EFFECT OF WEATHER AND INTEGRATED WEED MANAGEMENT ON PRODUCTION OF *KHARIF* SOYBEAN *(Glycine max* (L.) Merril)

By

PRANAV SINHA
B.Sc. (Ag.)

THESIS SUBMITTED TO THE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF AGRICULTURE SCIENCE
(DEPARTMENT OF AGRONOMY)

DEPARTMENT OF AGRONOMY
College of Agriculture, Rajendranagar
Acharya N.G. Ranga Agricultural University
Rajendranagar, Hyderabad – 500 030.

July, 2002

CERTIFICATE

Mr. PRANAV SINHA, has satisfactorily prosecuted the course of research and that the thesis entitled, "**EFFECT OF WEATHER AND INTEGRATED WEED MANAGEMENT ON PRODUCTION OF *KHARIF* SOYBEAN *(Glycine max* (L.) Merril)**" submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination, I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

Date : 12/7/12

Place : Hyderabad

(Dr. A. LATCHANNA)

Major Advisor

CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF WEATHER AND INTEGRATED WEED MANAGEMENT ON PRODUCTION OF *KHARIF* SOYBEAN *(Glycine max* (L.) Merril)**" submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N.G. Ranga Agricultural University, Hyderabad is record of the bonafide research work carried out by **Mr. PRANAV SINHA** under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee.

No part of the thesis has been submitted for any degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

(DR. A. LATCHANNA)
Chairman of the Advisory Committee.

Thesis approved by the student's Advisory Committee.

Chairman	: **Dr. A. LATCHANNA** Professor & Head AICRP on Weed Control Scheme ANGR Agricultural University Rajendranagar, Hyderabad.	
Member	: **Dr. V RADHAKRISHNA MURTHY** Associate Professor Department of Agronomy College of Agriculture Rajendranagar, Hyderabad.	V. Radhakrishna Murthy 12/7/02
Member	: **Dr. L M RAO** Professor and Head Department of Plant Physiology College of Agriculture Rajendranagar, Hyderabad.	12/7/0
Member	: **Sri. P R PAWAN KUMAR** Assistant Professor Dept. of Soil Science & Agril. Chemistry College of Agriculture Rajendranagar, Hyderabad.	P.R. Pawan Kumar 12/7/2002

LIST OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

*At the out set, I owe my obeisance to the **Almighty God** for showering his grace and blessings on me for successful completion of my research work.*

*I deem it a great pleasure and proud privilege to have worked under the esteemed guidance of my major advisor **Dr A. Latchanna**, Professor and Head, AICRP on weed control scheme. Who has been my mentor during my academic tenure in this university. Diction is not enough to express my love and affection and sincere admiration of his positive attitude, indefatigable spirit and finesse. It is only for him constant support, encouragement, wise counsel, meticulous guidance, critical supervision and patient hearing that my work has seen the light of the day.*

*I wish to express my sincere thanks and deep sense of gratitude to the members of my Advisory Committee **Dr. V Radhakrishna Murthy**, Associate Professor, Department of Agronomy, College of Agriculture, Rajendranagar, **Dr. L M Rao**, Professor & Head, Department of Plant Physiology, College of Agriculture, Rajendranagar and **Sri. P R Pawan Kumar**, Assistant Professor, Department of Soil Science and Ag. Chemistry, College of Agriculture, Rajendranagar whose critical evaluation of my work was a constant morale boster.*

*I am profoundly indebted to **Dr. B Buchha Reddy**, Professor and Head, Department of Agronomy, College of Agriculture, Rajendranagar for providing me a milieu in the form of necessary facilities conducive enough to my research work completion.*

*I express my whole hearted gratitude to **Dr. Shaik Mohammed,** Professor, Department of Agronomy, College of Agriculture, Rajendranagar for his valuable help, suggestions and cooperation during the pursuit of my research work.*

I deem it necessary to express my thanks to the ***teaching staff (Dr. V.B.B. Murthy, Dr. Praveen Rao, Dr. S. C. Masthan, Dr. Vijay Kumar, Dr. M. Yakadri, Dr. M. Swamy and all Non-teaching staff of the Department*** *for their co-operation and helpful suggestions during the entire period of my investigation.*

"Friends are those who extend a hand when you are sinking into deep quicksand"words are not enough to express my love and affection for my friends who brought me out of the low ebbs of the research period. I thank my senior's, junior's and classmates ***Sahu, Nagabhushnam, Uppu, Kiran, Subbu, Thomas, Guru, Ashok, Saidulu, Mahadev, Balaji, Ramesh, Malli, Narsi, Lavanya, Silpa and Nandi,*** *for their affection and co-operation that made my study period a comfortable one.*

I would be failing in my duties if I don't acknowledge the everlasting Love, unparalleled affection, constant encouragement and moral support given to me by my ever -loving parents ***Shri. A. P. Sinha*** *and* ***Smt. Sadhana Sinha,*** *Sister* ***Pranoti*** *throughout my life.*

I deem it necessary to extend my heartful of thanks to "those behind the curtain" whose unfailing belief in me has shown me this day.

I wish to extend my thanks to one and all who have contributed even in a small way in the completion in my research work.

I record my sincere thanks to ***Indian Council of Agricultural Research*** *for nominating me as a candidate in this university.*

My thanks to all of them ***de profundis.***

(PRANAV SINHA)

DECLARATION

I, **PRANAV SINHA**, hereby declare that the thesis entitled "**EFFECT OF WEATHER AND INTEGRATED WEED MANAGEMENT ON PRODUCTION OF *KHARIF* SOYBEAN *(Glycine max* (L.) Merril)**" submitted to Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF AGRICULTURE SCIENCE,** is a result of the original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

Pranav Sinha

Date : 12/7/02

(PRANAV SINHA)

Place : HYDERABAD

Author	:	**PRANAV SINHA**
Title of the thesis	:	**Effect of weather and integrated weed management on production of *kharif* soybean (*Glycine max (L.) Merril*)**
Degree	:	**Master of Science in Agriculture**
Faculty	:	**Agriculture**
Discipline	:	**Agronomy**
Major Advisor	:	**Dr. A Latchanna**
University	:	**Acharya N.G. Ranga Agricultural University**
Year of submission	:	**2002**

ABSTRACT

A field experiment entitled "Effect of weather and integrated weed management on production of *kharif* soybean *(Glycine max (L.) Merril)*was conducted on clay loam soil at Agricultural College Farm during kharif 2001.

Soybean variety JS 335 was tested for it relative performance under different dates of sowing and weed management treatment. The layout was a randomized block design their were factorial combination of six herbicides treatment and 3 dates of sowing. The weed management treatment were hand weeding twice 20 and 40 DAS, preplant incorporation of fluchloralin at 1.5 kg ha^{-1}, preemergence application of pendimethalin at 1.5 kg ha^{-1} integration of these chemicals each at 0.75 kg ha^{-1} with hand weeding at 30 DAS and an unweeded check ,sowing dates were 9th July 23rd July and 6th August their were 3 replications. The results indicated that the predominant weed species among grasses are *Cynodon dactylon* (L.), *Dactyloctinum aegyptinum* (L.) while broad leaved weeds were *Parthenium hysterophorus* (L.), *Trianthema portulacastrum* (L.) and *Commelina benghalensis* (L.) and (sedge) *Cyperus rotundus* (L.) was observed in the experimental site. Among all *Cyperus rotundus* (L.) was the most dominant and problematic weed observed in the experiment.

The crop responded to the herbicide application and attained maximum plant height initially at 20 DAS. This trend was maintained until harvest. There treatment delayed the days to 50% flowering and 50% pod set significantly compared to unweeded control. The number of pods $plant^{-1}$ and number of seeds pod^{-1} were significantly more in hand weeding twice at 20 and 40 DAS or integrated weed management by the preplant incorporation of

fluchloralin at 0.75 kg ha^{-1} followed by hand weeding 30 DAS were the best treatments to maximise the yield components. The 100 seed weight was not influence by any weed management treatment.

The crop produced maximum seed yield at 966.7 kg ha^{-1} in response to hand weeding twice at 20 and 40 DAS. This was on par with the seed yield at 914.5 kg ha^{-1} obtained by the integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding once at 30 DAS.

The date of sowing had a significant impact on crop growth, yield components and yields. Soybean sown early on 9th July grow significantly tall in height through out the growth stages. It took significantly longer time for 50% flowering and pod set, produced more number of pod $plant^{-1}$ and seeds pod^{-1}. Consequently it produced maximum seed yield of 912.2 kg ha^{-1}. This was significantly more than the yield of 845 and 781.6 kg ha^{-1} obtained by sowing the crop latter on 23rd July and 6th August respectively.

The weather plays an important role in influencing the crop growth, yield component and yields. Maximum and minimum temperature or sunshine hours were not the important variables. The rainfall distribution pattern was the main weather variable that favoured the early sown crop on 9th July to perform better with high production.

The number of grasses and broad leaved weed were significantly reduced at 20 DAS by preplant incorporation of fluchloralin or preemergence application of pendimethalin at concentration of 1.5 kg ha^{-1} or 0.75 kg ha^{-1}. Hand weeding twice at 20 and 40 DAS minimised the weed flora in the later stages of crop growth. The grasses and broad leaved weeds were remarkably reduced by the herbicides while the sedges which were more predominant in this investigation were left unaffected. The dry matter of weeds also followed a similar trend. Maximum weed control efficiency of 57.7% was recorded at harvest by hand weeding twice at 20 and 40 DAS. The integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS was also vary effective to the extent of 52.8% weed control efficiency.

The study indicated that the sowing date of soybean on 1st fortnight of July was the ideal strategy to realise high production. Weed management is best attained by cultural method of hand weeding twice at 20 and 40 DAS or by the integrated approach of preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS.

INTRODUCTION

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L. Merril) is a highly nutritive and energy rich legume with biologically effective proteins (43%) and edible oil (20%), besides this it is also rich in vitamins, minerals, salts and essential amino acids. It serves as a pulse as well as oil seed crop. It gives 2-3 times more protein yield than other pulses or oil seed crop (Nawab Ali, 1992). Being a legume crop it fixes atmosphere nitrogen and add about 65-100 kg N ha^{-1} $year^{-1}$ which helps to increase the yields of following non-legume crops (Fujitha *et al.*, 1992). Therefore, it is called as the miracle crop of twentieth century due to its highest compound annual growth rate of production. During last decade, soybean out ranked the rapeseed and mustard and occupied the second position among oil seeds in India after groundnut (Hedge, 2000) though it is in first rank in the world in this regard.

Further, soybean has been recognised as a valuable food material even in pre-independent India. Eminent personality like Mahatma Gandhi and Maharaja Gaikwad showed their keen interest in third and fourth decades of present century in popularising its cultivation and domestic uses among the masses in India.

Substantial out put of edible oil seed was attained during early nineties due to 'yellow revolution'. The country is still in short of selfsufficient in oil scenario owing to exploding population. To meet the demand of oil seeds there is an urgent need to step up production on sustainable basis. Soybean can bridge the increasing gap between the demand and supply and can improve the per capita consumption of edible oil (11.5 kg in India as against 35 – 40 kg in developed countries) in the country. Such compulsion emphasized the need for its expansion in non traditional states like Andhra Pradesh.

Soybean is traditionally a *kharif* season crop prone to heavy weed infestation resulting in lower yields. Though soybean is a potential yielder, its productivity has been low due to several factors. The first and foremost among them is the menace caused by uncontrolled weed growth in the slow growing crop due to heavy and most competitive weed flora associated in *kharif* irrespective of crop and practices adopted (Kondap *et al.*, 1990). Weed cause substantial loss of about 59-87 per cent of total soybean yield (Mishra *et al.*, 1990). Weed emerges simultaneously with crop plants and compete severely for natural resources particularly for nutrients and soil moisture resulting in poor yield. The competition from weed is severe especially during early stages of crop growth due to the critical period of crop weed competition in soybean. The initial 20-40 DAS is found to be the most critical stage in soybean (Tjitro Semeto, 1990). Soybean fields are infested with grassy and broad leaved weeds and smothers the slow growing soybean heavily.

Among the several practices to control weeds, hand weeding is the most widely practiced and followed till today, as it control the weeds and accomplishes the job effectively. However, it became difficult and uneconomical due to high cost of manual labour. Time consuming and non- availability of labour during peak periods of agricultural operations makes this method as uneffective. Sometime untimely rains also make hand weeding difficult. In this context control of weeds by using chemical and cultural practices play a significant role. The herbicide used to control weed offers more practical and economical means for reducing weed competition and crop losses. However, continuous usage of herbicides might result in residual effect on subsequent crop besides leading to resurgence of secondary weed infestation and soil pollution. Due to this a system approach to weed management known as integrated weed management system is now gaining importance. Integrated weed management system aimed at combining two or more weed control means to manage weeds (Shah, 1982). In future, limited herbicide use will be a major issue, may have to rely on other methods in combination. Productivity and profitability can be maintained with minimal herbicide use and at less cost. Such programmes economically viable and feasible to farmers and also environmentally sound, so that farmers can adopt such systems without sacrificing the benefits of crop production.

The day-to-day variation at lower part of the atmosphere with referencc to temperature, rainfall, humidity, wind, solar radiation, viz.

weather plays a pivotal role not only in the crop growth and development, but also in weed flora associated. Weather parameters simultaneously effect the crop growth and weed flora, which can adjust thereby causing a serious threat to crop production. In this regard, it is essential to find the relation between weather and weed flora associated with *kharif* soybean crop.

Adjusting time of sowing (non cash input) has a tremendous effect on the soybean productivity particularly in India because of widely varying agroclimatic conditions, which intricate crop weather relationships. A good variety often fails to express its genetic potential even under judicious management unless it is sown at right time, which in addition may helps in avoiding one or two weed flushes that causes yield loss.

The information available in this direction is meagre. Therefore, the present investigation entitled "Effect of weather and integrated weed management on production of *kharif* soybean (*Glycine max* (L) Merril)" was under taken with following objectives :

1. To find out the best method of weed control and sowing time in *kharif* soybean.
2. To study the density and nature of weed flora in *kharif* soybean.
3. To study the extent of yield losses caused by weeds in soybean under different dates of sowing (weather variations).
4. To study the influence of weather factors on crop growth and weed control practices.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Weeds are the natural rivals of crop plants for the limited common growth requirements mainly comprising of light, moisture and nutrients. Weed competition reduces soybean production potential and makes its cultivation economically less viable.

2.1 WEED FLORA IN SOYBEAN ECOSYSTEM

The natural distribution and intensity of weed infestation in soybean fields are the function of a complex interaction among soil, weather, vegetation and management practices (Jordan *et al.*, 1987).

Dominant weed flora associated with soybean crop in Sagar (MP) majorly consists of grasses as compared to other weeds. Such weeds are *Echinochloa crusgalli, Panicum maximum, Caesulia axillaris, Commelina benghalensis,* while *Celosia argentea, Eclipta alba. Physalis minima, Euphorbia geniculata* were most noxious broad leaved weeds (Kurmawanshi *et al.*, 1995).

Velu and Sankaran (1996) reported that, the weed flora in sandy clay loam soil of Coimbatore are *Echinocloa colonum* in grasses, *Cyperus rotundus* in sedges and *Trianthema portulacastrum, Boerhavia* *diffusa, Amaranthus viridis, Digera arvenis* and *Flaveria austrolosica* in broad leaved weeds.

The weed species associated with soybean in vertisol of Andhra Pradesh during rabi season were *Cynodon dactylon, Cyperus rotundus, Chloris barbata, Commelina benghalensis, Dactyloctinum aegyptium, Digitaria sanguinalis. Dinebrea retroflexa, Echinocloa colonum, Panicum ramosum* among monocots and *Achyranthus aspera, Amaranthus viridis. Corchorus olitorius, Eclipta alba, Euphorbia hirta, Phyllanthus maderaspatensis, Physalis minima, Portulaca oleracea,and Solanum nigrum* (Rao, 1997).

Predominant weed species recorded during the *kharif* season at Indore are *Echinochloa crusgalli* (L), *Dinebra arabica, Digitaria sanguinalis, Cyperus rotundus, Cynodon dactylon, Euphorbia geniculata, Digera arvensis, Eclipta alba* (Billore *et al.*, 2001). Major weeds in the Medak district of AP were *Cyperus rotundus, Cynodon dactylon, Digitaria sanguinalis, Amaranthus viridis, Euphorbia hirta, Cleome viscosa, Parthenium hysterophorus, Tridax procumbens, Phyllanthus niruri* (Jeyabel *et al.*, 2001).

2.2 EFFECT OF WEEDS ON SOYBEAN YIELD

The extent of soybean yield reduction depends on the intensity, time and duration of infestation and distribution of diverse species of weed flora and their interaction with the crop variety and local agronomic practices. This complex interaction is influenced by the agro-ecological situation of particular locality (Koch *et al.*, 1982).

Yield losses due to uncontrolled weed competition in soybean ranges from 34 to 60 per cent in south India (Muniyappa *et al.*, 1986). Whereas, the yield losses due to weeds were as high as 95 per cent in silty clay loam soil of Pantnagar (Singh and Singh 1992). While, Bhan (1994) reported 40-60 per cent losses in seed yield in soybean due to weeds. Several workers have reported yield losses ranging from 10-95 per cent due to weed infestation in soybean (Padmavathi 1994; Angiras and Rana, 1995).

Singh and his coworkers (1994) reported that, the presence of weeds throughout the cropping season caused 54.91 per cent reduction in grain yield of soybean. The yield reduction due to weeds ranged from 35-55% depending upon the types of weeds (*Cynodon dactylon, Cyperus rotundus, Digitaria sanguinalis* etc.) and their densities (Tiwari *et al.*, 1996; Pandey *et al.*, 1996). Kohle (1996) revealed that, the weed infesting soybean cause losses ranging from 20 to 77 per cent. During *kharif* season, Kewat *et al.* (2000) reported the yield reduction to the extent of 50 per cent under weedy check in soybean.

