“Evaluation of Imazethapyr 10 % SL Herbicide Against Weeds in Soybean [*Glycine max* (L.) Merrill]”

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
In partial fulfillment of the requirements
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MASTER OF SCIENCE

In

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(AGRONOMY)

By

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2012

CERTIFICATE – I

This is to certify that the thesis entitled ***"Evaluation of Imazethapyr 10 % SL herbicide against weeds in soybean*** **[*Glycine max* (*L.*) Merrill]"** *submitted in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)*** *of* ***Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur*** *is a record of the bonafide research work carried out by* ***Miss.URVASHI DUBEY*** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

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

Place: Jabalpur

Date

Dr. Girish Jha

(Chairman of the Advisory Committee)

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member	**Dr. B.S.Dwivedi**	**…………………………**
Member	**Dr. R.B. Singh**	**…………………………..**

CERTIFICATE – II

This is to certify that the thesis entitled ***"Evaluation of Imazethapyr 10 % SL herbicide against weeds in soybean*** **[*Glycine max* (*L.*) Merrill]"** *submitted by* ***Miss Urvashi Dubey*** *to the* ***Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur*** *in partial fulfillment toward the requirement for the degree of* ***"MASTER OF SCIENCE IN AGRICULTURE" (AGRONOMY)*** *in the Department of* ***Agronomy*** *has been approved by the Student's Advisory Committee and the External Examiner's after an oral examination of the same.*

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Place: Jabalpur

Date: / /2012

(URVASHI DUBEY)

ABBREVIATIONS

Words		Abbreviations
Active ingredients	:	a.i.
Centimeters	:	cm
Centigrades	:	°C
Co workers	:	*et al.*
Critical difference	:	C.D.
Date of sowing	:	DOS
Days after sowing	:	DAS
Degree of freedom	:	df
Figure	:	Fig.
Grams	:	g
Hand weeding	:	HW
Harvest Index	:	HI
Hectare	:	ha
Kilograms	:	kg
Metre	:	m
Nitrogen	:	N
Not significant	:	NS
Percentage	:	%
Phosphorus	:	P_2O_5
Potassium	:	K_2O
Quintal	:	q
Rupees	:	Rs
Standard error of means	:	SEm±
Treatments	:	T
Weed control efficiency	:	WCE
Weed index	:	WI
Standard error of difference	:	SEd

INTRODUCTION

Soybean is one of the important oil seed crops of India with annual production of 9.34 million tones. Madhya Pradesh contributes nearly 55.68% in total production of soybean in the country. But the productivity (12q/ha) of the crop is quite low as against the advanced countries (Agricultural statistics 2008)

India occupies premier position in global oil seed scenario accounting for about 19% area and 9% production. Among oilseeds,soybean is one of the important crops of India.It has also been termed as miracle bean, because it contains about 40% protein well balanced in essential amino acid ,20% oil rich in poly unsaturated fatty acids,specially omega 6 and omega 3 fatty acids,6-7%total minerals,5-6% crude fibre and 17-19% carbohydrates (Chauhan and Joshi, 2005)

In kharif season, it has high yielding capacity, but weed infestation is one of the major constraints in soybean cultivation (Bhan et al, 1974).The weeds if not controlled during critical period of weed crop competition there is reduction in the yield of soybean from 58 to 85% depending upon type of weeds and weed intensity (Kolhe *et al,* 1998)

Mostly the farmer are using pre plant incorporation and pre-emergence herbicides for weed control in soybean,but their efficacy is reduced due to variation in climatic and edaphic factors.Sevral herbicides Viz. fluchloralin, trifluralin, metolachlor,alachlor and pendimethalin etc. are presently being used for controlling weeds associated with soybean, but these herbicides are found not much effective to control many broad leaved weeds existing in soybean.Therefore, it is imperative to evaluate efficacy of suitable early post-emergence herbicide, which could be able to control the dominating weeds in soybean field. According to Tiwari et al (1997), imazethapyr may be very effective post emergence herbicide for controlling both broad and grassy weeds in soybean.Weed Infestation causes more reduction in soybean yield.

The imazethapyr is a molecule of herbicide, which largely control the wide range of weed-flora having the mode of action. ie inhibition of Acetolactate synthase(ALS) or Acetohydorxyacid synthase (AHAS) under new group of herbicide –imidazolinone. Hence, imazethapyr suppresses both broad and narrow leaved weeds in soybean efficiently to control the weeds.

Although, the ecological conditions of the state are congenial for soybean production, but the yield is substantially low, despite of the best management practices. The poor weed management practices deprive the crop of its major requirement of nutrients, soil moisture, sunlight and space to poor crop growth yield. The stress is mainly due to presence of dominating grassy weeds viz. *Echinochloa crusgalli*, *Setaria glauca,*Cypress *spp*. and broad leaved weeds viz. *Commelina benghalensis*, *Commelina communis*, *Physalis minima*. (Tiwari and Kurchania, 1990). The yield losses to the extent of 30 to 100 % due to weed -competition have been estimated (Bhan,1976), which mostiy depend upon the type of weed species, their density, per unit area and duration of weed infestation.The period of crop-weed competition lies between 15 to 45DAS After that the crop cover and take care of emergent late shift of weeds, which are smothered by the lush canopy of soybean crop .The production potential of the crop could not be realized fully, if weeds are not controlled with in the critical period of crop- weed competition.

Generally, weeds are controlled by cultural, mechanical and chemical methods either done in combinations or seprately. But cultural and mechanical methods have several limitations such as availability of sufficient man power at the peak period demand with the higher labour cost. Under such conditions, chemical weed management is the only option,which can reduced the cost and also control the weeds most effectively. Hence on the basis of above facts, present experiment "Evaluation of Imazethapyr 10% SL herbicide against weeds in soybean" has been studied under agro-climatic conditions of Jabalpur with the following objectives :

1. To study the associated weed flora in soybean.
2. To observe the activity of early post emergence herbicides against weeds in soybean.
3. To study the effect of weed control treatments on growth parameters, yield attributes and yield of soybean.
4. To determine the economics of the treatments.

REVIEW OF LITERATURE

Weeds are ubiquitous and their effects create enormous losses not only in crop yield and quality but also remove a large amount of plant nutrients from the soil. Chemical weed control in various crops has received adequate attention by scientists engaged in the progress of weed science in India, during the recent past, and soybean crop is not the exception. The available literature on associated weed flora and effect of herbicides on weed intensity on crop growth, yield attributes and yield of soybean have been compiled and mentioned briefly under appropriate heads:

2.1 Associate Weed Flora

The associated weed flora with a particular crop, depends on environmental conditions, soil types crop, management practices and their identification provide the basis to formulate their effective control measures.

Singh *et al,* (1998) reported *Echinochloa crusgalli, Phylanthus niruri, Cyperus rotundus, Euphorbia hirta and Alternanthra spp.* as major associated weeds of soybean on medium black soils at Jabalpur.

Mandloi *et al*, (2000) reported that the monocot and dicot weeds species were associated with soybean. Among monocots, *Cyperus rotundus, Dinebra arabica, Digitaria sanguinalis, Echinochloa colona, Cynodon axillaries* and *Commelina benghalensis* and among dicots *Caesulia axillaries, Eclipta alba, Ageratum conyzoides, Acalypha indica, Anotis monttulani* and *Corchorus* spp. were recorded.

Billore *et al*, (2001) studied the prominence of weed species in soybean and reported that *Echinochloa crusgalli, Dinebra arabica, Dinebra retroflexa, Digitaria sanguinalis, Cyperus rotundus, Cynodon dactylon, Euphorbia geniculata, Digera arvensis, Eclipta alba, Corchorus olitorius* and *Acalypha indica* were the major weeds infesting the soybean crop at Indore, Madhya Pradesh.

Bhattacharya *et al*, (2002) reported that in Nadia (West Bengal) *Digera arvensis, Spilanthes acmella* (*Blainvillea aemella*), *Phyllanthus niruri, Dactyloctenium aegyptium, Eleusine indica* and *Cyperus rotundus* were dominant weeds in soybean.

Jain and Kurchania (2002) reported that the experimental field of soybean was mainly dominated by monoctyledonous weeds comprising of *Echinochloa crusgalli, Digitaria adsendens, Dinebra arabica, Commelina communis* and *Cyperus rotundus*, whereas *Phyllanthus niruri, Cyanotis axillaris, Corchorus acutangulus* and *Cichorium intybus*, constituted the dicotyledous weeds.

Nimje *et al*, (2002) reported that *Echinocloa crusgalli, Cynodon dactylon, Cyperus rotundus, Trianthema portulacastrum, Digera arvensis, Phyllanthus niruri, Euphorbia hirta* and *Celosia argentea* as the major weeds associated with soybean crop.

Singh *et al*, (2002) reported that the experimental field of soybean was infested mainly with *Echinocloa crusgalli, E. colona, Cyperus rotundus* and *Cechania argentea* with higher density.

In Jabalpur district of Madhya Pradesh, in general, the soybean fields are severely infested with monocot and dicot weeds. In the field studies, Bhan and Kewat (2003) observed that *Phyllanthus niruri*, *Echinochloa crus-galli, Cynotis auxiliaries* and *Commelina communis* were the rampant weeds in soybean ecosystem. Beside these, *Eclipta alba, Ageratum conyzoides, Parthenium hysterophorus, Cichorium intybus, Cynodon dactylon* and *Cyperus rotundus* also marked their presence in small numbers. At the same place,

Dixit *et al.* (2003) noted that *Euphorbia geniculata* and *Physalis minima* were the major associated weeds in soybean, whereas other weeds like *Phylanthus niruri, Chichorium intybus, Cyperus rotundus* and *Ageratum conyzoides* were present in low density,

Vyas and Jain (2003) at Sehore (M.P.) observed *Caesulia axillaries* Roxb., *Cyperus rotundus* , *Digitaria senguinalis* , *Echinochloa Colonum* , *Commelina benghalensis* , *Acalypha indica* and *Anotic monthuloni* Hook. as major associate weed flora in soybean,

Bhattacharya *et al*, (2004) reported that in Jhargram (West Bengal), *Echinochloa colonum* (*E. colona*), *Cynodon dactylon, Digitaria sanguinalis, Digera arvensis, Trianthema portulacastrum Euphorbia hirta* and *Cyperus rotundus* were dominant weeds in soybean,.

Kalpana and Velaytham (2004) reported that *Cyperus rotundus, Trianthema portulacastrum, Eleusine indica, Chloris barbata, Tridex procumbens, Caesuilia axillaries, Ceolosia argentia and Eclipta alba* were the predominant weed species in soybean,

Halvankar *et al,*(2005) observed *Digitaria muricata* Mart., *Acalypha ciliata* Forssk., *Septaria verticillata* Beauv., *Parthenium histerophorus* , *Cyperus rotundus*, *Commelina benghalensis* , *Amaranthus roxburghianus* Nevski., *Partulaca oleracea* etc. as dominent weed flora in soybean at Agharkar Research Institute's experimental farm at Hol, Dist. Pune (M.S.).

Girothia and Thakur (2006) reported *Echinochloa spp*., *Cynodon dactylon*, *Dinebra arebica, Cynotis auxillaris, Commelina benghalensis, Euphorbia geniculata, Acalypha indica, Corchorus acutangulis, Digera arvensis, Xanthium strumarium, Achyranthus aspera, Cyperus rotundus, Eleusine indica* and *Panicum repens* as the major associated weeds in soybean at college of agriculture, indore (M.P.).

Prabha *et al*. (2007) in a field experiment found that *Cynodon dactylon*, *Cyperus rotundus, Digera arvensis* and *Trianthema portulacastrum* were the dominant weeds in soybean.

Tomar *et al.* (2007) most prevalent weeds infesting *Kharif* soybean, jowar (*Sorghum bicolor*) and pigeon pea in Mandsour and Ratlam district of M.P., India were *Dinebra arveca* and *Echinochloa crusgalli* followed by *Disteria species*.

Kushwah and Vyas (2008) at Sehore reported that *Cyperus rotundus, Digitaria senguinalis, Echinochloa colonum, Commelina benghalensis, Cynotis axillaries and Dinebra arabica* were dominant weeds among monocots in soybean whereas, *Caesuilia axillaries, Acalypha indica, Anotis mothulani, Digera arvensis, Xanthium strimarium, Phylanthus maderaspteris, Corchorus sp.* and *Euphorbia sp.* were among dicots.

Pratap Singh and Raj Kumar (2008) observed that experiment field was infested mainly with monocot weeds (*Cynodon dactylon, Cyperus rotundus, Echinochloa crusgalli* and *E. colona)* and dicot weeds (*Celosia argentea, digera arvensis, Commelina benghalensis* and *Amaranthus viridis*) as associated weed flora of soybean at M.P.U.V. & T. Agriculture Research Station, Kota (Rajasthan).

2.2 Critical Period of Crop-Weed Competition

The shortest time span in ontogeny of crop growth, when it is most sensitive to weed competition and when weeding results in highest economic return is called critical period of weed competition.

Ponnuswamy *et al*, (1996) noted that the critical period of weed competition for soybean was 15-60 DAS.

Tiwari *et al*, (1997) found that weeds in general produce competitional stress on crop growth especially during the first 40 DAS and the yield reduced markedly.

Hadizadeh and Rahiman, (1998) in Mashhad (Iran) in a field study found that 23 Days after emergences determined as the critical time for weed control in soybean.

Mahapatra and Haldar, (1998) observed that the most critical period for weed competition was 4 to 6 weeks after sowing.

Chhokar and Balyan, (1999) carried out field trials at Hisar (Haryana) to evaluate critical period of weed control. They found that period between 30 to 45 DAS was critical for crop-weed competition and weed free situation up to 45 DAS resulted in 74% increase in seed yield of soybeans over unweeded control.

Cowan *et al*, (1999) revealed that soybean yield was less with high densitis of *Amaranthus* spp. and *Echinochloa crusgalli*.

Panneerselvam and Lourduraj, (2000) reported that the most critical period of crop-weed competition for soybean was upto 45 DAS. Yield reduction in soybean ranged from 10 to 86 per cent, depending upon the degree of weed infestation.

Gaikwad and Pawar, (2002) at Rahuri noted that critical period for weed control in soybean was between 20 to 40 days after sowing.

Kermati *et al,* (2008) in an experiment observed that the highest number of pods per plant was obtained from plots which kept weed free for whole season control. Result showed that weed control should be carried out between 26 to 63 days after sowing to provide maximum grain yield.

2.3 Losses due to Weeds

The competition is a natural force whereby crop and weed plants tend to attain a maximum combined growth and yield with the advancement of each species being to some extent at the expense of other. Competition may exist between crop and weed plants and also between individual plants of same species. Agronomic research in major soybean growing countries of the world depends on growth habit of weeds, their relative density and periodicity of crop–weed competition. The loss in yield due to weed infestation ranges from 20 to 80 per cent. Yield reduction to the tune of 30 to 100 per cent in India, 20 to 40 per cent in USSR, 8 to 24 per cent in USA and 6 to 50 per cent in UK are most common.

Singh and Sharma, (1990) observed 53 per cent loss in grain yield due to uncontrolled weeds in weedy plotsof soybean.

Jain and Kurchania, (2002) at Jabalpur reported that the yield losses due to uncontrolled weeds in soybean crop were upto 91.91%.

Singh *et al*, (2002) at Kota (Rajasthan) recorded 53.61 per cent reduction in seed yield of soybean when the weeds were allowed to grow along with the crop.

Singh *et al,* (2003) concluded the season long weed competition caused 82% reduction in the grain yield of soybean when compared with weed free treatment. The highest grain yield (1864 kg/ha.) was observed in weed free plot.

Singh and Jolly, (2004) reported 58.8 percent reduction in the grain yield under weedy check compared to two hand weeding done at 30 and 45 days after sowing.

Singh *et al,* (2004) observed that 88.6 percent reduction in the grain yield of soybean due to weeds in weedy check.

Singh *et al,* (2006) at Jabalpur found that Uncontrolled weeds caused 59% seed yield loss compared to the 0.5kg metribuzin/ha treatment.

Sharma *et al,* (2008) in a field experiment at Assam recorded 83% reduction in grain yield under weed control treatment.

2.4 Weed Density

Rana and Angiras (1996) at Palampur noted significantly lower weed biomass and weed intensity with imazethapyr 200 g/ha as pre emergence over weedy control. Hart *et al*. (1998) in USA found that thifensulfuron between 2.2-3.8 kg/ha in combination with bentazon 420 g/ha may be safely applied to soybean for broadleaf weed control.

Tiwari *et al.* (1996) studied the bioefficacy of chlorimuron-ethyl (25% WP) at 6 g/ha for weed control in soybean. All of the broad leaved weeds and purple nutsedge *(Cyperus rotundus)* were susceptible to chlorimuron-ethyl at all the rates and stages especially at 15 days stage. Herbicide efficacy increased with increased rates, barnyard grass *(E. crusgalli)* showed only cessation in growth.

