS. Weeds present in quadrate of 0.25 m^2 were uprooted carefully along with roots. The root portion was then detached and shoot portion of the weed plants was oven dried at 60°C for 24 hours. Dry matter of weeds was recorded after complete oven drying. Dry matter of weeds was subjected to square root transformation i.e. $\sqrt{x+1}$ for the purpose of statistical analysis.

3.16.3 Weed control efficiency (WCE)

The weed control efficiency was calculated on the basis of reduction in dry matter of production in treatment plot in comparison with the control plot and expressed in percentage. Weed control efficiency was computed at 30, 45 and 60 DAS.

$$\text{WCE (\%)} = \frac{\text{DMC - DMT}}{\text{DMC}} \times 100$$

where,

WCE = Weed Control Efficiency

DMC = Dry weight of weeds in unweeded plot

DMT = Dry weight of weeds in treated plot

3.17 Economics

Cost of cultivation for each treatment was calculated separately (Appendix II, III and IV). Gross return (Rs. ha^{-1}) was obtained by converting the harvest into monetary terms at the prevailing market rate during the course of investigation. Net return was obtained by deducting cost of cultivation from gross return. The benefit: cost ratio was calculated with the help of following formula:

$$\text{Benefit: cost ratio} = \frac{\text{Net return, Rs}}{\text{Total cost of cultivation, Rs.}}$$

3.18 Statistical analysis

For judging the effect of various treatments, all the collected data were statistically analyzed through randomized block design. and for significant treatment effects, standard error of means (SEm±) and critical difference (CD) were calculated at 5% level of significance as described in “Statistical procedure for Agricultural Research” by Gomez and Gomez (1984).

Source of variation	**d-f**	**S.S.**	**M.S.**	F		
					5%	1%
Replication	(r-1)	SS_R	MS_R	MS_R/MS_E		
Treatment	(t-1)	SS_T	MS_T	MS_T/MS_E		
Error	(r-1)(t-1)	SS_E	MS_E			
Total	(rt-1)					

where, r = number of replications,
t = number of treatments,
SS_R = Sum of square for replication,
SS_T = Sum of square for treatment
SS_E = Sum of square for error
MS_R = Mean sum of square for replication,
MS_T = Mean sum of square for treatment
MS_E = Mean sum of square for error

$$SEm\pm = \sqrt{\frac{\text{Error variance}}{\text{Number of replication}}}$$

$$SEd = \sqrt{\frac{2 \times \text{Error variance}}{\text{Number of replication}}}$$

CD = SEd x ‘t’ at 5% error degree of freedom

CHAPTER-IV

RESULTS AND DISCUSSION

The present chapter deals with the experimental findings obtained during the course of investigation on **"Weed control studies in carrot (*Daucus carota* L.)"**. The field experiment was conducted during winter season (November, 2004 to January, 2005) at the Research Farm, Department of Horticulture, IGAU, Raipur, Chhattisgarh. The experimental findings are statistically analyzed by using the analysis of variance technique in order to find out the significance of different treatments and the results are presented in different tables and graphs. The experimental findings along with its interpretation and support of research work of other scientists are highlighted under the following heads:

4.1 Studies on carrot

4.1.1 Pre harvest studies

4.1.1.1 Plant height

The plant height of carrot at different stages of growth as affected by weed management practices are presented in Table 4.1.

The findings revealed that plant height of carrot showed an increasing trend under all the treatments, though there was sharp increase from 30 DAS to 60 DAS, thereafter, the pace of growth was slightly reduced.

At all the stages of crop growth except at 60 DAS plant height of carrot under HW twice at 25 and 40 DAS (T_9) was significantly taller as compared to other treatments. However, at 60 DAS, treatments Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + HW at 30 DAS (T_4) and Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) also remained statistically similar to former treatment. Significantly lowest plant height of carrot was noted under weedy check (T_{10}) at all the stages of crop growth.

The superiority of former treatments over others might be due to greater utilization of nutrient, moisture, space and light under these treatments. Reduction of weeds under these treatments might have created better microclimate and less competition between weeds and plants which might have facilitated greater photosynthesis. Working in tomato, Chanda *et al*. (1994) also witnessed similar results.

4.1.1.2 Root length (cm)

The root length of carrot as influenced by different weed management practices at various growth stages are given in Table 4.2.

Various weed management practices had significantly affected the root length of carrot at 30 DAS and 45 DAS. However, at 60 DAS and at harvest weed management practices could not give significant impact on root length of carrot. In general root length sharply increased upto 60 DAS, thereafter at harvest, it increased with a slow rate. At 30 DAS, hand weeding twice at 25 DAS and 40 DAS (T_9) gave significantly longest root as compared to others.

At 45 DAS, root length of carrot was observed to be significantly longer under hand weeding twice at 25 and 40 DAS (T_9) as compared to others, except Pendimethalin @ 1.0 kg ha^{-1} PE (T_1), Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8) which also remained statistically similar to former treatment.

It seems that upto 45 DAS, the above better performing treatments resulted in reduced weed population and did not allow the weeds to compete with carrot crop during initial growth stage, however at 60 DAS and at harvest, later emerged weeds were not controlled properly, therefore, crop produced longer roots upto 45 DAS and later on non-significant effect of treatments were observed. There results are in close agreement with the findings of Malik *et al*. (1982), who concluded that super imposition of one hand weeding improved the onion yield.

4.1.1.3 Number of leaves plant^{-1}

The data for number of leaves plant^{-1} as influenced by weed management practices have been presented in Table 4.3.

It is clear from the data that there was continuous increase in number of leaves upto 60 DAS and thereafter it increased with very slow rate. As regards to effect of different weed management practices, its significant impact on number of leaves per plant was observed.

At all the stages of crop growth, hand weeding twice at 25 and 40 DAS (T_9) produced significantly taller plants over others. However, supplementation of one hand weeding at 30 DAS along with different tested herbicides also proved comparable at all the stages with the former best performing treatment. The lowest number of leaves per plant in carrot was noted under weedy check.

Similarly, Kumar *et al*. (2001) also observed that number of leaves of carrot were significantly increased by Pendimethalin 1.0 kg ha^{-1} and 0.75 kg ha^{-1} plus one hand weeding at 30 DAS and weed free compared with control and these three treatments were statistically at par with each other.

4.1.1.4 Fresh weight of shoots plant^{-1} (g)

The data on fresh weight of shoots as affected by different weed management practices are presented in Table 4.4.

The findings indicate that different weed management practices could not give significant impact on fresh weight of shoots at 30 and 45 DAS.

However, at 60 DAS, significantly highest fresh weight of leaves was noted under hand weeding twice at 25 and 40 DAS (T_9), which was comparable to Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 250 g ha^{-1} PE (T_7) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8). Whereas, at harvest also, hand weeding twice at 25 and 40 DAS gave significantly higher fresh weight of leaves, though, it was comparable to pendimethalin @ 1.0 kg ha^{-1} (T_1), pendimethalin @ 1.0 kg ha^{-1} + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1}, PE (T_3) Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5) Metribuzin @ 250 g ha^{-1} PE (T_7) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8). At both these stages of crop growth, the lowest fresh weight of leaves per plant in carrot was observed under weedy check.

The present findings clearly indicate that although no marked effect of herbicidal and cultural weed control treatments was noted on fresh weight of leaves in early stages *i.e.* 30 and 45 DAS, but at later stages of crop growth there was significant effect of these treatments which might be due to better macro and micro climatic conditions. It may also be due to higher number of leaves per plant, which would have been resulted in accumulation of higher food materials into roots. These findings are in close proximity with the results of Kumar *et al*. (2001).

4.1.1.5 Dry weight of shoots plant^{-1} (g)

The data on dry weight of shoots plant^{-1} as affected by different weed management practices are presented in Table 4.5.

The data revealed that dry weight of shoots plant^{-1} showed an increasing trend up to 60 DAS, thereafter, it increased with slow rate. The minimum dry weight of shoots plant^{-1} was noted under weedy check (T_{10}) throughout the period of investigation, except at 30 DAS, where minimum value was observed under Oxyfluorfen @ 0.2 kg ha^{-1} PE (T_3).

However, at 30 DAS, 45 DAS and at harvest, there was no significant impact of different weed control treatments on dry weight of shoots plant^{-1}. Whereas, at 60 DAS, HW twice at 25 and 40 DAS (T_9) recorded the highest dry weight of shoots plant^{-1}, though comparable values were noted under pendimethalin @ 1.00 kg ha^{-1} PE (T_1), Pendimethalin @ 1.00 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 0.250 g ha^{-1} PE (T_7) and Metribuzin @ 0.250 g ha^{-1} PE + 1 HW at 30 DAS (T_8).

