EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN *SENNA* (Cassia angustifolia) – *ISABGOL* (Plantago ovata) CROPPING SEQUENCE ON GROWTH, YIELD AND QUALITY OF CONSTITUENT CROPS.

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722, DIST: AHMEDNAGAR,
MAHARASHTRA STATE, INDIA

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

In

AGRONOMY

M. P. K. V., LIBRARY, RAHURI
ACC No. 1-6219
Call No. 630/ KHA

By

KHARBADE SWAPNIL HEMRAJ
M.Sc. (Agri.)

Regn. No.0102

**DEPARTMENT OF AGRONOMY,
POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722, DIST: AHMEDNAGAR,
MAHARASHTRA STATE, INDIA**

2006

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN *SENNA* (Cassia angustifolia) – *ISABGOL* (Plantago ovata) CROPPING SEQUENCE ON GROWTH, YIELD AND QUALITY OF CONSTITUENT CROPS.

By

KHARBADE SWAPNIL HEMRAJ

M.Sc. (Agri.)

Regn. No.0102

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722, DIST: AHMEDNAGAR,
MAHARASHTRA STATE, INDIA

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

In

AGRONOMY

APPROVED BY

Dr. C.B. Gaikwad
(Chairman and Research Guide)

Dr. A.S. Patil
(Committee Member)

Dr. U. V. Mahadkar
(Committee Member)

Dr. U.D. Chavan
(Committee Member)

Prof. A.D. Dumbre
(Committee Member)

DEPARTMENT OF AGRONOMY,
POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722, DIST:.AHMEDNAGAR,
MAHARASHTRA STATE, INDIA

2006

Affectionately dedicated

to my beloved parents, teachers,

ayurvedic medicine practitioners

and the farming community.

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof,
has not been submitted by me or any other person
to any other University or Institute
for a Degree or Diploma.

Place: M.P.K.V., Rahuri
Date: 19/05/2008

(Kharbade S.H.)

Dr. C.B. Gaikwad.
M.Sc. (Agri.) Ph.D.
Head, Department of Agronomy
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413 722, Dist: Ahmednagar,
Maharashtra State (India).

CERTIFICATE

This is to certify that the thesis entitled " **EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN *SENNA* (Cassia angustifolia) – *ISABGOL* (Plantago ovata) CROPPING SEQUENCE ON GROWTH, YIELD AND QUALITY OF CONSTITUENT CROPS** " submitted to the faculty of agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist: Ahmednagar, Maharashtra State. In partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** In **AGRONOMY**, embodies the results of a piece of *bonafide* research work carried out by **SHRI. KHARBADE S.H.** under my guidance and supervision and that no part of this thesis has been submitted for any other degree, diploma or published in any other form.

The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

Place: M.P.K.V., Rahuri
Date: 19 / 5 / 06

(C.B. Gaikwad)
Research Guide

Dr. A.S. Jadhav.
Associate Dean
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413 722, Dist: Ahmednagar,
Maharashtra State (India).

CERTIFICATE

This is to certify that the thesis entitled " **EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN *SENNA* (Cassia angustifolia) – *ISABGOL* (Plantago ovata) CROPPING SEQUENCE ON GROWTH, YIELD AND QUALITY OF CONSTITUENT CROPS** " submitted to the faculty of agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist: Ahmednagar, Maharashtra State. In partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** In **AGRONOMY**, embodies the results of a piece of *bona fide* research work carried out by **SHRI. KHARBADE S.H.** under the guidance and supervision of **Dr. C.B. GAIKWAD**, Head, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.). No part of this thesis has been submitted for any other degree, diploma or published in any other form.

Place: M.P.K.V., Rahuri
Date: / /

(A.S.Jadhav)
Associate Dean

ACKNOWLEDGEMENT

I consider myself fortunate to have had an opportunity to work under the guidance of Dr. C.B. Gaikwad, Head, Department of Agronomy, M.P.K.V., Rahuri (M.S.). It gives me immense pleasure to express my gratitude to him for his invaluable and painstaking guidance, suggestions and constructive criticism, constant encouragement and support during the course of this investigation and in the preparation of this manuscript of the research work.

I take this golden opportunity to express my deep sense of gratitude and indebt ness to Dr. U.V. Mahadkar, Ex-Professor of Agronomy and Chief Scientist, Water Management Project, M.P.K.V., Rahuri (M.S.) for his inspiring guidance, encouragement and help throughout the course of the studies. I am grateful to Dr. A.S. Patil, Soil Chemist, Department of Agril. Chemistry & Soil Science, Prof. A.D. Dumbre, Seed Specialist, Seed cell, Dr. U. D. Chavan, Asstt. Professor of Biochemistry, and Dr. D.W. Thawal, Professor of Agronomy M.P.K.V., Rahuri (M.S.) for their interest, encouragement and constructive criticism, which helped me to improve the quality of the research work.

I express my thanks to Dr. T.B. Londhe, Dr. K.E. Kasole, Dr. P.D. Girase, Dr. A.V. Solankhe, Dr.A.G. Wani and Dr. M.B. Dhonde faculty members at Department of Agronomy, M.P.K.V., Rahuri (M.S.). My heartiest thanks to Shri. S.B. Khomane and Shri. B.S. Mhaske, Agril. Assistants for their kind co-operation during the conduct of the research work. I am highly indebted to Shri. S.L. Pandav and Dr. S.P. Joshi for their kind co-operation in extremely difficult circumstances encountered during the study and to the Librarians of Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), National Chemical Laboratory, Pune (M.S.), Agharkhar Research Institute, Pune (M.S.), National Informatics Centre, Pune (M.S.), Indian Agricultural Research Institute, New Delhi and MSSRF, Chennai (T.N.) for their kind permission to avail the library facilities at their institutes.

I also place on record my thanks to the authors of scientific articles, journals, manuals, books, newsprint articles and web pages from where I obtained the data required for this thesis. I am grateful to my family members for their encouragement, patience and tolerance they had while I worked on this research work. I am also thankful to my mentors Dr. S.M. More and Shri. A.B. Kamble and my friends Shri. J.P. Deshmukh, Shri. P.V. Mahatale, Shri. S,V. Gadekar, Shri. H.R. Gaikwad, Miss. R.H. Shinde and Miss. M.D. Shirole for their help received during the course of this study.

Place: M.P.K.V., Rahuri. *(Kharbade S.H.)*

Date: / /

TABLE OF CONTENT

LIST OF TABLES

(List of tables cont'd...)

M.P.K.V. Rahuri LIBRARY

LIST OF FIGURES

LIST OF PHOTOPLATES

LIST OF APPENDICES

ABSTRACT

ABBREVIATIONS

@	At the rate of
%	Percent
$^{-1}$	Per
°C	Degree Centigradc
°E	Degree East
°N	Degree North
Anon.	Anonymous
BSS	Bright sunshine
C.D.	Critical difference
C.V.	Co-efficient of variation
cm	Centimeter
cc	Centimeter cube
Cv	Cultivar
d	Day
DAS	Days after sowing
dm^2	Decimetre square
dS m^{-1}	Decisiemen per metre
$	Dollar
et al.	Et alli (and other)
Fig.	Figure
g	Gram (s)
ha	Hectare
hr	Hour (s)
i.e.	Id est (that is)
kg / kg ha^{-1}	Kilogram (s) / Kilogram (s) ha^{-1}
K / K_2O	Potassium / Potassium oxide
km hr^{-1}	Kilometers per hour
m / m^2 / m^3	Metre (s) / Square metre (s) /Cubic metre (s)
Max / Min	Maximum /Minimum
min	Minutes
Mg / mg	Megagram / Milligram
ml / mm	Millilitre / Millimetre
N	Nitrogen
nm	Nanometre
No	Number
N.S.	Non-significant
P / P_2O_5	Phosphorus / Phosphorus pentaoxide
PP	Photoplate
pp	Particular page (s)
q / q ha^{-1}	Quintal (s) / Quintal (s) per hectare
RH	Relative humidity
Rs.	Rupees
S.E.	Standard error
t	Tonne (s)
US	United States
viz.,	Videlicet (namely)
M.S.	Maharashtra State

ABSTRACT

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN *SENNA* (Cassia angustifolia) – *ISABGOL* (Plantago ovata) CROPPING SEQUENCE ON GROWTH, YIELD AND QUALITY OF CONSTITUENT CROPS.

By

KHARBADE SWAPNIL HEMRAJ

A candidate for the degree of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

In

AGRONOMY

Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722,
Dist: Ahmednagar, Maharashtra State, India
2006

Research Guide : Dr. C.B. Gaikwad.

Department : Agronomy.

An experiment entitled "Effect of integrated nutrient management in *senna* (Cassia angustifolia)-*isabgol* (Plantago ovata) cropping sequence on growth, yield and quality of constituent crops" was conducted at the Post Graduate Institute, Instructional Farm, M.P.K.V., Rahuri for two consecutive years during 2002-03 and 2003-04 on a soil clayey in texture, low in available nitrogen (209.14 kgha^{-1}), medium in available phosphorus (24.94 kgha^{-1}) and high in available potassium (478.12 kgha^{-1}). An experiment was conducted to find out the appropriate level of recommended dose of fertilizers viz., 50%, 75%, 100% (75:50:0 NPK kgha^{-1}) and 125% and source of nitrogen application to *senna* (*sonamukhi*) during kharif through a combination of urea and FYM. The experiment was laid out in randomised block design during kharif. With a view to find out the residual effect of the treatments given to *senna* (*sonamukhi*) during kharif, *isabgol* was grown in the rabi season. An experiment was laid out in split plot design during rabi season, the kharif treatments were considered as main plot treatments and two levels of recommended dose of fertilizers viz., 75% and 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizers was applied as sub plot treatments to *isabgol* in rabi season.

In kharif season, for *senna* (*sonamukhi*) an application of 100% RDF

significantly superior to 100% RDF applied through inorganic fertilizer and the lower levels of fertilizers and at par to the higher levels of fertilizers in respect of plant height, plant spread, number of branches, leaf area, total fresh matter, total dry matter, number of filled pods, weight of filled pods, number of seeds plant^{-1}, weight of seeds plant^{-1}, thousand seed weight, total fresh and dry leaves yield ha^{-1} and seed yield ha^{-1}. The percent increase over the application of 100% RDF applied through inorganic fertilizer was 0.31 and 1.37, 1.38 and 1.06, 2.94 and 2.11, 3.10 and 1.32, 2.13 and 2.11, 2.46 and 3.42, 3.90 and 3.80, 2.61 and 1.39, 3.56 and 2.75, 5.10 and 5.26, 1.63 and 2.66, 2.57 and 2.49, 3.02 and 1.94, 2.44 and 3.40 during 2002-03 and 2003-2004, respectively. The N, P, K content in the plant parts was found to be at par. For uptake of N, P, K the percent increase over 100% RDF applied through inorganic fertilizer was 3.20 and 3.30, 2.99 and 2.86, 5.86 and 3.60 during 2002-03 and 2003-04, respectively. On pooled mean basis the percent increase for fresh and dry leaves yield and seed yield ha^{-1} was 2.53, 2.49 and 2.75 respectively.

The sennoside content in the leaves and pods was found to be at par. The highest net monetary returns (Rs. 65,711/- ha^{-1}) and Benefit:Cost Ratio (2.20) on pooled mean basis was obtained due to the application of 125% RDF (93.75:62.50:0 NPK kgha^{-1}) applied through inorganic fertilizer. A positive and significant correlation and regression association existed between plant height, plant spread, number of branches, total dry matter, number of filled pods, weight of filled pods, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight and dry leaves weight with weight of seeds plant^{-1}.

In rabi season, for *isabgol*, the main plot treatments were found to be at par. In case of sub plot treatments, the application of 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer was found to be significantly superior to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) applied through inorganic fertilizer in respect of plant height, number of leaves, number of productive tillers, total dry matter, number of productive spikes, number of seeds spike^{-1}, number of seeds plant^{-1}, weight of seeds plant^{-1}, thousand seed weight, seed yield and total straw yield ha^{-1}. The percent decrease by the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) applied through inorganic fertilizer was 3.58 and 3.50, 5.34 and 5.59, 1.99 and 3.06, 3.98 and 4.21, 15.41 and 15.57, 0.67 and 1.08, 16.33 and 16.68, 7.45 and 5.88, 5.39 and 7.78, 5.04 and 5.75, 4.74 and 5.54 during 2002-03 and 2003-04, respectively. On pooled mean basis the percent decrease for seed yield and total straw yield was 5.39 and 5.14, respectively. The N, P, K content in the plant parts was found to be at par. For N, P, K uptake the percent decrease was 10.53 and 9.27, 6.43 and 7.48, 10.51 and 12.33 during 2002-03 and 2003-04, respectively. The protein content, husk percentage and the swelling factor was found to be at par. The highest net monetary returns (Rs. 11,247/- ha^{-1}) and Benefit:Cost Ratio (1.62) on pooled mean

applied through inorganic fertilizer to *isabgol*. A positive and significant correlation and regression association existed between plant height, number of productive tillers, total dry matter, number of productive spikes, length of spike, girth of spike, number of seeds spike^{-1}, weight of seeds spike^{-1}, number of seeds plant^{-1} and thousand seed weight with weight of seeds plant^{-1}.

After two years of *senna* (*sonamukhi*) - *isabgol* cropping sequence the pH of soil was decreased from 8.12 to 8.09 due to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* crop preceded by the use of 50% RDF (37.50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *senna* (*sonamukhi*). Application of 100% RDF (50:25:0 NPK kgha^{-1}) and 75% RDF (37.50:18.75:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* preceded by the use of 125% RDF (93.75:62.50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) to *senna* (*sonamukhi*) increased the organic carbon of soil from 0.512 to 0.518% and total nitrogen from 0.0458 to 0.0467% only in application of 100% RDF. The maximum gain of nitrogen (29.33 kgha^{-1}), phosphorus (5.82 kgha^{-1}) and potassium (10.76 kgha^{-1}) was obtained with application of 125% RDF (93.75:62.50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) to *senna* (*sonamukhi*) during kharif and 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* during rabi season. Application of 125% RDF (93.75:62.50:0 NPK kgha^{-1}) through inorganic fertilizer to *senna* (*sonamukhi*) and 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* in a sequence registered significantly higher net monetary returns (Rs. 76,901/-ha^{-1}) and Benefit:Cost ratio (2.04) at the end of two years of experimentation. The correlation and regression association between the different plant characters with weight of seeds plant^{-1} for *senna* (*sonamukhi*) and *isabgol* was positive and significant.

It could be concluded from the results obtained from the experiment conducted that, an appropriate level and combination of treatment is to apply 125% RDF (93.75:62.50:0 NPK kgha^{-1}) through inorganic ferilizer to *senna* (*sonamukhi*) during kharif season followed by application of 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* crop during *rabi* season for achieving maximum monetary returns and improving soil health.

Pages 1 to 213.

M.P.K.V. ★ Rahuri ★ LIBRARY

1. INTRODUCTION

1. INTRODUCTION

Cultivation of medicinal and aromatic plants has emerged as a new perspective in modern day agriculture due to an increased global interest in medicinal plants especially in the western countries. About 80% of the population of many developing countries still uses traditional medicines for their health care. Except for the use of these plants for local health care needs, not much information has been available on their industrial utilization, market potential and trading possibilities. Yet local consumers, industries and exporters are demanding more herbal ingredients and as such demand is likely to increase while supplies of raw materials from wild sources of medicinal plants are rapidly shrinking (Lambert *et al.,* 1997). It is therefore, necessary that systematic cultivation of medicinal plants be introduced in order to conserve biodiversity and protect threatened species.

The international medicinal plant market is worth US $ 60 billion year^{-1} and growing at the rate of 7% annum^{-1} (Bhojvaid, 2003). The world trade figures suggest that India is next to China by exporting 32,600 tonnes of medicinal raw material worth US $ 46 million annually (Lange, 1997; Dhar *et al.,* 2000 and Manjkhola and Dhar, 2002). The planning commission of the Government of India has planned to increase the trade in medicinal plant extracts to Rs. 10,000 crores by the year 2010. Domestic demand of medicinal plants is expected to rise to Rs. 2,000 crores by the year 2004-2005 as per CERPA estimates (Bhattacharya and Mittra, 2002).

With increasing demand, the market for medicinal plants has expanded. This has created the challenge for more sustainable, efficient and equitable management of these valuable products, as unsustainable harvesting, inequitable benefits distribution and overall economic inefficiencies characterize the current trend in marketing of medicinal plants (Kala, 2003). Farming these species would help even the supply to regularize the trade, provide certifiable products of uniform quality and make available to rural areas new source of income (Lambert *et al.,* 1997). Systematic cultivation of many medicinal plants needs specific cultural practices and agronomical requirements. Hence, research and development work has to be done to formulate good agricultural practices (De Silva, 1995). Cultivation of medicinal plants has now become an economically viable proposition owing to their increasing demand in food, pharmaceutical and cosmetic industries all over the world. Development and transfer of farm worthy technologies can improve the overall contribution of medicinal plants in each producing country's economy in the 21st century (Singh and Kumar, 1998).

From technical, economical and environmental considerations the best course is to adopt an integrated nutrient management under intensive agriculture system.

This will integrate the use of organic manures and inorganic fertilizers (Motsara, 1999). An application of nutrients from an integrated source i.e. inorganic alongwith organic, proved to be superior to an application of inorganic fertilizer or organic fertilizer alone (Jagtap, 1993, Bansode, 1995 and Bacchav and Sabale, 1996).

Senna (*sonamukhi*) is a small undershrub with spreading branches. It's leaves and pods are the economic parts and are used as a medicine for treatment of abdominal disorders, jaundice, anaemia, bronchitis and splenomegaly. It contains the glycoside sennoside (Anon., 1994). In India, *senna* (*sonamukhi*) is cultivated over an area of 25,000 ha. mainly in the states of Tamilnadu, Maharashtra, Gujarat, Rajasthan and Delhi with a production of 22,500 tonnes of leaves and 7,500 tonnes of pods (Anon., 2005 a). The export of *senna* (*sonamukhi*) leaves and pods was valued at Rs. 36.84 crores during 2002-03 and Rs. 36.19 crores during 2003-04 (Anon., 2005 b).

Isabgol is a small annual plant, growing 7 to 30 cm tall and tillers arise from the base of the plant. The seed and husk are mild laxative, emollient and demulcent. In addition to medicinal uses it has a place in drying calico printing and in the ice-cream industry as a stabilizer. The seed without husk are used as a cattle feed (Kalyansundaram *et al.*, 1984). In India, it is cultivated over an area of 50,000 ha. mainly in the states of Gujarat, Haryana and Punjab with a production of 48,000 tonnes of seed (Anon., 2005 a). The export of *isabgol* husk was valued at Rs.171.32 crores during 2002-03 and Rs. 58.60 crores during 2003-04, while that of *isabgol* seed was valued at Rs. 5.93 crores during 2002-03 and Rs. 24.61 crores during 2003-04 (Anon., 2005 b).

For most of the crops nitrogen is provided through chemical fertilizers, the cost of which is increasing day by day and they are going out of reach of the small and marginal farmers. Moreover, the constant use of chemical fertilizers has deteriorated the soil health. Hence, it will be of interest to see if a reduction in an application of nitrogen could be done without compromising on the yields by utilizing organic manures to supply nitrogen to the crops and simultaneously improve the soil health. An application of organic manures considerably increased the available nitrogen and phosphorus in soil and also the soil organic matter (Patil *et al.*, 1993).

In view of this, the present study was undertaken in *senna-isabgol* cropping sequence with combination of organic manure as a source of nitrogen alongwith chemical fertilizer and only chemical fertilizer in graded levels to *senna* (*sonamukhi*) in kharif as main plot treatments and testing the residual effects of the same for increasing the production of *isabgol* in rabi alongwith nitrogen and phosphorus management.

The experiment was conducted with the following objectives:

1. To study the effect of an integrated nutrient management on growth and yield of *senna* (*sonamukhi*).
2. To asses the residual effect of an integrated nutrient management of *senna* (*sonamukhi*) on growth and yield of subsequent *isabgol* crop.
3. To study the nutrient balance in *senna* (*sonamukhi*) -*isabgol* cropping sequence.
4. To study the nutrient management effect on quality of *senna* (*sonamukhi*) and *isabgol*.

2.REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The cropping system research is required in view of increasing the production and productivity unit area^{-1} unit time^{-1} besides, retaining and improving the soil fertility. Research on an integrated use of N through a combination of organic manure (farmyard manure) and chemical fertilizers for *senna* and their residual effect on *isabgol* are meager. Indian and foreign literatures have been reviewed in this chapter. In case of certain aspects such as effect of FYM and chemical fertilizers alone or in-combination on the particular crop were not available therefore, references on other crops are presented in view of supporting the work.

2.1 *Senna.*

2.1.1 Effect of nitrogen through fertilizer.

2.1.1.1 Effect on growth characters.

Choudhary *et al.* (1979) conducted a field experiment from June to December 1978 at Chatha, on Solanum khasianum with N levels (0, 40, 80 and 120 kg ha^{-1}) and found that an increasing level of application of N produced a significant increase in plant height and number of branches plant^{-1}. However, an application of 120 kg N ha^{-1} was found to be at par with 80 kg N ha^{-1}. Hegde (1988) conducted a field experiment during 1980-81 and 1981-82 at Hessaraghatta, on periwinkle (Catharanthus roseus L.) with N levels (0, 60 and 120 kg ha^{-1}) and reported that N application had a significant increase in plant height, number of branches plant^{-1} and stem diameter upto 120 kg ha^{-1}.

Pareek *et al.* (1988) conducted a field experiment during 1981-82 to 1983-84 at New Delhi, on three species of henbane Hyoscyamus (H. niger, H.muticus and H.albus) with N levels (0, 40, 80 and 120 kg ha^{-1}) and found that an application of 80 kg N ha^{-1} was found to increase significantly plant height and number of branches plant^{-1}. Sharma and Gupta (1988) at Jammu, applied 4 levels of N (0, 100, 150 and 200 kg ha^{-1}) to Tylophora indica and reported that there was a linear increase in herb yield with increase in N level. However, the higher dose of 200 kg ha^{-1} N did not increase the yield.

Ilangovan *et al.* (1990) conducted a field experiment during Oct.1983 and May 1984 at Madurai, on *senna* cv. Tinnevelly with N levels (0, 50 and100 kg ha^{-1}) and found that N levels had a significant effect on growth characters which increased with increasing N levels. Mali (1994) at Rahuri, found that increasing doses of N increased the plant height, number of branches and leaf area plant^{-1} of *senna*. Muniramappa *et al.* (1997) conducted a field experiment during 1993-94 at Bangalore, on *kalmegh* (Andrographis paniculata Nees.) with N levels (0, 50, 75 and

100 kg ha^{-1}) and revealed that an application of increasing levels of N significantly influenced plant height, plant spread, number of leaves, leaf area, fresh and dry weight of plant. Arumugam *et al.* (2001) at Killikulam, applied 4 levels of N (0, 25, 50 and 75 kg ha^{-1}) to *senna* and revealed that overall dry matter production increased with increasing levels of N application. Krishnamoorthy and Madalageri (2002) conducted a field experiment during kharif season of 1997 at Dharwad, on Trachyspermum ammi (Ajowan) with N levels (25, 50 and 100 kg ha^{-1}) and found that N application promoted all the growth characters viz., plant height, plant spread, number of branches, number of leaves and total dry matter production $plant^{-1}$ in a linear manner.

2.1.1.2 Effect on yield contributing characters.

Choudhary *et al.* (1979) found that an increase in an application of N produced a significant increase in the number of berrics $plant^{-1}$ and diameter of berries, however an application of 120 kg N ha^{-1} was found to be at par with 80 kg N ha^{-1} in Solanum khasianum. Ilangovan *et al.* (1989) at Madurai, applied N levels (0, 50 and 100 kg ha^{-1}) and found that the dry leaf and dry pod yield $plant^{-1}$ of *senna* increased with increasing N levels. Pareek *et al.* (1989) at New Delhi, found that increasing doses of N increased the yield contributing characters of *senna*. Mali (1994) found that increasing N levels increased the green leaves weight and dry matter $plant^{-1}$ of *senna*.

2.1.1.3 Effect on yield.

Choudhary *et al.* (1979) found that an application of N produced a significant increase in the fresh and dry yield of berries ha^{-1}, however an application of 120 kg N ha^{-1} was found to be at par with 80 kg N ha^{-1} in Solanum khasianum. Kalyansundaram *et al.* (1981 a) conducted a field experiment during kharif season of 1979-80 at Anand, with N levels (0, 25, 50 and 75 kg ha^{-1}) and found that the yield of green and dry leaflets of *senna* increased with increasing N levels. Sarma *et al.* (1982) conducted a field experiment during 1978-80 at Jorhat, on Digitalis lanata with N levels (40, 80, 120, 160 and 200 kg ha^{-1}) and reported that the yield of herbs increased significantly linear upto 160 kg N ha^{-1}. Hegde (1988) reported that there was an increase in the yield of roots, leaves and stems of periwinkle (Catharanthus roseus L.) during both the years due to an application of N fertilizer. Pareek *et al.* (1988) found that an application of N levels (0, 40, 80 and 120 kg ha^{-1}), showed a linear increase in the dry herbage yield of three species of henbane Hyoscyamus (H. niger, H. muticus and H. albus).

Singh and Kewalanand (1989) conducted a field experiment during kharif season of 1983-84 and 1984-85 at Pantnagar, on *sarpagandha* (Rauvolfia serpentina) with N levels (0, 50, and 100 kg ha^{-1}) and found that the yield of dry

roots increased significantly with an increase in N levels during both the years. Mali (1994) found that green leaf yield of *senna* increased with increasing levels of N fertilizer. Muniramappa *et al.* (1997) at Bangalore, revealed that an application of the different levels of N significantly influenced fresh and dry herbage yield ha^{-1} of *kalmegh* (Andrographis paniculata Nees.). Arumugam *et al.* (2001) revealed that dry leaf yield, pod yield and overall dry matter production of *senna* increased with increasing levels of N application.

2.1.1.4 Effect on concentration and uptake.

Bachhav (1994) and Bhand (1994) at Pune, found that the concentration and uptake of N in soybean increased with increasing N levels. Pattar *et al.* (1999) found that the concentration and uptake of N in groundnut increased with increasing levels of N.

2.1.1.5 Effect on alkaloid content.

Gupta *et al.* (1977) at Anand, grew *Cassia angustifolia* with N levels (0, 50 and 100 kg ha^{-1}) and revealed that the sennoside content of mature leaves and pods was unaffected by N levels. Choudhary *et al.* (1979) found that an application of N did not significantly affect the solasodine content in Solanum khasianum. Kalyansundaram *et al.* (1981 a) reported that an application of N levels (0, 25, 50 and 75 kg ha^{-1}) had no significant effect on the sennoside content of the leaflets of *senna*. Sarma *et al.* (1982) reported that an application of various N levels did not significantly affect the total glycosides and digoxin content of Digitalis lanata. Pareek *et al.* (1988) found that an application of N levels (0, 40, 80 and 120 kg ha^{-1}) did not significantly affect the total alkaloid content as hyoscyamine in three species of Hyoscyamus (H. niger, H. muticus and H. albus). Maheshwari *et al.* (2000 a) at Indore, reported that the percentage of total alkaloids present in the dry root of *ashwagandha* (Withania somnifera) was not affected by the different N treatments applied.

2.1.1.6 Effect on soil properties.

Jadhav *et al.* (1996) at Pune, observed that an application of N fertilizers increased the availability of N with increasing N doses to pearl millet. Patil *et al.* (1996 b) at Solapur, observed that the average available N and organic carbon increased with an increase in the application of urea to sorghum. Singh and Mandal (1997) at Mohanpur, reported that an application of urea to rice increased the buildup of N status of the soil. Singh *et al.* (1997) at Bilaspur, found that there was an increase in the organic carbon and available N status due to an application of N fertilizers to sesame. Mandal *et al.* (2001) at Murshidabad, observed that a continuous application of N resulted in a higher total N status of soil.

2.1.2 Effect of phosphorus through fertilizer.

2.1.2.1 Effect on growth characters.

Nandi and Chatterjee (1981) at Burdwan, found that in low P treatments, growth of *senna* was poor and plants responded little to K fertilizers. Hegde (1988) reported that an application of P levels (0, 40 and 80 kg ha^{-1}) had a significant increase in plant height, number of branches and stem diameter $plant^{-1}$ of periwinkle (Catharanthus roseus L.). Ilangovan *et al.* (1990) found that an application of P levels (0, 50 and 100 kg ha^{-1}) had a significant effect on growth characters of *senna* with increasing P levels. Muniramappa *et al.* (1997) revealed that an application of different levels of P levels (0, 25, 50 and 75 kg ha^{-1}) significantly influenced plant height, plant spread, number of leaves, leaf area, fresh and dry weight of plant of *kalmegh* (Andrographis paniculata Nees.). Bhaskar *et al.* (2002) conducted a field experiment during 1995-96 and 1996-97 at Bangalore, on Solanum viarum with P levels (0, 30, 60, 90 and 120 kg ha^{-1}) and found that plant height, number of branches and leaf area index $plant^{-1}$ showed a linear response to P application. Krishnamoorthy and Madalageri (2002) at Dharwad, found that P application (25 and 50 kg ha^{-1}) promoted all the growth characters viz., plant height, plant spread, number of branches, number of leaves and total dry matter production $plant^{-1}$ of Trachyspermum ammi (*Ajowan*). The increase was in a linear manner.

2.1.2.2 Effect on yield contributing characters.

Ilangovan *et al.* (1989) applied P levels (0, 50 and 100 kg ha^{-1}) and found that the dry leaf and dry pod yield $plant^{-1}$ of *senna* increased with increasing P levels. Bhaskar *et al.* (2002) reported that an application of P did not affect the number of fruiting points, number of fruits and density of fruits $plant^{-1}$ in Solanum viarum.

2.1.2.3 Effect on yield.

Kalyansundaram *et al.* (1981 a) found that yield of green and dry leaflets of *senna* progressively increased with increasing P levels (0, 50, 100 and 150 kg ha^{-1}). Sarma *et al.* (1982) reported that the effect of P levels (50 and 100 kg ha^{-1}) on the yield of herbs of Digitalis lanata was significant and linear. Sharma and Gupta (1988) at Jammu reported that there was a linear increase in herb yield of Tylophora indica with increasing P levels from 0 to 100 kg ha^{-1}. Singh and Kewalanand (1989) found that the yield of dry roots of *sarpagandha* (Rauvolfia serpentina) increased significantly with an increase in P levels (0, 45, 90, and 135 kg ha^{-1}). Muniramappa *et al.* (1997) revealed that an application of the different levels of P (0, 25, 50 and 75 kg ha^{-1}) significantly influenced fresh and dry herbage yield ha^{-1} of *kalmegh* (Andrographis paniculata Nees.). Bhaskar *et al.* (2002) reported that an application of P did not affect the fresh fruit and dry berry yield $plant^{-1}$ of Solanum viarum.

2.1.2.4 Effect on concentration and uptake.

Maliwal (1990) at Junagadh, found that an increase in levels of P fertilizer increased P uptake in groundnut. Sahu *et al.* (1993) reported that P uptake was increased with P application. Prasad and Kumar (1999) reported that there was an increased concentration and uptake in soybean with increased level of P fertilizer. Varavipour *et al.* (1999) at New Delhi, reported that uptake of P by soybean was enhanced with increased level of P fertilizer.

2.1.2.5 Effect on alkaloid content.

Gupta *et al.* (1977) revealed that the sennoside content of mature leaves and pods of *senna* was unaffected by P_2O_5 levels (0, 50 and 100 kg ha^{-1}). Kalyansundaram *et al.* (1981 a) reported that an application of P levels (0, 50, 100 and 150 kg ha^{-1}) had no significant effect on the sennoside content of the leaflets of *senna*. Sarma *et al.* (1982) reported that an application of various P levels did not significantly affect the total glycosides and digoxin content of Digitalis lanata.

2.1.2.6 Effect on soil properties.

Kamble and Mohite (1996) at Rahuri, found that there was an increase in the soil available NPK due to an increase in P application to groundnut. Kasturikrishna and Ahlawat (1999) at New Delhi, observed that an increase in the organic carbon, available N and available P status of the soil due to an increase in the application of phosphatic fertilizer to pea. Bhakare and Sonar (2000) at Rahuri, observed that the soil available P status was increased with an increase in the application of P to soybean. Patel and Shelke (2000) at Parbhani, observed an increase in the residual balance of P due to an application of P to mustard.

2.1.3 Effect of nitrogen alongwith phosphorus through fertilizer.

2.1.3.1 Effect on growth characters.

Hegde (1988) reported that N+P application had a significant increase in growth characters of periwinkle (Catharanthus roseus L.). Sharma and Gupta (1988) reported that a combination of N and P application showed beneficial effect on Tylophora indica. Muniramappa *et al.* (1997) revealed that due to an application of different levels of N and P the interaction effects were found to be non-significant on *kalmegh* (Andrographis paniculata Nees.). Krishnamoorthy and Madalageri (2002) found that N and P combined application promoted all the growth characters of Trachyspermum ammi (*Ajowan*).

2.1.3.2 Effect on yield contributing characters.

Duraisingh and Gopalaswamy (1991) observed that an application of 40 kg N + 120 kg P_2O_5 ha^{-1} produced higher yield attributes viz., pods $plant^{-1}$ and 1000 seed weight of soybean as compared to other combinations of N levels (20, 40 kg ha^{-1}) and P levels (80, 120 kg ha^{-1}). Patel *et al.* (1992) at Raipur, observed that the yield contributing characters of soybean were increased with increasing levels of N and P upto 40 kg N + 90 kg P_2O_5 ha^{-1}. Shelke (1994) observed that the yield contributing characters of soybean were maximum with an application of 40 kg N + 80 kg P_2O_5 ha^{-1}.

2.1.3.3 Effect on yield.

Gupta (1967 b) reported that an application of 20 kg N and 40 kg P ha^{-1} at planting supplemented with 40 to 60 kg N ha^{-1} produced 1 to 1.4 tonnes of dry leaves ha^{-1}. Kalyansundaram *et al.* (1981 a) found that yield of green and dry leaflets of *senna* progressively increased with increasing N and P levels. However, the interaction effects of N and P were non-significant. Muniramappa *et al.* (1997) revealed that the combined application of different levels of N and P significantly influenced fresh and dry herbage yield ha^{-1} of *kalmegh* (Andrographis paniculata Nees.). Singh and Kewalanand (1989) found that the yield of dry roots of *sarpagandha* (Rauvolfia serpentina) increased significantly with an increase in N and P levels. The interaction effects were also found to be significant.

2.1.3.4 Effect on concentration and uptake.

Sharma and Dixit (1987) found that the uptake of N and P by soybean was increased due to an application of increased levels of N and P. Reddy *et al.* (1990) at Baptala, reported that N and P uptake by soybean increased significantly with an increase in levels of N and P application.

2.1.3.5 Effect on alkaloid content.

Gupta *et al.* (1977) revealed that the sennoside content of mature leaves and pods of *senna* was unaffected by N and P levels. Ilangovan *et al.* (1991) at Madurai, revealed that N increased pod sennoside content but had no appreciable effect on leaves of *senna*. Leaf sennoside content increased with rising P application rates. The effects due to interactions of N X P on sennoside content and yield were found to be non-significant.

2.1.3.6 Effect on soil properties.

Chawla and Chabra (1991) at Karnal, found that an application of P alongwith N increased the infiltration rate of the soil and there was no change in the organic carbon status of the soil. Balasubramaniyan (1997) at Vrindhachalam,

observed an increase in the soil available N and P status due to an increase in the NP fertilization to groundnut. Navale *et al.* (2000) at Rahuri, reported that an application of 60 kg N + 120 kg P_2O_5 ha^{-1} to soybean resulted in higher soil available N and P than 40 kg N + 80 kg P_2O_5 ha^{-1} and 20 kg N + 40 kg P_2O_5 ha^{-1}. There was also a marginal increase in soil available K by the fertilizer applied. Raju and Reddy (2000) at Maruteru, observed that higher electrical conductivity values were observed in plots receiving NP fertilization to rice. Sengar *et al.* (2000) at Jagdalpur, observed that an application of NP fertilizers to rice increased the soil pH and no significant influence on organic carbon.

2.1.4 Effect of nitrogen through farmyard manure alongwith or without phosphorus fertilizer.

2.1.4.1 Effect on growth characters.

Rayer (1984) found that an application of 10 to 12 t FYM ha^{-1} increased the root dry matter $plant^{-1}$ of groundnut. Muthuvel *et al.* (1985) observed that an application of FYM @ 10 t ha^{-1} to redgram resulted in significantly higher number of branches $plant^{-1}$ over control. Nimje and Seth (1987) at New Delhi, reported that an application of FYM @ 15 t ha^{-1} to soybean increased the number of branches and dry matter accumulation $plant^{-1}$ over the unmanured crop. Nimje and Seth (1988) at New Delhi, found that increasing rate of P_2O_5 (0, 40 and 80 kg ha^{-1}) and FYM (0 and 15 t ha^{-1}) increased the dry matter production of plants. Gaidhane (1994) at Pune, observed that an application of 5 t ha^{-1} of farmyard manure to groundnut increased the plant spread $plant^{-1}$ over control. Singh *et al.* (1995 a) revealed that the plant height $plant^{-1}$ of soybean was significantly higher due an application of 15 t ha^{-1} of FYM + full dose of NPK than with the control.

2.1.4.2 Effect on yield contributing characters.

Muthuvel *et al.* (1985) found that an application of FYM gave a significantly higher number of pods $plant^{-1}$ and thousand grain weight of redgram. Nimje and Seth (1987) reported that an application of FYM @ 15 t ha^{-1} to soybean significantly increased the pod and grain number $plant^{-1}$ and thousand grain weight over the unmanured crop. Sagare *et al.* (1992) at Akola, found that a fertilization of 25 kg N + 50 kg P_2O_5 ha^{-1} applied half through FYM and half through chemical fertilizer significantly increased the pod yield of peanut. Patel (1994) at Pune, found that an application of FYM @ 5 t ha^{-1} to pigeonpea for supply of 25 kg ha^{-1} increased the number of seeds $plant^{-1}$. Singh *et al.* (1995 a) revealed that the number of pods $plant^{-1}$ of soybean was significantly higher due an application of 15 t ha^{-1} of FYM + full dose of NPK than with the control.

2.1.4.3 Effect on yield.

Pareek *et al.* (1989) reported that FYM application at 10 t ha^{-1}, improved the total leaf and pod yield of *senna* by 38.7 and 45.5 % respectively over the control. Supplementing this with 30 kg N ha^{-1} further increased the yield to that following treatment with 60 kg N ha^{-1} by a further 24.3% (leaf and pod). Sharma *et al.* (1999 a) conducted a field experiment during 1995-97 at Barmer and reported that an application of 5 t ha^{-1} of FYM to *senna* gave a seed yield of 150 kg ha^{-1}. Maheshwari *et al.* (2000 a) reported that an application of 2.5 t ha^{-1} FYM along with 12.5 kg N + 25 kg P_2O_5 ha^{-1} resulted in maximum root yield (465 kg ha^{-1}) of *ashwagandha* (Withania somnifera) over the control (425 kg ha^{-1}). Ramamoorthy *et al.* (2003) conducted a field experiment during rabi seasons of 1997 and 1998 at Killikulam, and reported that an application of 12.5 t ha^{-1} of FYM in combination with a fertilizer level of 60:25:40 kg NPK ha^{-1} be recommended for enhanced herbage, pod yield and seed yield of *senna*.

2.1.4.4 Effect on concentration and uptake.

Banait (1991) reported that an application of FYM was more effective for total nutrient uptake of groundnut plant. Bachhav (1994) at Pune, observed that there was more uptake of plant nutrient in soybean crop to which 25 kg ha^{-1} of N was supplied through 5 t ha^{-1} of FYM.

2.1.4.5 Effect on alkaloid content.

Pareek *et al.* (1989) reported that with the application of various treatments of FYM and fertilizers, the total sennosides concentration in the leaves and pods of *senna* remained unchanged. Maheshwari *et al.* (2000 a) reported that, percentage of total alkaloids present in the dry root of *ashwagandha* (Withania somnifera) was not affected by the different N treatments applied.

2.1.4.6 Effect on soil properties.

Mahimaraja *et al.* (1986) observed that the combined application of inorganic fertilizer alongwith FYM improved the physical condition of soil by increasing the hydraulic conductivity, porosity and aggregation and reducing the bulk density of soils. Kwakye (1988) observed that the fertility status of the soil was maintained chiefly by manuring which significantly increased the levels of organic carbon, total N and available P and K while the soil pH was reduced. Badanur *et al.* (1990) found that an application of farmyard manure increased the organic carbon, available N and P over control. Bellaki and Badanur (1997) at Dharwad, reported that the bulk density of soil decreased due to an application of farmyard manure either or in combination with fertilizers. Purakayastha *et al.* (1997) at New Delhi, observed that an application of farmyard manure alongwith urea had no effect on pH changes

as compared to urea alone. Pattar *et al.* (1999) found that higher organic carbon, available NPK were recorded in treatment receiving FYM @ 10 t ha^{-1} to groundnut. Singh *et al.* (2000) at Pusa, found that the bulk density of surface soil was reduced due to an application of FYM (1.32 Mg m^{-3}) as compared to control (1.45 Mg m^{-3}).

2.2 Effect of preceding crops on following crops.

Sharma *et al.* (1999 b) at Morena, during 1993-94 and 1994-95 in soybean-mustard sequence applied NPK (40:40:20, 40:60:20 and 40:80:20 kg ha^{-1}) alone or alongwith substitution of ½ through farmyard manure to soybean. This application did not significantly influence the yield of mustard, which received an application of 80:40:20 kg NPK ha^{-1} of inorganic fertilizer. Singh (1999 a) at Mainpuri, during 1996-97 and 1997-98 in groundnut-wheat sequence observed that the yield contributing traits and yield of wheat receiving 80 kg N ha^{-1} and 40 kg P ha^{-1} grown on different residue treatments of groundnuts receiving inorganic and FYM fertilizer combinations did not show significant variation. Singh *et al.* (1999 b) at Hissar, during 1984-85 to 1996-97 in pearlmillet-wheat sequence, revealed that an application of 50% recommended dose through chemical fertilizers with 50% N through FYM in pearlmillet and 100% recommended dose of NPK in wheat produced grain yield of both pearlmillet and wheat at par with that of recommended dose of fertilizers in both the crops of the sequence. Verma and Rajput (1999) at Agra, during 1990-91 and 1992-93 in pearlmillet-wheat sequence, applied N levels (40, 80 and 120 kg ha^{-1}), P levels (40, 80 and 120 kg ha^{-1}) and K levels (0 and 40 kg ha^{-1}) to both the crops and revealed that the continuous cropping of pearlmillet sequence over a fixed site reduced the available soil NPK year after year at lower levels of fertilizers, but the same was sustained at higher levels.