Askew *et al*, (1999) found that acifluorfen + bentazon or chlorimuron as post emergence controlled yellow nut sedge *(Cyperus esculentus*). Similarly, (Patil *et al*., 1999) observed that fenoxaprop-p-ethyl applied alone at 21 days after sowing (DAS) proved effective against annual grassy weeds.

2.5 Effect of Weed Management Practice in Soybean

2.5.1 Hand weeding

Among the different methods of weed control, manual weeding is the conventional practice and also most effective in various crops including soybean. Availability of required manpower at right time and high labour cost are some of the limitations of this method. There is difficulty in performing this operation particularly during rainy season due to unfavourable weather conditions and sticky nature of clayey soils, resulting in delay in weed control.

Mishra *et al,* (2001) observed that two hand weeding at 22 and 45 DAS resulted in highest WCE (95%), lowest Weed Index (0%) and growth characters *viz.* plant height, number of branches, number of leaves, leaf area index and dry matter accumulation were superior under two hand weeding over rest of the treatments.

Chouhan *et al,* (2002) at Gwalior observed that two hand weedings at 20 and 35 day after sowing led to recorded thehigher seed yield (1156 kg/ha) and proved good to pre-emergence application of pendimethalin 1.5 kg/ha (1149 kg/ha) and alachlor 1.5 kg/ha (1146 kg/ha).

2.5.2 Imazethapyr

Mishra *et al,* (2001) at Indore notice that post emergence application of imazethapyr was found to be more effective in controlling weed population, weed dry biomass, weed index and increased weed control efficiency at 60 days after sowing.

Vyas and Jai, (2003) reported that among post-emergence herbicides, combi product of imazamox + imazethapyr at 75g/ha were effective against both monocot and dicot weeds and has highest weed controlled efficiency and also significantly increased the value of yield attributes and yield.

Halvankar *et al,* (2005) in an experiment found that application of Imazamox + Imazethapyr @75gha^{-1} effectively controlled the weeds over weedy check and also increased the yield of soybean. Kushwah and Vyas (2005) at Sehore (M.P.) reported that application of imazethapyr 10% at 75 g/ha was the most effective in reducing weed biomass and gave the highest weed control efficiency over other pre and post-emergence herbicides. Imazethapyr 10% at 75 g/ha also gave the highest value of growth parameters, yield attributes, harvest index and yield among all herbicidal treatments.

Girothia and Thakur, (2006) at Indore observed that application of post-emergence herbicides i.e. Imazamox + Imazethapyr @ 800 to 1000 ml ha^{-1} or Imazethapyr @ 75 to 100 g a.i. per ha^{-1} at 25 DAS were found as effective as weed free or check herbicide those were reflected in higher weed control efficiency, lower weed index and enhanced seed yield over weedy check.

Kothawade et al, (2007) at Rahauri observed that application of Imazethapyr 75 and 100 g a.i. ha^{-1} at 25 DAS effectively reduced the dry weight of weeds and significantly increased the yield over weedy check.

Pandey *et al,* (2007) in a field experiment at Indore reported that post-emergence application of imazamox + imazethapyr

(800 ml per hectare) was effective to reduced the total density of weeds as well as their total dry biomass at 60 DAS. They also reported that seed and straw yields were higher under imazamox + imazethapyr (800 ml per hectare).

Shete *et al,* (2007) a field experiment was conducted at Rahuri and found that weed control efficiency and dry matter of weeds were observed significantly higher in the application of imazethapyr @ 87.5 g a.i. /ha followed by imazethapyr 75 g a.i. /ha at harvest.

Tiwari *et al,* (2007) in a field experiment at Jabalpur found that post emergence application of Imazethapyr at 75 g ha^{-1} controlled broad leaf weeds in soybean.

Pratap Singh and Raj Kumar, (2008) in a study at Kota reported that post emergence application of imazethapyr (100 g/ha) significantly reduced weed density and weed dry matter at all the stages of observation. He furtherreported significant increase in seed yield of soybean compared to weedy check.

Kushwah and Vyas, (2009) in a field experiment at Sehore reported that two hand weeding gave significantly higher values for crop growth rate, net assimilation, oil and protein contents over no weed control, closely followed by the post-emergence application of imazethapyr 10%. Significantly higher LAI was also recorded in application of imazethapyr 10% SL at 75 g/ha.

2.5.3 Fenoxoprop ethyl

Barros *et al*. (1992) at Brazil evaluated the efficacy and selectivity of some post-emergence herbicides including fenoxaprop-p-ethyl @ 33 g/ha for controlling grasses in soybean. The results revealed that grasses were controlled effectively by fenoxaprop-p-ethyl.

Tu *et al*, (1994) reported that the post-emergence application of quizalofop-p-ethyl and fenoxaprop-p-ethyl were effective against wild oat and increased the grain yield of soybean effectively.

Vidrine *et al*, (1995) at Alexandria evaluated sethoxydin and fenoxaprop-p-ethyl alone and with chlorimuron-ethyl against *Sorghum helepense* and *Echinocloa crusgalli.* The graminicides applied alone resulted in 83-99 per cent control of both the weeds. The yield was found to be generally greater, following herbicide application when compared with control plot. It was further noted that Chlorimuron-ethyl was the most antagonistic of the broadleaf herbicide towards the activity of graminicides.

Patil *et al*, (1999) noted that fenoxaprop-p-ethyl at 70 g/ha applied alone at 14 and 21 DAS proved effective against annual grassy weeds and no phytotoxic symptoms on soybean crop were observed.

Kurchania *et al*, (1999) tested fenoxaprop-p-ethyl @ 50, 70 and 100 g/ha at 14 and 21 DAS alone and tank mixed with lactofen@ 90, 120 and 150 g/ha at 21 DAS. The study revealed the effective control of *Echinochloa crusgalli* @ 100 g/ha at 21 DAS but when it was tank mixed with lactofen, its bioefficency was reduced. The higher weed control efficiency was noted under fenoxaprop-p-ethyl applied @ 100 g/ha at 21 DAS (66%) followed by similar rate at 14 DAS (60.3%) seed yield was highest under hand weeding (1813 kg/ha) followed by fenoxaprop-p-ethyl @ 100 g/ha at 21 DAS (1632 kg/ha) and both were on par.

Kurchania *et al*, (2001) studied the bio-efficacy of post emergence herbicides for weed control in soybean and observed that fenoxaprop-p-ethyl at 70 g/ha controlled the most dominant weed *Echinocloa crusgalli,* effectively.

Jain and Kurchania (2002) observed that application of fenoxaprop-p-ethyl @ 70 g/ha was very effective for controlling weeds in soybean with weed control efficiency of 70.23 per cent

2.5.4 Phytotoxicity of Herbicides

Tiwari *et al,* (1996) observed that chlorimuron-ethyl (25% WP) cause yellowing of leaves and cessation of growth in soybean, but this negative effect disappeared after a week.

Foloni and Christoffoleti, (1998) found that the newly introduced herbicides carfentrazone and carfentrazone-ester sprayed alone and in mixture with chlorimunon-ethyl for weed control in soybean. They did not find any phytotoxicity on the vegetative growth of soybean. Nelson and Renner (1998) evaluated the efficacy of imazethapyr plus quizalofop applied as post emergence in soybean and reported that soybean injury from all herbicides was minimal at 14 days after treatment.

Patil *et al*, (1999) noted that fenoxaprop-p-ethyl at 70 g/ha applied alone at 14 and 21 DAS did not show any phytotoxic symptoms on soybean crop.

Nadasy *et al*, (2000) in green house trial tested three herbicides in single and double dose to determine the sensitivity of 4 soybean varieties. Imazethapyr had no harmful effects on any variety on either rates. Metolachlor only caused significantly damage, including reduction in leaf area and fresh leaf weight and phytotoxicity symptoms when applied at the double dose. The double dose of metribuzin caused the serious crop damage out of the three herbicides at Keszthely, Hungary.

2.5.5 Growth and Development of Soybean

Scarponi *et al,* (1996) observed decreased dry weight, increased fresh weight, phenylalanine ammonia-lyase and tyrosine-ammonia-lyase activities under imazethapyr (6 and 9 g/ha) treated roots and shoots of soybean compared with untreated control.

Marenco and Lopes, (1998) found that total plant dry matter accumulation was reduced by the herbicidal treatments upto 28 DAE. During the vegetative growth stages, the assimilation rate and specific leaf area were greater in herbicide treated plants, while leaf area ratio, relative growth were lower.

2.5.6 Yield and Yield Attributes

Patil *et al*, (1999) noticed that lactofen applied alone or in combinations with fenoxaprop-p-ethyl resulted in higher seed yields (2.12-2.25 t/ha), which was significantly more than in the untreated control plot (1.48 t/ha) and comparable to weed free plot (2.88 t/ha). They also found that fenoxaprop-p-ethyl at 50-100 g/ha applied alone gave similar seed yield (1.57-1.74 t/ha) to that of untreated control (1.48 t/ha).

Godara and Deshmukh, (2000) reported that the post emergence application of imazethapyr at 75 g/ha at 25 DAS, gave higher grain yield over other herbicide.

Singh *et al*, (2003) concluded that on an average season long weed competition caused 82.0 per cent reduction in the grain yield of soybean when compared with weed free treatment. The highest grain yield (1864 kg/ha) was observed in weed free plots.

Vyas and Jain, (2003) conducted field study at Sehore, Madhya Pradesh and reported that among the tested herbicides, the highest seed yield was recorded with combi product of imazamox + imazethapyr at 75 g/ha POE, i.e. 1622 kg/ha and it was significantly on at par with 2 hand weedings (1710 kg/ha).

Kothawade *et al,* (2007) conducted field study at Rahuri, Maharashtra. The effects of Raptor [Imazamox] (30 or 40 g/ha), Pursuit [imazethapyr] (75 or 100 g/ha), odyssey [imazamox + imazethapyr] (0.8 or 1.5 litre/ha), alachlor (2.5 kg/ha) and fluchloralin (1.0 kg/ha) on soybean yield and yield components. The weed-free treatment recorded the highest values of yield and yield components. Among the herbicides, odyssey at 0.8 and 1.0 litre/ha gave the highest weight of pods per plant (19.26 and 20.60 g, respectively), weight of seeds per plant (14.60 and 14.80 g), 1000-seed weight (140.33 and 141.00 g), and seed yield (30.11 and 30.26 q/ha).

2.6 Effect of Herbicides

Johnson *et al,* (1998) conducted field studies in Missouri (Columbia) to evaluate the weed control and crop response to metolachlor plus combination of 0.5x and 1.0x rates of imazaquin applied pre-plant and imazethapyr as post emergence in no-till narrow row soybean production. *Setaria faberi, Ambrosia artemisiifolia, Xanthium strumarium and Digitaria sanguinalis* population reduction was greater with sequential application of metolachlor plus imazaquin as PPI followed by post emergence application of imazethapyr alone.

Bhalla *et al*, (2000) reported that chlorimuron-ethyl applied at 6, 9 and 12 g/ha at five stages (3, 5, 7, 10 and 15 DAS) in soybean reduced the population of broadleaved weeds viz., *Commelina communis, Ceasulia axillaris, Cyperus rotundus* and *Corchorus olitorius* compared to weedy control. However, the efficacy against *Echinochloa crusgalli* was poor. Significantly higher yield was obtained under chlorimuron-ethyl at 12 g/ha at 5 DAS (1268 kg/ha) followed by 15 DAS (1163 kg/ha), chlorimuron-ethyl at 12 g/ha at 10 DAS (1130 kg/ha) and 9 g/ha at 5 DAS (1123 kg/ha).

Vega *et al*, (2000) recorded 67 per cent mortality of weeds with post emergence application of imazethapyr in soybean crop.

Chandel and Saxena, (2001) from Pantnagar reported that post emergence application of imazethapyr at 100 g/ha proved effective in controlling weeds and recorded the highest seed yield of soybean.

Mishra *et al*, (2001) concluded that imazethapyr at 75 g/ha gave an effective control of grassy as well as broad leaved weeds.

The results from “All India Coordinated Research Project on Weed Control” at Gwalior revealed that the grassy weeds such as *Cyperus rotundus* and *Echinochloa crusgalli* were reduced markedly by application of imazethapyr @ 1.0 kg/ha (Annual Report, AICRP-WC, 2001-2002).

Dixit *et al*, (2003) evaluated the efficacy of chlorimuron-ethyl at 6 or 9 g/ha with and without 0.2% surfactant applied at different soybean (cv. JS-335) stages (7, 14 or 20 days after sowing) against broad-leaved weeds and sedges and reported that the highest weed control efficiency with chlorimuron-ethyl at 9 g/ha was effective for the overall control of broad-leaved weeds. Application of chlorimuron-ethyl did not cause any phytotoxic effect to the crop.

Kalpana and Velayutham, (2004) studied the effect of herbicides on weeds and yield of soybean. Among the post emergence herbicides, imazethapyr (100 g/ha) performed better than lactofen and chlorimuron, resulting in the moderate control of all types of weed. However, lactofen (120 g/ha) and chlorimuron (9 g/ha) gave an effective control of sedges and broadleaved weeds but were least effective against grasses.

Singh and Jolly, (2004) at Ludhiana (Punjab) applied different herbicides viz., imazthaypr, quizalofop-p-ethyl, alachlor to check weed infestation and increase seed yield of soybean. They observed that weedy lots resulted in 58.8 and 58.1% reduction in the seed yield in the two years over two hand-weedings at 30 and 45 DAS, which gave seed yields of 1326 and 2029 kg/ha. None of the herbicides was significantly superior to the two hand-weedings treatments in influencing the seed yield.

Singh and Jolly, (2004) assessed the bioefficacy of chlorimuron-ethyl in soybean at various doses (6, 9 and 18 g/ha) on non grassy weeds in soybean. Chlorimuron-ethyl at 9 g/ha was better than its application at 6 g/ha.

Raghuwanshi *et al*, (2005) conducted a field studies in Jabalpur (MP), to study the effect of post emergence application of imazethapyr at 100 g/ha (pre emergence), trifluralin at 1 kg/ha, imazethapyr at 75 g/ha (post emergence; 20 DAS), imazethapyr + imazamox at 50 g/ha (post emergence), fenoxaprop-p-ethyl at 148 g/ha + chlorimuron-ethyl at 37.12 g/ha. Higher seed yield and seed production efficiency were obtained under weed free treatment up to 60 DAS after sowing and with imazethapyr+imazamox at 25 g/ha as post emergence (20 DAS).

Kushwah and Vyas, (2005) found that growth, yield and economics of soybean were higher due to the application of imazethapyr at 75 g/ha was the most effective in reducing weed biomass and gave the highest weed control efficiency over other pre and post emergence herbicides. Quizalofop ethyl at 50 g/ha was also found effective with fairly low weed biomass and controlled particularly the monocot weeds more effectively. The hand-weeding recorded superior values of growth parameters, yield attributes, harvest index and yield, followed by imazethapyr at 75 g/ha.

Girothia and Thakur, (2006) reported that imazethapyr at 75 or 100 g/ha, imazamox at 30 or 40 g/ha and imazamox (2.5%) + imazethapyr (2.5%) formulated product at 800 or 1000 ml/ha were applied at post emergence (25 DAS) in soybean. They noted the highest weed control efficiency (93.8 %) from the weed free treatment followed by imazamox + imazethapyr at 1000 ml (84.8%) and imazethapyr 100 g/ha (79.7%). The highest seed yield was obtained with the weed free plots (1362 kg/ha), followed by imazamox+ imazethapyr at 1000ml/ha (1353 kg/ha), imazethapyr 75 and 100 g/ha (1299 and 1301 kg/ha, respectively).

Singh *et al*, (2006) studied the comparative bio efficacy of different herbicide and reported that chlorimuron–ethyl 0.01 kg/ha, being at par with metribuzin 0.5 kg/ha, significantly reduced the growth of *Euphorbia geniculata*. Uncontrolled weed growth caused 59% reduction in seed yield compared to the metribuzin 0.5 kg/ha at Jabalpur in M.P.

Pandey *et al*, (2007) studied the efficacy of herbicidal weed control in soybean and reported that application of quizalofop ethyl and quizalofop-p-tefuril significantly reduced the growth of monocots while imazamox and imazamox+imazethapyr paralyzed the dicot weeds. The seed and straw yields were higher under imazamox+imazethapyr (8009 kg/ha) and quizalofop-ethyl (50 g/ha) being comparable to two hand-weeding.

