

INTEGRATED WEED MANAGEMENT IN POTATO
(*Solanum tuberosum* L.)

VIDYADHAR KANNUR

DEPARTMENT OF AGRONOMY
UNIVERSITY OF AGRICULTURAL SCIENCES
DHARWAD - 580 005.

SEPTEMBER, 1996

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INTEGRATED WEED MANAGEMENT IN POTATO (*Solanum tuberosum* L.)

Thesis Submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements for the

Degree of

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IN
AGRONOMY

By
VIDYADHAR KANNUR

DEPARTMENT OF AGRONOMY,
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

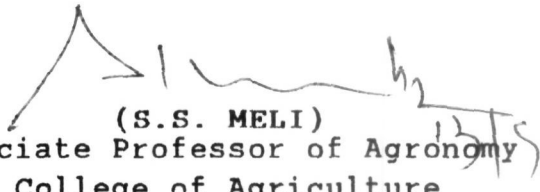
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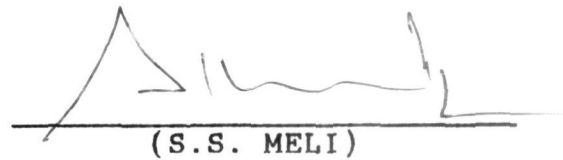
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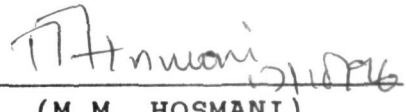

(S.S. MELI)
Associate Professor of Agronomy
College of Agriculture
U.A.S., Dharwad

Approved by :

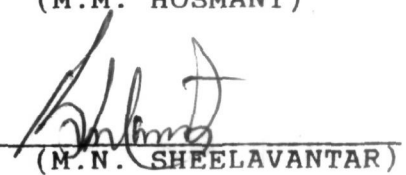
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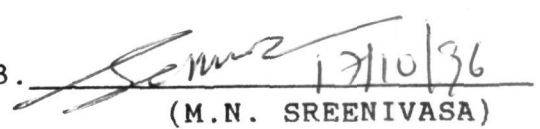
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2.


(M.N. SHEELAVANTAR)

3.


(M.N. SREENIVASA)

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INTRODUCTION

I INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the humanity's most valuable food crops, grown in most parts of the world. The original home of potato is Andean plateau of South America, and is believed to be introduced to India by Portuguese explorers in 17th century (Pushkarnath, 1976). It is popularly grown in most of the countries than any other crop except maize. Its volume of production ranks fourth in the world after rice, wheat and maize. The yield of edible energy and protein per ha per day by potato is at the top in the list of major world food crops. Potato tuber contains high quality protein, starch and substantial amount of essential vitamins, minerals and trace elements. Potato has earned the name as poor man's food in England, as it is known to produce more food and energy per ha when compared to cereals. In recent years the growth rate of potato production in the developing countries has exceeded to other food crops because of its higher production potential (75-85 t/ha) (Anderson and Hewgill, 1978).

In India potato occupies an area of 1.08 m.ha with the production of 18.0 m.tonnes with productivity of 15.8

tonnes per ha (Anon., 1995a). In Karnataka it occupies an area of 30,000 ha with the production of 4.5 lakh tonnes and productivity of 15 tonnes per ha, constituting about 2.8 per cent of the area under potato in the nation, which is concentrated mainly in Dharwad, Belgaum and Hassan districts (Anon., 1995b).

Potato yield depends on biogenetic potential of the variety and the cultural practices to which crop is subjected. For balanced plant development and to realise the yield potential of a cultivar, it should be grown under ideal environmental conditions. There are several constraints in potato production, of which weeds often pose a serious problem. They not only compete with the crop plants for nutrients, soil moisture, space and sunlight but also serve as alternate host for several insect pests and diseases. Wider spacing, frequent irrigations in the plains or rains in the hills or in *Kharif* potato growing areas, liberal use of manures and fertilizers provide favourable conditions for early germination and establishment of weeds well before the potato crop emergence. It creates growth margin in favour of weeds, thus resulting in lower yields. The yield reduction due to weeds in potato is estimated to be as high as 10 to 80

per cent under different agroclimatic conditions of India (Lal and Gupta, 1984).

Apart from these, potato crop infested with weeds requires extra labour for interculture and harvesting operations. The presence of weeds cause blockage of farm machinery at the time of earthing up and harvesting of the crop. Weeds also create problem in irrigation and drainage system of potato fields. Some weeds damage tubers by growing through them and resulting in deterioration of quality of tubers.

Hand weeding and hoeing are the common practices followed in India. However, timely weed control may not be possible manually due to non-availability of labourers and high rate of wages during peak period of farm operations. Chemical weed control proved to be economical and suitable alternative under these circumstances. In the integrated weed management, the weed infestation is reduced below the economic threshold by the judicious combination of all feasible means. The objective is to maintain the weed population well below the level that causes economic loss with adverse environmental effects. Keeping all these points in view the present investigation was initiated, with following objectives.

1. To study the efficacy of herbicides for controlling weeds in potato.
2. To compare the performance of herbicides with cultural methods of weed control.
3. To study the economics of weed control methods.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Literature pertaining to weed flora in potato, crop weed competition, management of weeds by chemical and cultural methods and their combinations, effect on growth and yield of potato and the economics of weed control is presented in this chapter.

2.1 Weed flora in potato

Srikant (1975) reported the important weed flora in potato from Dharwad namely *Cynodon dactylon*, *Elusina indica*, *Cyperus rotundus*, *Amaranthus viridis*, *Solanum nigrum*, *Hibiscus ponduriformis*, *Portulaca oleraceae*, *Lactuca runcinata* and *Tridax procumbense*.

Bhattacharya et al. (1989) from Kalyani (WB) reported the important weed flora in potato on sandy loams consisted of grasses; *Cynodon dactylon*, *Elusina indica*, *Echinochloa colonum*, sedges; *Cyperus rotundus*, *Fimbristylis miliacea* and broad leaved weeds; *Chenopodium album*, *Solanum nigrum*, *Amaranthus spinosus*, *Amaranthus viridis*, *Melilotus alba* and *Nicotina plumbaginifolia*. Similarly, Lal (1990) from Shillong reported that important weed species found in potato

field were *Digitaria adscedens*, *Setaria glauca* and *Echinochloa* sp. among the monocots and *Spergula arvensis*, *Oxalis corniculata*, *Polygonum alatum* and *Galinsoga purviflora* among the dicots.

Nadekar et al. (1990) noticed the important weed flora in potato were *Cynodon dactylon*, *Eleusine indica*, *Cyperus rotundus* among the grasses and broad leaved weeds like *Chenopodium album*, *Melilotus alba*, *Convolvulus arvensis*, *Portulaca oleracea*, *Ageratum conizyoids*, *Euphorbia hirta*, *Xanthium strumarium* and *Euphorbia geniculata*.

Thakral et al. (1990) noticed the most prevalent weed species on sandy loams (Hissar) associated with potato crop were *Trianthema portulacastrum*, *Chenopodium album*, *Chenopodium murale*, *Coronopus didymus* and *Amaranthus* spp. among the dicots and *Cyperus rotundus*, *Echinochloa crusgalli* and other grasses among the monocots.

According to Jaiswal (1994) at Jalandhar the predominant weed species present in potato field were *Chenopodium album*, *Rumex* spp., *Melilotus indica*, *Trianthema monogyne*, *Cyperus rotundus*, *Spergula arvensis*, *Anagallis arvensis*, *Veronica* sp. and *Chenopodium murale*.

2.2 Losses by weeds

Weeds cause losses and inconvenience to man in many ways and the attention is most often directed towards loss of crop yield. Reduction of potato yield estimated in various field experiments ranged from 10 to 80 per cent (Lal and Gupta, 1984). Yield loss in potato due to weeds occur in several ways, among them competition between potato plants and weeds for nutrients is the major contributing factor. Besides these competitive effects, weeds may release biochemical substances in the environment that adversely affect the growth and development of potato plants called allelopathy (Gupta *et al.*, 1987). Weeds also harbour insect pests and diseases of potato and provide ideal ecological conditions for their shelter and proliferation.

Tripathi *et al.* (1988) reported that on an average 64 to 70 per cent reduction in tuber yield due to uncontrolled weeds over weed free plots. Weeds offer severe competition to potato crop and cause marked reduction in tuber yield to the extent of 31.5 per cent (Jaiswal, 1994).

2.3 Crop weed competition

It is evident that weeds are adopted to rapid dissemination, faster growth and multiplication enabling them

to compete at every stage of crop growth for nutrients, moisture, light and space thus reduce the quality and quantity of the produce (Moolani and Sachan, 1966). The extent of yield reduction depends upon time duration and intensity of weed infestation.

2.3.1 Critical period of crop weed competition

The effect of competition of weeds on crop depends to a larger extent on the duration of competition. Crop plants particularly slow growing, shallow rooted and short statured during their early stages of growth are very much susceptible to weeds. Hence, elimination of competition by the weeds during this period would help the crop plants to grow better and consequently to yield better. Therefore, it is imperative that the critical period of crop weed competition need to be determined so as to obtain the maximum benefits from well defined weed management practices.

Bhan et al. (1971) noticed that 75 per cent of all weeds emerged during first 30 DAS. Hammerton (1974) reported that when weeds were allowed to grow upto 40 DAS they significantly reduced the yield. Singh (1982) indicated that weeding in potato should not be delayed four weeks of planting and delay in weeding will adversely affect the tuber yield.

The most critical period of crop weed competition in potato was from four to six weeks after planting (Thakral et al., 1985). Lal and Jaiswal (1991) noticed that weed competition up to 35 to 55 DAP reduced the tuber yield greatly and stated that this period of crop growth was critical for crop weed competition.

✓ Jaiswal (1991) recorded maximum reduction in tuber yield with delayed weeding i.e. from 25 to 35 DAP, and concluded that this period was the most critical for crop weed competition. Maximum weed competition with potato was at 40 DAP and delay in weeding reduced the tuber yield (Maliwal and Shekhavat, 1991).

2.3.2 Growth and yield of potato

Weed competition has direct correlation with the crop yield reduction. Weeds thrive better than the crop plants, when left uncontrolled, weeds can grow taller than the crop plants and suppress the growth to a considerable extent.

Ramgopal and Mani (1969) reported that nutsedge suffered drastically in the weight of underground parts due to application of herbicides and hence increased the tuber yield of potato. Pandey and Ghai (1977) evaluated the methods of

control of nut sedge in potato and found that pre-emergence application of eptam recorded significantly higher potato yield over control, further stated that eptam reduced the number and weight of nuts.

Kamal Singh (1988) investigated the methods of weed control in potato and stated that increased tuber yield was associated with reduction in weed population and recorded on an average weeds decreased potato yield by 13.8 per cent over weed free plots.

Bhattacharya *et al.* (1989) recorded 37.3 and 34.3 per cent higher tuber yield with application of Goal @0.83 l/ha and Lasso @3.0 l/ha respectively over unweeded plots. And higher LAI of 2.89 and 2.75 were recorded in hand weeded twice and Goal treatments respectively.

Nadekar *et al.* (1990) evaluated the weed control methods indicated that application of fluchloralin @ 0.9 kg a.i./ha recorded highest tuber yield (260 q/ha). whereas, earthingup and handweeded treatments recorded maximum plant height (62.50 cm).

2.3.3 Competition for nutrient uptake

Yield losses in potato occur in several ways, of which competition between potato plants and weeds for

nutrients is the major contributing factor. According to Nankar and Singh (1982) the nutrient losses caused by weeds in the potato crop was amounted to 43.0, 8.0 and 49.0 N, P₂O₅ and K₂O kg per ha respectively and the nutrient uptake by the crop was inversely related to nutrient removal by the weeds.

Govind Krishnan and Singh (1985) recorded the nutrient losses caused by weeds in potato i.e., 21.0, 7.0 and 19.0 N, P₂O₅ and K₂O kg per ha respectively. Increased N, P₂O₅ and K₂O uptake by the crop with weed control practices over unweeded control (Nimje *et al.*, 1987).

Tripathi *et al.* (1988) quantified the nutrient losses caused by weeds in potato, which was 40.3, 7.6 N and P₂O₅ kg per ha respectively. Further reasoned out that increased removal of nitrogen and phosphorus by weeds in unweeded plots resulted in drastic reduction in potato yield owing to increased crop weed competition and consequently poor availability of nutrients to the potato crop.

Bhattacharya *et al.* (1989) reported that removal of nitrogen was higher by sedges than grasses or broad leaved weeds. Further stated that all the cultural and chemical weed control treatments exerted considerable check on nitrogen removal from soil over unweeded control.

Weed control treatments significantly increased the uptake of nitrogen and phosphorus by the crop (Maliwal and Shekavat, 1991).

Kamalsingh and Lal (1994) recorded on an average weed control treatments reduced 78, 68 and 77 per cent loss of N, P_2O_5 and K_2O , respectively.

2.4 Methods of weed management

Different methods used to manage weeds in potato have their own advantages and limitations. The selection of any method depends on its efficiency and economics. The different weed management methods followed in potato were as under.

2.4.1 Cultural methods

Different cultural weed management practices employed were hand weeding, hoeing by bullock drawn implements or by using power driven machines.

Naidu *et al.* (1977) reported that weed free environment maintained upto 45 days increased the yield and yield components over unweeded control in groundnut. Borgohain and Dutta (1977) noticed that application of alachlor

@ 2.0 kg a.i./ha was on par with two hand weeding at 30 and 45 DAP with respect to weed control and tuber yield.

Significant increase in tuber yield was recorded with earthing up practice (Tiwari *et al.*, 1988).

Nadekar *et al.* (1990) reported that one hand weeding supplemented with one earthing up recorded the highest tuber yield followed by fluchloralin @ 0.9 kg a.i./ha, further stated that increased number of tubers per plant was obtained in cultural methods than chemical methods of weed control.

Lal and Jaiswal (1993) noticed that application of alachlor @ 1.5 kg a.i./ha recorded on par yield with manual weeding and earthing up treatments.

2.4.2 Chemical weed control

Cultural method of weed control ignores early flushes of weeds during the emergence phase of potato crop. Labour shortage, wet weather, higher cost etc. make the manual weeding impossible. Herbicides hold a good promise for timely and effective weed control.

2.4.2.1 Fluchloralin

Effective weed control and increased tuber yield was achieved with pre-plant application of 0.5 kg fluchloralin per ha (Mani *et al.*, 1981).

Randhawa and Sandhu (1981) reported that application of fluchloralin @ 1.0 kg a.i./ha effectively controlled the weeds thus recorded higher tuber yield. Mehta et al. (1985) reported that application of fluchloralin @ 1.0 kg a.i./ha was better than that of 0.5 kg diuron and paraquat. Fluchloralin @ 0.7 to 1.0 kg a.i./ha was the most effective herbicide at most of the places tried under all India coordinated potato improvement project (Anon., 1987).

Tripathi et al. (1989) obtained effective weed control in potato with fluchloralin @ 0.72 kg a.i./ha.

2.4.2.2 Pendimethalin

Liquid and granular formulations of pendimethalin @ 0.75-1.5 kg/ha checked the weed population effectively (Husain and Ghosh, 1985).

Hooda (1985) reported that application of pendimethalin @ 1.0 kg/ha recorded similar yield to that with weed free treatment. Thakral et al. (1988) obtained higher tuber yield (252.6 q/ha) with application of pendimethalin @ 1.5 kg/ha and was found to be superior over hand weeded treatments.

Effective suppression of grassy weeds was obtained with pre-plant application of pendimethalin @ 1.0 kg/ha (Bhattacharya et al., 1989).

2.4.2.3 Alachlor

Application of alachlor @ 1.5 kg/ha was most effective for reducing weed growth in potato (Anon., 1975).

Nankar (1976) reported that application of alachlor @ 1.5 kg/ha effectively suppressed the growth of *Cyperus rotundus* at Jalandhar. Borgohain and Dutta (1977) reported that pre-emergence application of alachlor @ 2.0 kg/ha was as good as hand weeding for controlling weeds.