Singh *et al.* (2000) at Pusa, during 1994-95 to 1996-97 in rice-wheat sequence observed that an application of FYM significantly brought down the bulk density of surface and sub-surface soils in comparison with that of control. Application of different levels of fertilizers did not affect the bulk density. Sharma *et al.* (2003 a) at Pura, during 1981-82 to 1995-96 in rice-wheat sequence, applied N levels (40, 80, and 120 kg ha^{-1}), P levels (0, 40 and 80 kg ha^{-1}) and K levels (0 and 40 kg ha^{-1}) to both the crops and found that the grain yield of both the crops increased significantly with an increase in N levels upto 120 kg ha^{-1}, P levels upto 80 kg ha^{-1} and K levels upto 40 kg ha^{-1} fertilizer during all the years of experimentation. The organic carbon content, available N and P levels increased while the available K decreased.

2.3 *Isabgol.*

2.3.1 Effect of nitrogen through fertilizer.

2.3.1.1 Effect on growth characters.

Mann and Vyas (1999) conducted a field experiment on *isabgol* cv. GI-2 with four N levels (0, 15, 30 and 45 kg ha^{-1}) during rabi season of 1995-96 at Udaipur, and reported that plant height, number of leaves and dry matter accumulation $plant^{-1}$ were significantly increased up to 45 kg N ha^{-1}. Solanki and Shaktawat (1999) conducted a field experiment during 1992-95 at Bikaner, on *isabgol* with N levels (0, 30, 45 and 60 kg ha^{-1}) and found that all the growth characters were promoted with increasing doses of N. Bist *et al.* (2000) conducted a field experiment during 1998-99 at Pantnagar, with N doses (0, 20, 40, 60, 80, 100, 120 and 140 kg ha^{-1}) and reported that the increasing rates of N application had significant influence on growth of Plantago ovata.

Maheshwari *et al.* (2000 b) conducted a field experiment during winter season of 1996 and 1997 at Indore, and reported that the maximum plant height of *isabgol* was recorded at 25 kg N ha^{-1}. Bist *et al.* (2001) conducted a field experiment during 1997-98 and 1998-99 at Pantnagar, on psyllium cv. GI-1 and GI-2 with N levels (0, 10, 20, 40 and 50 kg ha^{-1}) and found that with increasing N rates the growth characters were significantly increased. Singh *et al.* (2003 a) at Bikaner, reported that an application of 30 kg N ha^{-1} increased the plant height, number of leaves and dry matter accumulation $plant^{-1}$ of *isabgol* over the control by 75.39, 27.48 and 74.74% respectively. Utgikar *et al.* (2003) conducted a field experiment during rabi season of 2000-01 at Akola, on *isabgol* with treatments 0, 25, 50 and 75 kg N ha^{-1}. N application at 50 kg ha^{-1} gave the highest number of leaves (90.57) and number of tillers $plant^{-1}$ (8.12), whereas N at 75 kg ha^{-1} gave the highest plant height (41.1 cm).

2.3.1.2 Effect on yield contributing characters.

Intodia and Tomar (1998) conducted a field experiment during 1994-96 at Chittorgarh, on psyllium genotypes (GI-2, HI-5 and RI-89) with N levels (0, 15 and 30 kg ha^{-1}) and observed a positive response to N application with respect to yield attributes. Solanki and Shaktawat (1999) conducted a field experiment during 1992-95 at Bikaner, on *isabgol* with N levels (0, 30, 45 and 60 kg ha^{-1}) and found that all the yield characters were promoted with increasing doses of N. Maheshwari *et al.* (2000 b) conducted a field experiment during winter season of 1996 and 1997 at Indore, and reported that the maximum number of spike bearing tillers and length of spikes of *isabgol* were recorded at 25 kg N ha^{-1}.

Mann and Vyas (2001) at Udaipur, reported that the increasing N rate (0-40 kg ha^{-1}) resulted in the increase in yield components of psyllium, the highest number of spikes (36.43), spike length (3.9 cm), number of spikelets $spike^{-1}$ (65.5) were recorded with an application of 45 kg N ha^{-1}. Deore *et al.* (2002) conducted a field

experiment during rabi 1997 at Rahuri, on *isabgol* cv. GI-1. The results revealed that N application with 75 kg ha^{-1} recorded the higher number of productive spikes plant^{-1}. Sharma *et al.* (2003 b) conducted a field experiment in winter season of 1996-97 and 1997-98 at Jaipur, with N levels (0, 15, 30, 45 and 60 kg ha^{-1}) and reported that the number of spikes and seed weight plant^{-1} of psyllium increased with increasing rates of N upto 45 kg ha^{-1}.

Singh *et al.* (2003 a) reported that an application of 30 kg N ha^{-1} to *isabgol* increased the spikes m^{-1} row length by 53.86%, spike length by 50.66%, spikelets spike^{-1} by 15.42% and seed weight spike^{-1} by 12.36% over the control. Utgikar *et al.* (2003) conducted a field experiment during rabi season of 2000-01 at Akola, on *isabgol* with treatments 0, 25, 50, and 75 kg N ha^{-1} and found that N application at 50 kg ha^{-1} gave the highest number of spikes plant^{-1} (39.66), number of seeds spike^{-1} (87.30), seed yield plot^{-1} (0.362 kg), whereas N at 75 kg ha^{-1} gave the highest spike length (3.60 cm).

2.3.1.3 Effect on yield.

Kalyansundaram *et al.* (1982) at Anand, reported that highest seed yield of Plantago ovata was obtained with an application of 50 kg N ha^{-1}. Singh and Kewalanand (1988) conducted a field experiment during the rabi seasons of 1983-84 and 1984-85 at Pantnagar, on *isabgol* with four levels of N (0, 40, 80 and 120 kg ha^{-1}) and found an almost linear increase in seed yield of *isabgol* with N fertilization upto 80 kg ha^{-1} and then declined with further increase in the levels of N. Ramesh *et al.* (1989) conducted a field experiment during July to October at Bangalore, with N levels (50, 75 and 100 kg ha^{-1}) on *isabgol* and reported that an application of 75 kg N ha^{-1} resulted in higher seed yield plant^{-1}.

Intodia and Tomar (1998) observed the positive response of seed yield ha^{-1} of psyllium to N application. Solanki and Shaktawat (1999) conducted a field experiment during 1992-95 at Bikaner, on *isabgol* with N levels (0, 30, 45 and 60 kg ha^{-1}) and found that the seed yield was promoted with increasing doses of N. Bist *et al.* (2000) conducted a field experiment during 1998-99 at Pantnagar, with N doses (0, 20, 40, 60, 80, 100, 120 and 140 kg ha^{-1}) and reported that the increasing rates of N application had significant influence on yield of Plantago ovata. Maheshwari *et al.* (2000 b) at Indore, reported that higher seed yield of *isabgol* by 30% was obtained at 25 kg N ha^{-1} compared with control. Bist *et al.* (2001) conducted a field experiment during 1997-98 and 1998-99 at Pantnagar, on psyllium cv. GI-1 and GI-2 with N levels (0, 10, 20, 40 and 50 kg ha^{-1}) and found that increasing N rates of application significantly increased the seed yield. Deore *et al.* (2002) conducted a field experiment during rabi 1997 at Rahuri, with *isabgol* cv.GI-1 and revealed that N application with 75 kg ha^{-1} recorded the highest seed yield ha^{-1}.

Kumawat *et al.* (2002) conducted a field experiment during 1998-99 and 1999-2000 at Udaipur, application of N levels (20, 40 and 60 kg ha^{-1}) found that with increasing N levels the seed yield and biological yield of psyllium was increased. Rathore and Chandawat (2003) conducted field experiments during rabi season of 1991-92, 1992-93, 2000-01 and 2001-02 at Jodhpur on *isabgol* cv. GI-2 with three N levels (0, 30 and 60 kg ha^{-1}) and revealed that there was a significant increase in the seed and straw yield. Sharma *et al.* (2003 b) conducted a field experiment during the winter season of 1996-97 and 1997-98 at Jaipur, with N levels (0, 15, 30, 45 and 60 kg ha^{-1}) and reported that the seed yield and straw yield of *isabgol* increased with increasing rates of N upto 45 kg ha^{-1}. Application of 45 kg N ha^{-1} resulted in significantly higher seed yield (19.35 q ha^{-1}) which was 32, 21 and 12% higher than with the application of 0, 15 and 30 kg N ha^{-1}, respectively. Singh *et al.* (2003 a) reported that an application of 30 kg N ha^{-1} increased the seed and straw yield of *isabgol* by 23.3% and 55.4% respectively over the control.

2.3.1.4 Effect on concentration and uptake.

Shakhela *et al.* (1984) reported that the N concentration in seed, husk and straw were increased with increasing N application to *isabgol*. Mann and Vyas (1999) reported that NPK uptake of *isabgol* was enhanced by the highest levels of N but it was found to be non-significant. Burman *et al.* (2002) reported that an application of 30 kg N ha^{-1}, led to an increase in the concentration of NPK over control (0 kg Nha^{-1}) in *isabgol*. Kumawat *et al.* (2002) reported that increasing N levels increased the NPK uptake (kg ha^{-1}) of psyllium. Singh *et al.* (2003 b) reported that the N uptake by *isabgol* was higher with the application of 45 kg N ha^{-1} compared to other rates (0, 15, 30 and 45 kg ha^{-1}) of N application.

2.3.1.5 Effect on quality.

Maheshwari *et al.* (2000 b) at Indore, reported that the different N treatments applied did not show beneficial effect on the swelling factor of *isabgol* seed. Rathore and Chandawat (2003) revealed that there was a increase in the husk yield of psyllium with increasing doses of N however, the increase at 60 kg N ha^{-1} application was not significantly higher to 30 kg N ha^{-1}. Utgikar *et al.* (2003) reported that from the treatments 0, 25, 50, and 75 kg N ha^{-1} to *isabgol*, an application of 75 kg N ha^{-1} gave the higher husk percentage (23.28%).

2.3.2 Effect of phosphorus through fertilizer.

2.3.2.1 Effect on growth characters.

Hooda and Agarwal (1987) observed that the dry matter production of wheat was increased with an increase in the P level upto 60 kg ha^{-1}.

Singh *et al.* (1996) at Udaipur, observed that an application of 40 and 60 kg P_2O_5 ha^{-1} significantly increased the plant height, total number of tillers and number of effective tillers $plant^{-1}$ of wheat than 20 kg P_2O_5 ha^{-1}. Flavido and Grant (1998) reported that tiller production and number of leaves $plant^{-1}$ of wheat was increased due to an application of P fertilizers. Rai *et al.* (2002) conducted a field experiment during 1998-99 at Lucknow on *Foeniculum vulgare* with P levels (0, 25, and 50 kg ha^{-1}) and found that increasing P application showed a significant increase in the plant height, plant spread, stem diameter, number of branches, number of leaves, length of internode and numbers of tillers $plant^{-1}$. Utgikar *et al.* (2003) found that increasing levels of P application (0, 15 and 30 kg P ha^{-1}) to *isabgol* increased the growth characters.

2.3.2.2 Effect on yield contributing characters.

Ramesh *et al.* (1989) at Bangalore, reported that an application of P levels (0, 25 and 50 kg ha^{-1}) resulted in an increase in the yield contributing characters of *isabgol*. Singh *et al.* (1995 b) at Udaipur, observed that the number of grains $panicle^{-1}$, thousand grain weight of *isabgol* were increased due to an application of 60 kg P_2O_5 ha^{-1}. Intodia and Tomar (1998) found that a positive response to P application (0 and 6.55 kg ha^{-1}) was observed with respect to yield attributes of psyllium. Solanki and Shaktawat (1999) applied P levels (0, 30, 45 and 60 kg ha^{-1}) to *isabgol* and found that all the yield characters were promoted with increasing doses of N. Utgikar *et al.* (2003) found that an application of P levels (0, 15 and 30 kg ha^{-1}), P at 30 kg ha^{-1} gave the higher yield components of *isabgol*.

2.3.2.3 Effect on yield.

Ramesh *et al.* (1989) reported that an application of P levels (0, 25 and 50 kg ha^{-1}), P at 25 kg ha^{-1} resulted in the higher seed yield $plant^{-1}$ of *isabgol*. Parihar and Singh (1995) conducted a field experiment during 1990-92 at Mandor, the results revealed that mean seed yield of psyllium increased with increasing levels of P. Singh *et al.* (1995 d) observed that the grain yield of wheat was increased due to an application of 60 kg P_2O_5 ha^{-1}. Patel *et al.* (1996) at Junagadh, found that an application of 0, 10 and 20 kg ha^{-1} P_2O_5, an application of 20 kg ha^{-1} of P_2O_5 gave the higher seed yield of psyllium. Jadhav *et al.* (2000) at Junagadh, observed that a 20 kg ha^{-1} P_2O_5 application gave the higher seed and straw yields of *isabgol*. Utgikar *et al.* (2003) reported that P application at 30 kg ha^{-1} gave the higher yield of *isabgol*.

2.3.2.4 Effect on concentration and uptake.

Auti (1996) at Rahuri, reported that the concentration of P in grain and straw of wheat increased due to an increase in levels of P application. Varavipour *et al.*

(1999) at New Delhi, reported that the uptake of P by wheat was enhanced due to an application of P.

2.3.2.5 Effect on quality.

Patel and Upadhyay (1993) at Anand, reported that the protein content of wheat grain increased with an increase of P level upto 75 kg ha^{-1}. Utgikar *et al.* (2003) found that increasing P application with 0, 15 and 30 kg ha^{-1} increased the husk percentage of *isabgol.*

2.3.3 Effect of nitrogen alongwith phosphorus through fertilizer.

2.3.3.1 Effect on growth characters.

Hooda and Agarwal (1987) observed that an application of 120 kg N + 60 kg P_2O_5 ha^{-1} produced higher plant height and dry matter $plant^{-1}$ of wheat as compared to other combinations of N and P levels. Singh and Chouhan (1994) conducted a field experiment during winter season of 1990-91 and 1991-92 on a sandy loam soil at Sumerpur. N and P was applied at 20+10, 40+20, 60+30 and 80+40 kg ($N+P_2O_5$) ha^{-1}. The results revealed that plant height of psyllium increased with increased fertilization upto 80+40 kg ($N+P_2O_5$) ha^{-1}. Rai *et al.* (2002) reported that N and P application showed a significant increase in the plant height, plant spread, stem diameter, number of branches, number of leaves, length of internode and numbers of tillers $plant^{-1}$ of Foeniculum vulgare.

2.3.3.2 Effect on yield contributing characters.

Ramesh *et al.* (1989) reported that an application of 75 kg N + 25 kg P ha^{-1} resulted in the highest number of spikes $plant^{-1}$ of *isabgol.* Singh and Chouhan (1994) found that the number of spikes $plant^{-1}$, 1000 seed weight of psyllium were increased with increasing N and P upto 60+30 kg ha^{-1}, while spike length and grains $spike^{-1}$ increased with increased fertilization upto 80+40 kg ha^{-1}.

2.3.3.3 Effect on yield.

Gupta (1967 a) reported that an application of 25 kg N with 25 kg P ha^{-1} at planting supplemented with 25 kg N ha^{-1} as top dressing produced one tonne ha^{-1} seed yield of *isabgol.* Ramesh *et al.* (1989) reported that an application of 75 kg N + 25 kg P ha^{-1} resulted in the higher seed yield $plant^{-1}$ of *isabgol.* Singh and Chouhan (1994) revealed that seed yield of psyllium increased with increasing N and P doses. Parihar and Singh (1995) conducted a field experiment during 1990-92 at Mandor, the results revealed that mean seed yield of psyllium increased with increasing levels of N and P. Singh *et al.* (2001 a) at Agra, found that an application of 50 kg N + 25 kg P_2O_5 ha^{-1} resulted in an increase in seed yield of psyllium. Singh and Pal

(2003) at Bichpuri, found that an application of 50 kg N + 25 kg P_2O_5 ha^{-1} proved to be significantly superior for enhancing the seed yield of psyllium.

2.3.3.4 Effect on concentration and uptake.

Mann and Vyas (1999) found that NPK uptake by *isabgol* was enhanced by the higher levels of N and P application. Singh *et al.* (2001 b) at Agra, found that an application of 50 kg N + 25 kg P_2O_5 ha^{-1} resulted in a increase in N and P uptake in both seed and straw of psyllium.

2.3.3.5 Effect on quality.

Maheshwari *et al.* (2000 b) reported that the different NP treatments applied did not show beneficial effect on the swelling factor of *isabgol* seed. Utgikar *et al.* (2003) found that N and P application increased the husk percentage of *isabgol*.

2.4 Correlation and regression studies.

2.4.1 *Senna.*

Lal *et al.* (1992) studied 49 germplasms of *senna* and found that dry leaf yield, dry pod yield and seed yield were favourably correlated. Sankaranarayanan *et al.* (1992) evaluated 23 selections and 6 hybrids of Cassia angustifolia during 1981-82 and reported that leaf yield was strongly and positively correlated with number of branches, length of leaves, number of leaves $plant^{-1}$. Path coefficient analysis revealed that plant height had the greatest direct effect on pod yield. Sankaranarayanan (1995) evaluated 23 selections and 6 hybrids of Cassia angustifolia during 1981-82 and found that pod yield was significantly correlated with plant height, number of branches, length of racemes, number of pods set, length of pods.

2.4.2 *Isabgol.*

Kalyansundaram and Dalal (1981 b) at Anand, found that the correlation of seed yield of *isabgol* to the total spikes, number of effective spikes and tillers $plant^{-1}$ was very high and significant. Singh *et al.* (1995 c) conducted a field experiment during rabi 1992-93 at Udaipur, under 12 fertilizer regimes and reported that yield of *isabgol* was positively correlated with number of ears $metre^{-1}$ row (0.8), number of spikelets ear^{-1} (0.83), ear length (0.69), grain length ear^{-1} (0.51) and test weight (0.36 g). The regression co-efficient was also observed to be significant. Kumar *et al.* (2000) at Anand, found that in *isabgol* the number of effective spikes and number of total spikes $plant^{-1}$ were positively correlated with seed yield $plant^{-1}$. Sharma and Garg (2002) at Jodhpur, observed a significant and positive correlation for seed yield $plant^{-1}$ with plant height, number of tillers, number of spikes $plant^{-1}$ and 1000 seed weight. A significant and positive correlation was also observed for plant height with number of tillers $plant^{-1}$, spike length and 1000 seed weight.

3.MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was carried out to study the effect of an integrated nutrient management on growth, yield and quality of *senna* (Cassia angustifolia) during kharif and to study the residual effects on *isabgol* (Plantago ovata) during rabi alongwith nitrogen and phosphorus management. The relevant details of the materials used and the methods followed for conducting this investigation are presented in this chapter.

3.1 Materials.

3.1.1 Experimental site.

An experiment was carried out at Post Graduate Institute, Instructional Farm, in 'B' block of Central Campus, Group No.6, Survey No. 70, Mahatma Phule Krishi Vidyapeeth, Rahuri, District-Ahmednagar (M.S.) during kharif and rabi seasons in a sequence during the years 2002-03 and 2003-04.

3.1.1.1 Soil.

The topography of experimental field was uniform and fairly leveled. The soil was medium black in colour, clayey in texture and well drained. Soil samples from 0-30 cm depth were taken from ten randomly selected spots in the experimental field by using a screw auger. These samples were mixed together and a composite soil sample was prepared for determining the physical and chemical properties. The results of analysis, presented in Table 1 indicated that the soil was clayey in texture, low in available nitrogen (209.14 kg ha^{-1}), medium in available phosphorus (24.94 kg ha^{-1}) and high in available potassium (478.12 kg ha^{-1}) (Muhr *et al.,* 1965).

3.1.2 Climatic conditions.

3.1.2.1 General.

Geographically, the Central Campus of Mahatma Phule Krishi Vidyapeeth, is situated in the subtropical region of India and comes under the scarcity zone of Maharashtra state. It is situated between North latitude 19°48'N and 19°57'N and East longitude 74°19'E and 74°57'E, 35 Km from Ahmednagar on Ahmednagar-Manmad State Highway No.14. It has an altitude of 495 to 569 m. The annual rainfall varies from 307 to 619 mm, with average 520 mm. The distribution of rains is erratic with 15 to 45 number of rainy days $year^{-1}$. Out of the total rainfall, about 80% is received during June to September from South-West monsoon, while the rest 20% is received during October and November from the North-East monsoon. The annual mean maximum temperature is 37.9°C with a range

Table 1. Mechanical and chemical analysis of the soil of the experimental plot (0-30 cm depth).

Sr. No.	Characteristics	Composition	Reference
A.	**Mechanical analysis.**		
1.	Coarse sand (%)	8.04	Gee and Boudar (1986)
2.	Fine sand (%)	12.82	------"------
3.	Silt (%)	19.21	------"------
4.	Clay (%)	59.05	------"------
5.	Textural class	Clay	------"------
B.	**Chemical composition.**		
1.	Available nitrogen (kg ha^{-1})	209.14	Alkaline permanganate method (Subbiah and Asija, 1956)
2.	Available phosphorus (kg ha^{-1})	24.94	(Olsen and Sommers, 1982)
3.	Available potassium (kg ha^{-1})	478.12	Flame photometer method (Knudsen and Peterson, 1982)
4.	Organic carbon (%)	0.512	Walkely and Black rapid titration method (Nelson and Sommers, 1982)
5.	Organic matter	0.88	% organic carbon x 1.724
6.	Total nitrogen (%)	0.0458	Modified Kjeldhal's method (A.O.A.C., 1975)
7.	Carbon : nitrogen ratio	11.18	------
8.	pH (soil : water, 1:2.5)	8.12	Potentiometric method (Piper,1966)
9.	Electrical conductivity (dS m^{-1})	0.12	Conductometry (Piper, 1966)
C.	**Single value physical constants.**		
1.	Field capacity (%)	36.17	Pressure membrane apparatus (Richards, 1948)
2.	Wilting point (%)	16.48	------"------
3.	Maximum water holding capacity (%)	58.36	
4.	Porosity (%)	50.19	------
5.	Bulk density (g cc^{-1})	1.32	Clod method(Brasher *etal*,1966)

of 33 to 43°C. The annual mean minimum temperature is 17.2°C with a range from 3 to 18°C. The mean morning relative humidity is 59% and the evening is 35%.

3.1.2.2 Climatic conditions during the experimental period.

Meteorological data on important parameters during the experimental period for both the trials recorded at the meteorological observatory of the Central Campus Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri are presented in Table 2 and 3, and graphically depicted in Fig.1 and 2.

During *senna* (kharif) cropping period of 2002-03, rainfall ranged between 1.0 and 98.3 mm and the rainy days ranged between 1 to 3 while, during 2003-04 the rainfall ranged between 2.7 and 59.8 mm and the rainy days between 1 to 4. The mean maximum temperature ranged between 27.8 to 34.5°C while, the mean minimum temperature ranged between 8.7 to 22.1°C during 2002-03 while, during 2003-04 the mean maximum temperature ranged between 28.4 to 33.3°C while, the mean minimum temperature ranged between 8.2 to 23.1°C. The mean morning relative humidity ranged between 59.6 to 94.1% while, the evening relative humidity ranged between 23.7 to 70.9% during 2002-03 while, during 2003-04 the mean morning relative humidity ranged between 64.7 to 91.4% while, the evening relative humidity ranged between 27.3 to 71.1%. The mean wind speed ranged between 1.5 to 10.5 km hr^{-1}, the bright sunshine ranged between 2.1 to 10.1 hrs d^{-1} and the evaporation ranged between 3.3 to 5.6 mm d^{-1} during 2002-03 while, during 2003-04 the mean wind speed ranged between 2.3 to 17.1 km hr^{-1}, the bright sunshine ranged between 1.1 to 10.1 hrs d^{-1} and the evaporation ranged between 2.7 to 7.6 mm d^{-1}.

In the *isabgol* (rabi) cropping period of 2002-03 and 2003-04 there was no rainfall during both the years. The mean maximum temperature ranged between 31.6 to 38.2°C while the mean minimum temperature ranged between 10.8 to 19.0°C during 2002-03 while, during 2003-04 the mean maximum temperature ranged between 29.2 to 39.1°C while, the mean minimum temperature ranged between 7.5 to 18.0°C. The mean morning relative humidity ranged between 62.6 to 86.1% while, the evening relative humidity ranged between 19.4 to 51.3% during 2002-03 while, during 2003-04 the mean morning relative humidity ranged between 82.3 to 86.5% while, the evening relative humidity ranged between 17.3 to 35.0%. The mean wind speed ranged between 2.2 to 6.1 km hr^{-1}, the bright sunshine ranged between 8.8 to 10.5 hrs d^{-1} and the evaporation ranged between 4.8 to 10.6 mm d^{-1} during 2002-03 while, during 2003-04 the mean wind speed ranged between 3.0 to 8.1 km hr^{-1}, the bright sunshine ranged between 8.6 to 11.2 hrs d^{-1} and the evaporation ranged between 4.6 to 13.2 mm d^{-1}.

Table 2. Meteorological data for kharif and rabi seasons of cropping period 2002-03 at Rahuri.

Met. Week	Mean temperature (°C)		Mean relative humidity (%)		Mean wind speed (km hr^{-1})	Mean Bright sun shine (hrs d^{-1})	Total Rain fall (mm)	Number of rainy day/s	Pan evaporation (mm)
	Max.	Min.	Morning	Evening					
19	38.3	14.5	80.1	43.9	3.5	9.9	0.0	0	11.7
20	38.1	21.9	77.9	52.9	6.3	10.4	0.0	0	11.5
21	37.3	18.0	85.3	47.9	3.8	10.0	0.0	0	11.0
22	37.5	20.8	88.9	56.4	2.2	8.5	0.0	0	9.6
23	36.7	15.1	90.0	55.9	2.7	7.2	0.0	0	9.3
24	33.3	12.3	83.9	51.7	3.2	2.7	86.8	3	5.4
25	32.7	12.4	80.3	56.3	7.9	2.1	6.2	1	6.1
26	27.7	11.6	84.6	72.6	7.3	0.9	65.5	3	3.6
27	31.6	16.8	78.7	55.6	8.1	4.3	0.0	0	7.0
28	32.4	22.0	81.9	47.7	5.1	7.6	0.0	0	8.2
29	30.0	21.6	85.3	62.3	4.2	3.6	0.0	0	5.4
30	30.5	22.1	82.6	58.9	5.5	4.4	0.0	0	5.6
31	30.5	21.9	91.3	64.4	2.2	5.5	98.3	3	4.0
32	27.8	21.5	89.4	70.9	4.2	5.4	1.5	0	3.3
33	29.2	22.0	88.3	63.7	5.4	2.4	0.9	0	4.4
34	29.1	21.1	89.9	62.3	10.5	2.1	37.7	1	4.6
35	29.2	20.4	90.7	64.4	7.1	4.9	6.2	1	4.1
36	29.4	21.0	91.4	65.1	7.2	3.4	33.7	2	3.8
37	31.8	19.4	87.6	48.6	5.5	8.1	1.8	0	5.4
38	31.6	19.5	90.6	50.4	4.5	7.3	5.2	1	4.8
39	32.1	20.2	94.1	51.9	3.4	6.7	37.8	2	3.7
40	34.5	18.4	91.4	38.7	2.2	9.4	0.0	0	5.0
41	33.2	20.7	83.3	47.1	3.4	6.5	0.0	0	4.8
42	32.0	19.3	90.1	45.9	3.0	7.1	1.2	0	4.2
43	32.5	14.1	84.9	27.6	2.5	9.1	0.0	0	4.9
44	31.7	11.7	82.1	23.7	3.0	10.2	0.0	0	4.7
45	31.3	10.8	82.9	31.0	4.8	9.2	0.0	0	4.6
46	30.1	13.3	85.6	36.1	2.3	8.3	1.0	0	4.6
47	30.1	9.0	59.6	25.0	2.5	10.1	0.0	0	5.0
48	31.9	10.6	66.7	30.9	1.6	10.1	0.0	0	4.8
49	31.2	28.4	75.4	37.9	2.8	9.1	0.0	0	4.6
50	30.3	9.7	79.1	31.4	2.0	9.2	0.0	0	4.5
51	31.4	8.7	84.4	30.1	1.5	9.5	0.0	0	4.0
52	29.5	9.5	84.0	32.0	2.7	9.7	0.0	0	4.3
1	27.9	11.6	87.0	35.6	2.4	8.4	0.0	0	4.0
2	29.8	12.7	91.1	38.1	2.5	6.1	0.0	0	4.3
3	27.9	7.3	72.7	28.4	2.0	8.9	0.0	0	4.0
4	31.8	10.8	73.4	27.6	2.6	9.0	0.0	0	4.8
5	31.6	11.4	73.9	28.0	2.2	9.1	0.0	0	5.0
6	32.1	12.1	81.4	29.1	3.3	9.3	0.0	0	5.2
7	33.3	11.6	82.7	26.7	4.4	8.8	0.0	0	5.9
8	32.4	12.2	82.7	26.9	6.0	10.5	0.0	0	7.1
9	35.0	14.1	78.3	23.7	4.6	10.2	0.0	0	7.4
10	33.6	11.2	83.4	21.3	4.4	9.1	0.0	0	7.3
11	35.2	12.8	86.1	19.4	4.8	9.6	0.0	0	8.6
12	36.4	16.7	62.6	21.0	4.6	9.7	0.0	0	9.0
13	38.0	15.4	45.6	24.7	5.5	9.7	1.5	0	10.3
14	37.9	17.2	69.1	49.9	6.1	9.0	2.4	0	10.6
15	38.2	19.0	68.7	51.3	5.7	9.5	0.0	0	9.2
16	39.4	18.8	72.7	50.6	3.5	11.0	0.0	0	10.9
17	40.5	21.4	79.7	47.3	5.8	10.1	0.0	0	11.3
18	40.2	19.2	60.9	24.6	6.9	11.3	0.0	0	11.1

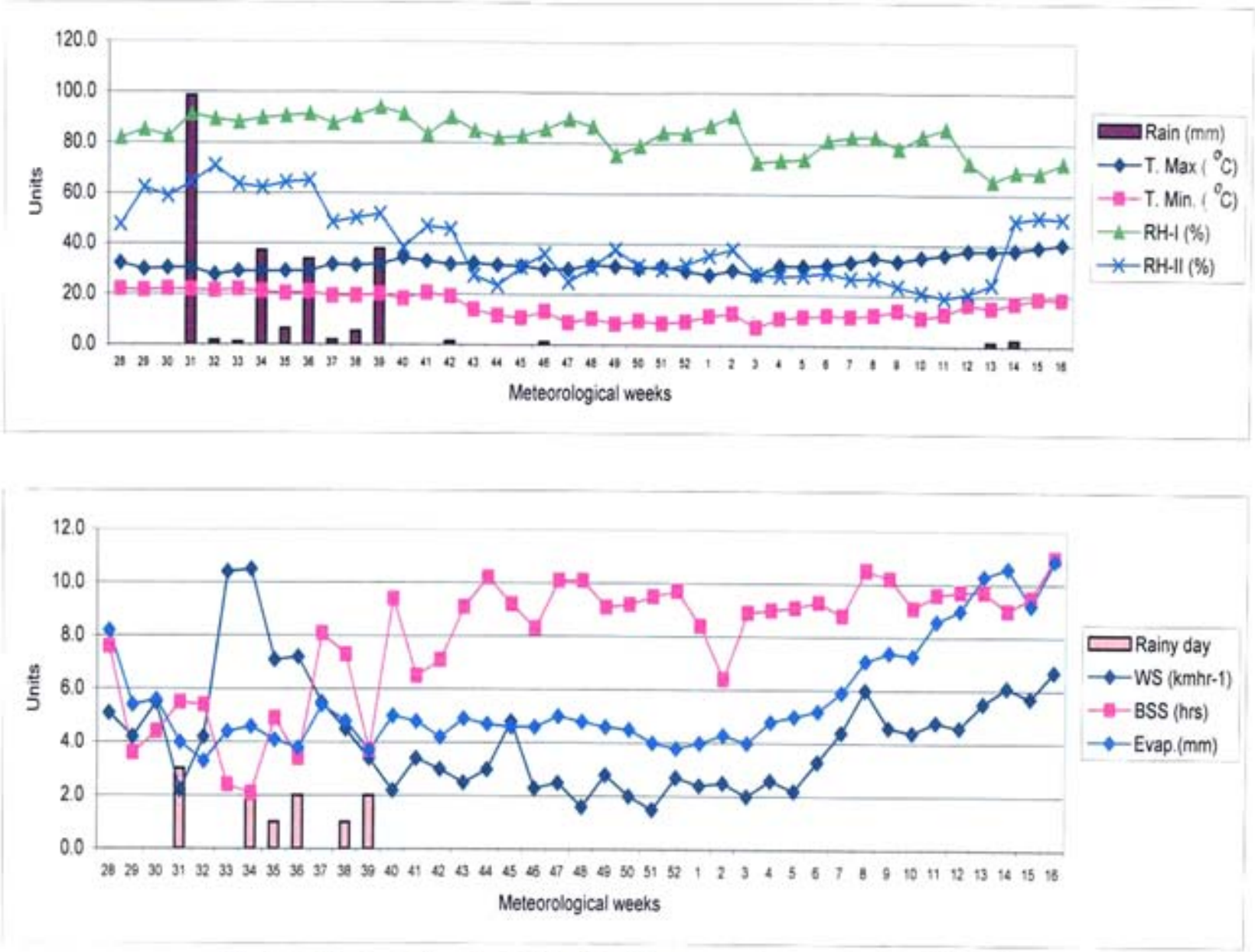


Fig. 1. Meteorological data for the cropping period 2002-03.

Table 3. Meteorological data for kharif and rabi seasons of cropping period 2003-04 at Rahuri.

Met. Week	Mean temperature (°C)		Mean relative humidity (%)		Mean wind speed (km hr^{-1})	Mean Bright sun shine (hrs d^{-1})	Total Rain fall (mm)	Number of rainy day/s	Pan evaporation (mm)
	Max.	Min.	Morning	Evening					
19	40.0	19.6	68.4	16.9	11.8	9.4	0.0	0	13.2
20	40.6	22.4	68.1	16.3	12.9	10.1	0.0	0	14.1
21	39.4	21.8	76.3	18.9	10.3	10.8	1.3	0	12.2
22	39.4	21.6	74.6	20.3	10.2	10.2	0.0	0	14.2
23	39.2	23.0	77.4	24.9	13.4	10.8	0.0	0	15.7
24	35.5	23.4	89.0	51.3	10.6	4.5	8.9	2	6.9
25	33.1	23.1	85.3	49.7	17.5	1.4	30.1	1	7.8
26	32.2	23.4	87.7	49.4	15.8	2.5	0.0	0	6.6
27	32.1	22.5	88.4	58.7	10.7	3.5	27.4	3	4.5
28	32.3	22.7	88.6	55.3	13.3	5.3	29.5	1	5.9
29	32.0	23.1	86.6	52.0	15.4	2.5	0.0	0	7.6
30	29.9	22.7	86.0	67.0	17.1	1.1	22.3	1	6.4
31	31.2	21.5	86.3	56.0	13.1	4.2	10.6	1	4.8
32	30.7	21.7	89.6	58.7	10.6	3.2	6.0	1	4.8
33	32.0	21.0	87.7	50.3	11.8	6.6	4.9	1	6.7
34	29.9	21.2	90.3	61.7	11.5	3.0	58.3	2	4.8
35	30.3	21.0	85.7	59.1	11.8	5.5	0.0	0	7.0
36	31.0	20.0	86.6	52.4	10.5	3.8	2.8	0	4.8
37	31.6	18.7	87.0	53.0	8.2	6.8	4.6	1	5.5
38	32.9	19.4	86.3	55.7	6.3	5.9	2.7	1	5.8
39	28.8	21.1	91.4	71.1	4.5	2.2	59.8	4	2.7
40	31.8	18.9	87.1	53.4	2.8	7.5	21.0	2	3.2
41	33.3	19.8	88.4	43.3	3.9	8.4	0.0	0	5.2
42	33.2	15.3	82.1	35.9	2.3	9.9	0.0	0	4.5
43	32.5	12.1	85.1	29.4	3.2	10.0	0.0	0	4.7
44	32.1	19.5	87.1	51.3	3.2	8.2	3.0	1	4.1
45	32.1	12.8	72.4	30.3	3.8	10.1	0.0	0	3.9
46	31.0	13.8	69.6	37.9	3.2	9.4	0.0	0	3.7
47	32.0	13.5	64.7	33.1	4.4	9.8	0.0	0	4.1
48	32.0	13.4	79.3	33.6	4.3	9.2	0.0	0	4.6
49	30.8	10.0	84.1	28.7	2.8	9.5	0.0	0	4.7
50	31.0	9.0	76.7	27.3	4.1	9.5	0.0	0	4.8
51	29.1	8.2	75.6	27.3	2.4	9.6	0.0	0	4.4
52	28.5	9.6	83.1	41.0	3.5	8.8	0.0	0	4.5
1	29.9	10.5	73.6	31.3	4.0	8.9	0.0	0	4.8
2	28.4	8.4	83.4	32.1	3.7	9.3	0.0	0	4.0
3	31.6	10.1	75.9	27.7	3.5	9.6	0.0	0	4.5
4	28.0	10.2	84.9	36.1	4.5	9.5	0.0	0	4.7
5	29.2	11.0	85.1	35.0	4.6	9.3	0.0	0	4.6
6	30.6	7.5	84.3	26.3	3.5	10.4	0.0	0	4.9
7	32.8	12.9	84.1	27.1	3.9	10.0	0.0	0	5.6
8	34.1	11.5	85.9	25.6	3.1	10.4	0.0	0	6.2
9	35.4	13.3	86.5	22.5	3.0	9.2	0.0	0	8.0
10	36.0	12.8	85.3	20.9	4.1	8.6	0.0	0	7.4
11	37.2	14.7	85.0	17.3	3.0	9.8	0.0	0	7.9
12	39.1	14.7	82.9	16.0	4.1	9.9	0.0	0	8.7
13	37.1	16.9	82.3	21.6	4.8	9.2	0.0	0	9.4
14	37.8	17.9	84.3	19.9	6.6	9.4	0.0	0	10.7
15	38.9	17.2	81.0	17.6	5.8	10.5	0.0	0	12.3
16	38.6	18.0	79.9	19.1	8.1	11.2	0.0	0	13.2
17	39.3	20.1	81.1	20.3	6.8	10.0	0.0	0	13.5

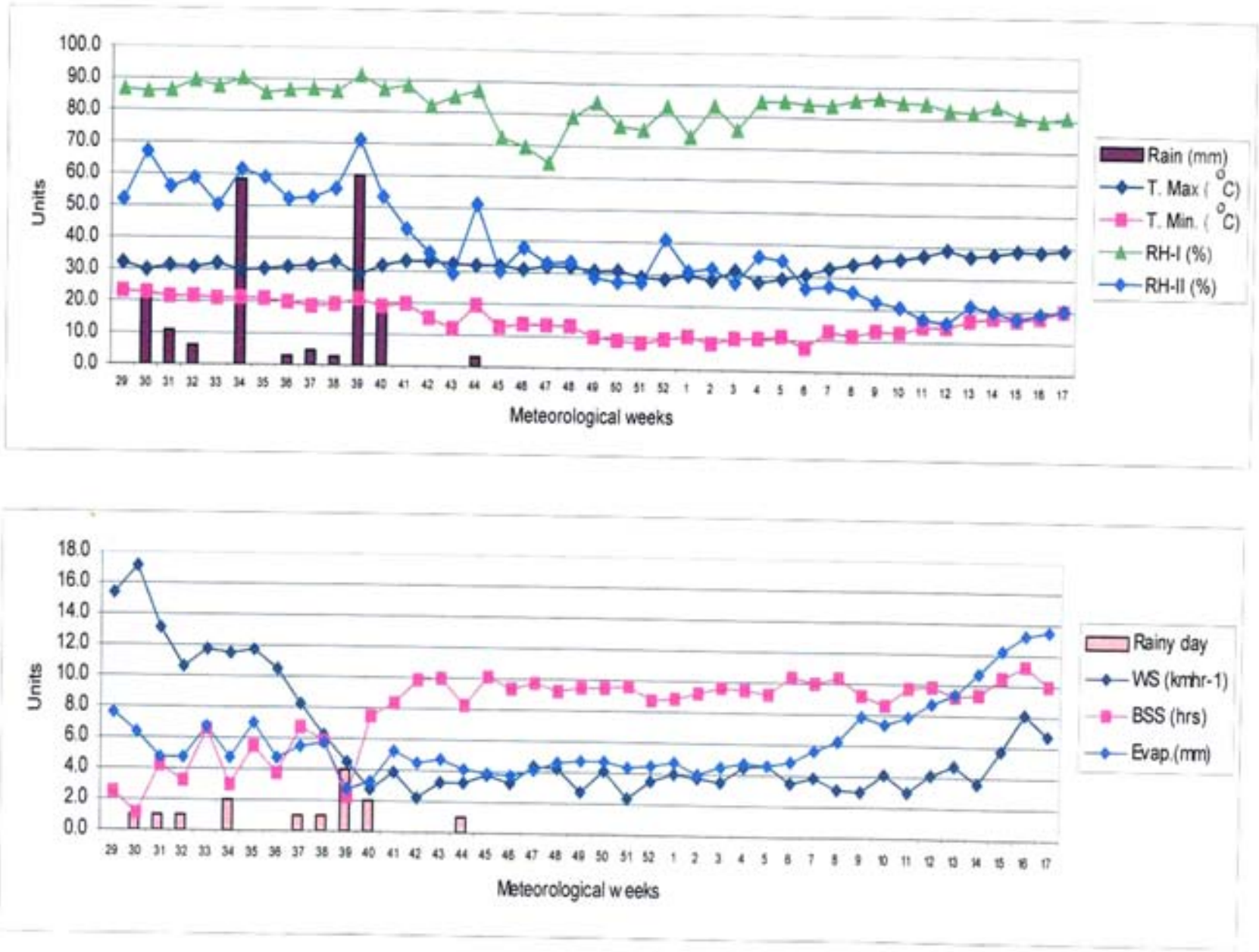


Fig. 2. Meteorological data for the cropping period 2003-04.