Procopio *et al, (*2007) evaluated the efficacy and selectivity of chlorimuron-ethyl, imazethapyr in association with glyphosate in controlling weeds in Roundup Ready (RR) soybean. Glyphosate applied at 480, 960 and 1440 g/ applied alone did not cause phytotoxicity nor reduced plant height and biomass accumulation of Roundup Ready soybean plants. However, the addition of the herbicides imazethapyr and chlorimuron-ethyl to glyphosate caused phytotoxicity in the soybean plants, though at an acceptable degree. The symptoms caused by imazethapyr were more severe than those of chlorimuron-ethyl. The association of imazethapyr and glyphosate led to reduced plant height and biomass. Chlorimuron-ethyl applied incombination with imazethapyr addition did not increase yield.

Tiwari *et al,* (2007) evaluated the efficacy of post emergence herbicides against weeds in soybean and reported that post emergence application of haloxyfop ethoxy-ethyl at 50 g/ha or higher rates 75 and 100 g/ha gave effective control of grassy weeds only. Imazethapyr at 75 g/ha controlled only broad leaved weeds. Haloxyfop-ethoxy-ethyl (50 g/ha) controlled grassy weeds better and gave superior values of yield attributes and seed yield comparable to those of hand weeding and proved more remunerative than imazethapyr at 75 g/ha as well as hand weeding treatment.

Shete *et al,* (2007) applied different doses of imazethapyr at 52.5, 75 and 87.5 g/ha, chlorimuron –ethyl at 9.37 g/ha and one hoeing (20DAS) + two hand-weedings (30and 60 DAS). The yield attributing characters were significantly higher under mechanical weed control. Weed control efficiency was significantly the highest in the plots receiving application of imazethapyr at 87.5 g /ha.

Shete *et al*, (2008) conducted field studies in Rahuri, (Maharashtra) to evaluate the post emergence application of imazethapyr at 52.5, 75.0 and 87.5 g/ha, chlorimuron-ethyl at 9.37 g/ha and fenoxoprop-P-ethyl at 67.5 g/ha. Among the herbicidal treatments, the highest weed control efficiency (85.77%), lowest dry matter of weeds (3.27 q/ha) and significantly higher yield (27.19 q/ha) were recorded with imazethapyr (87.5 g/ha).

2.7 Economics

Tiwari (2009) observed that the NMR was maximum in quizalofop-ethyl (50 g/ha) + chlorimuron-ethyl (9 g/ha) followed by in-situ mulching with weeds, two hand weeding imazethapyr (75 g/ha) and quizalofop-ethyl (50 g/ha) respectively. The incremental benefit cost ratio however, was the highest (2.8) in imazethapyr (75 g/ha) followed by clomazone (1000 g/ha), quizalofop-ethyl (50 g/ha) quizalofop-ethyl + chlorimuron (50 + 9 g/ha) and in-situ mulching with weeds.

Patidar (2007) observed that clomazone (1000 g/ha) recorded the highest net-return of (Rs 6015/ha) and B:C ratio (2.72) followed by two hand weeding, fluazifop-p-ethyl (500 g/ha) and imazethapyr (75 g/ha).

Pathak (2007) was observed that the maximum net return (Rs14796/ha) was recorded in quizalofop-ethyl 50g+ chlorimuron-ethyl 9 g/ha followed by two hand weeding and imazethapyr 150 g/ha being the minimum (Rs 2609/ha) under untreated plot and hoeing at 30 DAS. The combined application of quizalofop-ethyl 50 g + chlorimuron-ethyl 9 g/ha fetched the highest, B:C ratio (2.26), whereas, it was minimum (1.7) under weedy check plots.

Singh (2009) obtained minimum GMR and NMR minimum (Rs 6092/ha and 1327/ha, respectively), in weedy check plot which increased remarkably under all the plots receiving weed control treatment. The plots receiving combined application of quizalofop-p-ethyl (37.5 g/ha) + chlorimuron (24 g/ha) fetched the higher GMR and NMR (Rs 31848/ha and 15918/ha) respectively followed by imazethapyr (75 g/ha) and fenoxaprop-ethyl (100 g/ha). However, B:C ratio was higher (1.99) under combined application quizalofop-p-ethyl (37.5 g/ha) + chlorimuron (24 g/ha) closely followed by imazethapyr 75 g/ha (1.91) and hand weeding (1.72).

MATERIALS AND METHODS

The experiment was conducted at research farm of JNKVV, Jabalpur to study the **"Evaluation of Imazethapyr 10% SL herbicide against weeds in soybean"** during the *kharif* season of 2011 under edaphic and climatic conditions of Jabalpur (M.P.). The materials used and the methods employed during the course of investigation in the yield as well as laboratory are briefly described in this chapter under the appropriate heads.

3.1 Experimental Site

A field experiment was conducted at product testing Unit, Adhartal, Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur (M.P.). The field selected for experimentation was fairly infested with location specific weeds representing to this area. All physical facilities viz., labour, agrochemicals, equipments and irrigation water etc. were adequately available as per needs on the research farm.

3.2 Climate

Jabalpur is situated in the central part of M.P at 23^0 9' North latitude and 79^0 58' East longitudes with an altitude of 411.78 metres above the mean sea level. The climate of locality is characterized as typically sub-humid and Sub-tropical, which is featured by hot dry summers and cool dry winters. It is classified as "Kymore Plateau and Satpura Hills" agro climatic zone as per norms of National Agriculture Research Project (ICAR), New Delhi. Recently, it has been identified as agro-ecological region number 10 named as central high lands (Malwa and Bundhelkhand), sub region number 10.1 named as hot sub-humid eco-region (Malwa Plateau, Vindhyan scarpland and Narmada Valley).

The mean annual rainfall of Jabalpur 1350 mm mostly received between mid-June to end of September with a little and occasional rainfall in remaining part of year. The mean monthly temperature goes down to the limit of 4 ^{0}C during winter while the maximum temperature reaches as high as 45 ^{0}C during the summer. Generally, relative humidity remains very low during summer (15 to 30%), moderate during winter (60 to 75%) and it attains higher value (80 to 95%) during rainy season.

3.3 Weather Conditions during Crop Season

Seasonal variations prevailing during the growth period play an important role not only in the growth and development of the crop but also in the intensity of weeds which ultimately influence the final yield of crop. The weekly meteorological data recorded during crop season at Meteorological Observatory, College of Agriculture Engineering, Jabalpur are presented in Table 3.1 and graphically illustrated through the figure1.

Table 3.1. Weekly meteorological parameters during entire crop season.

Months	Meto. Week (#)	Temperature (^0C)		Relative humidity (%)		Sunshine (hrs/day)	Rainfall (mm)	Rainy days (#)
		Max.	Min.	Max	Min			
July 02	26	27.4	22.8	90	80	0.4	91.3	4
	27	32.8	23.8	86	61	4.9	15.2	2
	28	32.0	23.5	92	71	3.1	46.4	3
	29	30.3	22.8	93	83	2.5	429.1	6
	30	29.9	22.7	90	70	9.4	119.2	3
Aug.06	31	31.1	23.6	92	82	3.9	140	5
	32	28.7	22.7	93	85	1.5	118.5	6
	33	29.8	22.7	92	78	4.0	57.6	3
	34	30.9	22.9	93	70	6.3	14.6	3
Sep. 03	35	31.5	22.8	96	71	5.8	150.6	7
	36	29.5	22.6	94	80	1.2	221.6	4
	37	29.7	22.4	93	73	3.9	92.2	3
	38	30.8	21.9	93	67	5.1	41.0	4
Oct. 01	39	31.1	20.8	86	56	6.9	0.0	0
	40	32.2	18.6	90	54	9.0	52.0	1
	41	32.4	19.1	92	43	8.3	0.0	0
	42	32.6	15.8	89	31	9.3	0.0	0
	43	31.8	13.9	87	30	8.9	0.0	0

It is evident from the data that weather conditions were almost favourable for the growth and development of soybean. The monsoon commenced in the first week of July and terminated in the last week of October. The total rainfall received during the crop season was 1589.3 mm, which was equally distributed in 54 rainy days from July to fourth week of October. Minimum and maximum mean temperature ranged from 13.9 ^{0}C to 32.8 ^{0}C respectively. The relative humidity ranged from 71 to 96% in morning and 31 to 89% in evening. The mean sunshine hour remained between 0.4 to 9.4 hours per day. There was no rain in the month of November.

3.4 Soil

The soil of the Jabalpur region is broadly classified as vertisol as per norms of US as classification of soil. It has medium to deep in depth and black in colour. It swells by wetting and shrink when dries. Thus, it develops wide cracks, on the surface during summer season. The soil of the experimental field offers infestation of several weeds depending on the season crops grown and management practices followed during the course of crop production.

For Analyzing the physico-chemical properties of the soil in the experiment field. Five samples were taken randomly with the help of screw type soil auger from different places in each replication to a depth of 15 cm. These soil samples were thoroughly mixed together to get a composite sample. After proper drying, the samples were powered finely with the help of pistal and mortar and later composite sample was drawn by quartering. Then this composite soil sample was subjected to various analysis in the laboratory, Department of Agronomy, JNKVV, Jabalpur. The analytical values are given in the Table 2. It is obvious from the data given in table that the soil of the experimental field is clayey in texture, neutral in reaction (7.1), medium in organic carbon and available N (370 kg/ha), and available P (16.45 kg P_2O_5/ha) and high available K (295 kg K_2O/ha).

Table3.2 Physico-chemical properties of the soil of experimental field

Constituents	Value	Class	Method of Analysis
A. Mechanical composition			
Sand (%)	25.18	Clayey	International pipette method (Piper, 1967)
Silt (%)	19.18		
Clay (%)	55.64		
B. Chemical analysis			
Organic carbon (%)	0.64	Medium	Walkley and Black rapid titration method (Walkey and Black,1934)
Available nitrogen (kg/ha)	372	Medium	Alkaline permanganate method (Subbiah and Asija,1956)
Available P_2O_5 (kg/ha)	17.45	Medium	Calorimeter method (Olsen *et al.,* 1954)
Available K_2O (kg/ha)	297	High	Flame photometer method (Chapman and Pratt, 1961)
Soil pH (1:2.5 soil water ratio)	7.1	Neutral	Glass electric pH meter (Piper,1967)
Electrical Conductivity (ds/m)	0.31	Neutral	Solu-bridge method (Black, 1965)

Table 3.3 Cropping history of experimental field

Year	Kharif ($N+P_2O + K_2O$/ha)	Rabi ($N+P_2O + K_2O$/ha)
2006-2007	Soybean (20+60+20)	Brinjal (100+60+50)
2007-2008	Fallow	Fallow
2008-2009	Fallow	Fallow
2009-2010	Soybean (20+60+20)	Wheat (120+60+40)
2010-2011	Soybean (20+60+20)	Wheat (120+60+40)

The cropping history of the experimental field during last four years are given in the Table 3.3 It is obvious from the information given in the above table that soybean-brinjal cropping system was followed in the experimental field with the uniform dose of fertilizers both to the crops during 2006-067 Thereafter, the experimental field was kept fallow for last two years before conduction of the present experiment in the year (2009) during kharif season for the first time and to conform the result the same experiment was repeated in the year 2011 during kharif season for the second time followed by wheat in rabi season.

3.5 Preparation of the Field

In order to get a good tilth for sowing of soybean in the present experimental field one summer ploughing followed by three harrowings with the help of tractor driven cultivator (one pass) disk harrow (two pass) were done before sowing of the crop. The field was finally leveled by leveler, before seeding of the soybean crop.

3.6 Layout of the Experiment

Total 7 treatments were laid out on well prepared seed bed in randomized block design with three replication. The layout plan of the treatments are graphically illustrated through the Figure 2. The details of the treatments are given as below:

Details of the treatments

Treatments : 7 weed control measures

1.	Imazethapyr 10SL	100 g/ ha
2.	Imazethapyr 10SL +HW at 40 DAS	100 g/ ha
3.	Imazethapyr 10SL	200 g/ha
4.	Imazethapyr 10SL	400 g/ha
5.	Fenoxaprop-ethyl 9.3EC‘ (standard check)	75 g/ha
6.	Hand weeding twice	20 and 40DAS
7.	Weedy check	--

Other details of the experiment

Design	:	Randomized Block Design
Replication	:	3
Gross plot size	:	5.0 m x 3.6 m
Net plot size	:	4.0 m x 2.7 m
Distance between replication	:	1.5m
Distance between plots	:	1.0 m
Spacing (row to row)	:	45 cm
Total number of plots	:	21
Variety	:	JS 97-52

3.7 Agronomic Characters of Crop Variety

The variety JS 97-52 has been evolved during 2008 from a selection of crosses between PK 327 x LI 29 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. It is a high yielding variety with 3-4 seeds per pod. The plants are 60-80 cm tall with tawny colour pubescence on the stem. Growth habit of the variety is semi determinate. Flowers are white and initiates in 45 days after sowing and ceases in about 75 days. The variety matures within 98-102 days. Seeds are greenish yellow, lustrous with blackish hilum. The seed size is medium with 100 seed weight of nearly 10-12 g. The variety is resistant to major diseases and abiotic stress. The yield potential of the variety is 25-30 q/ha.

3.8 Schedule of Agronomic Operations

Schedule of agronomic operations done in the main field during the course of experimentation are given in Table 3.4 in chronological order.

Table3.5. Details of different field operations done in soybean during kharif 2011

S. No.	Field operation	Date	Remarks
1.	**Land preparation**		
a.	Harrowing with cultivator	31/06/11	Tractor drawn
b.	Harrowing with disc harrow and leveling	01/07/11	Tractor drawn
c.	Layout of the experiment	02/07/11	Manually by hand
2.	**Application of fertilizers**	03/07/11	Manually by hand
3.	**Seed treatment and sowing of seeds**	03/07/11	Manually by hand
4.	**Application of herbicides**	18/07/11	By Knapsack sprayer with flat fan nozzle
5.	**Hand weeding**		
A B.	1^{st}at 20 DAS 2^{nd} at 40 DAS	23/07/11 13/08/11	Manually by *Khurpi*
6.	**Harvesting**	18/10/11	Manually
7.	**Irrigation**	20/10/11	Manually by pipe
8.	**Threshing and winnowing**	03/11/11	Manually

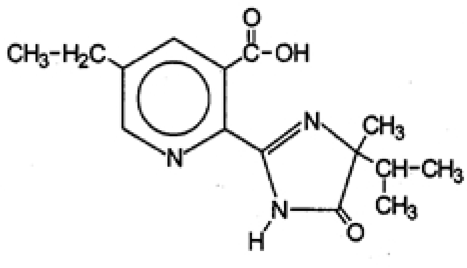
3.9 Properties and Mode of Action of Herbicides

Imazethapyr

It is a selective pre plant incorporation pre emergence and early post emergence herbicide recommended for soybean, peas, beans, chickpea and lentil etc.

- Group : Imidazolinone
- Active ingredient : 10% SL
- Trade name : Pursuit
- Common name : Imazethapyr
- Chemical name : [2- {4,5- dihydro – 4-methyl -4- (1-methylethyl) -5-oxo – 1H- imidazol -2-yl} -5- ethyl -3- pyridine carboxylic acid]
- Emperical formula : $C_{15}H_{19}N_3O_3$

Structural formula



imazethapyr acid

Mode of action

It inhibits acetolactate synthase (ALS), also called acetohydorxyacid acid synthase (AHAS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine. Plant death results from events occurring in response to ALS inhibition, but the actual sequence of phytotoxic processes is unclear. Some secondary, effects may include disruption of photosynthate translocation, hormone imbalance due to interruption of source/sink relationships, and interference in DNA synthesis and cell growth.

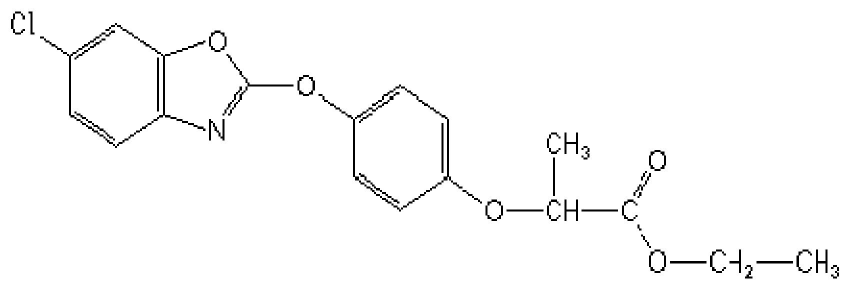
Fenoxaprop- ethyl

It is a selective, post-emergence herbicide recommended for control of annual and perennial grasses in broad leaf crops *viz*., cotton, soybean, pea etc.

Group - Aryloxy phenoxy propionate

Active ingredient	:	10% EC
Trade name	:	Whip super
Common name	:	Fenoxaprop-p-ethyl
Chemical name	:	-2-(4-6-chloro-benzoxazolyphenoxy propanoic acid)
Empirical formula	:	$C_{15}H_{17}NO_5C$

Structural formula:



Mode of action

Fenoxaprop is applied (30-100 g/ha) as post-emergence in soybean and turf. Fenoxaprop by itself may be phytotoxic to wheat and other crops, but it shows selectivity when applied with 2,4-D, MCPA, Triben-sulfuron and tribenuron which antagonize its activity. It controls many annual and some perennial grass weeds with no injury to broad leaf weeds. The field half life of fenoxaprop is 5-14 days depending on soil type.