Verma and Grewal (1980) observed that pre-emergence application of alachlor @ 1.25 kg/ha was most effective against weeds at Shimla and resulted in 12 t/ha higher tuber yield over unweeded control. Similar results were obtained by Ghosh and Banarjee (1981) with pre-emergence application of alachlor @ 1.0 kg/ha.

2.4.2.4 Atrazine

Ranbir (1970) indicated that pre-emergence spray of atrazine @ 0.25 kg/ha effectively controlled annual grasses

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and broad leaved weeds in potato and was found to be as good as three hand weedings.

Srikant (1975) reported that application of atrazine @ 0.5 kg a.i./ha reduced 39 per cent plant population at harvest. Akhade et al. (1984) indicated that application of atrazine @ 0.5 kg/ha effectively controlled both monocot and dicot weeds in potato and had no residual effect on succeeding wheat and pearl millet.

Tiwari et al. (1988) found satisfactory weed control and higher tuber yield with application of simazine @ 0.25 kg a.i./ha.

2.4.2.5 Paraquat

Among the various herbicides evaluated at Patna, paraquat proved to be the best for satisfactory weed control in potato and recorded higher tuber yield over other herbicides tried (Akhade et al., 1975).

Bhan and Tripathi (1981) reported that application of paraquat @ 0.5 kg a.i./ha as early pre-emergence of potato plants recorded effective weed control. Similar results were obtained by Singh and Chabaria (1985).

Hooda (1987) obtained highest weed control efficiency and tuber yield with application of paraquat @ 2.0 kg/ha. Thakral et al. (1988) indicated that application of paraquat @ 0.5 kg/ha recorded highest weed control efficiency and tuber yield (250.6 q/ha) which was on par with metribuzin @ 1.0 kg/ha. Similar results were obtained by Tiwari et al. (1988).

Lal (1990) reported that application of paraquat @ 0.5 kg a.i./ha reduced the weed population and weed weight thus increased the tuber yield (216 q/ha).

2.5 Integrated weed management

The objective of integrated weed management is to reduce the weed infestation below the economic threshold by judicious combination of all feasible means. Cultural and chemical methods can be integrated to reduce the weed infestation effectively and efficiently.

At Shillong, one hand weeding was not found sufficient to reduce the weed infestation as it encourages the emergence of new weeds due to frequent rain showers. Combination of cultural and chemical methods of weed control was found to be superior to take care of weeds that emerge in the later part of the crop season (Anon., 1972).

At Ooty, alachlor @ 1.0 kg a.i./ha + earthing up and paraquat @ 0.4 kg a.i./ha + earthing up were found to be most effective than application of herbicides alone (Anon., 1982).

Combination of cultural and chemical methods of weed control was proved to be the best, and recorded higher weed control efficiency and tuber yield over cultural methods alone (Phogat et al., 1989).

Lal and Jaiswal (1994) reported that application of oxyfluorfen @ 0.15 kg/ha supplemented with one hand hoeing by triphali at 30 DAP recorded highest weed control efficiency and tuber yield.

2.6 Economics of weed control methods

Bhattacharya et al. (1989) reported that the B:C ratio was highest (28.70) in goal (0.83 l/ha) treated plots over other herbicides tried in potato. Nadekar et al. (1990) reported that application of fluchloralin @ 0.9 kg/ha as pre-emergence recorded highest economic returns (Rs.25655/ha) in potato which was closely followed by propanil @ 0.7 kg/ha (Rs.25411/ha).

Tiwari and Singh (1993) reported that application of isoproturon @ 0.75 kg/ha as pre-emergence in potato recorded

highest net returns (Rs.3406/ha) which was closely followed by pendimethalin @ 0.75 kg/ha as pre-emergence (Rs.2479/ha).

Kamalsingh and Lal (1994) reported that application of metribuzin @ 0.75 kg/ha recorded highest B:C ratio (28.4), followed by fluchloralin @ 0.9 kg/ha (22.8) in potato.

From this review it can be inferred that weed flora varies from location to location and cause greater reduction in yield by way of competition for nutrients, moisture, space and light. The available information indicates that weed competition during the first four to six weeks after sowing is very critical and results in higher crop losses. Chemical weed control seems to be feasible being economical and effective in areas where labour is costly and scarce during peak period of farm operations.

MATERIAL AND METHODS

III MATERIAL AND METHODS

A field experiment was conducted during *Kharif* 1995 to study the weed management practices in potato under rainfed condition. The details of material used and techniques adopted are presented in this chapter.

3.1 Experimental site

The experiment was conducted on vertisols in plot No.151 of 'F' block of Agricultural College Farm, University of Agricultural Sciences, Dharwad.

3.2 Soil and its characteristics

The soil of the experimental site was black and clayey in nature. Composite soil sample to a depth of 0 to 30 cm was collected from the experimental site before sowing and analysed for physical and chemical properties. The results of the analysis along with their methods of determination are furnished in Table-1.

3.3 Climatic conditions

The Agricultural college, University of Agricultural Sciences, Dharwad is situated in northern transitional tract

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

Particulars	Value obtained	Method employed
Physical properties		
Coarse sand (%)	5.81	International pipette method (Piper, 1966)
Fine Sand (%)	14.70	International pipette method (Piper, 1966)
Silt (%)	27.19	International pipette method (Piper, 1966)
Clay (%)	52.30	International pipette method (Piper, 1966)
Chemical Properties		
Available nitrogen (N) (kg/ha)	149.80	Modified Kjeldahl's method (Jackson, 1967)
Available phosphorus (P ₂ O ₅) (kg/ha)	41.00	Olsen's method (Muhr et al., 1965)
Available potassium (K ₂ O) (kg/ha)	329.00	Flame photometer (Muhr et al., 1965)
Soil pH	7.50	pH meter (Piper, 1966)

of Karnataka state at $12^{\circ}26'$ N latitude and $70^{\circ}07'$ E longitude with an altitude of 678 m above the mean sea level. The monthly meteorological data for the year 1995 and the average for the past 44 years (1950-1994) as recorded at the meteorological observatory of the Agricultural College Farm, Dharwad is furnished in Table-2 and depicted in Fig.1. During 1995 the total rainfall received was 790.8 mm which was 9.8 mm lesser than the average of past 44 years (1950-1994). The total rainfall was distributed in 46 rainy days from January to December. During the period of experimentation (8-7-1995 to 10-10-1995) a rainfall of 413.90 mm was recorded. The mean maximum and minimum temperatures and relative humidity during the year did not deviate much from the mean values of the past 44 years.

3.4 Previous crop in experimental site

Safflower cv. Annigeri-1 was grown during *Rabi* 1994 with uniform cultural practices in the experimental site.

3.5 Experimental details

3.5.1 Treatments

The experiment comprised of 10 treatments, the details of which are given below.

Table 2. Monthly meteorological data for the year 1995 and average of 44 years (1950-1994) recorded at the meteorological observatory of the Agricultural college farm, Dharwad

Months	Temperature ($^{\circ}$ C)							
	Rainfall		Mean maximum		Mean minimum		Mean RH (%)	
	1995	1950-94	1995	1950-94	1995	1950-94	1995	1950-94
January	5.20	0.00	27.70	29.17	13.70	14.64	83.00	61.85
February	0.00	0.00	32.60	34.92	16.70	15.63	73.00	55.08
March	0.00	7.00	35.10	35.79	19.10	18.73	68.00	55.97
April	20.60	50.00	36.80	37.16	21.30	21.43	66.00	60.20
May	56.60	90.00	33.80	36.84	21.30	21.47	68.00	67.24
June	143.40	112.00	31.40	29.94	22.10	21.20	75.00	82.13
July	184.40	158.00	27.10	27.06	21.00	20.97	87.00	88.43
August	50.50	102.00	28.10	27.14	20.70	20.65	86.00	86.64
September	121.60	105.00	28.30	28.75	20.60	20.17	82.00	83.31
October	127.50	137.00	29.30	30.24	20.20	19.19	80.00	75.88
November	81.00	34.00	29.10	29.38	15.20	16.26	81.00	67.63
December	0.00	6.00	29.40	29.19	13.50	13.31	77.00	63.70

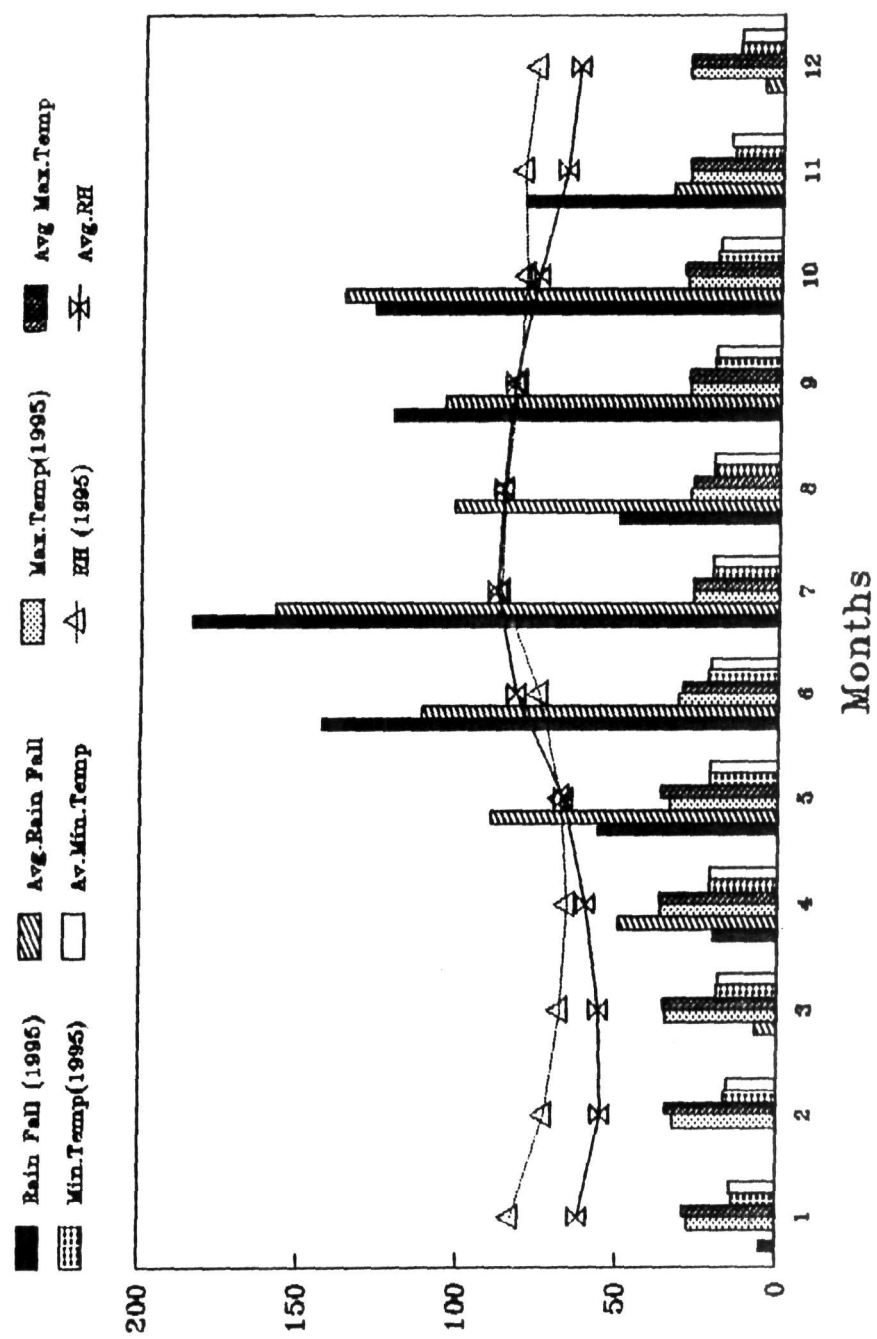


Fig. 1 Monthly meteorological data for the year 1995 and the average of the 44 years (1950-1994)

- T₁ Fluchloralin (PE) @ 1 kg a.i./ha + one hoeing at 30 DAP
- T₂ Pendimethalin (PE) @1 kg a.i.per ha +one hoeing at 30 DAP
- T₃ Metolachlor (PE) @ 1 kg a.i./ha + one hoeing at 30 DAP
- T₄ Alachlor (PE) @ 1 kg a.i./ha + one hoeing at 30 DAP
- T₅ Atrazine (PE) @ 0.5 kg a.i./ha + one hoeing at 30 DAP
- T₆ Paraquat (POE) @ 0.5 kg a.i./ha + one hoeing at 30 DAP
- T₇ Two hoeings + two hand weedings at 30 and 45 DAP
- T₈ One hoeing + one hand weeding at 30 DAP
- T₉ Weed free check
- T₁₀ Unweeded check (Control) *weedy check*

Legend

DAP : Days after planting

a.i.: Active ingredient

PE : Pre-emergence

POE : Post-emergence

3.5.2 Design and layout

The experiment was laidout in a randomised block design with three replications. The plan of layout is presented in Fig.2.

3.5.3 Plot size

Gross plot = 6.0 m x 5.0 m (30 m²)

Net plot = 3.6 m x 3.0 m (10.8 m²)

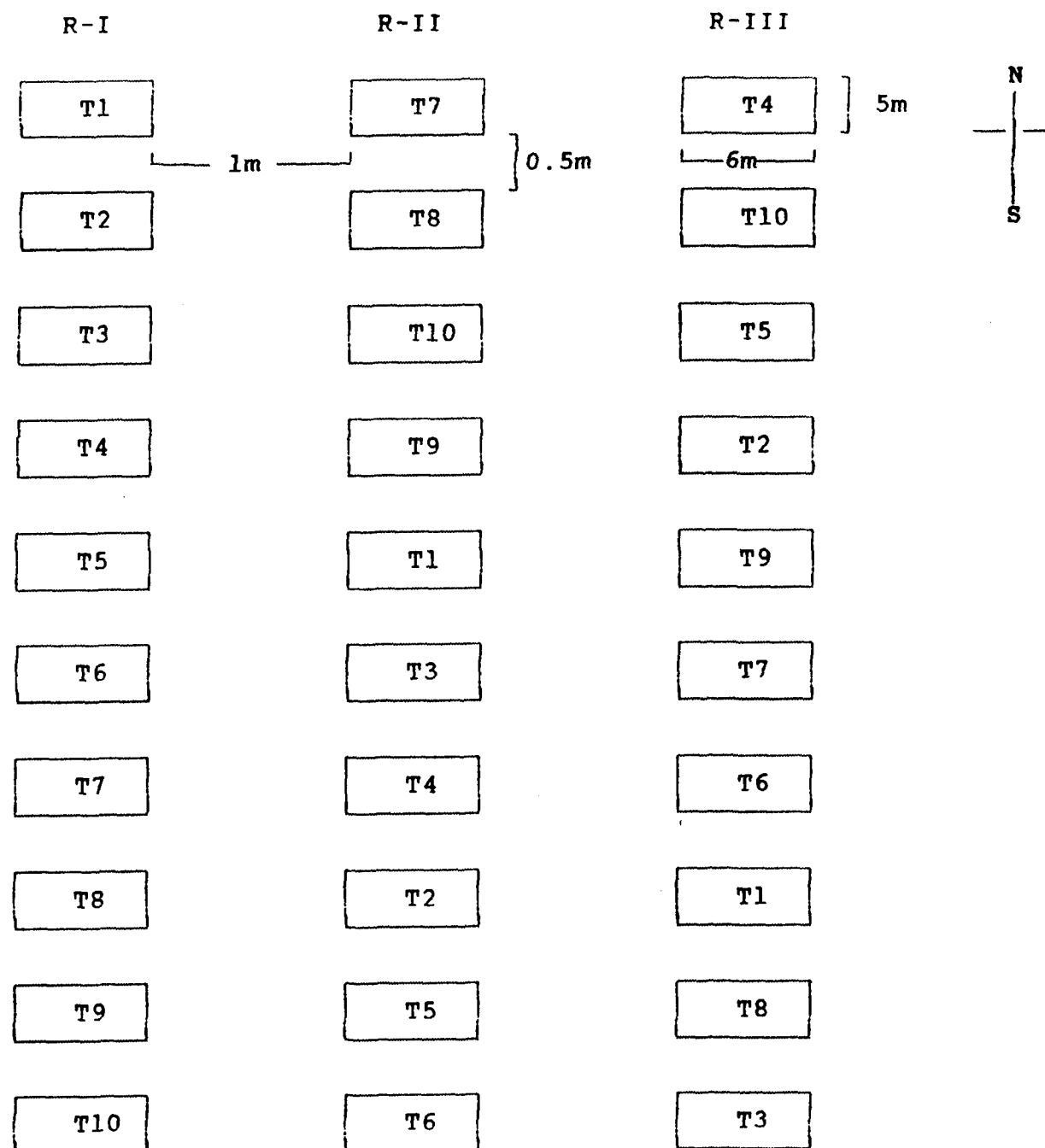


Fig.2 : P L A N O F L A Y O U T

3.5.4 Pre-emergence application of herbicides

The crop was planted on 8th July 1995 and the pre-emergence herbicides Fluchloralin, Pendimethalin, Metolachlor, Alachlor and Atrazine were sprayed uniformly on 9th July 1995 with high volume sprayer (750 litres/ha).

