

INTEGRATED WEED MANAGEMENT IN SOYBEAN

THESIS

**Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of**

MASTER OF SCIENCE

IN

**AGRICULTURE
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2011

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled “**INTEGRATED WEED MANAGEMENT IN SOYBEAN**” or part thereof has neither been submitted for any other Degree or Diploma of any University, nor the data have been derived from any thesis or publication of any university or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Nagpur

Date: 24/05/2011

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CERTIFICATE

This is to certify that the thesis entitled **"INTEGRATED WEED MANAGEMENT IN SOYBEAN"** submitted in partial fulfillment of the requirements for the Degree of **"Master of Science in Agriculture" (Agronomy)** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, is a record of bonafied research work carried out by **Mr. A.M.Wadafale** under my guidance and supervision.

The subject of the thesis has been approved by the student's Advisory Committee.

Place: Nagpur

Date: 24/05/2011



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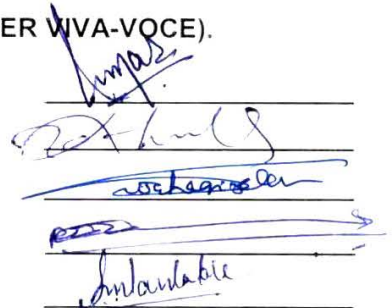


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(Wadafale Akash Manoharrao)

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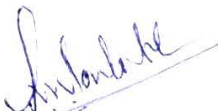
%	:	Per cent
/	:	Per
°C	:	Degree Celsius
a.i.	:	Active ingredient
BSH	:	Bright sunshine hours
C.D.	:	Critical difference
cm	:	Centimeter
cm ²	:	Centimeter square
AH	:	At harvest
d.f.	:	Degrees of freedom
DAS	:	Days after sowing
DAE	:	Days after emergence
e.g.	:	For example
<i>et al.</i>	:	et alia (and associates)
Fig.	:	Figure
g	:	Gram
G.M.	:	General Mean
GMR	:	Gross Monitory Returns
ha	:	Hectare
i.e.	:	that is
K	:	potash
K ₂ O	:	Potassium oxide
kg	:	Kilogram
Max.	:	Maximum
MW	:	Meteorological Week
Min.	:	Minimum
mm	:	Millimeter
MSL	:	Means Sea Level
N	:	Nitrogen
H	:	Hoeing

fb	:	Followed by
ha ⁻¹	:	Per hectare
HI	:	Harvest Index
lit	:	Litre
m	:	Meter
m ²	:	Meter square
m ⁻²	:	Per meter square
HW	:	Hand weeding
Imz	:	Imazethapyr
N.S.	:	Non significant
NMR	:	Net Monitory Returns
No.	:	Number
P	:	Phosphorus
P ₂ O ₅	:	Phosphorus pentaoxide
pH	:	Hydrogen ion concentration
PPI	:	Pre Plant Incorporation
PRE	:	Pre emergence
POE	:	Post emergence
q	:	Quintal
q ⁻¹	:	Per quintal
RDF	:	Recommended Dose of Fertilizers
RH	:	Relative humidity
Rs.	:	Rupees
S.E. (m) ±	:	Standard error (mean) ±
SSP	:	Single super phosphate
T	:	Treatments
WCE	:	Weed control efficiency
WI	:	Weed index
viz,	:	Namely

(D)

THESIS ABSTRACT

- a) Title of the Thesis : "Integrated weed management in soybean"
- b) Full name of the student : **Wadafale Akash Manoharrao**
- c) Name and address of Advisor : **Dr. P.C. Pagar**
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- i) Signature of the student : *A.M. Wadafale*
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ABSTRACT

A Field investigation entitled "Integrated weed management in soybean" was carried out at farm of Agronomy department, College of Agriculture, during 2010-2011.

The investigation was carried out to study the time of application and concentration of imazethapyr, fenoxaprop-p-ethyl and chlorimuron ethyl in controlling weeds in terms of growth and yield performance of soybean crop and to workout economics of chemical and cultural weed management practices in soybean. The experiment was laid out in RBD design with ten treatments and four replication. The treatment comprised of unweeded control (T_1), 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T_2), fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS (T_3), chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS (T_4), imazethapyr @75g a.i. ha⁻¹ at 15 DAS (T_5), fenoxaprop-P-ethyl @100 a.i .ha⁻¹ + chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS (T_6), and imazethapyr @75g a.i. ha⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS (T_7), fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_8), chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_9) and imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_{10}).

The soil of the experimental field was clayey in texture with slightly alkaline (pH 7.7) moderate organic in carbon status, low in available nitrogen and phosphorous content and fairly rich in potassium.

Soybean crop (JS-335) was sown on 24th June 2010 at 45 X 5 cm spacing. Entire dose of fertilizer 30:75:00 NPK kg ha⁻¹. applied at sowing time. The crop was harvested at 10th October 2010.

In the experiment at field, predominant weeds species were *Parthenium hysterophorus*, *Euphorbia hirta*, *Digera arvensis*, *Lagasca mollis* among dicot weeds. *Cynodon dactylon*, *Echinochloa crusgalli*, *Ergotis major*, *Poa annua*, *Sorghum halepense* among the grasses and sedges *Cyperus rotundus*. Other weeds present in less number.

The treatment of two Hoeing and two hand weeding at 20 DAS and at 35 DAS being at par with application of imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS provided more effective control of the weeds throughout crop growth period of soybean improving growth and yield contributing character and consequently produced highest grain yield of soybean. GMR and NMR was maximum under two hoeing and two hand weeding at 20 and 35 DAS. The treatment imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS followed the treatment of two hoeing and two hand weeding at 20 and 35 DAS in respect of GMR and NMR. However, in respect of benefit : cost ratio two hoeing and two hand weeding at 20 and 35 DAS showed maximum B:C ratio followed by of imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS.

Chapter - I

INTRODUCTION

1.1 Background Information

Soybean (*Glycine max* (L.) Merrill) is a miracle "Golden bean" which occupies an important position in agricultural economy of India and claims premier position among the major oil producing countries of world. It is also known as "Gold of the soil" and rarely called as "soybean" or "soybean".

Soybean has flourished as one of the major crop of central India. Soybean ranks highest among leguminous crop of the world in nutritive value and occupies an intermediate position between legumes and oilseeds.

Soybean with its 40% protein and 20% oil hold great promise in meeting the gap between the requirement and supply of protein and oil as protein calorie malnutrition is posing a serious threat to ever-increasing population. In addition, soybean is the cheapest source of vegetable protein equivalent to meat, milk product and egg protein. Intake of meat, poultry, milk and eggs is more expensive than soy protein and remain away from the reach of common people. It also contains more essential amino acid and lysine (6.4%) which are the limiting factors in cereals. Soybean is unique crop in nutritional value because it contains complete protein, carbohydrates, fats, vitamins and folic acid as well as minerals including calcium and iron required for good nutrition. It has been used in production of variety of food products like soy flour, soy grits, soymilk and industrial products such as beverages, nuggets, chunk and milk.

Further, it improves the fertility of soil by leaving residual nitrogen (30-40 kg/ha) through fixation of atmospheric nitrogen. It is a good rotational crop and can be used as green manure or forage such as hay and silage.

1.2 Importance of study

Soybean being rainy season and slow growing crop in early stages faces severe weed competition, resulting in a loss of about 40-60% of the potential yield, depending on the intensity, nature and duration of weed competition. It is heavily infested with grasses, sedges and broad leaf weed due to slow crop growth during the initial period which favors the growth and proliferation of these weeds.

Weed competes with soybean for nutrient, soil moisture and sunlight, when they are limiting. The losses comprises if direct yield loss resulting from competition, indirect losses from reduced crop quality increased costs in harvesting, land preparation and similar operation, and harbours insect pest and diseases. Besides, weed remove 30-60 kg nitrogen, 8-10 kg phosphorous and 40-100 kg potash /ha from soil.(J S Mishra 1997)

Recently some new molecular selective post-emergence herbicide viz. Imazethapyr, Chlorimuron ethyl, Fenoxaprop-p-ethyl are being marketed with the assurance of selective control of post emergent weeds in soybean. Imazethapyr has been developed for control of grassy and broad leaf weeds. While Fenoxaprop-p-ethyl has been developed for control of grassy weeds and Chlorimuron ethyl for control of broad leaf weeds with no damage to the soybean crop (Rajvir Sharma 2007)

In soybean crop first 20 to 45 days after sowing is considered the most critical period for weed competition and weed are to be kept under control for optimum yield (Rajvir Sharma 2007). Similarly competition between crop and weed plant caused several morphological changes in the soybean canopy (Handizadeh and Rahimian 1998).

1.3 Objective of study

With the changing scenario of weed management farmers need post emergence herbicides and there is an urgent need to evaluate the performance of new herbicides for grassy weeds, sedges and broad leaf weed control in soybean, Hence present investigation was conducted to study the "Integrated weed management in soybean " with following objectives

1. To find out most suitable weed control method for soybean.
2. To study the effect of combined used of herbicides on growth and yield of soybean.
3. To workout the economics of weed control.

1.4 Hypothesis

Soybean crop has a very high yield potential of 2,500-2800 kg ha⁻¹, however the average yield (777 kg ha⁻¹) of India is considered to be very low as compared to the productivity of the world (1832 kg ha⁻¹) (Rajvir Sharma. 2007). Soybean being a rainy season crop, suffers severely with the weed infestation resulting in yield losses up to 77% depending on the weed species their density and period of weed-crop competition (Tiwari and Kurchania, 1990).

The nature of the weed growth is greatly affected by edaphic, climatic, and cultural practices. Among these soil moisture is the most important. Usually only 15-20 weeds are problematic

weed in soybean which are broadly classified as grasses, sedges and broad leaf weeds. The major weeds species which generally associated with soybean crop are *Cynodon dactylon*, *Digitaria sanguinalis*, *Eragrostis tenella*, *Dactyloctenium aegypticum*, *Cyperus rotundus*, *Cyperus esculentus*, *Echinochloa colonum*, *Eleusine indica*, *Commelina benghalensis*, *Digera arvensis*, *Phyllanthus niruri*, *Parthenium hysterophorus*, *Eclipta alba*, *Celosia argentea*, *Euphorbia hirta*, *Oxalis latifolia* and *Xanthium strumarium*. Which affect the growth and yield of soybean in Vidharbha region (Bhan et al. 1974).

Yield loss due to weeds ranges from 31% to 84% depending on crop cultivar, nature and density of weed, spacing, fertilizer application method, duration and time of weed infestation and environmental condition. (Kachroo et al. 2003)

1.5 Scope and Limitations

Soybean ranks second after groundnut in term of production contributing 28% of the total oilseed production. Soybean grown as major crop in many countries of the world but USA, Brazil, China, U.S.S.R. and Argentina are main soybean growing countries. In India, according to survey conducted by "The Soybean Processors Association of India" and "State Department of Agriculture" soybean is grown over an area of 96.709 lakh ha with production of 97.246 lakh MT and average productivity of 1124 kg ha⁻¹ in India. While in Maharashtra it is grown on area of 30.320 lakh ha with total production of 29.74 lakh MT and average productivity of 982 kg ha⁻¹. and in Vidharbha it is grown over an area of 6.579 lakh ha with total production of 6.449 lakh MT and average productivity of 980 kg ha⁻¹.

In soybean crop first 20 to 45 days after sowing is considered the most critical period for crop-weed competition and weeds are to be kept under control for optimum yield. One of the reasons for low productivity of soybean is the poor weed control during early period of crop weed competition. Hoeing and hand weeding are the most efficient methods of weed control. But these operations could not be performed in time due to erratic weather conditions and labour scarcity. The chemical method of weed control can be very effective in killing the weeds before their emergence as well as after emergence. The use of herbicides or chemicals has assumed a great significance, particularly in intensive agriculture due to their ability of providing quick, effective, selective and economical weed management in term of time, money and labour.

Chapter - II

REVIEW OF LITERATURE

This chapter deals with the review of research work done by different workers on the aspect of integrated weed management in soybean. The review although is confined to researches done on soybean but relevant work on crops other than soybean is also included where necessary. The review of literature is classified and presented under different heads to support the findings of the present investigation.

- 2.1 Weed flora in soybean**
- 2.2 Losses caused by weeds**
- 2.3 Critical period of crop-weed competition**
- 2.4 Chemical weed control**
 - 2.4.1 Effect of Imazethapyr**
 - 2.4.2 Effect of Chlorimuron Ethyl**
 - 2.4.3 Effect of Fenaxoprop-p-ethyl**
- 2.5 Cultural method of weed control**
- 2.6 Integrated method of weed management**
- 2.7 Economics of weed management**

2.1 Weed flora in soybean:

Weed flora in soybean differs from place to place and it varies according to location, climate, soil type and the cropping systems.

Chandel and Saxena (1986) from Pantnagar (UP) reported *Echinochloa colonum*, *Setaria glauca*, *Cyperus iria*, *Cyperus rotundus*, *Cynodon dactylon* as a dominant weeds in soybean.

At Akola, Amin (1987) observed *Commelina benghalensis*, *Parthenium hysterophorus*, *Euphorbia hirta* and *Phyllanthus niruri* as dominant weeds in soybean.

At Jabalpur, Agrawal (1990) found that weed flora in soybean comprised of *Phyllanthus niruri*, *Echinochloa crusgalli*, *Cyperus* spp., *Ageratum conyzoides*, *Cyanotis axillaris*, *Digitaria odscendens* and *Caesulina axillaris*

At Akola, Savita Choudhary (1991) found *Cyperus rotundus* and *Cynodon dactylon* as the perennial weeds and *Parthenium hysterophorus*, *Denebra arabica*, *Cardiospermum helicarpium* as the dominant annual weeds in soybean.

At Sehore, weed flora of soybean consisted of *Cyperus rotundus*, *Echinochloa colonum*, *Digitaria sanguinalis* and *Acalypha indica* as grassy and non-grassy weeds (Sharma et al., 1992)

At Akola, Chandurkar (1993) found that the narrow leaf weeds viz., *Panicum* spp., *Cynodon dactylon*, *Cyperus rotundus* and broad leaves viz., *Parthenium hysterophorus*, *Euphorbia hirta*, *Ocimum canum* and *Commelina benghalensis* were dominant in soybean experimental plot.

Shekara and Nanjappa (1993) from Bangalore noted that *Cynodon dactssylon*, *Eragrotis tenula* and *Commelina benghalensis* among the monocot and *Acanthospermum hispidum*, *Argemone mexicana*, *Celosia argentea* among the dicots were the predominant weeds in soybean.

Upadhyay et al., (1993) from Ujjain found that weed flora in soybean mainly consisted of *Echinichloa colonum*, *Cyperus rotundus*, *Eleusine indica*, *Phyllanthus niruri* and *Phyllanthus simplex*. Other weeds such as *Cynodon dactylon*, *Digitaria sanguinalis* and *Euphorbia geniculata* were also present but in low density.

Thakare (1996) at Akola (M. S.) observed *Cyperus rotundus*, *Cynodon dactylon*, as perennial weeds and *Parthenium hysterophorus*, as dominant annual weeds in soybean, whereas others weeds such as *Amaranthus viridus*, *Celosia argentea*, *Digera arvensis*, *Lagasca mollis*, *Cyanotis axillaris*, *Denebra arabica* were also found in soybean experimental field in small number.

Velu and Sankaran (1996) reported that the weed flora in soybean experimental plots consisted of *Cynodon dactylon*, *Dactyloctenium aegyptium* and *Echinochloa colonum* as grasses, *Cyperus rotundus* and *Trianthema portulacastrum*, *Boerhaavia diffusa*, *Amaranthus viridis*, *Digera arvensis* and *Flaveria australiasia* as broad leaf weeds.

Reddy *et al.*, (1998) reported that the important weed species observed in soybean were *Cyperus rotundus*, *Cynodon dactylon*, *Commelina benghalensis*, *Euphorbia geniculata*, *Lagasca mollis*, *Celosia argentea*, *Amaranthus viridis*, *Tridax procumbens*, *Physalis minima*, *Digera arvensis* and *Cleome viscosa*.

Sharma and Raghuwanshi (1999) found that *Echinochloa crusgalli*, *Denebra arabica*, *Rottbrellia exallta*, *Digitaria sanguinalis*, *Cyperus rotundus*, *Commelina benghalensis* and *Euphorbia geniculata* were predominant in soybean crop.

Bhan and Kewat (2002) reported that *Phyllanthus niruri*, *Echinochloa crusgalli* and *commelina communis* were the rampant weeds and *Eclipta alba*, *Ageratum conyzoides*, *Parthenium hysterophorus*, *Cyperus rotundus* and *Cynodon dactylon* were common weeds in soybean.

Kamala Bai and Nanjappa (2003) found that *Cyperus rotundus*, *Cynodon dactylon*, *Eragrotis cilianesis*, *Dactyloctenium*

aegyptium, *Acanthospermum hispidum* and *Phyllanthus niruri* were the predominant weeds in soybean.

According to Smita Mandhre (2005) the major weeds in the soybean experimental field were *Lagasca mollis*, *Physalis minima*, *Euphorbia hirta*, *Digera arvensis*, *Alysicarpus rugosus* and *Parthenium hysterophorus* among the dicots. Annual monocots were *Echinochloa crusgalli*, *Commelina benghalensis*, *Sorghum halepense* and *Poa annua*. Perennial includes *Cyperus rotundus* and *Cynodon dactylon*.

Thakur (2008) observed mainly comprised weed flora in experimental field of soybean mainly i.e. *Logasca Monis Euphorbia geniculata*, *sParthenium hysterophorus*, *Digera arvensis* among dicot weeds. *Echinochloa crusgalli*, *Cynodon dactylon*, *Eragrostis major*, *Poa annua*, *Sorghum halepense* among the grasses and sedge *Cyperus rotundus*. Other weeds were present in less number.

2.2 Losses caused by weeds :

Bhan *et al.*, (1974) Found that soybean produced maximum yield when kept weed free upto 30 DAS.

Jatain and Kairon (1987) observed that weeds in general compete with soybean crop for nutrients, light, moisture and space but under water stress conditions the competition is mainly for soil moisture.

Channabasappa and Nanjappa (1990) reported that weeds in soybean removed 25.6, 6.5 and 27.2 kg NPK ha⁻¹ respectively.

Mishra *et al.*, (1990) observed that uncontrolled weeds caused about 87 per cent reduction in seed yield of soybean.

Pal and Singh (1990) reported that the competition with weeds during entire crop season resulted in reduction of soybean yield to the extent of 74 per cent.

Reddy *et al.*, (1990) reported that weed competition lowered seed yield of soybean by 79 per cent due to reduction in pods per plant and seed yield per plants.

Singh and Sharma (1991) found that higher amount of nutrients were taken up by grassy weeds viz., *Echinochloa colonum*, *Eleusine indica* and *Digitaria sanguinalis* than broad leaved weeds viz., *Commelina bengalensis* and *Portulaca oleracea* in soybean experimental plot.

Singh and Singh (1992) reported that uncontrolled weed caused 67 per cent reduction in soybean seed yield.

Chandurkar (1993) noted that un-weeded control caused loss of 46.0, 9.5 and 49.6 kg NPK ha⁻¹, respectively through weeds in soybean.

Chhokar *et al.*, (1995) revealed that weed free maintenance up to 45 DAS resulted in 96 per cent increase in seed yield of soybean over weedy check.

Bhandiwaddar and Intal (1998) reported that weed competition reduced the yield of soybean by 63.4 per cent from weed free control.

Chinnamuthu (2000) revealed that losses caused by weeds in soybean were 59.98 per cent:

Singh *et al.*, (2000) studied that presence of weeds through the growing season reduced yield of soybean by 40 per cent.

Ravi *et al.*, (2001) reported that soybean yield reduction varied from 35 to 50 per cent depending upon the type of weeds, their intensity and crop weed competition.

Bonsch *et al.*, (2003) determined that due to Palmer amaranth, common waterhemp and red root pigweed interference in soybean, yield loss occurred was 78.7, 56.2 and 38.0 per cent, respectively.

Shailaja Chintalwar (2004) reported that weedy condition caused seed yield reduction to the extent of 57.39 per cent in soybean crop.

According to Smita Mandhre (2005) weedy condition caused seed yield reduction to the extent of 50.84 per cent in soybean crop.

Shete *et al.* (2008) conducted field experiment during kharif 2005 at M.P.K.V.Rahuri and observed the significantly lowest dry matter of weeds and highest weed control efficiency of monocot and dicot weeds was observed in one hoeing (20 DAS) + 2 hand weedings at 30 and 60 DAS.

Thakur (2008) conducted experiment on effect of time of application and concentration of imazethapyr on weed control in soybean at Nagpur and found that treatment of two weedings and two hoeings at 20 and 35 DAS is effective method of weed control.