3.1.3 Cropping history of the experimental plot.

Cropping history of the experimental plot for the previous three years is presented in Table 4.

Table 4. Cropping history of the experimental plot.

Year	Kharif				Rabi			
	Crop	Fertilizer (kg ha^{-1})			Crop	Fertilizer (kg ha^{-1})		
		N	P	K		N	P	K
1999-00	Fallow	--	--	--	Gram	25	50	0
2000-01	Fallow	--	--	--	Gram	25	50	0
2001-02	Fallow	--	--	--	Gram	25	50	0
2002-03	*Senna*	(Present investigation)			*Isabgol*	(Present investigation)		
2003-04	*Senna*	(Present investigation)			*Isabgol*	(Present investigation)		

3.1.4 Seed material.

For *senna* crop Tinncvelly and for *isabgol* crop HI-2 variety were selected. The required seed material was obtained from " Dhanvantri " a medicinal plant garden of M.P.K.V., Rahuri.

3.1.5 Manure and fertilizers.

Recommended dose of N:P:K (75:50:0 kg ha^{-1}) for *senna* was applied @ 50%, 75%, 100% and 125% through different sources viz., FYM, urea and single super phosphate as per treatments. The recommended dose of N:P:K (50:25:0 kg ha^{-1}) for *isabgol* was applied @ 75% and 100% through urea and single super phosphate as per treatments. The nutrient contents of the various sources of nutrients utilized during kharif and rabi seasons of both the trials are presented in Table 5.

Table 5. Nutrient percent of different sources of fertilizers and farmyard manure utilized.

Sr. No.	Source	Nutrient content (%)					
		2002-03			2003-04		
		N	P	K	N	P	K
1.	Urea	46.00	--	--	46.00	--	--
2.	Single super phosphate	--	16.00	--	--	16.00	--
3.	Farmyard manure	0.55	0.20	0.50	0.50	0.18	0.45

3.1.6 Fungicides and insecticides.

To control the sclerotium wilt of *senna* and damping off disease of *isabgol*, seed treatment of thirum @ 3 g kg^{-1} of seed was performed and to control hairy caterpillar (*Helicoverpa armigera*) on *senna*, Endosulfan 35 E.C. was applied @

3.2 Methods.

3.2.1 Experimental details.

In kharif season, an experiment was laid out in a randomized block design with eight treatments and three replications. The eight main plots were given recommended dose of fertilizer at 50%, 75%, 100% (75:50:0 NPK kgha^{-1}) and 125% to *senna* through two different sources in combination. In rabi season, an experiment was laid out in split plot design on *isabgol*. The eight treatments laid out for kharif *senna* were considered as main plot. For testing their residual effect the main plots were further divided into two sub plots and recommended dose of fertilizer at 75% and 100% (50:25:0 NPK kgha^{-1}) to *isabgol* was applied as sub plot treatments. The treatment details and their symbols used are given in Table 6.

3.2.2 Cultural operations.

Details of the various cultural operations carried out in experimental plot during kharif and rabi seasons of both the trials are presented in Table 7.

3.2.2.1 Manure and fertilizer application.

In kharif season, the dose of farmyard manure and fertilizers viz., urea and single super phosphate to *senna* was worked out on the basis of their nutrient content. The manure alongwith the basal dose of fertilizer (50% N + 100% P) as per the treatments was evenly spread by broadcasting and then thoroughly mixed into the soil. Top dressing of fertilizer (50% N) as per treatments was performed 30 days after sowing of the crop. In rabi season, the dose of fertilizer was worked out on the basis of their nutrient content and applied to *isabgol* crop through different sources viz., urea and single super phosphate as per treatments, basal dose (50% N + 100% P) . Top dressing of fertilizer (50% N) as per treatments was performed 30 days after sowing of the crop.

3.2.2.2 Sowing.

The sowing details for the *senna* and *isabgol* crop are presented in Table 8. The plan of layout of the experiment for both the crops along with the allocation of their respective treatments and the symbols used are presented in Fig. 3.

Table 8. Sowing details for *senna* and *isabgol* during the year 2002-03 and 2003-04.

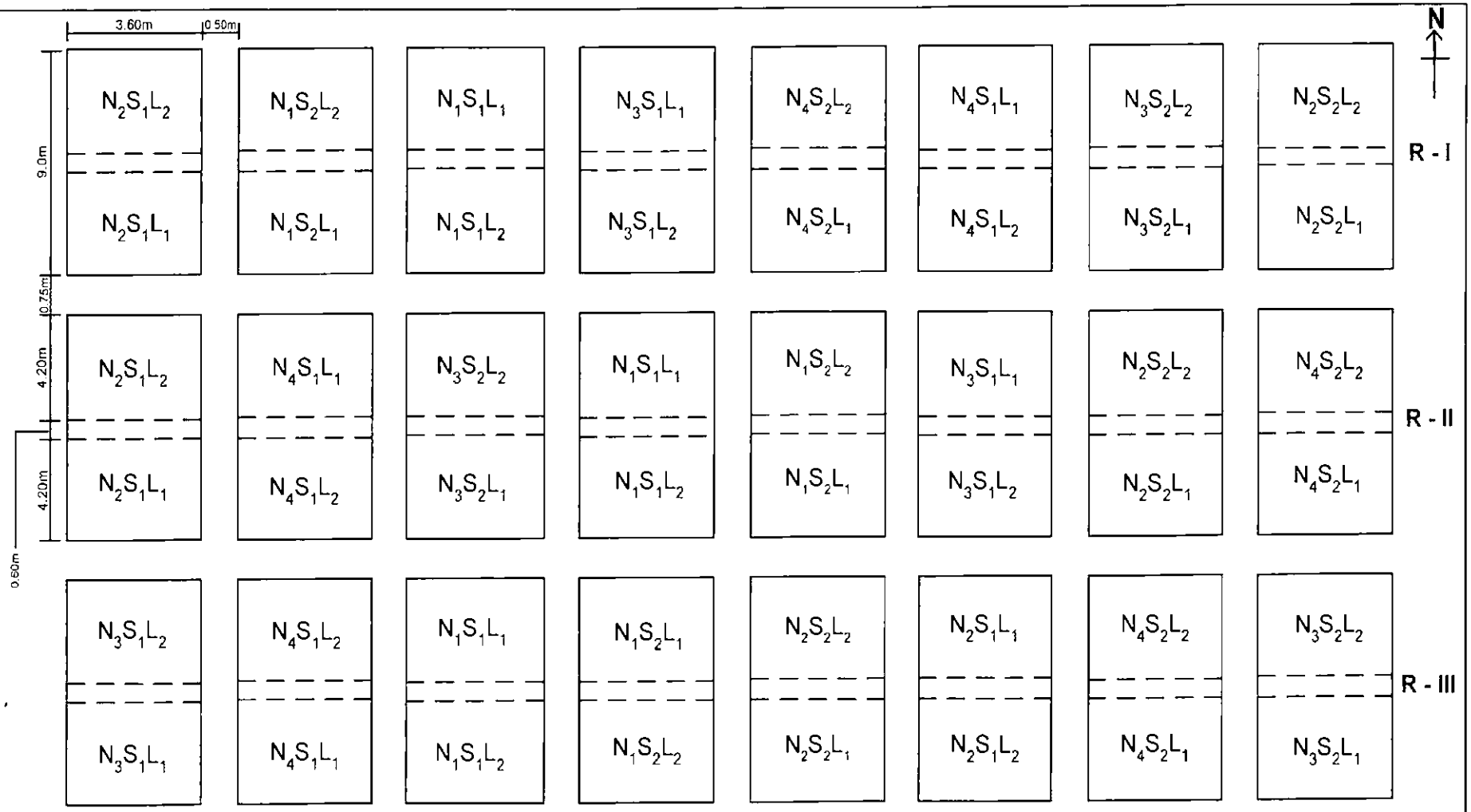
Season	Kharif	Rabi
Crop.	*Senna*	*Isabgol.*
Variety.	Tinnevelly	HI-2.
Design.	Randomised block design	Split plot design.
Replications.	Three.	Three.
Treatments.	Eight.	Main plot: Eight. Sub plot: Two.
Plot size: Gross.	9.00 x 3.60 m^2	4.20 x 3.60 m^2
Net.	8.40 x 2.70 m^2	3.60 x 3.00 m^2
Spacing.	45 x 30 cm^2	30 cm between rows.
Seed rate.	15 kg ha^{-1}.	10 kg ha^{-1}.
Sowing method.	Dibbling.	Line sowing

M.P.K.V. ★ Rahuri LIBRARY

Table 6. Treatment details for *senna* and *isabgol* during the year 2002-03 and 2003-04.

Sr. No.	Treatments	Symbol	
		Experiment layout	Table and Figure
	A) *Senna* (kharif) (Main plot treatments):		
1.	50% RDF (Inorganic fertilizer)	N_1S_1	50% RDF (100% IF)
2.	50% RDF (50% N through urea + 50% N through FYM)	N_1S_2	50% RDF (50:50% IF:FYM)
3.	75% RDF (Inorganic fertilizer)	N_2S_1	75% RDF (100% IF)
4.	75% RDF (50% N through urea + 50% N through FYM)	N_2S_2	75% RDF (50:50% IF:FYM)
5.	100% RDF (Inorganic fertilizer)	N_3S_1	100% RDF (100% IF)
6.	100% RDF (50% N through urea + 50% N through FYM)	N_3S_2	100% RDF (50:50% IF:FYM)
7.	125% RDF (Inorganic fertilizer)	N_4S_1	125% RDF (100% IF)
8.	125% RDF (50% N through urea + 50% N through FYM)	N_4S_2	125% RDF (50:50% IF:FYM)
	B) *Isabgol* (rabi) (Sub plot treatments):		
1.	75% RDF (Inorganic fertilizer)	L_1	75% RDF (100% IF)
2.	100% RDF (Inorganic fertilizer)	L_2	100% RDF (100% IF)

Note: i) Recommended dose of fertilizers, *senna* - 75:50:0 NPK kg ha^{-1}, *isabgol* - 50:25:0 NPK kg ha^{-1}.
ii) Inorganic fertilizer - N through urea, P through single super phosphate.



Design : In Kharif season - Randomized block design
Treatments : Eight
In Rabi season - Split plot design
Treatments : Main Plot: Eight, SubPlot: Two

Replications : 3

Plot Size :	Kharif	Rabi
Gross :	9.00 x 3.60 m^2	4.20 x 3.60 m^2
Net :	8.40 x 2.70 m^2	3.60 x 3.00 m^2

Crop:
Senna : Kharif
Spacing 45 x 30 cm^2

Isabgol : Rabi
Spacing 30 cm between rows.

Fig 3. Plan of layout of experiment.

PP 1. Experimental plot of *senna* during 2002-03 (1st year).

PP 2. Experimental plot of *senna* during 2003-04 (2nd year).

PP 3. Experimental plot of *isabgol* during 2002-03 (1st year).

PP 4. Experimental plot of *isabgol* during 2003-04 (2nd year).

Table 7. Schedule of cultural operations carried out in the experimental plot during 2002-03 and 2003-04.

Sr. No.	Operation	Frequency and Date			
		2002-03		2003-04	
I.	***Senna* (Kharif).**				
A)	**Preparatory tillage:**				
1.	Ploughing.	1	15/05/2002	1	13/05/2003
2.	Harrowing.	2	06/06/2002	2	09/06/2003
			13/06/2002		18/06/2003
3.	Stubble collection.	1	14/06/2002	1	19/06/2003
4.	Planking.	1	17/06/2002	1	23/06/2003
5.	Layout of experiment.	1	18/06/2002	1	24/06/2003
6.	Preparation of beds.	1	19/06/2002	1	25/06/2003
7.	Preparation of water channels.	1	21/06/2002	1	30/06/2003
B)	**Fertilizer and farmyard manure application.**				
1.	Application of farmyard manure as per treatments.	1	05/07/2002	1	07/07/2003
2.	Application of basal dose of fertilizers as per treatments.	1	15/07/2002	1	17/07/2003
C)	**Seeds and sowing:**				
1.	Seed treatment with *Thirum*.	1	15/07/2002	1	17/07/2003
2.	Sowing by dibbling.	1	15/07/2002	1	17/07/2003
D)	**Post-sowing operations.**				
1.	Gap filling.	1	19/07/2002	1	21/07/2003
2.	Thinning.	1	05/08/2002	1	06/08/2003
3.	Weeding.	3	24/07/2002	3	29/07/2003
			10/08/2002		10/08/2003
			12/09/2002		15/09/2003
4.	Top dressing with urea.	1	13/08/2002	1	15/08/2003
5.	Irrigation.	5	15/07/2002	5	17/07/2003
			13/08/2002		15/08/2003
			18/09/2002		15/09/2003
			22/10/2002		21/10/2003
			19/11/2002		20/11/2003
E)	**Plant protection measures.**		-		
1.	Soil drenching with *Thirum*.	1	23/08/2002	--	--

(cont'd...)

2.	*Spraying of endosulfan 35 E.C*	1	06/08/2002	--	--
F)	**Harvesting.**				
1.	Harvesting of fresh leaves.	3	12/10/2002	3	14/10/2003
			01/11/2002		03/11/2003
			09/01/2003		13/01/2003
2.	Harvesting of pods.	1	06/01/2003	1	10/01/2004
G)	**Threshing of pods.**	1	23/01/2003	1	29/01/2004
II.	***Isabgol* (Rabi).**				
A)	**Preparatory tillage.**				
1.	Harrowing.	2	13/01/2003	2	17/01/2004
			14/01/2003		19/01/2004
2.	Stubble collection.	1	14/01/2003	1	20/01/2003
3.	Layout of experiment.	1	15/01/2003	1	21/01/2004
4.	Preparation of beds.	1	15/01/2003	1	21/01/2004
5.	Preparation of water channels.	1	18/01/2003	1	24/01/2004
B)	**Fertilizer application.**				
1.	Application of basal dose of fertilizers as per treatments.	1	20/01/2003	1	26/01/2004
C)	**Seeds and sowing.**				
1.	Seed treatment with *Thirum*.	1	20/01/2003	1	26/01/2004
2.	Sowing by dibbling.	1	20/01/2003	1	26/01/2004
D)	**Post-sowing operations.**				
1.	Gap filling.	1	31/01/2003	1	06/02/2004
2.	Weeding.	3	14/02/2003	3	19/02/2004
			12/03/2003		03/03/2004
			31/03/2003		20/03/2004
3.	Top-dressing with urea.	1	18/02/2003	1	24/02/2004
4.	Irrigation.	4	20/01/2003	4	26/01/2004
			18/02/2003		24/02/2004
			04/03/2003		09/03/2004
			21/03/2003		25/03/2004
E)	**Harvesting.**	1	19/04/2003	1	26/04/2004
F)	**Threshing of spikes.**	1	21/04/2003	1	28/04/2004

3.2.3 Sampling techniques.

Various biometric observations were recorded on five randomly selected plants of *senna* and *isabgol* during both the trials in each net plot. Bamboo pegs were fixed at the north side of each plant for easy location. The growth observations were recorded on these plants from 30 days after sowing at an interval of 15 days upto harvest of the crop. These selected plants were further used for recording the yield contributing characters. The details of the various observations recorded during the period of investigation for *senna* and *isabgol* are presented in Table 9 and Table 10, respectively. Observations common to both the crops are presented in Table 11.

3.3 Statistical analysis and interpretation of data.

Data recorded was statistically analyzed by the technique of 'analysis of variance' (Fisher, 1970). 'F' test of significance was carried out as given by Cochron and Cox (1967) and Panse and Sukhatme (1978). In the tabular data, critical difference (C.D.) values have been given for comparison only in case where 'F' test was significant, figures of C.D. are not reported where 'F' test was not significant, only standard error (S.E.) values are presented. Pooled analysis of data was performed for the character of yield and economics. Significance of correlation co-efficient was tested against 't' values given by Fisher and Yates (1963) at five and one percent levels of significance. The regression co-efficient was tested by 'F' test at five and one percent levels of significance. Graphical representation of the data has been given at appropriate places.

Table 9. Details of observations recorded for *senna* during 2002-03 and 2003-04.

Sr. No. (1)	Observations (2)	Procedure (3)	Frequency (4)	Days after sowing (5)	Size of sample (6)
I.	**Plant count.**				
1.	Initial.	Plant count recorded at 20 days after sowing.	1	20 days.	All plants from net plot.
2.	Final.	Plant count recorded at the time of harvest of crop.	1	At harvest.	--"--
II.	**Growth studies.**				
1.	Plant height (plant^{-1}).	Height of the plant from the ground surface up to the base of last top leaf of the plant.	11	30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days and at harvest.	Five plants.
2.	Plant spread (plant^{-1}).	Maximum horizontal space occupied by a plant between tips of two extreme leaves in east-west direction of either side of the plant.	--"--	--"--	--"--
3.	Number of branches (plant^{-1}).	Number of branches borne on the main stem of the plant.	--"--	--"--	--"--
4.	Leaf area (plant^{-1}).	Leaves were separated from the plants and their area was measured by an automatic leaf area meter.	--"--	--"--	--"--
5.	Total fresh matter (plant^{-1}).	Two plants were uprooted and cleaned of soil and the weight of the plants was recorded on a weighing balance.	--"--	--"--	Two plants.
6.	Total dry matter (plant^{-1}).	Plants taken for fresh weight were kept in brown paper bag for air-drying, then they were oven dried at 60 ^{o}C temperature and weight of oven-dried plants was recorded on a weighing balance.	--"--	--"--	--"--
III.	**Post harvest studies.**				
1.	Number of filled pods (plant^{-1}).	Number of filled pods obtained from the observation plants were counted and worked out on plant^{-1} basis.	1	At harvest.	Five plants.

Table 9 cont'd...)

(1)	(2)	(3)	(4)	(5)	(6)
2.	Number of unfilled pods (plant^{-1}).	Number of unfilled pods obtained from the observation plants were counted and worked out on plant^{-1} basis.	--"--	--"--	--"--
3.	Total number of pods (plant^{-1}).	Total number of pods obtained from the observation plants were counted and worked out on plant^{-1} basis.	--"--	--"--	--"--
4.	Weight of filled pods (plant^{-1}).	Filled pods obtained from the observation plants were weighed and the weight worked out on plant^{-1} basis.	--"--	--"--	--"--
5.	Weight of unfilled pods (plant^{-1}).	Unfilled pods obtained from the observation plants were weighed and the weight worked out on plant^{-1} basis.	--"--	--"--	--"--
6.	Total weight of pods (plant^{-1}).	Total pods obtained from the observation plants were weighed and the weight worked out on plant^{-1} basis.	--"--	--"--	--"--
7.	Length of pod.	Pods obtained from the observation plants were utilized for measuring the length of pod and it was worked out on pod^{-1} basis.	--"--	--"--	--"--
8.	Breadth of pod.	Pods obtained from the observation plants were utilized for measuring the breadth of pod and it was worked out on pod^{-1} basis.	--"--	--"--	--"--
9.	Number of seeds (pod^{-1}).	Seeds obtained from the five observation plants were counted and the number of seeds was worked out on filled pod^{-1} basis.	--"--	--"--	--"--
10.	Weight of seeds (pod^{-1}).	Seeds obtained from the five observation plants were weighed and the weight of seeds was worked out on filled pod^{-1} basis.	--"--	--"--	--"--
11.	Number of seeds (plant^{-1}).	Seeds obtained from the five observation plants were counted and the number of seeds was worked out on plant^{-1} basis.	--"--	--"--	--"--
12.	Weight of seeds (plant^{-1}).	Seeds obtained from the five observation plants were weighed and the weight of seeds was worked out on plant^{-1} basis.	--"--	--"--	--"--
13.	Thousand seed weight.	A random sample of seeds from net plot produce was drawn, thousand seeds were counted and their weight was recorded.	--"--	--"--	Net plot
14.	Fresh root weight (plant^{-1}).	Fresh roots obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	Five plants.
15.	Dry root weight (plant^{-1}).	Dry roots obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--
16.	Fresh stalk weight (plant^{-1}).	Fresh stalks obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--
17.	Dry stalk weight (plant^{-1}).	Dry stalks obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--

(Table 9 cont`d...)

(1)	(2)	(3)	(4)	(5)	(6)
18.	Fresh leaves weight (plant^{-1}).	Fresh leaves obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	3	90, 110 days and at harvest.	--"--
19.	Dry leaves weight (plant^{-1}).	Dry leaves obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--
20.	Pod shell weight (plant^{-1}).	Pod shells obtained from the five observation plants were weighed and the weight was worked out on plant^{-1} basis.	1	At harvest.	--"--
21.	Fresh root yield (ha^{-1}).	Fresh roots obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	1	At harvest.	All plants from net plot.
22.	Dry root yield (ha^{-1}).	Dry roots obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
23.	Fresh stalk yield (ha^{-1}).	Fresh stalks obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
24.	Dry stalk yield (ha^{-1}).	Dry stalks obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
25.	Fresh leaves yield (ha^{-1}).	Fresh leaves obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	3	90, 110 days and at harvest.	--"--
26.	Dry leaves yield (ha^{-1}).	Dry leaves obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
27.	Seed yield (ha^{-1}).	Seeds obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	1	At harvest.	--"--
28.	Pod shell yield (ha^{-1}).	Pod shells obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
IV.	**Chemical studies.**				
1.	Plant analysis (sennoside).	As per the procedure given by Patil *et al.* 1996 a. pp. 207.	3	Leaf- 90 DAS, 110 DAS and at harvest. Pod- 90 DAS, 110 DAS and 120 DAS.	Adequate sample.

Table 10. Details of observations recorded for *isabgol* during 2002-03 and 2003-04.

Sr. No. (1)	Observations (2)	Procedure (3)	Frequency (4)	Days after sowing (5)	Size of sample (6)
I.	**Plant count.**				
1.	Initial.	Plant count recorded at 20 days after sowing in one metre length in five rows selected randomly in net plot.	1	20 days.	All plants from one metre row length
II.	**Growth studies.**				
1.	Plant height (plant^{-1}).	Height of the plant from the ground surface up to the base of last top leaf of the plant.	5	30, 45, 60, 75 days and at harvest.	Five plants.
2.	Number of leaves (plant^{-1}).	Number of leaves borne on the main stem of the plant.	--"--	--"--	--"--
3.	Number of productive tillers (plant^{-1}).	Tillers showing emergence of spikes were deemed to be productive.	4	45, 60, 75, days and at harvest.	--"--
4.	Number of unproductive tillers (plant^{-1}).	Tillers not showing any spikes were deemed to be unproductive.	--"--	--"--	--"--
5.	Total number of tillers (plant^{-1}).	Total number of tillers on observation plants were recorded and worked out on plant^{-1} basis.	--"--	--"--	--"--
6.	Total dry matter (plant^{-1}).	Plants were kept in brown paper bag for air-drying, then they were oven dried at 60 ^{o}C temperature and weight of oven-dried plants was recorded on a weighing balance.	5	30, 45, 60, 75, days and at harvest.	Two plants.
III.	**Post harvest studies.**				
1.	Number of productive spikes (plant^{-1}).	Productive spikes on the observation plants were counted and worked out on plant^{-1} basis.	1	At harvest.	Five plants.
2.	Number of unproductive spikes(plant^{-1}).	Unproductive spikes on the observation plants were counted and worked out on plant^{-1} basis.	--"--	--"--	--"--
3.	Total number of spikes(plant^{-1}).	Total number of spikes on the observation plants were counted and worked out on plant^{-1} basis.	--"--	--"--	--"--
4.	Length of spike	Spikes obtained from the observation plants were utilized for measuring length of spike and it was worked out on spike^{-1} basis.	--"--	--"--	--"--

(Table 10 cont'd...)

(1)	(2)	(3)	(4)	(5)	(6)
5.	Girth of spike	Spikes obtained from the observation plants were utilized for measuring girth of spike and it was worked out on spike^{-1} basis.	--"--	--"--	--"--
6.	Number of seeds (spike^{-1}).	Seeds obtained from the observation plants were counted and the number of seeds was worked out on spike^{-1} basis.	--"--	--"--	--"--
7.	Weight of seeds (spike^{-1}).	Seeds obtained from the observation plants were weighed and the weight of seeds was worked out on spike^{-1} basis.	--"--	--"--	--"--
8.	Number of seeds (plant^{-1}).	Seeds obtained from the observation plants were counted and the number of seeds was worked out on plant^{-1} basis.	--"--	--"--	--"--
9.	Weight of seeds (plant^{-1}).	Seeds obtained from the observation plants were weighed and the weight of seeds was worked out on plant^{-1} basis.	--"--	--"--	--"--
10.	Thousand seed weight.	A random sample of seeds from net plot produce was drawn, thousand seeds were counted and their weight was recorded.	--"--	--"--	Net plot
11.	Root weight (plant^{-1}).	Roots obtained from the observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	Five plants
12.	Stalk weight (plant^{-1}).	Stalks obtained from the observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--
13.	Leaves weight (plant^{-1}).	Leaves obtained from the observation plants were weighed and the weight was worked out on plant^{-1} basis.	--"--	--"--	--"--
14.	Root yield (ha^{-1}).	Roots obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	---"--	--"--	All plants from net plot.
15.	Stalk yield (ha^{-1}).	Stalks obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
16.	Leaves yield (ha^{-1}).	Leaves obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
17.	Seed yield (ha^{-1}).	Seeds obtained from the net plot were weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
18.	Total straw yield (ha^{-1}).	Total straw obtained from the net plot was weighed and the weight was worked out on ha^{-1} basis.	--"--	--"--	--"--
IV.	**Chemical studies.**				
1.	Protein content (%).	Nitrogen content of seed was multiplied by a factor of 6.25.	1	At harvest.	Adequate sample.
2.	Husk percentage.	As per the procedure given by Thanki and Talati, 1983. pp. 208.	---"--	--"--	--"--
3.	Swelling factor	As per the procedure given by Dalal and Sriram, 1995. pp. 208.	--"--	--"--	--"--

Table 11. Details of observations recorded common to *senna* and for *isabgol* during 2002-03 and 2003-04.

Sr. No. (1)	Observations recorded (2)	Procedure (3)	Frequency (4)	Days after sowing (5)	Size of sample (6)
I.	**Growth analysis.**				
1.	Absolute growth rate.	AGR of total dry matter was calculated as per the formula (Radford, 1967) $AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$ Where, W_1 and W_2 = dry matter weight of the plant at times t_1 and t_2 in weeks, respectively.	10	30-45,45-60, 60-75,75-90, 90-105,105-120, 120-135,135-50, 150-165,165-at harvest	Two plants
2.	Relative growth rate.	RGR of total dry matter was calculated as per the formula (Radford, 1967) $RGR = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$ Where, $\log_e W_1$ and $\log_e W_2$ = neperian log value of dry weight of the plant at times t_1 and t_2 in weeks, respectively.	--"--	--"--	--"--
II.	**Growth studies.**				
1.	Days to flower initiation.	Number of days required for first flower to open.	1	At flower initiation.	Twenty plants net plot[-1].
2.	Days to 50% flowering.	Number of days required for 50% flowering.	1	During flowering.	--"--
3.	Days to maturity.	Number of days required for majority of pods to dry.	1	At harvest.	--"--
III.	**Harvest Index.**	Calculated on dry weight basis as per the formula (Donald, 1962). $H.I.\ (\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$ *Senna*: Economic yield= Yield of dry leaves and seed. Biological yield= Yield of root, stalk, leaves, seed and pod shell. *Isabgol*: Economic yield= Yield of seed. Biological yield= Yield of root, stalk, leaves, seed.	1	--"--	----------

(Table 11 cont'd...)

(1)	(2)	(3)	(4)	(5)	(6)
IV.	**Plant analysis.**	Digestion of plant samples was carried out in digestion chamber (Huang and Shuttle, 1985).	1	At harvest.	Adequate sample
1.	Determination of N.	As per procedure given by Jackson (1973).	--"--	--"--	--"--
2.	Determination of P.	As per procedure given by Piper (1966) on Spectronic 20D+.	--"--	--"--	--"--
3.	Determination of K.	As per procedure given by Jackson (1973) on Flame Photometer.	--"--	--"--	--"--
V.	**Uptake Studies.**	Uptake of N,P,K in plant was calculated by the formula, $\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Yield of plant part (kg ha}^{-1}\text{) X Concentration of nutrient (\%)}}{100}$	--"--	--"--	--"--
VI.	**Soil analysis.**	The soil was analyzed for pH, electrical conductivity (dS m^{-1}), bulk density (g cc^{-1}), organic carbon (%), total nitrogen (%), available N, P and K (kg ha^{-1}). The C:N Ratio of soil was also worked out.	--"--	--"--	--"--
VII.	**Economics of cultivation.**				
1.	Gross monetary returns ha^{-1}.	Gross monetary returns were worked out for different treatments on ha^{-1} basis by multiplying the saleable yield obtained with the prevailing market prices.	--"--	--"--	----------
2.	Cost of cultivation ha^{-1}.	Cost of cultivation was worked out for different treatments on ha^{-1} basis by summing the cost for the materials and services utilized for cultivating the crop.	--"--	--"--	----------
3.	Net monetary returns ha^{-1}.	Net monetary returns were worked out for different treatments by subtracting cost of cultivation ha^{-1} from gross monetary returns ha^{-1} obtained.	--"--	--"--	----------
4.	Benefit:Cost Ratio.	Computed by the formula, $\text{B:C} = \frac{\text{Gross monetary returns}}{\text{Cost of cultivation}}$	--"--	--"--	----------

(Table 11 cont'd...)

(1)	(2)	(3)	(4)	(5)	(6)
VIII	**Correlation and regression studies.**	Simple correlation and regression for various growth and yield contributing characters with seed yield plant^{-1} was calculated as per the formula suggested by Snedecor and Cochron (1967).			
1.	Correlation	$r = \frac{\sum (X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum (X-\bar{X})^2 . \sum (Y-\bar{Y})^2}}$ Where, **r**= correlation coefficient of lines X and Y.	--"--	--"--	----------
2.	Regression.	$\mathbf{Y} = a \pm bx$ Where, Y= Dependent variate. a= Intercept. b= Regression coefficient. x= Independent variate. $\mathbf{a} = \bar{Y} - b\bar{X}$ **b= Regression coefficient of line Y on Line X.** $\mathbf{b_{xy}} = \frac{\sum Xi\,Yi - n\bar{X}\,\bar{Y}}{\sum X^2i - n\bar{X^2}}$ **r^2 = Coefficient of determination;** $\mathbf{r^2} = \frac{\{\sum (Y-\bar{Y}) . (X-\bar{X})\}^2}{\sum (X-\bar{X})^2 . \sum (Y-\bar{Y})^2}$	--"--	--"--	----------

4.EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The data on various growth and yield contributing characters, yield, quality, economics of cropping system, chemical studies regarding nitrogen, phosphate and potassium content of *senna* and their removal from soil, along with residual effects on succeeding crops as influenced by various treatments in respect of kharif *senna* and succeeding crop rabi *isabgol* are presented in this chapter.

4.1 *Senna.*

4.1.1 Pre-harvest studies.

4.1.1.1 Plant count.

4.1.1.1.1 Initial plant count.

The initial plant count net plot^{-1} was recorded 20 days after sowing for various treatments during 2002-03 and 2003-04 and presented in Table 12. The mean initial plant population net plot^{-1} was 165 during both the years. The mean initial plant count percentage to the expected plant population net plot^{-1} was 98.21 and 98.14 during 2002-03 and 2003-04, respectively. The treatments under study did not influence the plant count at the initial stage.

Table 12. Mean plant count of *senna* net plot^{-1} at 20 days after sowing and at harvest as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Plant count							
	2002-03				2003-04			
	Initial		At harvest		Initial		At harvest	
	Net plot^{-1}	% to the expected	Net plot^{-1}	% to the expected	Net plot^{-1}	% to the expected	Net plot^{-1}	% to th expecte
50% RDF (100% IF)	165	98.21	142	84.52	164	97.62	140	83.33
50% RDF (50:50% N IF:FYM)	165	98.21	141	83.93	165	98.21	141	83.93
75% RDF (100% IF)	165	98.21	142	84.52	166	98.81	142	84.52
75% RDF (50:50% N IF:FYM)	164	97.62	140	83.33	165	98.21	141	83.93
100% RDF (100% IF)	166	98.81	143	85.12	165	98.21	141	83.93
100% RDF (50:50% N IF:FYM)	165	98.21	142	84.52	164	97.62	141	83.93
125% RDF (100% IF)	164	97.62	140	83.33	165	98.21	142	84.52
125% RDF (50:50% N IF:FYM)	166	98.81	143	85.12	165	98.21	142	84.52
S.E. ±	0.78	–	1.04	–	0.69	–	0.87	–
C.D. at 5%	N.S.	–	N.S.	–	N.S.	–	N.S.	–
Mean	165	98.21	142	84.30	165	98.14	141	84.08

4.1.1.1.2 Final plant count.

The final plant count net plot^{-1} was recorded at harvest and presented in Table 12. The mean final plant population net plot^{-1} was 142 and 141 during 2002-03 and 2003-04, respectively. The mean final plant count percentage to the expected plant population net plot^{-1} was 84.30 and 84.08 during 2002-03 and 2003-04, respectively. The treatments under study did not influence the plant count at the harvest stage.

4.1.1.2 Growth studies.

4.1.1.2.1 Plant height plant^{-1}.

The data on plant height as influenced periodically by different treatments are presented in Table 13. The mean plant height of *senna* on the 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 8.10, 18.71, 36.53, 60.77, 75.48, 82.53, 89.24, 93.67, 96.35, 98.45 and 98.84 cm, respectively during 2002-03. The corresponding values during 2003-04 were 8.00, 18.37, 36.34, 60.02, 74.91, 82.10, 89.21, 93.73, 96.79, 98.74 and 99.59 cm, respectively.

At 30 days, the treatment differences were found to be non-significant in respect of plant height during both the years.

At 45 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum plant height (20.57 and 20.72 cm during 2002-03 and during 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was also observed at remaining days of observation during both the years.

4.1.1.2.2 Plant spread plant^{-1}.

The data on spread of plant as influenced periodically by different treatments are presented in Table 14. The mean plant spread of *senna* on 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 12.10, 25.30, 45.31, 66.50, 78.86, 84.13, 88.94, 92.41, 94.77, 96.88 and 97.13 cm, respectively during 2002-03. The corresponding values during 2003-04 were 12.00, 25.12, 44.90, 65.55, 77.40, 83.08, 88.45, 92.31, 94.78, 96.85 and 97.82 cm, respectively.

At 30 days, the treatment differences were found to be non-significant in respect of plant spread during both the years.

At 45 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum plant spread (28.19 and 29.12 cm during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through

Table 13. Mean plant height (cm plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

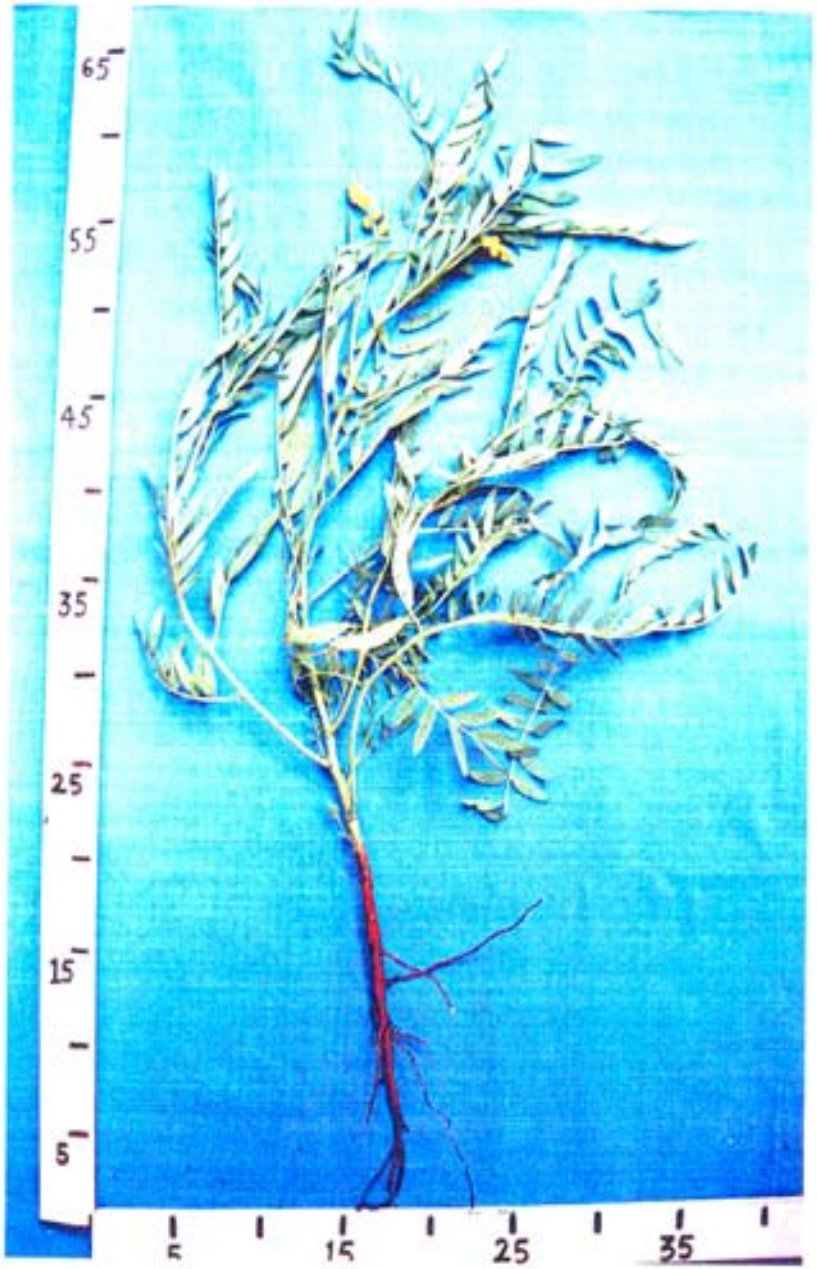
Treatment	Plant height (cm)																					
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	7.83	7.68	16.80	15.71	32.24	30.38	54.19	51.76	68.21	65.34	74.77	71.98	80.06	77.81	83.86	81.68	87.09	85.38	89.09	87.43	90.03	88.43
50% RDF (50:50% NIF:FYM)	7.78	7.65	16.92	15.87	32.90	31.05	54.85	52.43	68.40	65.71	75.35	73.04	80.53	78.56	84.91	82.93	87.78	86.27	89.79	88.44	90.13	89.05
75% RDF (100% IF)	7.95	7.80	18.02	16.98	35.63	33.86	58.56	55.48	73.47	70.70	80.40	77.98	87.56	85.76	90.95	89.13	93.75	91.88	95.63	93.87	95.88	94.88
75% RDF (50:50% NIF:FYM)	8.08	7.96	18.12	17.19	36.23	34.52	59.16	56.28	74.15	71.31	81.43	79.35	88.21	86.61	92.23	90.47	94.47	92.72	96.47	94.66	96.92	96.08
100% RDF (100% IF)	8.12	8.16	19.22	19.81	38.02	39.28	64.06	65.19	78.96	80.72	85.83	87.28	93.04	94.88	97.90	99.87	101.13	102.77	103.26	104.41	103.72	105.18
100% RDF (50:50% NIF:FYM)	8.22	8.20	19.84	20.20	38.73	40.21	64.78	66.08	79.85	81.37	86.98	88.48	94.23	96.13	99.17	101.18	101.82	104.21	103.92	105.98	104.04	106.62
125% RDF (100% IF)	8.37	8.25	20.21	20.50	39.03	40.45	65.03	66.24	80.10	81.80	87.37	88.92	94.97	96.70	99.96	102.07	102.24	105.15	104.65	107.03	104.89	107.90
125% RDF (50:50% NIF:FYM)	8.43	8.31	20.57	20.72	39.42	41.00	65.51	66.73	80.71	82.31	88.14	89.77	95.34	97.22	100.36	102.50	102.50	105.97	104.76	108.08	105.07	108.60
S.E. ±	0.21	0.22	0.28	0.19	0.28	0.32	0.25	0.33	0.32	0.34	0.41	0.47	0.45	0.44	0.44	0.46	0.25	0.65	0.29	0.73	0.36	0.70
C.D. at 5%	N.S.	N.S.	0.86	0.58	0.84	0.97	0.75	1.00	0.97	1.03	1.23	1.43	1.37	1.33	1.32	1.40	0.76	1.97	0.88	2.21	1.09	2.12
Mean	8.10	8.00	18.71	18.37	36.53	36.34	60.77	60.02	75.48	74.91	82.53	82.10	89.24	89.21	93.67	93.73	96.35	96.79	98.45	98.74	98.84	99.59

Table 14. Mean plant spread (cm plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

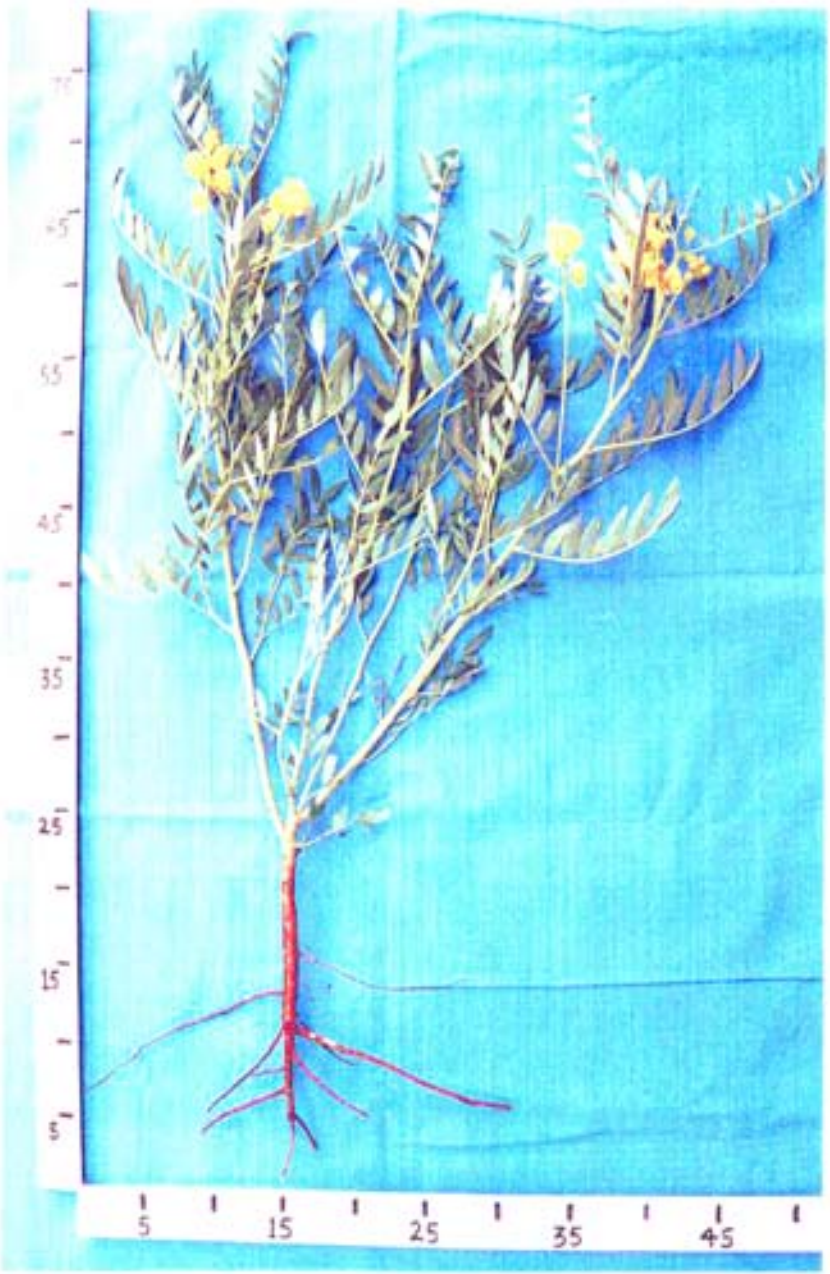
Treatment	Plant spread (cm)																					
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	11.89	11.74	21.50	20.22	39.47	37.10	59.03	55.38	70.46	66.21	74.88	70.38	78.85	75.18	81.77	79.85	83.77	82.69	85.74	84.38	86.07	85.18
50% RDF (50:50% N IF:FYM)	11.98	11.85	22.07	20.81	40.17	37.78	59.96	56.48	71.68	67.03	75.86	71.40	79.77	76.57	82.97	81.08	84.97	83.28	86.91	85.48	87.17	86.26
75% RDF (100% IF)	12.02	11.78	24.39	22.77	43.87	41.25	65.64	61.82	77.51	72.60	83.71	78.53	88.68	85.33	91.94	89.36	93.94	92.47	96.02	94.38	96.27	95.54
75% RDF (50:50% N IF:FYM)	12.10	12.02	25.04	23.58	44.59	42.00	66.24	62.92	78.05	73.60	84.01	79.40	88.98	86.13	92.37	90.10	94.37	93.12	96.45	95.28	96.71	96.37
100% RDF (100% IF)	12.12	12.07	26.38	27.54	46.97	48.56	68.52	70.82	81.84	83.42	87.65	89.82	92.84	94.74	96.20	98.13	98.96	100.44	100.93	102.52	101.04	103.50
100% RDF (50:50% N IF:FYM)	12.15	12.11	27.01	28.08	48.58	50.24	70.05	71.73	83.08	84.67	88.63	91.23	93.77	95.66	97.33	99.35	100.21	101.50	102.17	103.56	102.43	104.60
125% RDF (100% IF)	12.20	12.18	27.84	28.85	49.17	50.93	71.13	72.42	83.88	85.56	88.72	91.73	93.91	96.90	97.90	100.00	100.55	102.13	103.04	104.51	103.32	105.36
125% RDF (50:50% N IF:FYM)	12.31	12.26	28.19	29.12	49.68	51.37	71.44	72.85	84.38	86.12	89.60	92.16	94.70	97.05	98.77	100.60	101.36	102.60	103.81	104.72	104.04	105.71
S.E. ±	0.15	0.18	0.42	0.40	0.55	0.60	0.55	0.38	0.46	0.66	0.33	0.50	0.32	0.48	0.50	0.43	0.45	0.41	0.56	0.42	0.55	0.43
C.D. at 5%	N.S.	N.S.	1.28	1.21	1.67	1.82	1.67	1.15	1.40	2.00	1.00	1.52	0.97	1.46	1.52	1.30	1.37	1.24	1.70	1.27	1.67	1.31
Mean	12.10	12.00	25.30	25.12	45.31	44.90	66.50	65.55	78.86	77.40	84.13	83.08	88.94	88.45	92.41	92.31	94.77	94.78	96.88	96.85	97.13	97.82

PP 5. *Senna* plant at 30 DAS.