3.10 Fertilizer Application

Full dose of major plant nutrients (20 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha) was applied as basal application through urea, SSP and muriate of potash. The whole quantities of all the fertilizers was applied manually at the time of sowing in the furrows about 3 cm below the seed.

3.11 Sowing Management

3.11.1 Seed treatment

Before sowing, the seed were treated with carbendazim 1.0 g/kg of seeds followed by inoculation with *Rhizobium japonicum* culture 5 g/kg of seeds.

3.11.2 Sowing time and sowing method

Sowing of seeds was done manually at July 2, 2011. The rows were opened with the help of pick axe and later sowing was done in each plot by using a seed rate of 70 kg/ha. Sowing of seeds in each plots was done in the rows 45 cm apart at the depth of 3-4 cm and then seeds were covered with fine soil particles. There was a light rainfall just after sowing, which helped in proper germination of seeds.

3.12 Weed Management Treatments

3.12.1 weedy check:

In unweeded control plots, weeds were allowed to grow without any control measures throughout the crop growing period.

3.12.2 Application of herbicides

The solution of each herbicide desperately was prepared by mixing the required quantity of herbicide in water at 500 litre/ha for each plot. The for individual plot was prepared separately as per treatment. After completing the spraying of one herbicide, in the respective plots in all the three replications, the sprayer was washed thoroughly by detergent and rinsed several times with fresh water, before being used for another treatment. Knapsack sprayer was used for the spraying of herbicidal treatments. Uniform pressure was maintained to pump out nearly equal quantity of the herbicide uniformly as fine mist during the spray.

3.12.3 Early post-emergence application

Imazethapyr, and fenaxoprop ethyl were applied as early post-emergence application of herbicides in soybean. These were sprayed at 15 days after sowing.

3.12.4 Hand weeding

Hand weeding was done as per treatment manually with the help of Khurpi at 20 and 40 days after sowing as per need of the treatment in weed free plots.

3.13 Water Management

Normally, no irrigation is needed to soybean crop from sowing to harvesting being rainy season crop, but one irrigation was given uniformly to all plots on 20 October, 2011, because of long dry spell coinciding to the pre flowering stage of crop. Mean while, adequate drainage was also provided by making drainage channel between plots along the slope in the experimental field.

3.14 Harvesting

The crop was harvested when the foliage of the soybean plants turned yellowish brown to brown in colour and started to fall down. One border row from each side and 50 cm at both ends of the rows were harvested to eliminate the border effect. The harvested produced of each plot was removed from the field. After this, harvesting of crop from net plot area was done plot wise separately with the help of sickles. The harvested produce of each net plot was tied into bundles and tagged with luggage label for demarcation. The plot wise produce was transported to threshing floor and allowed to sun drying for 15 days.

3.15 Threshing and Winnowing

After sun drying of produce of each plot on threshing floor the produce was weighed plot wise by using spring balance. After this, threshing was done manually by beating with stick for each plot separately. The thresh material of each plot contained seeds and chaffy materials. The chaffs were removed and clean seeds of each plot was separated by winnowing with hand fan (supa) manually. The weight of clean seeds obtained for each plot was

3.16 Studies on Weeds

3.16.1 Florastic composition of weeds and relative weed density

The observations on population of major weeds *viz. Echinochloa colona, Cyperus iria, Dinebra retroflexa, Eclipta alba* and *Alternanthera philoxeroides* and other associated weeds were recorded at 40 DAS and harvest by quadrat count method. The quadrat of 0.25 square metre (0.5 m x 0.5 m) was randomly placed at four places in each plot and then the species wise and total weed count was recorded. The data thus obtained, were transformed and expressed in number per square metre. The percentage composition of weed flora was estimated from weedy check plot. The relative density of individual weed was worked out as per formula proposed by Mishra (1968).

$$\text{Relative Density (\%)} = \frac{\text{Number of individuals of a particular species}}{\text{Number of individuals of all species}} \times 100$$

3.16.2 Weed dry weight

The weed biomass from different plots under all the treatment was recorded only at 40 DAS and harvest. The associated weed were collected randomly with 0.25 square metre quadrat from four places in each plot. The weeds were first sun dried and thereafter kept in paper bags and dried in oven at 60 ^{0}C for 48 hours and dry weight was recorded till constant weight was achieved. Later on, the data on weed biomass was transformed and expressed in g per square metre.

3.16.3 Weed control efficiency :

Weed control efficiency measures the efficiency of any weed control treatment in comparison to no weeding treatment (Mani *et al*., 1968). Mathematically, it could be expressed as below.

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

where,

WCE = Weed control efficiency

DWC = Dry weight of weeds in control plots

DWT = Dry weight of weeds in treated plots

3.17 Pre-harvest Observations

3.17.1 Plant population

Initial and final plant population of crop was counted at 25 days after sowing and just before harvesting respectively from one metre running row length in 4 rows randomly in each plot and then averaged out. After this, plant population per metre row length was determined from each plot.

3.17.2 Plant height

Five plants per plot were selected randomly in each plot and tagged for recording various observations. The height of marked plants was taken from the base (ground surface) to the tip of main stem with the help of metre scale. This observation was recorded at 30 days interval in each plot starting from 30 DAS to the harvesting of the crop.

3.17.3 Leaves per plant

Leaves per plant was recorded at 30 and 60 DAS by counting number of leaves on the five tagged plant of each plot. and mean number of leaves per plant were determined by dividing the total value with five.

3.17.4 Branches per plant

The number of branches per plant were counted on the 5 tagged plants in each plot at 30, 60 and 90 DAS and then mean was determined for each treatment at all growth stages.

3.17.5 Dry weight/plant

Five plants were uprooted from the second row of border area of each plot at 30, 60, 90 DAS and at maturity stages. The weight of freshly uprooted plants of each plot was also recorded.

After this the plants of each plot were tied together and marked with luggage label. These labeled plant samples were sun dried and then in oven till constant weight in achieved. The weight of oven dried sample was recorded for each plot on electronic balance. After this the mean values were determined. Later on it was converted in to g/m^2 by multiplying the plant population/m^2 area.

3.17.6 Leaf area index

It expresses the total leaf area accumulated by the plants per unit of the ground area in which the crop is grown as explained in the following equation. This observation was taken at 30, 60 DAS as per following formula.

$$\text{Leaf area index} = \frac{\text{Total leaf area of crop}}{\text{Leaf area/plant x number of plant/m}^2}$$

3.18 Post-harvest Observations

3.18.1 Number of pods per plant

Number of pods were removed from tagged five plants in each plot at harvest and then counting of these collected pods was made for each plot. Finally, mean was computed by dividing the total value with 5.

3.18.2 Number of seeds per pod

Random samples of 20 pods were drawn from the harvested produce of each plot to work out the mean number of seeds per pod.

3.18.3 Seed index (100- seed weight)

The hundred seeds were randomly taken from the finally cleaned produce of each plot for recording test weight. Then weight of 100-seeds of each plot was recorded separately on an electrical balance.

3.18.4 Seed yield

The seed yield per net plot was recorded after winnowing the seed with the help of double pan balance. Finally, seed yield of each plot was converted in to seed yield per hectare by multiplying it with an appropriate conversion factor.

3.18.5 Straw yield

The straw or haulm yield per plot was determined by subtracting seed yield (economic yield) of each plot from biological yield (bundle weight) of the same plot. This was later on converted in to straw yield per hectare by multiplying with the same conversion factor, which was used in case of seed yield per hectare.

3.18.6 Harvest index

It is the ratio of economic yield to the biological yield. It was determined with the help of following formula and expressed in percentage as follows:

$$\text{Harvest index} = \frac{\text{Economic yield (seed yield)}}{\text{Biological yield (seed and straw yields)}} \text{ X100}$$

3.18.7 Weed index

Weed index may be defined as the percent reduction in the seed yield under a particular treatment due to the presence of weeds in comparison to the seed yield determined in weed free plot *i.e.* hand weeding as suggested by Gill and Kumar (1969). It is expressed in percentage and it was determined with the help of following formula :

$$WI\ (\%) = \frac{X - Y}{X} \times 100$$

where,

WI= Weed index

X = Seed yield from weed free plot (hand weeding)

Y = Seed yield from the treated plot for which weed index is to be worked out.

3.19 Economics of the Treatments

The economic analysis of the treatments is very important to asses the practical utility of treatments for farmers point of view. Therefore economics of different treatments were worked out in terms of cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR), and benefit -cost ratio (B:C) on per hectare area basis to ascertain the economic viability of the treatments. The detail for determination of economics are given in *Appendix* I to *Appendix* III for reference.

3.19.1 Cost of cultivation

The cost of cultivation for each treatment is determined on the basis of different inputs used for raising the crop under different treatments on one hectare area basis.

3.19.2 Gross monetary returns (GMR)

The values realized form the produce obtained under each treatment was computed on the basis of existing market price of the produce (both seed and stover) as the gross monetary returns (GMR), per hectare under different treatments.

Gross monetary returns = value of seed + value of straw

3.19.3 Net monetary returns (NMR)

The net monetary returns (NMR) per hectare under each treatment was determined by subtracting the cost of cultivation of a particular treatment from the GMR of the same treatment.

Net monetary returns = Gross monetary returns - cost of cultivation

3.19.4 Benefit-cost ratio (B:C)

To estimate the benefits obtained under different treatments for each rupee of expenditure incurred, B:C ratio of each treatments was calculated as below :-

$$\text{B:C ratio} = \frac{\text{Gross monetary returns/ ha}}{\text{Total cost of cultivation/ ha}}$$

3.20 Statistical Analysis

The data obtained on various observations were tabulated and subjected to their analysis by using the techniques of the analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1963) and the treatment was tested by F test shown. Critical difference (C.D.) at 5% level of significance was determined for each characters to compare the differences among treatment means. The data on weed count and weed biomass were subjected to square root transformation i.e. $\sqrt{x + 0.5}$, before carrying out analysis of variance and comparisons were made on transformed values.

Table 5. Analysis of variance

Source of variation	**d.f.**	**SS**	**MSS**	**F. cal.**	**F.tab.**
Replication	2				
Treatment	6				
Error	12				
Total	20				

SEm$\pm$ = $\sqrt{EMS/r}$

SEd = S.E.m. x $\sqrt{2}$

CD = SEd x t at 5% (14 d.f.)

RESULTS

This chapter deals with the findings of the present study. The observations recorded on the effect of various weed control treatments on weeds and yield attributing characters and seed yield of soybean are presented in this chapter with the figures wherever necessary. The current chapter has been divided under the following heads:-

[A] Study on Weeds

Weed flora of soybean

Data on species wise population recorded in weedy check plots at 40 DAS and harvest are presented in Table 4.1.

Table 4.1 . Weed flora of the experimental field in weedy plot at 40 DAS and harvest

Sr. No.	Weed species	Density m^{-2}		Relative density (%)	
		40 DAS	Harvest	40 DAS	Harvest
[A]	**Monocot weeds**				
1.	Grasses				
	(a) *Echinochloa colona*	11.07	11.40	24.56	28.08
	(b) *Digiteria sengunalis*	8.40	8.40	18.63	20.68
2.	Sedge				
	Cyperus iria	12.07	4.40	26.78	10.83
[B]	**Dicot weeds**				
	(a) *Alternanthra philoxiroides*	3.73	6.00	8.27	14.78
	(b) *Eclipta alba*	5.40	6.40	11.98	15.78
[C]	**Other weeds**	4.40	4.00	9.78	9.85
	Total (a+b+c)	45.07	40.6	100.00	100.00

It is obvious from the data presented in Table 4.1 that there were predominance of monocot weeds in weedy plots at 40 DAS and harvest of soybean crop at Jabalpur (M.P.). The relative density (%) at 40 DAS and harvest stages, the monocot weeds, *Cyprus iria* (26.78%) had the maximum relative density at 40 DAS followed by *Echinochloa colona* (24.56 %) and *Digitaria senguinalis* (18.63%). While, among dicot weeds *Eclipta alba* had the maximum relative density (11.98%) followed by *Alternanthra philoxiroides* (8.27%). Relative density of other minor weeds was 9.78%.

At harvest *Echinochloa colona* (28.08%) had the maximum relative density closely followed by *Digiteria senguinalis* (20.68%) among monocots. While, *Eclipta alba* (15.78%) had the maximum relative density followed by *Alternanthra philoxiroides* (14.78%) among dicots. Relative density of other weeds like *Commelina communis*, *Cyperus rotundus*, *Cynodon dactylon*, *Chichorium intybus* and *Phyllanthus niruri* was 9.85%.

Effect on weed density

The density of dominant weeds *viz*., *Cyperus iria*, *Echinochloa colona*, *Aiternanthra philoxiroides* as influenced by various weed control treatments are presented in Table 4.2 and Figure . The comparison among treatment means have been made on transformed values in case of weed density.

Echinochloa colona

The density of *Echinochloa colona* differed significantly at 40 DAS and harvest due to different weed control treatments, presented in Table .

At 40 DAS the maximum intensity was recorded in weedy check (3.54/m^2) while minimum intensity was recorded in hand weeding (1.35/m^2) followed by T_4 (2.14/m^2).

At harvest the density of *Echinochloa colona* was effectively reduced under each treatment over preceding status while minimum intensity was recorded in hand weeding (0.70/m^2) subsequently same trend was followed as at 40 DAS. However, all herbicidal treatments were found significantly effective to control the density of this weed over weedy check treatment.

Table 4.2 . Species wise density of dominant weeds/m$^{2(}$ #) at 40 DAS and harvest as influenced by different treatments

Tr. No.	Treatments	*Echinochloa colona*		*Digitaria sanguinalis*		*Cyperus iria*		*Alternanthra philoxiroides*		*Eclipta alba*		Others	
		40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest
T_1	Imazethapyr 100g/ha	2.36 (5.07)	1.69 (2.40)	2.43 (5.40)	2.05 (3.73)	2.43 (5.40)	1.97 (3.40)	1.70 (2.40)	1.57 (2.00)	2.21 (4.40)	1.70 (2.40)	2.05 (3.73)	1.95 (3.33)
T_2	Imazethapyr 100g/ha+HW at 40DAS	2.21 (4.40)	1.35 (1.40)	2.10 (4.07)	1.70 (2.40)	2.29 (4.73)	1.60 (2.07)	1.46 (1.73)	1.35 (1.33)	2.06 (3.73)	1.46 (1.73)	1.97 (3.40)	1.87 (3.00)
T_3	Imazethapyr 200g/ha	2.35 (5.07)	1.46 (1.73)	2.28 (4.73)	1.78 (2.73)	2.43 (5.40)	1.78 (2.73)	1.60 (2.07)	1.47 (1.67)	2.14 (4.07)	1.60 (2.07)	2.03 (3.63)	1.93 (3.23)
T_4	Imazethapyr 400g/ha	2.14 (4.07)	1.24 (1.07)	1.94 (3.40)	1.60 (2.07)	2.21 (4.40)	1.49 (1.73)	1.35 (1.40)	1.47 (1.67)	1.96 (3.40)	1.35 (1.40)	1.86 (3.07)	1.76 (2.67)
T_5	Fenoxoprop ethyl 75g/ha	2.50 (5.73)	1.69 (2.40)	2.69 (6.73)	2.14 (4.07)	2.50 (5.70)	2.06 (3.73)	1.88 (3.07)	1.87 (3.00)	2.24 (4.40)	1.87 (3.07)	2.14 (4.07)	2.04 (3.67)
T_6	Hand weeding 20&40 DAS	1.35 (1.40)	0.70 (0.07)	1.46 (1.73)	1.24 (1.07)	1.46 (1.73)	1.24 (1.07)	0.70 (0.07)	1.07 (0.67)	1.70 (2.40)	1.38 (1.40)	1.35 (1.40)	1.19 (1.00)
T_7	Weedy check	2.98 (8.40)	2.98 (8.40)	3.54 (12.07)	2.21 (4.40)	3.40 (11.07)	3.45 (11.40)	2.05 (3.73)	2.55 (6.00)	2.42 (5.40)	2.63 (6.40)	32.21 (4.40)	2.11 (4.00)
	SEm±	0.12	0.07	0.09	0.09	0.09	0.07	0.11	0.08	0.07	0.11	0.10	0.11
	C.D. at 5%	0.38	0.22	0.28	0.28	0.26	0.22	0.34	0.25	0.21	0.33	0.31	0.33

***DAS – Days after sowing, HW – Hand weeding, # - Number**

* Values in parenthesis are square root transformed (above value)

Digitaria senguinalis

The density of *Digitaria senguinalis* as affected by different weed control treatments has been given in Table 4.2

At 40 DAS maximum density was recorded in weedy check ($2.98/m^2$) while, minimum intensity was recorded in hand weeding ($1.46/m^2$) which was at par to T4($1.94/m^2$).