2.3 Critical period of crop weed competition:

Critical period of soybean crop weed competition was recorded to be 30-40 DAS by Singh and Singh (1987)

Borgohain and Upadhaya (1987) reported that number of pods plant⁻¹ in soybean increased from 11.1 in weeded control to 21.7 in the plot maintained weed free upto nine weeks from sowing.

Patra (1987) studied the effect of one hand weeding at different growth stages of soybean from 15 to 75 DAS with fortnightly intervals and observed that among the treatments weeding at 30 DAS was the most critical period as it recorded the highest seed yield.

Critical period of soybean crop weed competition was recorded to be 20-40 DAS by Channabasappa and Nanjappa (1990) and from 15 to 45 DAS by Saraswat (1990).

Akey *et al.*, (1990) studied the competition for light between Velvet leaf and soybean and found that weed was taller than soybean over most of the growing season and had greater light interception than soybean in the upper part of the canopy particularly early and late in day. Velvet leaf had higher light use efficiency or conversion of intercepted light into dry matter in middle part of the growing season.

Labrada *et al.*, (1990) reported that to achieve highest crop yield of soybean, plot should be kept free of weeds during the first 60 days after crop emergence, but the first weeding could be delayed until 20 to 30 days after crop emergence.

Varshney (1991) stated that there was a drastic reduction in grain yield when weeding was delayed beyond 40 DAS i.e. 49 days period was the critical time of weeding in soybean.

Everoats (1992) found in soybean that a period of around four weed free weeks after sowing was necessary to avoid yield reduction or too much weed growth at harvest.

Singh and Kolar (1994) reported that weed competition for initial 30 days caused more than one fourth (30.8 per cent) and 45 days of crop weed competition resulted in more than half (71.6 per cent) of total

losses. Maximum reduction in seed yield was observed by delaying weeding from this period as most critical for crop weed competition.

Chhokar *et al.*, (1995) stated that weed free maintenance up to 45 DAS resulted in 96 per cent increase in seed yield of soybean over weedy check. Weed free environment between 28 to 40 DAS in soybean was found imperative to record satisfactory yield.

Maintaining a weed free period until 20 DAE in soybean reduced weed dry weight by 85 per cent and the weed count by 70 per cent compared to the weedy control. Competition between crop and weed plants caused several morphological changes in the soybean canopy (Handizadch and Rahimian, 1998)

Chinnamuthu (2000) revealed that the critical period of weed control in soybean was 30 to 40 DAS.

Melo *et al.*, (2001) in Brazil studied that the soybean critical period of interference considering a 2 per cent crop yield reduction occurred between 7th and 53rd day and 18th and 47th day after crop emergence.

Meschede *et al.*, (2002) studied that the presence of weeds caused a daily yield loss of 5.15 kg ha⁻¹ whereas their absence provided a daily yield gain of 7.27 kg ha⁻¹ in soybean. The critical period of interference was from 17 to 44 DAE.

In Kashmir, Kachroo *et al.*, (2003) studied that the overall yield decline due to weed infestation varied from 31 to 84 per cent in soybean. The weed free period up-to 30 to 40 DAS is reported to be essential obtaining higher yield.

2.4 Chemical method of weed control:

Halvankar *et al.*, (1986) observed that herbicides in general decreased crop height, weed biomass but increased pods per plant, test weight, seed yield and harvest index as compared with un-weeded check in soybean.

Govindsingh and Dheersingh (1987) reported that weed density as well as dry weight of weeds reduced significantly due to application of herbicides in soybean.

Effective weed control with herbicides improved seed yield by 63 per cent in soybean (Reddy *et al.*, 1990).

Tiwari and Kurchania (1990) stated that among the various treatments, all herbicidal treatments were more economical than one or two hand weeding in soybean.

The phytolytic degradation of several imadazolinone herbicides in solution and in soil was investigated. UV light caused 100 per cent degradation of imazaquin, imazethapyr 87 per cent and 8 per cent degradation of imazamethabenz and atrazine in aqueous solutions, respectively after 48 hours (Curran *et al.*, 1992).

Ramamoorthy *et al.*, (1995) found that in soybean, chemical weed control was superior to cultural method of weed control.

Kamalabai and Nanjappa (2003) reported that all herbicidal treated plots gave significantly lower weed dry weight (880 to 1335 kg ha⁻¹) compared to weedy check (31232 kg ha⁻¹) in soybean experimental plots.

2.4.1 Effect of Imazethapyr :

Suhch and Harvey (1986) selected herbicide treatment for soybean in controlling woolly cup grass and the best treatment tested was

0.1 kg AC 263, 499 (Imazethapyr applied as early post-emergence which gave good control of woolly cup-grass).

Dobsen *et al.*, (1988) reported imazethapyr, a new herbicide for controlling broad spectrum of weeds in soybean.

Contwell *et al.*, (1989) reported that imazethapyr @ 0.1 kg ha⁻¹ controlled 90 per cent Velvet leaf (*Abutilon theophrasti*)

Shaw *et al.*, (1990) studied that increasing application of imazethapyr @ 0.07-0.1 kg ha⁻¹ rate did not increase control of morning glory but did increase Johnson grass control.

York *et al.* (1991) reported that application of Acifluorfen, Chlorimuron or Imazethapyr alone or combined with 2.4DB at 35 g ha⁻¹ did not not reduced soybean yield.

Baysinger and Sim (1992) reported that application chlorimuron and imazethapyr applied to 2.5 to 5 cm giant ragweed controlled more than 85% in 1988. While in 1989 imazethapyr controlled seedling giant ragweed at height up to 12 to 25 cm.

Foy and Witt (1993) studied that imazethapyr (70 g ha⁻¹) sprays improved control of *Digitaria sanguinalis*.

Terraborelli and Magnani (1993) reported effectiveness of imazethapyr for the post emergence control of both grassy and broad leaved weeds in soybean.

Barros *et al.*, (1994) observed that 100 g a. i. ha⁻¹ imazethapyr + surfactant at 0.25 per cent controlled *Pennisetum setosum* efficiently.

Ivany (1994) studied that the application time of post emergence imazethapyr (35-125 g) was critical with 2 to 3 weeks after crop emergence being most effective.

Angiras and Rana (1995) reported that application of imazethapyr at different dose (50,100,150 and 200 g ha⁻¹) and times of application (pre-plant incorporation, pre-emergence and early post emergence) in controlling weed in soybean. Significantly higher seed and straw yield of soybean were obtained with imazethapyr 200 g ha⁻¹ (pre-emergence) and were significantly at par with its early post-emergence application and hand weeding twice.

Mayo *et al.*, (1995) studied that Palmer amaranth was the most difficult species to control and only thifensulfuron and imazethapyr provided greater than 80 per cent control at all application timings.

Simpson and Stoller (1995) found that control of smooth pigweed, common lambs quarters and common cocklebur were not affected by reducing the rate of either herbicide in the tank mixture of imazethapyr 70 g a. i. ha⁻¹ + thifensulfuron 4.4 g a. i. ha⁻¹.

Wilson (1995) observed symptom of imazethapyr injury to grasses in the form of reduced plant height, reduced biomass, chlorosis and necrosis.

Symptom injury to nut-sedge caused by chlorimuron and imazethapyr included reduced biomass, chlorosis and leaf necrosis (Jordon, 1996)

Chandel and sexena (2001) reported that sprays of imazethapyr @ 75 g a. i. ha⁻¹ at 60 DAS caused better control of narrow and broad leaf weeds.

At Ashland Bottoms, Zhang et al. (2001) observed that at 8 cm growth stage of yellow nut-sedge, imazethapyr injured more than other herbicide i.e. glyphosate and glufosinate.

Grichar (2002) studied that post emergence imazethapyr applied at 70 g a. i. ha⁻¹ controlled yellow nut-sedge more efficiency than imazethapyr applied PPI.

Vyas and Jain (2003) reported that the effect of different pre and post-emergence herbicides on JS-335 soybean. Among the tested herbicides the highest seed yield was recorded with control product of imazamox + imazethapyr @ 75 g ha⁻¹ POE i.e 1.622 kg ha⁻¹ and it was significantly on a par with 2-hand weeding (1710 kg ha⁻¹). The highest weed control efficiency and lowest weed biomass were recorded with 2 hand weeding, followed by application of imazamox + imazethapyr @ 75 g ha⁻¹.

Grieve *et al.*, (2003) studied that imazethapyr applied at 70 g a.i. ha⁻¹ control of barnyard grass.

Papiernik *et al.*, (2003) observed that growth and survival of Barnyard grass was significantly reduced when plants were treated with imazethapyr.

Zhang *et al.*, (2001) reported that reduction in barnyard grass height was observed with post emergence application of imazethapyr in green house studies.

Kushwah and Vyas (2005) stated that application of imazethapyr @ 75 g a. i. ha⁻¹ was found most effective in reducing weed biomass and getting higher weed control efficiency over other pre and post emergence herbicide.

Tiwari *et al.* (2007) reported that imazethapyr (75 g ha⁻¹) gave excellent control of broad-leafy weeds only when applied at post-emergence to soybean, and it proved superior to rest of treatments except hand-weeding.

Soltani *et al.* (2009) reported that imazethapyr (100 g a.i ha⁻¹) was applied early and delayed pre emergence (PRE) and post-emergence (POST) at the spike to five-leaf stage of the weed soybean was not injured by any treatment. Imazethapyr applied PRE did not control long spined sandbur; post treatment resulted in upto 72,66,91,78 and 71% weed control when applied at spike, one, two, three, four and five-leaf stage respectively and crop yield increased 44, 28, 39, 24, and 20% respectively.

Gopinath and Mina (2009) reported that application of imazethapyr @ 0.077-0.1 kg a.i ha⁻¹ at 20 DAS controlling the broad-leaf weeds in soybean.

2.4.2 Effect of Chlorimuron ethyl :

Green *et al.* (1986) obtained the best control of *Xanthium strumarium*, *Cassia obtusifolia* hederacea and *Ipomea lacunose* due to application of chlorimuron ethyl in soybean.

Jon S. Calus (1987) reported that chlorimuron ethyl effective postemergence herbicides for control of many broadleaf weed such as cocklebur (*Xanthium spp.*) Pig-weed (*Amaranthus spp.*), Sunflower (*Heliantbus spp.*), and annual morningglory (*Iopmoea*) Nutsedge.

Reddy and bendixin (1988) reorted that foliar application of chlorimuron caused injury to both yellow and purple nutsedges at rates as low as 5 g a.i ha⁻¹. Visible injury increased as rates increased from 5 to 20 5 g a.i ha⁻¹ at all weekly evaluation dates. At 28 days aftrler application,

there was 84% control of yellow and 100% control of purple nutsedge from 20.5 g a.i ha⁻¹ of chlorimuron ethyl.

Walker *et al.* (1989) stated that post emergence application of chlorimuron @9.0 g ha⁻¹ in combination with either linuron at 108 g ha⁻¹ or metribuzin at 54 g ha⁻¹ controlled the *Datura stramonium*, *Amaranthus hybridus* and *Chenopodium album*.

Mosely and Hagood (1991) found that post-emergence application of chlorimuron +linuron (0.04+0.46 kg ha⁻¹) to soybean in 94-100% control of weeds viz. *Amaranthus retroflexus*, *Ambrosia artemisiifolia*, *Ipomoea hederacea*, *Polygonum pensylvanicum* and *Setaria jaberii*.

Timothy and Banks (1991) found that plant sprayed with Chlorimuron at 8.8 g ha⁻¹ at 14, 21, 28 and 35 days after planting, early chlorimuron application 14 DAS reduced dry weight, leaf area and water use levels of significantly less than those of plant treated at 28 and 35 DAS. Soybean dry weight and leaf area were not affected by chlorimuron.

King and Oliver (1992) reported that common cocklebur, smooth pigweed, and pitted moringglory were controlled 90 % with chlorimuron at 2 to 5 g a.i ha⁻¹.

Tiwari *et al.* (1996) reported that chlorimuron ethyl controlled all the broad leaf weeds and sedges at all the rates. At 12 g ha⁻¹ and higher levels it controlled grassy weed also, viz hairy crab grass and *dinebra spp.* It also reduced the growth and height of barnyard.

Dixit and Bhan (1997) revealed that chlorimuron @ 12 g ha⁻¹ found effective for reducing the weed biomass to obtain higher grain yield of 1165 kg so ha⁻¹ soybean.

Chhokar *et al.*(1997) reported that chlorimuron ethyl applied as post emergence is seemed to be a good offer.

Balyan and Malik (1998) reported that when chlorimuron applied at 20 DAS rather than 30 DAS, all the rates of chlorimuron were more toxic to carpet weed (*Trianthema portulacastrum*).

Balyan *et al.* (1999) reported that application of chlorimuron ethyl at 4 or 8 g ha⁻¹ proved highly effective in minimizing the population of barnyard grass and horse pureslane.

Gossett and Toler (1999) found that chlorimuron 9 g ha⁻¹ was more effective as compared with untreated control for controlling weeds in soybean.

Sharma and Raghuwanshi (1999) found that chlorimuron gave an effective level of control of sedges and all broad leaved weeds in soybean.

Dubey *et al.* (2000) found that chlorimuron ethyl @9 g and 12 g ha⁻¹ as pre-emergence applied 3 DAS reduced population of *cyperus rotundus* and seed yield of soybean increases significantly.

Manjusha Mohod (2002) reported that chlorimuron ethyl both the rates of application 9.0 and 12.0 g ha⁻¹ was more effective against dicot weeds than monocot weeds.

Chintalwar (2004) reported that application of chlorimuron ethyl @ 9.0 g ha⁻¹ (7 DAS) and 1 H (30 DAS) proved comparatively more effective in reducing weed population and weed dry weight than application of herbicides alone.

Behera at al. (2005) reported that application of chlorimuron ethyl @0.006 kg ha⁻¹ with metoalchlor @ 1.0 kg ha⁻¹ resulted in very

good control of narrow and broad leaf weed with no harmful effect on crop growth.

2.4.3 Effect of Fenoxaprop-P-ethyl:

Fenoxaprop-P-ethyl is a selective systematic post-emergence herbicide taken up via plant tissue and through roots. It is rapidly broken down in soil and presents non-residue hazards to following crop. It predominantly inhibits the meristem tissue of grassy weeds. (Worthing, 1983).

There was no phytotoxicity symptoms found on the foliage of soybean due to application of 0.05 to 0.1 kg ha⁻¹ either of 7 to 14 to 21 DAS. There was complete mortality of monocot weeds with slight suppression of *Cyperus rotundus* and *Commelina benghalensis* was unaffected. (R.R.C. 1997).

Kurchania *et al.* fenoxaprop-P-ethyl applied at different rates and times did not shown any phytotoxic effect on soybean crop but when it was mixed with lactofen at different rates its efficiency to control *Echinochloa crusgalli* was reduced.

Ozair and Moshier (1998) reported no significant effect on shoots, root or nodule weight, nodule no. or N fixation capacity of soybean due to fenoxaprop-P-ethyl at 0.17 and 0.64 kg ha⁻¹.

Pandey *et al.* (1989) observed fenoxaprop-P-ethyl to be most effective against broad leaf weeds but very effective against grasses at early growth stages.

Pinto and Fleck (1990) obtained effective control of *Digitaria ciliaris* at the earliest application time but control with the later application depended on soil moisture and weed growth stage.

Johnson and Frans (1991) reported that their is poor control of johnsongrass was obtained from Fenoxaprop-p-ethyl at both Fayetteville and Clarkdale.

Barros *et al.* (1992) reprinted that fenoxaprop-P-ethyl at 83 g ha⁻¹ did not significantly affect soybean plant height, final stand, density and seed yield.

Vidrine *et al.* (1995) observed that in fenoxaprop-P-ethyl treated plot, soybean yield were greater as compared to the yields recorded from the non-treated plots.

Schmid *et al.* (1996) found better performance of fenoxaprop-P-ethyl under conventional tillage.

Zaitsev and Teremyaeva (1996) found that tank mixture of fenoxaprop-P-ethyl (Furore) with quixoalofop-ethyl (Targa) 1.0 litre ha⁻¹ caused 97-98% mortality of all weeds before the harvest of soybean with higher yield.

Singh *et al.* (2006) observed that the mixture herbicide chlorimuron ethyl plus fenoxaprop-P-ethyl (9+70 g ha⁻¹) recorded highest weed-control efficiency. No crop injury could be seen on crop due to herbicide or herbicidal mixture. Among herbicides, chlorimuron ethyl plus fenoxaprop-P-ethyl (9+70 g ha⁻¹) gave the highest yield, which was at par with chlorimuron+ fenoxaprop-P-ethyl (6+50 g ha⁻¹).

2.5 Cultural method of weed control :

Minimum 2 hand weeding at 30 and 45 DAS necessary for reducing crop weed competition in soybean (Halvankar *et al.*, 1986).

Reddy *et al.*, (1990) stated that cultural practice of hoeing improved seed yield of soybean by 39 per cent as compared to control.

compared to weedy check (769 kg ha⁻¹), 1 weeding (1354 kg ha⁻¹) and 2 weeding (1302 kg ha⁻¹).

Savita Choudhari (1991) reported that keeping the plot weed free up to grain filling stage by repeated weeding and hoeing at 10 days interval gave better control of broad as well as narrow leaf weeds increased growth and yield contributing characters and seed and straw yields of soybean.

Douglas *et al.*, (1992) found that 2 hoeing between rows successfully substituted for 50 to 75 per cent of the herbicides. Two passes with rotary hoe followed by 2 row cultivations provided high degree of weed control in soybean.

Chandurkar (1993) concluded that amongst cultural and chemical methods of weed control in soybean, cultural methods of 2 hoeing plus 2 weeding was better in controlling weeds which ultimately resulted in higher seed and straw yields over chemical treatments.

Most of the workers have reported 1 hand weeding at 30 to 35 DAS as enough in soybean (Upadhyay *et al.*, 1993)

Bhattacharya *et al.*, (1994) found that hand weeding twice resulted in the greatest weed control efficiency (70.81 per cent) by 30 DAS which reflected in higher seed yield of soybean.

Singh and chandel (1995) reported that weed population, weed dry matter and weed-control efficiency were the lowest with 2 hand weeding at 30 and 45 days after sowing. The pod plant⁻¹, seed plant⁻¹ and 100 grain weight⁻¹ were the highest with 2 hand weeding.

Chandel *et al.*(1995) reported that maximum no. of pod plant⁻¹ was recorded with 2 hand-weeding which was significantly greater than rest of the treatment.

Nimje (1996) reported that the highest weed-control efficiency (70.3%) and weed suppressibility index (70.4%) were recorded in weed-free plots, followed by 2 hand weeding at 20 and 40 DAS (55%).

Thakare (1996) indicated that among the cultural and chemical methods of weed control, cultural method of 2 hoeing plus 2 hand weeding at 20 and 40 DAS resulted in higher dry matter production by soybean crop with significantly higher seed and straw yield.

Raghuwanshi *et al.*, (1997) revealed that highest weed control efficiency (84.40 per cent) and seed yield (23.60 q ha⁻¹) of soybean were recorded in the hand weeding treatment (20 DAS) with higher net returns of Rs. 12,833 ha⁻¹.

Thakare *et al.*, (1998) found that hoeing and one or two hand weeding treatment in soybean gave more number of branches per plant and seed yield.

Sharma (2000) reported that the significantly highest seed yield of 1273 kg ha⁻¹ was obtained with 2 hand weeding in soybean crop.

Veeranna *et al.*, (2000) revealed that hand weeding twice in soybean was efficient in controlling all the weeds.

Jain *et al.*, (2001) found that in soybean 2 hand weeding produced significantly highest seed yield of 13.03 q ha⁻¹ and 11.87 q ha⁻¹ during 1995 and 1996, respectively.

Rasker and Bhoi (2002) reported that minimum weed count (4.5 m⁻²) was recorded under 2 hand weeding at 15 and 30 DAS in soybean experimental field.

Shailaja Chintalwar (2004) reported that cultural method of weed control which included weed free check and 2 hoeing and 2 hand weeding (at 15 and 30 DAS) reduced the weed population, weed dry

matter, enhanced all growth characters and recorded higher seed yield of soybean.

Smita Mandhre (2005) reported that number of pods per plants, seed yield per plant, harvest index and seed to straw ratio of soybean were more due to cultural treatments 2 hoeing + 2 hand weeding and weed free control.

Pandya *et al.* (2005) reported that all the weed management treatment significantly reduced total weed dry matter compared with the weedy check. Two hand weeding and Clomazone + hand weeding (HW) were found at par but superior to Clomazone.

Kamdi Kishor Vishwanath (2010) Weed management through 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) provided most effective control of weed throughout the crop growth period of soybean thereby improving growth and yield contributing characters and consequently recorded highest seed yield.

2.6 Integrated weed management:

At Palampur, Angaris and Rana (1995) found significantly higher soybean seed and straw yield with 100 g imazethapyr as early post emergence application and hand weeding twice at 25 and 45 DAS.