The present findings clearly indicated that there was no marked effect on dry weight of shoots in early stags of herbicidal and cultural treatments. Whereas, at 60 DAS, dry weight of shoots significantly increased due to healthy plant and proper development of plants. It may also be due to higher plant height, higher number of shoots plant^{-1}, which would have been resulted in accumulation of higher food materials.

These findings are in close proximity with the results of Kumar *et al*. (2001).

4.1.1.6 Fresh weight of roots plant^{-1} (g)

The data on fresh weight of roots plant^{-1} as influenced by different weed management practices are given in Table 4.6.

Different weed control treatments had significant influence on fresh weight of roots plant^{-1} at 45 DAS, 60 DAS and at harvest, however, at 30 DAS, non significant result was observed.

Data revealed that fresh weight of roots plant^{-1} was significantly highest under HW twice at 25 and 40 DAS (T_9), though it was comparable to pendimethalin @ 1.00 kg ha^{-1} PE (T_1), Pendimethalin @ 1.00 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1}, PE (T_3) and Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4) at 45 DAS and 60 DAS and Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 0.250 g ha^{-1} PE (T_7) and Metribuzin @ 0.250 g ha^{-1} PE + 1 HW at 30 DAS (T_8) at harvest. The minimum fresh weight of roots plant^{-1} was observed under weedy check (T_{10}) at 30 DAS and at harvest and under Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5) and Metribuzin @ 0.250 g ha^{-1} PE (T_7) at 45 DAS and 60 DAS.

The higher fresh weight of roots plant^{-1} in former treatments might be the result of better growth and development of roots due to less crop-weed competition. The above findings clearly suggests that better weed control in hand weeding twice and herbicides supplemented with hand weeding enhanced the growth parameters which ultimately increased fresh weight of roots. The similar findings were also reported by Leal *et al*. (1973), Singh and Malik (1983) and Singh *et al*. (1997).

4.1.1.7 Dry weight of roots plant^{-1} (g)

The data on dry weight of roots plant^{-1} as influenced by different weed management practices are given in Table 4.7.

In general, dry weight of roots plant^{-1} in carrot increased from 30 DAS to harvest stage. Different weed control treatments showed significant influence on dry weight of roots plant^{-1} at 30, 45 and 60 DAS, however, at harvest, these treatments failed to show significant impact on this parameter. The results showed that HW twice at 25 and 40 DAS (T_9) produced significantly maximum dry weight of roots plant^{-1}, however, it was statistically similar to Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 0.250 g ha^{-1} PE (T_7) at 45 DAS and Metribuzin @ 0.250 g ha^{-1} PE + 1 HW at 30 DAS (T_8) at 60 DAS.

It was observed that weedy check and treatments involving only chemical weed control resulted in decreased dry weight of roots. The better growth and development of carrot root in former treatments led to increased dry weight of roots plant^{-1}. The similar findings were also reported by Leal *et al*. (1973), Singh and Malik (1983) and Singh *et al*. (1997).

4.1.1.8 Diameter of roots plant^{-1} (cm)

The data no diameter of roots plant^{-1} as affected by different weed management practices are presented in Table 4.8. The findings on diameter of roots plant^{-1} reveal that various weed management practices could not give significant impact on this parameters at 30, 45 DAS and at harvest. At 60 DAS, hand weeding twice at 25 and 40 DAS (T_9) exhibited maximum diameter of root, though it was statistically similar to all the other treatments except Metribuzin @ 250 g ha^{-1} PE T_7 and weedy check (T_{10}) which gave minimum diameter of roots plant^{-1}.

Diameter of root increased due to less weed competition under former treatments as more nutrient could be utilized by large size of roots. In treatments Metribuzin @ 250 g ha^{-1} PE (T_7) and weedy check (T_{10}), weed competition produced poor size of roots.

Similar results were also reported by Kumar *et al.* (2001) who reported that maximum root diameter was obtained in weed free plot and minimum was noted in weedy check.

4.1.1.9 Root: shoot ratio

The data on root:shoot ratio as influenced by different weed management practices are given in Table 4.9.

Root:shoot ratio remained unaffected due to various weed management practices at 30, 45 DAS and at harvest. Whereas, at 60 DAS, significantly highest root:shoot ratio were noted under hand weeding twice at 25 and 40 DAS (T_9), closely followed by Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE (T_8).

Malik *et al.* (1982) and Kumar *et al.* (2001) also noted similar observations.

4.1.2 Post-harvest studies

4.1.2.1 Marketable and unmarketable root yield (t ha^{-1})

The marketable and unmarketable root yield as affected by weed management practices are given in Table 4.10.

The marketable root yield of carrot was significantly higher under HW twice at 25 and 40 DAS (T_9) over others. However, it was comparable to pendimethalin @ 1.0 kg ha^{-1} PE (T_1), pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8). The lowest marketable root yield was observed under weedy check (T_{10}).

As regards to unmarketable root yield, different weed management practices failed to show any significant impact.

The greater marketable root yield in former treatments might be due to less weed competition which facilitated suitable environment for carrot resulting in better plant growth parameters and higher yield attributes. The minimum marketable root yield under weedy check was resultant of maximum weed competition which arrested nutrients availability of carrot crop. This in tern check translocation of food material to sink and therefore resulted in lower yield.

Sharma and Bhagchandani (1979) also obtained significantly higher marketable yield with the application of herbicides as compared to weedy check. Farag *et al.* (1994) also suggested that hand weeding twice or application of pre emergence herbicide can be used for satisfactory weed control, and improvement in yield and quality in carrots.

4.1.2.2 Total root yield (t ha^{-1})

Total root yield (marketable + unmarketable) as affected by weed management practices are presented in Table 4.11. The findings reveal that total root yield was significantly higher under HW twice at 25 and 40 DAS (T_9) over others. However, it was statistically similar to Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8). The lowest total root yield was observed under weedy check (T_{10}).

It seems that hand weeding twice at 25 and 40 DAS as well as Pendimethalin @ 1.0 kg ha^{-1} PE or Fluchloralin @ 1.0 kg ha^{-1} PPI or Metribuzin @ 250 g ha^{-1} PE supplemented with one hand weeding at 30 DAS did not allow the weeds to compete with carrot crop during initial growth stage and later emerged weeds were also controlled nicely, therefore, crop produced higher total root yield. Various growth and yield attributing characters also followed the same trend. These results are in close agreement with the findings of Farag *et al.* (1994) and Choudhary and Pathak (1992). Sharma and Bhagchandani (1979) indicated that all the herbicides applied as pre-emergence gave significantly higher yield than weedy check in carrot crop.

In this experiment, the above best performing treatments gave 80 to 100 per cent higher yield than weedy check.

4.1.2.3 Shoot yield (t ha^{-1})

Shoot yield of carrot as affected by weed management practices are presented in Table 4.11. The results indicate that various weed management practices had significant impact on shoot yield of carrot. Among the different treatments, hand weeding twice at 25 and 40 DAS (T_9) recorded significantly higher shoot yield than others, however it was at par to Oxyfluorfen @ 0.2 kg ha^{-1}, PE + 1 HW at 30 DAS (T_4) and metribuzin @ 250 g ha^{-1} PE (T_7). Whereas, the lowest shoot yield of carrot was recorded under treatment weedy check (T_{10}).

The higher shoot yield in above treatments might be due to higher growth characters, like number of leaves, plant height and less weed competition. These results are similar with the findings of Farag *et al.* (1994) and Kumar *et al.* (2001).

4.1.2.4 Harvest index (%)

Harvest index of carrot as affected by different weed management practices are given in Table 4.11. The data reveal that various weed management practices failed to produce any significant impact on harvest index of carrot.

However, the maximum harvest index (39.80%) was noted in Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) closely followed by Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) (39.1%). The minimum harvest index was noted under Oxyfluorfen @ 0.2 kg ha^{-1}, PE + 1 HW at 30 DAS (T_4) (30.47%).

Harvest index reflects the fresh weight partitioning behaviour between root and rest of the biomass of the plants as influenced by different treatments. In present study, harvest index was found to be non significant.

4.2 Studies on weeds in carrot

4.2.1 Floristic composition of weeds

In the experimental field following weed species were found pre dominant and these are given in Plate 1.

S. No.	Common name	Botanical name	Family
1.	Gajar Grass	*Parthenium hysterophorus*	Compositae
2.	Dhoodhi	Euphorbia heterophyla	Euphorbiaceae
3.	Safed Sainjee	*Melilotus indica*	Leguminoceae
4.	Chirpoti	*Physalis minima*	Solanaceae
5.	Hiran Khuri	*Convolvulus arvensis*	Convolvulaceae
6.	Bathua	*Chenopodium album*	Chenopodiaceae

4.2.2 Weed density

Data on density of weeds were recorded at 30, 45 and 60 DAS and presented in Table 4.12(a), (b) and (c). The findings revealed that weedy check had maximum weed density at 30, 45 and 60 DAS. At 30 DAS, *Physalis minima*, *Melilotus indica, Euphorbia macrophylla*, and *Chenopodium album* contributed major density of weeds under weedy check. Density of weeds under HW twice at 25 and 40 DAS (T_9), Oxyfluorfen @ 0.2 kg ha^{-1}, PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8) were comparatively lower than application of these herbicides alone as well as unweeded control.