2.3 CRITICAL PERIOD OF WEED CONTROL

Soybean owing to slow growth during the initial stages of crop growth severely suffers due to competition from weeds. Singh and Singh (1992) observed higher yield losses with crop weed competition for initial 45 days than at initial 30 days. Chhokar *et al.* (1995) reported the critical period of weed competition in soybean as 27-40 DAS.

The crop weed competition during the initial 30 days was with Parthenium species and sedges and 30-50 days with grasses and throughout the crop growth period (60-105 DAS) with all other broad leaved weeds (Mishra and Bhan, 1996). Das and Yaduraju (1996) observed that, the weed growth increased upto 60 DAS in soybean which was assumed to be the most critical period of weed competition. Rao and Veeraraghavaiah (1996) confirmed the critical period of weed competition as 20 – 40 DAS in soybean crop raised at Bapatla. Rani and Ramaiah (1997) reported that, the crop was sensitive to weeds upto 30-40 DAS. Effective control of weeds in the first 30 – 45 DAS of crop growth is essential for achieving higher productivity of soybean (Pushpendra *et al.*, 2000).

2.4 WEED MANAGEMENT PRACTICES

2.4.1 Manual weeding

Lokras *et al.* (1985) recorded higher weed control efficiency with, three, two and one hand weeding (97.80, 97.68 and 91.42 per cent, respectively). Balasubramanian and Arumugam (1996) observed the lower weed population (4.89 m^{-2}) and higher WCE (94.9%) with hand weeding twice at 20 and 40 DAS. Reddy (2000) reported the lowest weed dry matter (12.23 m^{-2}) and seed yield (971 kg ha^{-1}) with two hand weedings (20 and 40 DAS), which was comparable to metolachlor (0.5 kg ha^{-1}) + pendimethalin (0.5 kg ha^{-1}), both of them were superior to fluchloralin (0.5 kg ha^{-1}) + pendimethalin (0.5 kg ha^{-1}). Veeramani *et al.* (2000) during *kharif* obtained the weed control efficiency of 94.4% in two hand weeding treatments and application of alachlor 1.25 kg ha^{-1} + hand weeding (40 DAS) (92.45 %) was close to this treatment. Hand weeding twice at 20 and 30 DAS recorded maximum seed yield of 12.45 q ha^{-1} and weed control efficiency of 74.40% over other treatment (Jain *et al.*, 2000). Maximum weed control efficiency of 91.5% was recorded in two hand weedings as per weed dry matter recorded at final harvest (Chandel and Saxena, 2001).

2.4.2 Chemical weed control

Herbicides are the modern tools which can substantially improve the efficiency of weed management. Soybean and maize account for the major share of herbicide consumption in the world (Bhan and Kumar, 1996). More than fifty herbicides are in use world wide under varied situations of soybean cultivation. Paucity of labour and unfavourable weather and soil physical conditions are the major constraints for timely and efficient management of weeds through mechanical and manual means (Singh and Singh, 1992). Hence, the use of chemicals for weed control in crops has become indispensable. Among them pendimethalin and fluchloralin are reported to be in wide use in this crop.

Parka and Soper (1997) assumed that the primary mechanism of action of fluchloralin was interference with energy generation or transport or both, thus inhibiting ATP formation in mitochondria and its secondary mode of action was its effect on RNA, DNA and protein synthesis. Fluchloralin belongs to dinitroaniline group, which inhibits root and shoot growth. Kurchania (1989) reported that fluchloralin @1 kg ha^{-1} found effective in controlling *Echinochloa crusgalli*. While, Agrawal *et al.* (1995) observed that fluchloralin @ 1 kg ha^{-1} was quite effective in reducing weed density. Pre-plant incorporation of fluchloralin significantly increased the number of pods $plant^{-1}$ and test weight over the unweeded control in soybean (Tuteja *et al.*, 1995).

Agrawal *et al.* (1996) observed significant effect of fluchloralin as preplant incorporation @ 1 kg ha^{-1} in increasing the number of branches $plant^{-1}$ as compared to weedy check. The maintenance of weed free condition upto 75 DAS or application of fluchloralin @1.5 kg ha^{-1} PPI followed by interculturing at 40 DAS were equally effective (Nimje, 1996).

Singh and Bhan (1997) recorded that fluchloralin 1.25 kg ha^{-1} shown significantly superior grain yield of 13.65 q ha^{-1} over pendimethalin (1.25 kg ha^{-1}) and fluzifop-o-butyl, which were at par with each other. Jain *et al.* (2000) reported that the seed yield of 10.69 q ha^{-1} observed in fluchloralin (1.50 kg ha^{-1}) which was at par with hand weeding twice 20 and 30 DAS (12.42 q ha^{-1}). Application of fluchloralin at both levels (1 and 0.75 kg ha^{-1}) gave 15.42 and 16.28 q ha^{-1} yield, respectively and was significantly superior to hand weeding twice at 30 and 45 DAS as reported by Jeyabel *et al.* (2001).

Pendimethalin is a selective herbicide belonging to dinitroaniline group. It is absorbed by roots and leaves. It inhibits cell division and cell elongation. The affected plants die shortly after germination. (Tomline, 1994).

Presowing application of pendimethalin @1.7 kg ha^{-1} suppressed the dominant weeds like *Sorghum halepense* and increased seed yield of soybean (Langemeier *et al.*, 1983). Preemergence application of pendimethalin at 1.0 kg ha^{-1} improved the soybean yield by 256 per cent over weedy check (Lokras *et al.*, 1985). Where as Tiwari *et al.* (1996) reported only 46 per cent increase in yield of soybean with pendimethalin 1 kg ha^{-1} over control. Mishra and Bhan (1996) reported the negative growth rate of sedges in pendimethalin treated plots. Tiwari *et al.* (1996) found the application of pendimethalin @1.5 kg ha^{-1}

was more remunerative than manual weeding. Pendimethalin is the most potent and safe herbicide recommended for selective weed control in oil seed crop particularly in soybean (Bhalla *et al.*, 1998). Preemergence application of pendimethalin 1.25 kg ha^{-1} in granular form effectively reducing the weed population (88.6 m^{-2}) and it was at par with preemergence application of alachlor granules @ 2.5 kg ha^{-1} (90.77 m^{-2}) (Nayak *et al.*, 2000).

2.4.3 Integrated weed management practices

The components of integrated weed management are cultural, physical, biological and chemical methods. By using two or more of these methods, appropriate crop-weed situation, weeds can be controlled effectively and economically (Reddy and Reddy, 1995). Singh *et al.* (1992) inferred that the pendimethalin integrated with one hand weeding (30 DAS) enhanced the soybean pod $plant^{-1}$ to an extent of 8 % over the herbicides applied alone (34.6) and by 46 % over the unweeded control (25.7). Preemergence application of pendimethalin (0.5 kg ha^{-1}) followed by hand weeding at 30 DAS reduced the total weed dry matter from 36.6 to 0.08 g m^{-2} as compare to herbicide alone (Singh *et al.*, 1992).

Patil *et al.* (1996) observed that the number of pods $plant^{-1}$ was highest in 2 hoeing + 2 hand weeding (51.66) and was at par with oxadiazon (1 kg ha^{-1}) +1 hoeing and one hand weeding and the same trend was reflected in grain yield. Balasubramaniam and Arumugam (1996) obtained the higher seed yield of 2932 kg ha^{-1} with integrated practice viz., pendimethalin @ 0.5 kg ha^{-1} fb hand weeding at 20 DAS and this was comparable to the yields obtained by hand weeding twice at 20 and 40 DAS. Two hand weeding at 25 and 40 DAS recorded significantly higher seed yield and it was followed by application of alachlor 1 kg ha^{-1} fb HW at 30 DAS (Reddy *et al.*, 1998). Alachlor 1.25 kg ha^{-1} + hand weeding 40 DAS recorded the highest weed control efficiency (92.45%) which was as good as twice hand weeding at 20 and 40 DAS (Veeramani *et al.*, 2000).

2.4.4 Effect of weed management on weed parameters

2.4.4.1 Weed Control Efficiency

Dubey *et al.* (1984) recorded higher weed control efficiency of 81.6 % and higher seed yield of 1803 kg ha^{-1} with PPI of fluchloralin @1 kg ha^{-1}. Patra (1987) reported weed control efficiency with weeding thrice (15, 30 and 40 DAS), twice (30 and 45 DAS) and once (30 DAS) as 92, 84 and 68 per cent, respectively comparative to weed free condition. Kumar (1988) obtained higher weed control efficiency with twice hand weeding at 20 and 35 DAS (92.3 %) than with one hand weeding at 20 DAS (84.4 %), and he further reported that two hand weeding gave dry matter production of 6080 kg ha^{-1}, which was comparable to that of weed free treatment (6270 kg ha^{-1}) and both of these treatments were significantly superior over weedy check (4090 kg ha^{-1}).

Nimje (1989) observed the highest weed control efficiency of 91.4 per cent by manual weeding at 25 and 45 DAS. Kurchania *et al.* (1990) noticed the maximum weed control efficiency incase of oxadiazon (71.2 %) followed by oxyfluorfen (68.6 %) and fluchloralin (66 %). Higher weed control efficiency (72.8 %) was found with application of fluchloralin at 1.5 kg ha^{-1} + hand weeding at 30 DAS (Gogoi *et al.*, 1991). Metalachlor 2 kg ha^{-1} proved potential and registered the highest WEC (63.4 %) followed by trifluralin (54.1 %) and fluchloralin (Gogulwar *et al.*, 1992).

2.4.4.2 Weed dry weight

Preemergence application of pendimethalin @ 1 kg ha^{-1} gave the highest soybean yield with a weed control efficiency of 83.5 % and lower weed dry weight of 480 kg ha^{-1} when compared to weedy check Dubey *et al.* (1984). Maximum dry weight of total weeds (145 g) and *Cyperus rotundus* (89.4 g) were recorded with unweeded control while it was minimum with hand weeding at 25 and 45 DAS (Ghatak *et al.*, 1990). Mandloi *et al.* (2000) reported that the lowest mean weed dry matter (90.5 kg ha^{-1}) and highest mean grain yield (17 q ha^{-1}) was observed in two hand weedings (30 and 45 DAS).

2.4.4.3 Weed density

Studies carried at Rewa indicated minimum weed density of 24.5 m^{-2} with preemergence application of alachlor at 2 kg ha^{-1} as against a density of 193.2 m^{-2} in unweeded control (Malik and Lal, 1973). Nimje (1996) found that the pre-plant incorporation of fluchloralin @1 kg ha^{-1} significantly decreased weed density and plant biomass over unweeded control.

Maurya *et al.* (1990) reported that lowest weed density (3.5 m^{-2}) weed biomass (26 kg ha^{-1}) and maximum weed control efficiency (99.2 %) under two hand weeding (20 and 45 DAS). Gogoi *et al.* (1991) noticed that application of fluchloralin @1.5 kg ha^{-1} fb hand weeding at 30 DAS, caused the lowest weed density and biomass and highest weed control efficiency (72.8 %) and higher grain yield of soybean (25.8 q ha^{-1}) when compared to unweeded control. In weed control experiment on soybean at Jabalpur, cultural treatments (hand weeding and hand hoeing at 30 DAS) registered significantly lower weed population compared to all herbicides treatments except metolachlor @2.0 kg ha^{-1} applied as preemergence (Gogulwar *et al.*, 1992).

2.5 EFFECT OF WEED MANAGEMENT TREATMENTS ON SOYBEAN

2.5.1 Effect on crop growth

2.5.1.1 Plant height

Plant height was significantly more (81.2 cm) with fluchloralin application at 1 kg ha^{-1} fb handweeding at 30 DAS and it was at par (73.4 cm) with weedy check and pendimethalin at 0.5 kg ha^{-1} fb hand weeding at 30 DAS (Singh *et al.*, 1992).In contrary, Padmavathi (1994) reported reduction in plant height with fluchloralin application at 0.75 kg ha^{-1} fb hand weeding at 30 DAS. Halwankar *et al.* (1986) observed significant increase in plant height with application of fluchloralin, pendimethalin and metolachlor at 1 kg ha^{-1} fb hand weeding at 30 DAS.

2.5.2 Effect on yield components and yield attributes

2.5.2.1 Pods $plant^{-1}$

Significant increase in pods $plant^{-1}$ was observed due to hand weeding alone at 20 and 40 DAS as compared to unweeded control (Santharam and Shivasankar, 1982). Marold and Krausse (1987) found that the pods $plant^{-1}$ was the most variable yield components due to weed stress. Halvankar *et al.* (1995) reported that pod number $plant^{-1}$ increased with supplemental hand weeding at 30 DAS along with fluchloralin, pendimethalin or metolachlor all applied at 1 kg ha^{-1} (44.7, 42.6 and 42.1, respectively) and 100 seed weight did not vary significantly with application of herbicides alone or incombination with hand weeding.

Padmavathi *et al.* (1995) reported that hand weeding twice (20 and 40 DAS) recorded 43.4 pods plant^{-1}, whereas pre emergence application of oxyfluorfen @ 0.15 kg ha^{-1} or fluchloralin @ 0.75 kg ha^{-1} coupled with one hand weeding at 30 DAS recorded 38.0 and 38.3 pods plant^{-1}, respectively and there was no significant difference in seeds pod^{-1} and test weight among treatments. Number of pods plant^{-1} was highest in 2 hoeing + 2 hand weeding (51.66) and was at par with oxadiazon (1 kg ha^{-1}) + 1 hoeing and 1 hand weeding (50.67) (Patil *et al.* 1996.) Dubey (1993) reported that total pods plant^{-1} and total seed plant^{-1} in fluchloralin @ 1 kg ha^{-1} as preplant incorporation and hand weeding at 30 DAS were statistically at par. Jain *et al.* (2000) recorded that the pendimethalin (1.5 kg ha^{-1}) treatment gave significantly higher pods plant^{-1} (53.32) over weedy check but it was on par with alachlor at 1 kg ha^{-1}.

2.5.2.2 Number of seeds pod^{-1}

There was increase of 43 per cent in seed number plant^{-1} in hand weeding twice at 20 and 40 DAS as compare to weedy check (Tiwari *et al.*, 1988). Cultural methods of weed management (hand weeding and hand hoeing) recorded 46 to 64 seeds plant^{-1} compared to 42 in unweed plants (Jain *et al.*, 1988).

2.5.2.3 100 SEED WEIGHT

Singh *et al.* (1992) reported that 100 seed weight was found to be significant in hand weeding twice (17.26 g) and pendimethalin (0.5 kg ha^{-1}) + one hand weeding (30 DAS) treatment (16.93 g) than weedy check (15 g). Negi and Saini (1994) recorded significant more 100 seed weight in weed free soybean (19.43 g) than the crop subjected to weed stress (17.43 g). Similarly results were also observed by Singh *et al.* (1994). He found that the weed control treatments (pendimethalin, oxadiazon) produced higher 100 seed weight 10.0 to 10.4 g while (oxyfluorfen) those treatments (herbicides) which were less effective in weed control, produced seed with lower test weight (9.4 to 9.9 g) being on par with weedy check. On contrary some authors reported that weight of 100 seeds appears to be not much affected by weed competition as the test weight for soybean were similar under weed free and weedy conditions (Muniyappa *et al.*, 1986; Jain and Tiwari, 1995).

2.5.3 Seed yield

Hand weeding 30 and 45 DAS resulted in highest seed yield at 29.32 q ha^{-1} over 10.58 q ha^{-1} observed in weedy check (Negi and Saini, 1994). Chhokar *et al.* (1995) observed that weed free periods upto 45

DAS resulted in 95.7% increase in grain yield of soybean over weedy check. Pre emergence, pendimethalin (1 kg ha^{-1}) fb one hand hoeing at 35 DAS and two hand weeding (20 and 40 DAS) recorded seed yield of 2250.5 and 2576 kg ha^{-1} respectively which were at par with weed free check (2677 kg ha^{-1}) (Chhokar *et al.*, 1996). Velu and Sankaran (1996) realised highest yields (12.71 q ha^{-1}) with hand weeding twice (20 and 40 DAS) followed by pendimethalin (0.5 kg ha^{-1}) + fluchloralin (0.625 kg ha^{-1}) both when tank mixture applied (11.98 q ha^{-1}).

Kurchania *et al.* (1990) recorded significantly higher seed yield in treatment with oxadiazon (1587 kg ha^{-1}) followed by fluchloralin (1573 kg ha^{-1}) and oxyfluorfen (1444 kg ha^{-1}). While, Veeramani *et al.* (2000) reported that hand weeding twice (20 and 40 DAS) and alachlor 1.25 kg ha^{-1} + hand weeding recorded higher mean grain yields accounting 56.7 and 53.6 %, respectively over unweeded check (1511 kg ha^{-1}). Hand weeding twice (20 and 40 DAS) recorded significantly superior seed yield (24.57 q ha^{-1}) over other treatments but was at par with metribuzin (0.5 kg ha^{-1}) (Kewat *et al.*, 2000).

2.5.4 Haulm yield

Hand weeding twice (20 and 45 DAS) recorded higher haulm yield (4629 kg ha^{-1}) as compared to haulm yields of 4258, 3633 and 3445 to 3497 kg ha^{-1} recorded with one hand weeding (20 DAS), two mechanical weedings (20 and 45 DAS) and pre emergence application of pendimethalin at 1.0 to 1.5 kg ha^{-1}, respectively. All above haulm yield are significantly superior than weedy check with 2916 kg ha^{-1} (Maurya *et al.*, 1990)

2.5.5 Harvest index

Halwankar *et al.* (1986) reported that fluchloralin applied @ 1.0 and 1.5 kg ha^{-1} yielded higher pod $plant^{-1}$ and seed weight than weedy check. Kumar *et al.* (1994) noticed that harvest index (41.7%) with oxyfluorfen @ 0.25 kg ha^{-1} as post emergence application which was higher than that of fluchloralin @ 1.0 kg ha^{-1} as pre plant incorporation (40.3%). Jain *et al.* (1988) reported on integrated weed management in soybean that the highest harvest index with two hand weeding followed by fluchloralin 1 kg ha^{-1} + one hand weeding and metribuzin 1 kg ha^{-1} + one hand weeding. Padmavathi *et al.* (1995) noted the highest indices at 44.4, 43.4 and 39.6% as resulted form the treatments with hand weeding twice, fluchloralin (0.75 kg ha^{-1}) + one hand weeding and oxyfluorfen (0.75 kg ha^{-1}) + one hand weeding respectively. Billore *et al.* (2000) also reported progressive decrease in harvest index with each delay in sowing dates.