Rammoorthy *et al.* (1995) reported that all weed control treatments effectively reduced the weed intensity and the minimum weed were recorded with pre-emergence alachlor @ 2.0 kg ha⁻¹ on third day or 2 hand weeding at 15 and 30 DAS.

The application of herbicides followed by hand weeding at 30 DAS increased the weed control efficiency as compared to that with application of herbicides alone in soybean crop (Reddy *et al.*, 1998).

The application of herbicides followed by hand weeding at 30 DAS increased the weed control efficiency as compared to that with application of herbicides alone in soybean crop (Reddy *et al.*, 1998).

Bhandiwaddar *et al.*, (1998) studied that imazethapyr (POE) @ 75 and 100 g a. i. ha⁻¹ at 20 DAS and two inter-cultivation + two hand weeding at 30 and 40 DAS showed highest harvest index of soybean crop.

Manjusha Mohod (2002) reported that integrated weed management method proved significantly more effective in reducing the weed population and weed dry weight thereby increasing the seed yield of soybean as compared to herbicide alone treatments.

Bhattacharya *et al.*, (2002) reported that the highest weed control was observed with 2 hand weeding treatment closely followed by post emergence application of quizalofop ethyl 5 EC @ 2.0 ml lit⁻¹ at 15 DAS + one hand weeding at 35 DAS in soybean crop.

Smita Mandhre (2005) reported that cultural method of weed control which included weed free check and 2 hoeing + 2 hand weeding (at 15 and 40 DAS) and integrated weed management treatments imazethapyr @ 100 g a.i. ha⁻¹ at 15 DAS+ 1 hoeing + 1 hand weeding at 40 DAS reduced the weed population, weed dry matter and enhanced all crop growth characters and recorded higher seed as well as straw yield in soybean.

Pandya *et al.* (2005) reported that all the weed management treatment significantly reduced total weed dry matter compared with the weedy check. Two hand weeding and Clomazone + hand weeding (HW) were found at par but superior to Clomazone.

Dhane *et al.* (2009) was reported that the integrated weed control method the application of persuit (EPOE) @ 100 g a.i ha⁻¹ + one hand weeding at 30 DAS was found to superior vis-à-vis other integrated weed control method.

Dhane *et al.* (2010) reported that combination of chemical and cultural weed control measures, treatment persuit 100 g a.i ha⁻¹ (EPOE) + one hand weeding at 45 DAS was found to be the best after the treatment. Two hand weeding at 30 and 45 DAS regarding the character under consideration revealing the efficiency of chemical along with manual weeding in weed control, thereby resulting in better yield and yield parameter.

2.7 Economics of weed management:

Johnson *et al.*, (1991) stated that lowest cost of control and the highest average net returns over the three period was obtained with quizalofop ethyl (70-160 g ha⁻¹) application in soybean.

Singh and Sharma (1991) obtained highest average net returns (Rs. 8223 ha⁻¹) as compared to other treatments with two manual weeding at 20 and 40 DAS.

Tiwari *et al.*, (1993) reported highest soybean seed yield (11.84 q ha⁻¹) and maximum net returns (Rs. 3145 ha⁻¹) due to manual weeding at 35 DAS.

Padmavati. *et al.*, (1995) obtained highest soybean seed yield (910 kg ha⁻¹) and net returns (Rs. 9533 ha⁻¹) due to hand weeding twice at 20 and 40 DAS.

Herbicide costed lower than 2 hand weeding (Rs. 1800 ha⁻¹). There was a saving in weeding cost of Rs. 1050 to 1400 ha⁻¹ compared to hand weeding (Anonymous, 1998).

Manjhusha Mohod (2002) obtained maximum additional profit of Rs. 8333 ha⁻¹ with 1 weeding + 2 hoeing followed by chlorimuron ethyl 9.0 g + 1 hoeing at 30 DAS (Rs. 7117 ha⁻¹).

According to Smita Mandhre (2005) weed free control recorded the highest additional profit (Rs. 11505 ha⁻¹) followed by 2 hoeing + 2 hand weeding (Rs. 10454 ha⁻¹) and imazethapyr @ 100 g ha⁻¹ followed by 1 hoeing + 1 hand weeding (Rs. 8584 ha⁻¹).

Yadav *et. al.* (2009) conducted an experiment at Pune during 2006 and concluded that the highest B:C ratio of 2.11 was recorded under weed free check followed by 2.10 with two hand weedings (15 and 30 DAS).

Kamdi Kishor Vishwanath (2010) Weed management with 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂) recorded maximum GMR (37841 ha⁻¹) and NMR (21175 ha⁻¹) followed by the imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS(T₉). These treatment were at par with 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂).

Chapter - III
MATERIAL AND METHODS

A field experiment entitled "Integrated weed management in soybean" was conducted during *kharif* season of 2010. The details of the material used and methods adopted for the present investigation are summarized in this chapter under appropriate heads.

3.1 Basic resource information

3.1.1 Experimental site

The present investigation was laid out in field No. 10 at the Farm of Agronomy Section, College of Agriculture, Nagpur. The topography of the field was fairly uniform and leveled.

3.1.2 Cropping history of the experimental site

The cropping pattern followed on the experimental site during the preceding three years is given in Table 1. It is worth to mention that proper crop rotation was followed.

Table No. 1 Cropping history of the experimental field

Years	Crop cultivation	
	<i>Kharif</i> season	<i>Rabi</i> season
2007-2008	Soybean	Gram
2008-2009	Sorghum	Mustard
2009-2010	Soybean	Gram
2010-2011	Present investigation	-

3.1.3 Soil characteristics

To determine the physico-chemical properties of the soil, soil samples were drawn from 0-30 cm depth at various randomly selected spots spread over the experimental area before sowing of the crop. A composite sample was prepared and analyzed. The details of the analysis done and values obtained in various estimates are shown in Table 2.

Table No. 2: Physico-chemical properties of the experimental site

Sr No.	Particulars	Value	Method adopted
A) Mechanical analysis			
1)	Sand (%)	21.3	Standard International pipette method (Piper, 1966)
2)	Silt (%)	20.2	
3)	Clay (%)	58.9	
4)	Textural class	Clayey	
B) Chemical analysis			
1)	Organic carbon (%)	0.56	Walkley and Black method (Jackson, 1967)
2)	Available nitrogen (kg ha ⁻¹)	291.10	Alkaline permanganate method (Asija and Subbiah, 1956)
3)	Available phosphorus (kg ha ⁻¹)	24.16	Olsen's method (Jackson, 1967)
4)	Available potassium (kg ha ⁻¹)	464.30	Flame photometer (Jackson, 1967)
5)	pH	7.7	Glass electrode pH meter (Jackson, 1967)
6)	EC (dsm ⁻¹)	0.210	Electrical conductance method (Jackson, 1967)

The soil was characterized as clayey in texture and alkaline in reaction (pH 7.7). It was medium in organic carbon content, low in available nitrogen and phosphorus and fairly rich in available potassium.

3.2 Climate and weather condition:

Nagpur is situated at 321 meter above mean sea level and at latitude 21° 10' North and longitude at 79° 19' East, having tropical climate with assured but variable rainfall in *kharif* season associated with severe hot summer. Weekly and monthly meteorological data in respect of rainfall, humidity, minimum and maximum temperature and rainy days of *kharif* and *rabi*, 2010-2011 recorded at meteorological observatory, College of Agriculture, Nagpur is presented in Table no.3

Rains are mostly received from south west monsoon during June to October with mean annual precipitation of 1458.1mm which generally received in 55 rainy days. Winter rains are uncertain but have an average of 60 mm during October to January. The total rainfall received during (June, 2010 to December, 2010) was 1518.1 mm in 58 rainy days, and over all during the year 2010 (January, 2010 to December, 2010) was 1585.5 mm in 62 rainy days. Total rainfall received during crop season was 1436.5mm. The rainfall received in the month of June was 79 mm in 5 rainy days which was favorable to carry out sowing of soybean crop in last week of June. The rainfall received in the month of July was 375 mm in 17 rainy days which was congenial for emergence and initial growth of soybean. Rain received in the month of August was 386.1mm in 17 rainy days that helped in vegetative growth of crop. Rain received in the month of September was 595.8 mm in 15 rainy days which prolonged the vegetative growth and waterlogged condition reduced the yield of crop significantly



Table 3. Statement showing the Weekly Meteorological Data for the year 2010-11 recorded at Observatory, Agriculture College Farm, Nagpur - (January - December-2010)

Date	Met Week	Temp °C		R.H. %		Total Rainfall (mm)	No. of Rainy days	Bright sunshine hours	Wind speed km/hr.	Evaporation (mm)	
		Max	Min	Mor	Eve						
01-07	Jan.10	1	27.0	10.1	56	30	-	-	8.8	3.0	2.9
08-14		2	27.0	13.2	70	49	13.4	1	6.1	2.1	2.0
15-21		3	27.2	9.2	58	32	-	-	8.7	2.3	2.6
22-28		4	28.9	9.2	52	22	-	-	9.2	1.9	3.4
29-04	Feb.10	5	29.8	13.1	60	34	-	-	8.3	2.5	3.4
05-11		6	29.8	14.0	69	32	-	-	5.4	2.5	2.6
12-18		7	31.6	17.9	68	34	7.4	1	6.5	3.1	3.9
19-25		8	32.0	16.0	43	25	-	-	8.3	3.2	4.5
26-04	Mar.10	9	35.7	16.6	39	16	-	-	9.6	2.5	5.4
05-11		10	36.3	19.8	45	22	18.6	1	9.3	4.3	7.1
11-18		11	36.0	18.5	53	28	28.0	1	7.3	2.2	4.8
19-25		12	39.8	20.5	36	16	-	-	9.1	2.1	6.1
26-01	April 10	13	40.2	23.4	39	18	-	-	8.1	3.2	6.9
02-08		14	41.3	23.1	35	19	-	-	9.7	4.2	8.9
09-15		15	43.2	26.3	30	17	-	-	7.8	4.8	9.3
16-22		16	44.0	28.4	34	18	-	-	10.3	5.3	10.6
23-29		17	43.7	26.2	33	18	-	-	10.5	4.6	11.8
30-06	May 10	18	41.4	27.9	36	24	-	-	8.6	5.3	9.0
07-11		19	44.7	28.2	28	17	-	-	10.5	5.4	11.9
14-20		20	45.7	29.5	29	17	-	-	8.5	4.1	10.9
21-27		21	44.4	31.3	39	22	-	-	8.0	7.9	12.3
28-03	Jun 10	22	45.0	32.0	35	18	-	-	9.1	9.5	12.8
04-10		23	42.6	31.1	42	27	-	-	9.7	9.2	12.3
11-17		24	40.9	27.7	64	34	42.8	1	5.3	6.1	8.9
18-24		25	34.8	24.6	80	58	36.2	4	3.3	5.7	4.4
25-01	July10	26	36.9	25.9	80	49	55.4	2	5.0	5.5	6.1
02-08		27	31.5	24.7	86	81	104.4	4	0.8	3.8	3.7
09-15		28	31.2	24.6	86	73	106.0	4	1.2	4.6	3.1
16-22		29	33.2	25.6	82	70	46.4	2	3.0	3.6	4.0
23-29		30	29.6	24.2	86	78	62.8	5	1.4	5.1	2.4
30-05	Aug 10	31	30.4	24.0	87	75	123.5	7	0.9	4.6	3.1
06-12		32	29.6	23.9	89	79	167.8	5	1.5	4.9	2.8
13-19		33	32.1	24.5	86	75	20.8	3	0.7	2.5	2.7
20-26		34	32.2	24.5	83	68	74.0	2	1.0	3.6	3.3
27-02	Sept 10	35	31.5	24.2	90	78	295.6	4	0.9	3.7	2.5
03-09		36	30.3	24.6	88	83	129.0	3	2.1	5.8	3.2
10-16		37	31.6	23.4	86	71	100.4	3	4.5	3.0	3.3
17-23		38	31.5	23.7	83	67	43.4	4	4.3	2.6	3.0
24-30		39	33.0	22.8	76	52	28.0	1	7.6	2.3	3.2
01-07	Oct 10	40	32.6	22.2	73	55	-	-	6.9	3.1	3.0
08-14		41	33.9	22.7	69	46	-	-	7.3	3.1	3.2
15-21		42	31.3	23.1	76	66	00.8	-	3.6	4.2	3.0
22-28		43	32.0	19.9	78	49	20.8	1	5.0	2.6	3.0
29-04	Nov 10	44	29.4	19.0	73	57	-	-	4.3	3.5	2.3
05-11		45	31.2	19.5	72	56	1.6	-	6.7	3.2	2.2
12-18		46	31.7	20.5	77	63	20.4	1	-	2.0	2.2
19-25		47	30.9	18.8	69	53	38.0	2	-	2.4	2.6
26-02	Dec 10	48	31.7	19.1	74	47	-	-	-	1.5	2.5
03-09		49	28.7	16.5	67	46	-	-	-	4.3	2.9
10-16		50	28.4	13.9	61	37	-	-	-	2.8	2.8
17-23		51	26.7	07.7	57	29	-	-	-	2.0	2.2
24-31		52	28.3	11.9	70	38	-	-	-	1.7	2.2

(i) June 2010 to Dec-2010
(ii) Jan 2010 to Dec-2010

Total Rainfall - 1518.1 mm, Number of rainy days - 58
Total Rainfall - 1585.5 mm, Number of rainy days - 62

Table 4 : Weekly weather data for the year 2010-11 as recorded at meteorological observatory Agriculture College, Nagpur.

Date	MW	Max. Temp °C		Min. Temp °C		Total Rainfall (mm)		No. of Rainy days		Evaporation (mm)	
		N	A	N	A	N	A	N	A	N	A
18-24 June	25	35.2	34.8	26.3	24.6	43.1	36.2	2.3	4	6.6	4.4
25-01 July	26	32.5	36.9	24.4	25.9	145.4	55.4	4.2	2	4.1	6.1
02-08	27	31.8	31.5	24.4	24.7	54.7	104.4	2.7	4	4.0	3.7
09-15	28	31.7	31.2	24.7	24.6	76.7	106.0	3.1	4	4.2	3.1
16-22 July	29	30.5	33.2	22.5	25.6	84.7	46.4	3.3	2	3.4	4.0
23-29	30	35.4	29.6	23.7	24.2	69.0	62.8	3.2	5	4.1	2.4
30-05 Aug	31	30.8	30.4	25.7	24.0	71.1	123.5	3.6	7	4.2	3.1
06-12	32	32.1	29.6	23.6	23.9	84.1	167.8	3.4	5	3.3	2.8
13-19	33	31.1	32.1	23.2	24.5	21.3	20.8	2.5	3	2.7	2.7
20-26	34	30.6	32.2	24.1	24.5	70.1	74.0	3.3	2	2.8	3.3
27-02 Sept	35	31.7	31.5	21.0	24.2	34.8	295.6	1.8	4	4.6	2.5
03-09	36	29.9	30.3	31.0	24.6	51.0	129.0	2.6	3	3.9	3.2
10-16	37	32.5	31.6	23.1	23.4	69.2	100.4	3.4	3	3.3	3.3
17-23	38	29.5	31.5	23.0	23.7	19.5	43.4	2.4	4	2.8	3.0
24-30	39	33.0	33.0	23.6	22.8	27.5	28.0	1.6	1	3.5	3.2
01-07 Oct	40	33.5	32.6	19.4	22.2	43.8	-	1.3	-	3	3.0
08-14	41	32.7	33.9	19.9	22.7	14.1	-	0.8	-	4.4	3.2
15-21	42	31.8	31.3	20.1	23.1	15.8	00.8	0.9	-	3.8	3.0
22-28	43	33.5	32.0	20.4	19.9	0.1	20.8	0.2	1	3.1	3.0

N (Normal) = Ten years average (1999-2010)

A (Actual) = Present data (2010-2011)

Fig. 1 (a): Weekly temperature ($^{\circ}\text{C}$) during the year 2010 at Nagpur.

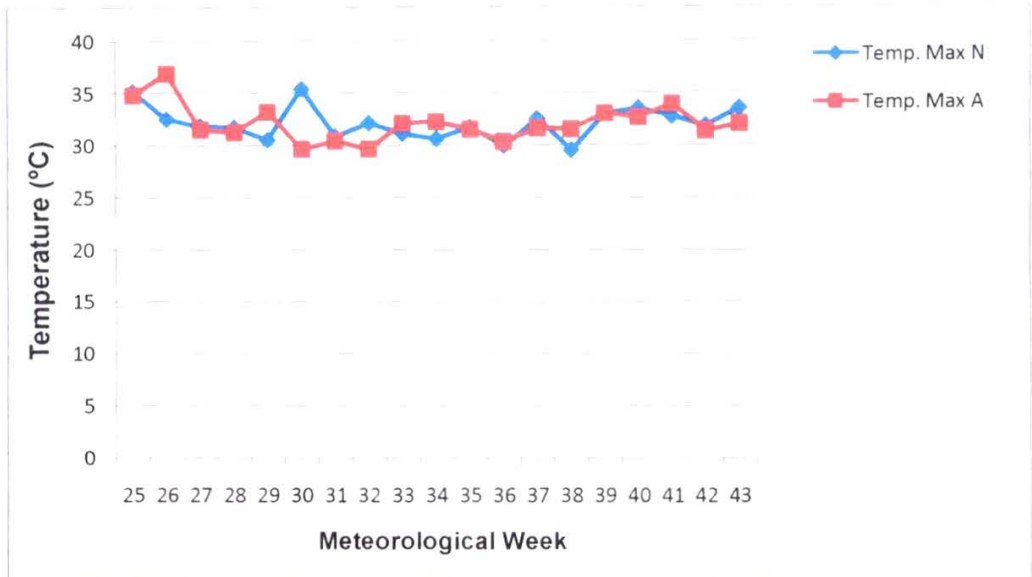


Fig. 1 (b): Weekly temperature ($^{\circ}\text{C}$) during the year 2010 at Nagpur.

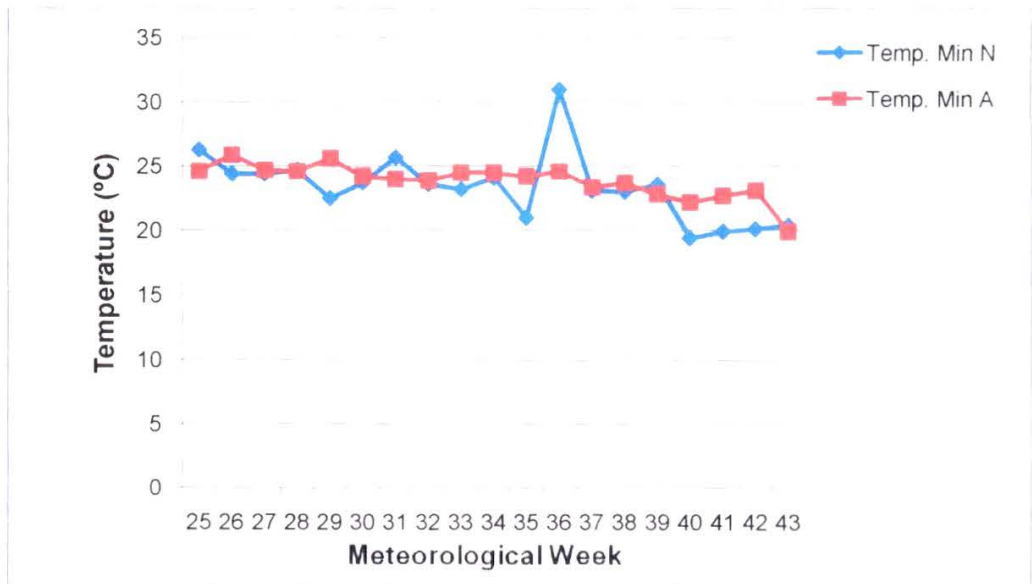


Fig. 1 (c) : Weekly Rainfall (mm) during the year 2010 at Nagpur.