At 45 DAS, density of weeds was found maximum under weedy check. *Parthenium hysterophorus*, *Melilotus indica, Physalis minima, Chenopodium album* and *Euphorbia macrophylla* contributed major density of weeds under weedy check (T_{10}). Density of weeds under Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1}, PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 250 g ha^{-1} PE (T_8) and HW twice at 25 and 40 DAS (T_9) was drastically lower.

At 60 DAS, density of weeds was found maximum under weedy check (T_{10}). *Parthenium hysterophorus*, *Melilotus indica, Euphorbia macrophylla* and *Physalis minima* contributed maximum density of weeds under weedy check. Density of weeds under HW twice at 25 and 40 DAS (T_9), Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8) was comparatively lower than application of these herbicides alone as well as unweeded control.

The performance of hand weeding twice at 25 and 40 DAS and weedicide supplemented with one hand weeding at 30 DAS were effective in minimizing the weed density. The maximum weed density was noted under weedy check followed by treatments involving only chemical control. Raghav (1995) and Meena (2004) also found similar findings in brinjal crops.

4.2.3 Dry matter of weeds (g m^{-2})

The data on dry matter of weeds are presented in Table 4.13. The findings indicated that all the weed management practices allowed significantly lower dry matter of weeds than weedy check, throughout the period of investigation. At 30 DAS, hand weeding twice at 25 and 40 DAS (T_9) exhibited minimum dry matter of weeds and it was significantly lower than other treatments. Similarly, at 45 DAS and 60 DAS, the performance of hand weeding twice at 25 and 40 DAS (T_9) proved best in minimizing dry matter of weeds and it was significantly lower than other treatments. Among chemical + cultural treatments of weed control, treatments involving both chemical and hand weeding like Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} + 1 HW at 30 DAS (T_8) proved better in minimizing dry matter of weeds than treatments involving only chemicals like Pendimethalin @ 1.0 kg ha^{-1} PE (T_1), Oxyfluorfen @ 0.2 kg ha^{-1} PE (T_3), Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5) and Metribuzin @ 250 g ha^{-1} (T_7). At all the stages of observations, weedy check showed maximum dry matter production of weeds.

All the herbicidal treatments significantly suppressed weeds as compared to weedy check. This is due to better control of weeds and thus resulted in lower accumulation of dry matter of weeds. Similar findings were also reported by Leela (1982), Singh *et al.* (1982), Raghav *et al.* (1987) and Nandal and Pandita (1988).

4.2.4 Weed control efficiency

Data on weed control efficiency are presented in Table 4.14.

The findings on weed control efficiency clearly indicated that at 30 DAS, maximum weed control efficiency (95.57%) was obtained under hand weeding twice at 25 and 40 DAS and it was followed by Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (93.70%) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (90.58%).

At 45 DAS, hand weeding twice at 25 and 40 DAS showed the maximum weed control efficiency of 97.93 per cent. Application of Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS and Metribuzin @ 250 g ha+ PE + 1 HW at 30 DAS showed the weed control efficiency of 94.38 and 93.48 per cent, respectively.

On the other hand, at 60 DAS, more than 90 per cent weed control efficiency was observed under treatments HW twice at 25 and 40 DAS (95.73%), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (94.08%), Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (94.06%), Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (93.96%) and Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (93.22%),

The weed control efficiency is inversely related to dry matter production of weeds. Weed control efficiency was found maximum under hand weeding twice at 25 and 40 DAS. Subsequently higher weed control efficiency was also noted in treatments involving integration of herbicides and hand weeding operations. This was due to lower accumulation of dry matter of weeds. Singh *et al*. (1997) also found higher weed control efficiency, when herbicide was supplemented with hand weeding.

4.3 Economics

The economics of carrot as influenced by different weed management practices are given in Table 4.15. The results indicated that the highest gross return (Rs. 1,82,640 ha^{-1}), net return (Rs.1,54,589 ha^{-1}) and benefit : cost ratio (Rs.5.51) was obtained under HW twice at 25 and 40 DAS (T_9), closely followed by Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) with gross return, net return and benefit : cost ratio of Rs.1,75,280 ha^{-1}, Rs.1,47,098 ha^{-1} and 5.22, respectively.

The lowest gross return (Rs.86,960 ha^{-1}), net return (Rs.61,725 ha^{-1}) and benefit :cost ratio (2.45) was observed under weedy check. The increased productivity under former treatments could cover up the additional cost of production, which resulted in higher benefit : cost ratio. Similar increased returns under two hand weeding and weedicide + 1 hand weeding were also noted by Prasad and Singh (1988) in onion and Ram *et al.* (1994) in tomato.

CHAPTER V

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH WORK

Carrot (*Daucus carota* L.) belonging to family Umbellifeare is an important root crop. Carrot is an winter season crop, largely grown in almost all parts of India as one of the principal root crop. It is a cool season root crop and seed are sown directly. Generally, it takes 20-25 days for proper establishment and problem of weeds is more severe in early stage of crop growth. The losses on account of high weed infestation one estimated to be much more in vegetables as compared to cereals and pulses. It is observed that, the carrot yield can shrink 30 to 60 per cent under severe crop weed competition. Unavailability of labours in time due to industrialization near by cities compel the farmers to adopt chemical measurer of weed management. Considering the acute problem of weeds and significance of weed management in enhancing the productivity of carrot, the present investigation was undertaken with the following objectives.

1. Documentation of weeds prevailing in carrot crop under agroclimatic condition of Chhattisgarh plains,
2. To study the effect of weed management practices on crop growth and yield attributing characters of carrot

3. To evaluate the efficiency of selected herbicides against the weed population and its impact on carrot yield, and
4. To work out the economics of chemical weed control in carrot.

The experiment was conducted during winter season (November-January of 2004-05) at the Research Farm, Department of Horticulture, Indira Gandhi Agriculture University, Raipur (C.G.). The experiment was laid out in randomized block design with four replications. The treatments comprised on ten weed management practices viz., Pendimethalin @ 1.0 kg ha^{-1} PE (T_1), Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) Oxyflourfen @ 0.2 kg ha^{-1} PE (T_3) Oxyflourfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS, (T_6) Metribuzin @ 250 g ha^{-1} (T_7) Metribuzin @ 250 g ha^{-1} PE + 1 H.W. at 30 DAS (T_8), hand weeding twice at 25-40 DAS (T_9) and weedy check (T_{10}). The carrot variety "Pusa kesar" was grown as test crop. Recommended practices of carrot were adopted during the period of investigation.

Data on plant height, number of leaves, root length, fresh weight of shoots and roots, dry weight of shoots and roots, root diameter, root:shoot ratio, weed density, weed dry weight, marketable and unmarketable root yield, shoot yield and harvest index were recorded and statistically analyzed. The economics and weed control efficiency were also. Workout. The observations on different parameter were recorded at 30, 45, 60 DAS and at harvest.

The results presented in earlier are summarized as follow :

- The plant height of carrot showed an increasing trend under all the treatments, though there was sharp increase from 30 DAS to 60 DAS, thereafter, the pace of growth was slightly reduced. At all the stages of crop growth except at 60 DAS plant height of carrot under HW twice at 25 and 40 DAS (T_9) was significantly taller as compared to other treatments. However, at 60 DAS, treatments Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + HW at 30 DAS (T_4) and Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) also remained statistically similar to former treatment. Significantly lowest plant height of carrot was noted under weedy check (T_{10}) at all the stages of crop growth.
- HW twice of 25 and 40 DAS and treatments involving herbicide and hand weeding gave longer roots then weedy check and treatments having herbicide alone. It seems that upto 45 DAS, the above better performing treatments resulted in reduced weed population and did not allow the weeds to compete with carrot crop during initial growth stage, however at 60 DAS and at harvest, later emerged weeds were not controlled properly, therefore, crop produced longer roots upto 45 DAS and later on non-significant effect of treatments were observed.