At harvest again density was found maximum under weedy check treatment ($2.98/m^2$) while minimum in hand weeding ($1.24/m^2$) which was at par to T_4 ($1.60/m^2$)and T_3 ($1.78/m^2$). However, all herbicidal treatments were found significantly effective to control this weed over weedy check.

Cyperus iria

Data on density of this weed at different growth stages under different weed control treatments are presented in Table . It is obvious from the data that all treatments have significantly lower population of *Cyperus iria* at 40 DAS compared to weedy check ($3.40/m^2$). Hand weeding ($1.46/m^2$) showed the minimum intensity of this weed followed by T_4 and T_3.

At harvest, the density of *Cyperus iria* was effectively increased under each treatment over preceding stage. Minimum density was recorded in hand weeding ($1.24/m^2$) which was at par to T_4 and T_3.

Alternanthra philoxiroides

The density of *Alteranthra philoxiroides* as affected by different weed control treatments has been given in Table 4.2

At 40 DAS, the maximum density of this weed was recorded in weedy check ($2.05/m^2$) while hand weeding ($0.70/m^2$) found completely weed free.

At harvest stage again hand weeding ($1.07/m^2$) found with minimum density of this weed while, other treatments also found significantly effective to control the density of this weed over weedy check. However T_4 was at par to hand weeding.

Eclipta alba

Data from the Table revealed that at 40 DAS maximum density of *Eclipta alba* was found under weedy check (2.42/m^2) while minimum density of this weed was recorded under hand weeding (1.70/m^2). Among herbicidal treatments T_4 (1.96/m^2) found superior which was at par to T_3.

At harvest all herbicidal treatments found significantly effective to lower the population of this weed. However, hand weeding (1.38/m^2) and T_4 (1.35/m^2) have lowest population of this weed and these were at par to T_3. However, all weed control treatments were superior over weedy check.

Other weeds

The population of other weeds comprised to broad leaved weed species *viz*., *Phylanthus niruri, Euphorbia geniculata* and monocot weeds *viz*., *Cynodon dactylon*, *Echinochloa crusgalli* and *Commelina communis* (Table 4.2).

Observation at 40 DAS indicated that population of other weeds vary significantly under various weed control treatments. Density of other weeds found maximum under weedy check (2.21/m^2) while it was minimum in hand weeding (1.35/m^2). Among herbicidal treatments T_4 (1.86/m^2) had minimum population of other weeds followed by T_3. Hand weeding (1.35/m^2) found superior to supress the population of other weeds at harvest which was at par to T_4 (1.86/ m^2) followed by T_3. However, all herbicidal treatments found significantly effective to control the population of other weeds over weedy check.

Weed biomass

The observation on weed biomass was recorded at 40 DAS and at harvest. Dry matter accumulation by weeds per unit area is an indication of weed growth and biomass production under particular treatment and depends on the degree of crop weed competition.

The biomass production of *Phylanthus niruri*, *Euphorbia geniculata, Alternanthera philoxiroides, Cynodon dactylon, Echinochloa crusgalli* and *Commelina communis* were marginal. Hence, these were encompassed under other weeds. The total weed biomass mainly comprised of *Eleusine indica*, *Partulaca oleracea*, *Cyperus iria*, *Eclipta alba, Digitaria senguinalis* and other weeds are presented in Table 4.3 and Fig.3

Echilochloa colona

Data provided in Table 4.3 and Figure 3 clearly revealed that the biomass of *Echilochloa colona* was maximum in weedy check (9.36g/m^2 and 4.53 g/m^2) and minimum in the plots received two hand weeding at 20 & 40 DAS (1.78 and 1.70 g/m^2) which was at par to T_4 (2.92 and 2.28 g/m^2) and T_3 (3.86 and 3.35 g/m^2) in order to increase in biomass production at 40 DAS and harvest respectively. However, all weed control treatments found significantly effective to control the weed biomass production over weedy check.

Table .4.3 Species wise dry weight of weeds at 40 DAS and harvest as influenced by different treatments

Tr. No.	Treatments (Dose g/ha)	*Echinochloa colona*		*Digitaria Sanguinalis*		*Cyperus iria*		*Alternanthra philoxiroides*		*Eclipta alba*		Others	
		40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest	40 DAS	Harvest
T_1	Imazethapyr 100g/ha	4.23 (17.40)	3.49 (11.73)	4.75 (22.07)	3.82 (14.07)	2.98 (8.40)	1.97 (3.40)	3.40 (11.07)	2.74 (7.07)	2.55 (6.07)	1.78 (2.73)	2.06 (3.73)	1.49 (1.73)
T_2	Imazethapyr 100g/ha+HW at 40 DAS	3.54 (12.07)	2.69 (6.73)	4.10 (16.73)	2.56 (6.40)	2.73 (6.97)	1.70 (2.40)	2.74 (7.07)	2.21 (4.40)	2.35 (5.07)	1.46 (1.73)	1.70 (2.40)	1.31 (1.23)
T_3	Imazethapyr 200g/ha	3.86 (14.40)	3.35 10.73)	4.53 (20.07)	3.40 (11.07)	2.81 (7.40)	1.96 (3.40)	2.92 (8.00)	2.50 (5.73)	2.42 (5.40)	1.70 (2.40)	1.97 (3.40)	1.38 (1.40)
T_4	Imazethapyr 400g/ha	2.92 (8.07)	2.28 (4.73)	3.20 (9.73)	2.50 (5.73)	2.61 (6.40)	1.63 (2.23)	2.56 (6.07)	2.06 (3.73)	2.21 (4.40)	1.42 (1.57)	1.60 (2.07)	1.18 (0.90)
T_5	Fenoxoprop ethyl 75g/ha	4.49 (19.73)	3.86 (14.40)	4.89 (23.40)	3.90 (14.73)	2.97 (8.40)	2.05 (3.73)	4.03 (15.73)	2.92 (8.07)	2.63 (6.40)	1.84 (2.90)	2.21 (4.40)	1.60 (2.07)
T_6	Hand weeding 20&40 DAS	1.78 (2.73)	1.70 (2.40)	2.35 (5.07)	1.48 (1.73)	1.51 (1.90)	1.11 (1.07)	0.70 (0.07)	0.70 (0.07)	1.38 (1.40)	1.38 (1.40)	1.38 (1.40)	1.12 (0.83)
T_7	Weedy check	9.36 (87.07)	4.53 (20.07)	5.85 (33.73)	6.18 (37.73)	4.15 (16.73)	4.42 (19.07)	5.25 (27.07)	6.09 (36.73)	3.15 (9.40)	3.81 (14.07)	3.53 (11.93)	8.50 (71.73)
	SEm±	0.12	0.07	0.06	0.19	0.10	0.16	0.09	0.11	0.08	0.10	0.33	0.07
	C.D. at 5%	0.37	0.23	0.18	0.58	0.31	0.48	0.29	0.33	0.23	0.30	1.00	0.23

***DAS – Days after sowing, HW – Hand weeding, # - Number**

* Values in parenthesis are square root transformed (above value)

Digitaria senguinalis

Data on dry weight of *Digitaria senguinalis* at 40 DAS and harvest has been given in Table 4.3.

At 40 DAS maximum dry weight of this weed was recorded in weedy check (5.85 g/m^2) while minimum dry weight was recorded in hand weeding (2.35 g/m^2). Among herbicidal treatments, T_4 (3.20g/m^2) had lowest dry weight which was at par to T_3 (4.53 g/m^2).

At harvest again hand weeding (1.48 g/m^2) found superior over all weed control treatments but was at par to T_4 (2.50 g/m^2) followed by T_3. However, all the herbicidal treatments found significant to control the biomass production of this weed at harvest over weedy check.

Cyperus iria

Data from Table 4.3 cleared that the maximum dry matter was produced by weedy check plots (4.15 g/m^2) and minimum in hand weeding (1.53 g/m^2). Among herbicidal treatment, T_4 (2.61 g/m^2) resulted in lowest weed biomass production which was at par to T_3 at 40 DAS.

At harvest again maximum weed biomass was recorded in weedy check (4.42 g/m^2) and minimum in hand weeding (1.11 g/m^2) which was at par to T_4(1.63 g/m^2) followed by T_3. All herbicidal treatments found significantly effective to control the weed biomass production at 40 DAS and harvest respectively.

Alternanthra philoxiroides

Data from Table 4.3 showed that at 40 DAS maximum biomass was produced in weedy check (5.25 g/m^2) while minimum in hand weeding (0.70 g/m^2). Among herbicidal treatments, T_4 (2.56 g/m^2) had lowest dry weight of weed which was at par to T_3. Treatments T_2 and T_1 were at par to each other while, than to T_1.

At harvest hand weeding (0.70 g/m^2) found superior over all weed control treatments. Among herbicidal treatments, T_4(2.06 g/m^2) produced lowest dry weight of weeds which was at par to T_3 and T_2. However, all weed control treatments found effective to control weed biomass production over weedy check.

Eclipta alba

Data recorded in Table 4.3 and Figure 4 revealed that among all treatments maximum dry weight of this weed was produced in weedy check (3.15 g/m^2) and minimum in hand weeding (1.38 g/m^2). Among herbicidal treatments T_4 and T_3 were at par to each other. However, all treatments were significant over weedy check.

At harvest all weed control treatments were significant to reduced weed biomass over weedy check.

Other weeds

The biomass of other weeds, Table 4.3 and Figure 4 indicated that it was significantly influenced by various treatments.

At 40 DAS maximum dry weight of weeds was recorded in weedy check (3.53 g/m^2) and minimum in hand weeding (1.38 g/m^2) which was at par to T_4 (1.60 g/m^2) and T_3 (1.70 g/m^2). At harvest all weed control treatments found significantly effective to reduce the dry weight of weeds.

Table .4.4 Weed control efficiency (%) of different weed control treatments over weedy check treatment at 40 DAS maturity.

Tr. No.	Treatments (Dose g/ha)	40 DAS	Harvest
T_1	Imazethapyr (100g/ha)	63.02	79.57
T_2	Imazethapyr (100g/ha+HWat40DAS)	72.94	88.52
T_3	Imazethapyr (200g/ha	68.40	82.58
T_4	Imazethapyr (400g/ha)	80.23	90.52
T_5	Fenoxoprop ethyl (75g/ha)	58.01	76.98
T_6	Hand weeding 20 &40 DAS	93.23	96.23
T_7	Weedy check	-	-

Weed control efficiency

Weed control efficiency (WCE) was calculated on the basis of weed biomass recorded under weedy check and other treatments at 40 DAS and harvest (Table 4.4 & Fig. 5). While comparing the WCE of different weed control treatments over weedy check, it was the highest under one hand weeding (93.23 and 96.23%). Among herbicidal treatments, T_4 (80.23and 90.52%) and T_3 (68.40 and 82.58%) were higher at 40 DAS and harvest, respectively over weedy check.

[B] Study on Crop

Plant population

Data recorded on plant population of soybean at 25 DAS and just before harvesting under different treatments are given in Table 4.5 and represented through Fig.6

At 25 DAS, plant population of soybean was not affected due to various weed control treatments including weedy check and it was almost similar (26.08 to 26.91 per meter Square) in all treatments.

The subsequent observation on plant population before harvest revealed slight declining trend under all the treatments.

Plant height

Data on plant height recorded at 30, 60, 90 DAS and harvest stages under different weed control treatments are presented in Table4.5 and Fig.6

At 30 DAS, the plant height was significantly affected by various treatments. Among all treatments, maximum plant height was recorded under T_4 (16.82 cm) followed by T_3, T_2, T_1 and T_7 whereas significantly lower plant height was recorded under weedy check (15.10 cm), which was almost similar to two hand weedings (16.73 cm) .

Table .4.5 Influence of different weed control treatments on plant population and plant height of soybean at different growth stages of soybean

Tr. No.	Treatments (Dose g/ha)	Plant population (m^{-1} Square)		Plant height (cm)			
		25 DAS	harvest	30 DAS	60 DAS	90 DAS	harvest
T_1	Imazethapyr (100g/ha)	26.16	25.58	15.26	56.3	63.93	63.23
T_2	Imazethapyr (100g/ha+HW at 40 DAS)	26.34	26.00	16.82	68.23	74.36	73.06
T_3	Imazethapyr (200g/ha)	26.43	25.90	15.71	55.89	67.20	64.03
T_4	Imazethapyr (400g/ha)	26.22	25.50	16.46	73.40	80.06	78.10
T_5	Fenoxoprop ethyl (75g/ha)	26.59	25.71	16.02	47.33	60.5	59.30
T_6	Hand weeding (20&40 DAS)	26.91	26.44	16.73	74.16	84.25	81.66
T_7	Weedy check	26.08	25.40	15.10	44.74	55.23	53.20
SEm±		**0.46**	**0.56**	**0.70**	**0.79**	**0.32**	**0.44**
C.D. at 5%		**1.39**	**1.66**	**2.09**	**2.36**	**0.95**	**1.33**

Plant height recorded at 60, 90 DAS and harvest also showed remarkable variation. Hand weeding treatment resulted in maximum plant height at 60 DAS (74.16 cm), 90 DAS (84.25 cm) and harvest (81.66 cm). While, lowest values of plant height were recorded under weedy check. Among the herbicidal treatments, maximum values of plant height were recorded under T_4 as at 60 DAS (73.40cm), 90 DAS (80.06cm) and harvest (78.10 cm) followed by T_3, T_2, T_1, and T_7 respectively at all growth stages of soybean. However, all the herbicidal treatments gave significantly higher values of plant height over weedy check at all growth stages of soybean.

Branches per plant

Data presented in Table 4.6 and Fig.7 showed the number of branches per plant at 30, 60 and 90 DAS. The number of branches per plant was significantly differed because of different treatments at all growth stages.

At 30 DAS, the number of branches per plant was the maximum under T_4 (1.38) which was at par to T_3(1.25) while, minimum number of branches per plant was recorded under weedy check (0.75). Hand weeding (1.49) was almost similar to weedy check plots.

At 60 DAS the maximum number of branches per plant was recorded under hand weeding (2.47) while lowest value of number of branches/plant was recorded under weedy check (0.59). Among herbicidal treatments, T_4 (2.27) produce the maximum number of branches per plant which was almost similar to hand weeding and it was followed by T_3 (1.56).Data recorded at 90 DAS showed similar trend to that of 60 DAS.

Leaves per plant

Data recorded on leaves per plant of soybean at 30 and 60 DAS were influenced significantly by different treatments are presented in Table4.6 and Fig.7 .

At 30 DAS, the number of leaves per plant was maximum under treatment T_4(8.13) followed by treatments T_3, T_7, T_2, T_1 and T_6. While, lowest value of leaves/plant was recorded under hand weeding (5.80) followed by weedy check (6.13).

At 60 DAS, maximum number of leaves per plant was recorded under hand weeding (22.63), while lowest value of leaves/plant was recorded under weedy check (15.67).

Among herbicidal treatments, T_4 gave maximum value of leaves/plant (21.07) which was at par to T_3 (18.60) followed by T_2, T_1, T_7 and T_6. However, all weed control treatments were found better to produce more number of leaves/plant at 30 and 60 DAS.

Table.4.6 Influence of different weed control treatments on number of branches as well as leaves per plant and leaf area index of soybean at different growth stages

Tr. No.	Treatments	Branches/plant(#)			Leaves per plant(#)		Leaf area index	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1	Imazethapyr 100g/ha	1.19	1.38	1.81	6.93	18.17	1.29	5.39
T_2	Imazethapyr 100g/ha+HWat 40 DAS	1.30	1.97	2.75	7.67	20.74	1.40	5.57
T_3	Imazethapyr 200g/ha	1.25	1.56	2.10	7.47	18.60	1.33	5.48
T_4	Imazethapyr 400g/ha	1.38	2.27	3.36	8.13	21.07	1.55	5.70
T_5	Fenoxoprop ethyl 75g/ha	1.00	1.04	1.40	7.60	17.45	1.16	5.18
T_6	Hand weeding 20&40 DAS	1.49	2.47	3.6	5.80	22.63	1.76	5.81
T_7	Weedy check	0.75	0.59	0.87	6.13	15.67	1.05	5.00
	SEm±	**0.06**	**0.03**	**0.13**	**0.10**	**0.31**	**0.01**	**0.02**
	C.D. at 5%	**0.19**	**0.10**	**0.39**	**0.29**	**0.92**	**0.03**	**0.06**

Leaf area index:-

The LAI values worked out at 30 DAS and 60 DAS growth stages under all treatments are shown in Table and also graphically illustrated through figure. The LAI values were higher at 60 DAS than at 30 DAS under all weed control treatments. The LAI was significantly differed due to the effect of different treatments at both the growth stages.