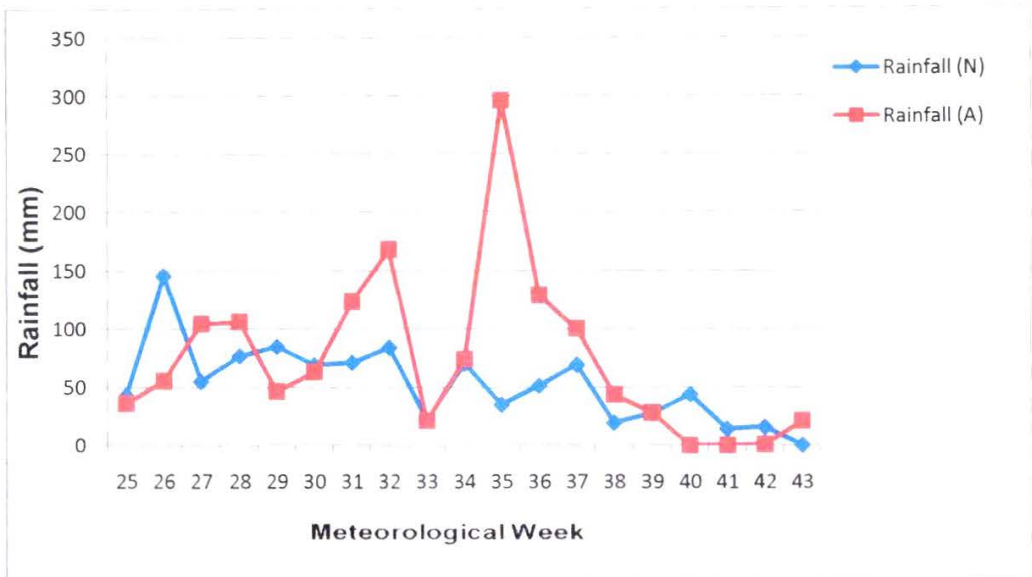
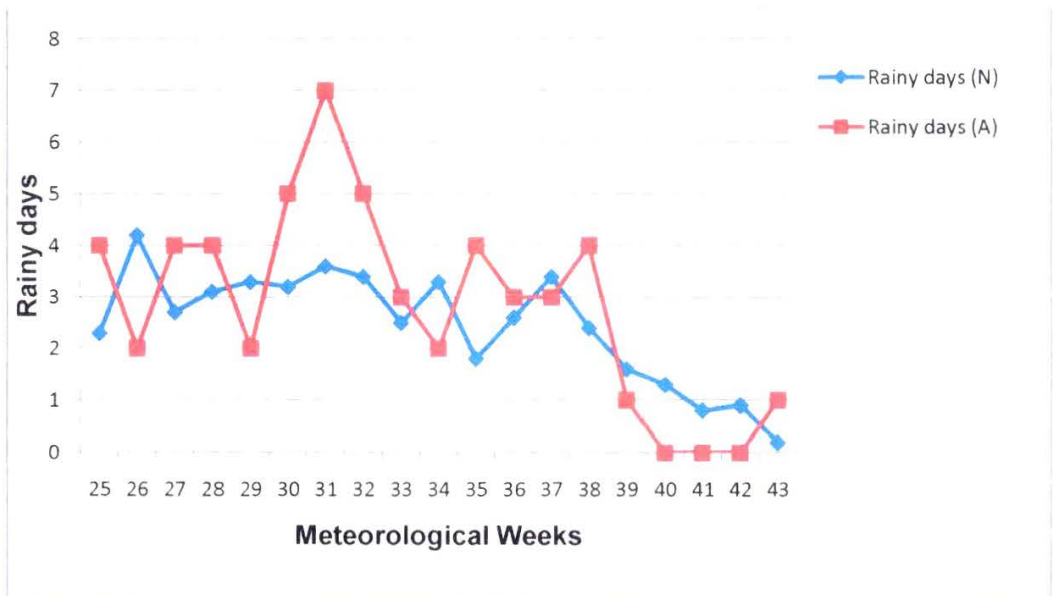


Fig. 1 (d) : Weekly Rainy days during the year 2010 at Nagpur



The annual mean minimum temperature varies from 7.7 – 32.0°C while the maximum temperature ranges from 26.7 – 45.7°C. The Bright sunshine hour ranges between 0.7 – 10.5 per day and wind speed from 1.5 – 9.5 km/hr. The morning relative humidity ranges between 28 – 90 percent and evening humidity between 16 – 83 percent respectively.

3.3 Experimental details

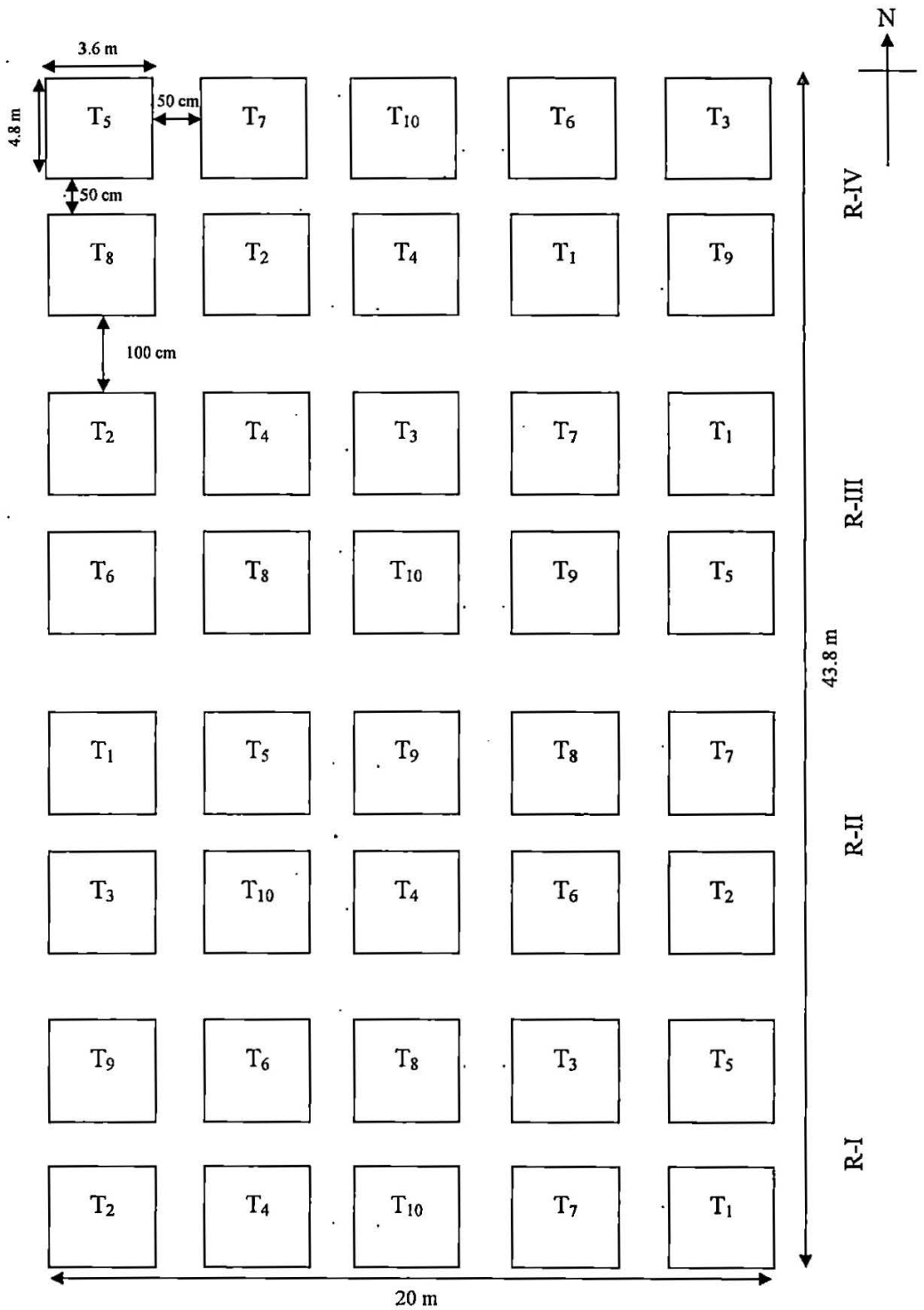
The details of the experiment are given below.

3.3.1 Treatment and statistical design

The present field experiment was laid out in a randomized block design with four replications. The details of treatment are given in Table 4 and plan of layout is depicted in Fig. 2.

3.3.2 Other details

1. Name of crop	:	Soybean
2. Variety	:	JS-335
3. Experimental design	:	Randomized Block Design
4. No. of replications	:	04
5. No. of treatments	:	10
6. No. of plots	:	40
7. Plot size		
(Gross)	:	3.6 x 4.8 m
(Net)	:	3.0 x 4.5 m
8. Plant spacing	:	45 x 5 cm
9. Seed rate	:	75 kg ha ⁻¹
10. Fertilizer dose	:	30:75:00 NPK kg ha ⁻¹
11. Sowing date	:	24 th June, 2010



Plot size : Gross plot 3.60 x 4.80 m²

Net plot 3.00 x 4.50 m²

Design : Randomized Block Design

Fig. 2 Plan of layout

Table 5: Details of experimental treatments:

Sr. No.	Treatments	Abbreviation
1	Control (unweeded)	T ₁
2	2 Hoeing + 2 hand weeding at 20 DAS and 35 DAS	T ₂
3	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	T ₃
4	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	T ₄
5	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	T ₅
6	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	T ₆
7	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	T ₇
8	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	T ₈
9	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	T ₉
10	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	T ₁₀

3.4 Details of field operations:

The details of cultural operations undertaken during the course of present experimentation are given in Table 6.

Table 6: Details of field operations:

Sr. No.	Field operation	Frequency	Date of operation
I) Preparatory tillage			
1)	Tractor ploughing	1	28 April, 2010
2)	Harrowing	2	24 May, 2010 10 June, 2010
3)	Stubble picking	1	5 June, 2010
4)	Layout of experimental field	1	18 June, 2010

II) Sowing			
1)	Sowing of seed by drilling	1	24 June, 2010
2)	Fertilizer application	1	24 June, 2010
3)	Gap filling by dibbling	1	2 July, 2010
III) Inter-culture operation			
1)	Thinning	1	7 July, 2010
2)	Hoeing	a)20 DAS	14 July, 2010
		b) 35 DAS	29 July, 2010
3)	Hand weeding	a) 20 DAS	14 July, 2010
		b)35 DAS	29 July, 2010
IV) Weed control treatment (weedicid spraying)			
1)	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	1	10 July, 2010
2)	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1	10 July, 2010
3)	Imazethapyr @ 75 ha ⁻¹ at 15 DAS	1	10 July, 2010
V) Crop protection measures (insecticide spraying)			
	a)Endosulfan		16 Aug. 2010
VI)	Harvesting	1	10 Oct. 2010
VII)	Threshing and winnowing	1	12 Oct. 2010

3.4.1 Land preparation:

The field was ploughed before monsoon and left as such till commencement of rains. The field was ploughed again and harrowing was done, the stubble picked out and experiment was laid out in RBD design.

3.4.2 Seed and sowing:

Soybean Seed material for the present investigation was obtained from the Agronomy Section Farm, College of Agriculture, Nagpur. Seed

rate for was used as per recommendation of the university (75 kg ha^{-1}). Sowing of seed was done on 24 June, 2010 by drilling method at an optimum soil moisture level. Soybean seeds were treated with thiram @ 3 g kg^{-1} of seed and trichoderma viride @ 4 g kg^{-1} of seed and rhizobium culture @ 25 g kg^{-1} of seed just before sowing. Gap filling wherever necessary was done 10 days after sowing of soybean. Undesired extra plants were thinned out so that proper row spacing and expected plant stand was achieved.

3.4.3 Details of crop variety:

Soybean variety JS – 335 was used for sowing which was released in 1993. The important characteristics of JS – 335 are - flower colour is purple, flowering at 40 – 42 DAS, maturity at 95 – 100 DAS, yield potential $22 - 25 \text{ q ha}^{-1}$, 100 seeds weight (Test weight) : 11 – 12 g and oil per cent - 20.

3.4.4 Fertilizer application:

Fertilizer was applied as per recommended dose of soybean @ 30:75:00 NPK kg ha^{-1} . The quantity of fertilizer was calculated on plot (gross plot) basis and applied. Nitrogen was applied through urea (46 per cent), phosphorus through single super phosphate (16 per cent). The entire dose of fertilizers was applied at the time of sowing.

3.4.5 Inter-culture:

Inter-culture operations viz. hoeing and hand weeding were carried out as per the treatments.

3.4.6 Plant protection measure:

Spraying of endosulfan @ 25 ml in 10 litre of water was done to control the insect pest during growth period of soybean.

3.4.7 Harvesting and threshing:

Harvesting was done manually when the crop showed physiological maturity and the grains were completely matured. The harvesting was done with sickle by cutting the stem portion at the ground surface. Border rows were harvested first and kept separately and then crop from each net plot area was harvested and the produce from each net plot was tied in bundles as per treatment. Observation plants were harvested separately and were taken to the laboratory for the post harvest studies. After sun drying the produce from each net plot was threshed manually and clean seeds were obtained by winnowing.

3.4.8 Weed control practices:

3.4.8.1 Hoeing and hand weeding:

The operations were carried out as per the treatments. In treatment (T₂) two hoeings and two hand weedings were given at 20 and 35 DAS respectively. In treatments (T₈, T₉ and T₁₀) 1 hand weeding and one hoeing was given at 35 DAS.

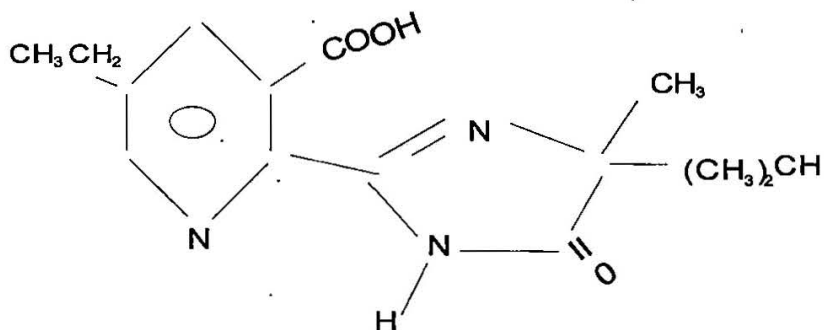
3.4.8.2 Application of herbicides:

The herbicide imazethapyr, Fenaxoprop-P-ethyl and Chlorimuron ethyl as post emergence was applied as per the treatments dose and time of application to the plot assigned as per layout of experiment. The quantity of herbicide required for gross plot area was calculated treatment wise. Quantity of water required for spraying was determined by calibration of sprayer.

3.4.8.3 Details of herbicides used

Imazethapyr : (Rao, 2000)

Trade name	:	Pursuit / Hammer
Origin	:	American Cyanamid
Chemical name	:	2[4, 5-dihydro-4-methyl-4-(1 methyl ethyl)-5- Oxo-1 H imidazol- 2y1]-5-ethyl-3-pyridine carboxylic acid
Herbicide group	:	Imidazolinoes
Structural formula	:	



Type of herbicide	:	Selective
General dosage	:	50 g ha ⁻¹
Application	:	E-PPI, pre-emergence and early post-emergence
Uptake and mode of action:	:	It is rapidly absorbed by foliage and very slowly by roots and translocated in both xylem and phloem and kills weed. Imazethapyr inhibits Acetyl-coenzyme A synthase (ALS).

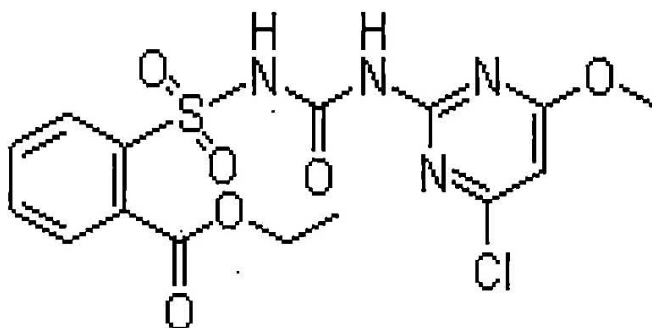
Properties:

Solubility	:	1,400 mg lit ⁻¹ at 25 ^o C
LD ₅₀	:	Less than 5000 (acute toxicity)
Price	:	Rs.1575 lit ⁻¹
Important weed controlled :		Imazethapyr controlled annual broad leaf and grass weeds including <i>Amaranthus spp.</i> , <i>Xanthium strumarium</i> , <i>Datura stramonium</i> , <i>Kohia scoparia</i> , <i>Chenopodium album</i> , <i>Ipomoea spp.</i> , <i>Solanum nigrum</i> , <i>Ambrosia spp.</i> , <i>Euphorbia spp.</i> , <i>Anoda cristata</i> , <i>Abutilon theophrasti</i> and annual grasses such as <i>Digitaria spp.</i> , <i>Setaria spp.</i> , <i>Echinochloa crusgalli</i> , <i>Panicum dichotomiflorum</i> , <i>Sorghum halepense</i> and <i>Nutsedge spp.</i>
Miscellaneous information :		Imazethapyr discovered in 1881, tested in 1987-88 and registered in 1989. It can be used in soybean, ground nut, peas, edible beans and imidazolinone tolerant maize.
Formulation	:	10 per cent SL

Chlorimuron ethyl: (Claus, 1987)

Trade name	: Classic / Kloben
Origin	: United States.
Chemical name	: Ethyl 2- { { { (4-chloro-6-methoxyprimidin-2- yl) amino} carbonyl} amino} sulfonyl} Benzoate.
Herbicidal group	: Sulfonylurea

Structural formula :



Type of herbicide	: Selective
General dosages	: 9 and 12 g ha ⁻¹
Application	: Pre-emergence and Post emergence
Uptake and mode of action	: Chlorimuron ethyl is a member of new class of highly phytotoxic herbicide called sulfonylureas. It blocks the production of the essential amino acid, valine and isoleucine by inhibiting the enzyme, acetolactate synthase metabolic inactivation by the soybean plant serve as the basis for selectivity.

Properties:

Solubility	:	White, solid solubility in water 11 ppm
LD ₅₀	:	Less than 2000
Price	:	Rs. 200 / 15 gm
Important weed controlled	:	Chlorimuron-ethyl is effective post emergence for control of many broad leaf weeds such as cocklebur (<i>Xanthium spp.</i>), Pigweed (<i>Amaranthus spp.</i>) and annual morning glory's, the problematic weed such as, <i>Phyllanthus niruri</i> , <i>Echinochloa colona</i> , <i>Cynodon dayctylon</i> . <i>Cyperous rotundous</i> and <i>Digera arvensis</i> .

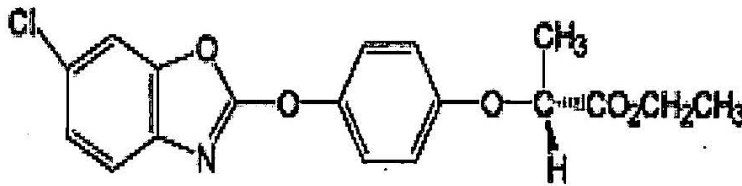
Miscellaneous information : Chlorimuron ethyl was first synthesized January 1982 by Dupont. First field test were conducted in 1982 in the United state and Brazil under the code DPX-F-6025. Chlorimuron ethyl was tested under experimental use permit in 1984 and 1985. Full United States Federal registration was obtained in 1986 with first commercial sales the same year. Registration is pending in Brazil and Argentina.

Formulation : 25 % Active ingredient dispersible granules

Fenoxaprop-p-ethyl:

Trade name	:	Whip super / Puma
Origin	:	China
Chemical name	:	Ethyl(R)-2-[4-[(6-chloro-2benzoxazolyl)oxy] phenoxy] Propionic acid.
Herbicidal group	:	Aryloxyphenoxy propionate (Fop)

Structural formula :



Type of herbicide	:	Selective
General dosage	:	40-100 g ha ⁻¹
Application	:	Post emergence
Uptake and mode of action	:	Fenoxaprop-p-ethyl is a selective herbicide with contact and systemic action absorbed, principally by the leaves with translocation both acropetally and basipetally to roots or rhizomes.

Properties:

Solubility	:	0.7 mg l ⁻¹ @ 20 ^o C
LD ₅₀	:	Less than 2000 (acute toxicity)
Price	:	Rs. 1200 l ⁻¹
Important weed controlled	:	Fenoxaprop-p-ethyl controls grassy weeds like <i>Avena fativa</i> , <i>A..sativa</i> , <i>Cenchrus spp.</i> , <i>Echinochloa crusgalli</i> , <i>Ergotis spp.</i> , <i>Panicum spp.</i> , <i>Phalaris minor</i> and <i>Setaria spp.</i> ,
Miscellaneous information	:	It has also been developed by M/S Hoechst Schering AgrEvo Ltd. It is found to be selective in crops like soybean, cotton, Groundnut, Potatoes, Beans and vegetables.
Formulation	:	9 and 12 EC

3.5 Biometric information and sampling techniques:

Five plants were randomly selected from each net plot treatment wise in all replication. The plants were labeled and various biometric observations were recorded and quality component studies are given in Table 7.