2.6 EFFECT OF SOWING DATES

2.6.1 Observation on weed

Singh and Bhan (1997) inferred that delay in sowing of soybean from 25 June to 15 July reduced the density and dry matter production of weeds. Nimje (1989) reported that the grassy weeds are dominated in the early stage of crop (40 DAS), whereas the broad leaved weed dominated 40 DAS and was maximum at harvest due to late germination of broad leaved weed during *kharif* season.

2.6.2 Observation on crop

Studies conducted by Muthuvel *et al.* (1989) under Bhavavi sagar conditions during kharif season revealed that second fortnight of June to first fortnight of July was the optimum sowing time which registered the maximum plant height. Kushwaha (1990) Noticed reduction in grain yield of soybean with delay in sowing but the yields were reduced significantly when sown in the month of August.

Sahoo *et al.* (1991) observed higher yield attributes of soybean with 20th June sowing and thereafter a significant reduction was observed. Whereas 100 seed weight and harvest index were not affected by sowing dates. Plant height were at par with 23rd June and 8th July (early) sowing, however leaf area significantly differed at all the four sowing dates viz., 23rd June, 8th July, 23rd July and 7th August on clay soil (Jasami *et al.*, 1993).

Paul and Guha (1994) recorded the decreased grain yields by 16-96 per cent compared to 16th April (18.3 q ha^{-1}) at Assam. They also reported that plant height were decreased due to delay in sowing at Gossaigaon, Assam. Delayed sowing may result in yield reduction to the magnitude of 17-39% (Karmakar and Bhatnagar, 1995). Shafshak *et al.* (1997) concluded that the soybean sown in early kharif season (May) attained increased plant height, pod number, 100 seed weight and seed yield as compared to late sowing in the same season.

Rani and Ramaiah (1999) reported that number of pods $plant^{-1}$ and days to harvest decreased with delay in sowing. Plant height and 100 seed weight decreased from 1st June to 1st September. Seed yield generally decreased with delay in sowing up to September/October. Billore *et al.* (2000) observed maximum seed yield (2341 kg ha^{-1}) when crop was planted on recommended sowing time i.e. 25 June and yield reduction on subsequent planting dates that is progressive delay in sowing resulted in progressive decrease is yield and also progressive decrease in harvest index with each delay in sowing dates.

2.7 EFFECT OF WEATHER FACTORS ON CROP

2.7.1 Solar radiation

2.7.1.1 Crop growth

Jhonson *et al.* (1960) stated that prolonged day lengths delayed the time from flowering to pod set in field studies. Lang *et al.* (1985) explained that the radiation is essential to photosynthesis, which affect the transpiration and temperature of plant parts. A late sown date resulted in short vegetative growth phase and ripening phases (Board and Settimi, 1988). Monteith *et al.* (1989) reported that the foliage intercepts solar radiation, absorb CO_2 and produces dry matter.

Egli and Yuzw (1991) observed that when crop was shaded from vegetative stage to maturity there were significant reductions in yield. Shading between 5 to 7 weeks after emergence of crop resulted in increased plant height noticed by Huang *et al.* (1993). Rivitake *et al.* (1997) explained that high intensity solar radiation conditions shown short vegetative and reproductive phases in soybean. Shih *et al.* (1997) recorded longer stems under reduced solar radiation conditions and crop coefficients values were 0.45, 0.89, 0.92 and 0.58 respectively for initial, crop development, mid season and late season stages respectively.

2.7.1.2 On yield and yield attributes

The value of extinction coefficient of net radiation for soybean crop ranged from 0.45 to 0.57 (Baldochi *et al.*, 1983). Asrar *et al.* (1989) defined absorbed photosynthetically active radiation (APAR) as that quantity of energy that is captured by a crop canopy.

Han and Wang (1995) explained that the flowering phase of early soybean genotypes was insensitive to photoperiod, where as post flowering development was affected by both pre and post flowering photoperiod. Sharma and Neelu (1996) recorded that the low light intensity (60% reduction of full solar radiation) from seedling emergence to anthesis decreases number of leaves and leaf area but plant height increases. Low light particularly at anthesis period reduce yield. Wang *et al.* (1997) reported that when low solar radiation intensity coupled with cold temperature delayed soybean reproductive stage and altered biomass partitioning.

2.7.2 Rainfall

2.7.2.1 Crop growth

The rainfall was positively correlated with vegetative growth seed yield and yield components. Increase in plant height was observed when rainfall was received at flowering and pod elongation stage on loam soils recorded by Korti *et al.* (1983).

Daniell and Scott (1991) noticed the importance of rainfall to ensure maximum LAI in drier seasons was also reported soybean grain yield increased significantly by rainfall till it initiates wet injury. Pookpakni and Kuo (1993) recorded lower seed yields in soybean due to saturated soil conditions which resulted from excessive rains and significantly higher plant height was observed in soybean when it received proper distribution of rainfall.

Balasundaram and Sen (1994) reported that rainfall was positively correlated with the yield of soybean. Sainik and Singh (1981) explained that rainfall immediately succeeding sowing was most deleterious for soybean in relation to seedling emergence. While, drought reduced the length of vegetative phase and flowering but increased the period of seed filling recorded by Ruizvega (1985).

2.7.2.2 On yield attributes and yields

Lower yield in case of 25th June sowing as compared to 10th July sowing was ascribed to excessive vegetative growth and excess amount of initial rain which is responsible for excessive vegetative growth (Barik and Sahoo, 1989). Boquet and Coco (1997) recorded that the rainfall was a major determinant of crop yield and uniform distribution of rainfall increased plant height, LAI in soybean irrespective of different maturity duration in USA.

2.7.3 AIR TEMPARATURE

2.7.3.1 Crop growth

Soybean successfully sets pod at low temperature especially during night suggested by Lawn and Hume (1985). The time of pod appearance was inversely related to temperature (Thomas *et al.*, 1981). Tyagi and Tripathi (1983) inferred that the optimum soil temperature for soybean germination was 28° C and optimum soil moisture content was 15 per cent (Laboratory experiment). Hadley *et al.* (1984) reported reciprocals of time for flowering were linear function of mean diurnal temperatures. Seeddigh and Jolliff (1994) explained that the high night temperature (24° C) enhanced early vegetative growth, advanced reproductive phase and increased seed yield.

Gibson and Mullen (1996) reported that with increase in day temperatures more than (30 °C) at flowering and pod set, decreased seed formation and decreased seed growth when exposed at seed fill, reduction in seed growth when accompanied due to high temperature and decreased photosynthetic rate. The highest yield reduction was 27 per cent observed when 35° C temperature for 10 hours day^{-1} occurred from flowering to maturity. Kane *et al.* (1997) suggested that early sowing may be a disadvantage for early maturity cultivars in seasons with favourable rainfall patterns. Particularly if canopy development is inhibited by cool temperatures during vegetative growth.

2.7.3.2 On yield attributes and yields

It was stated that either increases in day or night temperature increases pod length while greatest pods per plant was obtained at 30/14 and 26/14 °C. Gibbson and Mullen (1996) noticed the reduction of soybean seed yield due to high temperature showed primary response to high day temperature and moderate to high night temperature.

- - - - - oOo - - - - - -

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

3.1 EXPERIMENTAL SITE

The experiment entitled "Effect of Weather and Integrated weed management on production of *kharif* soybean" was conducted during *kharif* 2001 at the College Farm, College of Agriculture, Rajendranagar, Hyderabad. The farm is situated at an altitude of 542.6 m and geographical bearing of 18'-50° N latitude and 77'-53°E longitude.

3.2 WEATHER CONDITIONS

3.2.1 Climate during the crop period

The weekly mean meteorological data from July 2001 to November 2001 recorded in a class A meterological observatory which is situated at Agricultural Research Institute, Rajendranagar.

3.2.1.1 Rainfall

A total rainfall of 6.2 mm received on 9th July helped for proper germination of the crop sown on same days. During July 2001 there were only 5 rainy days with 32 mm of rain. A total of 513.5 mm of rain occurred during south west monsoon period (June-September) which was 80 percent of normal rainfall (680) during this period.

3.2.1.2 Temperature

The temperature recorded during *kharif* 2001 were with in favourable limits of crop production. The monthly means of maximum and minimum temperature during this period were 30.4 and 21.6°C, respectively. However, the maximum temperature recorded during crop (*kharif* season) growth was 34.8° C on 4th and 5th of July 2001 and minimum was 16.1° C on 31st October 2001.

3.2.1.3 Wind velocity

The meteorological data available for the last 5 decades at Rajendranagar was reported therefore, high wind's during *kharif* crop season in this tract. The wind velocity was higher in the afternoon hour's often touching even 16 km h^{-1} in the month of August. The average wind speed were ranged from 1.93 to 4.20 km h^{-1} during experimental period in *kharif*, 2001.

3.2.1.4 Relative humidity

The average relative humidity during the whole crop growth period was 34.75 percent while the maximum relative humidity of 100 percent was recorded on 6th and 14th of October 2001 and the minimum relative humidity (29 per cent) was reported on 30th August, 2001.

3.2.1.5 Evaporation

The mean evaporation during the crop season was 4.7 mm. The highest evaporation was observed on 2nd July (8.7 mm) and lowest evaporation was reported on 26th September (0.2 mm).

3.2.2 Meteorological observations

The daily values of meteorological parameters recorded at the meteorological observatory at Agricultural Research Institute, Rajendranagar were used. As this observatory is situated close to the experimental site.

3.2.2.1 Air temperature

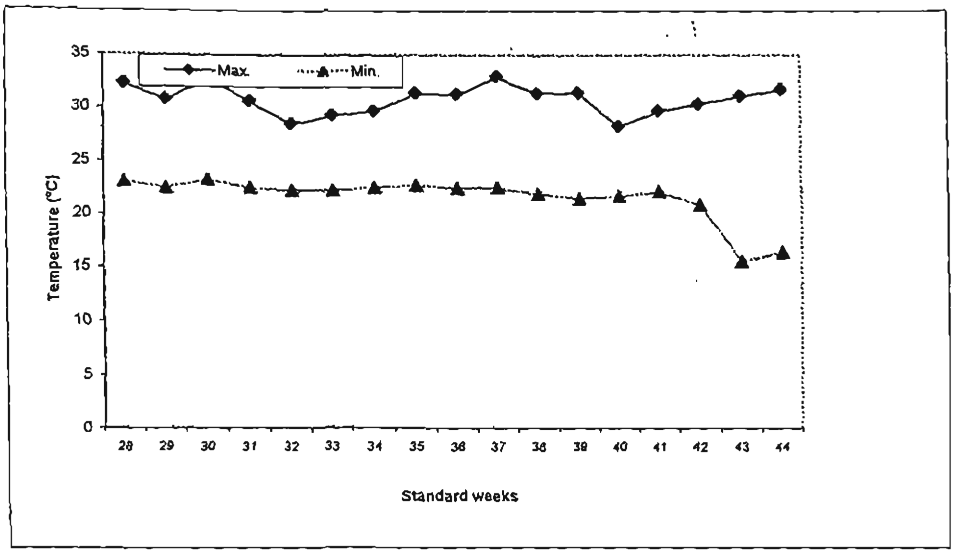
Maximum and minimum air temperature were recorded at four feet height in the Stevenson's screen.

3.2.2.2 Rainfall

Rainfall was recorded with the rain guage, installed in the experimental site.

3.2.2.3 Open pan evaporation

This was recorded from the US open pan evaporimeter, installed in the observatory.



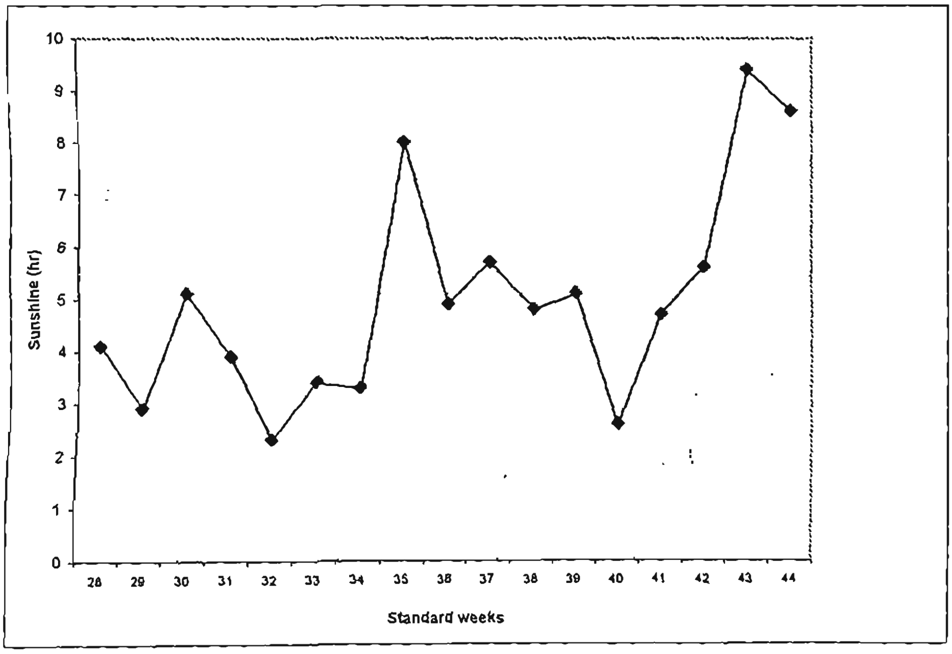
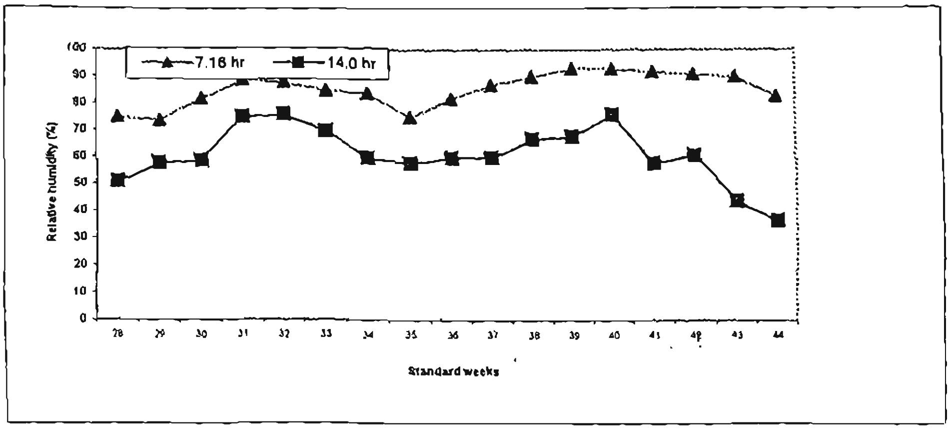
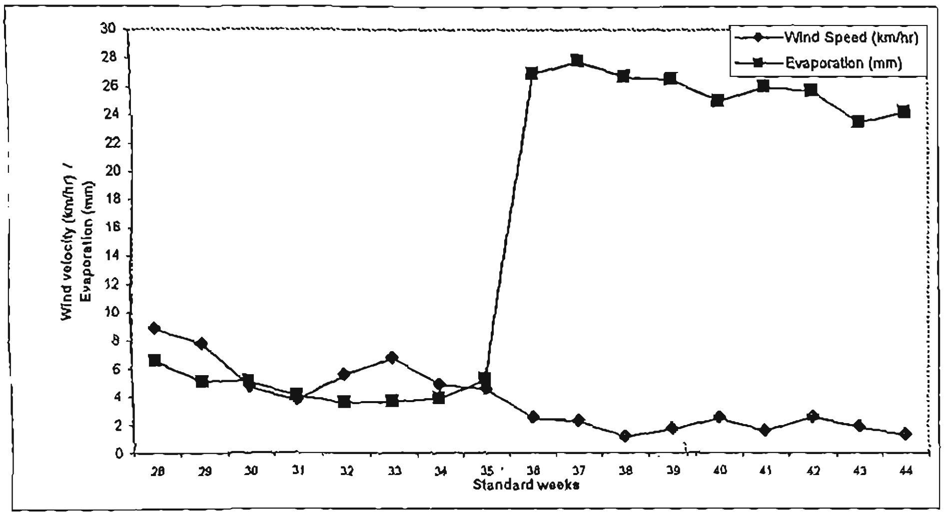


Fig. : Mean maximum and mean minimum temperature (°C) and sunshine (hr) during crop growth period





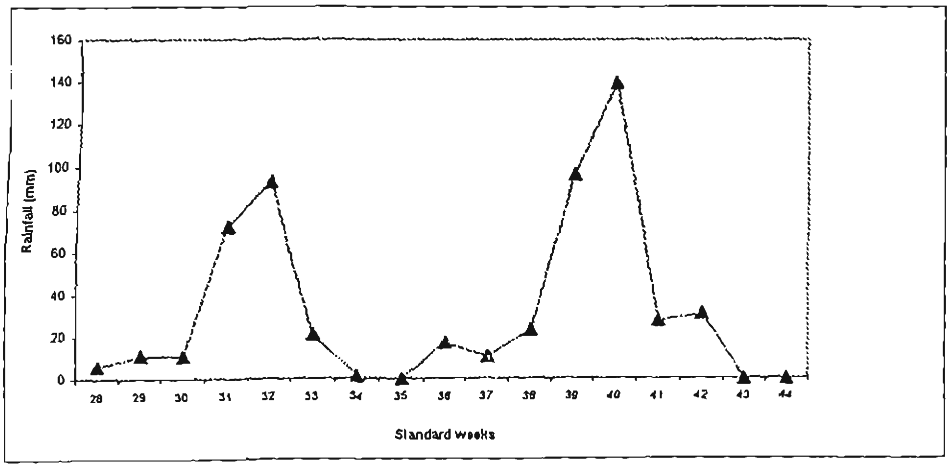


Fig. Relative humidty (%), wind velocity (km/hr), evaporation (mm) and rainfall during crop growth period (July, 2001 - November, 2001)

3.2.2.4 Wind velocity

This was recorded with a cup anemometer at twelve feet height.