3.5.5 Post-emergent application of herbicide

The post emergent herbicide paraquat was sprayed uniformly 10 days after planting with high volume sprayer.

3.5.6 Variety used

Recommended potato variety Kufri-chandramukhi was used for the experimentation. It is an early maturing cultivar and will be ready for harvest in 85-95 days. Tubers are large, oval, slightly curved and have excellent keeping and cooking qualities.

3.6 Cultural operations

3.6.1 Land preparation

The land was ploughed to a depth of 20-30 cm and the soil was brought to a fine tilth by repeated harrowing. Stubbles and weeds were cleared from the experimental area and

was smoothened with wooden plank to prepare a fine seed bed. Ridges and furrows were opened at 60 cm apart.

3.6.2 Fertilizer application

Nitrogen, phosphorus and potassium were applied at the rate of 100:75:100 kg N, P_2O_5 and K_2O per ha in the form of urea, single super phosphate and muriate of potash respectively. Entire quantity of phosphorus, potassium and 50 per cent of nitrogen was applied at the time of sowing in furrows 5 cm away and 10 cm deep from the seed line. Later the furrows were covered with soil. Remaining 50 per cent of nitrogen was top dressed at 30 DAP.

3.6.3 Seeds and sowing

Bold and healthy tubers of potato were selected and were cut into pieces with 2-3 eye buds in each piece and were treated with 0.2 per cent Dithane M-45 and sown in the furrows 20 cm apart.

3.6.4 Hand weeding and hoeing

Hand weeding and hoeing operations were carried out as per the treatments and the weed free check was hand weeded as and when the weeds emerged.

3.7 After care

3.7.1 Plant protection measures

Crop was sprayed with endosulfan (30 EC) @ 0.2 per cent and Dithane M-45 @ 0.2 per cent at early stages of crop growth as a preventive measure for controlling sucking pests and diseases.

3.8 Herbicides used

3.8.1 Fluchloralin (Basalin, 45 EC)

Chemical name : [N-(2-chloroethyl)-2, 6-dinitro-n-propyl-4 (trichloromethyl)-benzenamine].

Mode of action : Absorption by the roots and translocated throughout the plant system.

Uses : It controls most of annual grasses and several annual broadleaf weeds in potato. predominantly used as pre-emergent herbicide.

Formulation : Emulsifiable concentrate

3.8.2 Pendimethalin (Stomp, 30 EC)

Chemical name : [N-(1-ethyl propyl)-3, 4-dimethyl-2, 6-dinitro benzenamine]

Mode of action : Inhibits germination of the seed or destroys the seedlings.

Uses : It controls most of grassy weeds and certain broad leaf weeds in potato. It is a selective soil herbicide predominantly used for pre-emergence treatment.

Formulation : Emulsifiable concentrate.

3.8.3 Metolachlor (Dual, 50 EC)

Chemical name : [2-chloro-N-(2-ethyl-6-methyl phenyl)-N-(2-Methoxy-1-methyl ethyl)-acetamide].

Mode of action : Absorption via hypocotyl and coleoptile, inhibits germination.

Uses : Used as pre-emergence and pre-plant control of weeds mainly grasses in potato, cotton, maize, etc.

Formulation : Emulsifiable concentrate.

3.8.4 Alachlor (Lasso, 50 EC)

Chemical name : [2-chloro-2, 6-diethyl-N-(Methoxy methyl) acetanilide].

Mode of action : Grasses absorb this herbicide mainly through shoots, Where as broad leaf weeds through roots. Early seedling and root growth is inhibited.

Uses : A predominant pre-emergence herbicide used for the control of annual weeds mainly grasses and nutsedge in potato.

Formulation : Emulsifiable concentrate.

3.8.5 Atrazine (Atrataf, 50 WP)

Chemical name : [2-chloro-4-ethylamino-6-isopropylamino-s-triazine]

Mode of action : Rapid absorption by the roots and translocated throughout the plant system.

Uses : A pre-emergence herbicide used to control annual grasses and broad leaf weeds in sorghum, maize, potato etc.

Formulation : Wettable powder.

3.8.6 Paraquat (Gramoxone, 24 EC)

Chemical name : (1,1-dimethyl-4, 4-bipyridinium dichloride)

Mode of action : Inhibit photosynthesis, causes wilting and rapid desiccation of weed foliage.

Uses : A post-emergence herbicide used to control annual grasses and broad leaf weeds in potato.

Formulation : Emulsifiable concentrate

3.9 Dehaulming

The vegetative growth of the potato crop was cut at the base of the plant, 85 DAP to cure the tubers.

3.10 Harvesting and grading

All the tubers from each of the net plots were harvested 10 days after dehaulming. The tubers were cleaned, airdried and were graded based on their weight such as small (<20 g), medium (20-100 g) and large (>100 g) tubers.

3.11 Collection of experimental data

Following were the observations recorded along with the techniques adopted.

3.11.1 Observations on weeds

3.11.1.1 Weed population

Number of weeds present in 0.25 m^2 area in a permanently marked spot was counted in each plot at 30, 45, 60, 75 DAP and at harvest. They were further classified into monocots and dicots, before subjecting to statistical analysis.

3.11.1.2 Dry weight of weeds ($\text{g}/0.25 \text{ m}^2$)

Dry weight of weeds was recorded at 30, 45, 60, 75 DAP and at harvest. The weeds were uprooted from the 0.25 m^2 area selected at random at each time and were

ovendried to a constant weight at 75°C. The weight of ovendried weeds was recorded at each stage.

3.11.1.3 Weed weight per hectare

Weight of ovendried weeds from 0.25 m² area of each treatment at the time of harvest was recorded and was expressed in quintals per ha.

3.11.1.4 Weed index (%)

Weed index is defined as the magnitude of yield reduction due to the presence of weeds in comparison to weed free plot. Weed index was calculated by using the formula given by Gill and Vijaykumar (1969).

$$\text{Weed index} = \frac{X - Y}{X} \times 100$$

Where, X = Tuber yield of the weed free check.

Y = Tuber yield from the treatment for which weed index has to be calculated.

3.11.1.5 Weed control efficiency (%)

Weed control efficiency denotes the magnitude of weed reduction due to the weed control treatment. The weed control efficiency was calculated as follows.

$$\text{Weed control efficiency (\%)} = \frac{\text{Weed dry weight of unweeded control} - \text{Weed dry weight of treatment}}{\text{Weed dry weight of unweeded control}} \times 100$$

3.11.2 Crop observations

Five plants from the net plot area were selected randomly and were tagged for recording observations viz., plant height, number of stems per hill, number of tubers per plant, and tuber weight per plant.

3.11.3 Preharvest observations

3.11.3.1 Emergence count

Number of sets germinated in 3 meter row length were recorded at 28 DAP.

3.11.3.2 Crop stand at harvest

Number of plants per three meter row in a netplot area was counted at harvest and was recorded as crop stand. Based on these observations per cent reduction of plants was calculated.

3.11.3.3 Plant height (cm)

Plant height was measured from the ground level to the tip of the main stem at all the stages of crop growth. The mean of five plants in each treatment was worked out.

3.11.3.4 Number of stems per hill

The number of stems arising from each set were counted and recorded as number of stems per hill at 30, 45, 60, 75 DAP and at harvest.

3.11.3.5 Drymatter production

Total dry matter production was determined at 30, 45, 60, 75 DAP and at harvest. Three plants were uprooted carefully and were partitioned. Tubers were cut into small pieces with the help of stainless steel knife, and all the plant parts were oven-dried at 75°C to constant weight. Total dry matter production was worked out by adding dry weight of all the components.

3.11.3.6 Leaf area (dm²)

Leaf area per plant was worked out by disc method on dry weight basis (Vivekanandan *et al.*, 1972) at all the stages of crop growth. Leaves from the plants uprooted for determination of drymatter production were used for working out leaf area. The leaf area per plant was calculated by using the formula.

$$LA = \frac{W_a \times A}{W_d}$$

Where, LA = Leaf area (dm^2)

Wa = Weight of foliage (g)

(Inclusive of the weight of discs)

Wd = Weight of 25 discs (g)

A = Area of 25 discs (dm^2)

3.11.3.7 Leaf area index (LAI)

Leaf area index was worked out by dividing leaf area per plant by the land area (spacing) occupied by the plant at all the stages of crop growth (Sestak *et al.*, 1971).

$$\text{LAI} = \frac{A}{P}$$

Where, A = Leaf area (dm^2)

P = Land area or spacing (dm^2)

3.11.4 Post harvest observations

3.11.4.1 Number of tubers per plant

Number of tubers from randomly selected five plants within the net plot was taken and was recorded as number of tubers per plant.

3.11.4.2 Weight of tubers per plant (g)

Tubers collected from five plants were weighed individually on the electronic balance and the weight of tubers per plant was worked out.

3.11.4.3 Average tuber weight (g)

Average tuber weight was worked out by dividing tuber weight per plant with number of tubers per plant.

3.11.4.4 Grading of tubers

Total number of tubers obtained from five randomly selected plants were sorted out into different grades based on weight of tubers, as small (<20 g), medium (20-100 g) and large (>100 g) tubers, and weight of graded tubers was recorded.

3.11.4.5 Tuber yield (t/ha)

Tuber yield from net plot in kg was recorded and was converted to t/ha.

3.12 Estimation of nitrogen, phosphorus and potassium uptake by crop and weeds at harvest

Total nitrogen in the composite sample was estimated by modified Kjeidhal's method (Jackson, 1967) and was expressed in percentage on dry weight basis. Based on the nitrogen percentage obtained and total dry weight, the total uptake of nitrogen was calculated and expressed in kg per ha.

Phosphorus content in plant and weed samples was determined by vanedomolybdate yellow colour method using spectrophotometer as described by Jackson (1967) and was expressed as percentage phosphorus. Using the phosphorus content, total uptake of phosphorus was calculated and expressed in kg per ha.

Potassium content in crop and weed samples was determined by flame photometer method (Muhr *et al.*, 1965) and was expressed as percentage potassium. Based on potassium content, the total uptake was computed and expressed in kg per ha.

3.13 Economics of weed control

Market price of the produce at the time when the produce was ready for sale was obtained from Agricultural Produce Marketing Committee, Hubli. The income from tuber yield and cost of cultivation for individual treatment was used for calculating the net income and was expressed in rupees per ha. Net gain from the treatments over unweeded check was calculated by using the formula given below.

$$\begin{array}{rcl} \text{Net gain over} & \text{Net income from} & \text{Net income from} \\ \text{unweeded check} & \text{the treatment} & \text{the unweeded check} \\ \text{(Rs./ha)} & \text{(Rs./ha)} & \text{(Rs./ha)} \end{array} =$$

The price factor details are given in Apendix-I

3.14 Statistical analysis and interpretation of data

Fisher's method of analysis of variance was applied for the analysis and interpretation of data as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 'T' test was 0.05. Critical differences were calculated wherever 'F' test was significant.

3.14.1 Transformation

Data on weed count and weed weight have showed high degree of variation. A linear relationship between the means and variance was observed and therefore, the data on weed count was subjected to $(x+1)^{1/2}$ transformation while the data on weed weight was subjected to $\log(x+2)$ transformation to make analysis of variance valid as suggested by Bartlett (1947) and Blackman and Roberts (1950).

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of the experiment conducted to study the effects of various weed management practices in potato under rainfed condition during *Kharif* 1995 are presented in this chapter.

4.1 Observations on weeds

4.1.1 Weed flora

The important monocotyledonous weeds observed were *Cyperus rotundus*, *Cynodon dactylon*, *Pennisetum* Spp. *Commelina benghalensis*, *Panicum* Spp., *Echinocloa crusgalli* and *Digitaria marginata* while the common dicotyledonous weeds noticed were *Parthenium hysterophorus*, *Phyllanthus niruri*, *Solanum nigrum*, *Chenopodium album*, *Hibiscus ponduriformis*, *Trianthema monogyna*, *Eclipta alba*, *Amaranthus viridis*, *Portulaca oleraceae*, *Lactuca runcinata*, *Acanthospermum hispidum*, *Tridax procumbense* and *Euphorbia geniculata*.

4.1.2 Weed population

Observations recorded on weed population at different stages of crop growth are presented in Tables 3,4 and 5.

4.1.2.1 Monocot weeds per 0.25 m² (Table-3)

Unweeded control (T₁₀) recorded significantly the highest weed count at all the stages of crop growth (4.21, 4.88, 5.09 and 5.35 at 45, 60, 75 DAP and at harvest respectively) except at 30 DAP. Weed free check (T₉) had the lowest weed count at all the stages since no weeds were allowed to grow.

At 30 DAP, all the chemical treatments recorded significantly lower weed count and were on par with each other.

At 45 DAP, T₂ recorded significantly the lowest weed count and was on par with T₁.

At 60 DAP, significantly the lowest weed count was recorded in T₇ which was on par with T₂.

At 75 DAP, T₂ recorded significantly the lowest weed count and was on par with T₁ and T₄.

At harvest, T₂ again recorded significantly the lowest monocot weeds and was on par with rest of the treatments except T₅, T₈ and T₁₀.

4.1.2.2 Dicot weeds per 0.25 m² (Table-4)

Unweeded control (T₁₀) recorded significantly the highest weed count at all the stages of crop growth (4.36, 5.11, 5.46 and 6.15 at 45, 60, 75 DAP and at harvest, respectively) except at 30 DAP.