PP 6. *Senna* plant at 45 DAS.



PP 7. *Senna* plant at 60 DAS.



PP 8. *Senna* plant at 75 DAS.

PP 9. *Senna* plant at 90 DAS.

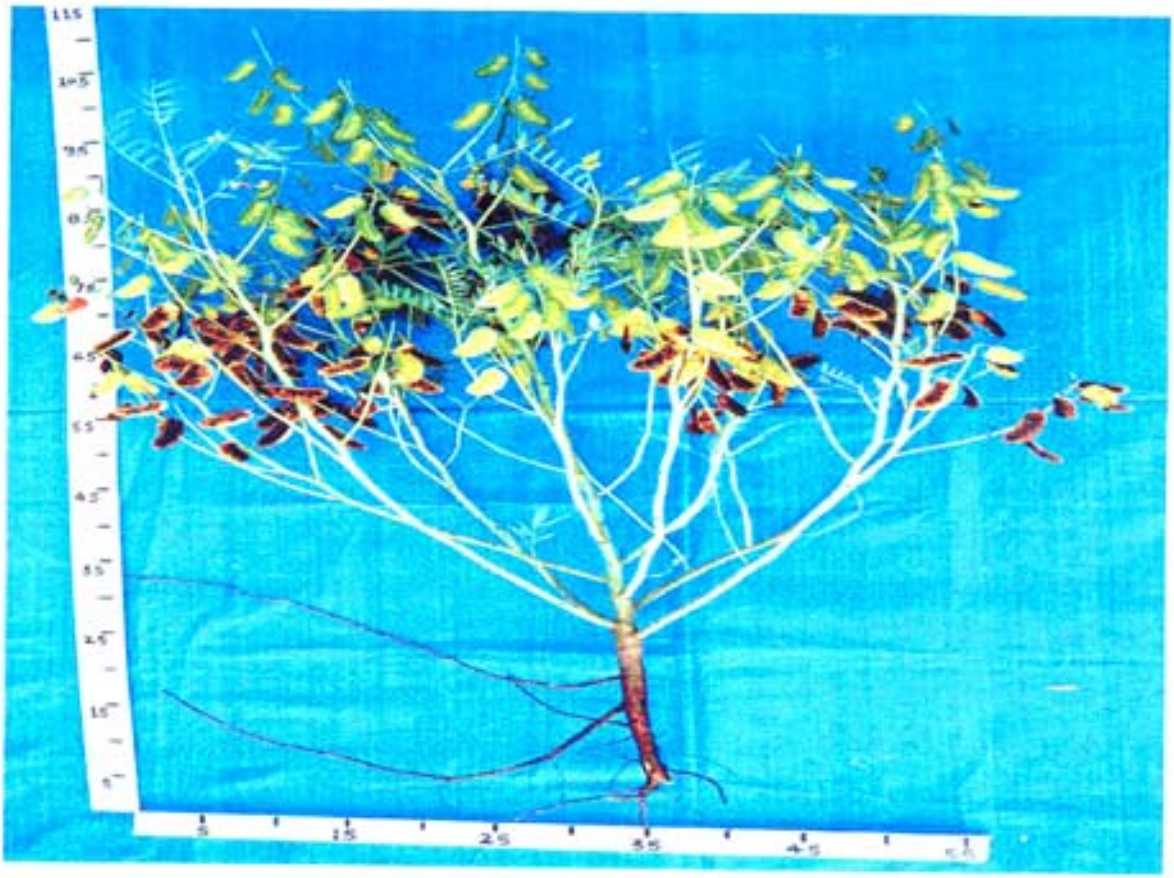
PP 10. *Senna* plant at 105 DAS.

PP 11. *Senna* plant at 120 DAS.

PP 12. *Senna* plant at 135 DAS.

PP 13. *Senna* plant at 150 DAS.

PP 14. *Senna* plant at 165 DAS.



PP 15: *Senna* plant at harvest.

urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was also observed at remaining days of observation during both the years.

4.1.1.2.3 Number of branches plant^{-1}.

The data on number of branches plant^{-1} as influenced periodically by different treatments are presented in Table 15. The mean number of branches plant^{-1} of *senna* on the 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 3.08, 6.08, 8.13, 8.69, 8.83, 8.88, 8.93, 8.95, 8.97 and 8.97, respectively during 2002-03. The corresponding values during 2003-04 were 3.02, 6.03, 8.00, 8.60, 8.75, 8.89, 8.97, 9.01, 9.02 and 9.02, respectively.

At 45 days, the treatment differences were found to be non-significant in respect of number of branches plant^{-1} during both the years.

At 60 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum number of branches plant^{-1} (6.67 and 6.80 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and 100% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

At 75 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum number of branches plant^{-1} (8.87 and 8.82 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was observed at 90, 105, 120, 135 and 150 days after sowing during both the years of study. Number of branches plant^{-1} remained constant after 150 days after sowing till harvest.

4.1.1.2.4 Leaf area plant^{-1}.

The data on leaf area plant^{-1} as influenced periodically by different treatments are presented in Table 16. The mean leaf area plant^{-1} of *senna* on the 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 0.61, 2.19, 4.50, 8.56, 14.16, 10.05, 9.44, 10.95, 13.17, 14.97 and 15.77 dm^2, respectively during 2002-03. The corresponding values during 2003-04 were 0.65, 2.15, 4.45, 8.49, 14.00, 9.92, 9.52, 10.90, 13.33, 14.77 and 15.16 dm^2, respectively.

Table 15. Mean number of branches (plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Number of branches																			
	45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50%RDF(100%IF)	3.00	2.93	5.33	5.13	7.27	7.00	7.80	7.60	7.87	7.73	7.93	7.87	8.00	7.93	8.00	8.00	8.00	8.00	8.00	8.00
50%RDF(50:50%NIF:FYM)	3.00	2.93	5.40	5.20	7.40	7.07	7.87	7.67	8.00	7.80	8.07	7.93	8.07	8.00	8.13	8.13	8.13	8.13	8.13	8.13
75%RDF(100%IF)	3.07	2.93	5.87	5.60	7.80	7.47	8.40	8.20	8.47	8.27	8.53	8.47	8.53	8.53	8.60	8.53	8.60	8.53	8.60	8.53
75%RDF(50:50%NIF:FYM)	3.07	3.00	5.93	5.73	8.00	7.60	8.53	8.33	8.67	8.40	8.73	8.60	8.80	8.73	8.83	8.73	8.87	8.73	8.87	8.73
100%RDF(100%IF)	3.07	3.00	6.33	6.40	8.33	8.53	8.92	9.07	9.07	9.20	9.13	9.33	9.20	9.47	9.20	9.47	9.20	9.47	9.20	9.47
100%RDF(50:50%NIF:FYM)	3.07	3.07	6.53	6.67	8.60	8.67	9.20	9.20	9.33	9.40	9.40	9.53	9.47	9.60	9.47	9.67	9.47	9.67	9.47	9.67
125%RDF(100%IF)	3.13	3.13	6.60	6.73	8.73	8.80	9.33	9.34	9.53	9.60	9.60	9.67	9.60	9.73	9.67	9.73	9.67	9.80	9.67	9.80
125%RDF(50:50%NIF:FYM)	3.20	3.13	6.67	6.80	8.87	8.82	9.46	9.40	9.67	9.60	9.67	9.73	9.73	9.73	9.73	9.80	9.80	9.80	9.80	9.80
S.E.±	0.09	0.08	0.12	0.09	0.10	0.05	0.11	0.08	0.12	0.08	0.12	0.08	0.11	0.07	0.11	0.08	0.10	0.06	0.10	0.06
C.D. at 5%	N.S.	N.S.	0.36	0.27	0.30	0.15	0.33	0.24	0.36	0.24	0.36	0.24	0.33	0.21	0.33	0.24	0.30	0.18	0.30	0.18
Mean	3.08	3.02	6.08	6.03	8.13	8.00	8.69	8.60	8.83	8.75	8.88	8.89	8.93	8.97	8.95	9.01	8.97	9.02	8.97	9.02

Table 16. Mean leaf area (dm^2 plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Leaf area (dm^2)																			
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.58	0.65	1.87	1.73	3.90	3.77	7.68	7.48	12.80	12.17	8.81	8.37	7.56	7.26	9.20	9.00	11.87	11.43	13.61	13.02	14.36	13.30
50% RDF (50:50% NIF:FYM)	0.60	0.63	1.98	1.81	4.00	3.88	7.89	7.57	13.02	12.32	9.00	8.58	8.05	8.23	9.71	9.45	11.94	11.66	13.80	13.30	14.63	13.74
75% RDF (100% IF)	0.63	0.61	2.07	1.94	4.36	4.18	8.33	7.98	13.68	12.98	9.83	9.41	8.86	8.76	10.53	10.18	12.60	12.30	14.46	13.86	15.27	14.32
75% RDF (50:50% NIF:FYM)	0.57	0.65	2.10	2.03	4.47	4.28	8.52	8.11	13.91	13.18	10.00	9.57	9.19	9.12	10.68	10.55	12.68	12.58	14.60	14.26	15.48	14.72
100% RDF (100% IF)	0.62	0.66	2.26	2.28	4.68	4.73	8.82	8.91	14.71	14.93	10.51	10.60	9.93	10.03	11.43	11.56	13.53	13.51	15.23	15.45	16.14	15.94
100% RDF (50:50% NIF:FYM)	0.61	0.67	2.37	2.40	4.78	4.85	8.96	9.15	14.92	15.28	10.68	10.81	10.40	10.56	11.82	11.90	14.02	14.80	15.69	15.84	16.64	16.15
125% RDF (100% IF)	0.62	0.63	2.42	2.47	4.87	4.94	9.11	9.30	15.12	15.45	10.77	10.96	10.68	10.86	12.08	12.20	14.20	15.11	16.14	16.17	16.78	16.52
125% RDF (50:50% NIF:FYM)	0.63	0.68	2.48	2.53	4.92	4.98	9.16	9.41	15.15	15.65	10.83	11.04	10.81	11.37	12.18	12.38	14.48	15.27	16.20	16.27	16.85	16.62
S.E. ±	0.03	0.02	0.05	0.05	0.05	0.06	0.08	0.09	0.11	0.13	0.08	0.10	0.20	0.23	0.19	0.17	0.17	0.18	0.18	0.17	0.17	0.18
C.D. at 5%	NS	NS	0.15	0.15	0.15	0.18	0.24	0.27	0.33	0.39	0.24	0.30	0.61	0.70	0.58	0.52	0.52	0.55	0.55	0.52	0.52	0.55
Mean	0.61	0.65	2.19	2.15	4.50	4.45	8.56	8.49	14.16	14.00	10.05	9.92	9.44	9.52	10.95	10.90	13.17	13.33	14.97	14.77	15.77	15.16

At 30 days, the treatment differences were found to be non-significant in respect of leaf area plant^{-1} during both the years.

At 45 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum leaf area plant^{-1} (2.48 and 2.53 dm^2 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was observed at 60, 75, 90 and 105 days after sowing during both the years.

At 120 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum leaf area plant^{-1} (10.81 and 11.37 dm^2 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

At 135 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum leaf area plant^{-1} (12.18 and 12.38 dm^2 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was observed at 150, 165 days after sowing and at harvest during both the years.

4.1.1.2.5 Total fresh matter plant^{-1}.

The data regarding total fresh matter plant^{-1} as influenced periodically by different treatments are presented in Table 17. The mean total fresh matter plant^{-1} of *senna* on the 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 12.77, 22.81, 48.53, 89.61, 121.75, 147.40, 168.12, 186.56, 198.12, 186.54 and 175.76 g, respectively during 2002-03. The corresponding values during 2003-04 were 12.91, 22.67, 47.66, 87.64, 120.85, 147.48, 167.50, 186.09, 197.25, 186.13 and 175.55 g, respectively.

At 30 days, the treatment differences were found to be non-significant in respect of total fresh matter plant^{-1} during both the years.

At 45 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh matter plant^{-1} (26.40 and 26.56 g during 2002-03 and 2003-04, respectively). It was found to be at par with an

Table 17. Mean total fresh matter (g plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Total fresh matter (g)																					
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	12.74	12.88	20.43	20.25	40.92	38.42	80.20	75.75	102.13	100.19	120.90	119.97	136.31	135.07	152.83	150.60	164.52	161.23	159.26	155.42	150.24	146.81
50% RDF (50:50% N IF:FYM)	12.64	12.81	20.85	20.47	42.50	39.83	81.68	76.70	104.42	102.79	124.74	123.46	143.47	140.13	159.38	156.90	170.54	166.77	161.66	158.81	154.39	150.70
75% RDF (100% IF)	12.60	12.82	21.70	20.81	44.80	42.17	86.76	81.62	115.75	112.68	138.40	137.21	161.93	158.98	179.32	175.68	190.58	187.00	183.31	180.31	170.20	166.07
75% RDF (50:50% N IF:FYM)	12.57	12.84	22.01	20.87	46.08	43.26	88.00	82.72	119.22	116.83	143.56	140.80	166.93	163.95	185.36	181.34	196.72	192.71	186.98	184.24	172.89	170.63
100% RDF (100% IF)	12.54	12.80	22.35	22.81	51.70	52.42	93.42	94.66	128.39	129.12	157.58	161.08	177.33	180.21	196.41	198.77	208.73	210.54	195.81	197.65	184.96	187.70
100% RDF (50:50% N IF:FYM)	12.84	12.86	23.54	23.98	53.47	54.36	94.96	95.88	132.00	132.42	162.72	163.88	184.72	185.30	203.00	205.13	214.80	216.56	199.33	201.51	188.90	191.66
125% RDF (100% IF)	13.12	13.15	25.18	25.57	53.64	54.64	95.31	96.52	135.83	135.98	164.94	166.00	186.43	187.05	207.08	209.20	218.08	220.12	202.25	204.81	190.99	194.40
125% RDF (50:50% N IF:FYM)	13.10	13.12	26.40	26.56	55.14	56.20	96.52	97.25	136.23	136.78	166.34	167.40	187.84	189.27	209.13	211.10	220.95	223.05	203.73	206.26	193.51	196.42
S.E. ±	0.21	0.15	0.44	0.47	0.61	0.66	0.53	0.50	1.42	1.75	1.76	1.34	2.54	1.70	2.22	2.21	2.12	2.22	1.59	1.86	1.57	1.65
C.D. at 5%	NS	NS	1.33	1.43	1.85	2.00	1.61	1.52	4.31	5.31	5.35	4.08	7.70	5.16	6.73	6.70	6.43	6.73	4.82	5.64	4.76	5.00
Mean	12.77	12.91	22.81	22.67	48.53	47.66	89.61	87.64	121.75	120.85	147.40	147.48	168.12	167.50	186.56	186.09	198.12	197.25	186.54	186.13	175.76	175.55

application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

At 60 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh matter plant^{-1} (55.14 and 56.20 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was observed at 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest during both the years.

4.1.1.2.6 Total dry matter plant^{-1}.

The data regarding total dry matter plant^{-1} as influenced periodically by different treatments are presented in Table 18 and graphically depicted in Fig. 4 and 5. The mean total dry matter plant^{-1} of *senna* on the 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 days after sowing and at harvest was 2.76, 5.19, 11.24, 20.66, 28.94, 38.50, 48.22, 55.59, 60.23, 63.95 and 66.30 g, respectively during 2002-03. The corresponding values during 2003-04 were 2.76, 5.17, 11.23, 20.60, 28.85, 38.42, 48.52, 55.83, 60.53, 64.30 and 66.71 g, respectively.

At 30 days, the treatment differences were found to be non-significant in respect of total dry matter plant^{-1} during both the years.

At 45 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry matter plant^{-1} (5.94 and 6.04 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments applied during both the years.

At 60 days, a trend similar to that at 45 days after sowing was observed.

At 75 days, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry matter plant^{-1} (22.43 and 22.85 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

A similar trend was observed at 90, 105, 120, 135, 150, 165 days after sowing and at harvest during both the years.

Table 18. Mean total dry matter (g plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Total dry matter (g)																					
	30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS		120 DAS		135 DAS		150 DAS		165 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	2.74	2.75	4.85	4.67	9.63	9.32	18.48	17.95	24.37	23.65	31.82	30.85	39.15	38.38	45.73	44.63	49.73	48.81	53.29	52.28	56.11	54.11
50% RDF (50:50% N IF:FYM)	2.74	2.70	4.86	4.74	9.79	9.51	18.81	18.27	24.78	24.12	32.70	31.78	41.12	40.31	46.75	45.60	51.31	50.57	54.08	53.16	57.78	55.97
75% RDF (100% IF)	2.72	2.73	4.88	4.76	10.46	10.22	19.88	19.30	26.94	26.23	35.93	34.92	46.25	44.98	54.06	52.98	58.50	57.36	61.76	60.73	63.74	62.27
75% RDF (50:50% N IF:FYM)	2.73	2.74	5.00	4.85	10.81	10.48	20.22	19.75	27.72	26.94	37.50	36.44	47.26	46.83	55.52	54.42	59.96	58.74	63.84	62.64	65.25	64.12
100% RDF (100% IF)	2.75	2.76	5.03	5.13	11.32	11.60	21.43	21.80	29.97	30.41	40.64	41.20	50.68	51.75	59.32	60.64	63.44	64.77	67.32	68.80	69.47	71.13
100% RDF (50:50% N IF:FYM)	2.77	2.75	5.28	5.40	11.62	11.85	21.83	22.24	31.65	32.22	42.15	43.04	51.98	53.88	60.30	61.57	65.26	66.67	68.88	70.98	71.18	73.56
125% RDF (100% IF)	2.81	2.80	5.67	5.78	13.00	13.31	22.20	22.62	32.70	33.15	43.06	44.01	54.17	55.71	61.28	63.07	66.57	68.11	71.08	72.42	72.74	75.55
125% RDF (50:50% N IF:FYM)	2.83	2.87	5.94	6.04	13.32	13.58	22.43	22.85	33.35	34.10	44.20	45.13	55.18	56.30	61.72	63.73	67.08	69.24	71.33	73.42	74.11	76.98
S.E. ±	0.05	0.06	0.10	0.11	0.15	0.17	0.23	0.23	0.58	0.67	0.69	0.71	1.09	0.81	0.50	0.78	0.66	0.87	0.82	0.83	0.98	1.18
C.D. at 5%	N.S.	N.S.	0.30	0.33	0.46	0.52	0.70	0.70	1.76	2.03	2.09	2.15	3.31	2.46	1.52	2.37	2.00	2.64	2.49	2.52	2.97	3.58
Mean	2.76	2.76	5.19	5.17	11.24	11.23	20.66	20.60	28.94	28.85	38.50	38.42	48.22	48.52	55.59	55.83	60.23	60.53	63.95	64.30	66.30	66.71

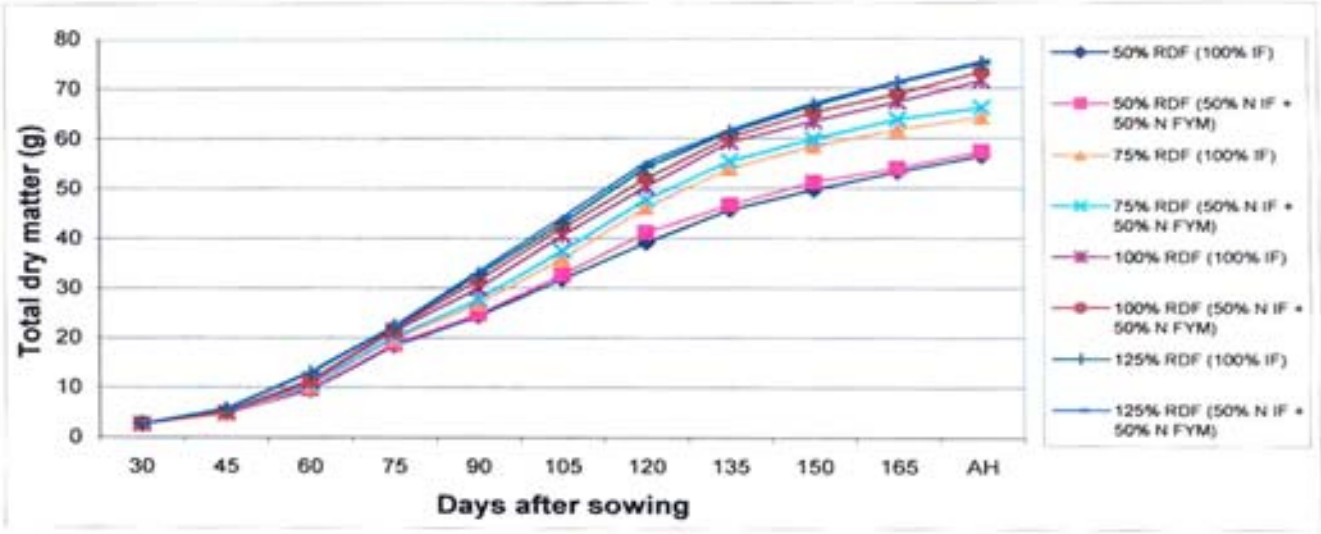


Fig. 4. Mean total dry matter (g plant^{-1}) of *senna* during 2002-03.

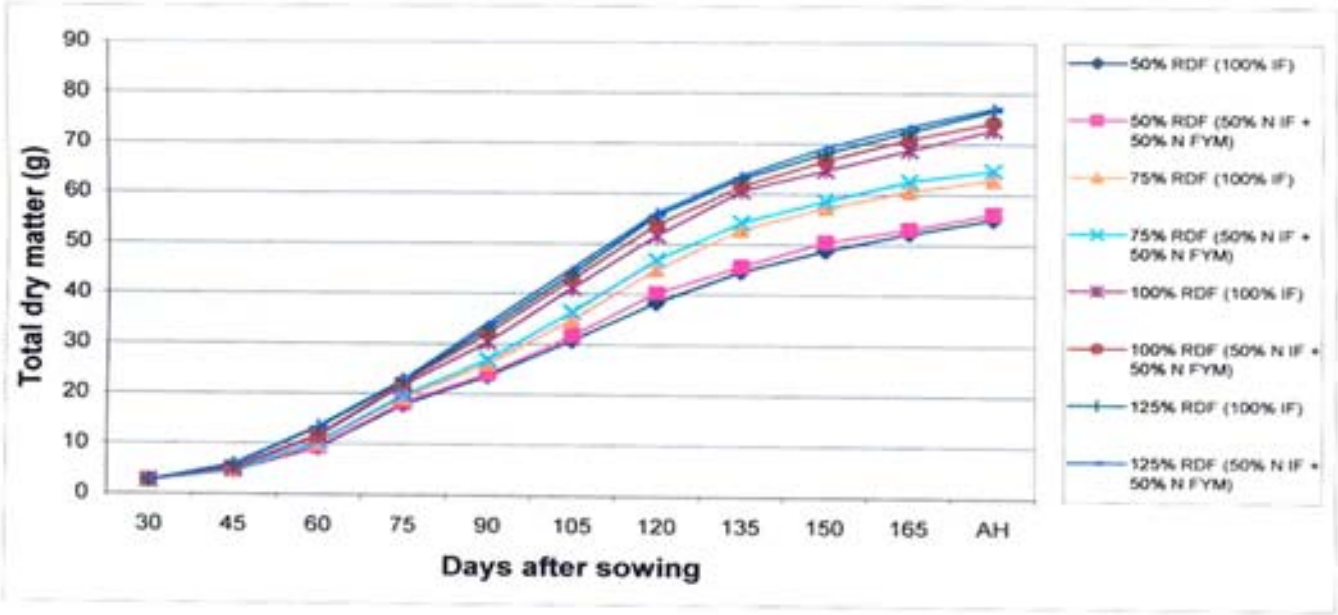


Fig. 5. Mean total dry matter (g plant^{-1}) of *senna* during 2003-04.

4.1.1.2.7 Growth functions.

4.1.1.2.7.1 Absolute growth rate (AGR).

Data pertaining to AGR of dry matter plant^{-1} as influenced periodically by different treatments are presented in Table 19. The data was not statistically analyzed and the inferences are based on mean values only. The mean AGR of *senna* during 30-45, 45-60, 60-75, 75-90, 90-105, 105-120, 120-135, 135-150, 150-165 and 165-At harvest was 1.22, 3.03, 4.72, 4.13, 4.78, 4.87, 3.67, 2.32, 1.86 and 1.18 g plant^{-1} week^{-1}, respectively during 2002-03. The corresponding values during 2003-04 were 1.21, 3.04, 4.68, 4.12, 4.79, 5.05, 3.66, 2.35, 1.88 and 1.21 g plant^{-1} week^{-1}, respectively.

The mean maximum AGR of dry matter was 4.87 and 5.05 g plant^{-1} week^{-1} during the period between 105-120 days during 2002-03 and 2003-04, respectively.

During 30-45 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (1.56 and 1.62 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 45-60 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (3.69 g plant^{-1} week^{-1}) during 2002-03 while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (3.77 g plant^{-1} week^{-1}).

During 60-75 DAS, an application of 100% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (5.11 and 5.19 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 75-90 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (5.46 and 5.62 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 90-105 DAS, a similar trend to that at 75-90 DAS was observed. During 105-120 DAS, an application of 125% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (5.56 and 5.85 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 120-135 DAS, an application of 100% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (4.47 and 4.45 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively).

During 135-150 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (2.68 and 2.75 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 150-165 DAS, an application of 125% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (2.26 g plant^{-1} week^{-1}) during 2002-03 while, during 2003-04 an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (2.16 g plant^{-1} week^{-1}). During 165 DAS - At harvest, an application of 50% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (1.85 g plant^{-1} week^{-1})

Table 19. Mean absolute growth rate (g week^{-1} plant $^{-1}$) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Absolute growth rate																			
	30-45 DAS		45-60 DAS		60-75 DAS		75-90 DAS		90-105 DAS		105-120 DAS		120-135 DAS		135-150 DAS		150-165 DAS		165-AH DAS	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	1.06	0.96	2.39	2.33	4.43	4.31	2.94	2.85	3.73	3.60	3.67	3.76	3.31	3.13	1.98	2.09	1.78	1.74	1.41	0.92
50% RDF (50:50% N IF:FYM)	1.06	1.02	2.47	2.39	4.51	4.38	2.98	2.92	3.96	3.83	4.23	4.26	2.79	2.64	2.28	2.49	1.39	1.29	1.85	1.41
75% RDF (100% IF)	1.08	1.01	2.79	2.73	4.71	4.54	3.53	3.43	4.49	4.38	5.16	5.03	3.90	4.00	2.22	2.19	1.63	1.69	0.99	0.77
75% RDF (50:50% N IF:FYM)	1.14	1.06	2.91	2.82	4.76	4.63	3.70	3.59	4.89	4.75	4.88	5.19	3.86	3.80	2.22	2.16	1.94	1.95	0.71	0.74
100% RDF (100% IF)	1.14	1.18	3.15	3.23	5.06	5.10	4.27	4.31	5.34	5.39	5.02	5.27	4.47	4.45	2.06	2.07	1.94	2.02	1.08	1.17
100% RDF (50:50% N IF:FYM)	1.26	1.33	3.16	3.23	5.11	5.19	4.91	4.99	5.25	5.41	4.92	5.42	4.16	3.84	2.48	2.55	1.81	2.16	1.15	1.29
125% RDF (100% IF)	1.43	1.49	3.67	3.77	4.60	4.66	5.25	5.26	5.18	5.43	5.56	5.85	3.56	3.68	2.64	2.52	2.26	2.16	0.83	1.57
125% RDF (50:50% N IF:FYM)	1.56	1.62	3.69	3.77	4.56	4.64	5.46	5.62	5.42	5.52	5.50	5.59	3.27	3.72	2.68	2.75	2.13	2.00	1.39	1.78
Mean	1.22	1.21	3.03	3.04	4.72	4.68	4.13	4.12	4.78	4.79	4.87	5.05	3.67	3.66	2.32	2.35	1.86	1.88	1.18	1.21

M.P.K.V. Rahuri LIBRARY

during 2002-03 while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (1.78 g plant^{-1} week^{-1}).

4.1.1.2.7.2 Relative growth rate (RGR).

Data pertaining to RGR of dry matter plant^{-1} as influenced periodically by different treatments are presented in Table 20. The data was not statistically analyzed and the inferences are based on mean values only. The mean RGR of *senna* during 30-45, 45-60, 60-75, 75-90, 90-105, 105-120, 120-135, 135-150, 150-165 and 165-At harvest was 0.31, 0.39, 0.31, 0.17, 0.14, 0.11, 0.07, 0.04, 0.03 and 0.04, respectively during 2002-03. The corresponding values during 2003-04 were 0.31, 0.39, 0.31, 0.17, 0.14, 0.12, 0.07, 0.04, 0.03 and 0.04, respectively.

The mean maximum RGR of dry matter was 0.39 and 0.39 during the period between 45-60 days in 2002-03 and 2003-04, respectively.

During 30-45 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest RGR of dry matter plant^{-1} (0.37 and 0.38 during 2002-03 and 2003-04, respectively). During 45-60 DAS, an application of 125% RDF (100% inorganic fertilizer) recorded the highest RGR of dry matter plant^{-1} (0.42) during both the years. During 60-75 DAS, an application of 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) recorded the highest RGR of dry matter plant^{-1} (0.33) during both the years. During 75-90 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest RGR of dry matter plant^{-1} (0.20) during both the years.

During 90-105 DAS, an application of 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM) recorded the highest RGR of dry matter plant^{-1} (0.15) during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM) and 75% RDF (100% inorganic fertilizer) recorded the highest RGR of dry matter plant^{-1} (0.15). During 105-120 DAS, an application of 75% RDF (100% inorganic fertilizer) recorded the highest RGR of dry matter plant^{-1} (0.13) during 2002-03 while, during 2003-04 an application of 75% RDF (50% N through urea and 50% N through FYM) and 75% RDF (100% inorganic fertilizer) recorded the highest RGR of dry matter plant^{-1} (0.13).

Not much variation in respect of RGR plant^{-1} was noticed in remaining days of observation.

4.1.1.2.8 Days to flower initiation.

The data regarding days to flower initiation plant^{-1} as *influenced* by different treatments are presented in Table 21. The mean days to flower intiation plant^{-1} of *senna* was 55 during both the years. This indicated that there was

Table 20. Mean relative growth rate (plant^{-1}) of *senna* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Relative growth rate																			
	30-45 DAS		45-60 DAS		60-75 DAS		75-90 DAS		90-105 DAS		105-120 DAS		120-135 DAS		135-150 DAS		150-165 DAS		165-AH DAS	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.29	0.27	0.34	0.35	0.33	0.33	0.14	0.14	0.13	0.13	0.10	0.11	0.08	0.08	0.04	0.04	0.03	0.03	0.05	0.03
50% RDF (50:50% N IF:FYM)	0.29	0.28	0.35	0.35	0.33	0.33	0.14	0.14	0.14	0.14	0.11	0.12	0.06	0.06	0.05	0.05	0.03	0.03	0.07	0.05
75% RDF (100% IF)	0.29	0.28	0.38	0.38	0.32	0.32	0.15	0.15	0.14	0.15	0.13	0.13	0.08	0.08	0.04	0.04	0.03	0.03	0.03	0.03
75% RDF (50:50% N IF:FYM)	0.30	0.29	0.39	0.39	0.32	0.32	0.16	0.16	0.15	0.15	0.12	0.13	0.09	0.08	0.04	0.04	0.03	0.03	0.02	0.02
100% RDF(100% IF)	0.30	0.31	0.41	0.41	0.32	0.32	0.17	0.17	0.15	0.15	0.11	0.11	0.08	0.08	0.03	0.03	0.03	0.03	0.03	0.03
100% RDF (50:50% N IF:FYM)	0.32	0.34	0.39	0.39	0.32	0.31	0.19	0.19	0.14	0.14	0.10	0.11	0.07	0.07	0.04	0.04	0.03	0.03	0.03	0.04
125% RDF (100% IF)	0.35	0.36	0.42	0.42	0.27	0.27	0.19	0.19	0.14	0.14	0.11	0.12	0.06	0.06	0.04	0.04	0.03	0.03	0.02	0.04
125% RDF (50:50% N IF:FYM)	0.37	0.38	0.40	0.40	0.26	0.26	0.20	0.20	0.14	0.14	0.11	0.11	0.06	0.06	0.04	0.04	0.03	0.03	0.04	0.05
Mean	0.31	0.31	0.39	0.39	0.31	0.31	0.17	0.17	0.14	0.14	0.11	0.12	0.07	0.07	0.04	0.04	0.03	0.03	0.04	0.04

no change in days flower initiation plant^{-1} during both the years. The treatment differences were found to be non-significant during both the years.

4.1.1.2.9 Days to 50% flowering.

The data pertaining days to 50% flowering plant^{-1} as influenced by different treatments are presented in Table 21. The mean days to 50% flowering plant^{-1} of *senna* was 58 and 59, respectively during 2002-03 and 2003-04. This indicated that there was no change in days to 50% flowering plant^{-1} during both the years. The treatment differences were found to be non-significant during both the years.

Table 21. Mean number of days to flower initiation, days to 50% flowering and days to maturity of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Days to flower initiation		Days to 50% flowering		Days to maturity	
	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	53	54	56	57	171	172
50% RDF (50:50% N IF:FYM)	54	56	58	59	172	173
75% RDF (100% IF)	54	54	57	58	172	172
75% RDF (50:50% N IF:FYM)	54	54	58	57	174	173
100% RDF (100% IF)	54	56	59	60	172	175
100% RDF (50:50% N IF:FYM)	55	55	59	60	174	173
125% RDF (100% IF)	55	56	60	60	174	174
125% RDF (50:50% N IF:FYM)	57	56	60	61	175	175
S.E. ±	1.48	1.18	1.39	1.37	1.41	1.43
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	55	55	58	59	173	173

4.1.1.2.10 Days to maturity.

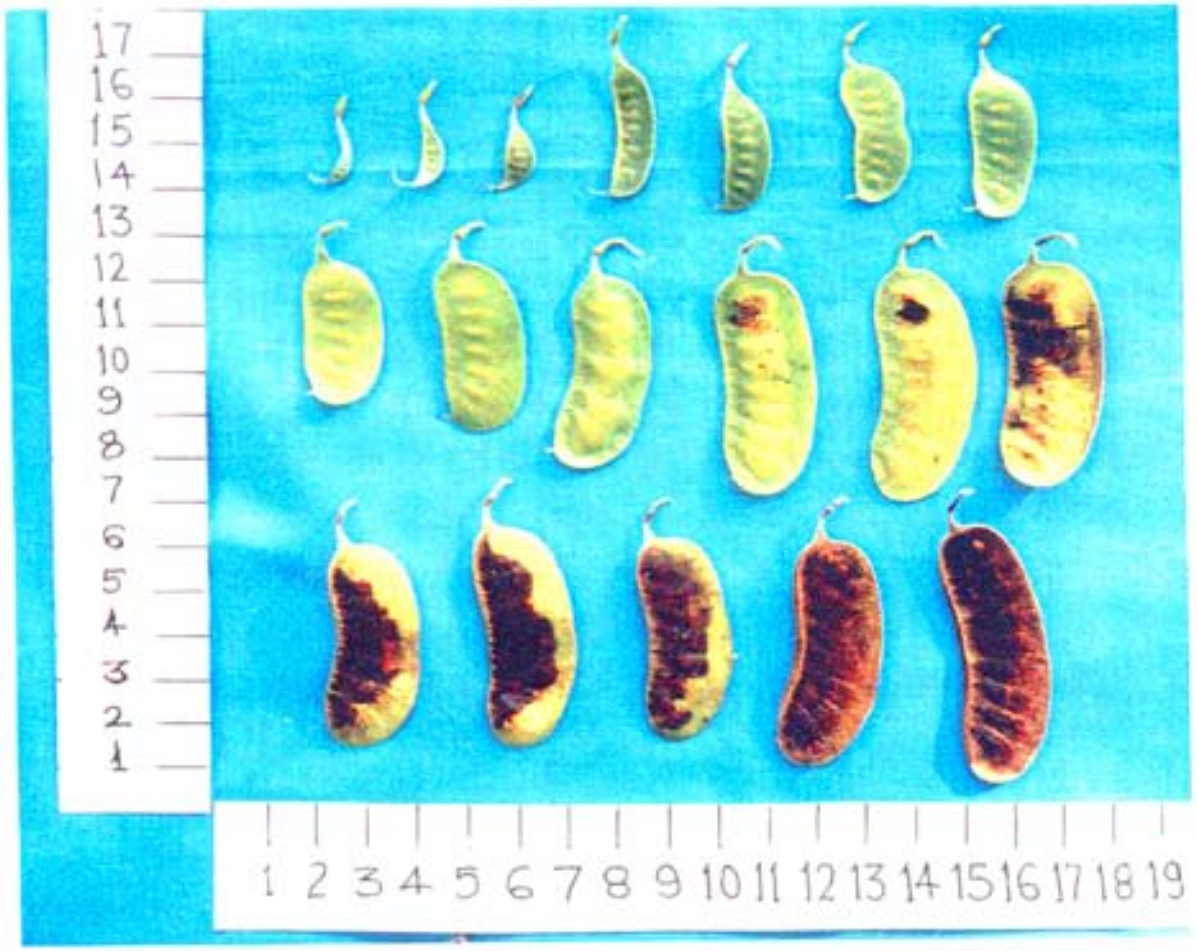
The data on days to maturity plant^{-1} as influenced by different treatments are presented in Table 21. The mean days to maturity plant^{-1} of *senna* was 173 during both the years. This indicated that there was no change in days to maturity plant^{-1} during both the years. The treatment differences were found to be non-significant during both the years.