- It is clear from the data that there was continuous increase in number of leaves upto 60 DAS and thereafter it increased with very slow rate. As regards to effect of different weed management practices, its significant impact on number of leaves per plant was observed. At all the stages of crop growth, hand weeding twice at 25 and 40 DAS (T_9) produced significantly taller plants over others. However, supplementation of one hand weeding at 30 DAS along with different tested herbicides also proved comparable at all the stages with the former best performing treatment. The lowest number of leaves per plant in carrot was noted under weedy check.
- At 30 DAS, 45 DAS and at harvest, there was no significant impact of different weed control treatments on dry weight of shoots plant^{-1}. Whereas, at 60 DAS, HW twice at 25 and 40 DAS (T_9) recorded the highest dry weight of shoots plant^{-1}, though comparable values were noted under pendimethalin @ 1.00 kg ha^{-1} PE (T_1), Pendimethalin @ 1.00 kg ha^{-1} PE + 1 HW at 30 DAS (T_2), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6), Metribuzin @ 0.250 g ha^{-1} PE (T_7) and Metribuzin @ 0.250 g ha^{-1} PE + 1 HW at 30 DAS (T_8).
- It was observed that weedy check and treatments involving only chemical weed control resulted in decreased dry weight of roots. The better growth and development of carrot root in HW twice at

25 and 40 DAS and in treatments involving herbicides and hand weeding led to increased dry weight of roots plant^{-1}.

- Diameter of roots increased due to less weed competition under HW twice at 25 and 40 DAS and in treatments involving herbicides and hand weeding as more nutrient could be utilized by large size of roots.
- In this experiment, total marketable + unmarketable root yield under HW twice at 25 and 40 DAS and in treatments involving herbicides and hand weeding was 80 to 100 per cent higher than weedy check.
- Shoot yield of carrot was highest under HW twice at 25 and 40 DAS, thought it was at par to Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4) and Metribuzin @ 250 g ha^{-1} PE (T_7).
- Harvest index was found to be non significant. Harvest index reflects the fresh weight partitioning behaviour between root and rest of the biomass of the plants as influenced by different treatments.
- The performance of hand weeding twice at 25 and 40 DAS and herbicide supplemented with one hand weeding at 30 DAS were effective in minimizing the weed density. The maximum weed density was noted under weedy check followed by treatments involving only chemical control.

- All the herbicidal treatments significantly suppressed weeds as compared to weedy check. This is due to better control of weeds and thus resulted in lower accumulation of dry matter of weeds.
- The results indicated that the highest gross return (Rs. 1,82,640 ha^{-1}), net return (Rs.1,54,589 ha^{-1}) and benefit : cost ratio (Rs.5.51) was obtained under HW twice at 25 and 40 DAS (T_9), closely followed by Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) with gross return, net return and benefit : cost ratio of Rs.1,75,280 ha^{-1}, Rs.1,47,098 ha^{-1} and 5.22, respectively

Conclusion

On the basis of one year investigation, it is concluded that two hand weeding at 25 and 40 DAS or Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS enhance the productivity and profitability of carrot in Chhattisgarh plains. The above weed management practices not only gave maximum weed control efficiency but also fetched highest benefit : cost ratio.

Suggestions for further research work

There is not much work has been made on weed management in carrot. Recently many new herbicides molecules are available in the market, Hence, there is necessity to test the efficiency of new herbicides molecules along or in combination with different herbicides as well as other management practices.

Weed control studies in carrot (*Daucus carota* L.)

by

Mannu Ram Netam

ABSTRACT

The present experiment was conduct at Research Farm, Department of Horticulture, IGAU, Raipur (C.G.) during winter season (November to January) of 2004-05 to find out the effect of weed management practices on growth, yield and economics of carrot as well as efficiency of selected herbicides against the weed population occurring in carrot. The experiment was laid out in randomized block design which four replications. The treatments comprised on ten weed management practices viz., Pendimethalin @ 1.0 kg ha^{-1} PE (T_1), Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) Oxyflourfen @ 0.2 kg ha^{-1} PE (T_3) Oxyflourfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI (T_5), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS, (T_6) Metribuzin @ 250 g ha^{-1} (T_7) Metribuzin @ 250 g ha^{-1} PE + 1 H.W. at 30 DAS (T_8), hand weeding twice at 25-40 DAS (T_9) and weedy check (T_{10}). Carrot variety “Pusa kesar” was grown as a test crop. Carrot was sown on 11th November, 2004 with a spacing of 40 cm x 10 cm. The crop was fertilized with 75:50:75 $N:P_2O_5:K_2O$ kg ha^{-1}.

The findings of this experiment revealed that various growth and yield attributes like plant height, number of leaves plant-1, root length, shoot length, fresh and dry weight of shoots and roots, root diameter, root : shoot ratio were significantly highest in hand weeding twice at 20 and 40 DAS, though it was at par with treatments involving herbicide alongwith hand weeding at 30 DAS i.e. Pendimethalin @ 1.0 kg ha^{-1} PE +1 HW at 30 DAS (T_2), Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS (T_4), Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS (T_6) and Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS (T_8).

Weed control efficiency was found maximum under hand weeding twice at 25 and 40 DAS. Subsequently higher weed control efficiency was also noted in treatments involving integration of herbicides and hand weeding operations.

The results indicated that the highest gross return (Rs. 1,82,640 ha^{-1}), net return (Rs.1,54,589 ha^{-1}) and benefit : cost ratio (Rs.5.51) was obtained under HW twice at 25 and 40 DAS (T_9), closely followed by Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS (T_2) with gross return, net return and benefit : cost ratio of Rs.1,75,280 ha^{-1}, Rs.1,47,098 ha^{-1} and 5.22, respectively.

On the basis of one year investigation, the farmers can opt for two hand weeding at 25 and 40 DAS or can apply Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS to enhance the productivity and profitability of carrot in Chhattisgarh plains. The above weed management practices not only gave maximum weed control efficiency but also fetched highest benefit : cost ratio.

Department of Horticulture
College of Agriculture
Raipur (C.G.)

(Dr. D.A. Sarnaik)
Major Advisor

REFERENCES

Anonymous, 2005. The Hindu Survey of Indian Agriculture.

Bell, C.E., Boutwell, B.E., Ogbuchiekwe, E.J. and Mc Giffen, M.E., Jr. 2000. Weed control in carrots .The efficacy and economic value of linuron. *Hort. Science* 35 (6) : 1089-1091.

Bellinder, R.R., Kirkwyland, J.J. and Wallace, R.W. 1997. Carrot (*Daucus carota*) and weed response to linuron and metribuzin applied at different crop stages. *Weed Technology* 11 (2) : 235-240.

Benoit, D.L., Cloutier, D. and Recasens J. 1995. Alternative methods for control of weeds : mechanical weeders and techniques of evaluation.*In: Pro. of the 1995, Congress of the Spanish Weed Science Society*, Huesca Spain. 14-16 November 1995; 27-36.

Black C.A 1965. Method of soil analysis Amar.Agcon.Inc. Madeson, Wisconsin, USA.pp.131-137.

Chanda, S., Chattopadhyay, P.K. and Bhattacharya, S.P. 1994. Herbicidal effect in preventing weeds in spring summer tomato. *Haryana J. Hort. Sci*. 23(2) : 144-148.

Choudhary, J.K. and Pathak, A.K. 1992. Chemical control of wood sorrel (*Oxalis martiana* [*O. carymbosa*]) in crop and non-crop situation. *Indian J. Agronomy*37(3) : 537-540.

Choudhary, B. 1990. Vegetable, *National Book Trust, India*, A-5 Green Park, New Delhi – 110016.

Farag, I.A., Hussein, H.A. and Farghali, M.A. 1994. Effect of chemical weed control on growth of weeds, yield and quality of carrot. *Assurt J. Agric. Sci*. 25 : 1-2.

Fiveland, T.J. 1972 .Chemical control of weed in carrot (1966-68). Foorskmed kjemiske midler moturgas igulrot (1966-68). *Fonsking or Forsk I Land, Druket*; 23:(2).

Fogelberg, F. 1999. Night time soil cultivation and intra row rush weeding for weed control in carrots (*Daucus carota* L.). *Biological Agriculture and Horticulture* 17(1) : 31-45.

Gomez, K.A. and Gomez, A.A 1984. Statistical procedures for agricultural research. *A Willy Inter. Sci. Publication*. John Wiley and Sons, New York.

Iskenderov, A.A. and Volvodin, A.V. 1983. Promising herbicides for seed carrot. *Kartofel. i. ovoshchi* (5) : 19.

Jackson, M.L 1967. Soil chemical analysis. *Prentice Hall of India Pvt. Ltd*, New Delhi.

Jadhao, B.J., Patil, B.M., Karunakar, A.P., Joshi, P.S. and Mohorkar, V.K. 2001. Chemical weed control in seed crop of radish (*Raphanus sativus* L*.). Veg. Sci.* 26 : 2, 190-191; 3 ref.

Kumar, P., Tewatia, A.S., Balyan, R.S. and Nehra, B.K. 2001. Weed control studies in carrot. *Haryana J. Hort. Sci.,* 30 (1-2) : 116-120.