At 30 DAS, the maximum LAI was recorded in T_4(1.55) which was at par to T_3 (1.40) and T_2 (1.33).

At 60 DAS, hand weeding (5.81) showed maximum LAI while, minimum in weedy check (5.00) among all treatments. Among herbicidal treatments T_4 (5.70) showed maximum LAI which was at par To T_3.

Dry matter production:-

Data pertaining to dry matter production (g/m^2) at successive growth stages of soybean influenced by various treatments are shown in Table 4.7 and graphically illustrated through the Figure8. Data given in the Table revealed that dry matter production (g/m2) orderly increased with the advancement in growth stages till to maturity of the crop under all treatments. However, rate of increment in dry matter production was more between 30 and 60 DAS.

The dry matter production significantly affected due to different weed control treatments at all growth stages. At 30 DAS, the maximum dry matter production was recorded under T_4 (149.31 g/m^2) followed by T_3, T_2, T_1, T_6 and T_7.The Lowest dry matter production was recorded under weedy check (100.30 g/m^2) followed by hand weeding (161.90 g/m^2).

At 60 DAS, hand weeding produced maximum dry matter (478.96 g/m2) while lowest value of dry matter production was recorded in weedy check (281.86 g/m2). Among herbicidal treatments T_4(456.43 g/m2) showed the maximum dry matter production followed by T_3 and T_2.

Data recorded at 90 DAS and harvest stages followed the same trend of treatment for dry matter production per m^2,but values reduced at harvest stages over 90DAS Result showed that, one hand weeding (at 30 DAS) and all herbicidal treatments were found better to produce maximum dry matter (g/m^2) than the weedy check.

Table 4.7 Dry matter production(g/m influenced by different weed control treatments

Tr. No.	Treatments	Dry weight of soybean plants (g/m^2)			
		30 DAS	**60 DAS**	**90 DAS**	**Harvest**
T_1	Imazethapyr (100g/ha)	114.30	368.96	569.46	553.36
T_2	Imazethapyr (100g/ha+HWat 40 DAS)	128.75	441.86	654.66	646.83
T_3	Imazethapyr (200g/ha)	121.94	392.73	623.63	619.63
T_4	Imazethapyr (400g/ha)	149.31	456.43	686.03	678.16
T_5	Fenoxoprop ethyl (75g/ha)	106.20	350.20	547.50	539.63
T_6	Hand weeding (20&40 DAS)	161.90	478.96	706.53	694.03
T_7	Weedy check	100.30	281.86	421.10	413.03
	SEm±	3.49	2.89	3.91	3.01
	C.D. at 5%	10.42	8.61	11.66	8.98

DAS- Days After sowing

Yield attributing characters

Pods per plant

Data related to number of pods per plant as influenced by different weed control treatments are given in Table. It is obvious from the data that number of pods per plant varied significantly under different treatments. Among all treatments, the minimum number of pods per plant was recorded under weedy check (61. 46 pods/plant), while maximum was in hand weeding (89.93 pods /plant). Among herbicidal treatments T_4 (88.04 pods/plant) was superior and was at par to T_3 (82.63 pods/plant) and minimum value was recorded under fenoxoprop-ethyl (78.34 Pods/plant). However, all herbicidal treatments found better over weedy check.

Table 4.8 Pods per plant, seeds per pod and seed index of soybean as Influenced by different weed control treatments

Tr. No.	Treatments	Yield attributes		
		Pods/ Plant	Seeds/ pod	Seed index
T_1	Imazethapyr (100g/ha)	81.14	1.37	9.37
T_2	Imazethapyr (100g/ha+HW at 40 DAS)	84.77	1.42	9.46
T_3	Imazethapyr (200g/ha)	82.63	1.39	9.26
T_4	Imazethapyr (400g/ha)	88.04	1.49	9.5
T_5	Fenoxoprop ethyl (75g/ha)	78.34	1.34	9.32
T_6	Hand weeding (20&40 DAS)	89.93	1.58	9.67
T_7	Weedy check	61.46	1.21	9.24
	SEm±	0.68	0.012	0.06
	C.D. at 5%	2.05	0.09	0.18

 # - Number

Seeds per pod

Data from Table 4.8 revealed that production of seeds per pod was differed significantly by different treatments. Hand weeding (1.58seeds/pod) gave maximum value of seeds per pod which was at par to the herbicidal treatments, T_4 (1.49 seeds/pod), T3 (1.42seeds/pod) and T_2(1.39 seeds/pod). Minimum value of seeds per pod was recorded in weedy check (1.21 seeds/pod). However, all the weed control treatments found significantly superior over weedy check.

Seed index

Data from Table 4.8 revealed that value of seed index was superior in the hand weeding (9.67) which was at par to T_4 (9.51), T_3 (9.26) and T_2 (9.46). However, all the herbicidal treatments found significantly superior over weedy check.

Grain yield

Data pertaining to grain yield in kg/ha as influenced by various treatments are presented in Table 4.9 and also graphically illustrated through the Figure.

It is evident from the data given in Table 4.9 that grain yield significantly varied due to the effect of different treatments. The grain yield of soybean among all treatments was highest under hand weeding (2556.78 kg/ha) which was at par to T_4 (2389.60kg/ha). The next best treatment was T_3 (2330.40 kg/ha) and T_2 (2370.85 kg/ha). However, all the herbicidal treatments were found significantly superior over weedy check (726.00 kg/ha).

Straw yield

Data on straw yield (kg/ha) as affected by different treatments are given in Table and depicted graphically in Figure .It is evident from the data that straw yield significantly varied due to different weed control treatments. All the treated plots produced significantly higher straw yield (3551.71 to 4174.29 kg/ha), than weedy check (1547.45kg/ha). However, hand weeding (4147.29kg/ha) was superior over all treatments except T_4 (3943.01 kg/ha).

Table 4.9 Seed yield, straw yield, harvest index and weed index of soybean as Influenced by different weed control treatments

Tr. No.	Treatments	Seed yields (Kg/ha)	Straw yields (Kg/ha)	Harvest index	Weed index
T_1	Imazethapyr (100g/ha)	2115.32	3705.68	36.30	17.26
T_2	Imazethapyr (100g/ha+HW at 40 DAS)	2370.85	4070.02	36.54	7.27
T_3	Imazethapyr (200g/ha)	2330.40	3940.65	37.18	8.81
T_4	Imazethapyr (400g/ha)	2389.60	3943.01	37.72	6.53
T_5	Fenoxoprop ethyl (75g/ha)	1925.69	3551.71	35.15	24.68
T_6	Hand weeding (20&40DAS)	2556.78	4174.29	37.98	-
T_7	Weedy check	726.00	1547.46	31.93	71.60
	SEm±	32.01	133.79	0.19	-
	C.D. at 5%	95.39	401.37	0.56	-

Harvest index

The ratio of economic yield to biological yield expressed in percentage was influenced by various treatments (Table & Fig.). The maximum harvest index was obtained under hand weeding (37.98%) which was close to T_4 (37.72%). While, minimum HI was recorded under weedy check plots (31.93%).

Weed index

Weed index is a measure of reduction in seed yield due to weed competitional stress as against weed free treatment (Hand weeding). The data on weed index (Table and figure) showed the maximum yield loss of 71.60 % in plots where weeds were not controlled in the entire crop season (weedy check). Among herbicidal treatments maximum yield reduction was recorded in fenoxoprop ethyl as 24.68% respectively over weed free treatment. Application of Imazethapyr 100g and 100g+ HW at 40 DAS resulted in reduction of yield as 17.26% and 7.27% respectively Imazethapyr (T_4) resulted in minimum yield reduction (6.53%) which was almost similar to weed free treatment.

Economic analysis of the treatments

The economic analysis of weed control treatments was determined on per hectare area basis, which includes cost of cultivation, gross monetary returns, net monetary returns and benefit cost ratio (profitability per rupee of investment) under different treatments.

Cost of cultivation

Cost of cultivation was determined treatment wise on the basis of market price of various common and variable agro-inputs used (Appendix -I). The values thus obtained are presented in Appendix -IV.

Weedy check treatment had the lowest cost of cultivation (Rs 15640/ha), but it increased in a range of Rs 15490 to Rs 18140/ha with the increase in application rate of imazethapyr from 100 to 400 g/ha and combination of adjuvant as early post emergence. Whereas, it was maximum under hand weeding (Rs 21640/ha) which needs 30labours per day per hectare.

Gross monetary returns

The value of seed and straw yields, depending on the existing market rate of each produce, was taken into consideration for determining gross monetary returns (GMR) under particular treatment (Appendix -IV). The GMR was minimum in weedy check (Rs 15757.96/ha) which increased remarkably under all the plots receiving weed control and being maximum under T_6 (hand weeding, Rs 54475.03/ha). Among the imazethapyr, T_4 (Rs 50946.4/ha) fetched the highest GMR followed by T_3, T_2, T_1, and $T_{7.}$

Net monetary returns

The net monetary return (NMR) under each treatment was determined by subtracting the cost of cultivation from GMR of the particular treatment. The treatment wise values, thus obtained, are given in Appendix-IV. It was obvious from the data that there was a marginal profit of Rs 117.96/ha when crop was not weeded (T_7) throughout the crop season while highest NMR was gained from hand weeding (Rs 32835.03/ha) followed by T_4, T_3, T_2, T_1, and T7

Benefit: cost ratio

It refers to net monetary gain under a particular treatment with each rupee of investment. The benefit cost indices as affected by different treatments are given in Appendix -IV. It is evident from the data that B:C ratio was maximum under T_4 (2.80) followed by T_1(2.63), T_6(2.51), T_2(2.50), T_3 (2.37), T_5(2.28) and minimum in T7(1.00).

DISCUSSION

The efficacy of early post emergence herbicides, imazethapyr were assessed in terms of their effect on population and dry matter production of weed, crop parameters like plant population, branches per plant, plant height, leaf area index, crop biomass, and number of active root nodules and finally the seed yield has been presented in this chapter and efforts has been made to discuss the reason which may be responsible for some of the important results outlined in the previous chapter. As the yield is the final criterion for the evaluation of the efficiency of different treatments. The discussion, therefore, is necessarily centered on the effect of treatments on various characters as they finally decided the yield. The results obtained and outlined in the forthcoming pages to reach at a valid conclusion. The findings of this investigation have also been supported with the findings of other research workers and data recorded on various parameters during the course of investigation.

Edaphic and climatic variation

The type and extent of weed flora in cropped area mainly depends on the soil type and climatic conditions of the area besides the impact of cultural practices followed under particular cropping system. In general weed flora and fertility status of the soil was identical to the area as the same crop sequence (Rice - wheat) was followed since last five years with recommended dose of fertilizers to both the crops in sequence. The weather conditions which prevailed during the crop season were almost similar to that of average conditions of the locality. Thus, it could be said that excessive higher rainfall at flowering stage have affected the crop yield by reducing pod formation and seed setting. And whatever variations that have been observed under different treatments were mainly due to treatments affect rather than other factors.

Dominant weed flora

The dominant weeds associated with soybean in the experimental field (Table 4.1) were mainly comprised of *Cyperus rotundus, Cyperus eria, Digitaria senguinalis, Ailernanthra philoxiroides* and *Eclipta alba* while other minor weeds were *Commelina communis, Echinochloa crusgalli, Cynodon dactylon,* and *Phyllanthus niruri.* Almost similar weed flora associated with soybean was reported by Vyas and Jain (2003), Halvankar *et al*, (2005), Girothia *and Thakur,* (2006), Pratap Singh and Raj Kumar (2008) and Suresh Kumar *et al*. (2008).

Activity of herbicides on weed density

The density of dominant weeds varied due to different weed control treatments and varying stages of crop growth (Table4.2)

Echinocloa Colona

This was the major weed in the experimental area. The severity of this weed was significantly lower under weed free treatment at all the stages of the crop growth. Similar result was obtained by Suresh Kumar *et al*, (2008).The activity of imazethapyr against *Echinocloa Colona* increased with increase in the application rate from 100 g/ha to 200 g/ha . These results are in agreement with those of Pratap Singh and Rajkumar (2008) and Kushwah and Vyas (2009). However, application of Imazethapyr reduced its population significantly (2.21 & 1.49/m^2 at 40 DAS and harvest respectively) over all herbicidal treatments and it was similar to weed free treatment (1.46 & 1.24/m^2 at 40 DAS and harvest respectively). Fenxoprop-ethyl (75 g/ha) controlled this weed significantly at 40 DAS and harvest respectively over weedy check

Digitaria senguinalis

The severity of this weed was significantly lower under weed free treatment (1.46 & 1.24 /m^2 at 40 DAS and harvest respectively) at all the stages of the crop growth (Table). Similar result was obtained by Suresh Kumar *et al.* (2008). The activities of imazethapyr against this weed increased with increase in the application rate Vyas and Jain (2003) and Vyas and Jain (2008) also found similar result. Among herbicidal treatments application of imazethapyr at the rate of 400 g caused maximum reduction (1.94 & 1.60/m^2 at 40 DAS and harvest respectively) in density of this weed over other rates of this herbicides. This was because of more concentration of imazethapyr molecules at the site of action and also increasing the efficiency of this herbicide by adjuvant and ammonium sulphate. Maximum density of this was reported in weedy check plots where, weed control measures were not applied.

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Cyperus iria

The density of this weed under different treatments is presented in Table It is evident from the data that density of this weed was the minimum under weed free treatment (hand weeding at 20 & 40 DAS). Among herbicidal treatments application of imazethapyr resulted in minimum density (2.14 & 1.24/m^2 at 40 DAS and harvest respectively) of this weed that was almost similar to weed free treatment (1.35 & 0.70/m^2 at 40 DAS and harvest respectively). On the other hand application of imazethapyr at 100g/ha found numerically better over fenoxaprop-ethyl . However, imazethapyr (100 g/ha) and fenoxaprop-ethyl (67.5 g/ha) were almost equally effective to suppress this weed. However, chlorimuron ethyl was inferior to other weed control treatments. While, maximum intensity of this weed was in the weedy check 3.54 & 2.21/m^2 at 40 DAS and harvest respectively because of no restriction on growth and development of the weeds. Almost similar findings were earlier reported by Kalpana and Velaytham (2004) and Girothia and Thakur (2006).

Alternanthra philoxiroides

Density of this weed was significantly affected by various treatments . Maximum intensity of this weed was recorded in weedy check while, minimum intensity was recorded in weed free treatment (0.71 & 1.07/m^2 at 40 DAS and harvest respectively) at all the stages of the crop growth. Among herbicidal treatments, T_4 (1.35 & 1.47/m^2 at 40 DAS and harvest respectively) was better to control this weed over other doses of imazethapyr *viz.* 200 g and 100g/ha +HW at 40 DAS . However, all herbicidal treatments were significant to control this weed over weedy check plots at all the growth stages except fenoxaporp-ethyl 75 g/ha. Because it's a graminicide. Almost similar finding was reported by Halvenkar *et al.* (2005)

Eclipta alba

The density of this weed at both the stages (40 DAS and harvest) under different treatments is given in Table 4.2. It is obvious from the data that density of this weed was numerically lowest under weed free treatment (1.70 & 1.38/m^2 at 40 DAS and harvest respectively) due to two hand weeding done at 20 & 40 DAS. Sharma and Shrivastav (2002) and Kalpana and Velaythum (2004) also reported similar results. Application of imazethapyr at 100 g/ha was less effective against this weed but its activity was enhanced when it was applied at 100 g/ha+HW at 40 DAS and even more when applied at 200 g/ha. However, imazethapyr 400g/ha arrested the population of *Eclipta alba* most effectively (1.96 & 1.35/m^2 at 40 DAS and harvest respectively) because of higher concentration and increasing in the efficiency of imazethapyr at the site of action compared to other treatments.

Other weeds

The population of other weeds comprised of broad leaved weed species viz., *Phylanthus niruri, Euphorbia geniculata* and monocots weeds *viz*., *Cynodon dactylon, Echinochloa crusgalli* and *Commelina communis*. The densities of these weeds were significantly affected by various treatments (Table4.2). The maximum densities of these weeds were recorded in weedy check treatment because of no restriction on growth and development of the weeds. While minimum intensity was recorded in weed free treatment (1.35 & 1.19/m^2 at 40 DAS and harvest respectively) received two hand weeding at 20 & 40 DAS. Application of imazethapyr (1.86 & 1.76/m^2 at 40 DAS and harvest respectively) was superior to suppress these weeds effectively than all herbicidal treatments. Whereas numerically more intensity of these weeds were found in the treatment was applied. Almost similar results were found by Mishra *et al,* (2001), Pratap Singh and Raj Kumar (2008), Suresh Kumar *et al,* (2008) and Kushwah and Vyas (2009).