3.2.2.5 Measurement of the components of photosynthetically active radiation (PAR)

3.2.2.5.1 Measurement of incident PAR (PARo)

For measurement of incoming PAR, the line quantum sensor was positioned facing up 30 cm above the top of the canopy and value was recorded for incoming PAR.

3.2.2.5.2 Measurement of transmitted PAR (TPAR)

Line quantum sensor was placed above the ground across the rows and value was recorded for TPAR.

3.2.2.5.3 Determination of intercepted PAR (IPAR)

IPAR was calculated according to Gallow and Daughtry (1986)

IPAR = PARo – TPAR

The IPAR values were recorded at an interval of 7 days from 21 DAS to harvest and they were converted into percentage IPAR.

3.3 EXPERIMENTAL SITE

3.3.1 Soil properties

Before start of experiment, soil samples were collected at random from 0-15 cm depth, shade dried, passed through a 2 mm sieve and the sieved sample was used for analysis of mechanical, physical and chemical characteristics by following the standard procedure (Jackson, 1973).

3.3.2 Characteristics of soil

Characteristics	Content	Reference
Mechanical composition, %		
Sand	35.00	Bouyoucos hydrometer
Silt	25.20	
Clay	39.80	
Textural class	Clay loam	
Chemical composition		
pH (1:2.5 soil:water)	8.3	Combined electrode pH meter (Jackson, 1973)
EC (dSm^{-1})	0.30	Digital EC meter (Jackson, 1973)
Organic carbon (%)	0.84	Wet digestion method (Walkley and Black, 1934)
Available nitrogen ($kg\ ha^{-1}$)	290 $kg\ ha^{-1}$	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available P_2O_5 ($kg\ ha^{-1}$)	13 $kg\ ha^{-1}$	Olsen's method (Olsen *et al.*, 1954)
Available K_2O ($kg\ ha^{-1}$)	140 $kg\ ha^{-1}$	NN NH_4OAC method (Jackson, 1973)

3.3.3 Previous crops grown

The following corps were grown in the experimental field previously

Year	Season	Crop
1999 – 2000	*Kharif* *Rabi*	Jowar Maize
2000 – 2001	*Kharif* *Rabi*	Fallow Jowar
2001 – 2002	*Kharif*	Soybean

3.4 EXPERIMENTAL DETAILS

3.4.1 Design of the experiment

The experiment was laid out in a Randomized block design with three replications. The experimental lay out is given in Fig 3.

3.4.1.1 Plot size

a) Gross plot size : 5.5 x 4.2 m

b) Net plot size : 4.5 x 3.2 m

3.4.1.2 Spacing adopted

30 cm x 10 cm

3.4.2 Treatments

Weed control treatments

T_1: Two hand weeding 20 and 40 DAS

T_2: Fluchloratin 1.5 kg ai ha^{-1} (PPI)

T_3: Pendimethalin 1.5 kg ai ha^{-1} (pre-emergence)

T_4: Fluchloralin 0.75 kg ai ha^{-1} + hand weeding 30 DAS

T_5: Pendimethalin 0.75 kg ai ha^{-1} + hand weeding 30 DAS

T_6: Unweeded check

Layout plan of experimental site

RI		RII		RIII
D_1T_1		D_1T_6		D_2T_6
D_2T_5		D_3T_6		D_1T_1
D_3T_1		D_2T_3		D_1T_4
D_2T_6		D_3T_2		D_1T_5
D_3T_3		D_1T_1		D_1T_3
D_1T_3		D_2T_2		D_2T_4
D_2T_6		D_3T_4		D_3T_3
D_1T_5		D_1T_5		D_2T_1
D_3T_2	IRRIGATION CHANNEL	D_2T_1	IRRIGATION CHANNEL	D_3T_4
D_1T_4		D_1T_2		D_3T_5
D_3T_5		D_2T_5		D_2T_2
D_1T_5		D_2T_4		D_1T_2
D_2T_4		D_2T_6		D_2T_5
D_2T_2		D_3T_1		D_3T_1
D_3T_4		D_3T_5		D_1T_6
D_2T_1		D_3T_3		D_3T_2
D_1T_2		D_1T_3		D_2T_3
D_3T_6		D_1T_4		D_3T_6

T_1 : Two hand weedings at 20 and 40 DAS

T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)

T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)

T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS

T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS

T_6 : Unweeded check

Dates of sowing

D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

Gross Area : 5.5 x 4.2 m

Net Area : 4.5 x 3.2 m

Date of sowing

D_1 : 9th July

D_2 : 23rd July

D_3 : 6th August

3.4.3 Details of the herbicides used

Two herbicides, pendimethalin, fluchloralin were tried in the experiment. The information of these herbicides is furnished below.

3.4.3.1 Pendimethalin

Common name	: *Pendimethalin*
Trade name & Formulation	: Stomp 30% EC
Chemical Name	: N – (1-ethyl propyl) – 3, 4 – dimethyl-2-6-Dinitrobenzenamine
Group	Dinitroaniline
Time of application	Pre-emergence, soil applied, and mode of action translocated
Manufacturing company	M/s Cynamid India Ltd., Bombay

3.4.3.2 Fluchloralin

Common Name	Fluchloralin
Trade name & Formulation	Basalin 45% EC
Chemical Name	N-(2-chloro-ethyl) –2-6-dinitro-N-Propyl-4-(trifluoromethyl) benzenamine
Group	Dinitroaniline
Time of application & mode of action	Pre-plant incorporation, soil applied, translocated
Manufacturing company	M/s BASF (India) Ltd., Bombay

3.4.3.3 Time and method of herbicide application

Herbicides were applied with Knapsack sprayer as per requirement to the treated area as water spray by using a spray fluid @ 600 litres ha^{-1}.

Fluchloralin was applied just before levelling and incorporated into the moist soil. Pendimethalin was applied 24 hours after sowing as pre-emergence application on moist soil based on the treatments used.

3.5 VARIETAL CHARACTERS OF SOYBEAN

JS-335 variety has been evolved at JNKVV Jabalpur. It matures in 85-95 DAS. The yield varies from 18-22 q ha^{-1}.

3.6 LAND PREPARATION

The experimental field was ploughed with tractor drawn disc plough and then worked with tractor drawn cultivator and levelling was done finally after the removal of stubbles and weed trash from the field.

3.6.1 Layout

The field was laid out into 54 plots using a bund former. The treatments were allotted randomly to different plots in each replication as shown in Fig. 3.

3.6.2 Fertilizer application

Uniform dose nitrogen @ 20 kg ha^{-1} phosphorus @ 60 kg ha^{-1} and potassium @ 20 kg ha^{-1} in the form of single super phosphate and Muriate of potash, respectively, along with full dose of nitrogen in the form of urea were applied as basal dose at the time of sowing.

3.6.3 Seeds and sowing

Bold and healthy seeds were selected and treated with thiram @ 3 g/kg seed to protect the crop from seed borne diseases. The seeds were sown on their respective sowing dates that is 9^{th}, 23^{rd} July and 6^{th} August, 2001 at a spacing of 30 cm x 10 cm and with two seeds per hill at a depth of 5 cm.

3.6.4 Irrigation

The crop was irrigated immediately after sowing to ensure good seedling emergence and the subsequent irrigation were given as and when required. The crop received a total of six irrigations during the crop season.

3.6.5 After care

Thinning was done at 10 DAS to maintain optimum plant population by leaving one healthy seedling per hill.

3.6.6 Intercultivation

Intercultivation with push-hoe was taken up as per the treatmental schedule after recording the species wise weed counts and the sampling of crop and weeds for dry matter production.

3.6.7 Plant protection

The crop was sprayed once each with endosulfon (0.07%) at 19 DAS for control of leaf caterpillar and with monocrotophos (0.05%) at 46 DAS as a prophylactic measure. In general, crop growth was good and healthy during the entire crop growing period.

3.6.8 Harvesting and threshing

The crop was harvested at physiological maturity when the leaves turned yellow and started dropping and also when the pods started drying and break open when pressed. All the plants from the net plot were harvested and dried under sun for 2-3 days and then threshed and the produce was cleaned. Dry weight of seeds and haulms were recorded separately.

3.7 EXPERIMENTAL OBSERVATIONS

3.7.1 Observations on weeds

3.7.1.1 Weed flora and density

Species wise weed flora and their counts were taken at 20, 40, 60 DAS and harvest in permanently marked one square metre area in the net plot of each plot. The data were statistically analysed after subjecting these values to square root transformations by using the following formula.

$$X = \sqrt{x + 1}$$

Where,

X = Transformed value

x = Original value

3.7.1.2 Dry matter production of weeds

The weeds were collected from an area of 0.25 m^2 from outside the net plot area earmarked for this purpose 20, 40, 60 DAS and at harvest and shade dried and kept in oven at 65°C until a constant weight was obtained.

Treatment wise dry matter of total weeds was recorded and expressed as g m^{-2}.

3.7.1.3 Weed control efficiency (W.C.E.)

From the dry weight of weeds, weed control efficiency was calculated at 20, 40, 60 DAS and harvest by using the following formula.

$$W.C.E.(\%) = \frac{\text{Dry mater of weeds in Unweeded plots (g m}^{-2}\text{)} - \text{Dry matter of weeds in treated plots (g m}^{-2}\text{)}}{\text{Dry matter of weeds in unweeded plot (g m}^{2}\text{)}} \times 100$$

3.7.2 Observations on crop

3.7.2.1 Emergence percentage

Plot wise emergence count was taken at 7 DAS. The germination percentage was calculated based on the following formula to find out the effect of herbicides on the emergence of the crop.

$$\text{Emergence \%} = \frac{\text{Number of seedlings emerged}}{\text{Expected (theoretical) population}} \times 100$$

3.7.2.2 *Selection of sampling plants for non-destructive growth parameters*

Five plants were randomly selected within the net plot area and tagged for recording the periodic biometric observations at various stages of crop growth.

3.7.2.3 Plant height

Bio-metric observations on plant height (cm) were taken at 20, 40, 60 DAS and harvest. Plant height was measured form the base of each plant to the tip of its terminal bud at vegetative stage and to the tip of the inflorescence at reproductive stage.

3.7.3 Post –harvest observations

3.7.3.1 Border rows and the sampling area

One row on either side of the plot and one plant on either side of each row were eliminated to avoid the border effect. Two rows were earmarked outside the net plot area excluding the border rows for destructive sampling.

3.7.3.2 Number of pods

The total number of pods from five sampled plants was counted and expressed as average number of pods per plant.

3.7.3.3 Number of seeds pod^{-1}

Number of seeds from all the estimated number of pods produced from five plants was counted and averaged to get number of seeds per pod.

3.7.3.4 100-seed weight (g)

From each treatmental produce, 100 seed were randomly selected and their weight was recorded.

3.7.3.5 *Seed and haulm yields*

Seed and haulm obtained from each net plot were shade dried to constant weight and their respective yields were recorded as kg ha^{-1}.

3.7.3.6 Harvest index (HI)

Harvest index (%) was expressed as the ratio of seed yield to biological yield and was calculated as given below.

$$H.I.(\%) = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.8 PHENOLOGY

In each plot 5 plants were examined for the occurrence of particular physiological event. The vegetative, reproductive and maturity stages of growth of soybean on which observations were recorded were as fallowed :

Growth stage	Description
Emergence	Plants with some part visible at soil surface in one metre row length
50%	Day on which 50 per cent of plants in one metre row length flowered
50% beinning podset	Day on which 50 per cent of plants in one metre pod row length set pod
Harvest	Day on which the pods develop brown round seed in one metre row length

- - - - - oOo - - - - -

RESULTS

CHAPTER IV

RESULTS

The findings of the present investigation entitled "Effect of weather and integrated weed management on production of *kharif* soybean" are furnished in tables and illustrated through figures when ever found necessary.

4.1 WEED DYNAMICS

Weed flora reported during the study were classified as grasses, sedges and broad leaved weed's (BLW's) observations were recorded on weed density, weed dry weight and weed control efficiency at 20, 40, 60 DAS and harvest of crop.

4.1.1 Weed flora

Weed flora of the experimental field consisted of 1sedge, 5 species of grasses and 8 species at BLW's.

Among grasses, *Cynodon dactylon* and *Dactyloctenium aegyptinum* were predominant. Only one sedge *Cyperus rotundus* was observed throughout the growth stage of crop, it was the predominant species among all weed management treatments. Under broad leaved weed's *Parthenium hysterophorus* and *Cleome viscosa, Celosia argentea, Trianthema portulacastrum* were the major weed's and other broad leaved weed are *Euphorbia hirta, Amaranthus viridis, Commelina benghalensis*

Weed Flora the experimental field

Sl.No.	Scientific Name	Family	Life span
MONOCOT Grasses			
1	*Cynodon dactylon*	Graminae	Perennial
2	*Dactyloctinum aegyptinum*	Graminae	Annual
3	*Panicum repen's*	Graminae	Annual
4	*Echinochloa colonum*	Graminae	Annual
5	*Digitaria sanguinalis*	Graminae	Annual
Sedges			
1	*Cyperus rotundus*	Cyperaceae	Perennial
DICOT			
Broad Leaved Weed's			
1	*Commelina benghalensis*	Commelinaceae	Annual
2	*Celosia argentia*	Amaranthaceae	Annual
3	*Parthenium hysterophorus*	Compositae	Perennial
4	*Trianthema portulacastrum*	Aizoaceae	Annual
5	*Cleome viscosa*	Leguminoceae	Annual
6	*Amaranthus viridis*	Amaranthaceae	Annual
7	*Euphorbia hirta*	Compositae	Annual
8	*Phyllanthus niruri*	Euphorbiaceae	Annual

Table 1: Effect of weed management treatments and dates of sowing on emergence per cent of soybean (7 DAS)

Treatment	Emergence Per cent
Two hand weedings at 20 and 40 DAS (T_1)	89.20
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	88.50
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	87.70
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	89.00
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	88.90
Unweeded check (T_6)	89.20
SE ±	0.35
CD (0.05)	0.70
9th July (D_1)	89.10
23rd July (D_2)	88.40
6th August (D_3)	87.30
SE ±	0.24
CD (0.05)	0.50
T x D	NS

The data pertaining to different aspects of weed management approaches and different dates of sowing on the effect of soybean crop growth, weed intensity and drymatter accumulation at different stages of crop growth are presented with interpretations in the present chapter.

4.2 CROP

4.2.1 SEEDLING EMERGENCE

The pre emergence application of pendimethalin at 1.5 kg ha^{-1} significantly deterred the percentage emergence of soybean seedlings compared to unweeded check or weed management through hand weeding or the herbicide spray of fluchloralin at 1.5 kg ha^{-1} (Table 1). The integrated weed management approaches by way of low dose at fluchloralin or pendimethalin at 0.75 kg ha^{-1} along with hand weeding had no significant effect in reducing the seedling emergence of soybean.

Sowing date had a pronounced influence on the seedling emergence the early sowing (9th July) had a maximum seedling emergence of (89.1 %). Delayed sowing reduced the seedling emergence significantly. The mean seedling emergence was reduced to 88.40 % by delaying the sowing up to 23rd July and further to as low as 87.3 % by extending the time of sowing to 6th August.

The interaction owing to different weed management treatment and dates of sowing had no significant influence to alter the seed to emergence of soybean crop.

Table 2 : Effect of weed management treatments and dates of sowing on plant height (cm) at 20, 40, 60 DAS and harvest

Weed management treatment \ Date of sowing	Plant height of soybean (cm)															
	20 DAS				40 DAS				60 DAS				Harvest			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	11.36	10.31	9.41	10.36	28.39	25.76	23.59	25.91	46.27	41.27	38.13	41.89	54.23	49.21	45.04	49.49
T_2	13.30	10.33	10.10	11.24	33.24	25.83	25.26	28.11	56.60	42.33	40.23	46.39	63.49	49.32	48.24	53.69
T_3	12.26	11.20	10.35	11.27	30.64	28.01	25.88	28.18	51.35	44.77	43.30	46.47	58.53	53.50	49.42	53.82
T_4	13.77	11.72	10.67	12.06	34.43	29.30	26.68	30.14	57.67	49.55	45.42	50.88	65.77	55.69	50.96	57.56
T_5	12.22	11.28	10.46	11.32	30.56	26.53	26.16	27.75	52.10	46.43	44.50	47.68	57.51	53.85	49.96	53.77
T_6	10.05	9.73	8.92	9.57	25.15	24.19	21.83	23.72	39.24	38.25	35.13	37.54	48.03	46.47	41.70	45.40
Mean	12.16	10.76	9.99		30.40	26.60	24.90		50.54	43.77	41.12		57.93	51.38	47.56	

	20 DAS SE ±	20 DAS CD (0.05)	40 DAS SE ±	40 DAS CD (0.05)	60 DAS SE ±	60 DAS CD (0.05)	Harvest SE ±	Harvest CD (0.05)
Weed management treatments (T)	0.08	0.16	0.37	0.75	0.35	0.71	0.39	0.79
Dates of sowing (D)	0.06	0.11	0.26	0.53	0.25	0.50	0.27	0.55
T X D	0.14	0.28	0.64	1.29	0.60	1.23	0.67	1.36

T_1 : Two hand weedings at 20 and 40 DAS
T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)
T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)
T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS
T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS
T_6 : Unweeded check

Dates of sowing
D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

4.2.2 Plant height

The plant height of soybean as influenced by different weed management treatments and dates of sowing are present in Table 2. The seedlings attained significantly tall height by the preplant incorporation of fluchloralin at 1.5 kg ha^{-1} or the preemergence application of pendimethalin at 1.5 kg ha^{-1} compared to unsprayed treatment plots. This response was similar even at a low dose of 0.75 kg ha^{-1} by spraying either of the two herbicides. The interaction established that seedlings were significantly tall by integrated management of weed through the preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at once at 30 DAS compared to the effect of fluchloralin or pendimethalin at a higher concentration of 1.5 kg ha^{-1}.