Table 3. Effect of weed control treatments on number of monocot weeds per 0.25m² at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.05 (3.22)	1.85 (2.44)	2.15 (3.66)	2.20 (4.10)	2.32 (4.44)
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.02 (3.11)	1.82 (2.22)	2.07 (3.33)	2.09 (3.44)	2.29 (4.33)
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.23 (3.99)	2.15 (3.66)	2.38 (4.77)	2.50 (5.33)	2.59 (5.77)
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.06 (3.33)	2.02 (3.11)	2.21 (3.99)	2.31 (4.44)	2.46 (5.11)
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.13 (4.10)	2.27 (3.88)	2.37 (4.66)	2.57 (5.66)	2.70 (6.33)
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.20 (3.88)	2.07 (3.33)	2.30 (4.33)	2.39 (4.77)	2.50 (5.33)
T7 Two hoeings + two HW at 30 and 45 DAP	3.17 (9.11)	2.07 (3.33)	1.82 (2.33)	2.36 (4.66)	2.60 (5.88)
T8 1 Hoeing + 1 HW at 30 DAP	3.21 (9.44)	2.12 (3.55)	2.67 (6.22)	3.22 (9.44)	3.39 (10.55)
T9 Weed free check	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T10 Unweeded check (control)	3.35 (10.33)	4.21 (16.77)	4.88 (22.88)	5.09 (24.99)	5.35 (27.77)
S.E.m. _±	0.117	0.066	0.096	0.086	0.114
C.D. at 5%	0.347	0.197	0.284	0.256	0.340

Original weed count (x) data were transformed to $(x+1)^{1/2}$

DAP = Days after planting

HW = Hand weeding

Figures in the parentheses indicate original values

Table 4. Effect of weed control treatments on dicot weed count per $0.25m^2$ at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.17 (3.77)	2.01 (3.11)	2.34 (4.55)	2.60 (5.88)	2.77 (6.77)
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.06 (3.33)	1.93 (2.77)	2.25 (4.10)	2.50 (5.33)	2.73 (6.55)
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.36 (4.66)	2.20 (3.88)	2.49 (5.33)	2.79 (6.88)	3.20 (9.33)
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.22 (3.99)	2.05 (3.22)	2.37 (4.66)	2.63 (5.99)	3.07 (8.55)
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.04 (3.22)	1.78 (2.21)	2.01 (3.11)	2.13 (3.55)	2.20 (3.88)
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.32 (4.44)	2.12 (3.55)	2.37 (4.66)	2.63 (5.99)	3.20 (9.33)
T7 Two hoeings + two HW at 30 and 45 DAP	3.35 (10.33)	2.04 (3.22)	1.96 (2.88)	2.56 (5.66)	3.13 (8.99)
T8 1 Hoeing + 1 HW at 30 DAP	3.26 (9.77)	2.15 (3.66)	3.30 (9.99)	3.75 (13.11)	3.96 (14.77)
T9 Weed free check	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T10 Unweeded check (control)	3.54 (11.66)	4.36 (18.11)	5.11 (25.22)	5.46 (28.88)	6.15 (36.88)
S.E.m. $\pm$	0.124	0.094	0.120	0.119	0.148
C.D. at 5%	0.367	0.279	0.355	0.353	0.439

Original weed count (x) data were transformed to $(x+1)^{1/2}$

DAP = Days after planting

HW = Hand weeding

Figures in the parentheses indicate original values

At 30 DAP, T₅ recorded significantly the lowest weed count (2.04) which was on par with rest of the treatments except T₇, T₈ and T₁₀. However, weed free check (T₉) was kept free of weeds throughout the crop growth period.

At 45 DAP, significantly the lowest weed count (1.78) was observed in T₅ and was on par with T₁, T₂, T₄ and T₇.

At 60 DAP, T₇ registered significantly the lowest number of weeds (1.96) which was on par with T₂ and T₅.

At 75 DAP, T₅ recorded significantly the lowest weed count (2.12), followed by T₂ which was on par with rest of the treatments except T₈ and T₁₀.

At harvest, T₅ again registered significantly the lowest number of weeds (2.20), followed by T₂ (2.73) which was on par with T₁, T₄ and T₇.

4.1.2.3 Total weed count per 0.25 m² (Table-5)

Unweeded check (T₁₀) recorded significantly the highest weed count at all the stages crop growth (4.78, 5.98, 7.00, 7.40 and 8.09 at 30, 45, 60, 75 DAP and at harvest respectively). Whereas, weed free check (T₉) had the lowest weed count.

Table 5. Effect of weed control treatments on total weed count per 0.25 m² at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.81 (6.99)	2.55 (5.55)	3.02 (8.21)	3.30 (9.98)	3.48 (11.21)
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.71 (6.44)	2.44 (4.99)	2.90 (7.43)	3.11 (8.77)	3.42 (10.88)
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	3.10 (8.65)	2.91 (7.54)	3.31 (10.07)	3.63 (12.21)	4.01 (15.10)
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.86 (7.32)	2.70 (6.33)	3.09 (8.59)	3.37 (10.43)	3.82 (13.66)
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.88 (7.32)	2.66 (6.09)	2.95 (7.77)	3.18 (9.21)	3.34 (10.21)
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	3.09 (8.32)	2.80 (6.88)	3.15 (8.99)	3.42 (10.76)	3.95 (14.66)
T7 Two hoeings + two HW at 30 and 45 DAP	4.51 (19.44)	2.74 (6.55)	2.48 (5.21)	3.35 (10.32)	3.95 (14.87)
T8 1 Hoeing + 1 HW at 30 DAP	4.49 (19.21)	2.85 (7.21)	4.14 (16.21)	4.84 (22.55)	5.12 (25.32)
T9 Weed free check	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T10 Unweeded check (control)	4.78 (21.99)	5.98 (34.88)	7.00 (48.10)	7.40 (53.87)	8.09 (64.65)
S.E.m. _±	0.139	0.082	0.121	0.121	0.160
C.D. at 5%	0.412	0.244	0.358	0.360	0.475

Original weed count (x) data were transformed to $(x+1)^{1/2}$

DAP = Days after planting

HW = Hand weeding

Figures in the parentheses indicate original values

At 30 DAP, T₂ recorded significantly the lowest weed count and was on par with rest of the treatments except T₇, T₈ and T₁₀.

At 45 DAP, significantly the lowest weed count was observed in T₂ (2.44) and was on par with T₁ and T₅. The treatments T₃, T₄, T₆, T₇ and T₈ were on par with each other.

At 60 DAP, T₇ recorded significantly the lowest weed count (2.48) followed by T₂ (2.90).

At 75 DAP, T₂ recorded significantly the lowest weed count (3.11) and was on par with rest of the treatments except T₃, T₈ and T₁₀.

At harvest, significantly the lowest weed count (3.42) was observed in T₂ and was on par with T₁, T₄ and T₅.

4.2 Dry weight of weeds (g/0.25 m²) (Table-6, Fig.3)

At 30 DAP, unweeded check (T₁₀) recorded significantly the highest weed dry weight (0.667) and was on par with T₇ and T₈. Whereas, T₂ recorded the lowest weed dry weight (0.408) which was on par with rest of the treatments.

At 45 DAP, T₂ recorded significantly the lowest weed weight (0.375) and was on par with rest of the treatments except T₁₀.

Table 6. Effect of weed control treatments on dry weight of weeds (g/0.25 m²) at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.419 (0.630)	0.378 (0.390)	0.598 (1.980)	1.167 (12.950)	1.325 (19.370)
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.408 (0.570)	0.375 (0.380)	0.571 (1.730)	1.053 (9.450)	1.272 (16.880)
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.441 (0.770)	0.392 (0.470)	0.638 (2.360)	1.255 (16.110)	1.403 (23.360)
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.426 (0.670)	0.385 (0.430)	0.630 (2.280)	1.199 (14.000)	1.385 (22.450)
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	0.417 (0.620)	0.374 (0.370)	0.607 (2.050)	1.226 (14.940)	1.361 (21.140)
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	0.432 (0.710)	0.383 (0.420)	0.635 (2.340)	1.253 (16.000)	1.395 (22.940)
T7 Two hoeings + two HW at 30 and 45 DAP	0.654 (2.520)	0.420 (0.630)	0.372 (0.360)	1.349 (20.500)	1.488 (28.990)
T8 1 Hoeing + 1 HW at 30 DAP	0.662 (2.600)	0.422 (0.650)	1.209 (14.330)	1.634 (41.320)	1.827 (65.480)
T9 Weed free check	0.301 (0.000)	0.301 (0.000)	0.301 (0.000)	0.301 (0.000)	0.301 (0.000)
T10 Unweeded check (control)	0.667 (2.650)	1.103 (10.660)	1.757 (55.700)	2.193 (154.780)	2.300 (212.240)
S.E.m. _±	0.017	0.018	0.026	0.036	0.027
C.D. at 5%	0.052	0.055	0.076	0.106	0.079

Original weed count (x) data were transformed to log (x + 2)

DAP = Days after planting

HW = Hand weeding

Figures in the parentheses indicate original values

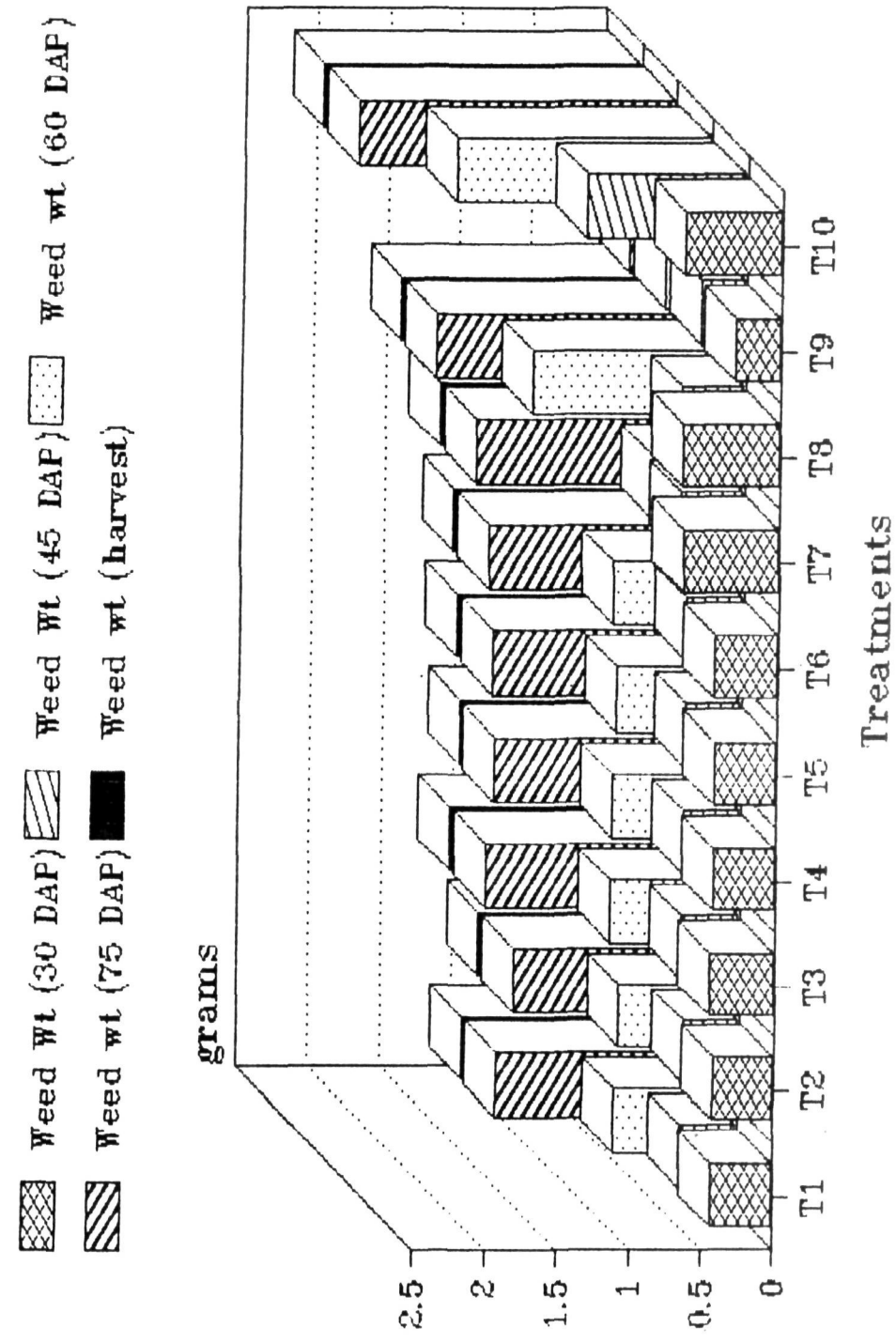


Fig. 3 Dry weight of weeds (g/0.25 sq.m) as influenced by weed control treatments

At 60 DAP, T₇ recorded significantly the lowest weed weight (0.372) followed by T₂ which was on par with rest of the treatments except T₈ and T₁₀.

At 75 DAP, T₂ recorded significantly lowest weed weight (1.053) followed by T₁ which was on par with rest of the treatments except T₇, T₈ and T₁₀.

At harvest, T₂ again recorded significantly the lowest weed weight (1.272) followed by T₁ which was on par with rest of the treatments except T₇, T₈ and T₁₀.

4.3 Weed weight (q/ha), weed control efficiency (%) and weed index (%) (Table-7)

4.3.1 Weed weight (q/ha)

Treatment T₁₀ recorded significantly the highest weed weight (84.89 q/ha) and lowest was observed in T₂ which was on par with rest of the treatments except T₇ and T₈. Among the cultural methods T₇ recorded 11.59 q/ha weed weight which was significantly superior over T₈ (26.19 q/ha).

4.3.2 Weed control efficiency (%) (Fig.4)

Significantly the highest weed control efficiency (91.97 %) was recorded in T₂ which was on par with rest of the

Table 7. Effect of weed control treatments on weed weight, weed control efficiency and weed index in potato

Treatment	Weed weight (q/ha)	Weed control efficiency (%)	Weed index (%)
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	7.74	90.83	15.61
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	6.75	91.97	13.41
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	9.35	88.97	18.60
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	8.98	89.37	16.65
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	8.45	90.03	45.31
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	9.17	89.17	17.23
T7 Two hoeings + two HW at 30 and 45 DAP	11.59	86.30	8.42
T8 1 Hoeing + 1 HW at 30 DAP	26.19	69.02	25.26
T9 Weed free check	0.00	100.00	0.00
T10 Unweeded check (control)	84.89	0.00	51.02
S.E.m. $\pm$	1.232	0.950	1.181
C.D at 5%	3.658	2.823	3.506

DAP = Days after planting

HW = Hand weeding

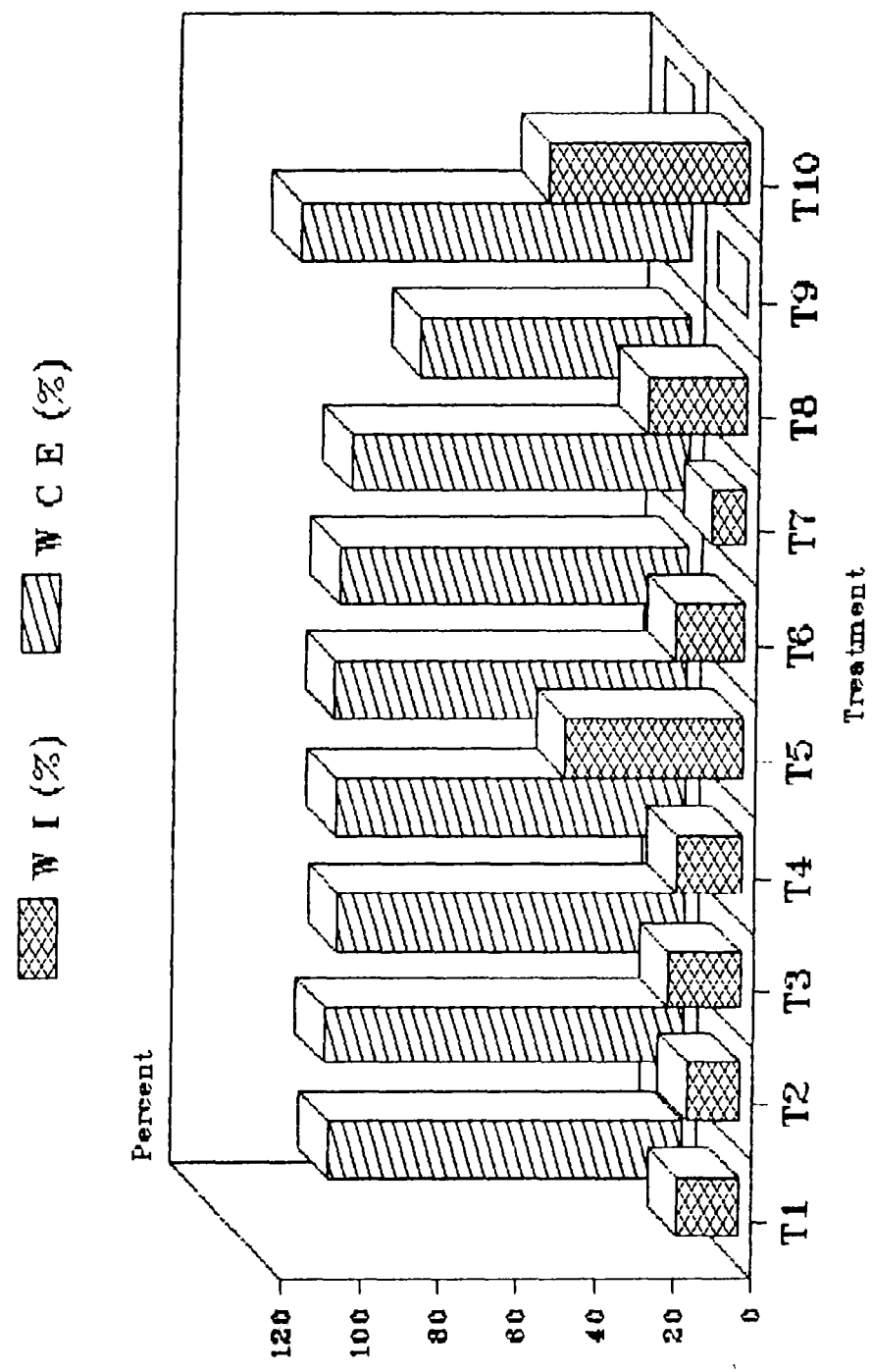


Fig. 4 Weed control efficiency (%) and weed index (%) as influenced by weed control treatments

treatments except T₇ and T₈. The treatment T₈ recorded the lowest weed control efficiency (69.02).