Dry weight of weeds

Dry matter production by weeds per unit area is an indication of weed growth under particular treatment. The observation on dry weight of weeds recorded at 40 DAS and harvest. Dry weight was recorded species wise after drying them in oven at 60^0C for 4 days till constant weight was achieved the matter acumulation at maturity over previous stages get reduced and data are given in Table4.3 and depicted through Fig.4

Echinoclova colona

All weed control treatments were superior to check the dry matter production of this weed over weedy check plots according to their potential to suppress the growth and development of this weed at 40 DAS and harvest respectively (Table4.3). The minimum dry weight of this weed was recorded in weed free treatment (1.53 &1.11 g/m^2 at 40 DAS and harvest respectively). Among herbicidal treatments application of imazethapyr (T_4 , T_3 as 2.62 & 1.63 g//m^2, 2.73 & 1.70g//m^2 and 2.81 & 1.96 g//m^2 respectively at 40 DAS and harvest) than imazethapyr (T_1 and T_2) and also found superior to fenoxaprop-ethyl because these were checked the growth and development of this weed significantly, However, maximum dry weight of this weed was recorded in weedy check where, no weed control measure was applied. Thus, there was no restriction on growth and development of this weed. These results are in conformity with the findings of Suresh Kumar *et al.* (2008), Pratap Singh and Raj Kumar (2008) and Kushwah and Vyas(2009).

Digitaria senguinalis

It is obvious from the data (Table 4.3), that the dry weight of this weed varied in different treatments at 40 DAS and harvest. Minimum dry weight of this weed was recorded in weed free treatment (2.35 & 1.48g/m^2 at 40 DAS and harvest respectively) closely followed by the treatment, imazethapyr (3.20 & 2.50 g/m^2 at 40 DAS and harvest respectively). Other doses of imazethapyr (100 + HW at 40 DAS and 200 g/ha) were also found effective to check the dry matter production of this weed because of excellent check on the growth and development according to their potential. However, maximum dry weight was recorded in weedy check at 40 DAS and harvest respectively because there was no restriction on the growth and development of weeds. These findings are in agreement with Suresh Kumar *et al.* (2008) and Vyas and Jain(2003 & 2008).

Cyperus iria

Dry weight of this weed was significantly influenced by various treatments at 40 DAS and harvest respectively (Table4.3). Lowest dry weight of the weed was recorded in the weed free treatment (1.78&1.70 g/m^2 at 40 DAS and harvest respectively) received two hand weeding at 20 & 40 DAS closely followed by application of Imezathepyr 400 g/ha (2.92 & 2.28g/m^2 at 40 DAS and harvest respectively). This is because of excellent check on the growth and development of this weed at 40 DAS and harvest respectively. Whereas, maximum dry weight of this weed was recorded in weedy check. Other doses of imazethapyr and fenoxaprop-ethyl also found superior over weedy check because of good check of growth and development of this weed. Almost similar findings were earlier reported by Jain and Kurchaniya (2002), Kalpana and Velaytham (2004) and Girothia and Thakur (2006). Chorimuron-ethyl being a broad leaved herbicide was inferior to that of other weed control treatments.

Alternanthra philoxiroides

Dry weight of this weed was significanlty affected by various treatments given in Table . The maximum dry weight of this weed was recorded in weedy check while, minimum dry weight of this weed was recorded in weed free treatment which was almost zero at 40 DAS and harvest respectively. Similar result was obtained by Halvankar *et al*, (2005). This was because of complete removal of this weed. Among herbicidal treatments, imazethapyr 400 g/ha produced least dry weight (2.56 & 2.06g//m^2 at 40 DAS and harvest respectively) of this weed. Other doses of imazethapyr were also effectively controlled the dry weight production of this weed. This was due to good suppression of growth and development of this weed than fenoxaprop-ethyl (75g/ha) However, fenoxaprop-ethyl being a graminicide was least effective to suppress the dry weight production of this weed.

Eclipta alba

Dry weight of this weed also affected significantly by various treatments at 40 DAS and harvest respectively. Data from Table4.3 revealed that two hand weeding at 20 & 40 DAS was superior over all weed control treatments to suppress the dry matter production (3.15 & 3.81g//m^2 at 40 DAS and harvest respectively) of this weed by checking the growth and development of this weed excellently. Among herbicidal treatments, imazethapyr was superior (2.21 & 1.42g at 40 DAS and harvest respectively) because of excellent check on growth and development, this may be because of increased in the efficiency of imazethapyr by adjuvant and AS at cite of action. Other doses of imazethapyr at the rate of 100 HW at 40 DAS and 200 g/ha was also effective to suppress the dry weight of this weed according to their potential to check the growth and development. While, fenoxaprop-ethyl @ 75 g/ha was inferior to control this weed compared to other herbicidal treatments . Being a graminicide fenoxaprop-ethyl was not as affective to suppress the growth and development of this weed as imazethapyr (Broad spectrum herbicide) and chlorimuron-ethyl (Broad leaved herbicide). However, maximum dry weight of this weed was recorded in weedy check plots. Results are matching with earlier findings of Sharma and Shrivastav (2002) and Kalpana and Velaythum (2004).

Other weeds

Dry matter production of other weeds *viz. Phylanthus niruri, Euphorbia geniculata, Cynodon dactylon, Echinochloa crussgalli* and *Commelina communis* was significantly influenced by various treatments at various growth stages (40 DAS and harvest) given in Table . The least value of dry weight of this weed was recorded in weed free treatment (1.38 & 1.12g//m^2 at 40 DAS and harvest respectively) because of better growth and development of soybean plants which suppressed the growth and development of weeds excellently. Being a broad spectrum herbicide application of imazethapyr at various doses (100g/ha + HW at 40 DAS) were effectively checked the growth and development of this weed as compared to fenoxaprop-ethyl (gramincide) thus, resulted in effectively control of the dry matter production of other weeds. However, application of imazethapyr was most effective to suppress the dry weight of other weeds (1.60 & 1.18g//m^2 at 40 DAS and harvest respectively). Maximum dry weight was recorded in weedy check plots where the weeds grew without any restriction. Similar results were obtained by Mishra *et al.* (2001), Pratap Singh and Raj Kumar (2008), Suresh Kumar *et al.* (2008) and Kushwah and Vyas (2009).

Weed control efficiency

Weed control efficiency (WCE) of a treatment has strong negative correlation with weed biomass. An increased trend of WCE was reported at harvest than at 40 DAS among all weed control treatments (Table4.4 & Fig.5). The weed free treatment registered maximum weed control efficiency (93.23 &96.23 % at 40 DAS and harvest respectively) than all other treatments because of least dry matter production of the weeds over weedy check treatment. Subsequent application of imazethapyr (80.23 &90.52% at 40 DAS and harvest respectively) was superior among herbicidal treatments. Application of imazethapyr @ 100 g/ha+ HW at 40 DAS to 200 g/ha with adjuvant curbed the weed growth to the tune of 68.40 to 82.58% and 72.94% to 88.52% at 40 DAS and harvest respectively. Which was superior to application of imazethapyr @ 100 g/ha fenoxaprop-ethyl @ 75 g/ha respectively. These findings are in agreement with findings of Singh *et al.* (2003), Shete *et al.* (2007), Suresh Kumar *et al.* (2008) and Kushwah and Vyas (2009).

Plant population

Data from Table4.5 and Fig6 revealed that the plant population per meter square was not affected significantly by herbicidal treatments at 25 DAS, indicating that the early post-emergence application of imazethapyr, chlorimuron-ethyl and fenoxaporp-ethy have no adverse effect on crop plants. The subsequent observation at harvest revealed slight declining trend under all the treatments but a greater drop was recorded in weedy check which may be attributed to severe competitional stress by weeds for space, light, moisture and nutrients, resulting in mortality of some of the crop plants. Among herbicidal treatments numerically maximum declination was observed in chlorimuron-ethyl.

Plant height

The plant height increased slowly during early stage of crop growth (up to 30 DAS) thereafter, increased sharply up to 60 day stage again growth increased slowly at 60 to 90 days stages. At harvest plant height declined slightly in all the treatments. Plant height too was significantly affected by various treatments at all the growth stages of crop (Table 4.5 & Fig.6). The height of plants considerably more under weed free plots (74.16, 84.25 & 81.66 cm at 60, 90 and harvest respectively) compared to rest of the treatments as crop was free from weed stress and all the growth resources were optimally utilized by the crop plants. This led to better plant height. Among the herbicidal treatments long stature plants were recorded under T_4 (16.46, 73.40 ,80.06 & 78.10 cm at 30, 60, 90 & harvest respectively). However, all the herbicidal treatments showed better plant height over weedy check plots. The excellent control of weeds under these treatments led to optimal utilization of growth resources therefore, these treatments have long stature plants. Similar results were obtained by Mishra *et al*, (2001) Kushwah and Vyas (2005) and Kushwah and Vyas (2009).

Branches per plant

Branches per plant remarkably differed due to different treatments at various growth stages of crop (30, 60 and 90 DAS.When fenoxaprop-ethyl (75 g/ha) and Imazethapyr 100 and 100 g/ha+HW at 40 DAS applied resulted in increased the number of branches per plant at all the stages. This may be attributed to reduced weed competition during critical period of crop growth as a result of effective weed control coupled with no phytotoxicity on soybean seedlings. But found significantly inferior to that of imazethapyr 400 g/ha (1.38,2.27 & 3.36 at 30, 60 and 90 DAS respectively) as well as weed free treatment (1.49, 2.47 & 3.63 at 30, 60 and 90 DAS respectively) because, both the treatments provided excellent control of associated weeds, resulting in almost weed free environment throughout the critical period of crop-weed competition which, led to optimum growth and development of crop plants and ultimately resulted in more number of branches per plant under these treatments. Almost similar results were obtained by Mishra *et al*. (2001), Vyas and Jain (2003), Suresh Kumar *et al,* (2008) and Kushwah and Vyas (2009).

Leaves per plant

Number of leaves per plant differed significantly due to different treatments at 30 and 60 days stages (Table 4.6 & Fig7.).

Number of leaves per plant was the maximum in the T_4 (8.13) while, minimum in hand weeding (5.80) at 30 DAS. But at 60 DAS, maximum number of leaves per plant was higher in weed free treatment (22.63) which was at par to T_4 (21.07). This may be because of better growth and development of foliage under weed free environment. Application of fenoxaprop-ethyl found inferior to that of all the doses of imazethapyr and weed free treatment to produce the more number of leaves per plant. However, weedy check produced significantly lower number of leaves per plant because of stressful condition. Mishra *et al*, (2001) and Kushwah and Vyas (2009) also reported similar results.

Leaf area index (LAI)

LAI differed significantly due to different treatments at 30 and 60 days growth stages (Table4.6 & Fig. 7). The LAI was maximum in T_4(1.55) at 30 days stage and it was almost similar in all the doses of imazethapyr along with adjuvant. Minimum value of LAI was recorded in weedy check plots. Fenoxaprop-ethyl also produced significantly higher LAI compared to weedy check but they were inferior to that of all doses of imazethapyr . At 60 days stage, maximum LAI was recorded in weed free treatment (5.81) followed by T_4 (5.70) which were at par to T_3 (5.57) and T_2 (5.48). This may be because of better growth and development of foliage under weed free environment and consequently resulted in more assimilatory area per unit land area. Relatively poor LAI under imazethapyr (100 g/ha), fenoxaprop-ethyl (75 g/ha) were on account of higher crop weed competition which did not compensate the leaf area index. Mishra *et al*, (2001) and Kushwah and Vyas (2009) also found similar result.

Dry matter production

Crop biomass varied during all growth stages under different treatments. Weedy check had significantly lower crop biomass among all the treatments at all the growth stages (30, 60, 90 DAS and harvest) due to severe competition between crop and weeds for growth resources during critical period of crop growth (Table4.7 & Fig.8). The increased crop biomass in plots receiving hand weeding (161.90, 478.96, 706.53 & 763.03 g/m^2 at 30, 60, 90 DAS and harvest respectively), Imazethapyr (149.31, 456.43, 686.03 & 706.16 g/m^2 at 30, 60, 90 DAS and harvest respectively) ,imazethapyr 100 g /ha +HW at 40 DAS (121.84, 392.73, 623.63 & 653.83 g/m^2 at 30, 60, 90 DAS and harvest respectively) and 200 g/ha (128.75, 441.86, 654.66 & 664.63 g/m^2 at 30, 60, 90 DAS and harvest respectively) along with adjuvant may be attributed to reduced weed competition as a result of effective control of weeds which promoted the better growth and development of plants and ultimately produced higher biomass compared to lower rate of imazethapyr (100 g/ha), fenoxaprop-ethyl (75 g/ha) . The results are in confirmation with findings of Mishra *et al*, (2001) and Dhane *et al,* (2009)

Effect on yield attributing characters of crop

Pods per plant and seeds per pod

Yield attributes namely pods per plant and seeds per pod were significantly superior in the weed free treatment (89.93 & 1.58 respectively) than weedy check (Table4.8). Excellent growth and development of soybean plants under weed free environment during critical period of crop growth might have resulted in higher number of pods per plant and seeds per pod under weed free treatment as compared to weedy check, which had severe weed competition right from early growth stages and ultimately resulted in most inferior yield attributes. Application of imazethapyr at 400 g/ha + 200 g/ha and 100g/ha+HW at 40 DAS produced higher number of pods per plant and seeds per pod as (88.04 & 1.49), (84.77 & 1.42) and (82.63 & 1.39) respectively compared to other treatments on account of maximum reduction in weed growth coupled with no inhibitory effects on soybean plants. Thus these treatments might have resulted in relatively better yield attributing traits. Whereas, poor weed control under T_1, T_7 and T_6 might have produced lower number of pods per plant and seeds per pod. Almost similar results were obtained by Vyas and Jain (2003), Kushwah and Vyas (2005), Pandya *et al*. (2005), Suresh Kumar *et al*, (2008) and Dhane *et al,* (2009).

Seed Index

Seed index (100 seeds weight) differed significantly due to various treatments (Table 4.8).fig.9 It was the maximum in weed free treatment (9.67) than weedy check (9.24). Excellent growth and development of soybean plants under weed free environment during critical period of crop growth might have resulted in higher seed index under weed free treatment as compared to weedy check. Among herbicidal treatments T_4 (9.57), T_3 (9.46) and T_2 (9.26) produced higher S.I. compared to other treatments. It may be because of maximum reduction in weed growth, coupled with no inhibitory effects on soybean plants and maximum transformation of nutrients as assimilates towards seeds resulted in higher S.I. in these treatments. Results are matching with the findings of Pandya *et al*, (2005), Suresh Kumar *et al,* (2008) and Dhane *et al,* (2009).

Seed yield

Seed yield under a particular treatment is the result of complex phenomenon, which not only depends on the genetic constitution of the crop plants but also on the production technology adopted. Weeds caused considerable damage to the crop depending upon the associated weed species, their density, duration of crop weed competition etc. and their cumulative effect reflected in terms of reduced crop yield. The seed yield was lowest (726 kg/ha) in the plots receiving no weed control measures (weedy check) due to severe competition stress right from crop establishment up to the end of critical period of crop growth, leading to poor growth parameters and yield attributing traits and finally the seed yield (Table 4.9 & Fig.9). All the treated plots receiving either manual weeding or herbicidal treatments produced higher yield over weedy check plots. Weed free treatment produced the maximum seed yield (2556.78 kg/ha) and proved its superiority over all the treatments. The crop under weed free plots attained lush growth due to elimination of weeds from inter and intra row spaces besides better aeration due to manipulation of surface soil and thus, more space, water, light and nutrients were available for the better growth and development, which resulted into superior yield attributes and development, and consequently the highest yield. Sharma and Shrivastava (2002), Vyas and Jain (2003), Halvankar *et al*,(2005), Pandya *et al*, (2005) and Dhane *et al,* (2009) also reported hand weeding as an effective method of weed control for achieving the maximum yield of soybean.

Among herbicidal treatments, application of imazethapyr 400 g/ha resulted in higher seed yield (2389.60 kg/ha) which was at par to weed free treatment because of relatively low stress and better yield attributes. Application of imazethapyr at 200 and 100 g/ha+HW at 40 DAS along with adjuvant also produced significantly higher yield (2330.40 & 2170.85 kg/ha respectively) over application of imazethapyr at 75 and 100 g/ha without adjuvant. Application of fenoxaprop-ethyl (75g/ha) found inferior to produced the higher seed yield than that of all doses of imazethapyr This may be because of selectivity of these herbicides to either monocots or dicots, resulted in poor control of weeds might have failed to arrest the weed growth this led to record lower yield attributing traits and consequently poor seed yield. Almost similar results were obtained by Pandey *et al,*(2007) and Pratap Singh and Raj Kumar (2008).