Leal, N.R., Barbosa, J.V.A, Pinheiro , F.F.M, Coelho, R.G and Araume, A., 1973. The effect of certain herbicide on weeds in carrot. *Efeitos dealgums herbicide on control deplont in Varoras macultura daconoura Revistaceres* 20(112); 460-464.

Leela, D. 1982. A decade of weed research in horticultural crops. *Pesticides,* 15 (10) : 3-8.

Malidza, G., Glusac, D.and Takac, A. 1997. Phyto pharmacological value of herbicides in carrot production. *Acta Horticulturae* (462) : 549-552.

Malik, Y.S., Singh, K.P. and Pandita, M.L. 1982. Chemical weed control in onion (*Allium cepa* L.). *Indian J. Weed Sci*. 14 : 24-27.

Marenco, R.A. and Lustosa, D.C. 2000. Soil solarization for weed control in carrot. *Penquisa. Agropecuaria Brasileira* 35 (10) : 2025-3032.

Meena, R. 2004. Weed management in brinjal variety Mukta Keshi. *M.Sc. (Ag.) Thesis*, IGAU, Raipur.pp.59-81.

Nandal, T.R. and Pandita, M.L. 1988. Chemical weed control in brinjal (*Solanum melongena* L.). *Indian J. Weed Sci*. 20(3) : 55-59.

Olsen, S.R 1954. Estimation of available phosphorous in soil by extraction with sodium bi carbonate.USDA.Circ.No.939.pp 1-19.

Piper, C.S. 1967. Soil and Plant analysis. The University of Adelaide, Astralia,pp.186.

Popov, G.V. 2000. Peculiarities of herbicides use in the delta of Volga. *Zashchita, I. Karantin Rastinii*. (3) : 25.

Prasad, R.K. and Singh, K.P. 1988. A note on the chemical weed control in onion. *Haryana J. Hort. Sci*. 17(3-4) : 282-284.

Quaglitti, L. and Tosi, C. 1968. Esperienza triennale di diserbo chemicodella carota (*Daucus carota* L). A three years experiment on chemical weed control in carrot. *Ann Fac Sci. agror Tarino*.1966-67/1967-68; 4:375-408.

Raghav, M. 1995. Weed management studies in *kharif* brinjal. *Vegetable Science* 22(2) : 90-91.

Raghav, M., Abidi, A.B., Singh, A. and Shrivastava, S., 1987. Chemical weed control in onion. *Science and Culture* 53 : 53-55.

Ram, B., Singh, V.P. and Singh, J.P. 1994. Weed management in *kharif* tomato in low hill/ valley region of U.P. hills. *Vegetable Science* 21(1) : 20-22.

Rapparini, G.and Ballasso, G. 1977. Comparison of products applied to spring sown carrots at various stages of the crop. *Atti : Stato Attuale della lotta alle malerbe nelle culture. Arboree orto floricole-e-cerealicole Bologa*. 1977. 191-195.

Roberts, H.A. and Bond W. 1982. Evaluation of N252 for weed control in drilled vegetable crops. *Annals of Applied Biology*. 100 Supplement, Tests of Agrochemicals and Cultivars (3) : 70-71.

Sandhu, S.K., Singh, D., Sandhu, M.S. and Singh, J. 2001. Studies on weed management through use of herbicides in seed crop of carrot. *Veg. Sci*. 28 (1) : 70-71.

Sharma, R.K. and Bhagchandani, P.M. 1979. Chemical weed control in carrot (*Daucus carota* L*.). Vegetable Science* 6 (1) : 1-4.

Singh, B. 1994. Weed control studies in tomato. *Vegetable Science* 21(1) : 26-28.

Singh, K.P. and Malik, Y.S. 1983. Chemical weed control in carrot seed crop. *Indian J. of Weed Sci.* 15 (1) : 12-16.

Singh, K.P., Malik, Y.S., Thakral, K.K. and Lal, S. 1982. Chemical weed control in brinjal seed crop (*Solanum melongena* L.). *In*: Abstracts of papers, Annual conference of Indian Soc. of Weed Sci. pp.39.

Singh, S., Saimbhi, M.S. and Singh, D. 1996. Weed management in brinjal. *Haryana J. Hort. Sci*. 25 (1) : 51-54.

Singh, V., Bisen, R.K. and Agrawal, H.P. 1997. A note on weed control studies in Brinjal. *Vegetable Science* 24(2) : 162-163.

Subbiah, B.V. and Asija, G.L. 1956. A rapid method for the estimation of nitrogen in soils. *Curr. Sci*. 26 : 259-260.

Tag, E.L., Din, A.T.F., Soliman, F.S. and Al. Harbi, A. 1997. Effects of chemical weed control or root yield and quality of carrots (*Daucus carota* L.) *Journal of King Saud Uni. Agri. Sci*. 9 : 163-175.

Yogaratnam, V., Balasubramaniam, E.M. and Perera, W.G.S. 1982. Chemical weed control in carrots in the up country wet zone. *Tropical Agriculturist* (138) : 81-91.

Zagonel, J., Reghin, M.Y.and Venancio, W.S. 1999.Post emergence weed control in carrot crop. *Horticultura Brasi leira* 17 (1) : 69-71.

Appendix II : Fixed cost of cultivation of carrot ha^{-1}

S. No.	Particulars	Inputs	Rate (Rs.)	Total cost (Rs.)
1.	Land preparation			
a.	Deep ploughing	1 Tractor 3 hrs	190.00 hr^{-1}	570.00
b.	Harrowing (twice)	1 tractor 4 hrs	190.00 hr^{-1}	760.00
c.	Rotavating	1 tractor 1 hrs	190.00 hr^{-1}	190.00
d.	Leveling (once)	1 tractor 0.5 hrs	190.00 hr^{-1}	97.40
2.	Fertilizer application			
a.	FYM	20 t ha^{-1}	Rs.500.00 t^{-1}	10000.00
b.	Urea	162.75 kg ha^{-1}	Rs.5.06 kg^{-1}	823.51
c.	MOP	83.00 kg ha^{-1}	Rs.6.66 kg^{-1}	552.78
d.	SSP	468.75 kg ha^{-1}	Rs.3.00 kg^{-1}	1406.25
3.	Seed	6 kg ha^{-1}	180.00 kg^{-1}	1080.00
	Sowing	15 men day^{-1} ha^{-1}	72.40 man^{-1} day^{-1}	1056.00
4.	Irrigation	10 irrigation	450.00 ha^{-1}	450.00
5.	Harvesting	20 men day^{-1} ha^{-1}	72.40 man^{-1} day^{-1}	1408.00
6.	Land revenue	500.00 ha^{-1}	Rs. 500	500.00
A.	Common cost			22941.54
B.	Miscellaneous @ 10% of common cost			2294.15
	Grand total (A+B)			25235.69

Appendix III : Total cost of cultivation of carrot ha^{-1}

Weed management practices	Variable cost (Rs. ha^{-1})	Fixed cost (Rs. ha^{-1})	Total cost (Rs. ha^{-1})
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	1539.86	25235.65	26775.51
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	2947.00	25235.65	28182.65
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	1620.74	25235.65	26856.39
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	3028.00	25235.65	28263.65
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	1520.00	25235.65	26755.65
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	2928.00	25235.65	28163.65
T_7 : Metribuzin @ 250 g ha^{-1} PE	182.80	25235.65	25418.45
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	1590.80	25235.65	26826.45
T_9 : HW twice at 25 and 40 DAS	2816.00	25235.65	28051.65
T_{10} : Weedy check		25235.65	25235.65

Appendix IV : Variable cost of cultivation of carrot ha^{-1}

Tr. No.	Particulars	Inputs	Rate (Rs.)	Total cost (Rs. ha^{-1})
	Pendimethalin	@ 1.0 kg ha^{-1} PE	1399.86	26775.55
		2 man for spraying ha^{-1}	70.40	
	Pendimethalin	@ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	1399.86	28182.69
		2 man for spraying ha^{-1} + 20 man for HW ha^{-1}	70.40	
	Oxyfluorfen	@ 0.2 kg ha^{-1} PE	1480.74	26856.43
		2 man for spraying ha^{-1}	70.40	
	Oxyfluorfen	@ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	1480.74	28263.69
		2 man for spraying ha^{-1} + 20 man for HW ha^{-1}	70.40	
	Fluchloralin	@ 1.0 kg ha^{-1} PPI	1380.00	26755.69
		2 man for spraying ha^{-1}	70.40	
	Fluchloralin	@ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	1380.00	28163.89
		2 man for spraying ha^{-1} + 20 man for HW ha^{-1}	70.40	
	Metribuzin	@ 250 g ha^{-1} PE	42.80	25418.19
		2 man for spraying ha^{-1}	70.40	
	Metribuzin	@ 250 g ha^{-1} PE + 1 HW at 30 DAS	42.80	26825.91
		2 man for spraying ha^{-1} + 20 man for HW ha^{-1}	70.40	
	HW twice at 25 &40 DAS	20 man for HW ha^{-1}	70.40	28051.69
	Weedy check		-	25235.69