4.3.3 Weed index (%) (Fig.4)

The treatment T₇ recorded significantly the lowest weed index (8.42 %) followed by T₂ (13.41 %) which was on par with T₁ and T₄. Whereas, unweeded check (T₁₀) recorded the highest weed index (51.02) followed by T₅ and T₈.

4.4 Nutrient uptake by weeds (Kg/ha) (Table-8, Fig.5)

4.4.1 Nitrogen uptake

Significantly the highest nitrogen uptake was recorded in unweeded check (131.56 kg/ha) followed by T₈ (44.26 kg/ha) and the lowest (12.15 kg/ha) was observed in T₂ and was on par with T₁. The treatments T₃, T₄, T₅ and T₆ were on par with each other.

Among the cultural methods T₇ recorded significantly lower nitrogen uptake (20.01 kg/ha) over T₈ (44.26 kg/ha).

4.4.2 Phosphorus uptake

Unweeded check (T₁₀) recorded significantly the highest phosphorus uptake (44.14 kg/ha). Whereas, the lowest

Table 8. Effect of weed control treatments on nitrogen, phosphorus and potassium uptake by weeds (Kg/ha) at harvest

Treatment	Nitrogen	Phosphorus	Potassium
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	13.93	4.64	14.08
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	12.15	4.25	12.48
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	16.73	5.61	17.57
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	16.07	5.07	16.61
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	15.04	5.50	15.63
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	16.23	5.41	16.96
T7 Two hoeings + two HW at 30 and 45 DAP	20.01	6.49	21.57
T8 1 Hoeing + 1 HW at 30 DAP	44.26	14.40	47.14
T9 Weed free check	0.00	0.00	0.00
T10 Unweeded check (control)	131.56	44.14	137.48
S.E.m. _±	0.972	0.547	0.556
C.D. at 5%	2.888	1.625	1.651

DAP = Days after planting

HW = Hand weeding

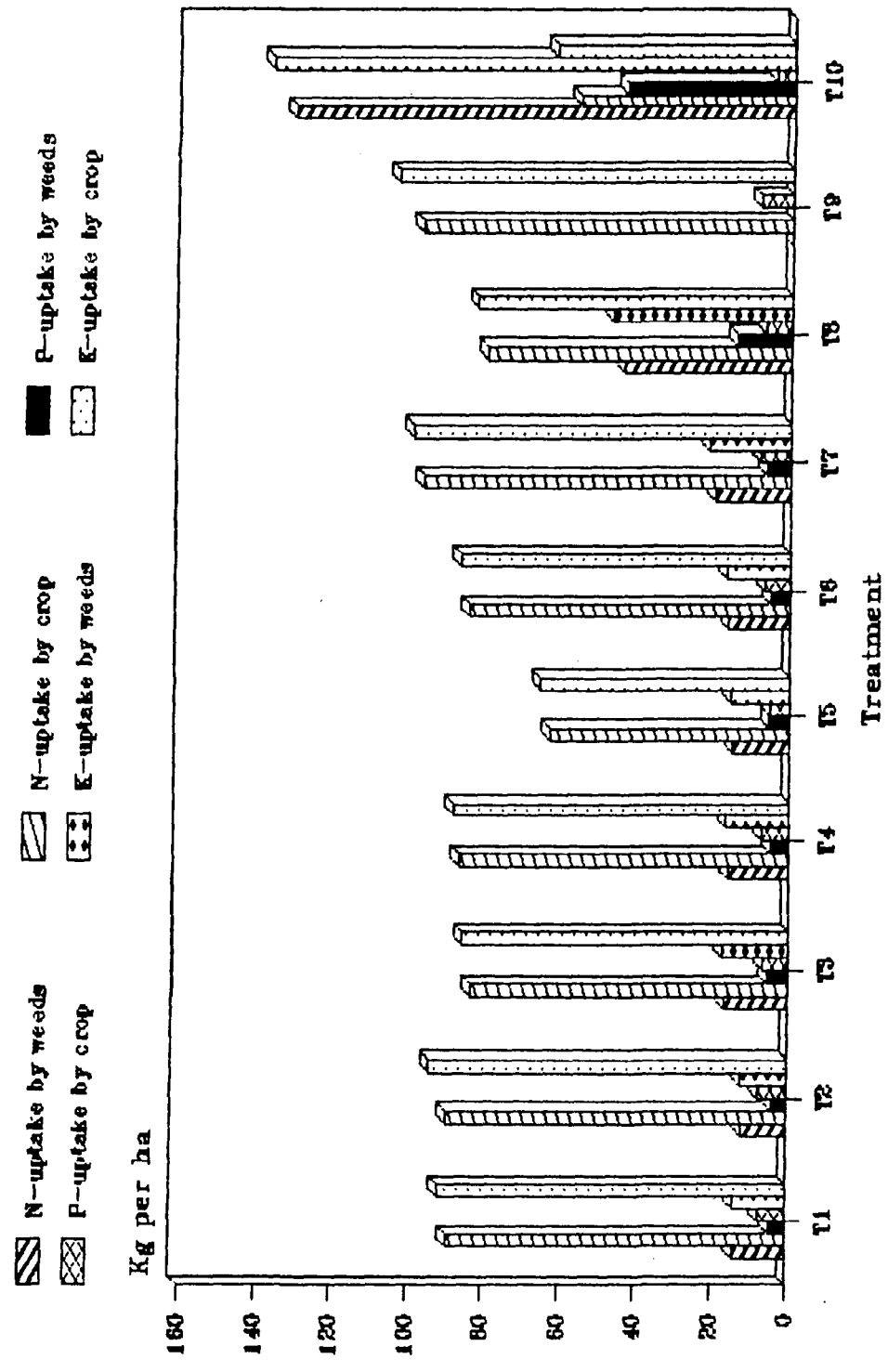


Fig.5 Nitrogen, phosphorus and potassium uptake (kg/ha) by weeds and crop as influenced by weed control treatments

phosphorus uptake (4.25 kg/ha) was recorded in T₂ which was on par with rest of the chemical treatments.

Among the cultural methods T₇ recorded significantly lower phosphorous uptake (6.49 kg/ha) over T₈ (14.40 kg/ha).

4.4.3 Potassium uptake

Unweeded check (T₁₀) recorded significantly the highest potassium uptake (137.48 kg/ha) followed by T₈ (47.14 kg/ha) whereas, the lowest uptake (12.48 kg/ha) was observed in T₂ and was on par with T₁ (14.08 kg/ha). The treatments T₄, T₅ and T₆ were on par with each other.

Among the cultural methods T₇ recorded significantly lower potassium uptake (21.57 kg/ha) over T₈ (47.14 kg/ha).

4.5 Potato emergence count and crop stand at harvest (Table-9)

Significantly the highest emergence count (14.55) was recorded in T₉ and was on par with rest of the treatments except T₅ (11.44).

Weed free check (T₉) recorded significantly the highest plant population (crop stand) and was on par with rest

Table 9. Effect of weed control treatments on potato emergence count, crop stand at harvest and percent reduction

Treatment	Potato emergence count (3 m row length)	Crop stand at harvest	Per cent reduction
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	13.99	12.99	13.40
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	14.11	13.55	9.66
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	13.66	13.11	12.60
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	13.88	13.33	11.13
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	11.44	9.33	37.80
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	13.88	13.44	10.40
T7 Two hoeings + two HW at 30 and 45 DAP	14.33	14.10	6.00
T8 1 Hoeing + 1 HW at 30 DAP	14.33	13.33	11.13
T9 Weed free check	14.55	14.33	4.46
T10 Weedy check	14.11	8.77	41.53
S.E.m. $\pm$	0.467	0.354	-
C.D. at 5%	1.387	1.051	-

DAP = Days after planting

HW = Hand weeding

of the treatments except T_1 , T_3 , T_5 and T_{10} . Whereas, the lowest plant population (8.77) was observed in T_{10} followed by T_5 (9.33).

4.6 Plant height (cm) (Table-10)

Plant height differed significantly due to treatments at all the stages of crop growth except at 30 DAP.

At 45 DAP, T_9 recorded significantly the highest plant height (29.88 cm) and was on par with rest of the treatments except T_5 (23.88 cm).

At 60 DAP, significantly the highest plant height (44.07 cm) was recorded by T_9 and was on par with T_1 , T_2 , T_4 and T_7 . Whereas, the lowest plant height (30.16 cm) was recorded in unweeded check (T_{10}) and was on par with T_5 (31.99 cm).

At 75 DAP, T_9 recorded significantly the highest plant height (54.60 cm) and was on par with rest of the treatments except T_5 and T_{10} .

At harvest, T_9 again registered significantly the highest plant height (63.49 cm) and was on par with rest of the treatments except T_5 , T_8 and T_{10} .

Table 10. Effect of weed control treatments on plant height(cm) at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	15.00	28.99	40.83	52.49	59.83
T2 Pendimethalin @ 1.0 kg a.i./ha+ 1 hoeing at 30 DAP	15.60	29.32	41.27	52.77	60.38
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	14.77	27.55	39.16	50.55	58.49
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	14.99	28.61	40.10	52.16	59.66
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	12.50	23.88	31.99	40.88	49.05
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	14.55	28.33	38.50	50.55	58.71
T7 Two hoeings + two HW at 30 and 45 DAP	14.10	29.66	43.88	53.55	62.38
T8 1 Hoeing + 1 HW at 30 DAP	13.77	28.77	38.61	50.00	54.99
T9 Weed free check	16.71	29.88	44.07	54.60	63.49
T10 Unweeded check (Control)	13.60	27.00	30.16	36.60	43.10
S.E.m. $\pm$	0.964	1.053	1.471	1.567	1.774
C.D. at 5%	NS	3.126	4.369	4.655	5.270

DAP = Days after planting
HW = Hand weeding
NS = Not significant

4.7 Number of stems per hill (Table-11)

Number of stems differed significantly due to treatments at all the stages of crop growth except at 30 and 45 DAP.

At 60 DAP, significantly the highest number of stems (3.66) was recorded in T₉ which was on par with rest of the treatments except T₅, T₆ and T₁₀. Whereas, the lowest number of stems (2.44) was observed in T₅ and was on par with T₁₀.

At 75 DAP, T₉ recorded significantly the highest number of stems (3.88) and was on par with rest of the treatments except T₅ and T₁₀. Whereas, the lowest number of stems (2.66) was observed in T₅ and was on par with T₁₀. Similar trend was noticed at harvest.

4.8 Leaf area index (LAI) (Table-12)

At 30 DAP, T₉ recorded significantly the highest LAI (0.586) which was on par with T₂, T₇, T₈ and T₁₀. Whereas, the lowest LAI was recorded by T₅.

At 45 DAP, significantly the highest LAI (1.209) was recorded in T₉ which was on par with T₇ and T₈. Among the chemical treatments significantly the highest LAI (1.162) was

Table 11. Effect of weed control treatments on number of stems per hill at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.10	2.55	3.33	3.66	3.66
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.22	2.67	3.44	3.66	3.77
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.21	2.44	3.22	3.44	3.66
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	1.99	2.55	3.22	3.66	3.77
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	1.78	2.10	2.44	2.66	2.77
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.11	2.55	3.11	3.44	3.55
T7 Two hoeings + two HW at 30 and 45 DAP	2.22	2.77	3.55	3.77	3.88
T8 1 Hoeing + 1 HW at 30 DAP	2.21	2.55	3.22	3.44	3.55
T9 Weed free check	2.44	2.99	3.66	3.88	3.88
T10 Unweeded check (Control)	2.10	2.11	2.55	2.77	2.88
S.E.m. $\pm$	0.218	0.196	0.146	0.155	0.125
C.D. at 5%	NS	NS	0.434	0.459	0.371

DAP = Days after planting

HW = Hand weeding

NS = Not significant

Table 12. Effect of weed control treatments on LAI at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.556	1.153	2.747	2.578	1.953
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.569	1.162	2.760	2.600	1.993
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.554	1.112	2.737	2.557	1.927
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	0.547	1.128	2.747	2.573	1.935
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	0.419	0.691	2.187	2.160	1.585
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	0.552	1.119	2.673	2.530	1.918
T7 Two hoeings + two HW at 30 and 45 DAP	0.576	1.207	2.802	2.607	2.077
T8 1 Hoeing + 1 HW at 30 DAP	0.571	1.194	2.740	2.497	1.754
T9 Weed free check	0.586	1.209	2.813	2.719	2.130
T10 Weedy check	0.561	0.856	2.207	2.170	1.493
S.E.m. _±	0.010	0.012	0.017	0.012	0.016
C.D. at 5%	0.028	0.035	0.050	0.035	0.048

DAP = Days after planting

HW = Hand weeding

recorded by T₂ and was on par with T₁ (1.153). Whereas, the lowest leaf area index (0.691) was recorded in T₅.

At 60 DAP, significantly the highest (2.813) was recorded by T₉ and was on par with T₇ (2.802). The next highest LAI (2.760) was recorded in T₂ which was on par with T₁, T₃, T₄ and T₈. Whereas, the lowest LAI (2.187) was recorded by T₅ and was on par with T₁₀ (2.207).

At 75 DAP, significantly the highest LAI (2.719) was recorded in T₉ followed by T₇ (2.607) which was on par with T₁, T₂ and T₄. Whereas, the lowest LAI (2.160) was recorded by T₅ which was on par with T₁₀ (2.170).

At harvest, T₉ recorded significantly the highest LAI (2.130) which was on par with T₇ (2.082). The next highest LAI (1.993) was observed in T₂ which was on par with T₁ (1.953). Whereas, the lowest LAI (1.493) was observed in T₁₀ followed by T₅ (1.585).

4.9 Drymatter production (g/pl) (Table-13)

At 30 DAP, T₉ recorded significantly the highest drymatter (4.54) which was on par with rest of the treatments except T₃ and T₅. Whereas, the lowest drymatter (3.05) was observed in T₅.

Table 13. Effect of weed control treatments on drymatter accumulation (g/pl) at different crop growth stages in potato

Treatment	Days after planting				
	30	45	60	75	At harvest
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	4.04	14.17	40.33	64.50	88.70
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	4.14	15.52	42.74	69.17	93.04
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	3.90	14.57	38.49	58.90	81.92
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	3.97	14.08	39.00	64.55	87.80
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	3.05	10.96	33.07	45.34	62.62
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	3.94	14.00	38.67	62.94	86.50
T7 Two hoeings + two HW at 30 and 45 DAP	4.14	17.64	44.36	74.98	102.98
T8 1 Hoeing + 1 HW at 30 DAP	4.10	17.34	38.00	54.30	79.50
T9 Weed free check	4.54	18.62	45.66	78.11	105.46
T10 Unweeded check (Control)	4.12	11.94	35.14	42.94	60.72
S.E.m. $\pm$	0.208	1.124	1.579	2.054	1.938
C.D. at 5%	0.618	3.337	4.690	6.110	5.754

DAP = Days after planting

HW = Hand weeding

At 45 DAP, significantly the highest drymatter (18.62) was recorded in T₉ which was on par with T₂, T₇ and T₈. Whereas, the lowest drymatter (10.96) was observed in T₅ which was on par with T₁₀(11.94). The treatments T₁, T₂, T₃, T₄ and T₆ were on par with each other.