4.1.2 Post harvest studies.

4.1.2.1 Number of filled pods plant^{-1}.

The data regarding number of filled pods plant^{-1} as influenced b different treatments are presented in Table 22. The mean number of filled pod plant^{-1} of *senna* was 65.67 and 65.36 during 2002-03 and 2003-04, respectively The number of filled pods plant^{-1} was significantly affected due to the differer treatments during both the years.

PP 16: Flowering in *senna*.



PP 17: Sequence of pod development of *senna*.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest number of filled pods plant^{-1} (73.57 and 75.53 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.2 Number of unfilled pods plant^{-1}.

The data pertaining to number of unfilled pods plant^{-1} as influenced by different treatments are presented in Table 22. The mean number of unfilled pods plant^{-1} of *senna* was 9.16 and 9.21 during 2002-03 and 2003-04, respectively. The number of unfilled pods plant^{-1} was at par due to the different treatments during both the years.

4.1.2.3 Total number of pods plant^{-1}.

The data on total number of pods plant^{-1} as influenced by different treatments are presented in Table 22. The mean total number of pods plant^{-1} of *senna* was 74.83 and 74.57 during 2002-03 and 2003-04, respectively. The total number of pods plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest total number of pods plant^{-1} (82.42 and 84.73 during 2002-03, and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.4 Weight of filled pods plant^{-1}.

The data regarding weight of filled pods plant^{-1} as influenced by different treatments are presented in Table 22. The weight of filled pods plant^{-1} of *senna* was 26.83 and 26.77 g during 2002-03 and 2003-04, respectively. The weight of pods plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest weight of filled pods plant^{-1} (30.82 and 31.37 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 and at par with an application of 125% RDF (100% inorganic fertilizer) during 2003-04 and significantly superior to rest of the treatments during both the years.

Table 22. Mean number and weight (g) of filled, unfilled and total pods (plant^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Number of filled pods plant^{-1}		Number of unfilled pods plant^{-1}		Total number of pods plant^{-1}		Weight of filled pods plant^{-1} (g)		Weight of unfilled pods plant^{-1} (g)		Total weight of pods plant^{-1} (g)	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	56.13	53.93	9.44	9.17	65.57	63.10	22.04	21.51	2.29	2.33	24.33	23.84
50% RDF (50:50% N IF:FYM)	57.97	54.50	9.37	9.19	67.34	63.69	22.96	22.47	2.26	2.27	25.22	24.74
75% RDF (100% IF)	61.83	59.33	9.53	9.20	71.36	68.53	25.23	24.68	2.31	2.34	27.54	27.02
75% RDF (50:50% N IF:FYM)	63.60	61.47	9.12	9.04	72.72	70.51	26.08	25.54	2.23	2.27	28.31	27.81
100% RDF (100% IF)	68.40	70.33	9.16	9.53	77.56	79.86	28.33	28.84	2.34	2.38	30.67	31.22
100% RDF (50:50% N IF:FYM)	71.07	73.00	8.97	9.20	80.04	82.20	29.07	29.24	2.28	2.31	31.35	31.55
125% RDF (100% IF)	72.80	74.80	8.86	9.13	81.66	83.93	30.07	30.48	2.32	2.34	32.39	32.82
125% RDF (50:50% N IF:FYM)	73.57	75.53	8.85	9.20	82.42	84.73	30.82	31.37	2.35	2.41	33.17	33.78
S.E. ±	1.13	1.16	0.24	0.22	1.10	1.27	0.68	0.56	0.05	0.08	0.66	0.53
C.D. at 5%	3.43	3.52	N.S.	N.S.	3.34	3.85	2.06	1.70	N.S.	N.S.	2.00	1.61
Mean	65.67	65.36	9.16	9.21	74.83	74.57	26.83	26.77	2.30	2.33	29.12	29.10

4.1.2.5 Weight of unfilled pods plant^{-1}.

The data regarding weight of unfilled pods plant^{-1} of *senna* as influenced by different treatments are presented in Table 22. The data revealed that the mean weight of unfilled pods plant^{-1} of *senna* was 2.30 and 2.33 g during 2002-03 and 2003-04, respectively. The weight of unfilled pods plant^{-1} remained unaffected by the different treatments during both the years.

4.1.2.6 Total weight of pods plant^{-1}.

The data pertaining to total weight of pods plant^{-1} as influenced by different treatments are presented in Table 22. The mean total weight of pods plant^{-1} of *senna* was 29.12 and 29.10 g during 2002-03 and 2003-04, respectively. The total weight of pods plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest total weight of filled pods plant^{-1} (33.17 and 33.78 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 and at par with an application of 125% RDF (100% inorganic fertilizer) during 2003-04 and significantly superior to rest of the treatments during both the years.

4.1.2.7 Length of pod.

The data regarding length of pod as influenced by different treatments are presented in Table 23. The mean length of pod of *senna* was 4.51 cm during both the years. The length of pod was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the maximum length of pod (5.16 and 5.21 cm during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.2.8 Breadth of pod.

The data pertaining to breadth of pod as influenced by different treatments are presented in Table 23. The mean breadth of pod of *senna* was 1.95 and 1.93 cm during 2002-03 and 2003-04, respectively. The treatment differences were found to be non-significant during both the years.

Table 23. Mean length and breadth of pod (cm), number and weight (g) of seeds(pod^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Length of pod (cm)		Breadth of pod (cm)		Number of seeds (pod^{-1})		Weight of seeds (g pod^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	4.06	4.04	1.76	1.75	7.63	7.52	0.14	0.15
50% RDF (50:50% N IF:FYM)	4.14	4.10	1.81	1.80	7.67	7.65	0.14	0.15
75% RDF (100% IF)	4.27	4.38	1.92	1.86	7.68	7.44	0.15	0.15
75% RDF (50:50% N IF:FYM)	4.38	4.41	1.90	1.92	7.69	7.40	0.15	0.16
100% RDF (100% IF)	4.61	4.50	1.95	1.91	7.71	7.81	0.16	0.16
100% RDF (50:50% N IF:FYM)	4.57	4.62	2.01	1.96	7.69	7.74	0.16	0.16
125% RDF (100% IF)	4.90	4.85	2.09	2.04	7.72	7.80	0.16	0.16
125% RDF (50:50% N IF:FYM)	5.16	5.21	2.12	2.16	7.73	7.83	0.16	0.17
S.E. ±	0.15	0.15	0.15	0.14	0.08	0.12	0.01	0.01
C.D. at 5%	0.46	0.46	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	4.51	4.51	1.95	1.93	7.69	7.65	0.15	0.16

4.1.2.9 Number of seeds pod^{-1}.

The data regarding number of seeds pod^{-1} as influenced by different treatments are presented in Table 23. The mean number of seeds pod^{-1} of *senna* was 7.69 and 7.65 during 2002-03 and 2003-04, respectively. The treatment differences were found to be non-significant during both the years.

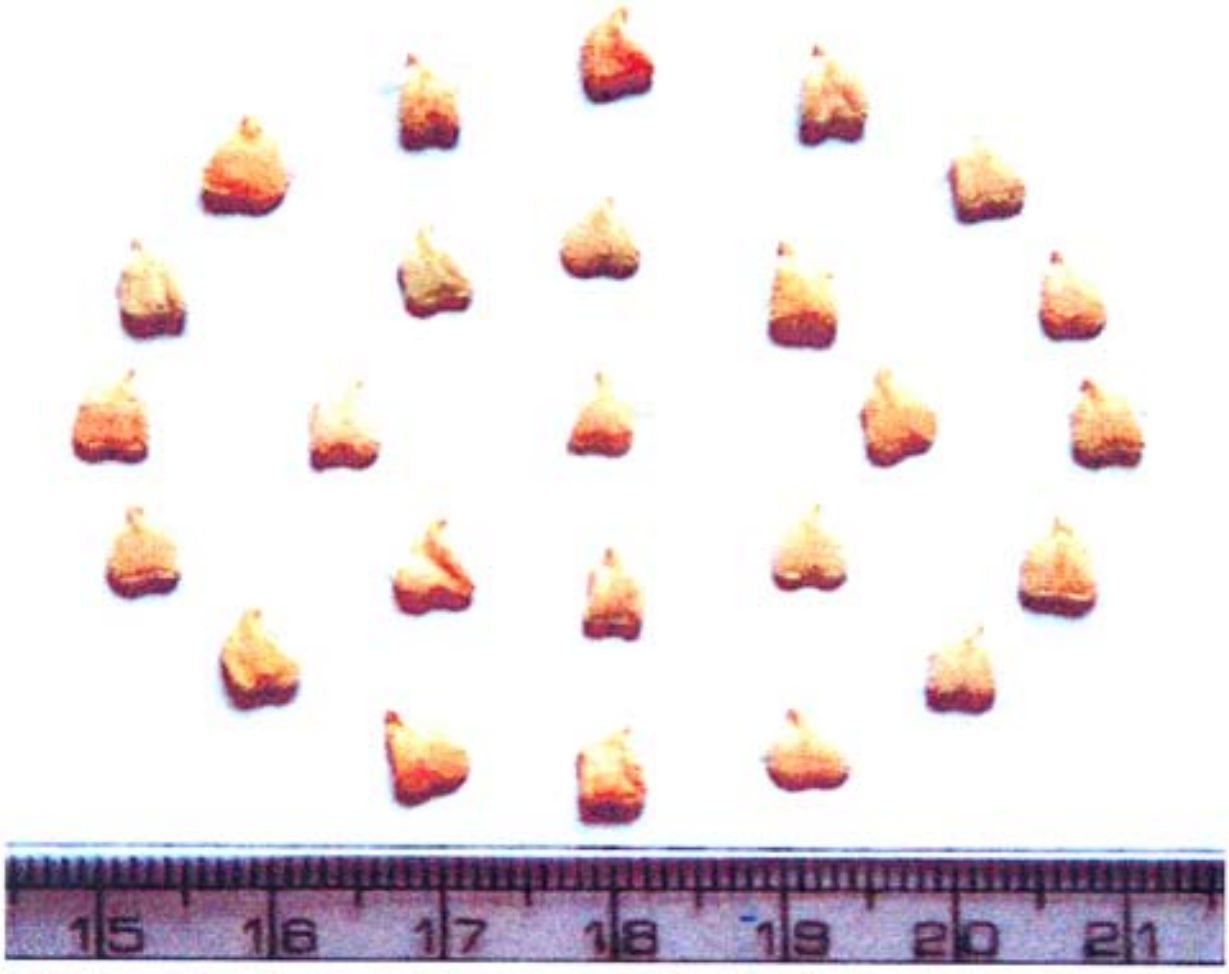
4.1.2.10 Weight of seeds pod^{-1}.

The data regarding weight of seeds pod^{-1} as influenced by different treatments are presented in Table 23. The mean weight of seeds pod^{-1} of *senna* was 0.15 and 0.16 g during 2002-03 and 2003-04, respectively. The treatment differences were found to be non-significant during both the years.

4.1.2.11 Number of seeds plant^{-1}.

The data regarding number of seeds plant^{-1} as influenced by different treatments are presented in Table 24. The mean number of seeds plant^{-1} of *senna* was 505.46 and 501.00 during 2002-03 and 2003-04, respectively. The number of seeds plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest number of seeds plant^{-1} (568.78 and 591.51 during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.



PP 18: Seeds of *senna*.

Table 24. Mean number and weight (g) of seeds (plant^{-1}) and thousand seed weight (g) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Number of seeds (plant^{-1})		Weight of seeds (g plant^{-1})		Thousand seed weight (g)	
	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	429.13	405.53	7.94	7.77	18.17	18.03
50% RDF (50:50% N IF:FYM)	444.88	416.53	8.31	8.13	18.63	18.41
75% RDF (100% IF)	475.39	441.64	9.16	8.87	19.33	19.65
75% RDF (50:50% N IF:FYM)	489.10	455.58	9.64	9.41	19.83	19.81
100% RDF (100% IF)	527.65	549.31	10.98	11.21	20.83	21.05
100% RDF (50:50% N IF:FYM)	546.45	564.39	11.54	11.80	21.17	21.61
125% RDF (100% IF)	562.33	583.54	11.93	12.18	21.80	21.98
125% RDF (50:50% N IF:FYM)	568.78	591.51	12.10	12.36	22.00	22.25
S.E. ±	15.63	16.55	0.32	0.34	0.32	0.33
C.D. at 5%	47.41	50.20	0.97	1.03	0.97	1.00
Mean	505.46	501.00	10.20	10.22	20.22	20.35

4.1.2.12 Weight of seeds plant^{-1}.

The data pertaining to weight of seeds plant^{-1} as influenced by different treatments are presented in Table 24. The mean weight of seeds plant^{-1} of *senna* was 10.20 and 10.22 g during 2002-03 and 2003-04, respectively. The weight of seeds plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest weight of seeds plant^{-1} (12.10 and 12.36 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.13 Thousand seed weight.

The data on thousand seed weight as influenced by different treatments are presented in Table 24. The mean thousand seed weight of *senna* was 20.22 and 20.35 g during 2002-03 and 2003-04, respectively. The thousand seed weight was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest thousand seed weight (22.00 and 22.25 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.14 Per plant basis.

4.1.2.14.1 Fresh root weight plant^{-1}.

The data regarding fresh root weight plant^{-1} as influenced by different treatments are presented in Table 25. The mean fresh root weight of *senna* was 10.54 and 11.26 g during 2002-03 and 2003-04, respectively. The fresh root weight plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh root weight plant^{-1} (11.62 and 12.73 g during 2002-03 and 2003-04, respectively). It was found to be significantly superior to rest of the treatments during 2002-03 while, during 2003-04 it was at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.2.14.2 Dry root weight plant^{-1}.

The data on dry root weight plant^{-1} as influenced by different treatments are presented in Table 25. The mean dry root weight of *senna* was 3.45 and 3.57 g during 2002-03 and 2003-04, respectively. The dry root weight plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry root weight plant^{-1} (3.78 and 4.11 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.2.14.3 Fresh stalk weight plant^{-1}.

The data pertaining to fresh stalk weight plant^{-1} of *senna* as influenced by different treatments are presented in Table 25. The mean fresh stalk weight plant^{-1} of *senna* was 108.95 and 108.00 g during 2002-03 and 2003-04, respectively. The fresh stalk weight plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh stalk weight plant^{-1} (119.70 and 120.10 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

Table 25. Mean fresh root weight, dry root weight, fresh stalk weight, dry stalk weight and pod shell weight (g plant^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Fresh root weight (g plant^{-1})		Dry root weight (g plant^{-1})		Fresh stalk weight (g plant^{-1})		Dry stalk weight (g plant^{-1})		Pod shell weight (g plant^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	9.24	9.16	3.11	3.04	91.56	89.79	21.35	20.13	16.39	16.07
50% RDF (50:50% N IF:FYM)	9.63	9.53	3.17	3.10	94.07	91.72	21.84	20.83	16.92	16.61
75% RDF (100% IF)	9.82	9.71	3.25	3.20	106.53	103.57	25.07	24.34	18.38	18.15
75% RDF (50:50% N IF:FYM)	10.40	11.88	3.32	3.25	107.41	104.58	25.51	25.16	18.67	18.40
100% RDF (100% IF)	11.03	12.13	3.58	3.86	115.58	116.13	26.80	27.46	19.69	20.02
100% RDF (50:50% N IF:FYM)	11.21	12.38	3.67	3.97	118.00	118.71	27.51	29.21	19.81	19.75
125% RDF (100% IF)	11.38	12.56	3.70	4.02	118.73	119.43	27.96	29.74	20.44	20.65
125% RDF (50:50% N IF:FYM)	11.62	12.73	3.78	4.11	119.70	120.10	28.27	30.02	21.06	21.42
S.E. ±	0.05	0.07	0.08	0.09	0.84	0.90	0.27	0.29	0.24	0.25
C.D. at 5%	0.15	0.21	0.24	0.27	2.55	2.73	0.82	0.88	0.73	0.76
Mean	10.54	11.26	3.45	3.57	108.95	108.00	25.54	25.86	18.92	18.88

4.1.2.14.4 Dry stalk weight plant^{-1}.

The data regarding stalk weight plant^{-1} of *senna* as influenced by different treatments are presented in Table 25. The mean dry stalk weight plant^{-1} of *senna* was 25.54 and 25.86 g during 2002-03 and 2003-04, respectively. The dry stalk weight plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry stalk weight plant^{-1} (28.27 and 30.02 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.14.5 Pod shell weight plant^{-1}.

The data on pod shell weight plant^{-1} as influenced by different treatments are presented in Table 25. The mean pod shell weight plant^{-1} of *senna* was 18.92 and 18.88 g during 2002-03 and 2003-04, respectively. The pod shell weight plant^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest pod shell weight plant^{-1} (21.06 and 21.42 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) during 2002-03 only and significantly superior to rest of the treatments during both the years.

4.1.2.14.6 Fresh leaves weight plant^{-1}.

The data regarding leaves weight plant^{-1} as influenced by different treatments are presented in Table 26. The mean fresh leaves weight plant^{-1} of *senna* was 21.54, 14.86, 27.15 and 63.55 g at first, second, third picking and total fresh leaves weight, respectively during 2002-03 and 21.59, 15.01, 27.19 and 63.78 g at first, second, third picking and total fresh leaves weight plant^{-1}, respectively during 2003-04. The fresh leaves weight plant^{-1} was significantly affected due to the different treatments during both the years.

4.1.2.14.6.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh leaves weight plant^{-1} (23.48 and 24.66 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

Table 26. Mean picking wise and total fresh leaves weight (g plant^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Fresh leaves weight (g)							
	First picking		Second picking		Third picking		Total	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	19.53	17.83	13.86	13.53	25.11	24.02	58.50	55.38
50% RDF (50:50% N IF:FYM)	19.70	18.61	13.95	13.65	25.46	24.71	59.11	56.97
75% RDF (100% IF)	20.71	19.83	14.18	13.87	26.31	25.77	61.20	59.47
75% RDF (50:50% N IF:FYM)	21.03	20.63	14.46	14.20	26.77	26.36	62.26	61.19
100% RDF (100% IF)	21.96	22.93	15.18	15.86	27.68	28.21	64.82	67.00
100% RDF (50:50% N IF:FYM)	22.68	23.84	15.54	16.10	28.34	29.02	66.56	68.96
125% RDF (100% IF)	23.20	24.36	15.81	16.35	28.51	29.58	67.52	70.29
125% RDF (50:50% N IF:FYM)	23.48	24.66	15.92	16.51	29.03	29.81	68.43	70.98
S.E. ±	0.28	0.31	0.14	0.17	0.25	0.29	0.63	0.68
C.D. at 5%	0.85	0.94	0.43	0.52	0.76	0.88	1.91	2.06
Mean	21.54	21.59	14.86	15.01	27.15	27.19	63.55	63.78

4.1.2.14.6.2 Second picking.

A similar trend to that at first picking was observed.

4.1.2.14.6.3 Third picking.

A similar trend to that at first picking was observed.

4.1.2.14.6.4 Total fresh leaves weight.

A similar trend to that at first picking was observed.

4.1.2.14.7 Dry leaves weight plant^{-1}.

The data pertaining to dry leaves weight plant^{-1} as influenced by different treatments are presented in Table 27. The mean dry leaves weight plant^{-1} of *senna* was 6.46, 4.54, 8.19 and 19.19 g at first, second, third picking and total dry leaves weight, respectively during 2002-03 and 6.51, 4.59, 8.18 and 19.28 g at first, second, third picking and total dry leaves weight plant^{-1}, respectively during 2003-04. The dry leaves weight plant^{-1} was significantly affected due to the different treatments during both the years.

4.1.2.14.7.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry leaves weight plant^{-1} (7.25 and 7.68 g during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.14.7.2 Second picking.

A similar trend to that at first picking was observed.

Table 27. Mean picking wise and total dry leaves weight (g plant^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Dry leaves weight (g)							
	First picking		Second picking		Third picking		Total	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	5.43	4.98	4.07	3.84	7.32	7.10	16.82	15.92
50% RDF (50:50% N IF:FYM)	5.71	5.31	4.20	4.02	7.54	7.30	17.45	16.63
75% RDF (100% IF)	6.11	6.03	4.31	4.20	7.88	7.71	18.30	17.94
75% RDF (50:50% N IF:FYM)	6.38	6.21	4.44	4.38	8.11	7.90	18.93	18.49
100% RDF (100% IF)	6.70	7.02	4.68	4.84	8.42	8.58	19.80	20.44
100% RDF (50:50% N IF:FYM)	6.92	7.33	4.84	5.00	8.65	8.83	20.41	21.16
125% RDF (100% IF)	7.14	7.51	4.87	5.16	8.71	8.96	20.72	21.63
125% RDF (50:50% N IF:FYM)	7.25	7.68	4.91	5.25	8.90	9.07	21.06	22.00
S.E. ±	0.12	0.13	0.07	0.11	0.09	0.10	0.22	0.29
C.D. at 5%	0.36	0.39	0.21	0.33	0.27	0.30	0.67	0.88
Mean	6.46	6.51	4.54	4.59	8.19	8.18	19.19	19.28

4.1.2.14.7.3 Third picking.

A similar trend to that at first picking was observed.

4.1.2.14.7.4 Total dry leaves weight.

A similar trend to that at first picking was observed.

4.1.2.15 Per hectare basis.

4.1.2.15.1 Fresh root yield ha^{-1}.

The data regarding fresh root yield ha^{-1} as influenced by different treatments are presented in Table 28. The mean fresh root yield of *senna* was 10.95, 11.07 and 11.01 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The fresh root yield ha^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh root yield (12.51, 12.60 and 12.56 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to rest of the treatments during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and on pooled mean basis it was significantly superior to rest of the treatments.

4.1.2.15.2 Dry root yield ha^{-1}.

The data regarding dry root yield ha^{-1} as influenced by different treatments are presented in Table 28. The mean dry root yield of *senna* was 3.58, 3.59 and 3.59 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The dry root yield ha^{-1} was significantly affected due to the different treatments during both the years.

Table 28. Mean fresh root yield, dry root yield, fresh stalk yield, dry stalk yield and pooled mean (q ha^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Root yield (q ha^{-1})						Stalk yield (q ha^{-1})					
	Fresh			Dry			Fresh			Dry		
	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean
50% RDF (100% IF)	9.70	9.60	9.65	3.20	3.18	3.19	60.84	59.72	60.28	22.50	22.06	22.28
50% RDF (50:50% N IF:FYM)	9.95	9.98	9.97	3.31	3.28	3.30	62.78	61.63	62.21	23.07	22.71	22.89
75% RDF (100% IF)	10.12	10.06	10.09	3.35	3.31	3.33	67.34	66.07	66.71	24.72	24.21	24.47
75% RDF (50:50% N IF:FYM)	10.46	10.24	10.35	3.44	3.40	3.42	68.84	67.29	68.07	25.34	24.80	25.07
100% RDF (100% IF)	11.17	11.28	11.23	3.70	3.75	3.73	74.02	75.17	74.60	27.38	28.10	27.74
100% RDF (50:50% N IF:FYM)	11.56	12.34	11.95	3.81	3.88	3.85	76.87	77.91	77.39	28.24	28.83	28.54
125% RDF (100% IF)	12.11	12.48	12.30	3.88	3.91	3.90	78.61	80.30	79.46	28.75	29.15	28.95
125% RDF (50:50% N IF:FYM)	12.51	12.60	12.56	3.91	4.00	3.96	79.09	80.70	79.90	29.11	29.64	29.38
S.E. ±	0.05	0.07	0.05	0.09	0.10	0.10	0.98	0.93	0.94	0.35	0.28	0.30
C.D. at 5%	0.15	0.21	0.15	0.27	0.30	0.30	2.97	2.82	2.85	1.06	0.85	0.91
C.V. %	9.84	10.94	10.06	8.15	8.65	8.19	9.58	11.24	10.39	9.44	11.09	10.25
Mean	10.95	11.07	11.01	3.58	3.59	3.59	71.05	71.10	71.08	26.14	26.19	26.17

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry root yield (3.91, 4.00 and 3.96 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.2.15.3 Fresh stalk yield ha^{-1}.

The data pertaining to fresh stalk yield ha^{-1} as influenced by different treatments are presented in Table 28. The mean fresh stalk yield of *senna* was 71.05, 71.10 and 71.08 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The fresh stalk yield ha^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh stalk yield (79.09, 80.70 and 79.90 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.2.15.4 Dry stalk yield ha^{-1}.

The data on dry stalk yield ha^{-1} as influenced by different treatments are presented in Table 28. The mean dry stalk yield of *senna* was 26.14, 26.19 and 26.17 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The dry stalk yield ha^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry stalk yield (29.11, 29.64 and 29.38 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.2.15.5 Fresh leaves yield ha^{-1}.

The data regarding fresh leaves yield ha^{-1} as influenced by different treatments are presented in Table 29. The mean fresh leaves yield of *senna* was 27.00, 9.42, 33.43 and 69.85 q ha^{-1} at first, second, third picking and total fresh leaves yield, respectively during 2002-03 and 27.09, 9.47, 33.53 and 70.08 q ha^{-1} at first, second, third picking and total fresh leaves yield, respectively during 2003-04. The pooled mean fresh leaves yield was 69.97 q ha^{-1}. The fresh leaves yield ha^{-1}

Table 29. Mean pickingwise, total fresh leaves yield and pooled mean (q ha^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Fresh leaves yield (q ha^{-1})								
	First picking		Second picking		Third picking		Total		
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	Pooled mean
50% RDF (100% IF)	22.27	21.88	7.86	7.57	28.27	27.63	58.40	57.08	57.74
50% RDF (50:50% N IF:FYM)	22.88	22.47	8.05	7.93	28.88	28.29	59.81	58.69	59.25
75% RDF (100% IF)	25.68	25.16	8.67	8.48	33.25	32.52	67.60	66.16	66.88
75% RDF (50:50% N IF:FYM)	26.40	25.87	8.96	8.75	33.71	33.00	69.07	67.62	68.35
100% RDF (100% IF)	28.88	29.47	10.10	10.37	34.83	35.61	73.81	75.45	74.63
100% RDF (50:50% N IF:FYM)	29.56	30.15	10.38	10.66	35.77	36.52	75.71	77.33	76.52
125% RDF (100% IF)	30.06	30.73	10.60	10.96	36.27	37.22	76.93	78.91	77.92
125% RDF (50:50% N IF:FYM)	30.24	30.95	10.75	11.03	36.48	37.41	77.47	79.39	78.43
S.E. ±	0.27	0.31	0.15	0.15	0.28	0.31	0.63	0.67	0.65
C.D. at 5%	0.82	0.94	0.46	0.46	0.85	0.94	1.91	2.03	1.97
C.V. %	11.15	12.94	11.84	14.32	9.08	10.91	10.11	12.03	11.05
Mean	27.00	27.09	9.42	9.47	33.43	33.53	69.85	70.08	69.97

was significantly affected due to the different treatments during both the years and on pooled mean basis.

4.1.2.15.5.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest fresh leaves yield (30.24 and 30.95 q ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.15.5.2 Second picking.

A similar trend to that at first picking was observed.

4.1.2.15.5.3 Third picking.

A similar trend to that at first picking was observed.

4.1.2.15.5.4 Total fresh leaves yield ha^{-1}.

A similar trend to that at first picking was observed.

4.1.2.15.6 Dry leaves yield ha^{-1}.

The data pertaining to dry leaves yield ha^{-1} as influenced by different treatments are presented in Table 30 and graphically depicted in Fig. 6. The mean dry leaves yield of *senna* was 8.36, 2.83, 10.22 and 21.41 q ha^{-1} at first, second, third picking and total dry leaves yield, respectively during 2002-03 and 8.38, 2.84, 10.28 and 21.50 q ha^{-1} at first, second, third and total dry leaves yield, respectively during 2003-04. The pooled mean dry leaves yield was 21.45 q ha^{-1}. The dry leaves yield ha^{-1} was significantly affected due to the different treatments during both the years and on pooled mean basis.

4.1.2.15.6.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry leaves yield (9.39 and 9.69 q ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.2.15.6.2 Second picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest dry leaves yield (3.23 and 3.31 q ha^{-1} during 2002-03 and

Table 30. Mean pickingwise, total dry leaves yield and pooled mean (q ha^{-1}) of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Dry leaves yield (q ha^{-1})								
	First picking		Second picking		Third picking		Total		
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	Pooled mean
50% RDF (100% IF)	7.01	6.84	2.36	2.30	8.69	8.61	18.06	17.75	17.91
50% RDF (50:50% N IF:FYM)	7.16	7.00	2.43	2.39	8.93	8.77	18.52	18.16	18.34
75% RDF (100% IF)	7.85	7.64	2.60	2.54	10.16	9.96	20.61	20.14	20.38
75% RDF (50:50% N IF:FYM)	8.05	7.87	2.71	2.65	10.25	10.02	21.01	20.54	20.78
100% RDF (100% IF)	8.96	9.11	3.03	3.07	10.51	11.06	22.50	23.24	22.87
100% RDF (50:50% N IF:FYM)	9.14	9.33	3.11	3.17	10.93	11.19	23.18	23.69	23.44
125% RDF (100% IF)	9.31	9.59	3.17	3.25	11.11	11.27	23.59	24.11	23.85
125% RDF (50:50% N IF:FYM)	9.39	9.69	3.23	3.31	11.16	11.34	23.78	24.34	24.06
S.E. ±	0.10	0.15	0.04	0.10	0.08	0.07	0.24	0.30	0.27
C.D. at 5%	0.30	0.46	0.12	0.30	0.24	0.21	0.73	0.91	0.82
C.V. %	10.98	13.42	11.72	14.54	8.74	10.23	9.82	11.79	10.77
Mean	8.36	8.38	2.83	2.84	10.22	10.28	21.41	21.50	21.45

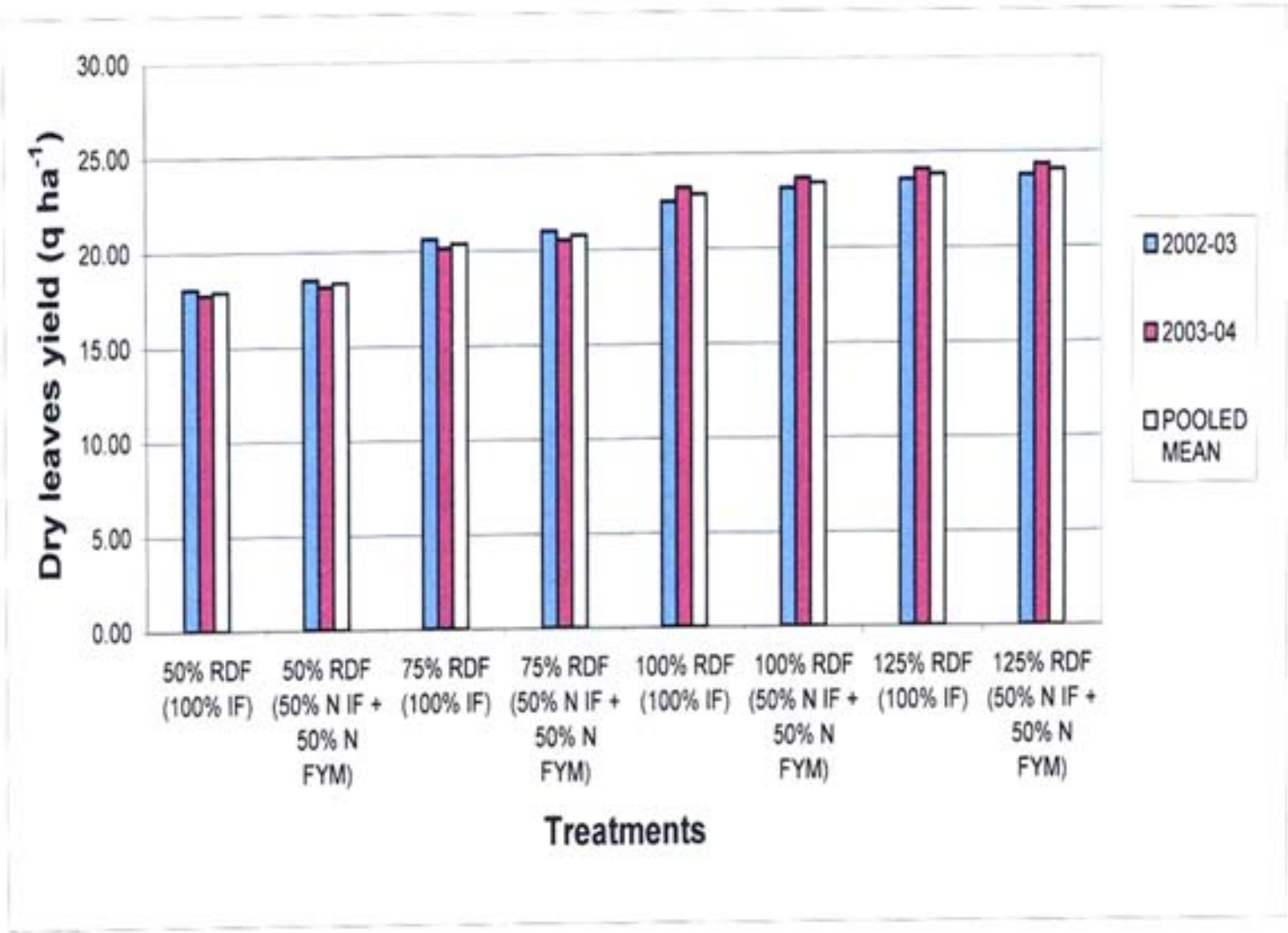


Fig. 6. Mean total and pooled mean dry leaves yield (q ha^{-1}) of *senna* during 2002-03 and 2003-04.

2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.2.15.6.3 Third picking.

A similar trend to that at first picking was observed.

4.1.2.15.6.4 Total dry leaves yield ha^{-1}.

A similar trend to that at first picking was observed.

4.1.2.15.7 Seed yield ha^{-1}.

The data on seed yield ha^{-1} as influenced by different treatments are presented in Table 31 and graphically depicted in Fig. 7. The mean seed yield of *senna* was 2.79, 2.81 and 2.80 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The seed yield ha^{-1} was significantly affected due to the different treatments during both the years.

Table 31. Mean seed yield, pod shell yield (q ha^{-1}), harvest index (%) and pooled mean of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Seed yield (q ha^{-1})			Pod shell yield (q ha^{-1})			Harvest index (%)		
	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean
50% RDF (100% IF)	2.52	2.45	2.48	3.88	3.80	3.84	41.03	41.03	41.03
50% RDF (50:50% N IF:FYM)	2.56	2.51	2.54	3.91	3.89	3.90	41.04	40.88	40.96
75% RDF (100% IF)	2.67	2.64	2.66	4.08	4.06	4.07	42.00	41.91	41.96
75% RDF (50:50% N IF:FYM)	2.72	2.70	2.71	4.16	4.12	4.14	41.88	41.84	41.86
100% RDF (100% IF)	2.87	2.94	2.91	4.22	4.25	4.24	41.82	42.04	41.93
100% RDF (50:50% N IF:FYM)	2.94	3.04	2.99	4.28	4.30	4.29	41.83	41.94	41.89
125% RDF (100% IF)	2.98	3.10	3.04	4.31	4.34	4.33	41.84	42.11	41.98
125% RDF (50:50% N IF:FYM)	3.02	3.12	3.07	4.34	4.36	4.35	41.77	41.95	41.86
S.E. ±	0.04	0.05	0.04	0.03	0.03	0.03	0.34	0.36	0.35
C.D. at 5%	0.12	0.15	0.12	0.09	0.09	0.09	N.S.	1.09	N.S.
C.V. %	6.76	9.19	7.91	5.24	5.82	5.46	-	-	-
Mean	2.79	2.81	2.80	4.15	4.14	4.15	41.65	41.71	41.68

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest seed yield (3.02, 3.12 and 3.07 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments

on pooled mean basis

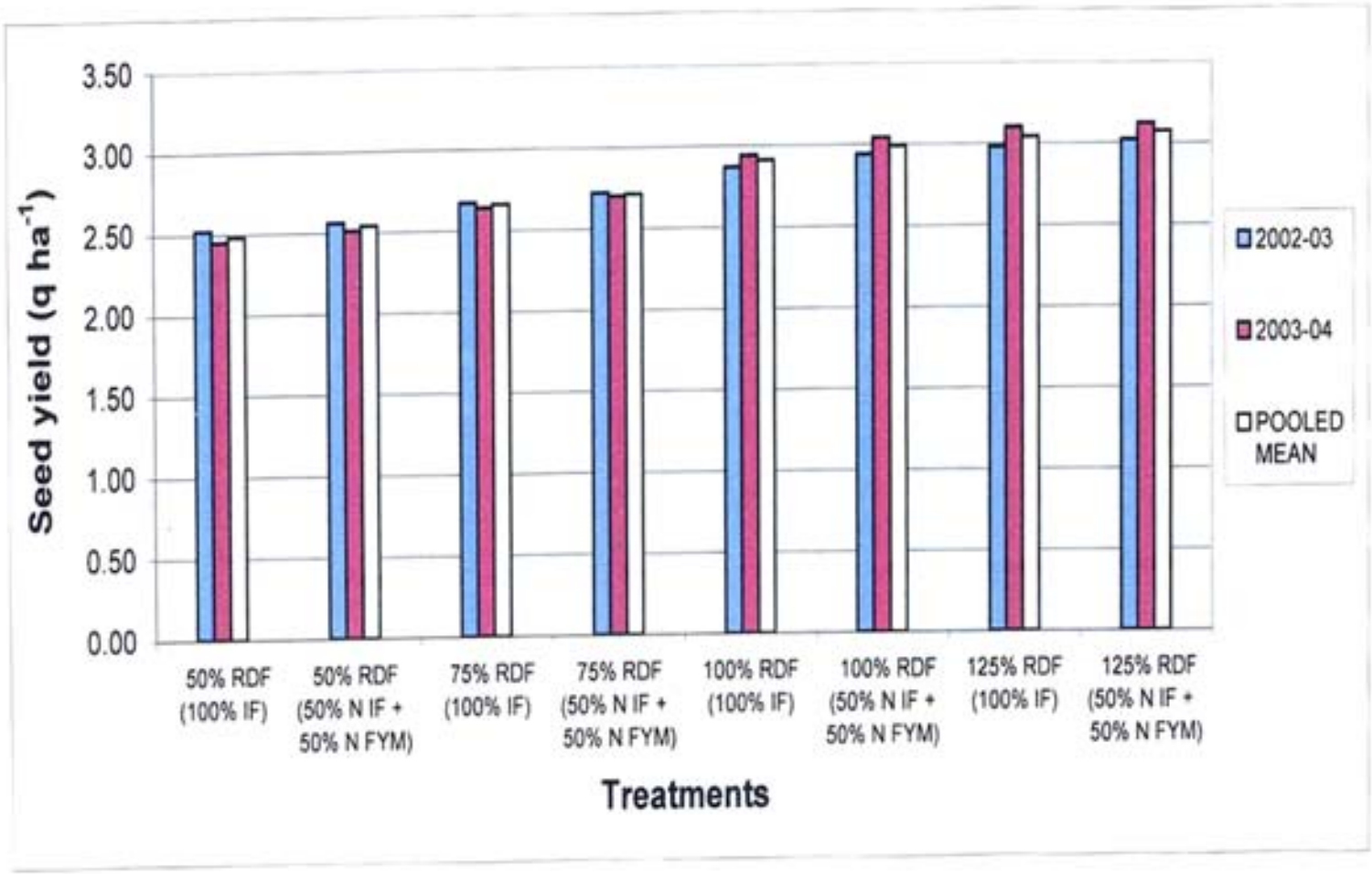


Fig. 7. Mean seed yield and pooled mean (q ha^{-1}) of *senna* during 2002-03 and 2003-04.

4.1.2.15.8 Pod shell yield ha^{-1}.

The data regarding pod shell yield ha^{-1} as influenced by different treatments are presented in Table 31. The mean pod shell yield of *senna* was 4.15, 4.14 and 4.15 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The pod shell yield ha^{-1} was significantly affected due to the different treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest pod shell yield (4.34, 4.36 and 4.35 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.3 Harvest index.

The data pertaining to harvest index of *senna* as influenced by different treatments are presented in Table 31. The mean harvest index of *senna* was 41.65, 41.71 and 41.68% during 2002-03, 2003-04 and on pooled mean basis, respectively. The harvest index was significantly affected due to the different treatments during 2003-04 only. During 2003-04, an application of 125% RDF (100% inorganic fertilizer) recorded the highest harvest index (42.11%). It was found to be at par with rest of the treatments except, with an application of 50% RDF (50% N through urea and 50% N through FYM), which recorded the lowest, harvest index (40.88%).

4.1.4 Chemical studies.

4.1.4.1 Concentration of nitrogen in plant at harvest.

The data regarding concentration of N in plant at harvest as influenced by different treatments are presented in Table 32. The mean percentage of N concentration in root, stalk, leaves (first, second and third picking), seed and pod shell was 0.92, 1.19, 1.32, 1.29, 1.31, 1.60 and 1.26 during 2002-03 and 0.91, 1.19, 1.33, 1.30, 1.32, 1.61 and 1.26 during 2003-04, respectively. The N concentration in plant parts at harvest and N concentration in leaves at different pickings was not significantly influenced by the treatments during both the years.