Table 4.1: Plant height of carrot at different growth stages as influenced by weed management practices

Weed management practices	Plant height (cm)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	34.8	42.9	58.5	60.7
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	35.2	46.5	60.1	61.4
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	33.2	42.5	48.9	51.0
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	38.8	48.2	57.8	62.5
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	37.2	47.1	55.4	57.5
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	39.5	51.1	63.2	64.2
T_7 : Metribuzin @ 250 g ha^{-1} PE	41.6	50.6	53.9	58.9
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	39.7	52.8	55.2	57.2
T_9 : HW twice at 25 and 40 DAS	46.2	58.9	67.9	75.7
T_{10} : Weedy check	28.3	33.6	38.5	46.3
SEm±	**1.41**	**1.80**	**3.47**	**1.85**
CD (p=0.05)	**4.11**	**5.23**	**10.10**	**5.38**

Table 4.2 : Root length of carrot at different growth stages as influenced by weed management practices

Weed management practices	Root length (cm)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	18.1	22.0	22.6	22.8
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	18.8	19.8	21.3	21.9
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	15.2	16.2	16.6	21.8
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	18.7	19.3	23.0	23.1
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	15.7	17.9	21.3	21.7
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	15.9	20.0	22.7	23.5
T_7 : Metribuzin @ 250 g ha^{-1} PE	14.9	17.8	18.5	22.4
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	15.0	19.4	19.8	21.4
T_9 : HW twice at 25 and 40 DAS	20.8	22.7	23.6	23.7
T_{10} : Weedy check	14.9	15.9	16.6	21.4
SEm±	**0.51**	**1.30**	**1.17**	**1.61**
CD (p=0.05)	**1.50**	**3.78**	**NS**	**4.80**

Table 4.3 : Number of leaves per plant of carrot at different growth stages as influenced by weed management practices

Weed management practices	Leaves plant^{-1} (No.)			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	5.7	7.7	11.7	12.7
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	7.8	9.8	13.8	14.8
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	5.8	7.5	11.8	12.8
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	6.9	8.9	13.0	13.9
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	7.0	9.1	13.1	14.1
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	5.8	7.8	11.8	12.8
T_7 : Metribuzin @ 250 g ha^{-1} PE	6.8	8.8	12.8	13.8
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	7.1	9.0	13.0	14.0
T_9 : HW twice at 25 and 40 DAS	8.4	10.4	14.4	15.1
T_{10} : Weedy check	5.1	7.1	10.9	12.1
SEm±	**0.55**	**0.55**	**0.5**	**0.57**
CD (p=0.05)	**1.62**	**1.60**	**1.62**	**1.66**

Table 4.4 : Fresh weight of leaves of carrot at different growth stages as influenced by weed management practices

Weed management practices	Fresh weight of leaves $plant^{-1}$ (g)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	28.2	59.2	89.3	173.9
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	21.9	73.8	91.1	160.8
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	23.7	71.1	95.7	209.5
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	17.4	72.0	87.6	120.7
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	24.6	47.7	89.7	208.0
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	19.2	55.6	100.9	110.8
T_7 : Metribuzin @ 250 g ha^{-1} PE	23.4	39.0	99.0	186.5
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	30.8	52.1	101.7	232.1
T_9 : HW twice at 25 and 40 DAS	30.2	63.8	115.1	233.7
T_{10} : Weedy check	13.3	116.7	71.3	89.2
SEm±	**10.6**	**21.2**	**5.63**	**29.68**
CD (p=0.05)	**NS**	**NS**	**19.35**	**86.13**

Table 4.5 : Dry weight of leaves of carrot at different growth stages as influenced by weed management practices

Weed management practices	Dry weight of leaves plant^{-1} (g)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	3.4	10.4	27.3	20.9
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	2.2	10.9	28.4	34.4
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	2.0	9.5	25.8	33.5
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	3.1	6.2	25.6	29.4
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	3.0	6.3	26.0	27.7
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	2.3	6.0	28.9	38.9
T_7 : Metribuzin @ 250 g ha^{-1} PE	3.0	5.4	34.0	37.2
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	2.7	7.8	40.2	47.9
T_9 : HW twice at 25 and 40 DAS	3.6	1.3	43.1	53.5
T_{10} : Weedy check	2.6	0.5	9.3	18.1
SEm±	**0.68**	**0.26**	**5.80**	**6.06**
CD (p=0.05)	**NS**	**NS**	**16.85**	**NS**

Table 4.6 : Fresh weight of root of carrot at different growth stages as influenced by weed management practices

Weed management practices	Fresh weight of root plant^{-1} (g)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	10.1	25.6	29.6	59.3
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	10.1	32.6	36.6	61.1
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	7.6	26.0	30.0	65.5
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	8.2	35.9	39.9	57.6
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	9.6	19.2	23.2	59.7
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	7.8	22.2	26.2	70.9
T_7 : Metribuzin @ 250 g ha^{-1} PE	6.1	19.2	23.2	69.0
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	8.3	22.9	26.9	71.7
T_9 : HW twice at 25 and 40 DAS	10.7	37.7	40.7	85.1
T_{10} : Weedy check	5.7	19.9	23.9	41.3
SEm±	**2.70**	**4.15**	**3.87**	**5.63**
CD (p=0.05)	**NS**	**12.05**	**11.23**	**16.34**

Table 4.7 : Dry weight of roots of carrot at different growth stages as influenced by weed management practices

Weed management practices	Dry weight of root $plant^{-1}$ (g)			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	1.1	3.4	7.0	8.0
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	1.1	3.4	8.3	7.4
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	1.2	2.6	8.2	9.1
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	2.3	3.5	8.6	10.5
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	1.3	3.6	9.0	9.7
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	1.4	4.9	10.4	7.0
T_7 : Metribuzin @ 250 g ha^{-1} PE	1.1	4.9	7.8	9.0
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	1.6	3.9	12.7	9.5
T_9 : HW twice at 25 and 40 DAS	3.4	5.7	14.8	10.6
T_{10} : Weedy check	1.0	3.2	7.0	7.6
SEm±	**0.30**	**0.29**	**1.06**	**1.52**
CD (p=0.05)	**0.88**	**0.87**	**3.09**	**NS**

Table 4.8 : Diameter of root of carrot at different growth stages as influenced by weed management practices

Weed management practices	Diameter of root plant^{-1} (cm)			
	30 DAS	**45 DAS**	**60 DAS**	**At harvest**
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	1.3	1.8	4.0	2.7
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	1.3	1.8	3.4	3.4
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	1.1	1.6	3.5	3.1
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	0.9	2.0	3.3	4.3
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	1.4	1.9	3.9	3.5
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	1.0	1.6	4.2	3.1
T_7 : Metribuzin @ 250 g ha^{-1} PE	1.3	1.5	2.9	3.3
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	0.9	1.4	3.9	4.1
T_9 : HW twice at 25 and 40 DAS	2.7	2.7	4.4	4.8
T_{10} : Weedy check	0.7	0.7	2.4	1.6
SEm±	**0.47**	**0.50**	**0.39**	**0.59**
CD (p=0.05)	**NS**	**NS**	**1.14**	**NS**

Table 4.9 : Root:shoot ratio in carrot at different growth stages as influenced by weed management practices

Weed management practices	Root shoot ratio			
	30 DAS	45 DAS	60 DAS	At harvest
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	2.5	2.3	3.5	3.0
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	2.2	2.3	2.4	2.4
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	3.0	1.8	2.8	2.4
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	2.3	2.1	2.3	2.0
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	2.6	2.1	4.3	3.4
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	2.5	2.4	3.8	2.8
T_7 : Metribuzin @ 250 g ha^{-1} PE	3.7	2.2	3.3	2.7
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	3.1	2.1	4.5	2.1
T_9 : HW twice at 25 and 40 DAS	2.9	2.4	5.8	2.1
T_{10} : Weedy check	3.8	2.6	2.3	3.6
SEm±	**0.54**	**0.36**	**0.69**	**0.49**
CD (p=0.05)	**NS**	**NS**	**2.0**	**NS**

Table 4.10 : Root yield of carrot as influenced by different weed management practices