At 60 DAP, T₉ recorded significantly the highest drymatter (45.66) which was on par with T₂ and T₇. Whereas, the lowest drymatter (33.07) was observed in T₅ and was on par with T₁₀ (35.14). The treatments T₁, T₃, T₄, T₆ and T₈ were on par with each other.

At 75 DAP, significantly the highest drymatter (78.11) was recorded in T₉ which was on par with T₇ (74.98). The next highest dry matter (69.17) was recorded in T₂ which was on par with T₁ and T₄. Whereas, the lowest drymatter (42.94) was recorded by T₁₀ and was on par with T₅ (45.34).

At harvest, T₉ recorded significantly the highest drymatter (105.46) which was on par with T₇ (102.96). The next highest drymatter (93.04) was observed in T₂ and was on par with T₁ and T₄. Whereas, the lowest drymatter (60.72) was recorded in T₁₀ which was on par with T₅ (62.62).

4.10 Yield and yield components (Table-14)

4.10.1 Number of tubers per plant

Significantly the highest number of tubers (7.99) was recorded in T₉ which was on par with T₁, T₂ and T₇.

Table 14. Effect of weed control treatments on number of tubers per plant, tuber weight (g/pl), average tuber weight (g) and tuber yield (t/ha)

Treatment	Number of tubers per plant	Tuber weight (g/pl)	Average tuber weight (g)	Tuber yield (t/ha)
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	6.66	315.36	48.05	22.99
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	6.99	328.64	48.37	23.58
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	6.11	294.78	48.75	22.17
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	6.22	310.48	47.52	22.71
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	4.77	209.66	44.18	14.90
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	6.21	300.44	48.54	22.55
T7 Two hoeings + two HW at 30 and 45 DAP	7.55	361.75	48.06	24.94
T8 1 Hoeing + 1 HW at 30 DAP	6.00	275.67	47.41	20.36
T9 Weed free check	7.99	372.34	47.04	27.25
T10 Unweeded check (Control)	4.89	204.50	42.23	13.33
S.E.m. $\pm$	0.493	5.808	3.767	0.319
C.D. at 5%	1.465	17.249	NS	0.947

DAP = Days after planting

HW = Hand weeding

Whereas, the lowest number of tubers (4.77) was observed in T₅ which was on par with rest of the treatments except T₁, T₂, T₇ and T₉.

4.10.2 Tuber weight (g/pl)

Weed free check (T₉) recorded significantly the highest tuber weight (372.34) which was on par with T₇ (361.75). The next highest tuber weight (328.64) was observed in T₂ which was on par with T₁ (315.36). Whereas, the lowest tuber weight (204.50) was recorded by T₁₀ and was on par with T₅ (209.66). The treatments T₃, T₄ and T₆ were on par with each other.

4.10.3 Average tuber weight (g)

Average tuber weight not differed significantly due to treatments.

4.10.4 Tuber yield (t/ha) (Fig. 6)

Significantly the highest tuber yield (27.25) was recorded in T₉ followed by T₇ (24.94). Among the chemical treatments T₂ recorded significantly the highest tuber yield (23.58) which was on par with T₁ and T₄. The lowest tuber yield (13.33) was recorded in T₁₀ and was on par with T₅ (14.90).

4.11 Tuber grading (Table-15, Fig.6)

4.11.1 Small tubers (<20 g, t/ha)

Significantly the lowest weight of small tubers (1.67) was recorded in T₇ which was on par with T₂ and T₉. Whereas, the highest tuber weight (3.46) was recorded in T₁₀ which was on par with T₅ (3.25).

4.11.2 Medium tubers (20-100 g, t/ha)

Weed free check (T₉) recorded significantly the highest weight of medium tubers (21.12), followed by T₇ (18.63) and T₂ (17.17). Whereas, the lowest tuber weight (7.50) was recorded in T₁₀ followed by T₅ (9.39). The treatments T₃, T₄ and T₆ were on par with each other.

4.11.3 Large tubers (>100 g, t/ha)

Significantly the highest weight of large tubers (4.91) was recorded in T₄ which was on par with rest of the treatments except T₅, T₈, T₉ and T₁₀. Whereas, the lowest tuber weight (2.26) was recorded by T₅ and was on par with T₁₀ (2.37).

4.12 Nutrient uptake by crop (Kg/ha) (Table-16, Fig.5)

4.12.1 Nitrogen uptake

Weed free check (T₉) recorded significantly the highest nitrogen uptake (97.5) which was on par with T₇ (96.9). Among the chemical treatments T₂ recorded

Table 15. Effect of weed control treatments on tuber grading small, medium and large tubers (t/ha) in potato

Treatment		Small tubers (t/ha) (<20 g)	Medium tubers (t/ha) (20-100 g)	Large tubers (t/ha) (>100 g)
T1	Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.16	16.15	4.68
T2	Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	1.82	17.17	4.59
T3	Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.34	15.22	4.61
T4	Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	2.08	15.72	4.91
T5	Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	3.25	9.39	2.26
T6	Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	2.42	15.43	4.70
T7	Two hoeings + two HW at 30 and 45 DAP	1.67	18.63	4.64
T8	1 Hoeing + 1 HW at 30 DAP	2.77	13.47	4.12
T9	Weed free check	1.74	21.12	4.39
T10	Unweeded check (Control)	3.46	7.50	2.37
S.E.m. $\pm$		0.105	0.271	0.152
C.D. at 5%		0.313	0.806	0.453

DAP = Days after planting
HW = Hand Weeding

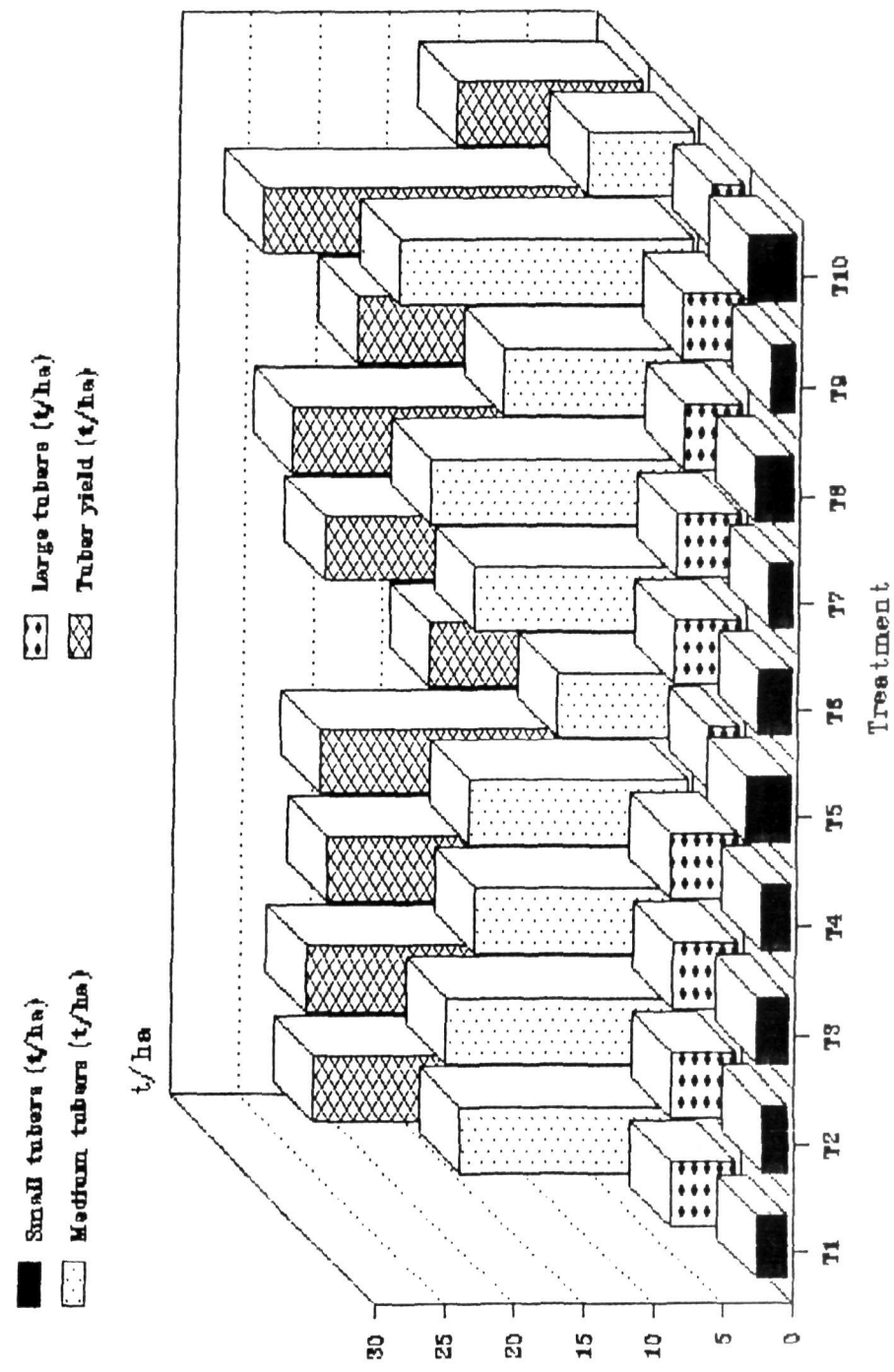


Fig. 6 Tuber yield (t/ha) and tuber grading (small, medium and large) as influenced by weed control treatments

significantly the highest nitrogen uptake (89.55) and was on par with T_1 , T_3 , T_4 and T_6 . The lowest nitrogen uptake (56.34) was recorded in T_{10} and was on par with T_5 (63.25).

4.12.2 Phosphorus uptake

Significantly the highest phosphorus uptake (8.45) was recorded in T_9 and was on par with T_1 , T_2 , T_4 and T_7 . Whereas, the lowest phosphorus uptake (5.09) was recorded by T_{10} and was on par with T_5 (5.27).

4.12.3 Potassium uptake

Weed free check (T_9) recorded significantly the highest potassium uptake (104.00) and was on par with T_7 (99.39). Among the chemical treatments T_2 recorded significantly the highest potassium uptake (94.20) and was on par with T_1 and T_4 . The lowest uptake (62.65) was recorded by T_{10} and was on par with T_5 (65.69). The treatments T_3 , T_4 , T_6 and T_8 were on par with each other.

4.13 Economics of weed control methods

The data pertaining to gross income, cost of cultivation, net income, net gain over unweeded control, cost

Table 16. Effect of weed control treatments on nitrogen, phosphorus and potassium uptake by crop (kg/ha) at harvest

Treatment	Nitrogen	Phosphorus	Potassium
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	89.26	7.43	91.55
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	89.55	7.65	94.20
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	83.72	6.93	85.86
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	86.77	7.18	88.43
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	63.25	5.27	65.69
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	84.63	7.05	86.80
T7 Two hoeings + two HW at 30 and 45 DAP	96.90	8.07	99.39
T8 1 Hoeing + 1 HW at 30 DAP	79.99	6.93	82.65
T9 Weed free check	97.50	8.45	104.00
T10 Unweeded check (Control)	56.34	5.09	62.65
S.E.m. _±	2.559	0.457	2.255
C.D. at 5%	7.601	1.357	6.697

DAP = Days after planting

HW = Hand Weeding

on weed control, net returns per rupee spent on weed control and B:C ratio is presented in Table-17.

Weed free check (T₉) recorded the highest gross income (Rs.109000/ha) followed by T₇ (Rs.99760/ha). Herbicide treatments recorded gross income with large variations. The highest being in T₂ (Rs.94320/ha) whereas, the lowest was recorded in T₅ (Rs.59600/ha). Unweeded check (T₁₀) recorded the lowest gross returns (Rs.53320/ha).

The highest net return was obtained in weed free check (Rs.86165/ha) followed by T₇ (Rs.79995/ha) and T₂ (Rs.74710/ha). Cost on weed control was maximum in weed free check (Rs.4625/ha) followed by T₇ (Rs.1625/ha) and T₂ (Rs.1510/ha). The lowest cost on weed control (Rs.617/ha) was recorded by T₅.

Net gain over unweeded control was highest in weed free check (Rs.50637/ha) followed by T₇ (Rs.44467/ha) and T₂ (Rs.39182/ha). Whereas, the lowest was recorded by T₅ (Rs.5620/ha).

Net returns per rupee spent on weed control was highest (Rs.91.70) in T₄ followed by T₆ (Rs.75.57). Whereas, the lowest was recorded in T₉ (Rs.18.63).

Benefit cost ratio (B:C) was highest in T₇ (4.04) followed by T₂ and T₄ (3.81). Whereas, the lowest B:C ratio (1.99) was recorded by T₁₀ followed by T₅ (2.23).

Table 17. Economics of weed control methods in potato

Treatment	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	Net gain over unweeded control (Rs/ha)	Cost on weed control (Rs/ha)	Net return per rupee spent on weed control (Rs/ha)	Net return per rupee spent (B:C) (Rs/Re)
T1 Fluchloralin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	91960	19152	72808	37280	1070	68.04	3.80
T2 Pendimethalin @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	94320	19610	74710	39182	1510	49.47	3.81
T3 Metolachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	88680	19020	69660	34132	962	72.41	3.66
T4 Alachlor @ 1.0 kg a.i./ha + 1 hoeing at 30 DAP	90840	18850	71990	36462	785	91.70	3.81
T5 Atrazine @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	59600	18452	41148	5620	617	66.69	2.23
T6 Paraquat @ 0.5 kg a.i./ha + 1 hoeing at 30 DAP	90200	19012	71188	35660	942	75.57	3.74
T7 Two hoeings + two HW at 30 and 45 DAP	99760	19765	79995	44467	1625	49.22	4.04
T8 1 Hoeing + 1 HW at 30 DAP	81440	18815	62625	27097	812	77.12	3.32
T9 Weed free check	109000	22835	86165	50637	4625	18.63	3.77
T10 Unweeded check (Control)	53320	17792	35528	-	-	-	1.99

DAP = Days after planting
HW = Hand Weeding

DISCUSSION

V DISCUSSION

Potato (*Solanum tuberosum* L.) is one of the most important commercial vegetable crops widely grown in India. In Karnataka, it is cultivated under rainfed conditions mainly in Belgaum and Dharwad districts of North Karnataka. Potato though possesses robust growing and quick spreading habit, is a very poor competitor with weeds on account of its extremely slow growth in the initial emergence phase. Control of weeds in the initial stages appear imperative as it plays an important role in maximising tuber production. Mechanical methods of weed control in potato crop though are effective but have certain practical limitations. Manual weeding cannot be practiced in time effectively on large scale, as labour is scarce, costly and time consuming. Incessant rains during initial periods often render the hand weeding impossible. Hence, chemical weed control appears to hold great promise in dealing with effective, timely and economic weed suppression (Lal, 1990).

The present study was initiated to find out suitable, effective and feasible weed management practice for suppression of weeds in potato, during *Kharif*, 1995, under

rainfed condition. The results obtained are discussed in this chapter.

5.1 Effect of weed control methods on weed growth

5.1.1 Weed count

The number of monocot, dicot and total weeds at all the crop growth stages (30, 45, 60, 75 DAP and at harvest) differed significantly among the treatments (Table 3,4 and 5).