The herbicidal sprays each at 1.5 kg ha^{-1} or there integration with hand weeding through reduced concentration of either chemical to only 0.75 % also maintained significantly more plant height of soybean during the subsequent growth stages recorded at 40 and 60 DAS and at harvest compared to the crop left unweeded or subjected to hand weeding twice.

The interaction effects consistently revealed that the plant height was significantly more in soybean grown early by 9th July and reduced weed competition by the integrated approach of spraying the plots with

Table 3 : Effect of weed management treatments and dates of sowing on days to 50 per cent flowering in soybean

Treatment	50 per cent flowering
Two hand weedings at 20 and 40 DAS (T_1)	41.28
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	39.00
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	38.60
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	40.00
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	39.54
Unweeded check (T_6)	38.20
SE ±	0.18
CD (0.05)	0.36
9th July (D_1)	41.00
23rd July (D_2)	40.30
6th August (D_3)	39.23
SE ±	0.16
CD (0.05)	0.32
T x D	NS

fluchloralin or pendimethalin at 0.75 kg ha^{-1} followed by hand weeding one month after sowing.

4.2.3 Days to 50 per cent flowering

The data on days to 50 percent flowering of soybean as influenced by different weed management treatments and dates of sowing are presented in Table 3. The days to 50 % flowering reduced significantly in response to the preplant incorporation of fluchloralin at 1.5 kg ha^{-1} or preemergence application of pendimethalin at 1.5 kg ha^{-1} compared to 50 % flowering attained by soybean crop grown in plot receiving two hand weedings. The integrated weed management through these chemicals sprayed at 0.75 kg ha^{-1} and hand weeding once showed a similar response, but the crop in unweeded check attained 50 % flowering stage significantly early compared to any of the five weed management practices tested.

The crop sown on 9th July attained 50 % flowering stage in 41.00 days. Delayed sowing hastened the flowering, the crop shown on 23rd July attained 50 % flowering stage in 40.30 days while that shown on 6th August in 39.23 days. The differences in early flowering were significant due to later sowing.

The interaction between the weed management treatments and the dates of sowing recorded no significant variability in days to 50 % flowering of soybean.

Table 4 : Effect of weed management treatments and dates of sowing on day's to *50 per cent pod set in soybean*

Treatment	50 per cent pod set
Two hand weedings at 20 and 40 DAS (T_1)	57.60
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	56.40
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	56.10
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	57.00
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	56.80
Unweeded check (T_6)	55.80
SE ±	0.36
CD (0.05)	0.73
9th July (D_1)	57.30
23rd July (D_2)	56.40
6th August (D_3)	55.60
SE ±	0.32
CD (0.05)	0.64
T x D	NS

4.2.4 Days to 50 % pod set

Soybean attained the stage of 50 % pod set in 57.60 days by resorting two hand weeding 20 and 40 DAS (Table 4). The unweeded check significantly reduced the duration to 50 % pod set stage to 55.80 days. The herbicides sprays of fluchloralin or pendimethalin had a similar effect as that of the unweeded check while, the reduction in days to 50 % pod set was significantly early compared to the hand weeding treatment.

Delayed sowing enabled the crop to display 50 % of the set pods significantly early. The crop sown on 9th July had attained 50 % pod setting stage 57.30 days. The crop sown on 23rd July and 6th August attained this stage in 56.40 and 55.80 day's, respectively.

The interaction effect due to the combined influence of weed management and sowing date variable was not significant.

4.2.5 Number of pods plant^{-1}

The number of pods plant^{-1} of soybean were remarkably influenced by different weed management and sowing date treatment (Table 5). Maximum number of 13.57 pods were recorded on soybean by adopting hand weeding twice at 20 and 40 DAS. The crop grown

Table 5 : Effect of weed management treatments and dates of sowing on number of pods $plant^{-1}$ in soybean

Treatment	No. of pods $plant^{-1}$
Two hand weedings at 20 and 40 DAS (T_1)	13.57
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	10.95
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	9.92
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	12.68
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	11.60
Unweeded check (T_6)	8.74
SE ±	0.49
CD (0.05)	0.99
9th July (D_1)	11.01
23rd July (D_2)	9.34
6th August (D_3)	8.66
SE ±	0.37
CD (0.05)	0.75
T x D	NS

without any weed management treatment produced significantly least number of 8.74 pods plant^{-1}.

The integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS were equally effective as two hand weedings. The crop in this treatment produced a mean of 12.80 pods plant^{-1} which was on par with the number of pods borne by the crop in two hand weeding treatment. Number of pods plant^{-1} were significantly low in rest of the treatments.

The number of pods plant^{-1} reduced by delayed sowing. The mean maximum and minimum number of 11.01 pods plants^{-1} were recorded in soybean grown on 9th July. Subsequent delay to 23rd July and 6th August significantly reduced to mean number of the pods 9.34 and 8.66 pods plant^{-1}. The interaction effect of weed management and sowing dates treatment was not significant.

4.2.6 Number of seeds pod^{-1}

The weed management treatment exerted a significant influence on number of seeds pods^{-1} on soybean (Table 6). Maximum number of 2.30 seeds pod^{-1} were recorded in the crop by adopting hand weeding twice at 20 and 40 DAS. The left unweeded produced least number of 1.85 seeds pod^{-1}. Weed management through preplant incorporation of fluchloralin or preemergence application of pendimethalin each at

Table 6 : Effect of weed management treatments and dates of sowing on numbers of seeds pod^{-1} in soybean

Treatment	No. of seeds pod^{-1}
Two hand weedings at 20 and 40 DAS (T_1)	2.30
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	2.08
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	1.98
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	2.25
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	2.17
Unweeded check (T_6)	1.85
SE ±	0.04
CD (0.05)	0.08
9th July (D_1)	2.25
23rd July (D_2)	2.11
6th August (D_3)	1.96
SE ±	0.03
CD (0.05)	0.06
T x D	NS

Table 7 : Effect of weed management treatments and dates of sowing on 100 seed weight (g) in soybean

Treatment	100 seed weight (g)
Two hand weedings at 20 and 40 DAS (T_1)	12.58
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	12.56
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	12.55
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	12.57
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	12.56
Unweeded check (T_6)	12.54
SE ±	0.03
CD (0.05)	NS
9th July (D_1)	12.58
23rd July (D_2)	12.56
6th August (D_3)	12.54
SE ±	0.02
CD (0.05)	NS
T x D	NS

1.5 kg ha^{-1} had a positive influence. The crop produced significantly more number of seeds pod^{-1} by these treatment compared to unweeded check. However, this influence was significantly inferior to hand weeding treatment. The integrated approach of weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS was as effective as hand weeding twice.

The number of seeds pod^{-1} reduced significantly consequent to each increment of 2 weeks delay in sowing from 9th July to 6th August. There were a mean number of 2.25, 2.11 and 1.96 seeds $pods^{-1}$ in the crop sown on 9th July, 23rd July and 6th August, respectively.

The number of seeds pod^{-1} of soybean was not influenced by the interaction effect of weed management and dates of sowing treatment.

4.2.7 100 Seed weight (g)

The hundred seed weight of soybean was not influenced by any of the weed management treatments in contrast to the unweeded check (Table 7). Similarly this parameter was not altered by the different dates of sowing from 9th July to 6th August. The interaction was also not significant.

Table 8 : Effect of weed management treatments and dates of sowing on seed yield (kg ha^{-1}) of soybean

Treatment	Seed yield (kg ha^{-1})
Two hand weedings at 20 and 40 DAS (T_1)	966.7
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	840.4
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	797.8
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	914.5
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	852.8
Unweeded check (T_6)	696.7
SE ±	26.6
CD (0.05)	52.2
9th July (D_1)	952.2
23rd July (D_2)	845.0
6th August (D_3)	731.7
SE ±	18.8
CD (0.05)	36.9
T x D	NS

4.2.8 Seed yield (kg ha^{-1})

The seed yield of soybean was substantially influenced by different weed management treatments (Table 8). The cultural method of hand weeding twice at 20 and 40 DAS was the most productive treatment. Maximum seed yield of 966.7 kg ha^{-1} was realised by this practice. The integrated approach of weed management by the preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by weeding once at 30 DAS was equally effective as with two hand weeding. The mean seed yield of 914.5 kg ha^{-1} realized by this practices was on par with the later treatment. The herbicide treatment by the preplant incorporation of fluchloralin at 1.5 kg ha^{-1} or pendimethalin (preemergence) application at 1.5 kg ha^{-1} were inferior to the hand weeding or the integrated weed management treatment with fluchloralin. The seed yield of 840.4 and 797.8 kg ha^{-1} was significantly low in these corresponding treatments. The crop grown unweeded produced significantly low yield of 696.7 kg ha^{-1} compared to any weed management practices tested.

The crop sown early on 9th July produced maximum seed yield of 952.2 kg ha^{-1}. The yield reduced significantly to 845 kg ha^{-1} by sowing the crop late on 23rd July. The reduction was more acute by sowing the

Table 9 : Effect of weed management treatments and dates of sowing on haulm yield (kg ha^{-1}) of soybean

Treatment	Haulm yield (kg ha^{-1})
Two hand weedings at 20 and 40 DAS (T_1)	2558
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	2394
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	2279
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	2497
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	2380
Unweeded check (T_6)	2025
SE ±	62
CD (0.05)	125
9[th] July (D_1)	2550
23[rd] July (D_2)	2310
6[th] August (D_3)	2175
SE ±	50
CD (0.05)	100
T x D	NS

crop still later on 6th August. The yield minimised to as low as 731.7 kg ha^{-1} due to this treatment.

The interaction due to different weed management practices and sowing dates was not significant to alter the seed yield of soybean.

4.2.9 Haulm yield

The weed management treatment had a significant influence of the yield of soybean haulm (Table 9). Maximum haulm yield of 2558 kg ha^{-1} was relaised by adopting hand weeding twice at 20 and 40 DAS. The integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} and hand weeding 30 DAS was equally effective as with hand weeding twice. The haulm yield 2497 kg ha^{-1} due to this treatment was on par with two hand weeding treatment. The crop produced least quantity of 2025 kg ha^{-1} haulm when it was left without weeding.

Early sowing by 9th July, enabled the crop to produce maximum haulm yield of 2550 kg ha^{-1} later sowing reduced the yield significantly. The crop sown on 23rd July produced haulm yield of 2310 kg ha^{-1} and 6th August sown crop produced least quantity of 2175 kg ha^{-1} haulm. The interaction was not significant.

Table 10 : Effect of weed management treatments and dates of sowing on harvest index % of soybean

Treatment	Harvest index (%)
Two hand weedings at 20 and 40 DAS (T_1)	37.78
Fluchloralin 1.5 kg ai. ha^{-1} (PPI) (T_2)	35.10
Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence) (T_3)	35.00
Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS (T_4)	36.62
Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS (T_5)	35.83
Unweeded check (T_6)	34.40
SE ±	0.27
CD (0.05)	0.54
9th July (D_1)	37.50
23rd July (D_2)	35.85
6th August (D_3)	34.20
SE ±	0.24
CD (0.05)	0.48
T x D	NS

4.2.10 Harvest index (%)

Harvest index (%) of soybean was significantly affected by weed management treatments and dates of sowing but their interaction was non-significant (Table 10). The significantly higher harvet index was obtained with (T_1) twice hand weeding (20 and 40 DAS) (37.78%) over other treatments. It was followed by (T_4) fluchloralin 0.75 kg ha^{-1} + 30 DAS treatment (36.62%). The lowest harvest index (34.40%) was observed with unweeded check. Among dates of sowing, the highest harvest index was recorded with (D_1) 9th July sowing (37.50%) which was significantly superior over other sowing dates while lowest harvest index was observed with (D_3) 6th August sowing (34.20%).

4.3 WEED

4.3.1 Weed density

The data on total number of weed (m^{-2}) and their spectrum classified as grasses, sedge and broad leaved weeds are presented in Table 11. Preplant incorporation of fluchloralin or preemergence application of pendimethalin at 1.5 kg ha^{-1} significantly reduced the total number of weeds (m^{-2}) 20 DAS of crop compared to the control treatment. This effect was similar on the number of grasses and broad leaf weeds but not sedges. The low concentration of these herbicides at 0.75 kg ha^{-1} were also effective to reduce the total number of weeds(m^{-2})

Table 11: Effect of weed management treatments and dates of sowing on weed density in (m^{-2}) at 20 DAS in soybean

Treatment	Weed density (m^{-2})			
	Grasses	Sedges	BLW's	Total
T_1	28.11	36.38	13.30	77.79
	(5.40)	(5.98)	(3.78)	(8.88)
T_2	9.10	30.14	2.66	41.90
	(3.18)	(5.58)	(1.91)	(6.55)
T_3	15.52	30.47	3.03	49.02
	(4.06)	(5.61)	(2.01)	(7.07)
T_4	19.90	31.30	3.16	54.36
	(4.57)	(5.68)	(2.04)	(7.44)
T_5	22.39	30.53	7.13	60.05
	(4.73)	(5.92)	(2.88)	(7.81)
T_6	34.04	37.71	15.28	87.03
	(5.92)	(6.22)	(4.03)	(9.38)
SE ±	0.34	0.36	0.04	0.50
CD (0.05)	0.68	NS	0.09	1.00
D_1	22.92	31.15	9.86	63.93
	(4.89)	(5.67)	(3.30)	(8.06)
D_2	26.03	33.75	9.94	69.72
	(5.20)	(5.89)	(3.31)	(8.41)
D_3	27.63	36.03	10.04	73.70
	(5.35)	(6.08)	(3.32)	(8.64)
SE ±	0.24	0.25	0.03	0.30
CD (0.05)	0.48	0.51	0.06	NS
T x D	NS	NS	NS	NS

T_1 : Two hand weedings at 20 and 40 DAS
T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)
T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)
T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS
T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS
T_6 : Unweeded check

Dates of sowing

D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

compared to control. This was also true for grasses and broad leaved weeds.

There were no significant difference in number of grasses, sedges and broad leaved weeds as well as the total number of weeds (m^{-2}) 20 DAS of the crop due to different dates of sowing. The interaction due to the weed management treatments and sowing dates had no significant influence on any one of these weed species and the total intensity.

4.3.2 Density of weed (m^{-2}) at 40 DAS

The density of weeds as influenced by different weed management treatments and dates of sowing are presented in Table 12. The total number of weed (m^{-2}) were significantly low in hand weeded treatment compared to control at 40 DAS. The number of weeds due to the sole use of herbicides or their integration with hand weeding did not cause a significant reduction in the total number of weeds (m^{-2}) compared to unweeded treatment. The density of grasses was significantly reduced by the cultural, chemical and integrated weed management practices compared to control. However these treatment were not effective to significantly reduced the number of sedges (m^{-2}). A significant reduction in number of sedge is evinced only by hand weeding twice at 20 and 40 DAS. Barring the effect of pendimethalin applied at 1.5 kg ha^{-1} the number of broad leaved weeds (m^{-2}) reduced

Table 12 : Effect of weed management treatments and dates of sowing on weed density (m^{-2}) at 40 DAS in soybean

Treatment	Weed density (m^{-2})			
	Grasses	Sedges	BLW's	Total
T_1	33.27	44.03	5.00	82.30
	(5.85)	(6.71)	(2.45)	(9.13)
T_2	34.34	51.64	13.10	99.58
	(5.99)	(7.26)	(3.75)	(10.03)
T_3	37.34	53.84	15.30	106.48
	(6.19)	(7.41)	(4.04)	(10.38)
T_4	30.23	53.84	6.72	90.79
	(5.59)	(7.41)	(2.77)	(9.58)
T_5	34.06	48.48	11.07	93.61
	(5.92)	(7.03)	(3.47)	(9.73)
T_6	46.66	57.07	16.23	119.96
	(6.90)	(7.62)	(4.15)	(11.00)
SE ±	0.34	0.37	0.06	0.72
CD (0.05)	0.68	0.75	0.13	1.44
D_1	33.69	47.09	11.11	91.89
	(5.89)	(6.93)	(3.48)	(9.64)
D_2	35.66	50.54	11.24	97.44
	(6.05)	(7.18)	(3.50)	(9.92)
D_3	38.85	53.10	11.35	103.30
	(6.31)	(7.36)	(3.51)	(10.21)
SE ±	0.23	0.26	0.04	0.50
CD (0.05)	NS	NS	0.09	NS
T x D	NS	NS	NS	NS

T_1 : Two hand weedings at 20 and 40 DAS

T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)

T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)

T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS

T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS

T_6 : Unweeded check

Dates of sowing

D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

significantly by the fore weed management treatment compared to control.

Sowing date treatment had no significant influence on the total number of weeds (m^{-2}). The number of grasses and sedges were on par by growing the crop on 9th July, 23rd July and 6th August. However a significant reduction was noticed in the number of broad leaved weeds (m^{-2}) when the crop was sown early on 6th July then in the latter dates.

The interaction effect were not significant in influencing the grasses, sedges and broad leaved weeds or their total intensity.