Table 7: Details of observation:

Sr. No.	Particulars	Days after sowing
I) Weed studies		
1)	Weed count m^{-2}	
	a) Dicot weed count m^{-2}	20, 40, 60, 80 DAS and at harvest
	b) Monocot weed count m^{-2}	20, 40, 60, 80 DAS and at harvest
	c) Total weed count m^{-2}	20, 40, 60, 80 DAS and at harvest
2)	Dry matter of weed ($g\ m^{-2}$)	20, 40, 60, 80 DAS and at harvest
3)	Weed control efficiency (%)	20, 40, 60, 80 DAS and at harvest
4)	Weed index (%)	
II) Crop studies		
A) Growth studies		
1)	Plant stand	10 DAS and at harvest
2)	Plant height (cm)	20, 40, 60, 80 DAS and at harvest
3)	Leaf area index	20, 40, 60 and 80 DAS
4)	Number of leaves $plant^{-1}$	20, 40, 60 and 80 DAS
5)	Number of branches $plant^{-1}$	60, 80 DAS and at harvest
6)	Dry matter $plant^{-1}$ (g)	60, 80 DAS and at harvest
B) Yield and yield attributes		
1)	Number of pods $plant^{-1}$	At Harvest
2)	Test weight (g)	At Harvest
3)	Weight of grains $plant^{-1}$ (g)	At Harvest
4)	Grain yield $kg\ ha^{-1}$	At Harvest
5)	Straw yield $kg\ ha^{-1}$	At Harvest
6)	Harvest index	At Harvest
C) Economics		

3.5.1 Weed studies:

3.5.1.1 Weed count:

For weed population study in each net plot, a quadrat of 1m x 1m area was randomly fixed. Number of weed observed in that area was counted at 20 days interval and finally at the harvest of the crop. These weeds were grouped as monocot and dicot weeds. The values were later converted to per square meter basis.

3.5.1.2 Dry matter of weeds (g m⁻²):

Weed dry weight was recorded by using a quadrat of 1m x 1m from a random spot in the plot where weed infestation was representative of the fixed quadrat area in the treatment. At the time of weeds removal through hand weeding and hoeing or any other treatment execution, selected fixed quadrat area was also carefully hand weeded and hoed or treatment wise treated. The weeds were first air dried and then kept in an oven at 65^o C till the constant dry weight was obtained. These observations were taken periodically and the values were later converted to per square meter basis.

3.5.1.3 Weed control efficiency (%):

The weed control efficiency was calculated by the following formula (Gautam et al., 1975)

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

Where,

WCE : Weed control efficiency

DMC : Dry matter of weeds in control plots

DMT : Dry matter of weeds in treated plots

3.5.1.4 Weed index:

The weed index was calculated by the formula proposed by (Gill and Vijaykumar, 1969).

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

Where,

WI - Weed index in percent

X - Yield from maximum yielding plot

Y - Yield under the treatment for which weed index is to be calculated

3.5.2 Crop growth studies:

3.5.2.1 Emergence count and final stand:

After crop emergence, plant population per meter row length was measured at four randomly selected spots at 10 days after sowing and then average worked out. Final plant stand of the crop was recorded at harvest same as emergence count.

3.5.2.2 Plant height (cm):

Five plants in each net plot were selected randomly and height of selected plants was measured from the surface of the soil up to the tip of main shoot. The height was measured at an interval of 20 days till the harvest of crop.

3.5.2.3 Functional leaves plant⁻¹:

The number of functional leaves i.e. fully opened green leaves was selected observation plant. The average was calculated and expressed as functional leaves plant⁻¹.

3.5.2.4 Leaf area plant⁻¹:

The leaves from the plant sampled for dry matter study were used for estimating the leaf area. The leaf area (sq. cm) was estimated by using the leaf area meter; model C1 – 203 laster Area Meter, CID, Inc. USA at the Agronomy Section, College of Agriculture, Nagpur.

3.5.2.5 Leaf area index (LAI):

Watson (1947) developed a growth function of leaf area index which is an expression of leaf surface per unit area of land surface and is worked out by following formula.

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}}{\text{Land area plant}^{-1}}$$

3.5.2.6 Number of branches plant⁻¹:

The number of branches from the randomly selected five plants was counted and average was worked out.

3.5.2.7 Dry matter accumulations plant⁻¹ (g):

For dry matter study one plant from each net plot was randomly sampled periodically. After uprooting the plant, root portion was separated and shoot portion of plant was kept in brown paper bag properly labeled. The samples were initially air dried for 2 to 3 days. After partial drying, samples were kept in hot air oven at 65⁰ C for drying till the constant weight was obtained. The weight was expressed as dry matter plant⁻¹ (g).

3.5.3 Yield studies:

3.5.3.1 Number of pods plant⁻¹:

The number of pods from five randomly selected plants from net plot was counted and average was worked out.

3.5.3.2 Grain weight plant⁻¹ (g):

From the pods of five observational plants, after shelling the seeds were separated, dried and then weighed (g) from which per plant⁻¹ seed weight was worked out.

3.5.3.3 Test weight (g):

From the grain produce of each plot, 100 seeds were randomly selected and weighed. The weight was expressed as test weight (g).

3.5.3.4 Seed yield (kg ha⁻¹):

After harvest, the plants were tied in bundles and air dried. The produce was threshed and seed produce from each net plot was weighed to record seed yield net plot⁻¹ and yield in kg ha⁻¹ was calculated.

3.5.3.5 Straw yield (kg ha⁻¹):

The straw derived from each net plot⁻¹ was recorded and expressed as straw yield kg ha⁻¹. After threshing the seeds were separated and the husk and the straw from each net plot⁻¹ was weighed and expressed as straw yield kg ha⁻¹

3.5.3.6 Harvest index:

Harvest index was worked out by using the following formula,

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.6 Economic studies:

The total expenditure involved in raising the crop was calculated at prevailing market rates. The cost of different weed management treatments was worked out considering the prevailing rates of wages and price of herbicide. Total monetary returns realized were

worked out considering the market prices of the soybean seeds. From these figures net monetary returns were calculated for each treatment for comparison.

3.6.1 Cost of cultivation (Rs. ha⁻¹) :

The total cost of cultivation was calculated considering the inputs used in each treatments with prevailing market rates.

3.6.2 Gross monetary return (Rs. ha⁻¹) :

The grain and straw yield of soybean was converted in money value i.e. Rs. ha⁻¹ at the rate recommended by price fixing committee, PDKV, Akola for the year 2009-2010. Price of grain was taken as Rs. q⁻¹ and straw as Rs. q⁻¹.

3.6.3 Net monetary returns (Rs. ha⁻¹) :

Net monetary returns were calculated by subtracting the cost of cultivation from gross monetary returns treatment wise.

3.6.4 Benefit: cost ratio :

The benefit Cost ratio was worked out by dividing gross monetary return (Rs. ha⁻¹) with total cost of cultivation (Rs. ha⁻¹).

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

3.7 Statistical analysis:

The experimental data were subjected to statistical test by following analysis of variance technique suggested by Panse and Sukhmate (1971). Wherever variance ratio ('F' value) was significant, critical difference (CD) values at 5 per cent level of probability were computed for making treatment comparison. The weed count and weed dry matter production m⁻² data were transformed into $\sqrt{x+0.5}$ before statistical analysis.

Chapter IV

RESULTS AND DISCUSSION

The present investigation entitled "Integrated weed management in soybean" was conducted during the *kharif* season of 2010 at Agronomy Farm, College of Agriculture, Nagpur. The observations taken during the course of investigation and the results obtained have been discussed in this chapter and the inferences have been supported with logical reasoning and appropriate evidences.

4.1 Soil :

Soil of experimental site was clayey in texture with slightly alkaline in nature. Crops like chick pea, pigeon pea, sorghum, and soybean have been taken up on this soil during the preceding three years following crop rotation. The initial soil fertility status indicated that the soil was medium in organic carbon, low in available nitrogen and phosphorus and fairly rich in potassium. The topography of the field was fairly uniform.

4.2 Season and crop :

Season plays an important role in crop growth and yield. Amongst the weather elements rainfall is the most important factor affecting the growth and yield of *kharif* crop. Soybean crop was sown on June, 24 (25 MW) and harvesting was undertaken on October, 10 (40 MW). The total rainfall received during the period of investigation was 1435.9 mm in 54 rainy days. As such the amount of rainfall was sufficient for successful completion of the crop as the water use by soybean is about 64-76 cm (Rajendra Prasad, 2002).

The onset of monsoon was normal with rainfall of 42.8 mm during 24th MW. As such, sowing of soybean was early (June, 24) considering the recommended sowing time (first fortnight of July). The rainfall till that

proper marking and successful sowing. Light showers amounting 55.4 mm across the next 7 days (26 MW) assured satisfactory germination of crop. Rainfall distribution during the important crop growth stages was quite satisfactory. Subsequent rains during 27th (104.4 mm), 28th (106.0 mm) and 29th (46.4 mm) MW, benefited the crop during its vegetative phase. During 30th to 32nd MW the rainfall received amounted to 354.1 mm which created waterlogged conditions that might have caused some adverse effect on crop growth i.e. plant growth stunted, yellowing of leaves, increase insect and pest incidence etc. In subsequent two meteorological weeks 33th and 34th 94.8 mm rainfall was received which prolonged waterlogged condition. The rainfall was high (525 mm) during 35th to 37th MW which affected early and late reproductive phase. Further rains during two weeks 38th and 39th MW caused waterlogged condition and affects the grain development and grain yield. Heavy Rainfall and waterlogged condition during grain development stage reduced grain size and ultimately the grain.

Maximum temperature remained lower than normal during cloudy weather followed by rains. Maximum temperature during the crop season fluctuated between 29.6^oC to 36.9^oC and minimum temperature between 22.2^oC to 25.9^oC. Warmer temperature over (30/20) favours vegetative tissues and higher pod set (Lawn and Hume, 1985). Morning relative humidity during the crop growing season ranged between 69 to 90% and evening relative humidity ranged between 49 to 79%. Bright sunshine hours fluctuated relative to the cloudy/rainy days and rainless periods. Average bright sunshine hours were 3.08 during crop season. Evaporative rate during the crop season ranged between 2.4 to 6.1 mm. Overall, the season was quite satisfactory for soybean crop.

4.3 Weed studies:

4.3.1 Weed flora :

Different weed species observed in experimental field were identified and a list is presented in Table 8.

Table 8: Weed flora observed in experimental plot

Sr. No.	Common name	Scientific name
A. Dicot weeds		
1.	Pandhari phuli	<i>Lagasca mollis</i>
2.	Dudhi (chhoti)	<i>Euphorbia hirta</i>
3.	Kunjar	<i>Digera arvensis</i>
4.	Kamber modi (Ekdandi)	<i>Tridax procumbens</i>
5.	Gajar gavat	<i>Parthenium hysterophorus</i>
6.	Cock's comb	<i>Celosia argentea</i>
7.	Dudhi (Mothi)	<i>Euphorbia geniculata</i>
8.	Shevara	<i>Alysicarpus rugosus</i>
9.	Bawachi	<i>Psorolea carylifolia</i>
10.	Reshinkata	<i>Alternanathera triandra</i>
11.	Hajardani	<i>Phyllanthus niruri</i>
12.	Takala/tarota	<i>Cassia tora</i>
Monocot weeds		
1.	Kena	<i>Commelina benghalensis</i>
2.	Lona grass	<i>Dinebra arabica</i>
3.	Pauna	<i>Poa annua</i>
4.	Barnyard grass	<i>Echinochloa crusgalli</i>
5.	Chimanchara	<i>Eragrostis major</i>
6.	Haryali	<i>Cynodon dactylon</i>
7.	Nagarmotha	<i>Cyperus rotundus</i>
8.	Jonhson grass	<i>Sorghum halepensis</i>
9.	Kunda	<i>Ischeaemum pilosum</i>

4.3.2 Effect of treatments on weed population :

The weeds were classified in two major groups i. e. monocot and dicot weed and to study the effect of different treatments on each group.

4.3.2.1 Effect of treatments on monocot weeds:

The data regarding the mean number of monocot weeds m^{-2} was presented in Table 9 and graphically shown in fig. 3

The data revealed that the number of monocot weeds was maximum at 80 DAS and lowest at 20 DAS. Two hoeing and two hand weeding at 20 DAS and 35 DAS (T_2) recorded significantly lowest monocot weed population at all periodical stages while highest weed population was observed under unweeded control (T_1).

At 20 DAS, the treatment comprising of two hoeing and two hand weeding at 20 and 35 DAS (T_2) was found significantly superior in reducing monocot weed population over all other treatments. Amongst herbicidal treatments the treatment consisting of Fenoxaprop-p-ethyl @ 100 g a.i. ha^{-1} + chlorimuron ethyl @10 g a.i ha^{-1} at 15 DAS (T_6) recorded significantly lowest monocot weed population over the herbicides applied alone and in combination with 1Hoeing and 1 hand weeding at 35 DAS except (T_7), (T_3) and (T_4) which was at par with (T_6).

At 40 DAS, two hoeing and two hand weeding at 20 and 35 DAS (T_2) and imazethapyr @ 75 g ha^{-1} at 15 DAS + one hoeing and one hand weeding at 35 DAS (T_{10}) was found significantly superior in reducing weed population over all treatments except, Fenoxaprop-p-ethyl @ 100 g a.i. ha^{-1} at 15 DAS + one hoeing and one hand weeding at 35 DAS (T_8) and chlorimuron ethyl @10 g a.i ha^{-1} at 15 DAS + one hoeing and one hand weeding at 35 DAS (T_9). However these treatments were at par with (T_2) and (T_{10}) treatments.

At 60 DAS, two hoeing and two hand weeding at 20 and 35 DAS (T_2) and imazethapyr @ 75 g ha^{-1} at 15 DAS + one hoeing and one hand weeding at 35 DAS (T_{10}) was found significantly superior in reducing

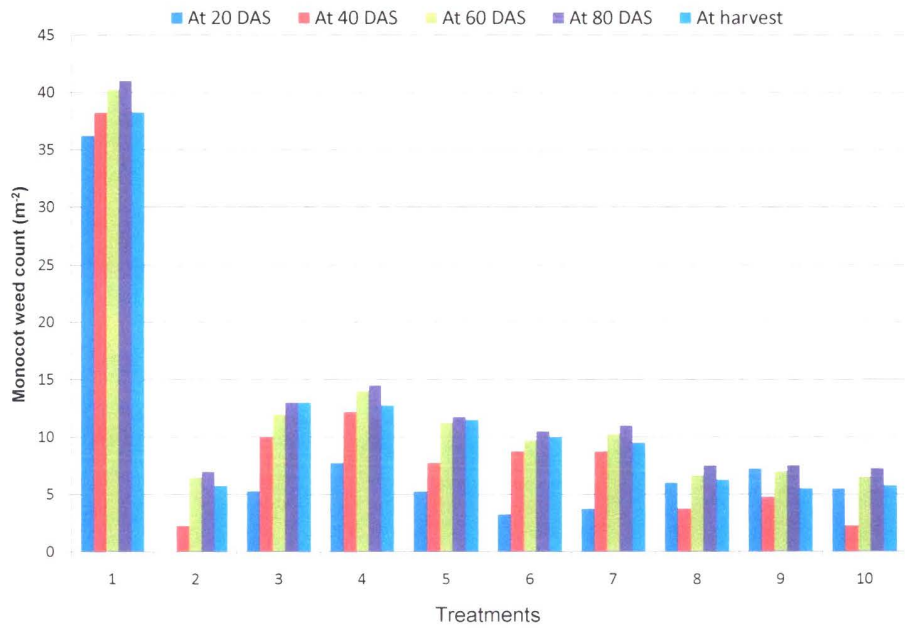


Fig. 3: Mean monocot weed count m⁻² as influenced by different treatments

Table 9: Mean monocot weed count (m⁻²) as influenced by different weed control treatments

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	6.05 (36.25)	6.22 (38.22)	6.38 (40.25)	6.44 (41.00)	6.26 (38.75)
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	0.71 (0.00)	1.65 (2.25)	2.64 (6.50)	2.73 (7.00)	2.50 (5.75)
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	2.39 (5.25)	3.24 (10.00)	3.53 (12.00)	3.67 (13.00)	3.67 (13.00)
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.78 (7.75)	3.60 (12.50)	3.80 (14.00)	3.87 (14.50)	3.64 (12.75)
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	2.39 (5.25)	2.87 (7.75)	3.42 (11.25)	3.50 (11.75)	3.46 (11.50)
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1.93 (3.25)	3.04 (8.75)	3.20 (9.25)	3.31 (10.50)	3.24 (10.00)
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	2.05 (3.72)	3.04 (8.75)	3.27 (10.25)	3.39 (11.00)	3.16 (9.50)
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	2.55 (6.02)	2.06 (3.75)	2.69 (6.57)	2.82 (7.50)	2.59 (6.25)
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	2.78 (7.25)	2.29 (4.75)	2.73 (7.00)	2.82 (7.50)	2.44 (5.50)
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	2.44 (5.50)	1.65 (2.25)	2.64 (6.50)	2.78 (7.25)	2.50 (5.75)
	SE(m)±	0.17	0.26	0.17	0.14	0.11
	CD at 5%	0.50	0.75	0.50	0.40	0.30
	GM	2.60	2.66	3.43	3.53	3.34

Upper values are transformed values $\sqrt{x+0.5}$

Figures in parenthesis are original values.

weed population over all treatments except. Fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₈) and chlorimuron ethyl @10 g a.i ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₉). However these treatments were at par with (T₂) and (T₁₀) treatments.

At 80 DAS and at harvest, two hoeing and two hand weeding at 20 and 35 DAS (T₂) recorded significantly lowest weed population over all other treatments except chlorimuron ethyl @10 g a.i ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₉), and imazethapyr @ 75 g ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₁₀) and Fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS one hoeing and one hand weeding at 35 DAS (T₈) and these treatments were at par with two hoeing and two hand weeding at 20 and 35 DAS (T₂).

The reason for better weed control in imazethapyr, chlorimuron ethyl and fenoxaprop-p-ethyl treated plots could be attributed to its wide spectrum control of annual broad leaf and grassy weeds (Claus, 1987) (Rao, 2002). The selective action of post emergence application of imazethapyr 75 g ha⁻¹ showed better control of grassy and broad leaf weed as reported by Jain *et al.* (2001), Kushwah and Vyas (2005), Pandaya *et al.* (2006), Singh *et al.* (2006), Tiwari *et al.* (2007) and Dhane *et al.* (2010) also reported similar results from their studies.

4.3.2.2 Effect of treatments on dicot weeds:

Data pertaining mean number of weeds m⁻² is presented in Table 10 and graphically illustrated in fig 4.

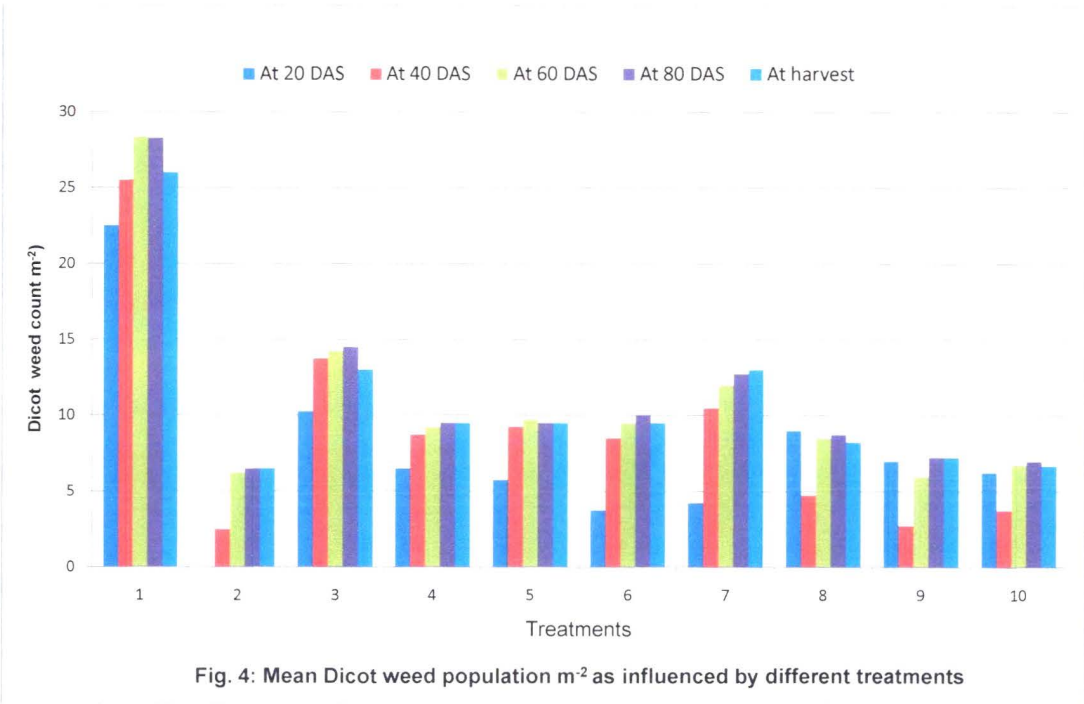
The data revealed that the dicot weed population was significantly influenced by different weed control treatment. The unweeded control treatment recorded significantly highest number of dicot weeds at all periodical stages, while significantly lowest dicot weed population was observed under two hoeing and two hand weeding at 20 and 35 DAS.