Weed free check recorded minimum weed count throughout the cropping season, since no weeds were allowed to grow (Plate 2). At 30 DAP, all the chemical weed control treatments recorded lower weed count than others, proving their effectiveness in combating the weed menace during initial stages of crop growth. Except unweeded check (T_{10}) rest of the treatments recorded significantly lower monocot weeds at all the stages of crop growth. Among the chemical treatments pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (T_2) and fluchloralin @1.0 kg a.i./ha + hoeing at 30 DAP (T_1) recorded significantly lower monocot weeds at all the stages of crop growth except at 60 DAP (Plate 3 & 4). This was mainly due to effectiveness of the integrated methods in combating monocot weeds. The treatment with two hoeings + two HW at 30 and 45 DAP, was effective at critical crop growth period (30-60 DAP). Since two hoeings and two HW operations



PLATE 1. GENERAL VIEW OF THE EXPERIMENTAL SITE



PLATE 2. WEED FREE CHECK

distributed during critical stages of crop growth period which did not allowed the weeds to establish. Higher monocot weed count in all the chemical treatments at later stages of crop growth justified their degradation and ineffectiveness. These results confirmed the findings of Patel *et al.* (1983) and Bhattacharya *et al.* (1989).

Atrazine @ 0.5 kg a.i./ha + hoeing at 30 DAP (T₅) recorded the lowest number of dicot weeds (Plate 6) followed by pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (T₂) at all the stages of crop growth except at 60 DAP. The effectiveness of the treatment atrazine + hoeing was due to selective phytotoxicity of the herbicide and removal of late emerged weeds by hoeing at 30 DAP. Similarly the long range phytotoxicity in pendimethalin suppressed the weeds effectively. Though atrazine suppressed the dicot weeds effectively but was proved to be phytotoxic to potato crop. Srikanth (1975) made similar observations. Dicot weeds were effectively controlled at critical stages of crop growth with two hoeings + two HW at 30 and 45 DAP. Since two hoeings and two hand weedings were done during critical stages of crop growth.

In general, weed free check (T₉) recorded minimum weed count (no weeds), since it was maintained free of weeds throughout the crop growth period. Whereas, unweeded check (T₁₀) recorded the highest dicot weeds at all stages of crop growth except at 30 DAP, due to unchecked weed emergence (Plate 5).

These confirmed the results of Kamal Singh and Lal (1994), Lal and Jaiswal (1994).

All the weed control treatments recorded lower total weed population over unweeded check. Total weed population was lowest at all stages of crop growth except at 60 DAP with pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (T_2). This was due to continued phytotoxicity for a prolonged period even at later stages of crop growth. The lowest total weed count at 60 DAP was observed in two hoeings + two HW at 30 and 45 DAP (T_7). This was due to hoeing and HW at 45 DAP checked the weed emergence effectively. The treatments pendimethalin @ 1.0 kg a.i./ha, fluchloralin @ 1.0 kg a.i./ha and atrazine @ 0.5 kg a.i./ha each supplemented with hoeing at 30 DAP, recorded on par results with respect to total weed count. These results suggest that the integration of herbicide and hoeing practices can keep the field free from weeds for a longer period of crop growth. This corroborated the findings of Lal and Jaiswal (1994), Rajendra Singh *et al.* (1986) and Dashora *et al.* (1990). Among the cultural methods, two hoeings + two HW at 30 and 45 DAP (T_7) recorded significantly lower weed count over hoeing + HW at 30 DAP (T_8). Since second hoeing and hand weeding at 45 DAP did not allowed the weeds for profuse growth and establishment.



PLATE 3. PENDIMETHALIN @ 1.0 kg a.i./ha +
HOEING AT 30 DAP



PLATE 4. FLUCHLORALIN @ 1.0 kg a.i./ha +
HOEING AT 30 DAP

Although all the weed control methods significantly reduced the weed density over unweeded check, pendimethalin (T_2) and fluchloralin @ 1.0 kg a.i./ha each supplemented with hoeing at 30 DAP performed excellent among them.

5.1.2 Weed dry weight (g/0.25 m²)

Unweeded control (T_{10}) recorded significantly the highest weed dry weight at all stages of crop growth except at 30 DAP due to unchecked weeds. Application of herbicides supplemented with hoeing at 30 DAP resulted in reduced dry weight of weeds. Lower weed dry weight in weed control treatments may be ascribed to the less number of weeds, rapid depletion of carbohydrate reserve of weeds through rapid respiration as per Dakshinadas (1962), and may also be due to inhibited photosynthetic activity as per Hill and Santlemann (1969).

Among the treatments hoeing + HW at 30 DAP (T_8) recorded significantly the highest weed dry weight than rest of the treatments because of ineffectiveness of this method at later stages of crop growth.

On the whole, pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (T_2) recorded the lowest weed dry weight followed by fluchloralin + hoeing (T_1) at all stages of crop growth which

is attributed to the efficacy of the herbicides in suppressing the weed growth drastically. Among the cultural methods, two hoeings + two HW at 30 and 45 DAP recorded significantly lower weed weight (Plate 7) over one hoeing + one HW at 30 DAP (T_8). This was mainly due to effective suppression of weeds by second hoeing and hand weeding at 45 DAP.

The lowest weed dry weight (q/ha) was noticed in the plots (Plate 8) which received pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (6.75 q/ha) followed by fluchloralin + hoeing at 30 DAP (7.70 q/ha). Lower weed population and weed weight per unit area resulted in lower weed weight per ha. While, the highest weed weight was recorded in unweeded control (84.89 q/ha). Higher number of weeds and weed weight per unit area, attributed for higher weed weight per ha in unweeded check. These results confirm the findings of Thakral *et al.* (1988) and Hooda (1987).

5.2 Weed control efficiency

Needless to say 100 per cent weed control efficiency (WCE) in weed free check because of the season long weed free condition prevailed in that treatment. The next highest WCE (91.97%) was obtained in pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (T_2), which was on par with fluchloralin,



PLATE 5. UNWEEDDED CHECK



PLATE 6. ATRAZINE @ 0.5 kg a.i./ha +
HOEING AT 30 DAP

alachlor each @ 1.0 kg a.i./ha and atrazine and paraquat each @ 0.5 kg a.i./ha supplemented with hoeing at 30 DAP. This was mainly due to reduced weed weight in these treatments. Weed control in early stage was achieved by the chemicals and late emerged weeds were controlled by hoeing at 30 DAP.

Among the cultural methods of weed control, two hoeings + two HW at 30 and 45 DAP (T_7) recorded 86.30 per cent WCE over one hoeing + one HW at 30 DAP (69.02%). Effective suppression of weeds in two hoeings + two HW at 30 and 45 DAP is attributed to lower weed dry weight and higher weed control efficiency. In general, higher WCE under herbicide treatments can be accounted to the lower dry weight of weeds per ha. This strengthens the results of Nadekar *et al.* (1990). Thakral *et al.* (1988) and Prasad and Singh (1988).

5.3 Nutrient uptake by weeds (N , P_2O_5 and K_2O , kg/ha)

There was inverse relationship between the nutrient uptake by the crop and weeds. Crop under unweeded check (T_{10}) utilized significantly the lower quantity of nitrogen while utilization by weeds was maximum. In general the nutrients removed by weeds in unweeded check was the highest (131.50: 44.14: 137.48, N , P_2O_5 and K_2O . kg/ha respectively). This was

mainly due to unchecked weed growth and higher weed dry weight. Results are in conformity with Girijesh and Patil (1989).

Among the herbicide treatments, pendimethalin (T_2) and fluchloralin (T_1) each @ 1.0 kg a.i./ha supplemented with hoeing at 30 DAP recorded the lowest nitrogen uptake by weeds. Highest weed control efficiency of these treatments resulted in lower weed weight per unit area and thus recorded lower N, P_2O_5 and K_2O uptake by weeds. Among the cultural methods, two hoeings + two HW at 30 and 45 DAP (T_7) recorded higher weed control efficiency and lower weed weight per unit area over one hoeing + one HW at 30 DAP (T_8). Hence, lower N, P_2O_5 and K_2O uptake by weeds was recorded.

Among different weed control treatments the nutrient uptake ranged from 12.15 to 131.56 N, 4.25 to 44.14 P_2O_5 and 12.48 to 137.48 K_2O , kg/ha. Treatments with both cultural and chemical methods reduced the uptake of nutrients by weeds due to decreased weed population and weed weight for a longer period of crop growth. These results confirmed the findings of Lal and Jaiswal (1994), Nankar and Singh (1982) and Bhattacharya *et al.* (1989).

5.4 Growth and growth characters of crop

Higher emergence count was observed in weed free check (T₉) and was on par with rest of the treatments except atrazine @ 0.5 kg a.i./ha + hoeing at 30 DAP (T₅). The phytotoxic effect of the atrazine affected the crop emergence adversely. Srikant (1975) also had made similar observations.

Weed free check recorded higher plant population at harvest and was on par with rest of the treatments except the plots sprayed with fluchloralin (T₁), metolachlor (T₃), atrazine (T₅) and unweeded check (T₁₀). The lowest plant population was observed in unweeded control followed by atrazine @ 0.5 kg a.i./ha + hoeing at 30 DAP. Severe crop weed competition in unweeded check and phytotoxic effect of atrazine resulted in higher mortality. Similar observations were made by Srikant (1975).

Weed free check (T₉) recorded significantly the highest plant height at all stages of crop growth and was on par with pendimethalin + hoeing (T₂) fluchloralin + hoeing (T₁), alachlor + hoeing (T₄) and two hoeings + two HW at 30 and 45 DAP (T₇). Efficient utilization of moisture and nutrients by the crop due to maintenance of weed free condition throughout the crop growth period resulted in higher

plant height. Similarly, higher weed control efficiency of the treatments with pendimethalin, fluchloralin and alachlor recorded to higher plant height. Next to weed free check, two hoeings + two HW at 30 and 45 DAP (T₇) recorded higher plant height which was mainly due to effective suppression of weeds during critical period of crop growth and good soil physical condition created by two hoeings and two hand weeding. Nadekar *et al.* (1990) made similar observations. The phytotoxic effect in the treatment sprayed with atrazine and Severe crop weed competition in unweeded control attributed for reduced plant height.

Number of stems per hill differed significantly due to treatments at all stages of crop growth except at 30 and 45 DAP. Weed free check had recorded higher number of stems which was on par with rest of the treatments except atrazine @ 0.5 kg a.i./ha + hoeing at 30 DAP (T₅) and unweeded control. The higher number of stems in weed free check was attributed to weed free condition of the treatment throughout the crop growth period. Phytotoxic effect in the treatment atrazine @ 0.5 kg a.i./ha + hoeing and severe crop weed competition in unweeded check resulted in lower number of stems.

Significantly the highest leaf area index (LAI) was observed in weed free check which was on par with two hoeings + two HW at 30 and 45 DAP (T₇) at all stages of crop growth. Season long weed free condition in weed free check and effective suppression of weeds during critical period of crop

growth resulted in better utilization of moisture, nutrients and light by the crop which attributed to better crop growth and hence higher LAI was observed. Among the treatments with herbicide pendimethalin supplemented with hoeing at 30 DAP had recorded higher LAI due to its higher weed control efficiency. Bhattacharya *et al.* (1989) also made similar observations. Unweeded control and atrazine + hoeing (T₅) recorded lowest LAI due to severe crop weed competition and phytotoxic effect of the chemical respectively. These confirmed the findings of Bhattacharya *et al.* (1989) and Srikanth (1975). Similar trend was observed with respect to dry matter production where weed free check recorded the highest dry matter and was on par with two hoeings + two HW at 30 and 45 DAP (T₇) at all stages of crop growth. Absence of crop weed competition and good physical condition maintained through frequent hand weedings and hoeings which enabled the crop to grow luxuriantly by utilizing the light, space, moisture and nutrients resulting in higher dry matter production (Tiwari *et al.*, 1988). Reduced dry matter production in hoeing + hand weeding at 30 DAP (T₈) was attributed to higher weed count and weed weight at later stages of crop growth due to lower weed control efficiency. Among the chemical treatments pendimethalin + hoeing (T₂) recorded higher dry matter production of crop due to its

higher weed control efficiency, and was on par with fluchloralin + hoeing (T₁) and alachlor + hoeing (T₄). On the contrary plots sprayed with atrazine + hoeing recorded lower dry matter production due to phytotoxic effect. Whereas, in unweeded control lower dry matter was due to severe crop weed competition. Bhattacharya *et al.* (1989) and Srikant (1975) had made similar observations.

5.5 Yield and yield components

Weed free check recorded significantly the highest number of tubers per plant (7.99) and was on par with two hoeings + two HW at 30 and 45 DAP (T₇), pendimethalin + hoeing (T₂) and fluchloralin + hoeing (T₁). Season long weed free condition in weed free check and higher weed control efficiency in pendimethalin + hoeing and fluchloralin + hoeing attributed to better crop growth. As a consequence higher number of tubers were recorded. In two hoeings + two HW at 30 and 45 DAP (T₇) effective suppression of weeds during critical crop growth period combined with good physical condition due to frequent hoeings and hand weeding operations are attributed for higher number of tubers. Tiwari *et al.* (1988) had also made similar observations. Phytotoxic effect of atrazine in atrazine + hoeing (T₅) and severe crop weed competition in

unweeded control (T₁₀) were attributed to reduced number of tubers in these treatments. Thakral *et al.* (1988) and Srikant (1975) had made similar observations.

Significantly the highest tuber weight per plant (372.34 g/pl) was recorded in weed free check followed by two hoeings + two HW at 30 and 45 DAP (T₇). Season long weed free condition in weed free check helped the crop to utilize nutrients, moisture and light efficiently thus resulted in better tuber development. Similarly in two hoeings + two HW at 30 and 45 DAP (T₇) effective suppression of weeds during critical crop growth period and soil physical condition modified by frequent hand weeding and hoeing operations during early period of crop growth were reflected on better crop growth and tuber development, hence higher tuber weight was recorded. Among the chemicals pendimethalin (T₂) and fluchloralin (T₁) each supplemented with hoeing had recorded higher tuber weight due to their higher weed control efficiency. This confirms the results of Lal and Jaiswal (1990). On the contrary, unweeded check (T₁₀) recorded the lowest tuber weight due to severe crop weed competition followed by atrazine + hoeing (T₅) due to its phytotoxic effect.



PLATE 7. TWO HOEINGS + TWO HW AT 30 AND 45 DAP



PLATE 8. PENDIMETHALIN @ 1.0 kg a.i./ha +
HOEING AT 30 DAP

Average tuber weight did not differ significantly due to treatments.

Weed free check (T_9) recorded the highest (27.25 t/ha) tuber yield followed by two hoeings + two HW at 30 and 45 DAP (24.94 t/ha). Weed free condition maintained throughout the crop growth period in weed free check enabled the crop to utilize nutrients and moisture efficiently. Similarly, in two hoeings + two HW at 30 and 45 DAP (T_7) effective suppression of weeds during critical crop growth period combined with congenial soil physical conditions resulted in better crop growth with higher LAI, tuber weight per plant and number of tubers per plant which were attributed for higher tuber yield. Later stage crop weed competition reduced the tuber yield in hoeing + hand weeding at 30 DAP (T_8).

Among the chemicals pendimethalin + hoeing (T_2) recorded the higher tuber yield (23.58 t/ha) and was on par with fluchloralin + hoeing (T_1) and alachlor + hoeing (T_4). The higher weed control efficiency of these treatments enabled the crop to utilize nutrients, moisture and light efficiently, hence recorded higher tuber yield. On the contrary, the treatments unweeded check (T_{10}) and atrazine + hoeing (T_5) were recorded lower tuber yield due to severe crop weed

competition and phytotoxic effect of the chemical respectively. Similar results were obtained by Bhattacharya *et al.* (1989) and Srikanth (1975).

5.6 Tuber grading

All the tuber grades namely small, medium and large tubers (t/ha) differed significantly due to treatments. Significantly the highest weight of small tubers (3.46 t/ha) was recorded in unweeded control and was on par with atrazine + hoeing (T₅). Severe crop weed competition in unweeded control and phytotoxic effect of the chemical in atrazine + hoeing (T₅) resulted in poor tuber development hence higher weight of small tubers was recorded. On the other hand two hoeings + two HW at 30 and 45 DAP (T₇) recorded lowest weight of small tubers (1.67 t/ha) which was on par with weed free check and Pendimethalin + hoeing treatments. Higher weed control efficiency of these treatments enabled the crop to utilize nutrients and moisture efficiently resulting in better tuber development, hence recorded higher weight of medium and large tubers over small tubers.