4.3.3 Density of weed (m^{-2}) at 60 DAS

The number of grasses (m^{-2}) were significantly low by preplant incorporation of fluchloralin or preemergence application of pendimethalin at 1.5 kg ha^{-1} followed by hand weeding once at 30 DAS compared to the maximum number of weeds recorded in unweeded plots (Table 13). None of the sedges significantly reduced in number owing to different weed management practices compared to control but a significant response was recorded in the management of broad leaved weeds. The cultural management was the best method. It minimised the number of broad leaf weeds to as low as 6.73 (m^{-2}). The integrated weed management by the preplant incorporation of fluchloralin at 0.75 kg ha^{-1} and hand weeding at 30 DAS was equally effective as with the

Table 13: Effect of weed management treatments and dates of sowing on weed density (m^{-2}) at 60 DAS in soybean

Treatment	Weed density (m^{-2})			
	Grasses	Sedges	BLW's	Total
T_1	45.56	65.38	6.73	117.67
	(6.82)	(8.15)	(2.78)	(10.89)
T_2	46.80	75.66	11.52	133.98
	(6.91)	(8.76)	(3.54)	(11.62)
T_3	49.44	78.72	17.57	145.73
	(7.10)	(8.93)	(4.31)	(12.11)
T_4	38.16	69.46	7.13	114.75
	(6.26)	(8.39)	(2.85)	(10.76)
T_5	41.64	73.14	11.90	126.68
	(6.53)	(8.61)	(3.59)	(11.30)
T_6	54.36	35.32	21.53	161.21
	(7.44)	(9.23)	(4.75)	(12.74)
SE ±	0.36	0.58	0.07	0.85
CD (0.05)	0.73	NS	0.14	1.70
D_1	43.37	69.88	12.63	125.88
	(6.66)	(8.42)	(3.69)	(11.26)
D_2	45.73	75.45	12.71	133.89
	(6.81)	(8.74)	(3.70)	(11.61)
D_3	48.88	78.52	12.85	140.25
	(7.06)	(8.92)	(3.72)	(11.88)
SE ±	0.25	0.41	0.05	0.75
CD (0.05)	NS	NS	0.10	NS
T x D	NS	NS	NS	NS

T_1 : Two hand weedings at 20 and 40 DAS
T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)
T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)
T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS
T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS
T_6 : Unweeded check

Dates of sowing
D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

hand weeding treatment. These two treatment were in turn significantly superior to the preplant incorporation of fluchloralin at 1.5 kg ha^{-1} or pre emergence application of pendimethalin 1.5 kg ha^{-1} and the pre emergence application of pendimethalin at 0.75 kg ha^{-1} followed by hand weeding 30 DAS.

The total number of weeds (m^{-2}) were significantly reduced by adopting the hand weeding twice at 20 and 40 DAS or by the preplant incorporation with fluchloralin at 0.75 kg ha^{-1} followed by hand weeding compared to unweeded control. Different dates of sowing had no significant influence on the number of grasses and sedges. However the broad leaved weeds were significantly more in number by sowing the crop late on 6th August. The total density of weeds was not altered by varying the sowing dates.

The interaction was not significant to influence number of grasses, sedges and broad leaved weeds or their cumulative intensity due to different weed management practices and sowing dates.

4.3.4 Density of weed (m^{-2}) at harvest

Maximum number of grasses and broad leaved weeds were recorded in unweeded treatment plots at harvest (Table 14). The grasses were significantly reduced by adopting hand weeding twice (20 and 40 DAS) or preplant incorporation of fluchloralin 0.75 kg ha^{-1} followed by

Table 14 : Effect of weed management treatments and dates of sowing on weed density (m^{-2}) at harvest in soybean

Treatment	Weed density (m^{-2})			
	Grasses	Sedges	BLW's	Total
T_1	58.06	73.47	12.58	144.11
	(7.69)	(8.63)	(3.69)	(12.05)
T_2	60.76	82.75	18.52	162.03
	(7.86)	(9.15)	(4.42)	(12.77)
T_3	63.40	85.42	27.29	176.11
	(8.02)	(9.20)	(5.32)	(13.31)
T_4	56.89	77.64	14.42	148.95
	(7.61)	(8.87)	(3.93)	(12.25)
T_5	59.56	82.20	19.80	161.56
	(7.78)	(9.12)	(4.56)	(12.75)
T_6	67.50	94.26	33.51	195.27
	(8.28)	(9.76)	(5.87)	(14.00)
SE ±	0.27	0.83	0.37	1.50
CD (0.05)	0.55	NS	0.75	NS
D_1	58.63	77.73	19.14	155.50
	(7.72)	(8.87)	(4.49)	(12.51)
D_2	60.60	82.76	21.10	164.46
	(7.78)	(9.15)	(4.70)	(12.86)
D_3	63.84	86.38	22.83	173.05
	(8.05)	(9.34)	(4.88)	(13.19)
SE ±	0.19	0.58	0.26	1.15
CD (0.05)	NS	1.19	0.53	2.30
T x D	NS	NS	NS	NS

T_1 : Two hand weedings at 20 and 40 DAS

T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)

T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)

T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS

T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS

T_6 : Unweeded check

Dates of sowing

D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

hand weeding at 30 DAS. The broad leaved weeds were significantly reduced by all the weed management treatment except preemergence application of pendimethalin at 1.5 kg ha^{-1}. The number of sedges (m^{-2}) were all on par in different treatments. The total number of weeds did not record a significant variants due to different treatments.

The date of sowing was not a significant parameter to influence number of grasses, sedges and broad leaved weed or total number of weed's (m^{-2}). The interaction effect was not significant.

4.3.4 Weed dry matter

The data on dry matter of weed as influenced by different weed management treatments and date of sowing are presented in Table 15. The weed accumulated maximum dry matter of 38.81 (g m^{-2}) in the unweeded plots by 20 DAS. A significant reduction in weed dry weight was incident by preplant incorporation of fluchloralin or pre emergence application of pendimethalin 1.5 kg ha^{-1}. The reduction was more severe than with the use of these herbicides sprayed at 0.75 kg ha^{-1}.

The date of sowing had a significant impact on dry weight of weeds. The extended date of sowing from 9th to 23rd July and 6th August significantly increased mean dry weight of weeds from 27.40 to 30.59 and further to 34.01 (g m^{-2}). The weeds gained more dry weight with advance in their growth at 40, 60 DAS and harvest in all the treatment.

Table 15 : Effect of weed management treatments and dates of sowing on weed drymatter (g m^{-2}) at 20, 40, 60 DAS and harvest

Weed Management treatment / Date of sowing	Weed drymatter (g m^{-2}) 20 DAS				40 DAS				60 DAS				Harvest			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
T_1	35.94	38.40	41.52	38.41	28.18	31.83	35.57	31.86	32.41	36.74	42.05	37.07	35.34	39.68	45.41	40.15
T_2	20.32	24.72	27.43	24.16	35.85	41.67	46.50	41.34	43.74	50.95	56.87	50.52	50.30	58.45	62.24	57.66
T_3	22.73	26.53	29.06	26.11	40.07	44.28	51.67	45.34	51.26	56.69	66.13	58.06	61.51	68.03	79.36	69.63
T_4	23.97	26.98	30.60	27.18	30.07	36.02	39.91	35.33	34.58	41.43	46.23	40.75	38.03	45.57	48.52	44.04
T_5	25.57	28.73	33.74	29.35	33.18	38.96	43.50	38.55	39.82	46.28	52.33	46.31	44.99	52.82	59.14	52.32
T_6	36.07	38.58	41.77	38.81	59.10	62.99	68.41	63.50	78.01	83.15	90.30	83.82	88.15	93.96	102.05	94.72
Mean	27.40	30.59	34.01		37.74	42.62	47.59		46.63	52.62	58.99		53.05	59.75	66.45	

	20 DAS SE ±	20 DAS CD (0.05)	40 DAS SE ±	40 DAS CD (0.05)	60 DAS SE ±	60 DAS CD (0.05)	Harvest SE ±	Harvest CD (0.05)
Weed management treatments (T)	0.28	0.57	0.27	0.54	0.35	0.71	0.69	1.41
Dates of sowing (D)	0.20	0.40	0.19	0.38	0.25	0.50	0.49	1.00
T X D	0.49	0.99	0.46	0.94	0.61	1.23	1.21	2.45

T_1 : Two hand weedings at 20 and 40 DAS
T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)
T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)
T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS
T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS
T_6 : Unweeded check

Dates of sowing
D_1 : 9[th], July D_2 : 23[rd], July D_3 : 6[th], August

At 40 DAS the accumulated weed dry matter was 63.50 (g m^{-2}), it reduced to only 31.86 (g m^{-2}) by adopting the hand weeding treatment. The integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} or preemergence application of pendimethalin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS reduced the dry weight of weeds compared to the use of these herbicides at higher concentration of 1.5 kg ha^{-1}. These trends were persistent at 60 DAS as well as at harvest stage of the crop.

The weed dry matter accumulation (g m^{-2}) increased progressively recording significant difference consequent to delay in sowing by two weeks from 9^{th} July to 6th August. These trends were similar through out the crop growth period. The significant interaction indicated that the hand weeding twice at 20 and 40 DAS was invariable the best treatment under different dates of sowing from 40 DAS untill harvest.

4.3.5 Weed control efficiency

The data on weed control efficiency to different weed control treatments is presented in Table 16. The maximum weed control efficiency of (55.60, 55.90, 57.73%) was recorded at 40, 60 DAS and at harvest was recorded in hand weeding twice (20 and 40 DAS) treatment. While maximum weed control efficiency of (37.98 %) was recorded in preplant incorporation of fluchloralin at 1.5 kg ha^{-1}.

Table 16: Effect of weed management treatments and dates of sowing on weed management efficiency (%) at 20, 40, 60 DAS and harvest

Weed management treatment / Date of sowing	20 DAS D_1	20 DAS D_2	20 DAS D_3	20 DAS Mean	40 DAS D_1	40 DAS D_2	40 DAS D_3	40 DAS Mean	60 DAS D_1	60 DAS D_2	60 DAS D_3	60 DAS Mean	Harvest D_1	Harvest D_2	Harvest D_3	Harvest Mean
T_1	0.36	0.47	0.60	0.48	52.32	49.48	48.01	55.60	58.46	55.81	53.44	55.90	59.92	57.77	55.50	57.73
T_2	43.67	35.94	34.32	37.98	39.32	33.75	31.68	34.92	43.93	38.87	37.18	39.99	42.94	37.79	37.05	39.26
T_3	36.98	31.24	29.62	32.61	32.18	29.43	24.34	28.65	34.29	31.82	26.77	30.96	30.22	27.60	22.23	26.69
T_4	35.55	30.08	26.34	29.99	49.11	42.60	41.66	44.46	55.68	50.17	48.77	51.54	56.85	51.50	50.17	52.84
T_5	28.45	25.54	19.21	24.40	43.48	37.61	36.39	39.16	49.50	43.28	42.05	45.11	48.96	43.76	42.05	44.93
T_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	24.17	20.55	18.35		37.37	37.11	37.26		40.31	36.74	34.70		37.00	36.77	36.94	

	20 DAS SE ±	20 DAS CD (0.05)	40 DAS SE ±	40 DAS CD (0.05)	60 DAS SE ±	60 DAS CD (0.05)	Harvest SE ±	Harvest CD (0.05)
Weed management treatments (T)	0.35	0.70	0.19	0.40	0.17	0.36	0.29	0.58
Dates of sowing (D)	0.25	0.50	0.14	0.29	0.12	0.25	0.20	0.41
T X D	0.60	1.22	0.34	0.71	0.30	0.63	0.50	1.01

T_1 : Two hand weedings at 20 and 40 DAS

T_2 : Fluchloralin 1.5 kg ai. ha^{-1} (PPI)

T_3 : Pendimethalin 1.5 kg a.i. ha^{-1} (pre-emergence)

T_4 : Fluchloralin 0.75 kg a.i.ha^{-1} (PPI) + hand weeding 30 DAS

T_5 : Pendimethalin 0.75 kg a.i. ha^{-1} (Pre-emergence) + hand weeding 30 DAS

T_6 : Unweeded check

Dates of sowing

D_1 : 9th, July D_2 : 23rd, July D_3 : 6th, August

Integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} and hand weeding once at 30 DAS was the next alternative to hand weeding treatment. It registered a mean weed control efficiency of 44.46, 51.54 % at 40 and 60 DAS respectively and 52.84% at harvest. The weed control efficiency was in general low by delayed sowing of crop from 9th July to 23rd July and further to 6th August.

The interaction effect recorded significantly higher weed control efficiency due to herbicide spray in early date of sowing initially at 20 growth stage of crop. But hand weeding twice at 20 and 40 DAS of the crop and it early sowing consistently recorded higher weed control efficiency at 40 and 60 DAS and at harvest.

----- oOo -----

DISCUSSION

CHAPTER V

DISCUSSION

The results of the present investigation "Effect of weather and integrated weed management on production of kharif soybean" are discussed in this chapter with probable cause and effect reasonings drawn from the scanned literature.

Soybean is a highly nutritive and energy rich legume crop. It is called the miracle crop of twentieth century because of its highest compound annual growth rate of production. Soybean on traditionally kharif season crop prone to heavy weed infestation and lower yields. Though soybean is a potential yielder it's productivity has been low due to several factors. The first and foremost among them is menace caused by uncontrolled weed growth in soybean. Weeds cause substantial loss of about 59.87 per cent of total soybean yield (Mishra *et al.*, 1990).

The success of crop production is depends upon the dynamic environmental variations and management strategies in specific ecological situations as agriculture is a gamble with climatic parameter. The weather elements have an direct effect from the germinability of seed sown to the maturity of the crop. So that it is necessary that information on crop weather relationship be generated to help the farmers to sow the crop at right time to exploit the genetic potential most efficiently.

However, the studies on weather with weed management in soybean are meagre. Hence, the present investigation was planned with a view to increase the soybean production through efficient association of weather with proper weed management practices. The results of the field experiment "Effect of weather and integrated weed management on production of kharif soybean" presented in the preceeding chapter are discussed here under.

5.1 WEED FLORA

Initially soybean is a slow growing crop so that it favours early establishment of weeds in the field. During the crop period fourteen weed species including five grasses, one sedge and eight broad leaved weeds were identified in the experimental field. The predominant weed species among grasses are *Cynodon dactylon, Dactyloctinum aegyptinum* while broad leaved weeds were *Parthenium hysterophorus Trianthema portulacastrum* and *Commelina benghalensis* and (sedge) *Cyperus rotundus* was observed in the experimental site. Among all *Cyperus rotundus* was the most dominant and problematic weed observed in the experiment. Monocot weeds dominated weed spectrum throughout the crop growth period accounting major part of weed while dicot weed present in lesser quantity. Similar association of weed flora with soybean has been obtained by Padmavathi

(1994) and Rao (1997) among Monocot weed *Cyperus rotundus* and *Cynodon dactylon* were the predominant, whereas among dicot weeds *Parthenium hysterophorus* and *Argemone mexicana* were most predominant. The results are in conformity with the findings of Jeyabel *et al.* (2001).

5.2 INFLUENCE OF WEATHER

The weather parameters have an indelible dictum on growth of crop and competing weed flora with no regard to the agronomic manipulation. The soybean crop is no exception. Its responses are greately directed by the weather elements. Therefore, its productivity should also guaged through the influence of these elements which is in turn largely influenced by the crop growth regulatory processes. Thus in the present investigation there was a good rainfall of 522.20, 539.7 and 468 mm, respectively during the crop growth period for the treatmental crops sown on 9th, 23rd July and 6th August. This indicates that the quantity of rainfall is sufficient to support good crop growth for each of the three sowing dates tested. Yet the performance of crop was relatively poor. When sowing were delayed to 23rd July and further to 6th August than the ideal time to sow it on 9th July. Significant difference were recorded in plant growth characters yield component and yield. The owes partly to the distribution pattern of rainfall and moisture availability in addition to the intrinsic complexcity of several other weather elements the dry spell in the month of July enforced irrigation for the crop sown on 9th and 23rd July.

(1994) and Rao (1997) among Monocot weed *Cyperus rotundus* and *Cynodon dactylon* were the predominant, whereas among dicot weeds *Parthenium hysterophorus* and *Argemone mexicana* were most predominant. The results are in conformity with the findings of Jeyabel *et al.* (2001).

5.2 INFLUENCE OF WEATHER

The weather parameters have an indelible dictum on growth of crop and competing weed flora with no regard to the agronomic manipulation. The soybean crop is no exception. Its responses are greately directed by the weather elements. Therefore, its productivity should also guaged through the influence of these elements which is in turn largely influenced by the crop growth regulatory processes. Thus in the present investigation there was a good rainfall of 522.20, 539.7 and 468 mm, respectively during the crop growth period for the treatmental crops sown on 9th, 23rd July and 6th August. This indicates that the quantity of rainfall is sufficient to support good crop growth for each of the three sowing dates tested. Yet the performance of crop was relatively poor. When sowing were delayed to 23rd July and further to 6th August than the ideal time to sow it on 9th July. Significant difference were recorded in plant growth characters yield component and yield. The owes partly to the distribution pattern of rainfall and moisture availability in addition to the intrinsic complexcity of several other weather elements the dry spell in the month of July enforced irrigation for the crop sown on 9th and 23rd July.

A precipitation of 72.4 mm incident in three consecutive rainy days early in August soaked the soil sufficient enough for sowing the crop on 6th August. This rainfall was a boom also to the crop sown earlier. The wet period in the first fortnight of August was very congenial for rapid vegetative growth and its ontegeny to flowering for the crop sown earliest on 9th July. The dry spell in the second fortnight of August was detrimental to the crop sown on 23rd July. The crop sown on this date was therefore exposed to the limitation of soil moisture during the critical period of reproductive phase. It had reached 50 % flowering stage by end of August and was further deprived of the first moisture untill 50 % pod setting stage in the fortnight of September. A rainfall of bare low intensity of only 24.7 mm in three days had a severe set back on pod and seed development. The crop sown on 6th August was exposed to a wet weather untill the seedling emergence by first fortnight of the month. But, the subsequent prolonged dry spell untill 4th September impaired the vegetative growth. This was followed by intermittent spells of low intensity only for three days in the subsequent two weed period this was the critical period for ample moisture availability for profuse flowering and effective pod set. The crop attained 50% flowering stage on 14th September thus the poor vegetative growth leading to reduced plant height, less number of pod plant^{-1}, less number of seeds pod^{-1} low test weight and consequently low seed yield and haulms yield ha^{-1} were the result of duration of dry spell coinciding with the critical reproductive stage of the crop than the less intensive drought spells experienced by the crop sown early on 9th July. The weed competition under limited moisture availability condition in the crop sown on later dates was also perhaps more acute to share the available resources and their by affect the crop growth and yield. Boquet and Coco (1997) also stressed that the rainfall is a major determinant of crop yield and its uniform distribution is imperative for realize bountiful yields.