Table 10: Mean Dicot weed count (m⁻²) as influenced by different weed control treatment

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	4.79 (22.50)	5.10 (25.50)	5.32 (28.35)	5.36 (28.25)	5.14 (26.00)
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	0.71 (0.00)	1.73 (2.50)	2.59 (6.25)	2.64 (6.50)	2.64 (6.50)
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	3.27 (10.25)	3.77 (13.75)	3.85 (14.25)	3.87 (14.50)	3.67 (13.00)
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.64 (6.50)	3.04 (8.75)	3.12 (9.25)	3.16 (9.50)	3.16 (9.50)
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	2.50 (5.75)	3.12 (9.25)	3.20 (9.75)	3.24 (10.00)	3.27 (10.25)
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.06 (3.75)	3.00 (8.50)	3.16 (9.50)	3.24 (10.00)	3.16 (9.50)
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	2.17 (4.25)	3.27 (10.50)	3.53 (12.00)	3.64 (12.75)	3.67 (13.00)
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	3.08 (9.00)	2.29 (4.75)	3.00 (8.50)	3.04 (8.75)	2.95 (8.25)
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	2.73 (7.00)	1.80 (2.75)	2.54 (6.00)	2.78 (7.25)	2.78 (7.25)
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	2.59 (6.25)	2.06 (3.75)	2.69 (6.75)	2.73 (7.00)	2.69 (6.69)
	SE(m)±	0.18	0.43	0.14	0.17	0.15
	CD at 5%	0.52	1.25	0.40	0.50	0.45
	GM	2.64	2.91	3.30	3.36	3.33

Upper values are transformed values $\sqrt{x+0.5}$

Figures in parenthesis are original values.



At 20 DAS, two hoeing and two hand weeding at 20 and 35 DAS (T₂) were found significantly superior in reducing dicot weed population over all treatments. The treatment consisting of fenoxoprop-p-ethyl @ 100 g a.i. ha⁻¹ + chlorimuron ethyl @ 10g a.i ha⁻¹ at 15 DAS (T₆) was found significantly effective in reducing dicot weeds as compared to all other treatments imazethapyr @ 75 g a.i. ha⁻¹ + Fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS (T₇) and imazethapyr @ 75g a.i. ha⁻¹ at 15 DAS (T₅).

The broad leaf weed population was significantly reduced with two hoeing and two hand weeding at 20 and 35 DAS (T₂) at 40, 60, 80 and at harvest amongst all other treatments. However, chlorimuron ethyl @ 10 g a.i ha⁻¹ at 15 DAS + 1 Hoeing and one hand weeding at 35 DAS (T₁₀), imazethapyr @ 75g ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₉) and Fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₈) were found comparable to two hoeing and two hand weeding at 20 and 35 DAS (T₂) in reducing dicot weed population.

Dicot weed population was reduced significantly due to various weed control treatments at all growth stages. The reason of lower weed population under herbicidal and mechanical treatments than unweeded control could be attributed to better control of weeds by the post emergence application of herbicide and two hoeing and two hand weeding at 20 and 35 DAS. Similar findings were found by Pandaya *et al.* (2006), Singh *et al.* (2006), Tiwari *et al.* (2007) and Dhane *et al.* (2010)

4.3.2.3 Effect of treatments on total weed population:

Data pertaining to the mean number of total weed count m⁻² is presented in Table 11 and depicted graphically in Fig 5.

Table 11: Mean total weed count (m⁻²) as influenced by different weed control treatments

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	7.69 (58.75)	8.01 (63.75)	8.30 (68.60)	8.35 (69.25)	8.07 (64.75)
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	0.71 (0.00)	2.29 (4.75)	3.64 (12.75)	3.74 (13.50)	3.57 (12.25)
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	3.60 (12.50)	4.92 (23.75)	5.17 (26.25)	4.94 (24.00)	4.82 (22.25)
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS ¹	3.84 (14.25)	4.71 (21.25)	4.92 (23.75)	4.94 (24.00)	4.82 (22.85)
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	3.39 (11.00)	4.18 (17.00)	4.63 (21.00)	4.71 (21.75)	4.71 (21.75)
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.73 (7.00)	4.21 (17.25)	4.44 (19.25)	4.58 (20.50)	4.47 (19.50)
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	2.91 (7.97)	4.44 (19.25)	4.76 (22.25)	4.92 (23.75)	4.79 (22.50)
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	3.93 (15.02)	3.00 (8.50)	3.96 (15.25)	4.10 (16.25)	3.87 (14.50)
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	3.84 (14.25)	2.82 (7.50)	3.67 (13.00)	3.90 (14.75)	3.64 (12.75)
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	3.50 (11.75)	2.54 (6.00)	3.70 (13.25)	3.84 (14.25)	3.59 (12.44)
	SE(m)±	0.84	0.37	0.21	0.0.17	0.18
	CD at 5%	2.55	1.10	0.60	0.50	0.52
	GM	3.58	4.10	4.69	4.76	4.59

Upper values are transformed values $\sqrt{x+0.5}$

Figures in parenthesis are original values.

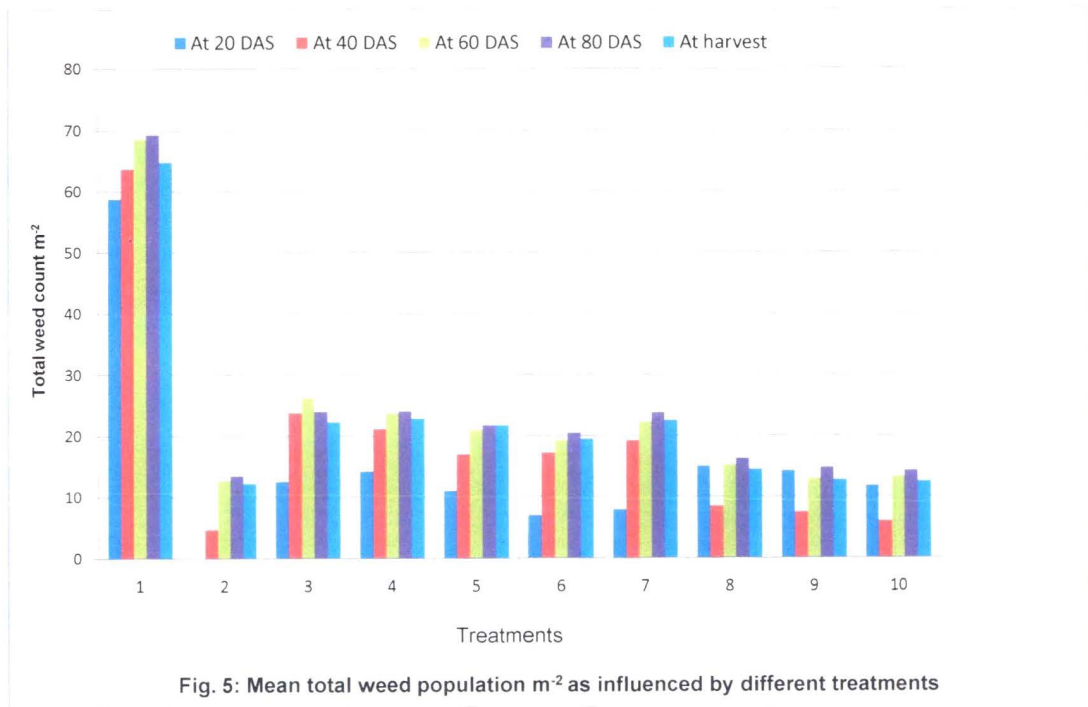


Fig. 5: Mean total weed population m^{-2} as influenced by different treatments

At 20 DAS, the treatment of two hoeing and two hand weeding at 20 and 35 DAS (T₂) was found significantly superior in reducing total weed population over all other treatments. The treatment comprising of fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ + chlorimuron ethyl @10 g a.i ha⁻¹ at 15 DAS (T₆) recorded significantly lowest number of total weed count m⁻² over unweeded control and other herbicidal treatment except imazethapyr @ 75g a.i. ha⁻¹ + Fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS (T₇) which were at par with each other.

At 40 DAS, lowest total weed count was observed in two hoeing and two hand weeding at 20 and 35 DAS (T₂) which was significantly superior over all other treatments except imazethapyr @ 75 g ha⁻¹ at 15 DAS + one hoeing and one hand weeding 35 DAS (T₁₀) and chlorimuron ethyl @10 g a.i ha⁻¹ at 15 DAS + one hoeing and one hand weeding at 35 DAS (T₉). However these treatments were at par with two hoeing and two hand weeding at 20 and 35 DAS (T₂). Similar trend was observed during 60, 80 and at harvest. Weed control treatment of hand weeding and hoeing twice at 20 and 35 DAS resulted in lowering total weed count. This might be due to increased weed control efficiency due to sequential weeding and hoeing and more persistent check on weeds by smothering effect on weeds by soybean vegetation. These results were also reported by Vyas and Jain (2003), Kushwah and Vyas (2005), Chandel and Saxena (2001), Pandya *et al.* (2006), Tiwari *et al.* (2007), Singh *et al.* (2006) and Dhane *et al.* (2010).

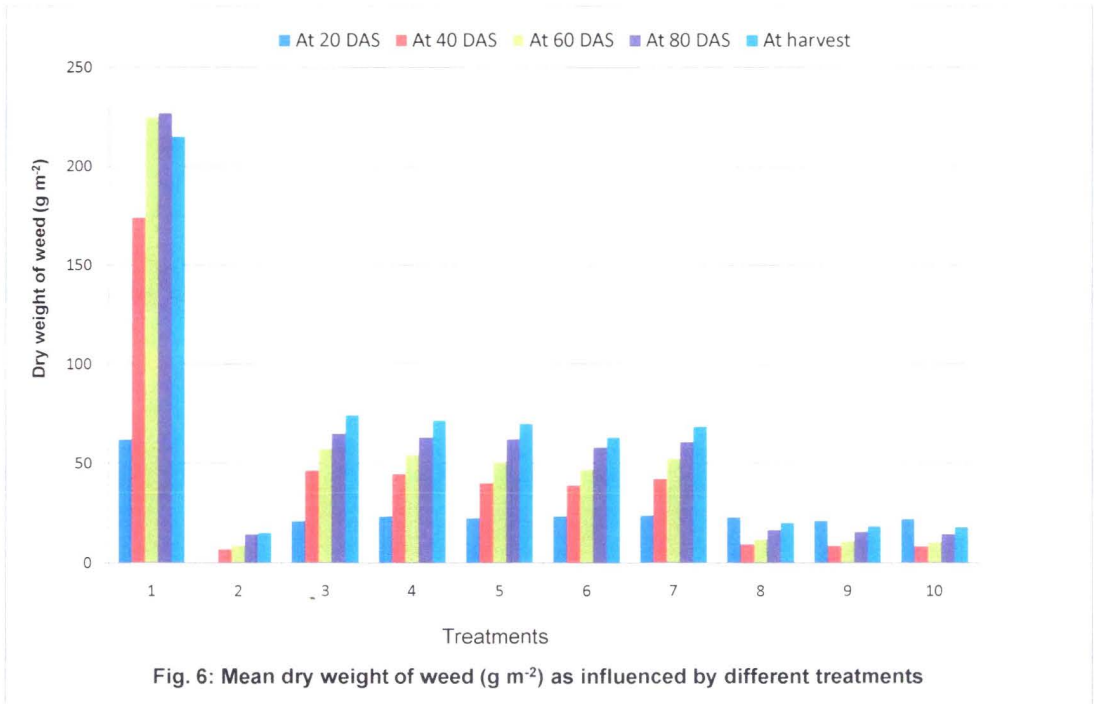
4.3.3 Effect of treatments on dry matter production by weeds:

Data pertaining to the dry matter produced by the weeds m⁻² was presented in Table 12 and illustrated graphically in Fig 6.

Dry weight of weeds showed increasing trend during different periodical stages up to harvest. In general, dry matter accumulation by weeds followed same trend as that of weed population. Dry matter accumulation by the weeds was significantly influenced by the different weed control treatments.

Table 12: Total weed dry matter (g m^{-2}) as influenced by different weed control treatments

Treatments		Days after Sowing				
		20	40	60	80	at harvest
T ₁	Control (unweeded)	62	174	225	227	215
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	0.00	7.00	9.00	14.50	15.20
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha^{-1} at 15 DAS	21.00	46.50	57.30	65.12	74.33
T ₄	Chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS	23.50	44.75	54.50	63.00	71.74
T ₅	Imazethapyr @75g a.i. ha^{-1} at 15 DAS	22.75	40.12	51.00	62.12	70.13
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha^{-1} + Chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS	23.50	40.00	47.50	58.75	63.00
T ₇	Imazethapyr @75g a.i. ha^{-1} + Fenoxaprop-P-ethyl @100 a.i. ha^{-1} at 15 DAS	24.00	42.26	52.54	60.75	68.64
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha^{-1} at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	23.10	9.50	12.00	16.65	20.12
T ₉	Chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	21.25	8.75	11.00	15.64	18.50
T ₁₀	Imazethapyr @75g a.i. ha^{-1} at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	22.10	8.35	10.50	14.50	18.00
	SE(m) \pm	0.37	0.62	0.68	0.96	1.23
	CD at 5%	1.1	1.80	2.00	2.89	3.60
	GM	22.32	42.10	53.03	59.63	63.46



All the weed control treatments brought about significantly reduction in weed dry matter over unweeded control treatments (T_1). At 20 DAS, two hoeing and two hand weeding at 20 DAS and 35 DAS significantly recorded lowest weed dry matter accumulation over other treatments. The treatment comprising fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS (T_3) showed significant reduction in dry weight of weeds over all other treatments except imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS (T_9) which were at par with each other.

At 40 DAS, the dry matter accumulation by the weeds was significantly reduced with two hoeing and two hand weeding at 20 and 35 DAS (T_2) as compared to all other treatments. However, application of imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS (T_9) were found at par with two hoeing and two hand weeding at 20 and 35 DAS (T_2). Similar trend was observed in respect of dry matter accumulation by weeds at 60 DAS and at harvest. Whereas at 80 DAS fenoxaprop-p-ethyl @ 100 g a.i. ha⁻¹ at 15 DAS+1 hoeing + 1 hand weeding at 35 DAS (T_8) was also at par with (T_2), (T_{10}) and (T_9) significantly highest dry matter accumulation by weeds was observed under unweeded control treatment (T_1) at all the periodical growth stages.

All the weed control treatments brought significant reduction in weed dry matter as compared to control treatment. The highest reduction of weed dry matter was found in two weedings and two hoeings treatment. (T_2) obviously this was due to higher reduction in weed population. The finding correlates with the findings of Vyas and Jain (2003) and Chandel and Saxena (2001).

Amongst the treatments combination of mechanical and post emergence herbicide treatment imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1

hoeing and 1 hand weeding at 35 DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_9) decrease weed biomass than other chemical treatments. Similar results were obtained by Panday *et al.* (2006), Billore *et al.* (2006), Singh *et al.* (2006), Tiwari *et al.* (2007) and Kamdi (2010).

4.3.4. Weed control efficiency:

Weed control efficiency as influenced by different weed control treatments is presented in Table 13 and graphically showed in Fig 7.

At all periodical observations, highest weed control efficiency was recorded with 2H + 2HW at 20 and 35 DAS (T_2) at 20 DAS (93 to 98 %) over allother treatments. The herbicidal treatments in combination with one hoeing and hand weeding at 35 DAS viz (T_{10}), (T_9) and (T_8) also recorded highest weed control efficiency as compared to herbicidal treatment when applied alone. The lowest weed control efficiency was observed with application of comprising fenoxaprop-p-ethyl @ 100 g a.i. ha^{-1} at 15 DAS (T_3) (65 to 75 %) at all periodical observations.

Highest weed control efficiency was recorded under treatment of two weedings and two hoeings (T_2) followed by herbicide treatment in combination with mechanical practice. This could be due to better control of weeds by hoeing plus weedings, application of imazethapyr, chlorimuron ethyl and fenoxaprop-p-ethyl herbicide and also suppression of weeds by crop due to its large canopy. These results were in agreement to that of Tiwari *et al.* (1996), Raghuwanshi *et al.* (1997), Reddy *et al.* (1998) and Vyas *et al.* (2003), Billore *et al.* (2006) and Kishor Kambdi (2010).

Table 13: Weed index (%) and weed control efficiency (%) as influenced by different weed control treatments

	Treatments	Weed Index %	Weed control efficiency				
			Day after sowing				
		After harvest	20	40	60	80	After harvest
T ₁	Control (unweeded)	42.78	-----	-----	-----	-----	-----
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	-----	-----	97.70	96.88	94.38	92.79
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	33.10	66.12	73.27	74.53	71.31	65.42
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	30.63	62.09	74.28	75.77	73.31	66.63
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	30.08	63.30	76.94	77.33	71.31	67.38
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	22.80	62.09	77.01	78.88	74.11	70.69
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	28.77	61.29	75.71	76.64	73.23	68.07
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	13.5	62.74	94.54	94.66	92.62	90.64
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	11.05	65.72	94.97	95.11	93.11	91.39
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	6.2	64.35	95.20	95.33	93.61	91.62
	GM	21.89	51.16	76.01	76.53	75.99	70.03

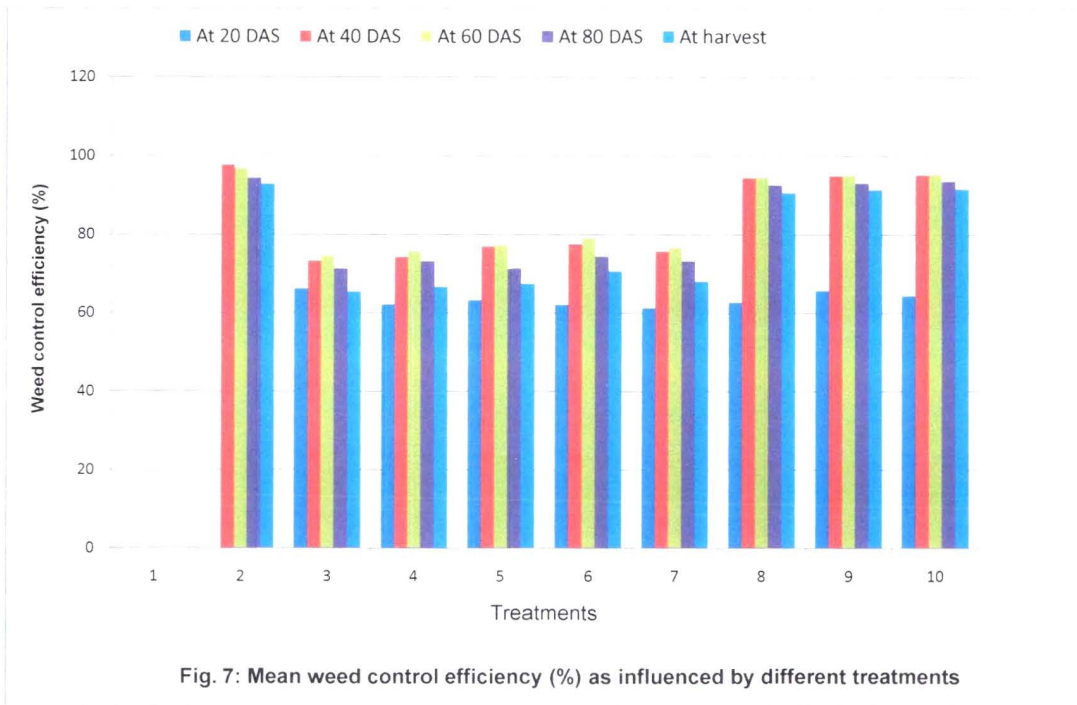


Fig. 7: Mean weed control efficiency (%) as influenced by different treatments

4.3.5 Weed index:

Data pertaining to weed index (%) is presented in Table 13. Weed index was computed as the yield reduction comparative to highest yielding treatment i. e. two hoeing and two hand weeding at 20 and 35 DAS (T_2). Among the weed management practices imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_{10}) showed minimum weed index (6.2%) as compared all the other treatments and was followed by chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_9) and fenoxaprop-p-ethyl @ a.i ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 354 DAS (T_8). Unweeded control treatment (T_1) recorded maximum weed index i. e. (42.78) indicating the reduction in soybean grain yield due to presence of weeds throughout crop growth period.

Lower weed index in herbicidal treatments in combination with mechanical weed control practices might be due to better weed control which provided favorable conditions for crop growth which ultimately increased the grain yield of soybean crop as compared to unweeded control treatment. Similar results were also reported by Chhokar *et al.* (1995), Chandel *et al.* (2001), Smita Mandhre (2005) Behera *et al.* (2005), Pandaya *et al.* (2006).