The highest weight of medium tubers was recorded in weed free check (21.12 t/ha) followed by two hoeings + two HW at 30 and 45 DAP (T₇). Season long weed free condition in weed

free check and effective suppression of weeds in two hoeings + two HW at 30 and 45 DAP (T₇) enabled the crop to utilize moisture, light and nutrients efficiently resulting in better crop growth and tuber development, hence higher weight of medium tubers was recorded. Among the chemicals pendimethalin + hoeing (T₂) recorded higher weight of medium tubers due to its higher weed control efficiency. Contrary to this unweeded control and atrazine + hoeing (T₅) were recorded lowest medium tuber weight due to poor tuber development.

Significantly the highest weight of large tubers was recorded in alachlor + hoeing (T₄) and was on par with rest of the treatments except atrazine + hoeing (T₅), hoeing + hand weeding at 30 DAP (T₈), weed free check (T₉) and unweeded check (T₁₀). Higher weight of large tubers was due to higher weed control efficiency. In the treatment hoeing + hand weeding at 30 DAP (T₈) later stage crop weed competition reduced the tuber development hence lower weight of large tubers was recorded. Whereas, phytotoxic effect of the chemical in atrazine + hoeing (T₅) and severe crop weed competition in unweeded control have got adverse effects on crop growth and tuber development hence recorded lower weight of large tubers. In weed free check lower weight of large tubers was due to more number of tubers, hence photosynthates

distributed to all the tubers resulted in more of medium tubers over large tubers.

5.7 Weed index

The per cent reduction of yield due to weeds was highest in unweeded check (51.0.2 %) followed by atrazine @ 0.5 kg a.i./ha supplemented with hoeing at 30 DAP (T₅). Higher weed index in unweeded control was due to unchecked weed growth and in atrazine + hoeing (T₅) phytotoxic effect of the chemical on the crop contrary to two hoeings + two HW at 30 and 45 DAP (8.42 %), pendimethalin + hoeing (13.41 %), fluchloralin + hoeing (15.61 %) and alachlor + hoeing (16.65 %) treatments recorded significantly lower weed index due to timely and effective weed control during critical stages of crop growth thus resulting in higher tuber yield. Nadagouda (1995) made similar observations.

5.8 Nutrient uptake by potato crop (N,P,K, kg/ha)

All the weed control treatments were superior to unweeded check with respect to N, P₂O₅ and K₂O uptake by potato crop. In general uptake of nutrients by crop was inversely proportional to the uptake by weeds. Higher N, P₂O₅ and K₂O uptake was due to the effective control of weeds

during critical period of crop growth might have provided the favourable condition for efficient utilization of light, space, moisture and nutrients in weed free check (97.5:8.45:104.0 NPK, kg/ha), two hoeings + two HW at 30 and 45 DAP (96.9: 8.07:99.39 NPK, kg/ha), pendimethalin + hoeing (89.55:7.65:94.20 NPK, kg/ha). Though, atrazine + hoeing (T₅) recorded higher weed control efficiency, due to its phytotoxic effect yield was reduced drastically hence lower N, P₂O₅ and K₂O uptake was recorded. Similar results were obtained by Kamal Singh and Lal (1994), Tripathi *et al.* (1988) and Porwal and Singh (1993).

5.9 Economics of weed control methods

Weed free check (T₉) recorded the highest gross income (Rs.109000/ha) followed by two hoeings + two HW at 30 and 45 DAP (Rs.99760/ha) and pendimethalin + hoeing (Rs.94320/ha). Whereas, lowest gross income was recorded in unweeded check (Rs.53320/ha) due to lower tuber yield.

Highest net income was recorded in weed free check (Rs.86165/ha) followed by two hoeings + two HW at 30 and 45 DAP (Rs.79995/ha) and pendimethalin + hoeing (Rs.74710/ha) this was due to higher tuber yield. Unweeded control recorded



PLATE 9. EFFECT OF WEED CONTROL TREATMENTS ON
TUBER GROWTH AND DEVELOPMENT



PLATE 10. EFFECT OF WEED CONTROL TREATMENTS ON
TUBER GROWTH AND DEVELOPMENT

the lowest net income (Rs.35528/ha) because of lower tuber yield, followed by atrazine + hoeing (Rs.41148/ha).

Net gain over unweeded control was lower in atrazine + hoeing (T₅) since atrazine found to be phytotoxic for plant growth resulting in lower plant population which inturn reduced the tuber yield. Net gain over unweeded control was higher in weed free check followed by two hoeings + two HW at 30 and 45 DAP (T₇) and pendimethalin + hoeing (T₂) treatments. This was due to higher tuber yield.

Two hoeings + two HW at 30 and 45 DAP (T₇) was recorded as the best method of weed control in potato, followed by pendimethalin @ 1.0 kg a.i./ha + hoeing at 30 DAP (T₂). Though the net income was higher in weed free check it was very difficult to maintain weed free condition by manual weeding throughout the cropping season. Moreover, it is very difficult to get sufficient labourers intime for weeding.

Higher returns per rupee invested were from two hoeings + two HW at 30 and 45 DAP (Rs.4.04) followed by pendimethalin (T₂) and alachlor (T₄) each supplemented with hoeing at 30 DAP (3.81) and fluchloralin + hoeing (3.80). The lowest returns per rupee invested (B:C ratio) was in unweeded

check (Rs.1.99) followed by atrazine + hoeing at 30 DAP (Rs.2.23).

5.10 Correlation studies

Tuber yield showed very strong positive association with N, P₂O₅ and K₂O uptake by crop (0.945, 0.824, 0.901) but it was highly negatively correlated with weed index (-1.000). Similarly, dry weight of weeds at 30, 45, 60, 75 DAP and at harvest had strong positive correlation among themselves. whereas, weed control efficiency (-0.786) and N, P₂O₅ and K₂O uptake by crop (-0.657, -0.587 and -0.574) were negatively correlated.

Nitrogen, phosphorus and potassium uptake by weeds showed strong positive association with dry weight of weeds at all stages of crop growth particularly at harvest (0.796, 0.793 and 0.798).

Weed control efficiency was positively correlated with N, P₂O₅ and K₂O uptake by crop and highly negatively correlated with NPK uptake by weeds (-0.997, -0.997, -0.998) and weed index (-0.712).

Weed index was highly negatively correlated with N, P₂O₅ and K₂O uptake by crop (-0.946, -0.845 and -0.903) and

Table 18. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.000	-0.413	-0.687	-0.748	-0.743	-0.722	0.712	-1.000	0.945	0.842	0.901	-0.718	-0.728	-0.717
2		1.000	0.584	0.655	0.814	0.802	-0.664	0.413	-0.343	-0.265	-0.290	0.681	0.670	0.688
3			1.000	0.860	0.780	0.738	-0.978	0.686	-0.686	-0.549	-0.604	0.974	0.973	0.973
4				1.000	0.850	0.827	-0.928	0.748	-0.735	-0.593	-0.675	0.938	0.936	0.938
5					1.000	0.990	-0.824	0.742	-0.689	-0.616	-0.608	0.837	0.834	0.838
6						1.000	-0.786	0.721	-0.657	-0.587	-0.574	0.796	0.793	0.798
7							1.000	-0.712	0.707	0.569	0.631	-0.997	-0.997	-0.998
8								1.000	-0.946	-0.845	-0.903	0.718	0.727	0.716
9									1.000	0.888	0.947	-0.705	-0.709	-0.703
10										1.000	0.913	-0.566	-0.574	-0.565
11											1.000	-0.631	-0.641	-0.630
12												1.000	0.999	0.999
13													1.000	0.998
14														1.000

1-Yield, 2-Weed dry weight 30 DAP, 3-Weed dry weight 45 DAP, 4-Weed dry weight 60 DAP, 5-Weed dry weight 75 DAP, 6-Weed dry weight at harvest, 7-Weed control efficiency, 8-Weed index, 9-Nitrogen uptake by crop, 10-Phosphorus uptake by crop, 11-Potassium uptake by crop, 12-Nitrogen uptake by weeds, 13-Phosphorus uptake by weeds, 14-Potassium uptake by weeds.

positively correlated with N, P_2O_5 and K_2O uptake by weeds (0.718, 0.727 and 0.716).

5.12 Practical application of the result

Based on the results of the investigation carried out on the weed management practices in potato, two hoeings + two HW at 30 and 45 DAP can be advocated for satisfactory weed control, higher tuber yield and net returns in potato. The next best option for effective weed control in potato was with pendimethalin @ 1.0 kg a.i./ha supplemented with hoeing at 30 DAP. Wherever manual weeding is not possible second option was found to be satisfactory for effective weed control, higher tuber yield and net income from potato in *Kharif* under rainfed condition.

5.12 Future line of work

The aspects of which further investigations in weed management practices in potato suggested are as under;

- 1) Screening of herbicide mixtures and their doses to achieve effective control of broad spectrum weeds in potato.
- 2) Studies on weed management practices in potato based cropping systems.
- 3) Studies on effect of these herbicides on soil microflora.
- 4) Residual effect of herbicides on succeeding crop.

SUMMARY

VI SUMMARY

A field experiment was conducted on black clay soil at the Agricultural College Farm, University of Agricultural Sciences, Dharwad, during *Kharif* 1995 to study weed management practices in potato under rainfed conditions. There were 10 treatment combinations : Fluchloralin (pre-em) @ 1.0 kg a.i./ha + hoeing at 30 DAP, pendimethalin (pre-em) @ 1.0 kg a.i./ha + hoeing at 30 DAP, Metolachlor (pre-em) @ 1.0 kg a.i./ha + hoeing at 30 DAP, Alachlor (pre-em) @ 1.0 kg a.i./ha + hoeing at 30 DAP, Atrazine (pre-em) @ 0.5 kg a.i./ha + hoeing at 30 DAP, Paraquat (post-em) @ 0.5 kg a.i./ha + hoeing at 30 DAP, Two hoeings + two HW at 30 and 45 DAP, one hoeing + one HW at 30 DAP, weed free check and weedy check.

The experiment was laid out in randomised block design with three replications. Observations on weed, crop growth (at 30, 45, 50, 75 DAP and at harvest) yield and yield components, nitrogen, phosphorus and potassium uptake by crop and weeds were recorded. Correlation matrix and economics were worked out. The results obtained are summarized here.

6.1 Weeds

In general weed control treatments recorded significantly lower number of weeds than un weeded check at all the stages of crop growth. Weed free check recorded the lowest weed count as it was maintained free of weeds

throughout the crop growth period. However, pendimethalin @ 1.0 kg a.i./ha + hoeing recorded significantly lower weed count which was on par with fluchloralin + hoeing and atrazine + hoeing at all the stages of crop growth. Dry weight of weeds at 30 DAP was highly positively correlated with dry weight of weeds both at 75 DAP and at harvest. While, it was negatively correlated with weed control efficiency. Dry weight of weeds at harvest was highly negatively correlated with weed control efficiency.

Significantly higher weed dry weight was noticed in unweeded control at all the growth stages. While, the lowest weed dry weight was recorded in pendimethalin @ 1.0 kg a.i./ha + hoeing at 30 DAP.

Weed control efficiency was highly negatively correlated with dry weight of weeds at 45, 60, 75 DAP and at harvest. Pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP recorded significantly the highest weed control efficiency (91.91%) and lowest was with one hoeing + one HW at 30 DAP (69.02%).

Weed index was highly negatively correlated with yield. Per cent reduction in yield of potato due to weed infestation was significantly higher in unweeded control

(51.02%) followed by atrazine @0.5 kg a.i./ha + hoeing (45.31%). Whereas, the lowest yield reduction was in two hoeings + two HW at 30 and 45 DAP (8.42%) followed by pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP (13.41%).

6.2 Potato

6.2.1 Growth parameters

Significantly the highest plant height was recorded in weed freed check and was on par with rest of the treatments except in atrazine + hoeing and unweeded control at all the stages of crop growth except at 30 DAP.

Similarly number of stems per hill differed significantly due to treatments at all the stages of crop growth except at 30 and 45 DAP. Significantly the highest number of stems per hill was recorded in weed free check and was on par with rest of the treatments except atrazine + hoeing and unweeded control.

Weed free check recorded significantly the higher leaf area index at all the stages of crop growth followed by two hoeings + two HW at 30 and 45 DAP and pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP. Whereas, the lowest LAI was observed in atrazine + hoeing and unweeded control, except at

30 DAP, where unweeded control was on par with rest of the treatments.

Significantly the highest dry matter production was recorded in weed free check and was on par with two hoeings + two HW at 30 and 45 DAP at all the stages of crop growth followed by pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP. Whereas, the lowest was recorded by the treatments unweeded control and atrazine + hoeing at 30 DAP.

6.22 Yield and yield components

Significantly the highest number of tubers per plant and tuber weight per plant were recorded in weed free check and was on par with two hoeings + two HW at 30 and 45 DAP followed by pendimethalin + hoeing at 30 DAP. Whereas, the lowest was recorded in the treatments unweeded control and atrazine + hoeing at 30 DAP. Weed free check recorded significantly the highest tuber yield (t/ha) followed by two hoeings + two HW at 30 and 45 DAP and pendimethalin + hoeing at 30 DAP. Whereas, the lowest was observed in unweeded control and was on par with atrazine + hoeing at 30 DAP.

Significantly the highest weight of small tubers was recorded in unweeded check which was on par with

atrazine + hoeing at 30 DAP. Whereas, the lowest was recorded in two hoeing + two HW at 30 and 45 DAP. Weed free check recorded significantly the highest weight of medium tubers followed by two hoeings + two HW at 30 and 45 DAP. Whereas, the lowest was observed in unweeded control. Weight of large tubers was significantly higher in alachlor + hoeing at 30 DAP and was on par with rest of the treatments except atrazine + hoeing at 30 DAP, one hoeing + one hand weeding at 30 DAP, weed free check and weedy check. Whereas, the lowest was recorded in atrazine + hoeing at 30 DAP, which was on par with unweeded control.

6.3 Nutrient uptake by crop and weeds

There was inverse relationship between the nutrient uptake by the crop and the weeds. Unweeded check recorded maximum uptake of nitrogen, phosphorus and potassium by weeds which was significantly higher than rest of the treatments.

Minimum uptake of nitrogen, phosphorus and potassium by weeds was noticed in pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP. In general all the weed control treatments recorded higher nitrogen, phosphorus and potassium uptake by the crop over unweeded control.

6.4 Economics of weed control

The maximum net income and highest net gain over unweeded control was obtained from weed free check closely followed by two hoeings + two HW at 30 and 45 DAP and pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP.

Net returns per rupee invested was highest (Rs.4.04) in two hoeings + two HW at 30 and 45 DAP, followed by pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP and alachlor @1.0 kg a.i./ha + hoeing at 30 DAP (3.81).

Based on the investigation it can be inferred that two hoeings + two HW at 30 and 45 DAP was more economical which was closely followed by pendimethalin @1.0 kg a.i./ha + hoeing at 30 DAP, in potato under rainfed condition.

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APPENDICES

ಕೆ.ಪಿ. ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ಗ್ರಂಥಾಲಯ
ಗಾ.ಕೆ. ರಸ್ತೆ, ಬೆಂಗಳೂರು-65
22 MAY 1997
ಅನುದಾನ ಸಂಖ್ಯೆ **Th 4421**
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Appendix - I

Sl.No	Particulars	Price (Rs)
Inputs		
1	Potato (Kufri-chandramukhi) seeds	650.00 /q
2	Urea	340.00 /q
3	Single super phosphate	282.00 /q
4	Muriate of potash	435.00 /q
5	Fluchloralin	340.00 /l
6	Pendimethalin	360.00 /l
7	Metolachlor	325.00 /l
8	Alachlor	236.00 /l
9	Atrazine	152.00 /kg
10	Paraquat	151.00 /l
11	Man and women labour	25.00 /day
12	Bullock pair	125.00 /day
Output		
13	Potato tubers	400.00 /q