Temperature exceeding 30°C during the day at flowering and pod set were reported to reduced the formation of seeds in the pods (Gibbson and Mullen, 1996). In the present investigation the day temperature ranged from 26 to 34.2°C with least deviations around 30°C for the crop sown on any of the three sowing dates. Emphasising the importance of night temperature (Siddigh and Jollif, 1994) reported that the temperature exceeding 24°C is conducive to increase the seed yield. In the present context, the night temperature during flowering and pod set ranged from 21.5 to 24.7°C for the crop grown on 9th, 23rd July and 6th August. The variability in seed yield due to different dates of sowing in the present investigation indicated that the day and night temperatures had least influence if any on the production of seed plant^{-1}. Sharma and Nellu (1996) observed that the low light at anthesis reduced the crop yield. However, brighter sun shine days for longer period were evinced during the anthesis period of soybean sown on 23rd July and 6th August compared to low sunshine hours experienced during the anthesis period for the crop sown on 9th July. Hence, it is inferred from the present investigation that the day and night temperature or sunshine hours are relatively less important than the rainfall distribution pattern specific to the experimental site at Rajendranagar.

5.3 EFFECT OF WEED MANAGEMENT TREATMENTS AND DATES OF SOWING ON GROWTH, YIELD COMPONENTS AND YIELDS OF SOYBEAN

Crop emergence is the important factor which decides the crop plant stand that inturn affect the crop grain yield. Except pendimethalin at 1.5 kg ha^{-1} *(87.70 %) no other treatment have significant reduction on the crop* emergence thereby indicating that pendimethalin have a phytotoxic effect on crop emergence which results in lower crop emergence percent over rest of the treatments. Ghatak *et al.* (1990) also reported that pendimethalin is phytotoxic to soybean crop at higher dose.

Soybean responded to grow vigorous consequent to the suppression of weeds through the preplant incorporation of fluchloralin or preemergence application of pendimethalin at 1.5 kg ha^{-1}. The seedlings of the crop attained significantly tall height at 20 DAS than the crop allowed to compete with the weed flora. The low concentrations of these herbicides at 0.75 kg ha^{-1} also had a significant impact on the plant height of soybean at this stage. But, the improvement in height due to reduced concentration was not on par with the effect of higher concentration. These trends were persistent on the plant height of soybean in the subsequent stages at 40, 60 DAS and at harvest. These results underline the importance of weed free situation during the seedling growth stage through the use of herbicides. The weeds allowed to grow initially upto 20 DAS and those emerging later upto 40 DAS exerted inter specific competition for resources both from below and above the ground level. The influence of fluchloralin in its interference with energy generation, transport or both was their by inhibiting the ATP formation in mitochondria was well documented by Parka and Soper (1997) as the primary mechanism. Its secondary mode of action is adverse effect on RNA, DNA and protein synthesis. It belongs to dinitroaniline group and is thus involved in the inhibition root and shoot growth. Pendimethalin – A dinitroaniline group chemical and selective in its mode of action. It absorbed by the roots as well as leaves. It inhibits cell division and elongation, rendering the death of germinating seedling (Tomline, 1994). Increase in plant height of soybean by preplant incorporation of fluchloralin by way of efficient weed management in the initital crop growth stage was also assertained. Singh *et al.* (1992) reported that plant height was more with fluchloralin application at 1 kg ha^{-1} followed by hand weeding 30 DAS. Similarly the preemergence application of pendimethalin was reported to minimize the weed flora and created a competition free environment to soybean seedlings in the initial growth stages and thus helped the crop to grow tall. These results are in the line with the findings of Halwankar *et al.* (1995) observed significant increase in plant height with application of pendimethalin 1 kg ha^{-1} followed by hand weeding 30 DAS.

The early vigrous vegetative growth of crop by initial weed management treatment as preplant incorporation of fluchloralin at 1.5 kg ha^{-1} or integrated method of applying fluchloralin at a low dose of 0.75 kg ha^{-1} followed by hand weeding ones at 30 DAS. Inducted the early flush as evinced by a significant advancement in days to 50% flowering and pod set. Similar observation were also earlier recorded by (Halwankar *et al.*, 1995) that the pod plant^{-1} increased with supplement hand weeding at 30 DAS along with fluchloralin or pendimethalin applied at 1 kg ha^{-1} while Marold and Krausse (1997) found that the pods plant^{-1} was the most variable yield component due to weed stress.

The number of pods plant^{-1} were also significantly more in the crop treated with preplant soil application of fluchloralin at 0.75 kg ha^{-1} followed by handweeding once compared to the unweeded check and unweeded treatment. The number of pods plant^{-1} in this treatment however at par with those on the crop subjected to hand weeding twice at 20 and 40 DAS. This result could probably be ascribed to the beneficial influence of aeration in the rhizosphere during the seedling stage of crop. The 100 seed weight was not influenced by any weed management or unmanaged treatment. This indicate that the weed competition exerted negative effect on the production of soybean seed only through the number of pods plant^{-1} and number of seeds pod^{-1}. The similar results were also reported by Muniyappa *et al.* (1986), Jain and Tiwari (1995) that the test weight for the soybean were similar under weed free and weedy condition. On contary Negi and Saini (1994) recorded significantly more 100 seed weight in weed free soybean (19.43 g) than the crop subjected to weed stress (17.43 g) whereas Padmavathi *et al.* (1995) recorded higher (43.4) pods plant^{-1} in hand weeding twice treatment followed by fluchloralin @0.75 kg ha^{-1} coupled with one hand weeding at 30 DAS and their was no significant difference in seed pod^{-1} and test weight among treatments while preplant incorporation of fluchloralin at 1 kg ha^{-1} and hand weeding at 30 DAS were statistically at par in pods plant^{-1} and seed plant^{-1} as revealed by Dubey (1993).

Hand weeding twice at 20 and 40 DAS after sowing was the most effective weed management strategy for maximum production of seed and haulm yield. The initial management of weeds early during the seedling stage upto 20 DAS through herbicides application benefited the crop to attained vigrous vegetative growth. But, weed management through hand weed at 20 and 40 DAS appeared to be more crucial as this practices helped in weed free environment to the crop during the reproductive growth for efficient utilization of resources thus this treatment was most productive with an yield of 966.7 kg ha^{-1} this accounts for as high as 138 % increase in yield over unweeded check. The integrated weed management by the preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding once at 30 DAS was also as effective as two hand weedings. The yield realised was 914.5 kg due to this treatment. This treatment provided a weed free condition to the young growing seedlings through the herbicides on one hand and to the quickly growing crop after one month of its sowing by hand weeding. The fast coverage of the canopy after 30 DAS could probably suppressed further intense weed competition and the crop produce more number of pods $plant^{-1}$ as well as seeds pod^{-1}. Hence, it is imperative that the option of weed management through preplant incorporation fluchloralin at 0.75 kg ha^{-1} in events of labour scarcity during times of peak agricultural operation would go a long way to overcome complete dependence on labour. Hand weeding a month after sowing subsequent to this herbicide treatment would obviously minimize the labour requirement compared to the crop in which the weeding is to be first initiated during 3 – 4 weeks period after sowing.

The date of sowing established that the soybean sown early or 9th July performed better than when sown 23rd July and 6th August. The early sown crop attained maximum plant height produced more number of pod $plant^{-1}$ and seed pod^{-1} there by producing significantly higher quantity of seed and haulm yield. Crop sown on 23rd July and 6th August recorded 88 and 76.8 % less yield over 9th July sowing. These beneficial effects of early sowing accrued mainly through coincidence of wet period during the reproductive phase of the crop compared to moisture deficit situation during the crucial reproductive phase of the crop sown on later dates. Kushwaha (1990) also noticed similar results with delay in sowing but the yields were reduced significantly when sown in the month of August. Sowing on 20th June resulted higher yield attributes and there after reported significant reduction in yield observed by Sahoo *et al.* (1991). While Billore *et al.* (2000) also, reported decrease in harvest index with each delay in sowing dates.

5.4 EFFECT OF WEED MANAGEMENT TREATMENTS AND DATES OF SOWING ON WEED DENSITY, WEED DRY WEIGHT AND WEED CONTROL EFFICIENCY

The mode of action of fluchloralin inhibiting the root and shoot elongation of the germinating weeds was perhaps very effective. Hence, it was noticed that their was a significant reduction in total number of weeds (m^{-2}) at 20 DAS of the crop. This affect was equally good both at a concentration 1.5 kg and 0.75 kg ha^{-1}. Similarly the mode of action of pendimethalin in reducing the cell division and cell elongation of the weed seedlings leading to their mortality was also splendid. Its preemergence application both at 1.5 and 0.75 kg ha^{-1} also reduced the total weed density (m^{-2}), significantly compared to the unweeded check. The sedges, which predominated the grasses or broad leaved weeds in the present investigation escaped the injurious effect of these herbicides. Hence, their was no significant differences in the density of sedges due to different treatments.

The effect of these herbicides was significant on the number of grasses and broad leaved weeds. New weeds probably emerged later both in the herbicide treated plots and in the integrated weed management plots. Later after 20 DAS this accounted for weed density on par with the unweeded check at 40 DAS. However, significantly less number of weeds were recorded only in the hand weeding treatment. Nonetheless, significantly less number of grasses were recorded in all the weed management treatment compared to unweeded check. On the contrary sedges alone were significantly less in number compared to unweeded check. The broad leaved were also significantly less in number by the weed management strategy except that of pendimethalin sprayed at 1.5 kg ha^{-1}. The hand weeded treatment excelled even in 60 DAS over all other treatments and was on par with integrated approach of managing the weed by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS. However this difference was offset at harvest stage. The grasses and broad leaved weeds were consistently low both at 60 DAS and harvest stage, owing to the hand weeding treatment, twice at 20 and 40 DAS and also due to preplant incorporation of fluchloralin at 0.75 kg ha^{-1} and hand weed at 30 DAS. The sedges were not influenced by herbicides at any stages Nimje (1996) found preplant incorporation of fluchloralin @ 1 kg ha^{-1} significantly decreased weed density over unweeded control and Mishra and Bhan (1996) reported negative growth rate of sedges in pendimethalin treated plots.

Weed dry matter is another important parameter to access the competition exerted on the crop. The density of weed may not be the sole criterion to access the inter-specific competition for growth and production of the crop. These weeds may put up low dry matter due to the herbicidal injury at thus become less dominant on the crop. The result of this study indicated that the weed seedlings had accumulated significantly less dry matter (m^{-1}) at 20 DAS of the crop due to, preplant incorporation of fluchloralin or preemergance application of pendimethalin both at 1.5 or 0.75 kg ha^{-1} this effect was persistent even in the later stages at 40 and 60 DAS as well as at harvest stage of the crop. However the hand weeding twice at 20 and 40 DAS treatment was most effective. Weed dry matter (m^{-2}) was least in this treatment from 40 DAS and till harvest.

Weed control efficiency of the herbicides ranged from 24 to 37% at 20 DAS. It improved substantially to 28.31-55% at 40 DAS. It remained high in the later stages and was as much as 53% at harvest in the integrated weed management by preplant incorporation of fluchloralin followed by hand weeding 30 DAS. The weed control efficiency had an edge overall the treatments. If ranged from 56-58% from 40 DAS until harvest.

The dates of sowing had an enormous influence on the occurrence of weed density and their weed dry weight. Relatively more number of weeds were prevalent when the crop was sown late on 23rd July and 6th August compared to those on the crop sown early on the 9th July. The dry weight of weeds also followed similar trends. The interaction established that early sowing by 9th July and weed management either by hand weeding twice at 20 and 40 DAS after sowing or the integrated approach through preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding once at 30 DAS are the most appropriate technology to check the weed density and weed dry matter for efficient weed control efficiency.

The study indicated that the time of sowing of soybean in the first fortnight of July during kharif season under situation of weather parameter incident during the year under report. Hand weeding twice at 20 and 40 DAS is the best weed management strategy. The integrated weed management by preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS is an alternative option to manage the weeds as effectively as two hand weeding instances of acute labour scarcity.

------ oOo -------

SUMMARY

... of grasses and broad leaved weeds but not sedges

... attained significantly tall height ...

... kg ha⁻¹ was also ...

CHAPTER VI

SUMMARY

A field investigation entitled "**Effect of weather and integrated weed management on production of *kharif* soybean *(Glycine max* (L.) merril)**" was carried out on clay loam soil at College Farm, Rajendranagar during Kharif season. Soybean variety JS335 was tested for ideal time of sowing and efficient weed management strategy. The results indicated that the herbicide fluchloralin and pendimethalin are effective in weed management. These herbicides reduced the density and dry weight of grasses and broad leaved weeds but not sedges.

The preplant incorporation of fluchloralin or preemergence application of pendimethalin reduced the weed density and weed dry matter recorded at 20 DAS. This trend was persistent until harvest. The weed free competition at 20 DAS enabled the soybean seedlings to attained significantly tall height. The influence of these herbicides applied at 0.75 kg ha^{-1} was also akin. These herbicides treatment delayed the duration for 50% flowering and pod set stage compared to unweeded check. The crop grown in plots subjected to hand weeding twice at 20 and 40 DAS attained the stage of 50% flowering and pod set significantly later then the herbicides treatment. The yield component were best benefited by the cultural weed management through hand weeding at 20 and 40 DAS and by integrate weed management through preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding at 30 DAS. The number of pods $plant^{-1}$ and number of seeds pod^{-1} were significantly in these treatments. However, the 100 seed weight was not influenced by the weed

management treatment. Maximum seed yielded 966.7 kg ha^{-1} was realized by adopting hand weeding at 20 and 40 DAS. This was 138 % more than the yield obtained by leaving the crop unweeded. The seed yield of 914.5 kg ha^{-1} obtained from the integrated weed management by preplant incorporation of fluchloralin, at 0.75 kg ha^{-1} followed by hand weeding once was on par with the yield of hand weeding treatment. Similar response was found with haulm yield.

Soybean sown early on 9th July performed better and was less exposed to density of weeds and their dry weight for competition then in the later dates of sowing. The crop grew significantly tall and maintained this trend all through the growth stages compared to the crop grown on 23rd July and 6th August. Days to 50% flowering and pod set were has similar trend by late sowing. The number of pods $plant^{-1}$ and number of seeds pod^{-1} were also significantly reduced. The 100 seed weight alone was not affected. The yield reduction was severe. The crop produced 952.2 kg ha^{-1} when it was sown on 9th July. The yield reduced to 845 kg ha^{-1} by extending the sowing time to 23rd July.

The yield reduced further to as low as 731.7 kg ha^{-1} by extending the sowing to 6th August. The study established that for weather parameters incident during the year under study soybean is ought to be sown in the 1st fortnight of July to realize optimum yield. The weeds are to be effectively managed by disorting to hand weeding twice at 20 and 40 DAS or by the integrated approach through preplant incorporation of fluchloralin at 0.75 kg ha^{-1} followed by hand weeding once at 30 DAS.

LITERATURE CITED

LITERATURE CITED

Agrawal S K, Agrawal K K and Jain K K 1995 Effect of herbicides and spacing on weed dynamics in soybean weed association. World Weeds 2 : 83-92.

Agrawal S K, Agrawal K K and Jain K K 1996 Efficacy and economics of weed control and row spacing in soybean weed ecosystem. P K V Research Journal 20 (2) : 118-121.

Angiras N N and Rana M C 1995 Dose and time of application of imazethapyar for weed control in soybean. Indian Journal of Agronomy 40 (1): 59-63.

*Asrar G, Mynemi R B and Kanemasa E T 1989 Estimation of plant canopy attributes from spectral reflectance measurements in theory and application of optimal remote sensing (Asrar G Ed). Willey New York 252-296.

Balasubramaniam N and Arumugam M 1996 Integrated weed management in soybean. Indian Journal of Weed Science 28 (1&2): 91-92.

*Balasundaram V R and Sen A 1994 Effect of climate on growth and nodulation of soybean proceedings of Indian National Science Academy 40 (6) : 642-628.

Baldochi D, Verma S B, Rosenberg N J, Blad B L, Garay A and Sphecht J E 1983 Influence of water stress on the diurnal exchange of mass and energy between atmosphere and soybean canopy. Agronomy Journal 75 (3) : 543 – 548.

Barik T and Sahoo K C 1989 Response of Soybean to dates of sowing and spacing. Indian Journal of Agronomy 34 (4): 464-466.

Bhalla C S, Kurchania S P, Tiwari J P and Paradkar M R 1998 Bioefficacy of pre and post emergence herbicides for weed control in soybean (*Glycine max* (L.) Merril). Indian Journal of Weed Science 30 : 149 – 152.

*Bhan V M 1994 Weed management – A factor for sustainability in crop production. : In proceedings of XXI national symposium on response management for sustained crop production held at Rajasthan Agriculture University, Bikaner 209-216.

Bhan V M and Kumar S 1996 Pollution free weed management an approach. Pestology 20 : 25 – 35.

Billore S D, Joshi O P and Ramesh A 2000 Performance of soybean (*Glycine max*) genotypes on different sowing dates and row spacing in vertisols. Indian Journal of Agricultural Sciences 70 (9) : 577-580.

Billore S D, Joshi O P and Ramesh A 2001 Effect of herbicides on nodulation, yield and weed control in soybean. Indian Journal of Agricultural Sciences 71 (3) 193-94.