Harvest index

Harvest index (the ratio of economic yield to the biological yield) was significantly higher under weed free treatment (37.98%) closely followed by T_4 (37.72%) and T_3 (37.18%) among all weed control treatments (Table 4.9 & Fig.10).It is ratio with excellent growth and development of soybean plants under weed free environment during critical period of crop growth might have resulted in higher harvest index under these treatments. While, weedy check resulted in the lowest value of H.I. (31.93%). Because, presence of weeds in this treatment resulted in stressful condition and ultimately suppress the growth and development of soybean plants. Kushwah and Vyas (2005) also found similar result.

Weed index

Weed index is a measure of reduction in the seed yield due to weed competitional stress as against weed free treatment. Data from Table 4.9 & Fig. showed that maximum yield loss of 71.60% was recorded under weedy check where, weeds were not controlled in the entire crop season. Presence of weeds created stressful conditions for nutrients, space, soil moisture and light thus, suppress the growth and development of soybean crops. Highest weed index was recorded under weed free treatment (0.00%). Maximum weed index among herbicidal treatments was recorded under T_4 (6.53%) which was almost similar to weed free treatment. Closely followed by T_3(8.81%). Excellent control on growth and development of weeds under these treatments resulted in minimum reduction of soybean yield as compared to other treatments those were inferior to suppress the growth and development of weeds. Mishra *et al*. (2001) also reported similar results.

Economic viability of treatments

Cost of cultivation

Cost of cultivation play an important role in deciding the acceptability of any treatment by the farmers. It was obvious from the data *(Appendix-III)* that weed free treatment receiving two hand weeding, required maximum variable cost (Rs 6000/ha), which was not affordable by the poor farmers and at the same time availability of laboures during peak period is also questionable. All the treatments received early post-emergence application of imazethapyr 400g/ha and imazethapyr @ 100 g/ha Fenoxaprop-ethy (75 g/ha) needed less variable cost (Rs 2500/ha) over hand weeding. Thus, use of herbicides for control of weeds seems to be cheaper.

Gross monetary returns (GMR)

The gross monetary returns (GMR) was minimum (Rs 15757.96/ha) under weedy check because of the lowest seed and straw yields. But it was increased to a maximum level (Rs 54475.03/ha) under weed free treatments received two hand weeding closely followed by application of imazethapyr 400g/ha(Rs 50946.40/ha) and imazethapyr 200g/ha (Rs 49780.52/ha). Other treatments like imazethapyr 100 g/ha+HW at 40 DAS , imazethapyr 75 g/ha, fenoxaprop-ethyl (75 g/ha) found superior to fetched greater GMR over weedy check because of increased seed and straw yields of the soybean (Appendix - IV).

Net monetary returns (NMR)

Net monetary returns was only Rs 117.96/ha under weedy check treatment where weeds were not controlled, but increased to a maximum level (Rs 32835.03/ha) under weed free treatment closely followed by T_4 and T_3 as Rs 30006.4and Rs 31340.52/ha respectively *(Appendix - IV).* The low investment and better seed and straw yields coupled with good economic returns might be the reason for higher NMR over remaining treatments *viz*., T_3, T_2, T_1, T_7, T_6 Application of imazethapyr @ 100 g/ha+HW at 40 DAS were also fetched the good economic yield might be the reason for higher NMR over imazethapyr (100 g/ha), fenoxaprop-ethyl (75 g/ha) . However all weed control treatments were found superior over weedy check treatment to fetched higher NMR. Pandya *et al.* (2005) also reported maximum NAR under hand weeding treatment.

Benefit: cost ratio

The benefit: cost ratio represents the profitability of the treatments with each rupee of investment. It is remarkable to note that the application of imazethapyr (100 g/ha+HW at 40 DAS) was more remunerable (2.76) than rest of all the treatments including weed free treatment (2.51). While weedy check was not advantageous as there was loss of almost 100 paisa per rupee investment. Similar findings have also been reported by Bhan and Kewat (2003).

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

Summary

The present investigation entitled “Evaluation of Imazethapyr 10 % SL herbicide against weeds in soybean” was conducted at Adhartal Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (M.P.).

The experiment carried out on sandy loam soil which was low in organic carbon, available nitrogen and phosphorus but medium in available potassium and neutral in reaction. The investigation was aimed to study the bio-efficacy of herbicides as early post-emergence for weed control and to determine economic viability of treatments. The experiment area has the natural weed flora comprising of grassy as well as broad leaved weeds. Seven treatments comprised of Imazethapyr 100 g ai/ha, Imazethapyr at 100 g ai /ha,+HW at 40 DAS, Imazethapyr at 200 g ai/ha, Imazethapyr 400 g ai/ha , Fenoxoprop ethyl (standard check) 75 g ai/ha , weed free treatment (Hand weeding at 20&40 DAS) and weedy check, were laid out in randomized block design with three replications. All herbicide treatments were applied in 500 litres of water per hectare, using flat fan nozzle. Different observations on the weeds and crop parameters were carried out during the course of investigation. Dominant weed flora, species wise weed population and their dry weight was recorded under all the treatments at 30,60,90 DAS and harvest stages. Plant population of soybean was recorded at 25 DAS and growth parameters *viz.* number of leaves per plant, leaf area index, plant height (cm), and branches per plant were recorded at periodic interval. Yield attributing traits *viz.* pods per plant, seeds per pod and seed index

(100 seed weight) were recorded treatment wise. Weed control efficiency, weed index, harvest index and economic viability of treatments were done from data generated. The salient findings of the investigation are briefly summarized as below :-

Effect on weeds

The rampant weed species identified in the experimental field were Echinoclova colona *Cyperus iria*and *Digiteria senguinalis* among monocots while, *Eclipta alba* and *Alternanthra philoxiroides* were among dicots.

In weedy check treatment the total weed population was significantly higher than all the herbicidal treatments (Imazethapyr, fenoxaprop-ethyl) including weed free treatments. The weed menace was the minimum under weed free treatment . Among herbicidal treatments Imazethapyr(400 g ai/ha) was most effective to reduced most of the weeds flora, which was almost similar to hand weeding.

Weedy check had the highest weed biomass and it had reduced significantly when weeds were controlled either by the use of herbicides or hand weeding (20 DAS and 40 DAS) respectively. . Application of imazethapyr at 400 g ai/ha found significant to reduced the weed biomass than application of imazethapyr at the rate of (200 g ai/ha) and also found significant over application of Imazethapyr (100 g ai/ha) and fenoxoprop ethyl (75 g ai/ha).

Effect on crop

The plant population of soybean was not affected under all treatments as early post-emergence at 25 DAS, indicating that these treatments did not adversely affect the germination and further survival of crop plants. Consequently, the plant population was almost similar under all treatments. Growth parameters like number of leaves per plant, LAI, branches per plant, plant height, crop biomass, nodules per plant and active root nodules per plant were significantly superior in treated plots than weedy check. However, weed free treatment was better over all treatments closely followed by T_4(Imazethapyr (400 g ai/ha). Yield attributing traits *viz.* pods per plant, seeds per pod and seed index (100 seed weight) were also remarkably superior under treated plots as compared to weedy check.

Both seed and straw yields were significantly higher under all the treatments receiving weed control measure than weedy check plots. Maximum seed yield of soybean was recorded under weed free treatment and proved superior over all the treatments. Among the imazethapyr treatments, application of Imazethapyr 100 g ai/ha$_{+HW\ at}$ DAS (T_2) was found significantly superior over all the rates of imazethapyr (100 and 200g ai/ha) as early post-emergence. Application of imazethapyr @ (100g ai/ha) was not found significant over fenoxaprop-ethyl (75g ai/ha) but found significant to Imazethpyr (400g ai//ha)

Economic Viability of Treatments

Weed free treatment received two hand weeding required maximum investment (Rs 21640/ha) to control weeds while, expenditure incurred under Imazethapyr 200 g ai/ha+HWat 40 DAS (T_2 Imazethapyr at (100and 200g ai/ha), fenoxaprop-ethyl ranged from Rs 16952/ha, indicating that control of weed through hand weeding was more expensive than the use of herbicides in soybean. Maximum gross monetary returns (Rs 54475.03/ha) was obtained under weed free treatment closely followed by T_4 (Rs 50946.4) and T_2(Rs 50673.01/ha). Though the gross monetary return was maximum in weed free treatment among all the treatments, but the net monetary return and B:C ratio were the highest under Imazethapyr 200 g/a.i/ha (T_2) closely followed by imazethapyr 400 g/ha (T_3) and imazethapyr @ 100g (T_1) as early post-emergence to soybean.

Conclusion

Based on the foregoing discussion the following conclusion could be drawn:

1. Dominant weeds infesting soybean crop were *Echinoclova colona Cyperus iria, Digitaria senguinalis* among monocots while, *Alternanthra philoxiroides* and *Eclipta alba* among dicots.
2. Early post emergence application of imazethapyr 100 g a.i./ha+HW at 40 DAS (T_2) was most effective in paralyzing the weed growth to that of imazethapyr (400and 100g/ha) and fenoxaprop-ethyl (75g/ha) .
3. Growth parameters, yield attributes and seed yield were superior under post- emergence application of Hand weeding at 20 and 40 DAS without any phytotoxicity on soybean plants.
4. Application of imazethapyr 100g /ha+HW at 40 DAS as early post emergence was more remunerative in terms of NMR (Rs 32333.01/ha) and benefit: cost ratio (2.75) than imazethapyr @ 400and 100g/ha and fenoxaprop-ethyl .

Suggestions for further work

Based on the experience of present investigation following studies for future, are suggested.

1. Since the conclusions are drawn on the basis of the results of only one year experimentation, this study should be repeated at least for 2-3 years to confirm the results.
2. These treatments need to be tested on other varieties of soybean also to screen out the sensitive varieties against imazethapyr , fenoxaprop-ethyl.

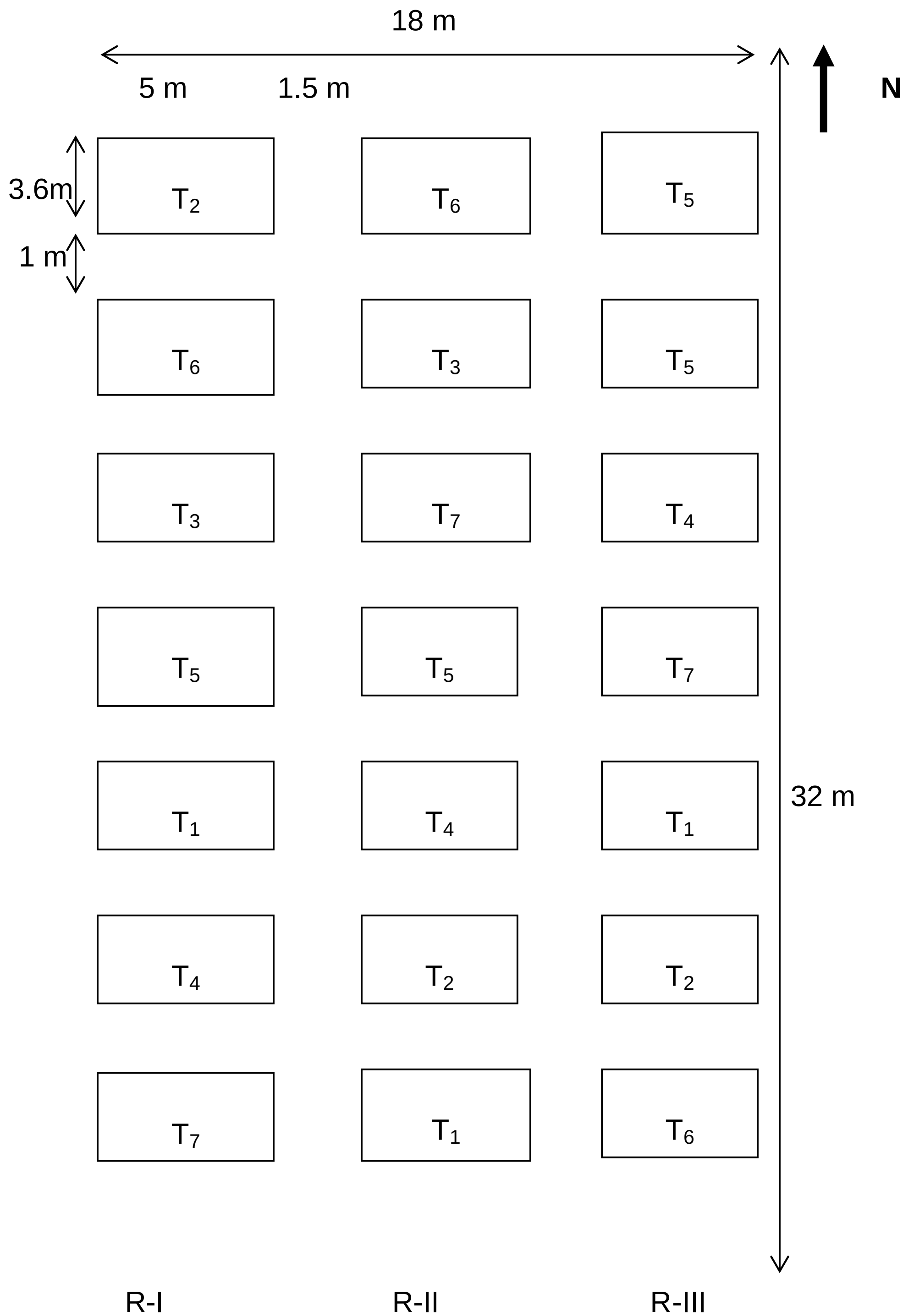

Fig. 2 LAYOUT OF THE EXPERIMENT

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Appendix – I

Common cost of cultivation per hectare area basis (Excluding cost of treatments)

Sr. No.	Particulars	Input (Per ha)	Cost /Unit (Rs.)	Cost (Rs/ha)
A	**Land preparation**			
I	Harrowing by cultivator	One pass	750	750
II	Disc harrow	One pass	750	750
III	Leveling	One pass	250	250
B	**Seed and sowing**			
I	Cost of seed	70 kg	30/kg	2100
V	Sowing charges		750	750
C	**Fertilizers**			
I	Cost of fertilizers	20 kg N	13/kg	260
		60 kg P_2O_5	25/kg	1500
		20 kg K_2O	9/kg	180
II	Application charges	2 man days	100	200
D	Irrigation through tube well (Including application charges)	One time	400	400
E	Harvesting,	30 man days	100	3000
F	Threshing and winnowing	30 man days	100	3000
G	Land rent	6 months	5000 per year	2500
	Total			15640

Appendix – II

Estimation of variable cost of cultivation due to various weed control treatments (Per hectare area basis)

Tr. No.	Treatments	Dose/ ha	Unit price (Rs/litre or kg)	Cost (Rs/ha) Including application charges (Rs300/ha)
		Formulation		
T_1	Imazethapyr 10% SL	1000 ml	1250	1550
T_2	Imazethapyr 10% SL+HW at 40 DAS	1000 ml+HW at 40 DAS	1250	2750
T_3	Imazethapyr 10% SL	2000ml	1250	2800
T_4	Imazethapyr 10% SL	4000 ml	1250	5300
T_5	Fenoxoprop ethyl (Standard check) 9.3%EC	750 ml	1350	1312
T_6	Hand weeding Twice (25 man/ha/day)	20 & 40 DAS (25and 25 man days)	Rs 120/ Man day	6000
T_7	Control			

Appendix – III

Economic analysis of different treatments in soybean

Tr. No.	Treatments	Cost of variable treatment (Rs/ha)	Common Cost of cultivation without treatments (Rs/ha)	Cost of cultivation (Rs/ha)
T_1	Imazethapyr 100g/ha	1550	15640	17190
T_2	Imazethapyr 100g/ha +HW at 40 DAS	2750	15640	18390
T_3	Imazethapyr 400 g /ha	2800	15640	18440
T_4	Imazethapyr 200g/ha	5300	15640	20940
T_5	Fenoxoprop ethyl (9.3EC)	1312	15640	16952
T_6	HW at 20 and 40 DAS	6000	15640	21640
T_7	Weedy check	–	15640	15640

APPENDIX- IV

Economic analysis of different treatments in soybean

Treatment	Grain yield (Kg/ha)	Values of grain Rs/ ha	Straw yield Kg/ha	Value of straw Rs/ha	Gross monetary returns Rs/ha	Cost of cultivation Rs/ha	Net monetary returns Rs/ha	B:C Ratio
T_1	2115.32	42306.4	3705.68	2964.54	45270.94	17190	28080.94	2.63
T_2	2370.85	47417	4070.02	3256.01	50673.01	18340	32333.01	2.75
T_3	2331.40	46628	3940.65	3152.52	49780.52	18440	31340.52	2.69
T_4	2389.60	47792	3943.01	3154.40	50946.4	20940	30006.4	2.43
T_5	1925.69	385138	3551.71	2841.36	38797.36	16952	21845.36	2.28
T_6	2556.78	51135.60	4174.29	3339.43	54475.03	21640	32835.03	2.51
T_7	726	14520	1547.45	1237.96	15757.96	15640	117.96	1.00

VITA

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