4.1.4.2 Concentration of phosphorus in plant at harvest.

The data on concentration of P in plant at harvest as influenced by different treatments are presented in Table 33. The mean percentage of P concentration in root, stalk, leaves (first, second and third picking), seed and pod shell was 0.60, 0.74, 1.01, 1.01, 1.01, 1.22 and 0.89 during 2002-03 and 0.60, 0.75, 1.00, 1.01, 1.01, 1.22 and 0.89 during 2003-04, respectively. The P concentration in

Table 32. Mean concentration of nitrogen (%) in *senna* root, stalk, leaf, seed and pod shell as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Nitrogen (%)													
	Root		Stalk		Leaf						Seed		Pod shell	
					First picking		Second picking		Third picking					
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.89	0.87	1.13	1.12	1.26	1.28	1.24	1.25	1.28	1.29	1.55	1.56	1.22	1.22
50% RDF (50:50% N IF:FYM)	0.91	0.90	1.14	1.15	1.28	1.29	1.26	1.27	1.29	1.30	1.57	1.57	1.22	1.23
75% RDF (100% IF)	0.88	0.86	1.16	1.15	1.29	1.28	1.27	1.28	1.31	1.32	1.58	1.58	1.23	1.24
75% RDF (50:50% N IF:FYM)	0.89	0.88	1.16	1.16	1.32	1.31	1.29	1.29	1.31	1.33	1.59	1.60	1.24	1.23
100% RDF (100% IF)	0.92	0.90	1.23	1.21	1.34	1.35	1.30	1.31	1.32	1.31	1.61	1.61	1.26	1.25
100% RDF (50:50% N IF:FYM)	0.95	0.93	1.22	1.22	1.35	1.35	1.32	1.31	1.33	1.32	1.62	1.63	1.28	1.29
125% RDF (100% IF)	0.95	0.95	1.24	1.23	1.37	1.38	1.33	1.32	1.33	1.32	1.63	1.64	1.29	1.30
125% RDF (50:50% N IF:FYM)	0.96	0.97	1.25	1.25	1.38	1.39	1.33	1.34	1.34	1.35	1.65	1.66	1.30	1.31
S.E. ±	0.04	0.05	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.06	0.09	0.06	0.04
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.92	0.91	1.19	1.19	1.32	1.33	1.29	1.30	1.31	1.32	1.60	1.61	1.26	1.26

Table 33. Mean concentration of phosphorus (%) in *senna* root, stalk, leaf, seed and pod shell as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Phosphorus (%)													
	Root		Stalk		Leaf						Seed		Pod shell	
					First picking		Second picking		Third picking					
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.56	0.55	0.70	0.69	0.96	0.95	0.96	0.95	0.97	0.97	1.17	1.16	0.83	0.82
50% RDF (50:50% N IF:FYM)	0.58	0.57	0.72	0.73	0.97	0.95	0.98	0.97	0.98	0.98	1.18	1.16	0.85	0.84
75% RDF (100% IF)	0.58	0.59	0.70	0.72	1.00	0.98	1.00	1.00	1.01	1.01	1.20	1.20	0.85	0.86
75% RDF (50:50% N IF:FYM)	0.57	0.56	0.72	0.72	1.01	1.00	1.01	0.99	1.01	1.02	1.21	1.22	0.84	0.85
100% RDF (100% IF)	0.60	0.60	0.75	0.76	1.02	1.01	1.03	1.01	1.03	1.02	1.22	1.23	0.91	0.90
100% RDF (50:50% N IF:FYM)	0.61	0.62	0.74	0.75	1.04	1.03	1.03	1.03	1.03	1.03	1.24	1.25	0.92	0.92
125% RDF (100% IF)	0.65	0.64	0.81	0.82	1.04	1.04	1.05	1.06	1.04	1.04	1.25	1.24	0.94	0.95
125% RDF (50:50% N IF:FYM)	0.67	0.68	0.81	0.81	1.06	1.07	1.05	1.06	1.04	1.04	1.27	1.28	0.94	0.96
S.E. ±	0.04	0.05	0.04	0.06	0.04	0.05	0.04	0.05	0.03	0.03	0.04	0.05	0.04	0.05
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.60	0.60	0.74	0.75	1.01	1.00	1.01	1.01	1.01	1.01	1.22	1.22	0.89	0.89

Table 34. Mean concentration of potassium (%) in *senna* root, stalk, leaf, seed and pod shell as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Potassium (%)													
	Root		Stalk		Leaf						Seed		Pod shell	
					First picking		Second picking		Third picking					
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.45	0.45	0.26	0.25	0.36	0.35	0.36	0.36	0.37	0.36	0.43	0.44	0.36	0.36
50% RDF (50:50% N IF:FYM)	0.45	0.45	0.26	0.26	0.37	0.37	0.37	0.37	0.38	0.37	0.44	0.46	0.36	0.37
75% RDF (100% IF)	0.47	0.46	0.27	0.26	0.39	0.39	0.39	0.39	0.41	0.39	0.45	0.47	0.38	0.38
75% RDF (50:50% N IF:FYM)	0.47	0.47	0.28	0.29	0.41	0.41	0.41	0.41	0.42	0.41	0.46	0.48	0.39	0.40
100% RDF (100% IF)	0.48	0.49	0.29	0.30	0.41	0.42	0.42	0.41	0.43	0.41	0.46	0.49	0.40	0.41
100% RDF (50:50% N IF:FYM)	0.49	0.50	0.30	0.30	0.42	0.43	0.43	0.42	0.44	0.42	0.48	0.50	0.41	0.41
125% RDF (100% IF)	0.50	0.51	0.31	0.31	0.43	0.43	0.42	0.43	0.44	0.43	0.48	0.51	0.42	0.42
125% RDF (50:50% N IF:FYM)	0.50	0.52	0.31	0.32	0.44	0.45	0.43	0.44	0.45	0.44	0.50	0.51	0.42	0.42
S.E. ±	0.03	0.03	0.03	0.03	0.05	0.05	0.04	0.05	0.05	0.05	0.03	0.03	0.05	0.05
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.48	0.48	0.29	0.29	0.40	0.41	0.40	0.40	0.42	0.40	0.46	0.48	0.39	0.40

the plant parts at harvest and P concentration in leaves at different pickings was not significantly influenced by the treatments during both the years.

4.1.4.3 Concentration of potassium in plant at harvest.

The data pertaining to concentration of K in plant at harvest as influenced by different treatments are presented in Table 34. The mean percentage of K concentration in root, stalk, leaves (first, second and third picking), seed and pod shell was 0.48, 0.29, 0.40, 0.40, 0.42, 0.46 and 0.39 during 2002-03 and 0.48, 0.29, 0.41, 0.40, 0.40, 0.48 and 0.40 during 2003-04, respectively. The K concentration in the plant parts at harvest and K concentration in leaves at different pickings was not significantly influenced by the treatments during both the years.

4.1.5 Uptake of nitrogen in plant at harvest.

The data pertaining to uptake of N in plant at harvest as influenced by different treatments are presented in Table 35. The mean uptake of N in root, stalk, leaves (first, second and third picking), seed, pod shell and total uptake was 3.29, 31.25, 11.10, 3.67, 13.44, 4.46 and 5.21 and 72.42 kg ha^{-1} during 2002-03 and 3.27, 31.19, 11.19, 3.69, 13.56, 4.53, 5.22 and 72.63 kg ha^{-1} during 2003-04, respectively.

4.1.5.1 Root.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (3.75 and 3.88 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.5.2 Stalk.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (36.39 and 37.05 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and 100% RDF (100% inorganic fertilizer) during 2002-03 while, it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) during 2003-04 and significantly superior to rest of the treatments during both the years.

4.1.5.3 Leaves.

4.1.5.3.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (12.96 and 13.47 kg ha^{-1} during 2002-03 and 2003-04,

Table 35. Mean uptake of nitrogen (kg ha^{-1}) in *senna* root, stalk, leaf, seed, pod shell and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Nitrogen (kg ha^{-1})															
	Root		Stalk		Leaf						Seed		Pod shell		Total	
					First picking		Second picking		Third picking							
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	2.85	2.77	25.43	24.70	8.83	8.76	2.93	2.88	11.12	11.11	3.91	3.82	4.73	4.64	59.80	58.68
50% RDF (50:50% N IF:FYM)	3.01	2.95	26.30	26.12	9.17	9.03	3.06	3.04	11.52	11.40	4.02	3.94	4.77	4.79	61.85	61.27
75% RDF (100% IF)	2.95	2.85	28.68	27.84	10.13	9.78	3.30	3.25	13.31	13.15	4.22	4.17	5.02	5.03	67.61	66.07
75% RDF (50:50% N IF:FYM)	3.06	2.99	29.39	28.77	10.63	10.31	3.50	3.42	13.43	13.33	4.33	4.32	5.16	5.07	69.50	68.21
100% RDF (100% IF)	3.40	3.38	33.68	34.00	12.01	12.30	3.94	4.02	13.87	14.49	4.62	4.73	5.32	5.31	76.84	78.23
100% RDF (50:50% N IF:FYM)	3.62	3.61	34.45	35.17	12.34	12.60	4.11	4.15	14.54	14.77	4.76	4.96	5.48	5.55	79.30	80.81
125% RDF (100% IF)	3.69	3.72	35.65	35.85	12.76	13.23	4.22	4.29	14.78	14.88	4.86	5.08	5.56	5.64	81.52	82.69
125% RDF (50:50% N IF:FYM)	3.75	3.88	36.39	37.05	12.96	13.47	4.30	4.44	14.95	15.31	4.98	5.18	5.64	5.71	82.97	85.04
S.E. ±	0.17	0.18	1.26	0.95	0.36	0.30	0.13	0.16	0.32	0.28	0.16	0.26	0.20	0.17	1.26	1.42
C.D. at 5%	0.52	0.55	3.82	2.88	1.09	0.91	0.39	0.49	0.97	0.85	0.49	0.79	0.61	0.52	3.82	4.31
Mean	3.29	3.27	31.25	31.19	11.10	11.19	3.67	3.69	13.44	13.56	4.46	4.53	5.21	5.22	72.42	72.63

respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and 100% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.5.3.2 Second picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (4.30 and 4.44 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.5.3.3 Third picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (14.95 and 15.31 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.5.4 Seed.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (4.98 and 5.18 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.5.5 Pod shell.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (5.64 and 5.71 kg ha^{-1} during 2002-03 and 2003-04, respectively) N uptake. It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50%

N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.5.6 Total uptake.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest N uptake (82.97 and 85.04 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.6 Uptake of phosphorus in plant at harvest.

The data regarding uptake of P in plant at harvest as influenced by different treatments are presented in Table 36. The mean uptake of P in root, stalk, leaves (first, second and third picking), seed, pod shell and total uptake was 2.16, 19.53, 8.49, 2.88, 10.38, 3.40, 3.68 and 50.51 kg ha^{-1} during 2002-03 and 2.17, 19.76, 8.46, 2.88, 10.44, 3.43, 3.69 and 50.82 kg ha^{-1} during 2003-04, respectively.

4.1.6.1 Root.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (2.62 and 2.72 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.6.2 Stalk.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (23.58 and 24.09 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.6.3 Leaves.

4.1.6.3.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (9.95 and 10.37 kg ha^{-1} during 2002-03 and 2003-04,

Table 36. Mean uptake of phosphorus (kg ha^{-1}) in *senna* root, stalk, leaf, seed, pod shell and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Phosphorus (kg ha^{-1})															
	Root		Stalk		Leaf						Seed		Pod shell		Total	
					First picking		Second picking		Third picking							
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	1.79	1.75	15.75	15.22	6.73	6.50	2.27	2.19	8.43	8.35	2.95	2.84	3.22	3.12	41.14	39.97
50% RDF (50:50% N IF:FYM)	1.92	1.87	16.61	16.58	6.95	6.65	2.38	2.32	8.75	8.60	3.02	2.91	3.32	3.27	42.95	42.20
75% RDF (100% IF)	1.94	1.95	17.30	17.43	7.85	7.49	2.60	2.54	10.26	10.06	3.20	3.17	3.47	3.49	46.62	46.13
75% RDF (50:50% N IF:FYM)	1.96	1.90	18.25	17.86	8.13	7.87	2.74	2.62	10.35	10.22	3.29	3.29	3.49	3.50	48.21	47.26
100% RDF (100% IF)	2.22	2.25	20.54	21.36	9.14	9.20	3.12	3.10	10.83	11.28	3.50	3.62	3.84	3.83	53.19	54.64
100% RDF (50:50% N IF:FYM)	2.32	2.41	20.90	21.62	9.51	9.61	3.20	3.27	11.26	11.53	3.65	3.80	3.94	3.96	54.78	56.20
125% RDF (100% IF)	2.52	2.50	23.29	23.90	9.68	9.97	3.33	3.45	11.55	11.72	3.73	3.84	4.05	4.12	58.15	59.50
125% RDF (50:50% N IF:FYM)	2.62	2.72	23.58	24.09	9.95	10.37	3.39	3.51	11.61	11.79	3.84	3.99	4.08	4.19	59.07	60.66
S.E. ±	0.08	0.11	0.84	0.93	0.22	0.26	0.10	0.11	0.12	0.18	0.08	0.10	0.12	0.14	0.95	0.87
C.D. at 5%	0.24	0.33	2.55	2.82	0.67	0.79	0.30	0.33	0.36	0.55	0.24	0.30	0.36	0.43	2.88	2.64
Mean	2.16	2.17	19.53	19.76	8.49	8.46	2.88	2.88	10.38	10.44	3.40	3.43	3.68	3.69	50.51	50.82

respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.6.3.2 Second picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (3.39 and 3.51 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and 100% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.6.3.3 Third picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (11.61 and 11.79 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.6.4 Seed.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (3.84 and 3.99 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with the treatment of an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.6.5 Pod shell.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (4.08 and 4.19 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.6.6 Total uptake.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest P uptake (59.07 and 60.66 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7 Uptake of potassium in plant at harvest.

The data on uptake of K in plant at harvest as influenced by different treatments are presented in Table 37. The mean uptake of K in root, stalk, leaves (first, second and third picking), seed, pod shell and total uptake was 1.71, 7.50, 3.43, 1.15, 4.29, 1.29, 1.63 and 21.00 kg ha^{-1} during 2002-03 and 1.74, 7.57, 3.44, 1.16, 4.18, 1.37, 1.64 and 21.09 kg ha^{-1} during 2003-04, respectively.

4.1.7.1 Root.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (1.96 and 2.08 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.2 Stalk.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (9.02 and 9.48 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.3 Leaves.

4.1.7.3.1 First picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (4.26 and 4.36 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was found at par with an

Table 37. Mean uptake of potassium (kg ha^{-1}) in *senna* root, stalk, leaf, seed, pod shell and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Potassium (kg ha^{-1})															
	Root		Stalk		Leaf						Seed		Pod shell		Total	
					First picking		Second picking		Third picking							
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	1.44	1.43	5.85	5.52	2.52	2.40	0.85	0.83	3.22	3.10	1.08	1.08	1.40	1.37	16.36	15.73
50% RDF (50:50% N IF:FYM)	1.49	1.48	6.00	5.91	2.65	2.60	0.90	0.88	3.39	3.25	1.13	1.16	1.41	1.44	16.97	16.72
75% RDF (100% IF)	1.58	1.52	6.67	6.30	3.06	2.98	1.02	1.00	4.17	3.88	1.20	1.24	1.55	1.54	19.25	18.46
75% RDF (50:50% N IF:FYM)	1.62	1.60	7.10	7.19	3.30	3.23	1.11	1.09	4.31	4.11	1.25	1.30	1.62	1.65	20.31	20.17
100% RDF (100% IF)	1.78	1.84	7.94	8.43	3.67	3.83	1.27	1.26	4.52	4.54	1.32	1.44	1.69	1.74	22.19	23.08
100% RDF (50:50% N IF:FYM)	1.87	1.94	8.47	8.65	3.84	4.01	1.34	1.33	4.81	4.70	1.41	1.52	1.75	1.76	23.49	23.91
125% RDF (100% IF)	1.94	2.00	8.91	9.04	4.12	4.12	1.33	1.40	4.89	4.85	1.43	1.58	1.81	1.82	24.43	24.81
125% RDF (50:50% N IF:FYM)	1.96	2.08	9.02	9.48	4.26	4.36	1.39	1.46	5.02	4.99	1.51	1.60	1.82	1.83	24.98	25.80
S.E. ±	0.11	0.14	0.22	0.26	0.32	0.35	0.11	0.14	0.24	0.27	0.06	0.08	0.08	0.10	0.97	0.96
C.D. at 5%	0.33	0.43	0.67	0.79	0.97	1.06	0.33	0.43	0.73	0.82	0.18	0.24	0.24	0.30	2.94	2.91
Mean	1.71	1.74	7.50	7.57	3.43	3.44	1.15	1.16	4.29	4.18	1.29	1.37	1.63	1.64	21.00	21.09

application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.3.2 Second picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (1.39 and 1.46 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

4.1.7.3.3 Third picking.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (5.02 and 4.99 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.4 Seed.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (1.51 and 1.60 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.5 Pod shell.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (1.82 and 1.83 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50%

N through FYM) during 2002-03 while, during 2003-04 it was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.7.6 Total uptake.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest K uptake (24.98 and 25.80 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

4.1.8 Sennoside content in leaves and pod.

The data regarding sennoside content in leaves and pod as influenced periodically by different treatments are presented in Table 38. The mean sennoside percentage of leaves (first, second and third picking) was 2.31, 2.28, 2.30 during 2002-03 and 2.30, 2.26, 2.28 during 2003-04, respectively. The mean sennoside percentage of pod (first, second and third picking) was 3.35, 3.31, 3.32 during 2002-03 and 3.33, 3.32, 3.33 during 2003-04, respectively. The sennoside content of the leaves and pod was not significantly influenced by the treatments at different pickings during both the years.

4.1.9 Soil status after harvest.

Data regarding physical and chemical properties of the soil after the harvest of *senna* are presented.

4.1.9.1 Physical properties of soil.

The data on pH, electrical conductivity and bulk density of soil as influenced by different treatments are presented in Table 39.

4.1.9.1.1 pH.

The mean pH of soil after harvest of *senna* was 8.11 and 8.10 during 2002-03 and 2003-04, respectively. The data was not statistically analyzed and the inferences are based on mean values only.

An application of 125% RDF (100% inorganic fertilizer) recorded the highest pH (8.13) during 2002-03 while, during 2003-04 an application of

Table 38. Mean sennoside content (%) in *senna* leaf and pod as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Leaf						Pod *					
	First picking (90 DAS)		Second picking (110 DAS)		Third picking (At harvest)		First picking (90 DAS)		Second picking (110 DAS)		Third picking (120 DAS)	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	2.28	2.27	2.24	2.25	2.29	2.27	3.32	3.30	3.33	3.33	3.34	3.33
50% RDF (50:50% N IF:FYM)	2.29	2.32	2.27	2.23	2.27	2.25	3.32	3.31	3.31	3.31	3.31	3.34
75% RDF (100% IF)	2.29	2.26	2.25	2.22	2.30	2.29	3.33	3.32	3.32	3.33	3.30	3.32
75% RDF (50:50% N IF:FYM)	2.30	2.28	2.35	2.29	2.32	2.30	3.34	3.33	3.31	3.30	3.33	3.32
100% RDF (100% IF)	2.31	2.30	2.34	2.31	2.27	2.24	3.37	3.35	3.33	3.31	3.34	3.31
100% RDF (50:50% N IF:FYM)	2.31	2.30	2.26	2.23	2.29	2.25	3.36	3.33	3.28	3.33	3.32	3.33
125% RDF (100% IF)	2.33	2.31	2.25	2.26	2.31	2.30	3.38	3.34	3.29	3.31	3.31	3.33
125% RDF (50:50% N IF:FYM)	2.34	2.32	2.29	2.25	2.32	2.30	3.35	3.33	3.28	3.33	3.31	3.32
S.E. ±	0.03	0.03	0.06	0.05	0.05	0.08	0.04	0.03	0.05	0.04	0.03	0.06
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	2.31	2.30	2.28	2.26	2.30	2.28	3.35	3.33	3.31	3.32	3.32	3.33

* Representative sample of pod was picked at 90,110 and 120 DAS.

Table 39. Mean pH, electrical conductivity (dS m^{-1}) and bulk density (g cc^{-1}) of soil after harvest of *senna* as influenced by different treatments during 2002-2003 and 2003-2004.

Treatment	pH				E.C. (dSm^{-1})				B.D. (g cc^{-1})			
	Initial		After harvest		Initial		After harvest		Initial		After harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	8.12	8.11	8.11	8.10	0.12	0.12	0.13	0.13	1.32	1.32	1.32	1.32
50% RDF (50:50% N IF:FYM)	8.12	8.10	8.10	8.09	0.12	0.12	0.13	0.13	1.32	1.32	1.32	1.32
75% RDF (100% IF)	8.12	8.11	8.11	8.10	0.12	0.13	0.13	0.13	1.32	1.32	1.32	1.32
75% RDF (50:50% N IF:FYM)	8.12	8.12	8.10	8.10	0.12	0.13	0.13	0.13	1.32	1.32	1.32	1.32
100% RDF (100% IF)	8.12	8.11	8.11	8.11	0.12	0.13	0.13	0.13	1.32	1.32	1.32	1.32
100% RDF (50:50% N IF:FYM)	8.12	8.10	8.10	8.09	0.12	0.13	0.13	0.13	1.32	1.32	1.31	1.31
125% RDF (100% IF)	8.12	8.12	8.13	8.11	0.12	0.13	0.13	0.14	1.32	1.32	1.32	1.32
125% RDF (50:50% N IF:FYM)	8.12	8.12	8.10	8.10	0.12	0.13	0.13	0.14	1.32	1.32	1.31	1.31
Mean	8.12	8.11	8.11	8.10	0.12	0.13	0.13	0.13	1.32	1.32	1.32	1.32

125% RDF (100% inorganic fertilizer) and 100% RDF (100% inorganic fertilizer) recorded the highest pH (8.11).

4.1.9.1.2 Electrical conductivity.

The mean E.C. of soil after harvest of *senna* was 0.13 dS m^{-1} during both the years. The data was not statistically analyzed and the inferences are based on mean values only.

During 2002-03 there was no change in E.C. due to the different treatments while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) recorded a slight improvement in E.C. (0.14 dS m^{-1}).

4.1.9.1.3 Bulk density.

The mean bulk density of soil after harvest of *senna* was 1.32 g cc^{-1} during both the years. The data was not statistically analyzed and the inferences are based on mean values only.

An application of 125% RDF (50% N through urea and 50% N through FYM) and 100% RDF (50% N through urea and 50% N through FYM) recorded a slight decrease in the bulk density (1.31 g cc^{-1}) during both the years.

4.1.9.2 Chemical properties of soil.

The data regarding organic carbon, total nitrogen and Carbon:Nitrogen Ratio of soil after harvest of *senna* as influenced by different treatments are presented in Table 40. The data regarding available nitrogen, available phosphorus and available potassium are presented in Table 41, 42 and 43, respectively.

4.1.9.2.1 Organic carbon.

The mean organic carbon content (%) of soil after harvest of *senna* was 0.512% during both the years. There was no change in the organic carbon content from the initial value for the respective year during both the years. The data was not statistically analyzed and inferences are based on mean values only.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest organic carbon (0.515%) during 2002-03 while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) recorded the highest organic carbon (0.515%) organic carbon.

4.1.9.2.2 Total nitrogen.

The mean total nitrogen content (%) of soil after harvest of *senna* was 0.0459 and 0.0460% during 2002-03 and 2003-04, respectively. The data was not statistically analyzed and the inferences are based on mean values only.

Table 40. Mean organic carbon (%), total nitrogen (%) and Carbon:Nitrogen Ratio of soil after harvest of *senna* as influenced by different treatments during 2002-2003 and 2003-2004.

Treatment	Organic carbon (%)				Total nitrogen (%)				C:N Ratio			
	Initial		After harvest		Initial		After harvest		Initial		After harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	0.512	0.509	0.509	0.506	0.0458	0.0457	0.0456	0.0455	11.18	11.14	11.16	11.12
50% RDF (50:50% N IF:FYM)	0.512	0.510	0.510	0.508	0.0458	0.0457	0.0456	0.0455	11.18	11.16	11.18	11.17
75% RDF (100% IF)	0.512	0.511	0.511	0.510	0.0458	0.0458	0.0457	0.0457	11.18	11.16	11.18	11.16
75% RDF (50:50% N IF:FYM)	0.512	0.514	0.513	0.513	0.0458	0.0460	0.0459	0.0460	11.18	11.18	11.18	11.15
100% RDF (100% IF)	0.512	0.513	0.513	0.514	0.0458	0.0461	0.0460	0.0463	11.18	11.13	11.15	11.10
100% RDF (50:50% N IF:FYM)	0.512	0.515	0.514	0.515	0.0458	0.0461	0.0461	0.0463	11.18	11.17	11.15	11.12
125% RDF (100% IF)	0.512	0.514	0.514	0.515	0.0458	0.0462	0.0461	0.0464	11.18	11.13	11.15	11.10
125% RDF (50:50% N IF:FYM)	0.512	0.516	0.515	0.515	0.0458	0.0463	0.0462	0.0465	11.18	11.15	11.15	11.14
Mean	0.512	0.513	0.512	0.512	0.0458	0.0460	0.0459	0.0460	11.18	11.15	11.16	11.13

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest total nitrogen (0.0462 and 0.0465% during 2002-03 and 2003-04, respectively).

4.1.9.2.3 C:N Ratio.

The mean C:N Ratio of soil after harvest of *senna* was 11.16 and 11.13 during 2002-03 and 2003-04, respectively. The data was not analyzed statistically and inferences are based on mean values only.

An application of 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) recorded the highest C:N ratio (11.18) during 2002-03 while, during 2003-04 an application of 50% RDF (50% N through urea and 50% N through FYM) recorded the highest C:N ratio (11.17).

4.1.9.2.4 Available nitrogen.

The mean available nitrogen of soil after harvest of *senna* was 205.27 and 201.01 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean balance in the available nitrogen from the initial value was -3.87 kg ha^{-1} and -5.31 kg ha^{-1} during 2002-03 and 2003-04, respectively. The available nitrogen was significantly affected during both the years.

Table 41. Balance sheet of mean available nitrogen (kg ha^{-1}) of soil after harvest of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil nitrogen		Nitrogen added		Total soil nitrogen		Nitrogen in soil after harvest		Balance of nitrogen in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	209.14	188.32	37.50	37.50	246.64	225.82	188.94	168.28	-20.20	-20.04
50% RDF (50:50% N IF:FYM)	209.14	191.72	37.50	37.50	246.64	229.22	191.90	171.15	-17.24	-20.57
75% RDF (100% IF)	209.14	199.21	56.25	56.25	265.39	255.46	199.87	188.54	-09.27	-10.67
75% RDF (50:50% N IF:FYM)	209.14	202.81	56.25	56.25	265.39	259.06	201.24	192.52	-07.90	-10.29
100% RDF (100% IF)	209.14	211.04	75.00	75.00	284.14	286.04	210.45	209.63	+01.31	-01.41
100% RDF (50:50% N IF:FYM)	209.14	215.78	75.00	75.00	284.14	290.78	212.54	217.15	+03.40	+01.37
125% RDF (100% IF)	209.14	219.05	93.75	93.75	302.89	312.80	217.12	228.15	+07.98	+09.10
125% RDF (50:50% N IF:FYM)	209.14	222.62	93.75	93.75	302.89	316.37	220.11	232.65	+10.97	+10.03
S.E. ±	–	–	–	–	–	–	1.14	2.96	–	–
C.D. at 5%	–	–	–	–	–	–	3.46	8.98	–	–
Mean	209.14	206.32	65.63	65.63	274.77	271.94	205.27	201.01	-3.87	-5.31

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available nitrogen (220.11 and 232.65 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest positive balance in available nitrogen (+10.97 and +10.03 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 100% RDF (100% inorganic fertilizer) recorded the lowest positive change in the available nitrogen (+1.31 kg ha^{-1}) during 2002-03 while, during 2003-04 an application of 100% RDF (50% N through urea and 50% N through FYM) recorded the lowest positive change in the available nitrogen (+1.37 kg ha^{-1}).

An application of 50% RDF (100% inorganic fertilizer) recorded the highest negative change in available nitrogen (-20.20 kg ha^{-1}) during 2002-03 while, during 2003-04 an application of 50% RDF (50% N through urea and 50% N through FYM) recorded the highest negative change in available nitrogen (-20.57 kg ha^{-1}). An application of 75% RDF (50% N through urea and 50% N through FYM) recorded the lowest negative change in available nitrogen (-7.90 kg ha^{-1}) during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer) recorded the lowest negative change in available nitrogen (-1.41 kg ha^{-1}).

4.1.9.2.5 Available phosphorus.

The mean available phosphorus of soil after harvest of *senna* was 25.14 and 25.57 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean change in the available phosphorus from the initial value was +0.20 and +0.15 kg ha^{-1} during 2002-03 and 2003-04, respectively. The available phosphorus was significantly affected during both the years.

Table 42. Balance sheet of mean available phosphorus (kg ha^{-1}) of soil after harvest of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil phosphorus		Phosphorus added		Total soil phosphorus		Phosphorus in soil after harvest		Balance of phosphorus in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	24.94	21.95	25.00	25.00	49.94	46.95	23.83	20.82	-1.11	-1.13
50% RDF (50:50% N IF:FYM)	24.94	23.34	31.82	31.82	56.76	55.16	24.50	22.87	-0.44	-0.47
75% RDF (100% IF)	24.94	23.86	37.50	37.50	62.44	61.36	24.06	23.12	-0.88	-0.74
75% RDF (50:50% N IF:FYM)	24.94	25.70	47.73	47.73	72.67	73.43	25.11	25.04	+0.17	-0.66
100% RDF (100% IF)	24.94	26.43	50.00	50.00	74.94	76.43	25.75	27.27	+0.81	+0.84
100% RDF (50:50% N IF:FYM)	24.94	27.48	63.63	63.63	88.57	91.11	25.96	28.58	+1.02	+1.10
125% RDF (100% IF)	24.94	26.86	62.50	62.50	87.44	89.36	25.82	27.83	+0.88	+0.97
125% RDF (50:50% N IF:FYM)	24.94	27.70	79.55	79.55	104.49	107.25	26.12	29.00	+1.18	+1.30
S.E. ±	–	–	–	–	–	–	0.25	0.42	–	–
C.D. at 5%	–	–	–	–	–	–	0.76	1.27	–	–
Mean	24.94	25.42	49.72	49.72	74.66	75.13	25.14	25.57	+0.20	+0.15

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available phosphorus (26.12 and 29.00 kg ha^{-1} during 2002-03

and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest positive change in available phosphorus (+1.18 and +1.30 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 75% RDF (50% N through urea and 50% N through FYM) recorded the lowest positive change in available phosphorus (+0.17 kg ha^{-1}) during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer) recorded the lowest positive change in available phosphorus (+0.84 kg ha^{-1}).

An application of 50% RDF (100% inorganic fertilizer) recorded the highest negative change in available phosphorus (-1.11 and -1.13 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 50% RDF (50% N through urea and 50% N through FYM) recorded the lowest negative change in available phosphorus (-0.44 and -0.47 kg ha^{-1} during 2002-03 and 2003-04, respectively).

4.1.9.2.6 Available potassium.

The mean available potassium of soil after harvest of *senna* was 474.97 and 464.42 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean change in available potassium from the initial value was -3.16 and -4.62 kg ha^{-1} during 2002-03 and 2003-04, respectively. The available potassium was significantly affected during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available potassium (496.05 and 498.63 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to rest of the treatments during 2002-03 while, during 2003-04 it was at par with an application of 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest positive change in available potassium (+17.93 and +14.58 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 50% RDF (50% N through urea and 50% N through FYM) recorded the lowest positive change in available potassium (+5.58 and +2.55 kg ha^{-1} during 2002-03 and 2003-04, respectively)

Table 43. Balance sheet of mean available potassium (kg ha^{-1}) of soil after harvest of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil potassium		Potassium added		Total soil potassium		Potassium in soil after harvest		Balance of potassium in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
50% RDF (100% IF)	478.12	459.61	–	–	478.12	459.61	464.52	445.23	- 13.60	- 14.38
50% RDF (50:50% N IF:FYM)	478.12	480.12	17.05	17.05	495.17	497.17	483.70	482.67	+ 05.58	+ 02.25
75% RDF (100% IF)	478.12	459.37	–	–	478.12	459.37	463.24	442.81	- 14.88	- 16.56
75% RDF (50:50% N IF:FYM)	478.12	482.12	25.57	25.57	503.69	507.69	485.28	490.04	+ 07.16	+ 07.92
100% RDF (100% IF)	478.12	454.25	–	–	478.12	454.25	459.65	434.38	- 18.47	- 19.87
100% RDF (50:50% N IF:FYM)	478.12	483.81	34.10	34.10	512.22	517.91	490.36	496.11	+ 12.24	+ 12.30
125% RDF (100% IF)	478.12	448.72	–	–	478.12	448.72	456.92	425.52	- 21.20	- 23.20
125% RDF (50:50% N IF:FYM)	478.12	484.05	42.62	42.62	520.74	526.67	496.05	498.63	+ 17.93	+ 14.58
S.E. ±	–	–	–	–	–	–	1.61	2.51	–	–
C.D. at 5%	–	–	–	–	–	–	4.88	7.61	–	–
Mean	478.12	469.01	29.84	29.84	493.04	483.92	474.97	464.42	- 3.16	- 4.62

An application of 125% RDF (100% inorganic fertilizer) recorded the highest negative change in available potassium (-21.20 and -23.20 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 50% RDF (100% inorganic fertilizer) recorded the lowest negative change in available potassium (-13.60 and -14.38 kg ha^{-1} during 2002-03 and 2003-04, respectively).

4.1.10 Economics.

The gross monetary returns, cost of cultivation, net monetary returns (Rs. ha^{-1}) and Benefit:Cost Ratio of *senna* as influenced by different treatments are presented in Table 44.

4.1.10.1 Gross monetary returns.

The mean gross monetary returns were Rs.1,09,187, 1,09,979 and 1,09,583 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The treatments significantly affected the gross monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest gross monetary returns (Rs.1,19,867, 1,23,250 and 1,21,559 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during 2002-03, 2003-04 and on pooled mean basis.

4.1.10.2 Cost of cultivation.

The mean cost of cultivation were Rs. 52,981, 53,308 and 53,145 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The treatments

Table 44. Mean gross monetary returns, cost of cultivation, net monetary returns (Rs ha^{-1}), Benefit:Cost Ratio and pooled mean of *senna* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Gross monetary returns (Rs ha^{-1})			Cost of cultivation (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			B:C ratio		
	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean
50% RDF (100% IF)	95483	93317	94400	47717	47309	47513	47766	46008	46887	2.00	1.97	1.99
50% RDF (50:50% N IF:FYM)	97433	95583	96508	49881	49719	49800	47552	45864	46708	1.95	1.92	1.94
75% RDF (100% IF)	105000	103150	104075	50226	49905	50066	54774	53245	54010	2.09	2.07	2.08
75% RDF (50:50% N IF:FYM)	106867	105400	106133	53220	53300	53260	53647	52100	52874	2.01	1.98	2.00
100% RDF (100% IF)	113575	116950	115263	52674	53357	53016	60901	63593	62247	2.16	2.19	2.18
100% RDF (50:50% N IF:FYM)	116750	119967	118359	56808	57836	57322	59942	62131	61037	2.06	2.07	2.07
125% RDF (100% IF)	118517	122217	120367	54328	54984	54656	64189	67233	65711	2.18	2.22	2.20
125% RDF (50:50% N IF:FYM)	119867	123250	121559	58992	60055	59524	60875	63195	62035	2.03	2.05	2.04
S.E. ±	806.34	753.01	646.21	150.79	140.81	120.84	655.56	612.20	525.37	0.01	0.01	0.01
C.D. at 5%	2446	2284	1960	457	427	367	1988	1857	1593	0.03	0.03	0.03
C.V. %	8.17	10.36	9.24	6.61	7.55	7.08	10.45	13.87	12.16	5.63	6.82	6.20
Mean	109187	109979	109583	52981	53308	53145	56206	56671	56439	2.06	2.06	2.06

* Price of dried leaves of *senna* Rs. 2500 q^{-1}, seeds Rs. 200 kg^{-1}

significantly affected the cost of cultivation ha^{-1} during both the years and on pooled mean basis.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest cost of cultivation (Rs. 58,992, 60,055 and 59,524 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.10.3 Net returns.

The mean net monetary returns were Rs. 56,206, 56,671 and 56,439 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively. The treatments significantly affected the net monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 125% RDF (100% inorganic fertilizer) recorded the maximum net monetary returns (Rs. 64,189, 67,233 and 65,711 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.10.4 Benefit:Cost Ratio.

The mean Benefit:Cost Ratio were 2.06, 2.06 and 2.06 during 2002-03, 2003-04 and on pooled mean basis, respectively. The treatments significantly affected the Benefit:Cost Ratio during both the years and on pooled mean basis.

An application of 125% RDF (100% inorganic fertilizer) recorded the highest Benefit:Cost Ratio (2.18, 2.22 and 2.20 during 2002-03, 2003-04 and on pooled mean basis, respectively). It was at found to be at par with an application of 100% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

4.1.11 Correlation.

Correlation study was carried out on some of the characters observed. The data regarding the correlation study of *senna* are presented in Table 45 and 46.

4.1.11.1 Plant height $plant^{-1}$.

Highly significant and positive relation between plant spread $plant^{-1}$, number of branches $plant^{-1}$, total dry matter $plant^{-1}$, number of filled pods $plant^{-1}$, weight of filled pods $plant^{-1}$, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds $plant^{-1}$, thousand seed weight, dry leaves weight $plant^{-1}$ and weight of seeds $plant^{-1}$.

Table 45: Correlation study of *senna* during 2002-2003 (1st Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.981 **	0.979 **	0.989 **	0.983 **	0.985 **	0.882 **	0.995 **	0.983 **	0.977 **	0.871 **	0.980 **
Plant spread plant^{-1}		0.974 **	0.990 **	0.968 **	0.978 **	0.899 **	0.985 **	0.968 **	0.961 **	0.855 **	0.963 **
No. of branches plant^{-1}			0.962 **	0.997 **	0.998 **	0.908 **	0.960 **	0.997 **	0.996 **	0.939 **	0.994 **
Total dry matter plant^{-1}				0.960 **	0.968 **	0.883 **	0.904 **	0.960 **	0.953 **	0.815 **	0.961 **
No. of filled pods plant^{-1}					0.997 **	0.903 **	0.964 **	0.996 **	0.998 **	0.938 **	0.995 **
Wt. of filled pods plant^{-1}						0.923 **	0.969 **	0.998 **	0.997 **	0.934 **	0.995 **
No. of seeds pod^{-1}							0.866 **	0.909 **	0.921 **	0.857 **	0.896 **
Wt. of seeds pod^{-1}								0.964 **	0.955 **	0.828 **	0.966 **
No. of seeds plant^{-1}									0.998 **	0.939 **	0.998 **
1000-seed weight										0.917 **	0.997 **
Dry leaves weight plant											0.933 **
Wt. of seeds plant^{-1}											

Table 46: Correlation study of *senna* during 2003-2004 (2nd Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.985 **	0.998 **	0.996 **	0.997 **	0.993 **	0.748 **	0.846 **	0.991 **	0.991 **	0.914 **	0.995 **
Plant spread plant^{-1}		0.980 **	0.987 **	0.973 **	0.979 **	0.638	0.823 *	0.951 **	0.983 **	0.893 **	0.967 **
No. of branches plant^{-1}			0.993 **	0.998 **	0.998 **	0.756 *	0.848 **	0.993 **	0.988 **	0.947 *	0.998 **
Total dry matter plant^{-1}				0.992 **	0.997 **	0.717 *	0.861 **	0.982 **	0.991 **	0.943 **	0.989 **
No. of filled pods plant^{-1}					0.993 **	0.765 *	0.858 **	0.996 **	0.988 **	0.960 **	0.996 **
Wt. of filled pods plant^{-1}						0.741 *	0.880 **	0.937 **	0.993 **	0.962 **	0.993 **
No. of seeds pod^{-1}							0.601	0.818 *	0.712 **	0.795 *	0.779 *
Wt. of seeds pod^{-1}								0.848 **	0.837 **	0.890 **	0.862 **
No. of seeds plant^{-1}									0.979 **	0.966 **	0.997 **
1000-seed weight										0.953 **	0.987 *
Dry leaves weight plant											0.965 *
Wt. of seeds plant^{-1}											

*, **: Significant at 5% and 1% level respectively.

4.1.11.2 Plant spread plant^{-1}.

Highly significant and positive relation between number of branches plant^{-1} total dry matter plant^{-1}, number of filled pods plant^{-1}, weight of filled pods plant^{-1} number of seeds plant^{-1}, thousand seed plant, dry leaves weight plant^{-1}, weight o seeds plant^{-1} during both the years, with number of seeds pod^{-1} and weight of seeds pod^{-1} during 2002-03. Significant and positive relation between weight of seeds pod^{-1} Non-significant positive relation between number of seeds pod^{-1} during 2003-04.

4.1.11.3 Number of branches plant^{-1}.

Highly significant and positive relation between total dry matter plant^{-1} number of filled pods plant^{-1}, weight of filled pods plant ^{1}, number of seeds pod^{-1} weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years, except number of seeds pod^{-1} during 2003-04, which had significant and positive relation.

4.1.11.4 Total dry matter plant^{-1}.

Highly significant and positive relation between number of filled pods plant^{-1}, weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except, number of seeds pod^{-1} during 2003-04 which had significant and positive relation.

4.1.11.5 Number of filled pods plant^{-1}.

Highly significant and positive relation between weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except, number of seeds pod^{-1} during 2003-04 which had significant and positive relation.

4.1.11.6 Weight of filled pods plant^{-1}.

Highly significant and positive relation between number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except, number of seeds pod^{-1} during 2003-04 which had significant and positive relation.

4.1.11.7 Number of seeds pod^{-1}.

Highly significant and positive relation between weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except, weight of seeds pod^{-1} during 2003-04 which had non-significant and positive relation.

4.1.11.8 Weight of seeds pod^{-1}.

Highly significant and positive relation between number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.11.9 Number of seeds plant^{-1}.

Highly significant and positive relation between thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.11.10 Thousand seed weight.

Highly significant and positive relation between dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.11.11 Dry leaves weight plant^{-1}.

Highly significant and positive relation between weight of seeds plant^{-1} during both the years.