Weed management practices	Root yield (t ha^{-1})	
	Marketable	Unmarketable
T_1:Pendimethalin @ 1.0 kg ha^{-1} PE	15.3	2.5
T_2:Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	16.8	4.3
T_3:Oxyfluorfen @ 0.2 kg ha^{-1} PE	14.2	3.0
T_4:Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	14.5	3.2
T_5:Fluchloralin @ 1.0 kg ha^{-1} PPI	13.9	3.9
T_6:Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	15.9	3.6
T_7:Metribuzin @ 250 g ha^{-1} PE	13.6	3.8
T_8:Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	16.0	2.9
T_9:HW twice at 25 and 40 DAS	17.2	2.8
T_{10}:Weedy check	6.6	4.6
SEm±	**0.81**	**0.55**
CD (p=0.05)	**2.36**	**NS**

Table 4.11 : Root and shoot yield and harvest index of carrot as influenced by different weed management practices

Weed management practices	Yield ($t\ ha^{-1}$)		Harvest index (%)
	Root (marketable & unmarketable)	Shoot	
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	17.8	54.8	33.6
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	21.9	53.0	39.1
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	17.2	47.9	35.9
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	17.5	58.3	30.4
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	17.7	53.7	32.9
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	19.5	54.1	39.8
T_7 : Metribuzin @ 250 g ha^{-1} PE	16.8	58.4	33.3
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	19.5	54.6	32.1
T_9 : HW twice at 25 and 40 DAS	22.8	67.7	32.7
T_{10} : Weedy check	10.8	32.4	33.8
SEm±	**1.50**	**3.41**	**2.12**
CD (p=0.05)	**4.37**	**9.92**	**NS**

Table 4.14 : Effect of different weed management practices on weed control efficiency

Weed management practices	Weed control efficiency		
	30 DAS	45 DAS	60 DAS
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	65.28	81.76	85.43
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	88.51	33.00	93.22
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	62.99	83.32	80.11
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	89.35	34.74	93.96
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	64.68	80.27	80.60
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	93.70	94.38	94.08
T_7 : Metribuzin @ 250 g ha^{-1} PE	62.61	73.84	80.16
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	90.58	93.48	94.06
T_9 : HW twice at 25 and 40 DAS	95.57	97.93	95.73
T_{10} : Weedy check	-	-	-

Table 4.15 : Economics of carrot as influenced by different weed management practices

Weed management practices	Cost of production (Rs. ha^{-1})	Yield (t ha^{-1})	Gross profit (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	Cost : benefit ratio
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	26775	17.85	142800	116025	4.33
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	28182	21.91	175280	147098	5.22
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	26856	17.25	138000	111144	4.14
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	28263	17.54	140320	112057	3.96
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	26755	17.70	141600	114845	4.29
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	28163	19.58	156640	128477	4.56
T_7 : Metribuzin @ 250 g ha^{-1} PE	25418	16.81	134480	109062	4.29
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	26825	19.50	156000	129175	4.82
T_9 : HW twice at 25 and 40 DAS	28051	22.83	182640	154589	5.51
T_{10} : Weedy check	25235	10.87	86960	61725	2.45

Table 4.12(a) : Weed density at 30 DAS as influenced by weed management practices in carrot

Weed management practices	*Parthenium hysterophorus*	*Euphorbia macrophyllae*	*Melilotus indica*	*Physalis minima*	*Convolvulus arvensis*	*Chenopodium album*
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	3.7 (2.00)	3.6 (2.00)	3.9 (2.00)	7.3 (2.76)	2.0 (1.58)	2.0 (1.57)
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	1.5 (1.60)	1.0 (1.20)	1.5 (1.40)	2.8 (1.82)	1.3 (1.01)	1.3 (1.30)
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	6.4 (2.60)	4.9 (2.32)	5.9 (2.50)	7.6 (2.82)	2.0 (1.53)	5.9 (2.49)
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	1.2 (1.30)	1.2 (1.30)	1.6 (1.40)	2.7 (1.78)	1.0 (1.08)	2.0 (1.31)
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	6.2 (2.50)	6.0 (2.53)	8.4 (2.90)	8.9 (3.04)	1.5 (1.38)	6.0 (2.54)
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	1.5 (1.40)	1.1 (1.28)	1.8 (1.50)	2.4 (1.69)	1.0 (1.08)	1.3 (1.33)
T_7 : Metribuzin @ 250 g ha^{-1} PE	7.1 (2.70)	6.8 (2.60)	7.8 (2.86)	7.9 (2.86)	1.8 (1.50)	4.9 (2.33)
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	1.5 (1.40)	1.3 (1.30)	2.5 (1.70)	2.9 (1.81)	1.3 (1.01)	1.4 (1.36)
T_9 : HW twice at 25 and 40 DAS	1.7 (1.40)	2.3 (1.60)	3.2 (1.90)	5.3 (2.27)	2.2 (1.39)	3.0 (1.87)
T_{10}: Weedy check	1.0 (3.29)	12.0 (3.50)	19.4 (4.40)	15.4 (3.97)	3.3 (1.92)	8.5 (2.93)
SEm±	**0.19**	**0.12**	**0.12**	**0.16**	**0.18**	**0.21**
CD (p=0.05)	**0.57**	**0.37**	**0.37**	**0.47**	**0.54**	**0.62**

Figures in parentheses indicates the original value

Table 4.12(b) : Weed density at 45 DAS as influenced by weed management practices in carrot

Weed management practices	*Parthenium hysterophorus*	*Euphorbia macrophyllae*	*Melilotus indica*	*Physalis minima*	*Convolvulus arvensis*	*Chenopodium album*
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	10.7 (3.34)	3.5 (1.99)	5.6 (2.45)	8.5 (2.98)	1.5 (1.27)	2.8 (1.79)
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	2.9 (1.84)	1.4 (1.32)	2.7 (1.75)	2.3 (1.65)	0.3 (0.80)	1.4 (1.25)
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	11.7 (3.47)	2.5 (1.75)	6.9 (2.70)	7.6 (2.84)	1.3 (1.25)	2.9 (1.83)
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	3.5 (1.98)	1.2 (1.19)	2.6 (1.50)	2.5 (1.72)	1.7 (1.27)	0.8 (0.99)
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	8.1 (2.82)	6.8 (2.68)	6.3 (2.54)	8.9 (3.04)	2.0 (1.51)	1.4 (1.34)
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	2.4 (1.69)	2.1 (1.60)	1.7 (1.46)	2.4 (1.69)	1.4 (1.25)	1.0 (1.15)
T_7 : Metribuzin @ 250 g ha^{-1} PE	10.1 (3.19)	4.1 (2.13)	6.6 (2.61)	7.9 (2.86)	1.3 (1.23)	4.2 (2.00)
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	3.7 (2.01)	1.0 (1.19)	2.2 (1.65)	2.3 (1.68)	1.6 (0.92)	1.8 (1.49)
T_9 : HW twice at 25 and 40 DAS	1.9 (1.53)	0.5 (0.96)	0.9 (1.12)	4.8 (2.27)	0.5 (0.70)	0.8 (1.05)
T_{10}: Weedy check	21.7 (4.67)	9.5 (3.15)	13.4 (3.71)	14.6 (3.88)	1.1 (1.23)	10.5 (3.26)
SEm±	**0.23**	**0.18**	**0.21**	**0.15**	**0.24**	**0.27**
CD (p=0.05)	**0.69**	**0.54**	**0.62**	**0.46**	**NS**	**0.79**

Figures in parentheses indicates the original value

Table 4.12(c) : Weed density at 60 DAS as influenced by weed management practices in carrot

Weed management practices	*Parthenium hysterophorus*	*Euphorbia macrophyllae*	*Melilotus indica*	*Physalis minima*	*Convolvulus arvensis*	*Chenopodium album*
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	5.6 (2.39)	2.4 (1.67)	2.9 (1.83)	2.9 (1.85)	0.6 (0.99)	1.5 (1.35)
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	3.3 (1.95)	1.7 (1.49)	1.5 (1.40)	1.3 (1.33)	0.0 (1.00)	1.8 (1.44)
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	4.8 (2.27)	3.2 (1.93)	1.7 (1.32)	1.8 (1.43)	1.2 (1.27)	1.0 (1.14)
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	2.2 (1.65)	1.1 (1.14)	1.8 (1.57)	1.7 (1.41)	0.5 (0.96)	1.1 (1.17)
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	6.2 (2.55)	3.0 (1.83)	2.6 (1.66)	3.0 (1.87)	2.6 (1.75)	1.9 (1.54)
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	1.7 (1.49)	2.0 (1.14)	1.8 (1.46)	1.6 (1.38)	1.0 (1.14)	1.3 (1.23)
T_7 : Metribuzin @ 250 g ha^{-1} PE	5.2 (2.34)	2.2 (1.51)	1.8 (1.41)	4.2 (2.16)	1.2 (1.27)	3.2 (1.88)
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	1.7 (1.46)	2.3 (1.64)	1.4 (1.36)	1.4 (1.38)	0.0 (1.00)	3.1 (1.16)
T_9 : HW twice at 25 and 40 DAS	0.6 (1.01)	1.3 (1.21)	0.5 (0.92)	0.6 (0.98)	1.0 (1.19)	0.4 (0.88)
T_{10}: Weedy check	10.8 (3.35)	7.5 (2.82)	11.9 (3.61)	6.4 (2.57)	2.3 (1.66)	3.5 (1.96)
SEm±	**0.18**	**0.21**	**0.23**	**0.18**	**0.16**	**0.24**
CD (p=0.05)	**0.55**	**0.61**	**0.68**	**0.55**	**0.48**	**NS**