4.4 Crop studies:

4.4.1 Emergence count and plant stand of soybean:

The data pertaining to initial plant stand at 10 DAS and final plant stand at harvest as influenced by different weed management treatments is presented in Table 14.

Data revealed that the mean emergence count and final plant stand plot⁻¹ were not influenced significantly due to different weed control treatments, there by indicating uniform emergence and its persistence throughout the crop growth period. Herbicides did not cause any mortality or reduction in plant population. Similar results were reported by Raskar *et al.* (2002) and Thakur (2008).

Table 14. Mean initial plant stand and final plant stand as influenced by different weed control treatments

Treatments		Plant population	
		Initial plant stand	Final plant stand
T ₁	Control (unweeded)	489	482
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and 35 DAS	508	505
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	496	493
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	497	493
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	493	491
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	495	492
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	494	490
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	500	496
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	504	501
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	505	501
SE (m) ±		21.53	20.31
CD at 5%		NS	NS
GM		498.1	494.5

4.4.2 Plant height (cm):

The periodical data on mean plant height (cm) of soybean as influenced by different weed management treatments are presented in Table 15 and graphically illustrated in Fig 8.

Table 15: Mean plant height (cm) at periodical growth stages as influenced by different weed control treatment

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	16.40	32.93	33.65	35.40	35.90
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and 35 DAS	17.70	41.70	44.60	47.15	47.75
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	16.00	34.35	35.50	36.95	37.20
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	17.90	34.70	35.65	37.23	37.44
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	16.95	34.95	36.05	38.15	38.45
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	16.50	36.06	37.48	39.45	39.75
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	15.90	35.65	36.75	38.60	39.00
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	15.20	38.60	40.95	42.30	42.70
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	16.10	39.95	42.55	45.20	45.65
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	16.35	40.41	42.60	45.95	46.25
	SE(m)±	4.95	0.68	0.76	0.80	0.80
	CD at 5%	NS	2.04	2.26	2.38	2.10
	GM	16.50	36.92	38.57	40.63	41.10

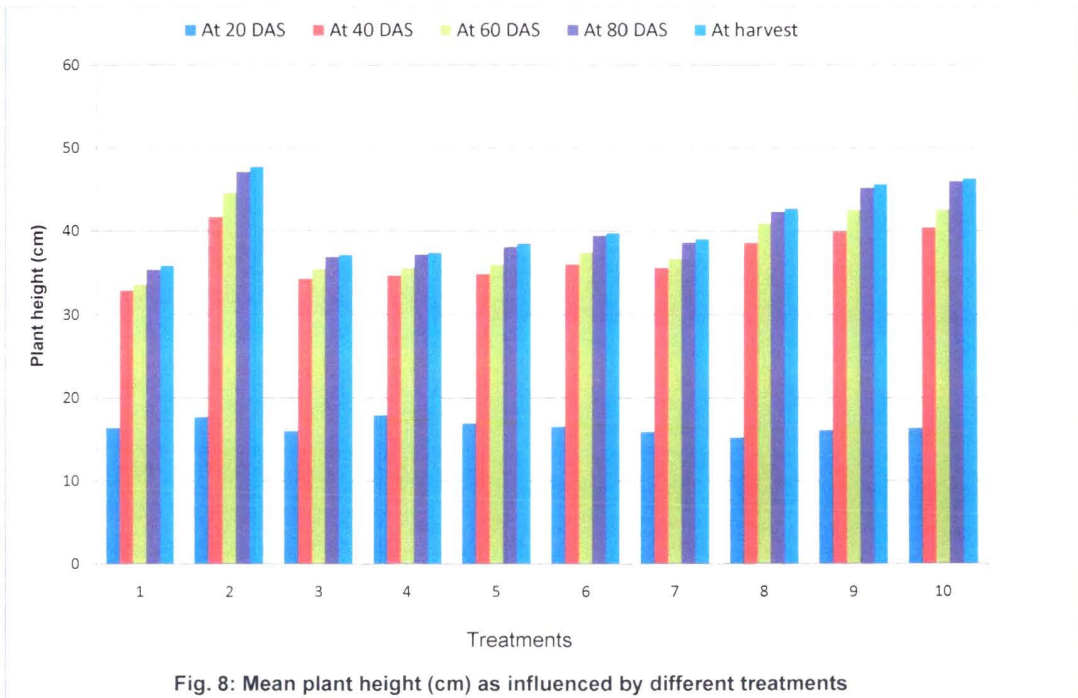


Fig. 8: Mean plant height (cm) as influenced by different treatments

Mean plant height was gradually increased with advancement in crop age up to harvest stage. The rate of increase in plant height was rapid during early vegetative growth and it was increased rapidly up to 60 DAS. Subsequently, the rate of increase in plant height slowed down toward harvest stage of the crop.

The plant height increased progressively up to harvest. The unweeded control treatment (T₁) recorded significantly lowest plant height at all growth stages of soybean crop.

The various weed control treatments significantly influenced the plant height at all growth stages except 20 DAS, where the treatment differences were not significant.

At 40 DAS, the treatment of 2H + 2HW at 20 and 35 DAS (T₂) recorded significantly higher plant height over all other treatments except imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T₉) which were at par with 2H + 2HW at 20 and 35 DAS (T₂) treatment. The control treatment (T₁) recorded minimum plant height. Similar trend was observed during 60, 80 DAS and at harvest.

The height of the soybean plant was an important parameter for higher yield of soybean. As more is the height more will be the internodes and at every internode there is induction of flower and pod formation (Maske *et al.*, 1998).

The increase in plant height of soybean under two hoeings and two hand weedings (T₂), imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T₉) might be due to least weed population observed in these treatment which reduced the crop weed competition for soil moisture, plant nutrients, solar radiation and space during active growth period. These results are in accordance with

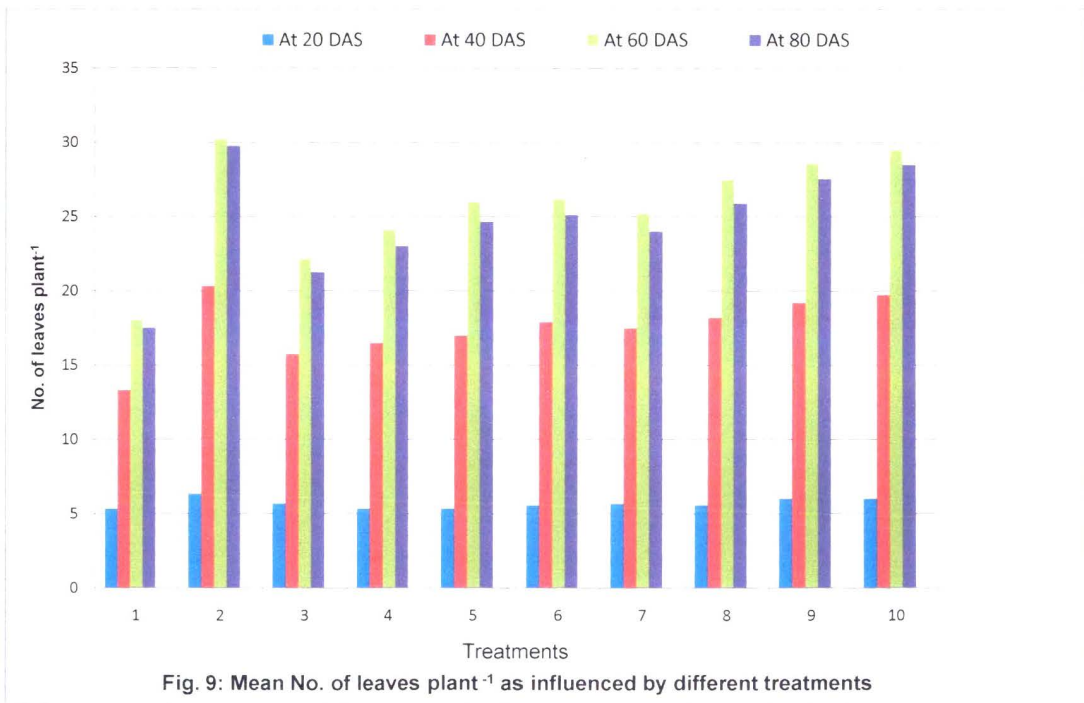
the results reported by Raskar (2002), Smita Mandhre (2005), Behera *et al.* (2005), Billore *et al.* (2006), Thakur (2008) and Dhane *et al.* (2010)

4.4.3 Number of leaves plant⁻¹:

The data pertaining to the number of leaves plant⁻¹ at periodical growth stages is presented in Table 16 and graphically illustrated in Fig 9.

Table 16 : Mean number of leaves plant⁻¹ as influenced by different weed control treatments

Treatment		Days after sowing			
		20	40	60	80
T ₁	Control (unweeded)	5.33	13.33	18.05	17.50
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	6.33	20.33	30.25	29.75
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	5.67	15.75	22.18	21.25
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	5.33	16.50	24.10	23.00
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	5.33	17.00	26.00	24.65
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	5.55	17.90	26.20	25.10
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	5.67	17.50	25.20	24.00
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	5.57	18.20	27.50	25.90
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	6.00	19.20	28.60	27.56
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	6.00	19.75	29.50	28.50
	SE(m)±	0.46	0.39	0.57	0.55
	CD at 5%	NS	1.33	1.65	1.60
	GM	5.67	17.54	25.75	24.66



Mean number of leaves plant⁻¹ was gradually increased with advancement in crop age up to harvest stage. The rate of increase in number of leaves plant⁻¹ was rapid during early vegetative growth and it maximum between 40 to 60 DAS. Subsequently, the rate of increase in number of leaves plant⁻¹ slowed down towards harvest stage.

The number of leaves plant⁻¹ increased progressively up to harvest. The unweeded control treatment (T₁) recorded significantly lowest number of leaves plant⁻¹ at all growth stages of soybean crop.

The higher number of leaves plant⁻¹ might be due to reduced weed population and increased plant height in these treatments resulting soil moisture and nutrient availability which helps in rapid cell development. Similar results were reported by Savita Chaudhari (1991), Sharma (2000), Manjusha Mohod (2002) and Smita Mandhre (2005) and Behera *et al.* (2005) and Kamdi (2010).

4.4.4 Leaf area index:

Data on leaf area index as influenced by various treatments at different stage of crop is presented in Table 17 and illustrated graphically in Fig 10.

The leaf area index increased progressively up to harvest. The control treatment (T₁) recorded significantly lowest leaf area index at all growth stages of soybean crop.

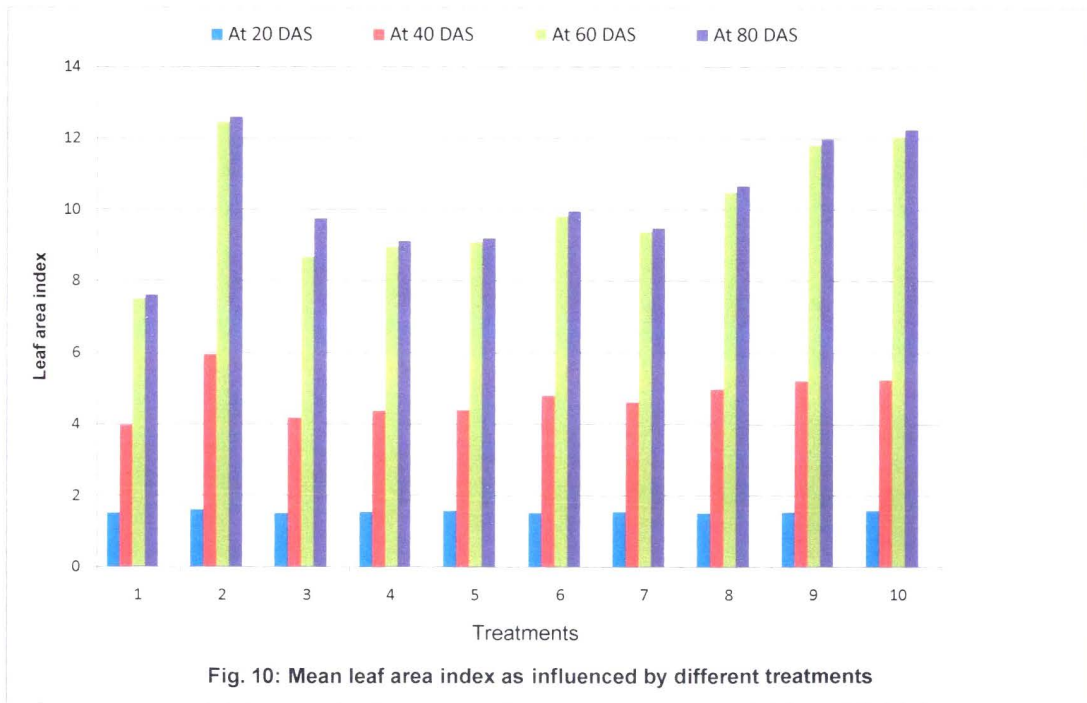
The various weed control treatments significantly influenced the leaf area index at all growth stages except 20 DAS, where the treatment differences were statistically not significant.

At all periodical observations, the treatment comprising of two hoeing and two hand weeding at 20 and 35 DAS (T₂) recorded significantly highest leaf area index over all other treatment which was comparable with treatments imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1

hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₉).

Table 17: Mean leaf area index as influenced by different weed control treatments

Treatment		Days after sowing			
		20	40	60	80
T ₁	Control (unweeded)	1.52	3.98	7.51	7.61
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	1.61	5.96	12.46	12.60
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	1.51	4.18	8.67	9.75
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1.55	4.38	8.96	9.11
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	1.58	4.40	9.09	9.20
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1.52	4.80	9.82	9.95
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	1.55	4.63	9.38	9.48
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	1.52	4.99	10.50	10.68
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	1.54	5.23	11.83	11.98
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	1.59	5.26	12.06	12.25
	SE(m)±	0.036	0.25	0.25	0.39
	CD at 5%	NS	0.76	0.74	1.18
	GM	1.54	4.7	10.02	10.16



Leaf area is the important indicator of total source available to the plant for the production of photosynthesis (Agrawal *et al.* 1996).

The higher leaf area index might be due to increased leaf area as a result of reduced weed population and increased plant height in these treatments resulting in availability soil moisture and nutrients which helps in rapid cell development. Similar results were reported by Savita Chaudhari (1991), Sharma (2000), Manjusha Mohod (2002), Smita Mandhre (2005), Behera *et al.* (2005) and Kambdi (2010).

4.4.5 Number of branches plant⁻¹:

The data pertaining to mean number of branches plant⁻¹ at all periodical interval is shown in Table 18 and graphically illustrated in Fig 11.

The various weed control treatments significantly influenced number of branches plant⁻¹ at all growth stages except 20 DAS, where the treatment differences were statistically not significant.

At 40 DAS, the treatment comprising of two hoeing and two hand weeding at 20 and 35 DAS (T₂) recorded significantly highest number of branches plant⁻¹ as compared to all other treatments. However imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₉). The control treatment was show lowest number of branches plant⁻¹.

At 60 DAS, 80 DAS and at harvest, similar findings were observed as that of 40 DAS. More number of branches plant⁻¹ might be due to less weed crop competition for moisture and nutrients.

These finding were in accordance with results reported by Tiwari *et al.* (1996), Smita Mandhre (2005) and Gayatri Devi Konda (2007).

Thakare *et al.* (1998) reported that more number of branches plant⁻¹ were observed under weed control treatments. Similarly Handizadeh and Rahimian (1998) also reported adverse morphological changes in soybean because of crop weed competition.

Table 18: Mean Number of branches per plant as influenced by different weed control treatments

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	1.55	2.50	3.50	3.90	3.90
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	1.50	3.70	4.65	5.75	5.75
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	1.50	2.50	3.60	4.12	4.12
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1.50	2.60	3.70	4.25	4.25
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	1.45	2.72	3.50	4.30	4.30
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1.50	2.95	3.80	4.40	4.40
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	1.50	2.75	3.65	4.30	4.30
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	1.55	3.20	4.25	5.30	5.30
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	1.50	3.40	4.50	5.44	5.44
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	1.50	3.50	4.55	5.55	5.55
	SE(m)±	1.50	0.11	0.10	0.11	0.11
	CD at 5%	NS	0.32	0.29	0.32	0.32
	GM	0.255	2.98	3.97	4.73	4.73

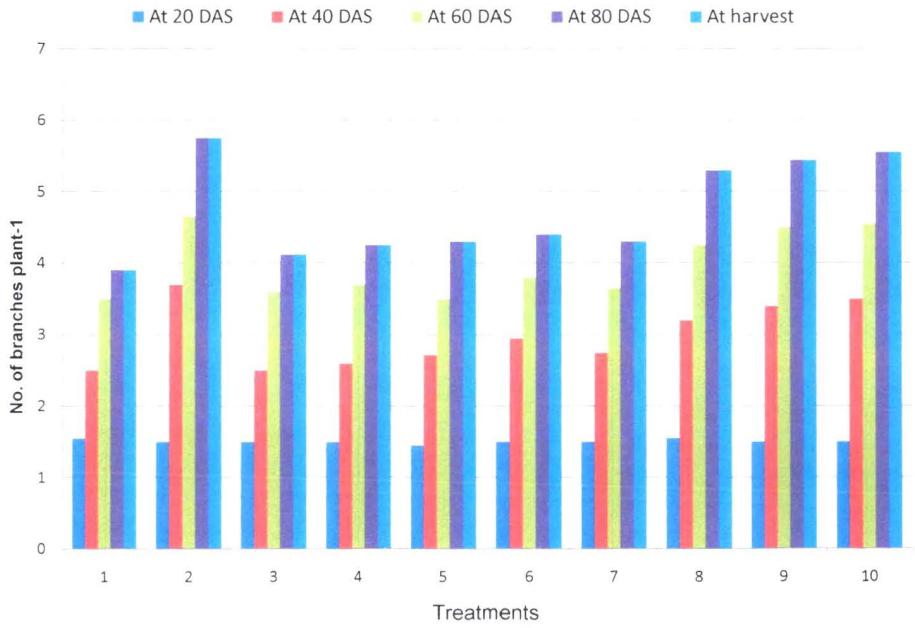


Fig. 11: Mean number of branches plant⁻¹ as influenced by different treatments

Dry matter accumulation plant⁻¹ :

The data pertaining to the total dry matter accumulation plant⁻¹ at periodical growth stages is presented in Table 19 and illustrated in Fig 12.

The data in Table 19 revealed that the total dry matter plant⁻¹ of soybean increased gradually at every stages of crop growth up to maturity. The rate of increase was at peak during 80 DAS to at harvest and maximum mean dry matter of 19.44 g plant⁻¹ was recorded at maturity.

The various weed control treatments significantly influenced the total dry matter accumulation plant⁻¹ at all growth stages except 20 DAS, where the treatment differences were statistically not significantly.

The treatment two hoeing and two hand weeding at 20 and 35 DAS (T₂) recorded significantly higher dry matter accumulation plant⁻¹ over all other treatments during 40, 60, 80 and at harvest imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₉) were found at par with (T₂) at all periodical observations except at 20 DAS. Control treatment (T₁) showed lowest dry matter plant⁻¹ at all the periodical growth stages.

The increased in dry matter accumulation might be due to less weed competition, there by facilitating luxurious crop growth resulting in to more dry matter production plant⁻¹ as compared to control treatment (T₁). Results are in conformity with the findings of Raghuwanshi (1997), Smita Mandhre (2005), Behera *et al.* (2005), Thakur (2008) and Dhane *et al.* (2009).