Board J E and Settimi J R 1988 Photoperiod requirements for flowering and flower production in soybean. Agronomy Journal 80 : 518-525.

*Boquet D J and Coco A B 1997 Short season soybean production to increase yield and decrease risk. Lousiana Agriculture 40 (1):25-27.

Chandel A S and Saxena S C 2001 Effect of some new post emergence herbicide on weed parameter and seed yield of soybean. Indian Journal of Agronomy 46 (2): 332-338.

Chhokar R S, Balyan R S and Pahuja S S 1996 Integrated weed management studies in soybean (Glycine max (L) Menill) Indian Journal of Weed Science 28 (3&4): 133-136.

Chhokar R S, Balyan R S, Pahuja S S 1995 The critical period on weed competition in soybean. Indian Journal of Weed Science 27 (3&4): 197-200.

Daniell M B and Scott H D 1991 Water use efficiency of double cropped wheat and soybean. Agronomy Journal 83 :564-570.

Das T K and Yadaraju N T 1996 Crop weed competition studies in some *kharif* crops part-I physiological parameters. Indian Journal of Agricultural Research 30 (4) : 235-241.

Dubey M P 1993 Weed management in soybean (*Glycine max*) based intercropping system. Indian Journal of Agronomy 43 (4) : 606-611.

Dubey S K, Jain H C, Kosta E D and Raghu J S 1984 Integrated weed management in soybean. Indian Journal of Weed Science 16 (4) : 238 – 243.

Egli D B and Yuzw 1991 Crop growth rate and seeds per unit area. Crop Science 31 : 439-442.

Fujitha K, Ofosu- Badu K G and Ogata S 1992 Biological nitrogen fixation in mixed legume - cereals cropping system. Plant and Soil 141 (1-2) : 155 – 175.

Ghatak S, Sanda G, Bhattacharya S P and Battacharjee D 1990 Efficiency of herbicides in controlling weeds in soybean. Pestology 14 (7) : 11 – 16.

Gibson L R and Mullen R E 1996 Influence of day and night temperature on soybean seed yield. Crop Science 36 (1): 98-104.

Gogoi A K, Kalitha M, Rathak A K and Deka J 1991 Integrated weed management in soybean (*Glycine max* (L). Merill). Indian Journal of Agronomy 36 (3) : 453 – 454.

Gogulwar M, Raikwar K K, Jain H C and Kurchania S P 1992 Comparative efficacy of herbicides and mechanical methods of weed control in soybean. JMKVV Research Journal 26 (2) : 8 – 11.

*Hadley P E H, Roberts R J Summer Field and Minchin F R 1984 Effects of temperature and photoperiod on flowering in soybean. A quantitative model. Annals on Botany 53:669-681.

Halvankar G B, Raut V M, Taware S P and Patil V P 1995 Integrated weed control in soybean Journal of Oilseeds Research 12 (1): 69-73.

Halwankar G B, Raut V M and Patil V P 1986 Chemical weed control in soybean. Pesticides 20 (11):49-51.

*Han I F and Wang J L 1995 Pre and Post Flowering photoperiod responses in early soybean varieties. Soybean Genetics News Letter 22 : 89-92.

Haung S, Ashley D A and Boerma H R 1993 Light intensity row spacing and photoperiod effects on expression branches on stem in soybean. Crop Science 33 : 29-37.

Hedge D M 2000 *Oil Seeds – Technology for high yields.* The Hindu Survey of Indian Agriculture pp. 65 – 71.

*Jackson M L 1973 Soil chemical analysis. Prentice hall of India private Ltd., New Delhi.

Jain H C and Dubey S K and Bisen J S 1988 Influence of weed control and fertility levels on soybean. Indian Journal of Weed Science 20 (2) : 68 – 74.

Jain K K and Tiwari J P 1995 Effect of herbicides and tillage operations on weeds yield attributes and yield of soybean. Indian Journal of Weed Science 27 (1 & 2) : 32 – 35.

Jain V K, Chauhan Y S, Bhargava M K and Sharma A K 2000 Chemical weed control in soybean. Indian Journal of Agronomy 45 (1) : 153-157.

Jasami K P, Patel M P and Patil H S 1993 Growth and yield of soybean (*Glycine max*) as influenced by sowing period and seed rate. Indian Journal of Agronomy 38 (4): 670-672.

Jeyabel, Palaniappan S P and Chelliah S 2001 Efficacy of metribuzin and trifluralin on weed managemnet in soybean. Indian Journal of Agronomy 46 (2) : 339-342.

*Jhonson H W, Borth Wick J A and Leffel R C 1960 Effects of photo period and time of planting on rates of development of the soybean in various stages of the life cycle. Botanical Gazette 122: 75-95.

*Jordan T N Coble H D and Wax L M 1987 Weed control – In soybeans – Improvement production and uses. Agronomy Monograph No.16, Agronomy Society of America USA 429-461.

Kane M V, Steele C C and Graban L J 1997 Early maturing soybean cropping pattern yield response to planting dates Agronomy Journal 89 (3):454-458.

Karmakar P G and Bhatnagar P S 1995 Performance of soybean varieties at different dates of sowing in malwa plateau. Indian Journal of Agricultural Sciences 65 (2) : 138-139.

Kewat M L, Pandey J, Yaduraju N T and Kulshrestra G 2000 Economic and Ecofriendly weed management in soybean (*Glycine max* (L) Merril). Indian Journal of Weed Science 32 (3&4): 135-139.

*Koch W, Beshir M E and Unter Ladstatter R 1982 Crop losses due to weeds. In improving weed management FAO. Plant Production and Protection paper 44: 153-165 Rome.

Kohle S S 1996 Integrated weed management in soybean. Annual report, kharif 1996. Department of Agronomy. IGKVV, Raipur, 84-86.

Kondap S M, Chandrasekhar Rao P, Reddy C N and Reddy N V 1990 Weed management on crops. Bulletin published for Officers of State Department of Agriculture.

Korti L L, Williams J M, Sphecht J E and Soranson R C 1983 Irrigation of soybean genotypes during reproductive ontogeny. Agronomic Responses. Crop Science 23:521-527.

Kumar G S N S 1988 Effect on herbicides on weed flora, growth and yield of soybean. M.Sc.(Ag.) Thesis submitted to ANGRAU, Hyderabad.

Kumar G S N S, Rao V V and Rao A S 1994 Performance of some herbicide in soybean. The Andhra Agricultural Journal 41 (1-4) : 57 – 60.

Kurchania S P 1989 Comparative efficacy of herbicides and mechanical methods of weed control soybean. JNKVV Research Journal 26 (2) : 8 –11.

Kurchania S P, Trivedi K K and Dubey M P 1990 Herbicidal weed control in soybean. Indian Journal of Weed Science 22 (3) : 25 – 30.

Kurmawanshi S M, Sharma R S and Sahu T R 1995 Studies on Economic viability of weed control with herbicides in soybean. Indian Journal of Weed Science 27 (3&4) 110-113.

Kushwaha H S 1990 Response of soybean to dates of sowing and levels of phosporus. Agricultural Science Digest 10 (4): 231-232.

*Lang A R G , Xiang Yueqin and Norman J M 1985 Crop Structure and the penetration of direct sunlight. Agricultural and Forest Meteorology 35 : 83-101.

*Langemeier M L, Martin J R and Slack C S 1983 Controlling Johnson grass in reduced tillage systems of soybean. Abstracts in Proceeding North Central Weed Conference. Weed Abstract 34 (10) : 258.

Lawn G J and Hume D J 1985 Response to tropical and temperate soybean genotypes to temperature during early reproductive growth. Crop Science 25 : 137-142.

Lokras V G, Singh V K, Bisen C R and Tiwari J P 1985 Chemical weed control in soybean. Indian Journal of Weed Science 17 (4) : 45 – 48.

Malik D S and Lal J P 1973 Control of weeds by chemical and cultural methods in soybean. Indian Journal of Weed Science 5 (1) : 11 – 15.

Mandloi K S, Vyas M D and Tomar V S 2000 Effect of weed management methods in soybean (Glycine max) grown in vertisols of Madhya Pradesh. Indian Journal of Agronomy 45 (1): 158-161.

Maurya B M, Gogulwar N M and Tiwari J P 1990 Herbicidal weed control efficiency and nutrient removal by weeds in soybean. Indian Journal of Weed Science 22 (3 & 4) : 51 – 56.

Mishra J S and Bhan V M 1996 Growth pattern of weeds and soybean under various weed management practices. World Weeds 3: 61-66.

*Mishra O P, Tiwari S and Rani R 1990 Weed control in soybean. Abstracts of Biennial Conference of Indian Society of Weed Science, Jabalpur p. 75.

*Monteith J L, Huda A K S and Midya D 1989 Modelling the growth and development of sorghum and pearl millet. Research Bulletin No.12, ICRISAT, (AP) India 30-39.

*Morold R and Krausse G W 1987 The effect of natural weed flora on development and yield formation in soybean. Eurosoya 5 : 12 – 21.

Muniyappa T V, Rama Chandra Prasad T V and Krishna Murthy 1986 Critical stages of crop weed competion and chemical weed control in soybean. Indian Journal of Weed Science 18 : 34 – 38.

Muthuvel P, Udaya Soorian C, Chamy A and Pallikondaperumal 1989 Studies on time of sowing. Madras Agricultural Journal 76 (4) : 237 – 238.

*Nawab Ali 1992 Soybean food potential and its exploitation for Indian situation. Agricultural Situation in India 17 : 395 – 402.

Nayak M P, Vyas M D and Mandloi K S 2000 Efficacy of pendimethalin in soybean (Glycine max). Indian Journal of Agronomy 45 (1): 162-165.

Negi S C and Saini J P 1994 Studies on integrated weed control in soybean (*Glycine max*). Indian Journal of Weed Science 26 (3 & 4) : 100 – 103.

Nimje P M 1989 Weed management studies in soybean invertisols. Indian Journal of Weed Science 21 : 88 – 91.

Nimje P M 1996 Effect of row spacing, mulching and weed control on weed growth and yield of soybean. Indian Journal of Agronomy 41 (3) : 427 – 432.

*Olsen S R, Codec C L, Watanabe F S and Dean D A 1954 Estimation of available phosphorous in soils by extraction with sodium carbonate. USDA, Circular No. 939.

Padmavathi P 1994 Integrated Weed Management in soybean (*Glycine max* L) M.Sc.(Ag.) Thesis submitted to ANGRAU, Hyderabad.

Padmavathi P, Satyanarayana V, Chandra Sekhara Rao P, Latchanna A and Vara Prasad P V 1995 Integrated Weed management system in soybean (*Glycine max* L) Journal of Oil Seeds Research 12 (2):282-285.

Pandey J, Sharma R and Verma A K 1996 Effect of dose and time of chlorimuran ethyl on weeds and yield on soybean. Annals Agricultural Research 17 : 205-208.

Parka S T and Soper O H 1977 The physiology and mode of action of dinotroaniline herbicide. Weed Science 25 : 79 – 87.

Patil B M, Satao R H and Lahariya G S 1996 Weed control studies in soybean. Indian Journal of Weed Science 28 (3&4): 212-213.

Patra A P 1987 Weed control in soybean. Indian Journal of Weed Science 19 (1 & 2):47-51.

Paul S R and Guha B 1994 Effect of varieties and dates of sowing on growth and yield of soybean under rainfed condition in Assam.. Annuals of Agricultural Research 15 (1): 102-104.

*Pookpakni A and Kuo G C 1993 Soybean production under saturated soil conditions in Thailand proceedings of an International symposium, Tiwan 479-485.

Pramila B and Kodandaramaiah D 1997 Influence of integration of cultural practices and herbicides on weed control in soybean. Journal of *Research*, ANGRAU, 25 (2): 4-7.

Pushpendra, Kamandra Singh and Manoj Kumar 2000 Grow soybean in rabi season. Indian Farmers Digest 32 (2): 13-14.

Rani B P and Ramaiah D K 1999 Responses of soybean varieties to different sowing dates under rainfed condition of Nagarjuna Sagar Project area of Andhra Pradesh. Annals of Agricultural Research 20 (2) : 235 – 237.

Rao S and Veeraraghavaiah R 1996 Nutrient uptake of soybean as affected by weed management. The Andhra Agricultural Journal 43 (2-4) 194-195.

Rao S N R 1997 Integrated weed management in irrigated rabi soybean (*Glycine max* (L.) Merill) Ph.D. Thesis submitted to ANGRAU, Hyderabad.

Reddy C N, Reddy V N, Reddy M D and Padmavati Devi M 1998 Studies on the integrated weed management in soybean. Indian Journal of Weed Science 30 (3&4): 172-175.

Reddy S R M 2000 Response of soybean to crop stand and weed management practice. M.Sc. (Ag.) Thesis submitted to ANGRAU, Hyderabad.

Reddy T Y and Reddy G H S 1995 Principles of Agronomy. Kalyani Publishers, New Delhi 452.

*Rivitake H, Wong Yair W, Hiramatsu K and Ynezaju T 1997 The effect of environmental factors on elongation pattern of soybean pods. Crop Science Society of Japan 63: 51-52.

*Ruiz Vega J 1985 Soybean phenology and yield as influenced by environmental and management factors. Desertation and Abstracts International (Science and Engineering) 46 (1) : 78.

Sahoo N C, Mahapatra P K, Dixit R C and Uttaray S K 1991 Effect of sowing date on growth, yield and quality of soybean (*Glycine max*). Indian Journal of Agricultural Sciences 61 (9): 665-668.

Sainik S K and Singh J N 1981 Effect of post planting stimulated rainfall and planting depth on seedling emergence in soybean. Legume Research 4 (1): 43-47.

Santharam and Shiv Shankar K, 1982 Effect of weed control in enhancing fertilizer use efficiency in soybean. Indian Journal of Weeds Science 14 (2) : 89 – 95.

Seedigh M and Jolliff G D 1984 Night temperature effect on morphology, phenology, yield and yield components of indeterminate field grown soybean. Agronomy Journal 76:824-828.

Shafshak S E, Eldin G M S, Hassan M Z, Mohammed M S A 1997 Evaluation of six soybean genotypes under different population densities and two dates of sowing. Annals of Agricultural Sciences 35 (91) : 115 – 130.

*Shah S K, Gopalan A K S and Kamat D S 1982 Relations between remotely sensed canopy temperature, crop water stress, air vapour pressure deficit and evapotranspiration in chick pea. Agricultural and Forest Meterology 38 : 17 – 26.

*Sharma K and Neelu Walia 1996 Growth and yield of soybean as influenced by light intensity and cytokinin. Environment and Ecology 14 (2) : 307-310.

*Shih C C , Shin Shen H O, Kuosheng Feug 1997 Extension of crop coefficient for sorghum soybean in Tiwan Under tropical condition. International Agricultural Engineering Journal 6 (2): 95-108.

Singh G and Singh D 1992 Weed control efficiency of oxyfluorfen, acifluorfen, metribuzin and liuron in soybean (*Glycine max* (L) Merill). Indian Journal of Weed Sciences 24 (2) : 97-99.

Singh H, Singh J K and Brar L S 1994 Crop weed competition studies in soybean (*Glycine max* (L) Merill). Indian Journal of Weed Science 26 (3&4) 148-151.

Singh R, Kalia B D and Negi P S 1992 Integrated weed management in soybean. Indian Journal of Weed Science 21 (1&2) : 94-96.

Singh V P and Bhan V M 1997 Influence of dates of sowing, weed control measures and row spacing in soybean. Indian Journal of Weed Science 29 (3&4): 115-119.

Singh V P, Mishra J S and Bhan V M 1996 Integrated weed management in soybean (*Glycine max* (L) merill). Indian Journal of Weed Science 31 (3&4) : 267-268.

Subbaiah and Asija G L 1956 Rapid procedure for estimation of available nitrogen in soils. Current Science 25: 259 – 260.

Thomas J F, Raper C D and Week W W 1981 Day and night temperature effect on nitrogen and soluble carbohydrate allocation during early, reproductive growth in soybean. Agronomy Journal 73 : 577 – 582.

Tiwari J P, Kurchania S P, Paradhkar N R and Bhalla C S 1996 Direct and residual effects of herbicides in a soybean wheat cropping system. Indian Journal of Weed Sciences 28 : 150-155.

Tiwari J P, Trivedi K K and Dubey S 1988 Study on the effect of herbicides on soybean. Indian Journal of Weed Science 20 : 76 - 78.

*Tjitra Semeto 1990 A study on weed control in soybean. Biotropia 4 : 49 – 56.

*Tomline C 1994 A world compendium. The pesticide manual : Incorporating the (Agrochemicals hand book) Tenth edition. Crop protection publications. The royal society of chemists British corp protection Council.

Tuteja S S , Lakpale R, Pandey N and Tripathi R S 1995 Effect of herbicide and phosphorus on yield and quality of soybean. Indian Journal of Agronomy 40 (1) 128-129.

Tyagi S K and Tripathi R P 1983 Effect of temperature on soybean germination. Plant and Soil 74 (2): 272-280.

Veeramani A, Palchamy A, Ramasamy S and Ranga Raju G 2000 Integrated weed management in soybean (Glycine max) under different moisture regimes and population densities. Indian Journal of Agronomy 45 (4) : 740-745.

Velu G and Sankaran S 1996 Herbicidal weed management in soybean. Madras Agricultural Journal 83 (6): 331-334.

*Walkley A J and Black C A 1934 Estimation of organic carbon by chromic acid titration method. Soil Science 37 : 29 – 38.

*Wang Z, Reddy V R and Querbedequz B 1997 Growth and photo synthetic responses of short term cold temperature and solar radiation. Environmental and experimental botany 37 (1): 13-24.

Note : Literature cited is as per the thesis guidelines of Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad.

* Originals not seen

EFFECT OF TILLAGE AND INTEGRATED WEED MANAGEMENT ON PRODUCTION OF *KHARIF* SOYBEAN (*Glycine max* (L.) Merril)

PRANAV SINHA
B.Sc. (Ag.)

JULY, 2009

843

12)