Figures in parentheses indicates the original value

Table 4.13 : Dry matter production of total weeds as influenced by different weed management practices in carrot

Weed management practices	Dry matter production (g m^{-2})		
	30 DAS	**45 DAS**	**60 DAS**
T_1 : Pendimethalin @ 1.0 kg ha^{-1} PE	36.9 (6.09)	38.6 (6.09)	29.5 (5.46)
T_2 : Pendimethalin @ 1.0 kg ha^{-1} PE + 1 HW at 30 DAS	12.2 (3.56)	12.0 (3.52)	13.7 (3.75)
T_3 : Oxyfluorfen @ 0.2 kg ha^{-1} PE	39.3 (6.30)	35.3 (5.89)	40.2 (6.37)
T_4 : Oxyfluorfen @ 0.2 kg ha^{-1} PE + 1 HW at 30 DAS	11.3 (3.43)	9.9 (3.18)	12.2 (3.57)
T_5 : Fluchloralin @ 1.0 kg ha^{-1} PPI	37.5 (6.16)	41.7 (6.40)	39.2 (6.29)
T_6 : Fluchloralin @ 1.0 kg ha^{-1} PPI + 1 HW at 30 DAS	7.0 (2.75)	11.9 (3.49)	12.0 (3.52)
T_7 : Metribuzin @ 250 g ha^{-1} PE	39.7 (6.33)	55.3 (7.43)	40.1 (6.35)
T_8 : Metribuzin @ 250 g ha^{-1} PE + 1 HW at 30 DAS	10.0 (3.24)	13.8 (3.76)	12.0 (3.52)
T_9 : HW twice at 25 and 40 DAS	4.7 (2.28)	4.4 (2.29)	8.6 (3.01)
T_{10} : Weedy check	106.2 (10.32)	211.4 (14.55)	202.2 (14.23)
SEm±	**0.13**	**0.31**	**0.16**
CD (p=0.05)	**0.39**	**0.91**	**0.48**

Figures in parentheses indicates the original value

Table 3.3 : Brief information of herbicides used in the experiment

Common name	Trade name	Structural formula	Group	Formulation	Manufacturer
Pendimethalin	Stomp	N-(1-ethylpropyl)-3,4 dimethyl-2,6 dinitro benzeneamine	Dinitroaniline	30% EC	Meghmani Industries Ltd, Ahmedabad
Fluchloralin	Basalin	N-propyl-N(2'chloroethyl) –2, 6 di nitro tri fluoroinethyl aniline	Dinitroanilne	45% EC	BASF India Ltd., Mumbai
Oxyflourafen	Goal	2-chloro-1(3-ethyoxy-4-nitro phenoxy)-4 (trifluor-methyl) benzene	Nitrophenyl ether	24% EC	Indofil chemical, Mumbai
Metribuzin	Sencor	4-amino-6 tert-butyl 3-(methyl-thio)-as-triazines 5 (4H) one	Triazines	75% EC	Bayer

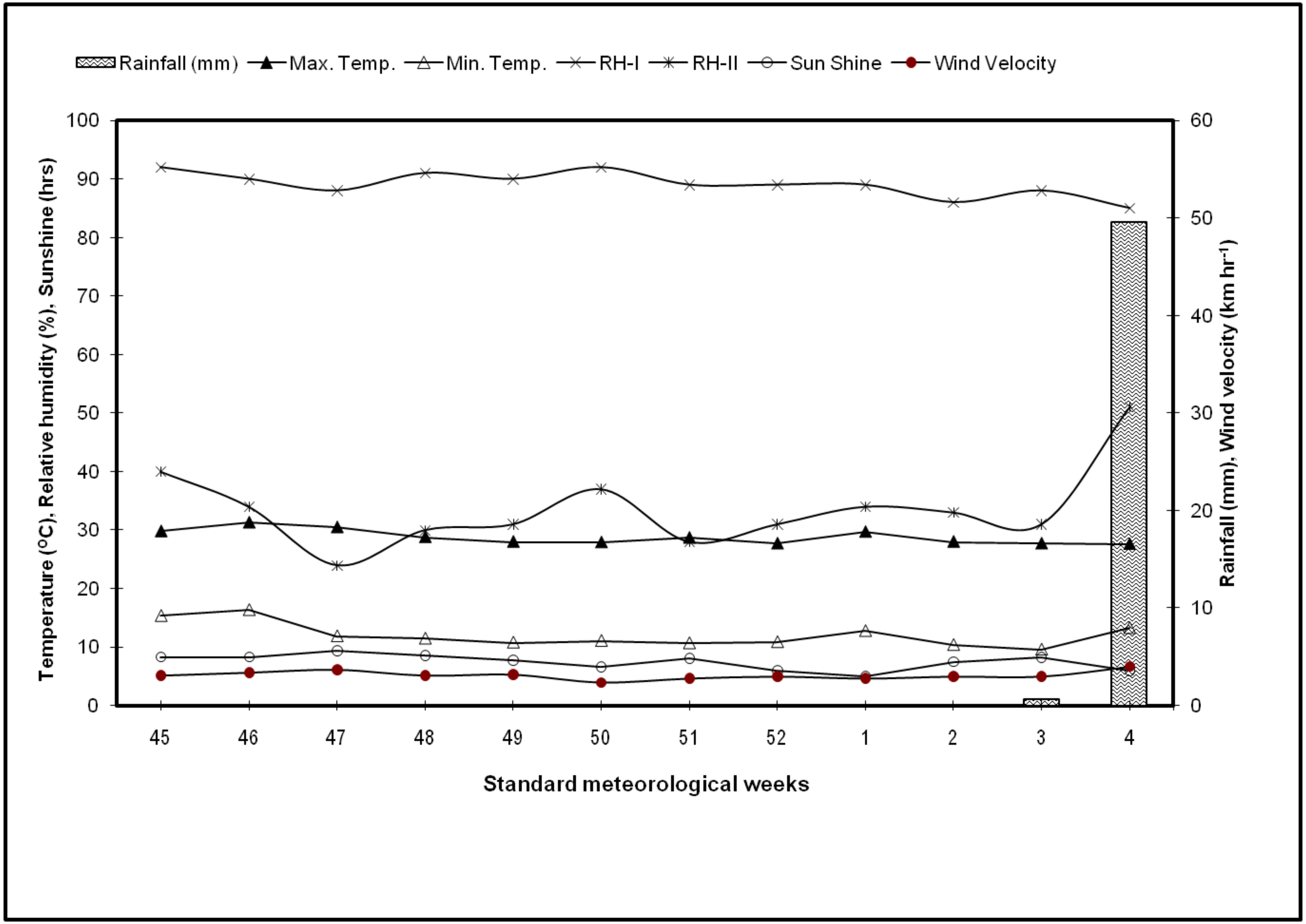

Fig. 3.1 : Weekly meteorological parameters during crop growth period (Nov. 10, 2004 to January 28, 2005)

Appendix I : Weekly meteorological data during crop growth period (Nov. 10, 2004 to Jan. 28, 2005)

Week No.	Date & month		Temperature (°C)		Rainfall (mm)	Relative Humidity		Wind Velocity (Kmph)	Evapo-ration (mm)	Sun Shine (hours)
			Max.	Min.		I	II			
45	Nov. 2004	05-11	29.8	15.4	0	92	40	2.2	3.1	8.3
46		12-18	31.3	16.4	0	90	34	2.3	3.4	8.3
47		19-25	30.5	11.9	0	88	24	2.1	3.7	9.4
48		26-02	28.8	11.5	0	91	30	2.2	3.1	8.6
49	Dec. 2004	03-09	28.0	10.8	0	90	31	2.2	3.2	7.8
50		10-16	27.9	11.1	0	92	37	1.9	2.4	6.6
51		17-23	28.7	10.7	0	89	28	1.8	2.8	8.1
52		24-31	27.7	10.9	0	89	31	2.3	3.0	6.0
1	Jan., 2005	01-07	29.7	12.8	0	89	34	2.2	2.8	5.0
2		08-14	28.0	10.4	0	86	33	2.5	3.0	7.5
3		15-21	27.7	9.6	0.6	88	31	2.1	3.0	8.2
4		22-28	27.6	13.3	49.6	85	51	4.0	3.4	6.0