4.1.12 Regression.

Regression study was carried out on some of the characters observed. The data regarding the regression study of senna are presented in Table 47, 48, 49, 50, 51 and 52.

4.1.12.1 Plant height plant^{-1}.

Highly significant association with plant spread plant^{-1}, number of branches plant^{-1}, total dry matter plant^{-1}, number of filled pods plant^{-1}, weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1}.

4.1.12.2 Plant spread plant^{-1}.

Highly significant association with number of branches plant^{-1}, total dry matter plant^{-1}, number of filled pods plant^{-1}, weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years, except with weight of seeds pod^{-1} which had significant association and number of seeds pod^{-1} which had non-significant association during 2003-04.

4.1.12.3 Number of branches plant^{-1}.

Highly significant association with total dry matter plant^{-1}, number of filled pods plant^{-1}, weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years, except with number of seeds pod^{-1} during 2003-04 which had significant association

Table 47: Regression study (b co-efficient) of *senna* during 2002-2003 (1st Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	1.077**	0.104**	0.989**	1.027**	0.498**	0.004**	0.001**	8.147**	0.219**	0.180**	0.252**
Plant spread plant^{-1}		0.094**	0.902**	0.922**	0.451**	0.004**	0.001**	7.315**	0.196**	0.161**	0.224**
No. of branches plant^{-1}			9.084**	9.839**	4.766**	0.042**	0.012**	78.058**	2.104**	1.837**	2.599**
Total dry matter plant^{-1}				1.004**	0.489**	0.004**	0.001**	7.961**	0.213**	0.169**	0.246**
No. of filled pods plant^{-1}					0.482**	0.004**	0.001**	7.931**	0.214**	0.186**	0.244**
Wt. of filled pods plant^{-1}						0.009**	0.003**	16.359**	0.441**	0.382**	0.503**
No. of seeds pod^{-1}							0.243**	1539.257**	42.071**	36.243**	46.757**
Wt. of seeds pod^{-1}								5823.136**	155.636**	124.864**	180.000**
No. of seeds plant^{-1}									0.027**	0.023**	0.031**
1000-seed weight										0.876**	1.139**
Dry leaves weight plant^{-1}										—	1.152**
Wt. of seeds plant^{-1}											

Table 48: Regression study (b co-efficient) of *senna* during 2003-2004 (2nd Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.982**	0.089**	1.030**	1.069**	0.438**	0.015**	0.001**	9.204**	0.189**	0.239**	0.221**
Plant spread plant^{-1}	—	0.088**	1.026**	1.046**	0.433**	0.013	0.001*	8.885**	0.188**	0.179**	0.216**
No. of branches plant^{-1}			11.511**	11.981**	4.900**	0.174*	0.008**	103.226**	2.113**	2.118**	2.482**
Total dry matter plant^{-1}				1.026**	0.424**	0.014*	0.001**	8.808**	0.183**	0.182**	0.212**
No. of filled pods plant^{-1}				—	0.409**	0.015*	0.001**	8.628**	0.176**	0.179**	0.207**
Wt. of filled pods plant^{-1}					—	0.035*	0.002**	20.796**	0.430**	0.436**	0.501**
No. of seeds pod^{-1}						—	0.024	369.372*	6.610*	7.720*	8.413**
Wt. of seeds pod^{-1}							—	9423.357**	191.357**	212.714**	229.214**
No. of seeds plant^{-1}								—	0.020**	0.021**	0.024**
1000-seed weight									—	0.997**	1.148**
Dry leaves weight plant^{-1}										—	1.073**
Wt. of seeds plant^{-1}											—

Note: *, **: Significant at 5% and 1% level respectively.

Table 49: Regression study (a co-efficient) of *senna* during 2002-2003 (1st Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	-9.314	-1.311	-31.450	-35.832	-22.394	7.298	0.053	-299.745	-1.424	1.395	-14.706
Plant spread plant^{-1}	—	-0.173	-21.314	-23.883	-16.981	7.305	0.055	-205.05	1.182	3.548	-11.557
No. of branches plant^{-1}		—	-15.163	-22.560	-15.914	7.317	0.044	-194.521	1.352	2.712	-11.313
Total dry matter plant^{-1}			—	-0.891	-5.594	7.428	0.086	-22.330	6.098	7.981	-6.109
No. of filled pods plant^{-1}				—	-4.828	7.431	0.086	-15.374	6.166	6.971	-5.823
Wt. of filled pods plant^{-1}					—	7.452	0.072	66.633	8.390	8.939	-3.292
No. of seeds pod^{-1}						—	-1.717	-11337.20	-303.464	-259.658	-349.537
Wt. of seeds pod^{-1}							—	-382.564	-3.514	0.144	-17.25
No. of seeds plant^{-1}								—	6.572	7.560	-5.469
1000-seed weight									—	1.473	-12.830
Dry leaves weight plant^{-1}										—	-11.902
Wt. of seeds plant^{-1}											—

Table 50: Regression study (a co-efficient) of *senna* during 2003-2004 (2nd Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filed pods plant^{-1}	Wt. of filed pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.015	0.152	-35.869	-41.103	-16.855	6.154	0.057	-415.646	1.525	-4.526	-11.793
Plant spread plant^{-1}		0.408	-33.646	-36.953	-15.587	6.377	0.059	-368.083	1.959	1.767	-10.911
No. of branches plant^{-1}		—	-37.074	-42.662	-17.413	6.079	0.085	-429.708	1.297	0.179	-12.162
Total dry matter plant^{-1}			—	-3.084	-1.519	6.714	0.090	-86.588	8.140	7.134	-3.926
No. of filled pods plant^{-1}				—	0.033	6.668	0.092	-62.933	8.845	7.576	-3.313
Wt. of filled pods plant^{-1}					—	6.711	0.103	-55.627	8.839	7.606	-3.193
No. of seeds pod^{-1}						—	-0.026	-2324.230	-30.209	-39.772	-54.132
Wt. of seeds pod^{-1}							—	-983.175	-9.789	-14.226	-25.885
No. of seeds plant^{-1}								—	10.328	8.755	-1.807
1000-seed weight									—	-1.011	-13.144
Dry leaves weight plant^{-1}										—	-10.467
Wt. of seeds plant^{-1}											—

Table 51: Regression study (r^2) of *senna* during 2002-2003 (1st Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.963	0.958	0.974	0.966	0.969	0.754	0.900	0.965	0.954	0.958	0.971
Plant spread plant^{-1}		0.949	0.979	0.936	0.956	0.739	0.909	0.937	0.924	0.945	0.928
No. of branches plant^{-1}			0.991	0.993	0.995	0.709	0.921	0.993	0.992	0.995	0.988
Total dry matter plant^{-1}				0.985	0.995	0.751	0.954	0.986	0.980	0.990	0.979
No. of filled pods plant^{-1}					0.994	0.713	0.929	0.999	0.995	0.994	0.998
Wt. of filled pods plant^{-1}						0.756	0.938	0.995	0.994	0.995	0.990
No. of seeds pod^{-1}							0.749	0.725	0.744	0.735	0.717
Wt. of seeds pod^{-1}								0.928	0.911	0.923	0.933
No. of seeds plant^{-1}									0.997	0.994	0.997
1000-seed weight										0.992	0.993
Dry leaves weight plant^{-1}											0.989
Wt. of seeds plant^{-1}											

Table 52: Regression study (r^2) of *senna* during 2003-2004 (2nd Year).

	Plant spread plant^{-1}	No. of branches plant^{-1}	Total dry matter plant^{-1}	No. of filled pods plant^{-1}	Wt. of filled pods plant^{-1}	No. of seeds pod^{-1}	Wt. of seeds pod^{-1}	No. of seeds plant^{-1}	1000-seed weight	Dry leaves weight plant^{-1}	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.969	0.996	0.990	0.994	0.986	0.559	0.715	0.982	0.985	0.989	0.989
Plant spread plant^{-1}		0.959	0.972	0.946	0.957	0.406	0.677	0.910	0.969	0.961	0.935
No. of branches plant^{-1}			0.989	0.996	0.986	0.571	0.719	0.986	0.984	0.993	0.995
Total dry matter plant^{-1}				0.988	0.995	0.509	0.751	0.968	0.998	0.997	0.986
No. of filled pods plant^{-1}					0.986	0.585	0.735	0.992	0.983	0.991	0.998
Wt. of filled pods plant^{-1}						0.549	0.774	0.974	0.992	0.995	0.986
No. of seeds pod^{-1}							0.360	0.669	0.502	0.546	0.606
Wt. of seeds pod^{-1}								0.719	0.735	0.750	0.743
No. of seeds plant^{-1}									0.962	0.977	0.994
1000-seed weight										0.995	0.981
Dry leaves weight plant^{-1}											0.992
Wt. of seeds plant^{-1}											

4.1.12.4 Total dry matter plant^{-1}.

Highly significant association with number of filled pods plant^{-1}, weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except with number of seeds pod^{-1} during 2003-04 which had significant association.

4.1.12.5 Number of filled pods plant^{-1}.

Highly significant association with weight of filled pods plant^{-1}, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except with number of seeds pod^{-1} during 2003-04 which had significant association.

4.1.12.6 Weight of filled pods plant^{-1}.

Highly significant association with number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years except with number of seeds pod^{-1} during 2003-04 which had significant association.

4.1.12.7 Number of seeds pod^{-1}.

Highly significant association with weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during 2002-03 while, during 2003-04 highly significant association with weight of seeds plant^{-1} and significant association with number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and non-significant association with weight of seeds pod^{-1}.

4.1.12.8 Weight of seeds pod^{-1}.

Highly significant association with number of seeds plant^{-1}, thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.12.9 Number of seeds plant^{-1}.

Highly significant association with thousand seed weight, dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.12.10 Thousand seed weight.

Highly significant association with dry leaves weight plant^{-1} and weight of seeds plant^{-1} during both the years.

4.1.12.11 Dry leaves weight plant^{-1}.

Highly significant association with weight of seeds plant^{-1} during both the years.

M.P.K.V. Rahuri LIBRARY

4.2 Rabi season (*Isabgol*).

The second experiment was carried out on *isabgol* crop cv. HI-2 in the same field and in the same plots where experiment in kharif season was carried out. The plots treated and used in kharif season were considered as main plots for rabi seasons. The plots were split into two sub plots and two levels of fertilizer as sub plots were applied to test the residual effect of main plot treatments and also to find out the reduction in fertilizer requirement of *isabgol*.

4.2.1 Pre-harvest studies.

4.2.1.1 Plant count.

4.2.1.1.1 Initial plant count.

The data pertaining to initial plant count metre^{-1} row length and net plot^{-1} were recorded after sowing for various treatments during 2002-03 and 2003-04 and are presented in Table 53. The data indicated that the mean initial plant population metre^{-1} row length was 40.90 during both the years. The mean initial plant population net plot^{-1} was 1472 and 1471 during 2002-03 and 2003-04, respectively. The treatments under study did not influence the plant count at the initial stage.

Table 53. Mean plant count of *isabgol* metre^{-1} row length and net plot^{-1} at 20 days after sowing as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Plant count			
	2002-03		2003-04	
	Plants metre^{-1}	Plants net plot^{-1}	Plants metre^{-1}	Plants net plot^{-1}
MAIN PLOT				
50% RDF (100% IF)	40.20	1447	40.00	1440
50% RDF (50:50% N IF:FYM)	41.20	1483	41.20	1483
75% RDF (100% IF)	40.60	1462	40.40	1454
75% RDF (50:50% N IF:FYM)	40.60	1462	40.40	1454
100% RDF (100% IF)	41.40	1490	41.60	1498
100% RDF (50:50% N IF:FYM)	41.00	1476	41.00	1476
125% RDF (100% IF)	40.80	1469	40.60	1462
125% RDF (50:50% N IF:FYM)	41.40	1490	41.60	1498
S.E. ±	0.57	20.53	0.61	21.23
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
SUB PLOT				
75% RDF (100% IF)	40.80	1469	40.60	1462
100% RDF (100% IF)	41.00	1476	40.60	1462
S.E. ±	0.44	6.01	0.31	4.68
C.D. at 5%	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.
Mean	40.90	1472	40.90	1471

4.2.1.2 Growth studies.

4.2.1.2.1 Plant height plant^{-1}.

The plant height of *isabgol* as influenced periodically by different treatments are presented in Table 54. The mean plant height of *isabgol* on the 30, 45, 60, 75 days after sowing and at harvest was 3.95, 7.00, 11.25, 13.01 and 13.17 cm, respectively during 2002-03. The corresponding values during 2003-04 were 3.94, 7.00, 11.27, 13.09 and 13.20 cm, respectively.

Table 54. Mean plant height (cm plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

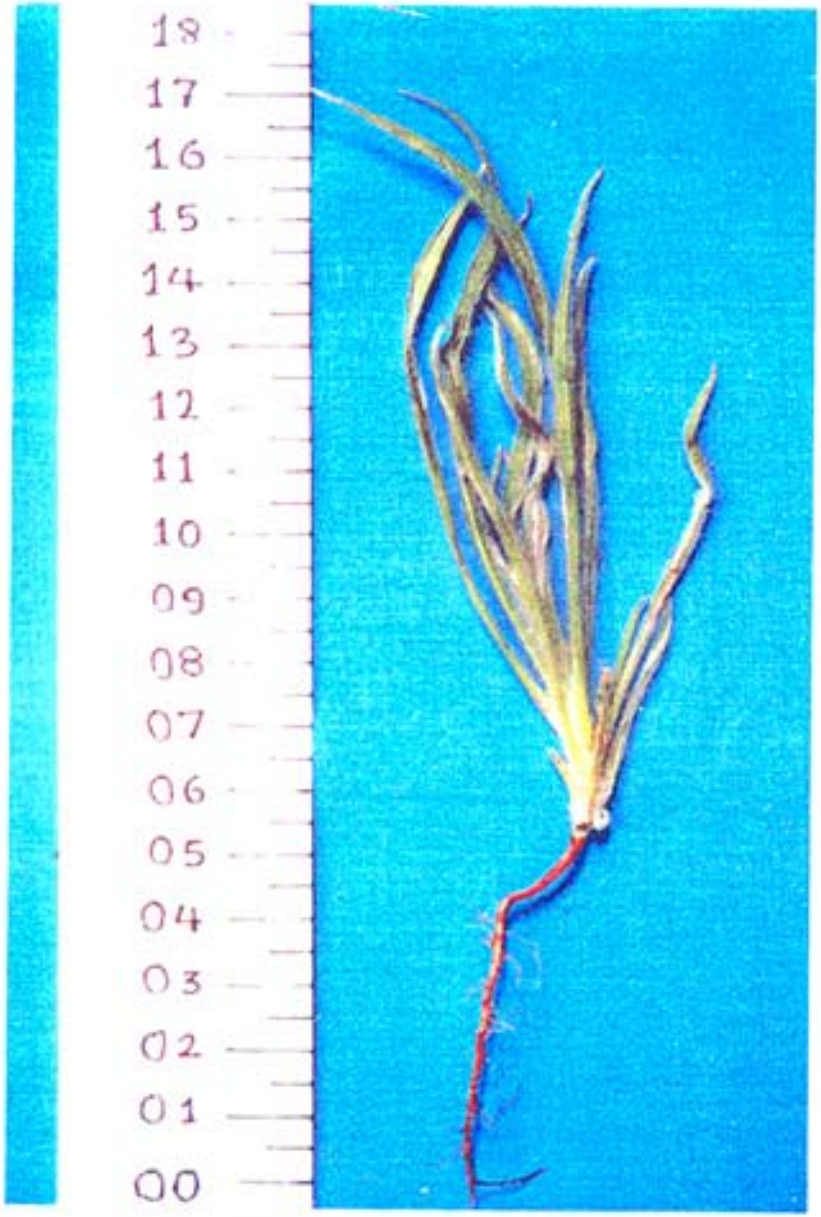
Treatment	Plant height (cm)									
	30 DAS		45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	3.73	3.62	6.73	6.60	10.77	10.56	12.59	12.47	12.75	12.61
50% RDF (50:50% N IF:FYM)	3.83	3.78	6.85	6.73	10.90	10.71	12.64	12.49	12.79	12.67
75% RDF (100% IF)	3.67	3.71	6.90	6.82	11.16	11.06	12.88	12.72	13.01	12.82
75% RDF (50:50% N IF:FYM)	4.00	3.86	6.96	6.88	11.26	11.18	12.96	13.17	13.06	12.91
100% RDF (100% IF)	4.07	4.13	7.03	7.11	11.32	11.43	13.05	13.19	13.25	13.39
100% RDF (50:50% N IF:FYM)	4.03	4.08	7.13	7.21	11.45	11.58	13.13	13.25	13.30	13.46
125% RDF (100% IF)	4.13	4.16	7.15	7.27	11.51	11.74	13.30	13.55	13.47	13.77
125% RDF (50:50% N IF:FYM)	4.10	4.18	7.25	7.40	11.62	11.86	13.55	13.84	13.69	13.95
S.E. ±	0.31	0.29	0.36	0.34	0.30	0.44	0.35	0.47	0.36	0.47
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	3.93	3.90	6.87	6.82	11.06	11.09	12.78	12.89	12.92	12.96
100%RDF (100% IF)	3.96	3.98	7.14	7.16	11.44	11.43	13.25	13.28	13.40	13.43
S.E. ±	0.05	0.05	0.03	0.04	0.04	0.06	0.07	0.11	0.08	0.09
C.D. at 5%	N.S.	N.S.	0.09	0.11	0.12	0.19	0.22	0.33	0.23	0.27
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	3.95	3.94	7.00	7.00	11.25	11.27	13.01	13.09	13.17	13.20

Effect of kharif treatments.

The kharif treatments did not significantly affect the plant height plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the plant height plant^{-1} at different dates of observation during both the years.



PP 19. *Isabgol* plant at 30 DAS.

PP 20. *Isabgol* plant at 45 DAS.

PP 21. *Isabgol* plant at 60 DAS.

PP 22. *Isabgol* plant at 75 DAS.

PP 23: *Isabgol* plant at harvest.

At 30 days, the treatment differences were found to be non-significant in respect of plant height during both the years.

At 45 days, an application of 100% RDF (100% inorganic fertilizer) recorded the highest plant height plant^{-1} (7.14 and 7.16 cm during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

A similar trend was observed at 60, 75 days after sowing and at harvest.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

4.2.1.2.2 Number of leaves plant^{-1}.

The number of leaves plant^{-1} of *isabgol* as influenced periodically by different treatments are presented in Table 55. The mean number of leaves plant^{-1} of *isabgol* on the 30, 45, 60, 75 days after sowing and at harvest was 13.12, 21.11, 29.70, 18.94 and 7.84, respectively during 2002-03. The corresponding values during 2003-04 were 12.28, 21.10, 29.80, 18.93 and 7.30, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of leaves plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the number of leaves plant^{-1} at different dates of observation during both the years.

At 30 days, the treatment differences were found to be non-significant in respect of number of leaves plant^{-1} during both the years.

At 45 days, an application of 100% RDF (100% inorganic fertilizer) recorded the highest number of leaves plant^{-1} (21.64 and 21.73 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

A similar trend was observed at 60, 75 days after sowing and at harvest.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

Table 55. Mean number of leaves (plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Number of leaves (plant^{-1})									
	30 DAS		45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	11.92	11.80	19.67	19.58	28.90	28.57	17.88	17.70	6.90	6.51
50% RDF (50:50% N IF:FYM)	12.17	12.20	20.47	20.13	29.01	28.64	18.30	18.05	7.26	6.38
75% RDF (100% IF)	12.87	11.43	20.80	20.63	29.32	29.01	18.51	18.22	7.42	6.75
75% RDF (50:50% N IF:FYM)	12.95	11.57	21.07	20.84	29.66	29.43	18.77	18.54	7.95	7.30
100% RDF (100% IF)	13.43	12.10	21.24	21.40	29.81	30.13	18.97	19.10	8.21	7.56
100% RDF (50:50% N IF:FYM)	13.77	12.60	21.61	21.76	30.10	30.52	19.50	19.65	8.23	7.80
125% RDF (100% IF)	13.90	12.87	21.98	22.13	30.30	30.88	19.67	20.01	8.26	7.86
125% RDF (50:50% N IF:FYM)	13.98	13.63	22.02	22.28	30.48	31.22	19.91	20.20	8.48	8.27
S.E. ±	0.71	0.75	0.85	0.92	0.54	0.90	0.70	0.85	0.54	0.63
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	13.04	12.86	20.57	20.61	29.09	29.16	18.32	18.36	7.62	7.09
100%RDF (100% IF)	13.19	13.17	21.64	21.73	30.31	30.33	19.56	19.50	8.05	7.51
S.E. ±	0.13	0.18	0.17	0.21	0.18	0.20	0.10	0.19	0.08	0.11
C.D. at 5%	N.S.	N.S.	0.51	0.63	0.54	0.61	0.30	0.56	0.24	0.33
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	13.12	12.28	21.11	21.10	29.70	29.80	18.94	18.93	7.84	7.30

4.2.1.2.3 Number of productive tillers plant^{-1}.

The number of productive tillers plant^{-1} of *isabgol* as influenced periodically by different treatments are presented in Table 56. The mean number of productive tillers plant^{-1} of *isabgol* on the 45, 60, 75 days after sowing and at harvest was 2.18, 3.65, 4.51 and 4.51, respectively during 2002-03. The corresponding values during 2003-04 were 2.20, 3.66, 4.50 and 4.50, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of productive tillers plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the number of productive tillers plant^{-1} at different dates of observation during both the years.

Table 56. Mean number of productive tillers (plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Number of productive tillers (plant^{-1})							
	45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	2.07	2.07	3.50	3.47	4.30	4.27	4.30	4.27
50% RDF (50:50% N IF:FYM)	2.10	2.07	3.53	3.50	4.33	4.27	4.33	4.27
75% RDF (100% IF)	2.13	2.10	3.57	3.50	4.47	4.40	4.47	4.40
75% RDF (50:50% N IF:FYM)	2.17	2.17	3.63	3.57	4.50	4.43	4.50	4.43
100% RDF (100% IF)	2.20	2.27	3.70	3.77	4.53	4.60	4.53	4.60
100% RDF (50:50% N IF:FYM)	2.23	2.27	3.73	3.80	4.57	4.60	4.57	4.60
125% RDF (100% IF)	2.27	2.30	3.77	3.83	4.67	4.70	4.67	4.70
125% RDF (50:50% N IF:FYM)	2.27	2.33	3.80	3.87	4.70	4.73	4.70	4.73
S.E. ±	0.08	0.10	0.11	0.16	0.14	0.17	0.14	0.17
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	2.10	2.11	3.60	3.58	4.44	4.41	4.43	4.43
100%RDF (100% IF)	2.26	2.28	3.71	3.74	4.58	4.57	4.52	4.57
S.E. ±	0.02	0.04	0.03	0.04	0.02	0.04	0.02	0.04
C.D. at 5%	0.06	0.12	0.09	0.12	0.06	0.12	0.06	0.12
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	2.18	2.20	3.65	3.66	4.51	4.50	4.51	4.50

At 45 days, an application of 100% RDF (100% inorganic fertilizer) recorded the highest number of productive tillers plant^{-1} (2.26 and 2.28 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

A similar trend was observed at 60, 75 days after sowing and at harvest during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

4.2.1.2.4 Number of unproductive tillers plant^{-1}.

The number of unproductive tillers plant^{-1} of *isabgol* as influenced periodically by different treatments are presented in Table 57. The mean number of unproductive tillers plant^{-1} of *isabgol* on the 45, 60, 75 days after sowing and at

harvest was 1.32, 1.01, 0.75 and 0.78, respectively during 2002-03. The corresponding values during 2003-04 were 1.31, 1.00, 0.74 and 0.74, respectively.

Table 57. Mean number of unproductive tillers (plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Number of unproductive tillers (plant^{-1})							
	45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	1.27	1.23	0.93	0.90	0.70	0.67	0.73	0.67
50% RDF (50:50% N IF:FYM)	1.27	1.20	0.97	0.93	0.73	0.70	0.77	0.70
75% RDF (100% IF)	1.30	1.27	1.03	1.00	0.77	0.73	0.80	0.73
75% RDF (50:50% N IF:FYM)	1.33	1.33	1.07	1.00	0.73	0.73	0.77	0.73
100% RDF (100% IF)	1.33	1.33	1.00	1.03	0.77	0.73	0.80	0.73
100% RDF (50:50% N IF:FYM)	1.33	1.33	1.00	1.00	0.73	0.77	0.80	0.77
125% RDF (100% IF)	1.37	1.40	1.03	1.03	0.77	0.80	0.80	0.80
125% RDF (50:50% N IF:FYM)	1.37	1.40	1.03	1.07	0.80	0.80	0.80	0.80
S.E. ±	0.04	0.07	0.04	0.07	0.04	0.06	0.04	0.05
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	1.29	1.27	1.00	0.95	0.72	0.71	0.77	0.73
100%RDF (100% IF)	1.35	1.36	1.02	1.04	0.78	0.80	0.80	0.80
S.E. ±	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	1.32	1.31	1.01	1.00	0.75	0.74	0.78	0.74

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of unproductive tillers plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the number of unproductive tillers plant^{-1} at different dates of observation during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

4.2.1.2.5 Total number of tillers plant^{-1}.

The total number of tillers plant^{-1} of *isabgol* as influenced periodically by different treatments are presented in Table 58. The mean total number of tillers plant^{-1} of *isabgol* on the 45, 60, 75 days after sowing and at harvest was 3.50, 4.66, 5.26 and 5.29, respectively during 2002-03. The corresponding values during 2003-04 were 3.51, 4.66, 5.24 and 5.24, respectively.

Table 58. Mean total number of tillers (plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Total number of tillers (plant^{-1})							
	45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	3.34	3.30	4.43	4.37	5.00	4.94	5.03	4.94
50% RDF (50:50% N IF:FYM)	3.37	3.27	4.50	4.43	5.06	4.97	5.10	4.97
75% RDF (100% IF)	3.43	3.37	4.60	4.50	5.24	5.13	5.27	5.13
75% RDF (50:50% N IF:FYM)	3.50	3.50	4.70	4.57	5.23	5.16	5.27	5.16
100% RDF (100% IF)	3.53	3.60	4.70	4.80	5.30	5.33	5.33	5.33
100% RDF (50:50% N IF:FYM)	3.56	3.60	4.73	4.80	5.30	5.37	5.37	5.37
125% RDF (100% IF)	3.64	3.70	4.80	4.86	5.44	5.50	5.47	5.50
125% RDF (50:50% N IF:FYM)	3.64	3.73	4.83	4.94	5.50	5.53	5.50	5.53
S.E. ±	0.13	0.16	0.16	0.20	0.18	0.21	0.14	0.20
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	3.39	3.38	4.60	4.53	5.16	5.12	5.20	5.16
100%RDF (100% IF)	3.61	3.64	4.73	4.78	5.36	5.37	5.32	5.37
S.E. ±	0.04	0.05	0.03	0.04	0.03	0.05	0.03	0.05
C.D. at 5%	0.11	0.15	0.09	0.12	0.09	0.15	0.09	0.15
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	3.50	3.51	4.66	4.66	5.26	5.24	5.29	5.24

Effect of kharif treatments.

The kharif treatments did not significantly affect the total number of tillers plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total number of tillers plant^{-1} at different dates of observation during both the years.

At 45 days, an application of 100% RDF (100% inorganic fertilizer) recorded the highest total number of tillers plant^{-1} (3.61 and 3.64 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an

application of 75% RDF (100% inorganic fertilizer) during both the years. A similar trend was observed at 60, 75 days after sowing and at harvest during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

4.2.1.2.6 Total dry matter plant^{-1}.

The total dry matter plant^{-1} of *isabgol* as influenced periodically by different treatments are presented in Table 59 and graphically depicted in Fig. 8 and 9. The mean total dry matter plant^{-1} of *isabgol* on the 30, 45, 60, 75 days after sowing and at harvest was 0.34, 1.69, 3.43, 5.90 and 7.45 g, respectively during 2002-03. The corresponding values during 2003-04 were 0.34, 1.70, 3.43, 5.87 and 7.44 g, respectively.

Table 59. Mean total dry matter (g plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Total dry matter (g)									
	30 DAS		45 DAS		60 DAS		75 DAS		At harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	0.31	0.25	1.58	1.56	3.25	3.22	5.61	5.56	7.26	7.20
50% RDF (50:50% N IF:FYM)	0.31	0.27	1.60	1.58	3.28	3.24	5.66	5.65	7.28	7.22
75% RDF (100% IF)	0.32	0.27	1.63	1.62	3.32	3.30	5.75	5.69	7.34	7.27
75% RDF (50:50% N IF:FYM)	0.35	0.38	1.68	1.68	3.37	3.35	5.85	5.80	7.42	7.35
100% RDF (100% IF)	0.34	0.40	1.66	1.70	3.52	3.53	5.86	5.59	7.51	7.56
100% RDF (50:50% N IF:FYM)	0.35	0.34	1.76	1.76	3.53	3.56	6.08	6.13	7.52	7.59
125% RDF (100% IF)	0.34	0.36	1.78	1.83	3.59	3.62	6.17	6.23	7.61	7.66
125% RDF (50:50% N IF:FYM)	0.38	0.41	1.81	1.86	3.61	3.65	6.20	6.30	7.67	7.68
S.E. ±	0.03	0.06	0.09	0.11	0.13	0.15	0.22	0.27	0.16	0.19
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	0.33	0.30	1.65	1.63	3.32	3.29	5.63	5.50	7.30	7.28
100%RDF (100% IF)	0.34	0.36	1.73	1.76	3.55	3.61	6.16	6.24	7.60	7.60
S.E. ±	0.01	0.02	0.02	0.01	0.04	0.04	0.07	0.06	0.05	0.05
C.D. at 5%	N.S.	N.S.	0.06	0.04	0.12	0.12	0.21	0.18	0.15	0.15
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.34	0.34	1.69	1.70	3.43	3.43	5.90	5.87	7.45	7.44

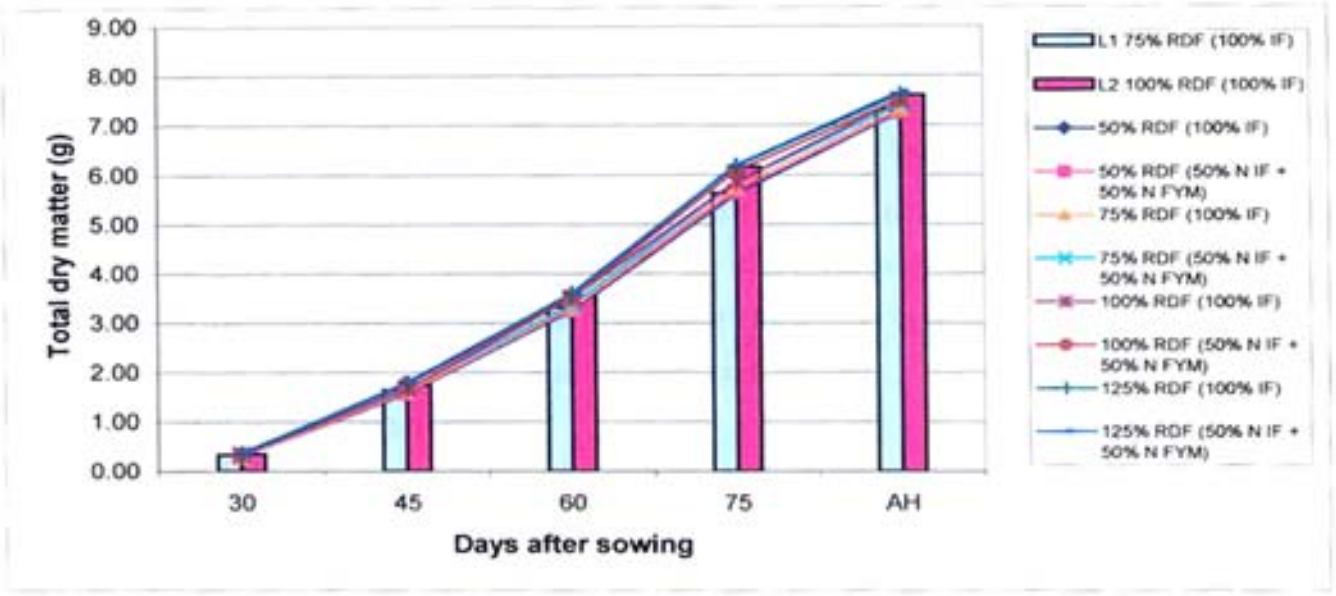


Fig. 8. Mean total dry matter (g plant^{-1}) of *isabgol* during 2002-03.

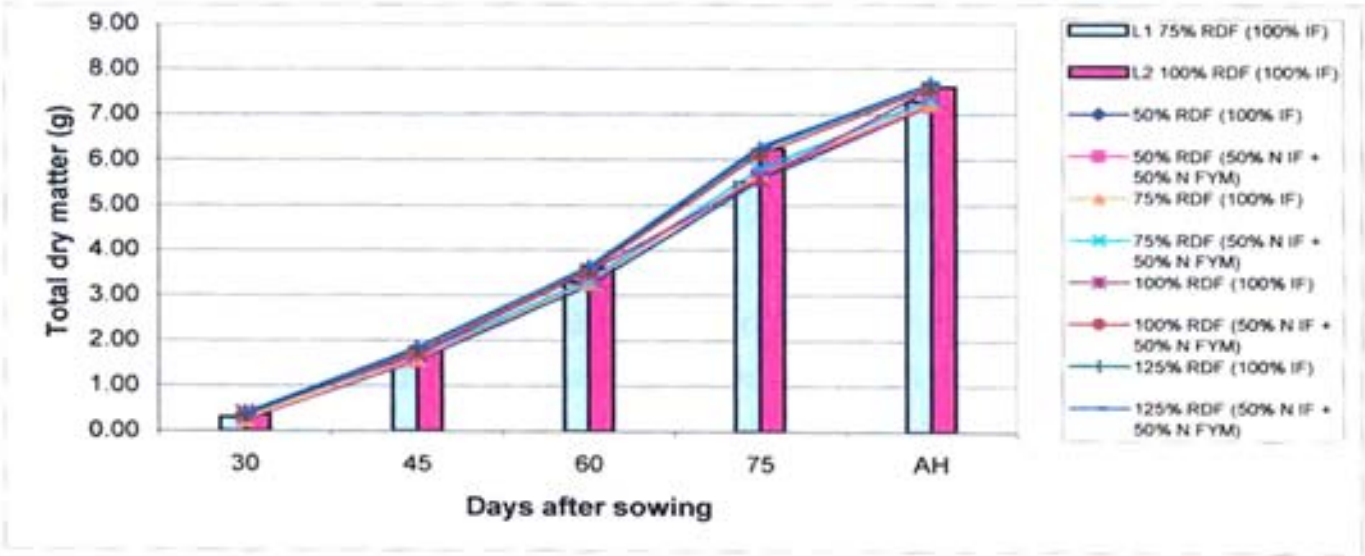


Fig. 9. Mean total dry matter (g plant^{-1}) of *isabgol* during 2003-04.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total dry matter plant^{-1} at different dates of observation during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total dry matter plant^{-1} at different dates of observation during both the years.

At 30 days, the treatment differences were found to be non-significant in respect of total dry matter plant^{-1} during both the years.

At 45 days, an application of 100% RDF (100% inorganic fertilizer) recorded the highest total dry matter plant^{-1} (1.73 and 1.76 g during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

A similar trend was observed at 60, 75 days after sowing and at harvest during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant at different dates of observation during both the years.

4.2.1.2.7 Growth functions.

4.2.1.2.7.1 Absolute growth rate (AGR).

Data pertaining to the AGR of dry matter plant^{-1} as influenced periodically by different treatments recorded at 15 days interval are presented in Table 60. The mean AGR of *isabgol* during 30-45, 45-60, 60-75, and 75-At harvest was 0.68, 0.87, 1.23 and 0.78 g plant^{-1} week^{-1}, respectively during 2002-03. The corresponding values during 2003-04 were 0.68, 0.87, 1.22 and 0.81 g plant^{-1} week^{-1}, respectively. The mean maximum AGR of dry matter was 1.23 and 1.22 g plant^{-1} during the period between 60-75 days in 2002-03 and 2003-04, respectively. The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

During 30-45 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (0.73 g plant^{-1} week^{-1}) during 2002-03 while, during 2003-04 an application of 125% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (0.78 g plant^{-1} week^{-1}). During 45-60 DAS, an application of 100% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (0.93 and 0.91 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 60-75 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest AGR of dry matter (1.30 and 1.32 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively). During 75 DAS-AH, an application of 50% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (0.83 g plant^{-1} week^{-1})

during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (0.99 g plant^{-1} week^{-1}).

Table 60. Mean absolute growth rate (g week^{-1} plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Absolute growth rate							
	30-45 DAS		45-60 DAS		60-75 DAS		75-AH DAS	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	0.63	0.66	0.83	0.83	1.18	1.17	0.83	0.82
50% RDF (50:50% N IF:FYM)	0.64	0.66	0.84	0.83	1.19	1.20	0.81	0.87
75% RDF (100% IF)	0.66	0.68	0.84	0.84	1.21	1.19	0.80	0.79
75% RDF (50:50% N IF:FYM)	0.67	0.65	0.85	0.84	1.24	1.23	0.79	0.79
100% RDF (100% IF)	0.66	0.65	0.93	0.91	1.17	1.03	0.82	0.99
100% RDF (50:50% N IF:FYM)	0.71	0.71	0.88	0.90	1.28	1.29	0.72	0.73
125% RDF (100% IF)	0.72	0.78	0.91	0.90	1.29	1.31	0.72	0.71
125% RDF (50:50% N IF:FYM)	0.73	0.67	0.90	0.90	1.30	1.32	0.74	0.78
SUB PLOT								
75% RDF (100% IF)	0.66	0.67	0.84	0.81	1.16	1.12	0.71	0.75
100%RDF (100% IF)	0.70	0.71	0.91	0.93	1.31	1.31	0.84	0.87
Mean	0.68	0.68	0.87	0.87	1.23	1.22	0.78	0.81

Effect of <u>rabi</u> treatments.

During 30-45 DAS, an application of 100% RDF (100% inorganic fertilizer) recorded the highest AGR of dry matter (0.70 and 0.71 g plant^{-1} week^{-1} during 2002-03 and 2003-04, respectively).

Similar trend was observed during 45-60 DAS, 60-75 DAS and 75 DAS- AH during both the years.

4.2.1.2.7.2 Relative growth rate (RGR).

Data pertaining to the RGR of dry matter plant^{-1} as influenced periodically by different treatments recorded at 15 days interval are presented in Table 61. The mean RGR of *isabgol* during 30-45 DAS, 45-60 DAS, 60-75 DAS, and 75 DAS-At harvest was 0.82, 0.36, 0.27 and 0.12, respectively during 2002-03. The corresponding values during 2003-04 were 0.85, 0.35, 0.27 and 0.12, respectively. The mean maximum RGR of dry matter was 0.82 and 0.85 during the period between 30-45 days in 2002-03 and 2003-04, respectively. The data was not statistically analyzed and the inferences are based on mean values only.

Effect of <u>kharif</u> treatments.

During 30-45 DAS, an application of 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) recorded the highest RGR (0.83) during 2002-03 while, during 2003-04 an application of 125% RDF (100% inorganic fertilizer) recorded the highest RGR (0.99). During 45-60 DAS,

an application of 100% RDF (100% inorganic fertilizer) recorded the highest RGR (0.38) during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) recorded the highest RGR (0.36).

Table 61. Mean relative growth rate (plant^{-1}) of *isabgol* as influenced periodically by different treatments during 2002-03 and 2003-04.

Treatment	Relative growth rate							
	30-45 DAS		45-60 DAS		60-75 DAS		75-AH DAS	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	0.82	0.95	0.36	0.36	0.27	0.27	0.13	0.13
50% RDF (50:50% N IF:FYM)	0.82	0.89	0.36	0.36	0.27	0.28	0.13	0.13
75% RDF (100% IF)	0.81	0.90	0.35	0.36	0.27	0.27	0.12	0.12
75% RDF (50:50% N IF:FYM)	0.78	0.74	0.35	0.36	0.28	0.27	0.12	0.12
100% RDF (100% IF)	0.82	0.75	0.38	0.36	0.26	0.23	0.12	0.15
100% RDF (50:50% N IF:FYM)	0.81	0.83	0.35	0.35	0.27	0.27	0.11	0.11
125% RDF (100% IF)	0.83	0.99	0.35	0.34	0.27	0.27	0.10	0.10
125% RDF (50:50% N IF:FYM)	0.83	0.72	0.35	0.33	0.27	0.27	0.11	0.12
SUB PLOT								
75% RDF (100% IF)	0.80	0.83	0.35	0.34	0.26	0.26	0.11	0.12
100%RDF (100% IF)	0.82	0.86	0.36	0.36	0.28	0.27	0.12	0.12
Mean	0.82	0.85	0.36	0.35	0.27	0.27	0.12	0.12

During 60-75 DAS, an application of 75% RDF (50% N through urea and 50% N through FYM) recorded the highest RGR (0.28) during 2002-03 while, during 2003-04 an application of 50% RDF (50% N through urea and 50% N through FYM) recorded the highest RGR (0.28). During 75 DAS-AH, an application of 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) recorded the highest RGR (0.13) during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer) recorded the highest RGR (0.15).

Effect of rabi treatments.

During 30-45 DAS, an application of 100% RDF (100% inorganic fertilizer) recorded the highest RGR (0.82 and 0.86 during 2002-03 and 2003-04, respectively).

Similar trend was observed during 45-60 DAS, 60-75 DAS and 75 DAS- AH during both the years except during 2003-04 in the period 75 DAS- AH where an application of 100% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer) recorded the same RGR (0.12).

4.2.1.2.8 Days to flower initiation.

The number of days flower initiation plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 62. The mean number of days to flower initiation plant^{-1} of *isabgol* was 56 days after sowing during both the years.