Table 19: Mean plant dry matter accumulation (g) as influenced by different weed control treatments

Treatments		Days after Sowing				
		20	40	60	80	At harvest
T ₁	Control (unweeded)	2.58	5.32	8.06	11.74	16.66
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	2.69	8.15	12.50	17.52	23.02
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	2.55	6.62	8.79	11.98	17.52
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.65	6.65	9.00	12.32	17.97
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	2.67	6.73	9.02	12.42	18.16
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	2.66	6.84	9.10	12.48	18.28
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	2.49	6.71	9.05	12.38	18.20
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	2.53	7.27	10.98	15.93	20.50
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	2.53	7.50	11.51	16.47	21.90
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	2.68	7.71	11.70	16.68	22.08
	SE(m)±	0.79	0.24	0.39	0.37	0.44
	CD at 5%	NS	0.73	1.17	1.09	1.31
	GM	2.603	6.95	9.97	13.98	19.44

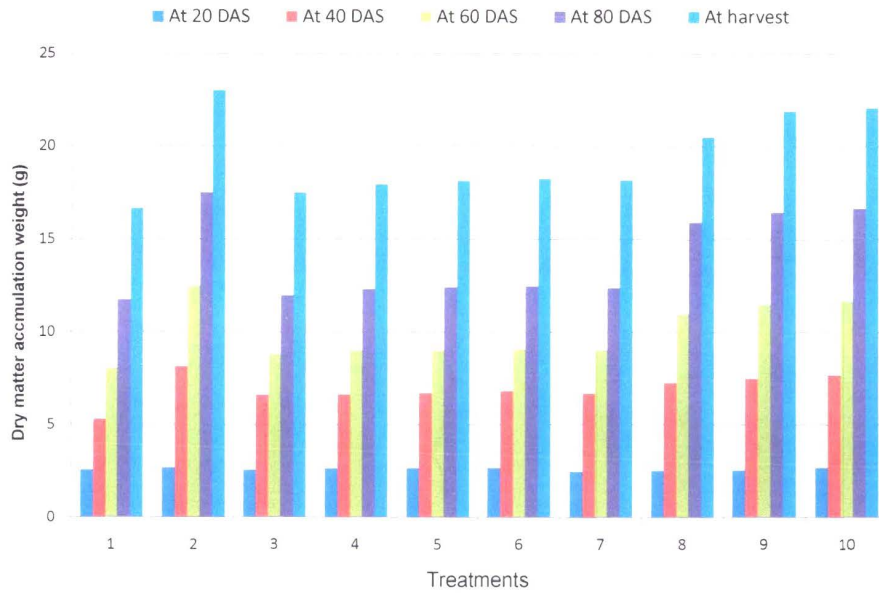


Fig. 12: Mean dry matter accumulation weight plant (g) as influenced by different treatments

4.5 Post harvest studies:

4.5.1 Yield contributing characters :

The data in respect of yield contributing characters viz. number of pods plant⁻¹, weight of grains plant⁻¹ and test weight as influenced by various weed control treatments is presented in Table 20 .

4.5.1.1 Number of pods plant⁻¹ :

Data in Table 20 revealed that, the weed control treatments had significant influence on number of pods plant⁻¹. The mean number of pods plant⁻¹ was 37.34.

Treatment of two hoeing and two hand weeding at 20 and 35 DAS (T₂) recorded significantly more number of pods plant⁻¹ (45.19) as compared to all other treatments except and imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T₉). These treatments were at par with the treatment of two hoeing and two hand weeding at 20 and 35 DAS (T₂). Control treatment (T₁) recorded least number of pods plant⁻¹.

Smita Mandhre (2005) recorded maximum pods plant⁻¹ in treatment of two hoeings and two hand weedings and minimum number of pods plant⁻¹ in control treatment. Similar result was obtained by Kishor Kamdi (2010).

It might be due to reduction in dry matter production by weeds under herbicidal and cultural treatments that subsequently increased nutrient and moisture availability to the soybean crop as compared to rest of the treatments. Similar results were also reported by Halwankar *et al.* (1986), Lambade (2000) and Smita Mandhre (2005), Behera *et al.* (2005) and Dhane *et al.* (2009).

Table 20: Mean number of pod plant⁻¹, Grain weight plant⁻¹ and test weight (g) as influenced by different weed control treatments

Treatments		Number of pod plant ⁻¹	Grain wt. plant ⁻¹ (g)	100 grain weight (g)
T ₁	Control (unweeded)	27.50	4.55	7.83
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS	45.19	7.16	10.80
T ₃	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	31.21	4.96	9.65
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	35.87	5.28	9.90
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	36.21	5.41	9.75
T ₆	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	38.87	5.68	9.95
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS	36.53	5.51	9.70
T ₈	Fenoxaprop-P-ethyl @100 a.i .ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	39.23	5.95	10.02
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	40.68	6.12	10.27
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	42.21	6.48	10.43
SE (m) ±		1.65	0.40	0.52
CD at 5%		4.51	1.05	NS
GM		37.34	5.709	9.799

4.5.1.2 Grain weight plant⁻¹:

Data on grain weight plant⁻¹ presented in Table 20 indicated that treatment of two hoeing and two hand weeding at 20 and 35 DAS (T₂) produced significantly higher grain yield plant⁻¹ (7.16 g) as compared to all other treatments. However, imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1

hoeing and 1 hand weeding at 35 DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_9) were at par with treatment of two hoeings and two hand weedings at 20 and 35 DAS (T_2). Similar result was also obtained by Chandel *et al.* (2001).

This could be due to reduction in dry matter production by weeds under herbicidal and cultural treatments that subsequently increased nutrient and soil moisture availability to the soybean crop as compared to rest of the treatments that increased grain weight $plant^{-1}$. Similar results were obtained by Halwankar *et al.* (1986), Sharma and Raghuwanshi (1999) Lambade (2000), Behera *et al.* (2005), Thakur (2008) and Dhane *et al.* (2009).

4.5.1.3 Test weight:

Data on 100 grain weight presented table in 20 indicated that different weed control treatments did not have any significant influence on the 100 grain weight of soybean. However, numerically highest 100 grain weight was observed under the treatment of two hoeing and two hand weeding at 20 and 35 DAS (T_2), followed by imazethapyr @75g a.i. ha^{-1} at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_{10}). Unweeded control treatment (T_1) recorded lowest 100 grain weight of soybean. The similar result was found by Behera *et al.* (2005), Dhane *et al.* (2009) and Kamdi (2010).

4.5.2 Yield studies :

The data pertaining to seed yield and straw yield are presented in Table 21 and graphically illustrated in Fig.

4.5.2.1 Seed yield:

Data related to seed yield of soybean significantly influenced by various weed control treatments. The mean seed yield of soybean was 1127 kg ha^{-1} . The treatment of two hoeing and two hand weeding at 20 and 35 DAS (T_2) produced significantly maximum soybean seed yield

(1456 kg ha⁻¹) as compared to all other treatments. However the treatments of imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing and one hand weeding at 35 DAS (T₉) had recorded statistically

Table 21: Mean grain yield (kg ha⁻¹) and straw yield (kg ha⁻¹) as influenced by different weed control treatments

Treatments		Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
T ₁	Control (unweeded)	833	1541	35.08
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and 35 DAS	1456	2737	34.72
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	974	1650	37.11
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1010	1878	34.97
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	1018	1894	34.95
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	1124	2100	34.80
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	1037	1940	34.83
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	1258	2365	34.72
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS	1295	2435	34.71
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS	1365	2580	34.33
SE (m) ±		66	67	
CD at 5%		195	198	
GM		1127	2243	

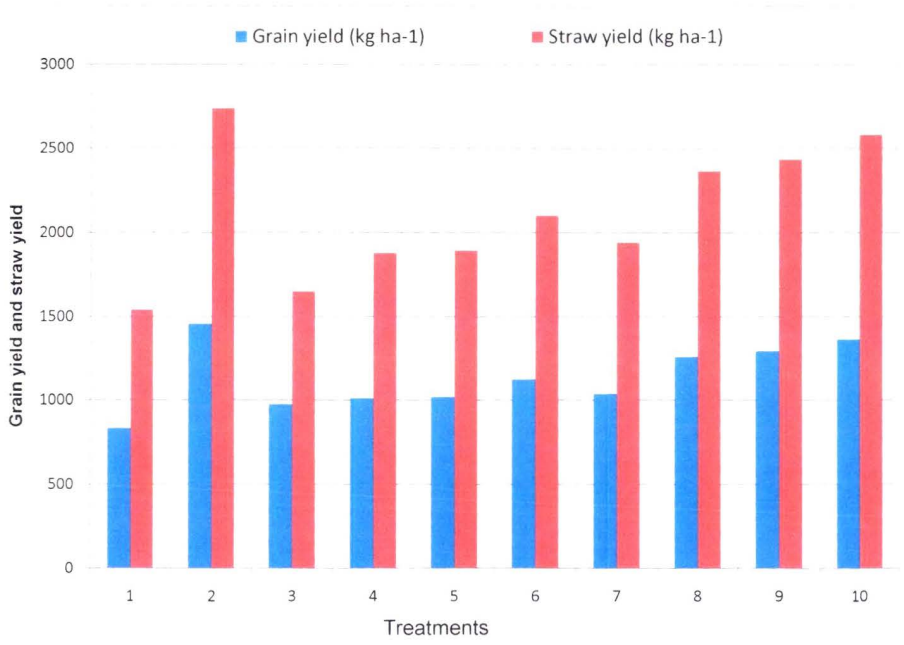


Fig. 13: Mean grain yield and straw yield as influenced by different treatments

similar yield as that of two hoeing and two hand weeding at 20 and 35 DAS (T_2). The control treatment (T_1) recorded lowest soybean seed yield (833 kg ha^{-1}).

The herbicide in combination with mechanical weed control resulted in producing significantly higher seed yield than the control treatment. Mechanical as well as chemical treatment in combination with mechanical practices were effective in reducing weed population, weed dry matter production and increasing seed yield of soybean. Beneficial effect of post emergence application of Imazethapyr and chlorimuron ethyl in combination with mechanical method in increasing soybean yield that might be due to suppression of monocot and dicot weeds that helped in reducing soil moisture and nutrient losses that made available to the soybean crop. The result is in accordance to findings of Tiwari *et al.* (1996), Sharma (2000), Raskar *et al.* (2002), Billore *et al.* (2006), Thakur (2008) and Dhane *et al.* (2009).

4.5.2.2 Straw yield:

Data pertaining to straw yield of soybean as influenced by different weed control treatments is presented in Table 21 and graphically shown in fig. 13. The similar trend in respect of straw yield was noticed as that of seed yield.

Treatment of two hoeing and two hand weeding at 20 and 35 DAS (T_2) (2737 kg ha^{-1}) recorded significantly higher straw yield over all other treatments except treatment imazethapyr @75g a.i. ha^{-1} at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS (T_9). However these treatments were at par with two hoeing and two hand weeding (T_2). Least soybean straw yield (1541 kg ha^{-1}) was recorded in unweeded control treatment (T_1).

Increase in straw yield of soybean might be due to luxurious crop growth and less crop weed competition in the cultural and herbicidal treatments. Similar results were also reported by Angiras *et al.* (1995), Sharma (2000),

Ravi *et al.* (2001), Smita Mandhre (2005), Billore *et al.* (2006), Thakur (2008) and Dhane *et al.* (2009).

4.6 Economic studies :

Considering the prevailing cost of labour and inputs required for weed control treatments, economics was worked out for various treatments and data is presented in Table 22.

Weed management with two hoeing and two hand weeding at 20 and 35 DAS (T_2) recorded significantly more GMR (Rs. 37841 ha^{-1}) and NMR (Rs. 21175 ha^{-1}) over rest of the treatments, except treatments of imazethapyr @ 75 g ha^{-1} at 15 DAS + 1H and 1HW at 35DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS +1 hoeing and 1 hand weeding at 35 DAS (T_9). However, in respect of all these treatments were at par with two hoeing and two hand weeding treatments at 20 and 35 DAS (T_2).

Effective weed management with better seed yield resulted in higher returns in these treatments. Padmavati *et al.* (1995) reported highest soybean yield and net returns due to hand weedings twice at 20 and 40 DAS. Maximum Benefit : Cost ratio (B:C) was obtained with the treatment consisting of 2H + 2HW at 20 and 35 DAS (2.27) followed by imazethapyr @ 75 g ha^{-1} at 15 DAS + 1H & 1HW at 35DAS (T_{10}) and chlorimuron ethyl @10g a.i. ha^{-1} at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS (T_9). However, the unweeded control treatment recorded lowest B:C ratio (1.56) as a result of higher crop weed competition which reduced the soybean yield significantly. Similar results were obtained by Singh and Sharma (1991), Tiwari *et al.* (1993), Padmavati *et al.* (1995), Smita Mandhre (2005), Behera *et al.* (2005) and Dhane *et al.* (2009)

Table 22: Economics of different weed control treatments.

Treatments		Gross monetary return (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net monetary return (Rs. ha ⁻¹)	B:C Ratio
T ₁	Control (unweeded)	20315	12986	7329	1.56
T ₂	2 Hoeing + 2 hand weeding at 20 DAS and 35 DAS	37841	16666	21175	2.27
T ₃	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	24126	14262	9864	1.69
T ₄	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	25144	13519	11625	1.85
T ₅	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS	25344	14167	11177	1.78
T ₆	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ + Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS	27989	14795	13194	1.89
T ₇	Imazethapyr @75g a.i. ha ⁻¹ + Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS	25825	15443	10382	1.67
T ₈	Fenoxaprop-P-ethyl @100 a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	31337	15882	15515	1.97
T ₉	Chlorimuron ethyl @10g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	32259	15119	17140	2.13
T ₁₀	Imazethapyr @75g a.i. ha ⁻¹ at 15 DAS + 1 hoeing + 1 hand weeding at 35 DAS	34013	15767	18246	2.15
SE (m) ±		1863		1863	
CD at 5%		5582		5582	
GM		28419.3		13564	

Chapter-V

SUMMARY AND CONCLUSION

The present investigation "Integrated weed management in soybean" was carried out at Agronomy Farm, College of Agriculture, Nagpur during 2010 in *kharif* season.

In the present investigation chemical weed management practices includes herbicides like fenoxaprop-p-ethyl, chlorimuron ethyl and imazethapyr with following concentrations and time of application i. e. fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS (T₃), chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS(T₄), imazethapyr @75g a.i. ha⁻¹ at 15 DAS(T₅), fenoxaprop-P-ethyl @100 a.i .ha⁻¹ + chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS (T₆), and imazethapyr @75g a.i. ha⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS(T₇) and combination of chemical and mechanical weed management practices i. e. fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS(T₈), chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS(T₉) and imazethapyr @75g a.i. ha⁻¹ at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS(T₁₀) respectively. One treatment of 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂) and Control (unweeded) (T₁) was also incorporated.

The important research findings are summarized here:

1. Weed flora observed in experimental field mainly comprised of *Parthenium hysterophorus*, *Euphorbia hirta*, *Digera arvensis*, *Lagasca mollis* among dicot weeds *Cynodon dactylon*, *Echinochloa crusgalli*, *Ergotis major*, *Poa annua*, *Sorghum halepense* among the grasses and sedges *Cyperus rotundus*. Other weed present in less number.
2. 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1

hoeing + 1 hand weeding at 35 DAS(T₉) recorded the lowest monocot, dicot, total weed count, total dry matter and highest weed control efficiency.

3. Weed index was highest in control treatment and followed by fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS (T₃), chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS(T₄), imazethapyr @75g a.i. ha⁻¹ at 15 DAS(T₅), imazethapyr @75g a.i. ha⁻¹ + Fenoxaprop-P-ethyl @100 a.i .ha⁻¹ at 15 DAS(T₇) and fenoxaprop-P-ethyl @100 a.i .ha⁻¹ + chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS (T₆). This indicated that above treatments were not effective in controlling weeds.
4. The growth characters namely plant height, number of leaves plant⁻¹, leaf area index, number of branches plant⁻¹ and dry matter plant⁻¹ as well as yield contributing characters viz. number of pod plant⁻¹, grain weight plant⁻¹ were significantly higher in 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) followed by imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS(T₉) were at par with treatment 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂). All the growth characters and yield contributing characters were recorded lowest in unweeded control treatment.
5. Two Hoeing + two hand weeding at 20 DAS and at 35 DAS(T₂) produced significantly more grain yield and straw yield of 1456 kg ha⁻¹ and 2737 kg ha⁻¹ followed by imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS(T₉) respectively. These treatment were at par with 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂). Lowest grain yield and straw yield was recorded in control treatment.

6. Weed management with 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂) recorded maximum GMR (37841 ha⁻¹) and NMR (21175 ha⁻¹) followed by the imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS (T₉). These treatments were at par with 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂).
7. Maximum Benefit:cost ratio was observed with the 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) (2.27) followed by imazethapyr. @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) (2.15)and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS(T₉) (2.13).

Conclusion:

1. Weed management through 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) provided most effective control of weed throughout the crop growth period of soybean thereby improving growth and yield contributing characters and consequently recorded highest seed yield GMR and NMR ha⁻¹.
2. Weed control through viz. herbicidal treatment with combination with mechanical weed control, imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS (T₁₀) and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS (T₉) proved comparable to 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS (T₂) in respect of seed yield, GMR and NMR.
3. In terms of benefit:cost ratio, 2 Hoeing + 2 hand weeding at 20 DAS and at 35 DAS(T₂) proved superior with maximum B:C ratio (2.27). It was followed by imazethapyr @75g a.i. ha⁻¹ at 15 DAS +1 hoeing +1 hand weeding at 35 DAS(T₁₀) (2.15)and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS +1 hoeing + 1 hand weeding at 35 DAS (T₉) (2.13).

Hence, in situation where timely weeding is not feasible due to paucity and high cost of laborers as well as unfavorable weather and soil condition, integrated weed management through post emergence application of imazethapyr @ 75 g a.i. ha⁻¹ at 15 DAS in combination with 1 hoeing and 1 hand weeding at 35 DAS and chlorimuron ethyl @10g a.i. ha⁻¹ at 15 DAS+1 hoeing and 1 hand weeding at 35 DAS may be preferred to farmers practices for better weed management in soybean.

Chapter-VI

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Sr. No.	Name of Degrees awarded	Year in which obtained	Division /Class	Name of awarding University	Subjects
1	S.S.C.	2002	First	Nagpur Board	General
2	Diploma (Agri.)	2004	First	Dr. P.D.K.V. , Akola	Agriculture
3	B.Sc.(Agri)	2008	First	Dr. P.D.K.V. , Akola	Agriculture

6. Field of interest (which you desire to work): Agriculture and Business

Place: Nagpur

Date: 24/05/2011

A.M. Wadafale
Signature of student

APPENDIX – I

Sr. No	Particulars	Freq.	M	F	B.P.	Total
1	Ploughing			-	-	750
2	Harrowing	2	4	-	4	1280
3	Clod crushing	1	1	-	1	320
4	Stubble picking	1	-	5	-	600
5	Cost of fertilizer application	1	-	2	-	240
6	Cost of seed and sowing	-	-	-	-	3000
	a) Cost of seed (75 kg ha ⁻¹)					
	b) Sowing and covering	1	2	3	2	1000
7	Seed treatment	-	-	-	-	-
	a) (Rhizobium) @25 g kg ⁻¹	-	-	-	-	80
	b) Thiram @4 g kg ⁻¹	-	-	-	-	150
	c) Trichoderma@5g kg ⁻¹	-	-	-	-	40
8	Cost of fertilizer (30: 75:00 NPK kg ha ⁻¹).	-	-	-	-	2296
9	Thinning and Gap filling	1	-	2	-	240
10	Plant protection	1	-	-	-	-
	a) Cost spraying	-	1	1	-	240
	b) Cost endosulphan.	-	-	-	-	250
12	Harvesting	1		12	-	1440
13	Threshing machine	-	2	-	-	740
14	Transport and marketing	-	-	-	-	200
15	Land Revenue	-	-	-	-	120
Total cost of cultivation						12986

Working rate:

1. Bullock pair cost : Rs. 200 day⁻¹
2. Labour cost : Rs. 120 day⁻¹
3. Nitrogen 30 kg : Rs. 10.91 kg⁻¹
4. Phosphorous 75 kg : Rs. 23.37 kg⁻¹
5. Endosulphan : Rs. 250 lit⁻¹
6. Rhizobium : 40 kg⁻¹
7. Trichoderma : Rs. 100 kg⁻¹
8. Thiram : Rs. 480 kg⁻¹
9. Threshing Machine : Rs. 500

APPENDIX – II

Treatments wise cost of cultivation (Rs.ha⁻¹) of soybean as influenced by various treatments.

Treatment	Common cost of cultivation (Rs. ha ⁻¹)	Treatment expenditure (Rs. ha ⁻¹)	Total cost of cultivation (Rs. ha ⁻¹)
T ₁	12986	-	12986
T ₂	12986	3680	16666
T ₃	12986	1276	14262
T ₄	12986	533	13519
T ₅	12986	1181	14167
T ₆	12986	1809	14795
T ₇	12986	2457	15443
T ₈	12986	2876	15882
T ₉	12986	2133	15119
T ₁₀	12986	2781	15767

Working rate :

First hoeing to T₂ : Rs. 880 ha-1

Second hoeing to T₂, T₈, T₉ and T₁₀ : 880 ha-1

First hand weeding to T₂ Rs. 1200 ha-1

Second hand weeding to T₂, T₈, T₉ and T₁₀ : 720 ha-1

Cost of spraying : 240 ha-1

Cost of Herbicides :

Fenoxaprop-p-ethyl @ 100 g a.i. ha-1: Rs. 1276 ha-1

Imazethapyr @ 75 g a.i. ha-1 : Rs.1181 ha-1

Chlorimuron ethyl @ 10 g a.i ha-1 : Rs. 533 ha-1

Cost of yield :

Soybean grain : Rs. 2350 q-1

Soybean Straw : Rs. 75 q-1