Table 62. Mean number of days to flower initiation, days to 50% flowering and days to maturity of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Days to flower initiation		Days to 50% flowering		Days to maturity	
	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT						
50% RDF (100% IF)	55	54	59	59	85	86
50% RDF (50:50% N IF:FYM)	56	55	58	60	87	86
75% RDF (100% IF)	56	55	59	60	86	87
75% RDF (50:50% N IF:FYM)	57	56	61	60	87	88
100% RDF (100% IF)	56	56	61	62	86.	88
100% RDF (50:50% N IF:FYM)	57	56	61	61	87	88
125% RDF (100% IF)	57	58	61	62	88	89
125% RDF (50:50% N IF:FYM)	57	58	61	62	88	89
S.E. ±	1.17	1.26	1.28	1.36	1.12	1.17
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
75% RDF (100% IF)	56	55	59	59	86	87
100%RDF (100% IF)	59	59	60	62	88	89
S.E. ±	1.19	1.23	1.18	1.23	0.81	0.93
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	56	56	60	61	87	88

Effect of kharif treatments.

The kharif treatments did not significantly affect the days to flower initiation plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the days to flower initiation plant^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.1.2.9 Days to 50% flowering.

The number of days to 50% flowering plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 62. The mean number of days to 50% flowering plant^{-1} of *isabgol* was 60 and 61 days after sowing during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the days to 50% flowering plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the days to 50% flowering plant^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.1.2.10 Days to maturity.

The data regarding number of days to maturity plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 62. The mean number of days to maturity plant^{-1} of *isabgol* were 87 and 88 days after sowing during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of days to maturity plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the days to maturity plant^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2 Yield contributing characters.

4.2.2.1 Number of productive spikes plant^{-1}.

The data regarding the number of productive spikes plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 63. The mean number of productive spikes plant^{-1} of *isabgol* was 16.71 at harvest during both the years.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of productive spikes plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the number of productive spikes plant^{-1} during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum number of productive spikes plant^{-1} (18.11 during both the years). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Table 63. Mean number of productive spikes, number of unproductive spikes and total number of spikes (plant^{-1}) of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Number of productive spikes (plant^{-1})		Number of unproductive spikes (plant^{-1})		Total number of spikes (plant^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT						
50% RDF (100% IF)	16.37	16.33	3.27	3.20	19.64	19.53
50% RDF (50:50% N IF:FYM)	16.40	16.36	3.30	3.27	19.70	19.63
75% RDF (100% IF)	16.53	16.43	3.30	3.27	19.83	19.70
75% RDF (50:50% N IF:FYM)	16.57	16.40	3.27	3.23	19.84	19.63
100% RDF (100% IF)	16.67	16.73	3.23	3.30	19.90	20.03
100% RDF (50:50% N IF:FYM)	16.73	16.83	3.20	3.23	19.93	20.06
125% RDF (100% IF)	17.17	17.27	3.37	3.33	20.54	20.60
125% RDF (50:50% N IF:FYM)	17.27	17.33	3.27	3.30	20.54	20.63
S.E. ±	0.34	0.34	0.07	0.10	0.34	0.45
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
75% RDF (100% IF)	16.32	16.29	3.38	3.36	19.70	19.65
100%RDF (100% IF)	18.11	18.11	3.15	3.18	21.26	21.29
S.E. ±	0.16	0.17	0.08	0.08	0.16	0.19
C.D. at 5%	0.48	0.51	0.24	0.24	0.48	0.57
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	16.71	16.71	3.28	3.27	19.99	19.98

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.2 Number of unproductive spikes plant^{-1}.

The data pertaining to number of unproductive spikes plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 63. The mean number of unproductive spikes plant^{-1} of *isabgol* was 3.28 and 3.27 at harvest during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of unproductive spikes plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the number of unproductive spikes plant^{-1} during both the years.

An application of 75% RDF (100% inorganic fertilizer) recorded the maximum number of unproductive spikes plant^{-1} (3.38 and 3.36 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.3 Total number of spikes plant^{-1}.

The data regarding total number of spikes plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 63. The mean total number of spikes plant^{-1} of *isabgol* was 19.99 and 19.98 at harvest during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total number of spikes plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total number of spikes plant^{-1} during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum total number of spikes plant^{-1} (21.26 and 21.29 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.4 Length of spike.

The data regarding the length of spike of *isabgol* as influenced by different treatments are presented in Table 64. The mean length of spike was 3.58 and 3.60 cm during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the length of spike during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the length of spike during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum length of spike (3.85 and 3.86 cm during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 64. Mean length of spike (cm), girth of spike (cm), number of seeds and weight (g) of seeds (spike^{-1}) of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Length of spike (cm)		Girth of spike (cm)		Number of seeds spike^{-1}		Weight of seeds (g spike^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	3.48	3.46	2.63	2.61	69.23	68.08	0.10	0.10
50% RDF (50:50% N IF:FYM)	3.50	3.47	2.67	2.65	69.54	68.59	0.10	0.10
75% RDF (100% IF)	3.53	3.50	2.73	2.79	68.47	68.27	0.11	0.10
75% RDF (50:50% N IF:FYM)	3.57	3.54	2.75	2.82	70.50	69.49	0.11	0.11
100% RDF (100% IF)	3.58	3.61	2.79	2.81	69.94	70.36	0.11	0.11
100% RDF (50:50% N IF:FYM)	3.62	3.68	2.83	2.83	71.63	72.19	0.11	0.11
125% RDF (100% IF)	3.68	3.75	2.84	2.86	71.26	70.81	0.11	0.11
125% RDF (50:50% N IF:FYM)	3.71	3.78	2.85	2.87	71.98	71.49	0.11	0.11
S.E. ±	0.09	0.12	0.09	0.11	2.82	3.25	0.01	0.01
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	3.52	3.53	2.67	2.65	70.08	69.53	0.10	0.10
100%RDF (100% IF)	3.85	3.86	2.78	2.81	70.55	70.29	0.11	0.11
S.E. ±	0.04	0.04	0.05	0.07	0.86	0.98	0.01	0.01
C.D. at 5%	0.12	0.12	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	3.58	3.60	2.76	2.78	70.32	69.91	0.11	0.11

4.2.2.5 Girth of spike.

The data on girth of spike of *isabgol* as influenced by different treatments are presented in Table 64. The mean girth of spike was 2.76 and 2.78 cm during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the girth of spike during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the girth of spike during both the years.

Interaction.

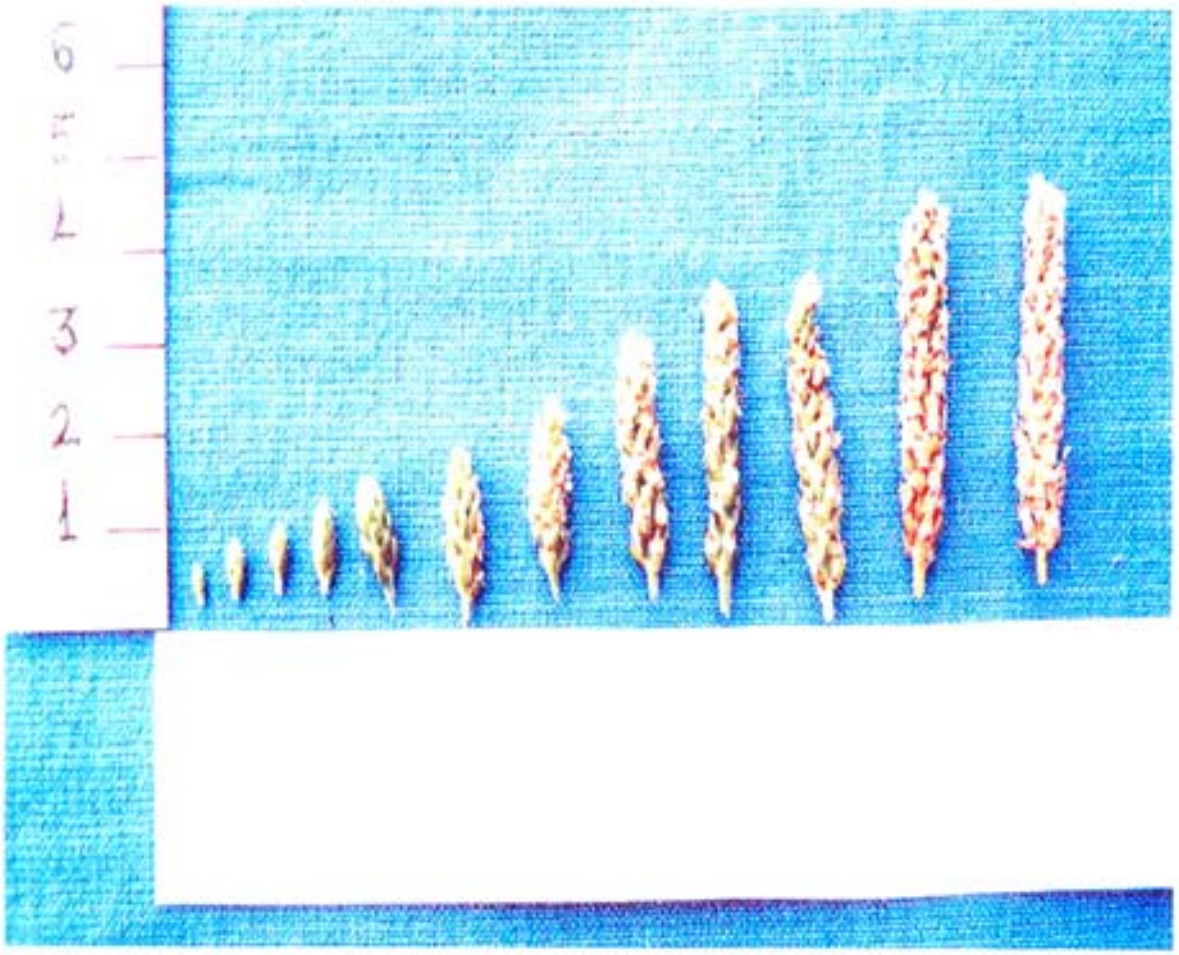
The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.6 Number of seeds spike^{-1}.

The data pertaining to number of seeds spike^{-1} of *isabgol* as influenced by different treatments are presented in Table 64. The mean number of seeds spike^{-1} was 70.32 and 69.91 during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of seeds



PP 24: Sequence of spike development of *isabgol*.

Effect of rabi treatments.

The rabi treatments did not significantly affect the number of seeds spike^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.7 Weight of seeds spike^{-1}.

The data on weight of seeds spike^{-1} of *isabgol* as influenced by different treatments are presented in Table 64. The mean weight of seeds spike^{-1} was 0.11 g during both the years.

Effect of kharif treatments.

The kharif treatments did not significantly affect the weight of seeds spike^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the weight of seeds spike^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.8 Number of seeds plant^{-1}.

The data regarding number of seeds plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 65. The mean number of seeds plant^{-1} was 1160.83 and 1166.03 during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the number of seeds plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the number of seeds plant^{-1} during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum number of seeds plant^{-1} (1277.66 and 1272.13 during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 65. Mean number of seeds (plant^{-1}), weight of seeds (g plant^{-1}) and thousand seed weight (g) of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Number of seeds plant^{-1}		Weight of seeds (g plant^{-1})		Thousand seed weight (g)	
	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT						
50% RDF (100% IF)	1133.87	1106.93	1.67	1.66	1.52	1.48
50% RDF (50:50% N IF:FYM)	1140.27	1114.70	1.70	1.68	1.55	1.53
75% RDF (100% IF)	1130.78	1123.77	1.72	1.71	1.57	1.57
75% RDF (50:50% N IF:FYM)	1161.17	1134.00	1.75	1.75	1.60	1.60
100% RDF (100% IF)	1168.47	1179.93	1.77	1.78	1.61	1.64
100% RDF (50:50% N IF:FYM)	1189.33	1204.10	1.80	1.82	1.63	1.65
125% RDF (100% IF)	1122.40	1221.87	1.83	1.86	1.65	1.68
125% RDF (50:50% N IF:FYM)	1240.33	1242.97	1.84	1.88	1.70	1.72
S.E. ±	38.96	46.31	0.07	0.08	0.07	0.09
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
75% RDF (100% IF)	1068.98	1059.93	1.74	1.76	1.58	1.54
100%RDF (100% IF)	1277.66	1272.13	1.88	1.87	1.67	1.67
S.E. ±	9.81	9.29	0.01	0.02	0.02	0.03
C.D. at 5%	29.41	27.85	0.03	0.06	0.06	0.09
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	1160.83	1166.03	1.76	1.77	1.60	1.61

4.2.2.9 Weight of seeds plant^{-1}.

The data on weight of seeds plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 65. The mean weight of seeds plant^{-1} was 1.76 and 1.77 g during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the weight of seeds plant^{-1} during both the years.

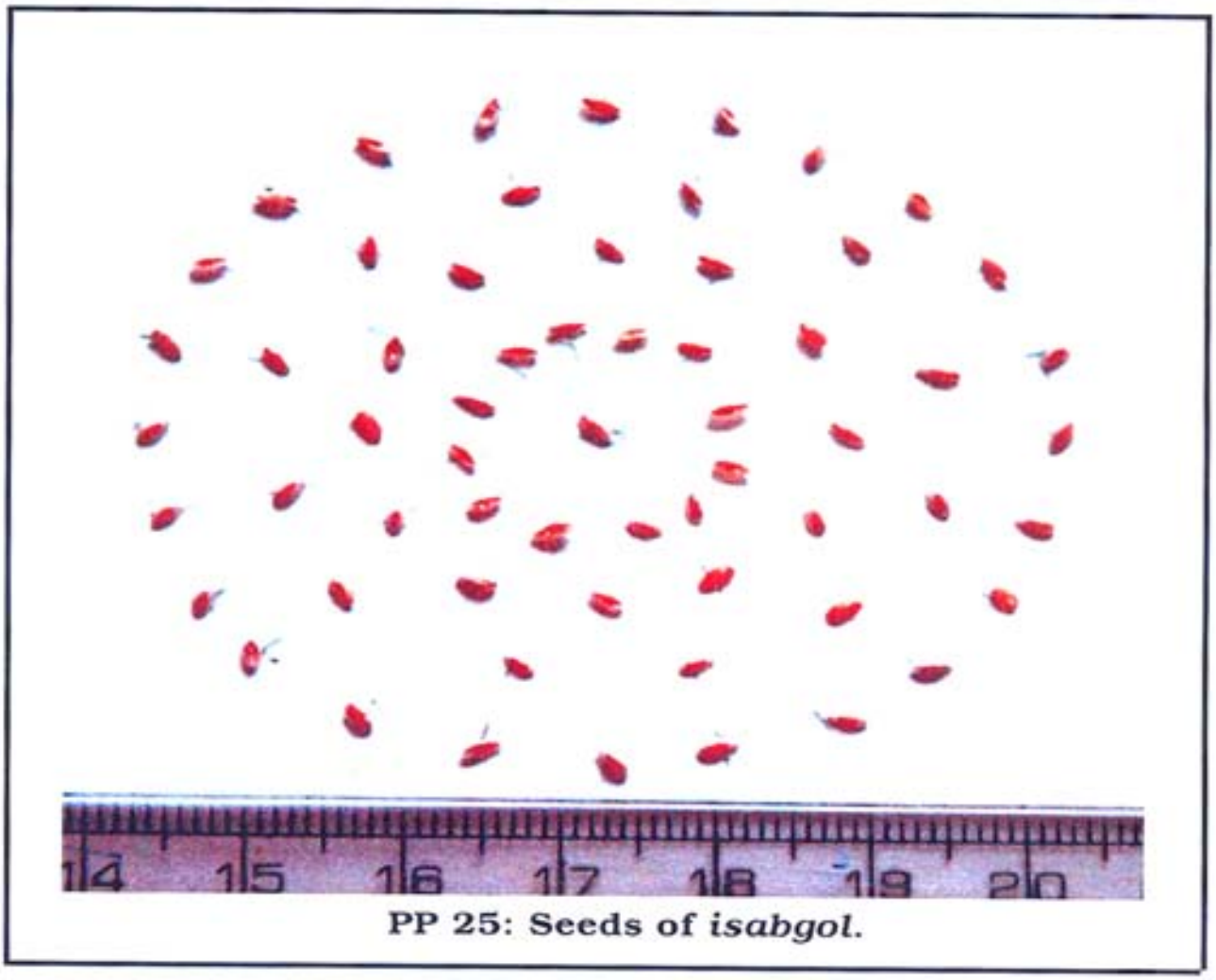
Effect of rabi treatments.

The rabi treatments significantly affected the weight of seeds plant^{-1} during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum weight of seeds plant^{-1} (1.88 and 1.87 g during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.



PP 25: Seeds of *isabgol*.

4.2.2.10 Thousand seed weight.

The data on thousand seed weight of *isabgol* as influenced by different treatments are presented in Table 65. The mean thousand seed weight was 1.60 and 1.61 g during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the thousand seed weight during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the thousand seed weight during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the maximum thousand seed weight (1.67 g during both the years). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.11 Per plant basis.

4.2.2.11.1 Root weight plant^{-1}.

The data regarding root weight plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 66. The mean root weight plant^{-1} was 0.38 g during both the years.

Effect of kharif treatments.

The kharif treatments did not significantly affect the root weight plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the root weight plant^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.11.2 Stalk weight plant^{-1}.

The data pertaining to stalk weight plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 66. The mean stalk weight plant^{-1} was 4.43 and 4.31 g during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the stalk weight plant^{-1} during both the years.

Table 66. Mean root weight, stalk weight and leaves weight (g plant^{-1}) of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Root weight (g plant^{-1})		Stalk weight (g plant^{-1})		Leaves weight (g plant^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT						
50% RDF (100% IF)	0.37	0.37	4.35	4.31	0.87	0.86
50% RDF (50:50% N IF:FYM)	0.37	0.37	4.35	4.32	0.86	0.85
75% RDF (100% IF)	0.37	0.37	4.37	4.33	0.88	0.86
75% RDF (50:50% N IF:FYM)	0.37	0.37	4.41	4.35	0.89	0.88
100% RDF (100% IF)	0.38	0.39	4.47	4.48	0.88	0.91
100% RDF (50:50% N IF:FYM)	0.38	0.39	4.46	4.47	0.88	0.91
125% RDF (100% IF)	0.38	0.39	4.51	4.50	0.89	0.91
125% RDF (50:50% N IF:FYM)	0.38	0.38	4.54	4.52	0.91	0.90
S.E. ±	0.02	0.02	0.08	0.08	0.02	0.03
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
75% RDF (100% IF)	0.37	0.37	4.41	4.38	0.88	0.87
100%RDF (100% IF)	0.38	0.38	4.48	4.51	0.90	0.92
S.E. ±	0.01	0.01	0.02	0.03	0.02	0.02
C.D. at 5%	N.S.	N.S.	0.06	0.09	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.38	0.38	4.43	4.41	0.88	0.89

Effect of rabi treatments.

The rabi treatments significantly affected the stalk weight plant^{-1} during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest stalk weight plant^{-1} (4.48 and 4.51 g during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.2.11.3 Leaves weight plant^{-1}.

The data regarding leaves weight plant^{-1} of *isabgol* as influenced by different treatments are presented in Table 66. The mean leaves weight plant^{-1} was 0.88 and 0.89 g during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the leaves weight plant^{-1} during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the leaves weight plant^{-1} during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.3 Per hectare basis.

4.2.3.1 Root yield ha^{-1}.

The data regarding root yield ha^{-1} of *isabgol* as influenced by different treatments are presented in Table 67. The mean root yield ha^{-1} was 1.40 q ha^{-1} during both the years and on pooled mean basis.

Table 67. Mean root yield, stalk yield, leaves yield (q ha^{-1}) and pooled mean of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Root yield (q ha^{-1})			Stalk yield (q ha^{-1})			Leaves yield (q ha^{-1})		
	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean
MAIN PLOT									
50% RDF (100% IF)	1.34	1.33	1.34	15.80	15.67	15.74	3.10	3.07	3.09
50% RDF (50:50% N IF:FYM)	1.36	1.34	1.35	16.00	15.87	15.94	3.14	3.11	3.13
75% RDF (100% IF)	1.38	1.36	1.37	16.27	16.11	16.19	3.21	3.16	3.19
75% RDF (50:50% N IF:FYM)	1.39	1.38	1.39	16.45	16.31	16.38	3.24	3.20	3.22
100% RDF (100% IF)	1.40	1.42	1.41	16.62	16.79	16.71	3.26	3.29	3.28
100% RDF (50:50% N	1.43	1.45	1.44	16.91	17.10	17.01	3.32	3.35	3.34
125% RDF (100% IF)	1.45	1.47	1.46	17.22	17.39	17.31	3.37	3.41	3.39
125% RDF (50:50% N	1.46	1.48	1.47	17.30	17.51	17.41	3.39	3.43	3.41
S.E. ±	0.05	0.06	0.05	0.52	0.63	0.57	0.10	0.13	0.12
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT									
75% RDF (100% IF)	1.37	1.36	1.37	16.17	16.12	16.15	3.17	3.16	3.17
100%RDF (100% IF)	1.44	1.46	1.45	16.97	17.07	17.02	3.33	3.36	3.35
S.E. ±	0.01	0.01	0.01	0.14	0.12	0.12	0.03	0.02	0.02
C.D. at 5%	0.03	0.03	0.03	0.42	0.36	0.36	0.09	0.06	0.06
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. %	6.48	7.75	7.00	6.51	7.64	6.97	6.47	7.63	6.93
Mean	1.40	1.40	1.40	16.57	16.59	16.59	3.25	3.25	3.26

Effect of kharif treatments.

The kharif treatments did not significantly affect the root yield ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the root yield ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest root yield (1.44, 1.46 and 1.45 q ha^{-1} during 2002-03, 2003-04 and on pooled

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.3.2 Stalk yield ha^{-1}.

The data pertaining to stalk yield ha^{-1} of *isabgol* as influenced by different treatments are presented in Table 67. The mean stalk yield ha^{-1} was 16.57, 16.59 and 16.59 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the stalk yield ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the stalk yield ha^{-1} during both the years and on pooled mean basis. An application of 100% RDF (100% inorganic fertilizer) recorded the highest stalk yield (16.97, 17.07 and 17.02 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.3.3 Leaves yield ha^{-1}.

The data regarding leaves yield ha^{-1} of *isabgol* as influenced by different treatments are presented in Table 67. The mean leaves yield ha^{-1} was 3.25 q ha^{-1} during both the years and 3.26 q ha^{-1} on pooled mean basis.

Effect of kharif treatments.

The kharif treatments did not significantly affect the leaves yield ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the leaves yield ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest leaves yield (3.33, 3.36 and 3.35 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.3.4 Seed yield ha^{-1}.

The data on seed yield ha^{-1} of *isabgol* as influenced by different treatments are presented in Table 68 and graphically depicted in Fig. 10. The mean seed yield ha^{-1} was 7.93, 7.94 and 7.94 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Table 68. Mean seed yield, total straw yield (q ha^{-1}), harvest index (%) and pooled mean of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Seed yield (q ha^{-1})			Total straw yield (q ha^{-1})			Harvest index (%)		
	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean	02-03	03-04	Pooled mean
MAIN PLOT									
50% RDF (100% IF)	7.66	7.60	7.63	20.24	20.07	20.16	27.52	27.55	27.54
50% RDF (50:50% N IF:FYM)	7.71	7.65	7.68	20.50	20.32	20.41	27.43	27.45	27.44
75% RDF (100% IF)	7.81	7.75	7.78	20.86	20.63	20.75	27.27	27.34	27.31
75% RDF (50:50% N IF:FYM)	7.89	7.83	7.86	21.08	20.89	20.99	27.24	27.26	27.25
100% RDF (100% IF)	8.05	8.11	8.08	21.28	21.50	21.39	27.45	27.40	27.43
100% RDF (50:50% N IF:FYM)	8.08	8.15	8.12	21.66	21.90	21.78	27.17	27.12	27.15
125% RDF (100% IF)	8.12	8.21	8.17	22.04	22.27	22.16	26.94	27.00	26.97
125% RDF (50:50% N IF:FYM)	8.15	8.25	8.20	22.15	22.42	22.29	26.92	26.98	26.95
S.E. ±	0.17	0.22	0.20	0.67	0.80	0.73	0.78	1.03	0.90
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT									
75% RDF (100% IF)	7.73	7.71	7.72	20.70	20.64	20.67	27.22	27.24	27.23
100%RDF (100% IF)	8.14	8.18	8.16	21.73	21.85	21.79	27.27	27.28	27.28
S.E. ±	0.06	0.06	0.05	0.18	0.16	0.16	0.20	0.15	0.14
C.D. at 5%	0.18	0.18	0.15	0.54	0.48	0.48	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. %	5.04	6.44	5.56	6.51	7.64	6.97	-	-	-
Mean	7.93	7.94	7.94	21.23	21.25	21.24	27.24	27.26	27.26

Effect of kharif treatments.

The kharif treatments did not significantly affect the seed yield ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the seed yield ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest seed yield (8.14, 8.18 and 8.16 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found

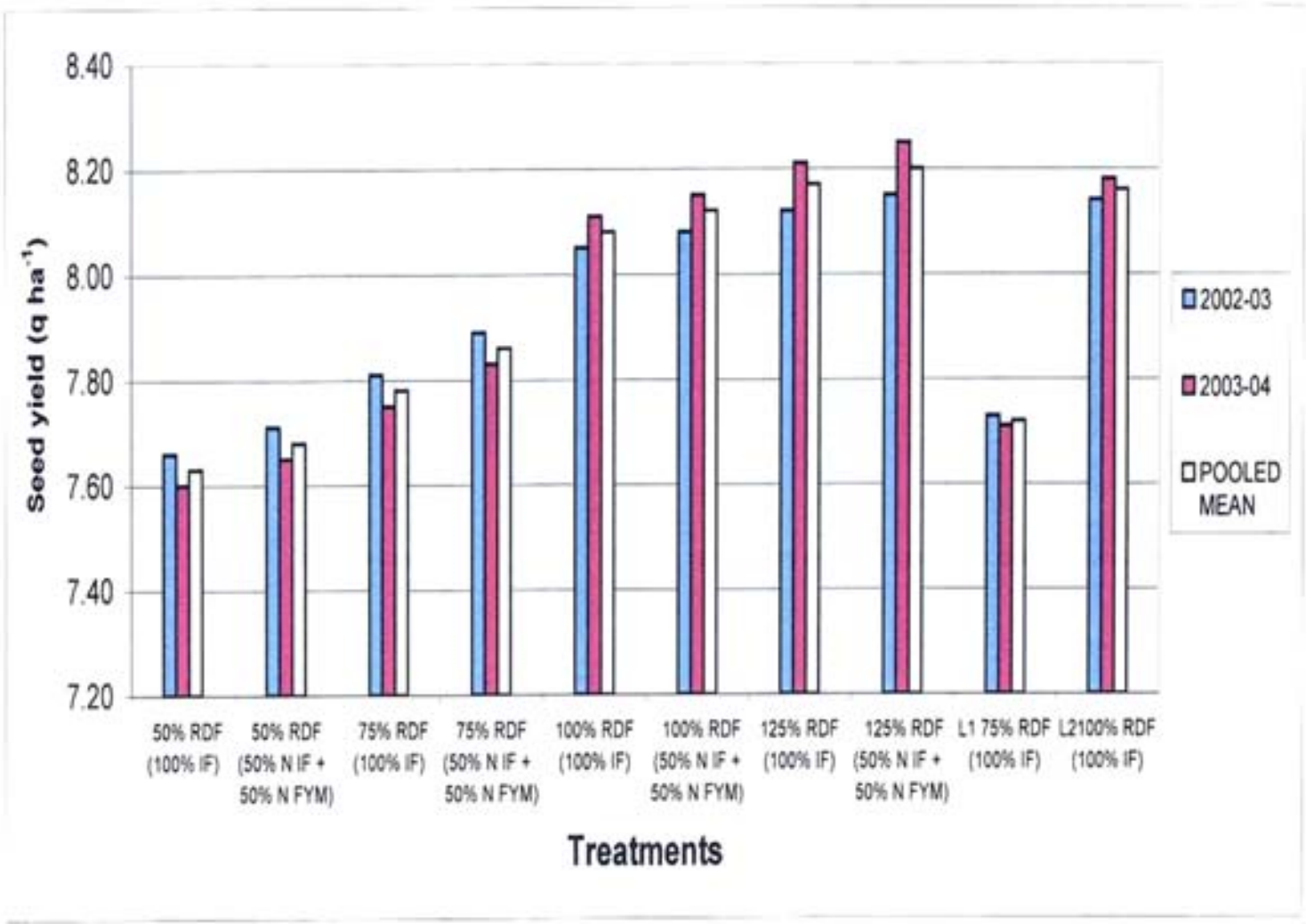


Fig. 10. Mean seed yield and pooled mean (q ha^{-1}) of *isabgol* during 2002-03 and 2003-04.

4.2.3.5 Total straw yield ha^{-1}.

The data on total straw yield ha^{-1} of *isabgol* as influenced by different treatments are presented in Table 68. The mean total straw yield ha^{-1} was 21.23, 21.25 and 21.24 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total straw yield ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the total straw yield ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest total straw yield (21.73, 21.85 and 21.79 q ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.4 Harvest index.

The data on harvest index of *isabgol* as influenced by different treatments are presented in Table 68. The mean harvest index was 27.24% during 2002-03 and 27.26% during 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the harvest index during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments did not significantly affect the harvest index during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.5 Chemical studies.

4.2.5.1 Concentration of nitrogen in plant at harvest.

The data regarding concentration of N in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 69. The mean percentage of N concentration in root, stalk, leaves and seed was 1.11, 1.16, 1.46 and 2.47, respectively during 2002-03 and 1.11, 1.17, 1.46 and 2.46, respectively during 2003-04.

Table 69. Mean concentration of nitrogen (%) in *isabgol* root, stalk, leaves and seed as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Nitrogen (%)							
	Root		Stalk		Leaves		Seed	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	1.10	1.09	1.15	1.15	1.45	1.45	2.47	2.46
50% RDF (50:50% N IF:FYM)	1.12	1.11	1.16	1.16	1.45	1.45	2.47	2.46
75% RDF (100% IF)	1.11	1.10	1.15	1.16	1.45	1.43	2.46	2.45
75% RDF (50:50% N IF:FYM)	1.11	1.10	1.17	1.16	1.45	1.45	2.46	2.47
100% RDF (100% IF)	1.11	1.11	1.15	1.16	1.47	1.48	2.49	2.48
100% RDF (50:50% N IF:FYM)	1.10	1.11	1.15	1.16	1.44	1.45	2.45	2.45
125% RDF (100% IF)	1.11	1.11	1.17	1.18	1.46	1.47	2.46	2.46
125% RDF (50:50% N IF:FYM)	1.10	1.11	1.18	1.19	1.47	1.49	2.48	2.48
S.E. ±	0.04	0.04	0.06	0.06	0.03	0.03	0.05	0.05
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	1.09	1.09	1.18	1.17	1.44	1.43	2.47	2.43
100%RDF (100% IF)	1.11	1.11	1.21	1.22	1.49	1.51	2.50	2.49
S.E. ±	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.03
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	1.11	1.11	1.16	1.17	1.46	1.46	2.47	2.46

4.2.5.1.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of N in root during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of N in root during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.1.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of N in stalk during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of N in stalk during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.1.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of N in leaves during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of N in leaves during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.1.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of N in seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of N in seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.2 Concentration of phosphorus in plant at harvest.

The data pertaining to concentration of P in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 70. The mean percentage of P concentration in root, stalk, leaves and seed was 0.37, 0.62, 0.72 and 1.08, respectively during 2002-03 and 0.36, 0.62, 0.73 and 1.08, respectively during 2003-04.

4.2.5.2.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of P in root during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of P in root during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 70. Mean concentration of phosphorus (%) in *isabgol* root, stalk, leaves and seed as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Phosphorus (%)							
	Root		Stalk		Leaves		Seed	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	0.35	0.34	0.60	0.61	0.70	0.71	1.06	1.05
50% RDF (50:50% N IF:FYM)	0.36	0.35	0.61	0.62	0.71	0.72	1.07	1.06
75% RDF (100% IF)	0.35	0.34	0.61	0.61	0.72	0.74	1.06	1.06
75% RDF (50:50% N IF:FYM)	0.37	0.36	0.63	0.63	0.73	0.74	1.07	1.07
100% RDF (100% IF)	0.37	0.36	0.62	0.62	0.72	0.72	1.08	1.07
100% RDF (50:50% N IF:FYM)	0.38	0.37	0.63	0.63	0.72	0.73	1.09	1.08
125% RDF (100% IF)	0.38	0.39	0.62	0.63	0.74	0.75	1.10	1.10
125% RDF (50:50% N IF:FYM)	0.38	0.40	0.63	0.64	0.75	0.76	1.11	1.11
S.E. ±	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	0.36	0.35	0.61	0.62	0.71	0.72	1.07	1.06
100%RDF (100% IF)	0.37	0.37	0.62	0.63	0.73	0.74	1.09	1.09
S.E. ±	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.37	0.36	0.62	0.62	0.72	0.73	1.08	1.08

4.2.5.2.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of P in stalk during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of P in stalk during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.2.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of P in leaves during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of P in leaves during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.2.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of P in seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of P in seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.3 Concentration of potassium in plant at harvest.

The data on concentration of K in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 71. The mean percentage of K concentration in root, stalk, leaves and seed was 0.85, 0.25, 0.76 and 0.55, respectively during 2002-03 and 0.85, 0.25, 0.75 and 0.55, respectively during 2003-04.

4.2.5.3.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of K in root during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of K in root during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.3.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of K in stalk during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of K in stalk during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 71. Mean concentration of potassium (%) in *isabgol* root, stalk, leaves and seed as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Potassium (%)							
	Root		Stalk		Leaves		Seed	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT								
50% RDF (100% IF)	0.82	0.81	0.23	0.22	0.73	0.72	0.53	0.52
50% RDF (50:50% N IF:FYM)	0.83	0.82	0.24	0.22	0.74	0.73	0.54	0.53
75% RDF (100% IF)	0.82	0.82	0.25	0.23	0.75	0.74	0.53	0.53
75% RDF (50:50% N IF:FYM)	0.85	0.84	0.24	0.24	0.74	0.75	0.55	0.54
100% RDF (100% IF)	0.86	0.86	0.25	0.25	0.75	0.76	0.55	0.55
100% RDF (50:50% N IF:FYM)	0.87	0.88	0.23	0.24	0.76	0.76	0.56	0.56
125% RDF (100% IF)	0.88	0.88	0.28	0.28	0.78	0.78	0.56	0.57
125% RDF (50:50% N IF:FYM)	0.90	0.89	0.28	0.29	0.79	0.79	0.57	0.58
S.E. ±	0.04	0.04	0.02	0.03	0.03	0.04	0.02	0.02
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT								
75% RDF (100% IF)	0.84	0.83	0.23	0.22	0.75	0.75	0.54	0.54
100%RDF (100% IF)	0.86	0.86	0.27	0.27	0.76	0.76	0.55	0.56
S.E. ±	0.01	0.01	0.02	0.03	0.01	0.01	0.02	0.02
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.85	0.85	0.25	0.25	0.76	0.75	0.55	0.55

4.2.5.3.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of K in leaves during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of K in leaves during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.5.3.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the concentration of K in seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the concentration of K in seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.6 Uptake of nitrogen in plant at harvest.

The data regarding uptake of N in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 72. The mean uptake of N in root, stalk, leaves, seed and total uptake was 1.55, 19.23, 4.74, 19.58 and 45.09 kg ha^{-1}, respectively during 2002-03 and 1.55, 19.34, 4.77, 19.57 and 45.23 kg ha^{-1}, respectively during 2003-04.

Table 72. Mean uptake of nitrogen (kg ha^{-1}) in *isabgol* root, stalk, leaves, seed and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Nitrogen (kg ha^{-1})									
	Root		Stalk		Leaves		Seed		Total	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	1.47	1.45	18.17	18.02	4.50	4.60	18.92	18.70	43.06	42.77
50% RDF (50:50% N IF:FYM)	1.52	1.49	18.56	18.41	4.55	4.51	19.04	18.82	43.67	43.23
75% RDF (100% IF)	1.53	1.50	18.71	18.69	4.66	4.52	19.21	18.99	44.11	43.70
75% RDF (50:50% N IF:FYM)	1.54	1.52	19.25	18.92	4.70	4.64	19.41	19.34	44.90	44.42
100% RDF (100% IF)	1.55	1.58	19.11	19.48	4.79	4.87	20.05	20.11	45.50	46.04
100% RDF (50:50% N IF:FYM)	1.57	1.61	19.45	19.84	4.78	4.86	19.80	19.97	45.60	46.28
125% RDF (100% IF)	1.61	1.63	20.15	20.52	4.92	5.01	19.98	20.20	46.66	47.36
125% RDF (50:50% N IF:FYM)	1.61	1.64	20.41	20.84	4.98	5.11	20.21	20.46	47.21	48.05
S.E. ±	0.06	0.07	1.20	1.19	0.14	0.17	0.65	0.72	1.41	1.77
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	1.40	1.45	18.66	18.75	4.52	4.53	18.59	18.74	43.16	43.46
100%RDF (100% IF)	1.64	1.60	20.44	20.77	5.15	5.13	20.61	20.40	48.24	47.90
S.E. ±	0.02	0.03	0.51	0.48	0.09	0.09	0.28	0.29	0.52	0.81
C.D. at 5%	0.06	0.09	1.53	1.44	0.27	0.27	0.84	0.87	1.56	2.43
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	1.55	1.55	19.23	19.34	4.74	4.77	19.58	19.57	45.09	45.23

4.2.6.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of N in root during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of N in root during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest N uptake (1.64 and 1.60 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.6.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of N in stalk during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of N in stalk during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest N uptake (20.44 and 20.77 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.6.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of N in leaves during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of N in leaves during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest N uptake (5.15 and 5.13 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.6.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of N in seed during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of N in seed during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest N uptake (20.61and 20.40 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.6.5 Total N uptake.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total uptake of N during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total uptake of N during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest total uptake of N (48.24 and 47.90 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.7 Uptake of phosphorus in plant at harvest.

The data regarding uptake of P in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 73. The mean uptake of P in root, stalk, leaves, seed and total uptake was 0.52, 10.26, 2.36, 8.57 and 21.70 kg ha^{-1}, respectively during 2002-03 and 0.51, 10.36, 2.39, 8.55 and 21.80 kg ha^{-1}, respectively during 2003-04.

4.2.7.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of P in root during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of P in root during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest P uptake (0.53 and 0.54 kg ha^{-1} during 2002-03 and 2003-04, respectively).

It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 73. Mean uptake of phosphorus (kg ha^{-1}) in *isabgol* root, stalk, leaves, seed and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Phosphorus (kg ha^{-1})									
	Root		Stalk		Leaves		Seed		Total	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	0.47	0.45	9.48	9.56	2.17	2.18	8.12	7.98	20.24	20.17
50% RDF (50:50% N IF:FYM)	0.49	0.47	9.76	9.84	2.23	2.24	8.25	8.11	20.73	20.66
75% RDF (100% IF)	0.48	0.46	9.92	9.83	2.31	2.34	8.28	8.22	20.99	20.85
75% RDF (50:50% N IF:FYM)	0.51	0.50	10.36	10.28	2.37	2.37	8.44	8.38	21.68	21.53
100% RDF (100% IF)	0.52	0.51	10.31	10.41	2.35	2.37	8.69	8.68	21.87	21.97
100% RDF (50:50% N IF:FYM)	0.54	0.54	10.65	10.77	2.39	2.45	8.81	8.80	22.39	22.56
125% RDF (100% IF)	0.55	0.57	10.68	10.96	2.50	2.56	8.93	9.03	22.66	23.12
125% RDF (50:50% N IF:FYM)	0.56	0.59	10.90	11.21	2.54	2.61	9.05	9.16	23.05	23.57
S.E. ±	0.04	0.05	0.48	0.56	0.13	0.15	0.32	0.40	0.98	1.19
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	0.49	0.48	9.88	9.92	2.26	2.29	8.22	8.20	20.94	20.89
100%RDF (100% IF)	0.53	0.54	10.58	10.68	2.44	2.48	8.83	8.89	22.38	22.58
S.E. ±	0.01	0.01	0.16	0.16	0.02	0.03	0.16	0.15	0.14	0.14
C.D. at 5%	0.03	0.03	0.48	0.48	0.06	0.09	0.48	0.45	0.42	0.42
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	0.52	0.51	10.26	10.36	2.36	2.39	8.57	8.55	21.70	21.80

4.2.7.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of P in stalk during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of P in stalk during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest P uptake (10.58 and 10.68 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.7.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of P in leaves during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of P in leaves during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest P uptake (2.44 and 2.48 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.7.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of P in seed during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of P in seed during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest P uptake (8.83 and 8.89 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.7.5 Total P uptake.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total uptake of P during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total uptake of P during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest total uptake of P (22.38 and 22.58 kg ha^{-1} during 2002-03 and 2003-04,

respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.8 Uptake of potassium in plant at harvest.

The data regarding uptake of K in plant at harvest of *isabgol* as influenced by different treatments are presented in Table 74. The mean uptake of K in root, stalk, leaves, seed and total uptake was 1.20, 4.15, 2.46, 4.36 and 12.16 kg ha^{-1}, respectively during 2002-03 and 1.20, 4.10, 2.46, 4.36 and 12.11 kg ha^{-1}, respectively during 2003-04.

Table74. Mean uptake of potassium (kg ha^{-1}) in *isabgol* root, stalk, leaves, seed and total uptake as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Potassium (kg ha^{-1})									
	Root		Stalk		Leaves		Seed		Total	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	1.10	1.08	3.63	3.45	2.26	2.21	4.06	3.95	11.05	10.69
50% RDF (50:50% N IF:FYM)	1.13	1.10	3.84	3.49	2.32	2.27	4.16	4.06	11.45	10.92
75% RDF (100% IF)	1.13	1.12	4.07	3.71	2.41	2.34	4.14	4.11	11.75	11.28
75% RDF (50:50% N IF:FYM)	1.18	1.16	3.95	3.92	2.40	2.40	4.34	4.23	11.87	11.71
100% RDF (100% IF)	1.20	1.22	4.16	4.20	2.45	2.50	4.43	4.46	12.24	12.38
100% RDF (50:50% N IF:FYM)	1.24	1.28	3.89	4.10	2.52	2.55	4.52	4.56	12.17	12.49
125% RDF (100% IF)	1.28	1.29	4.82	4.87	2.63	2.66	4.55	4.68	13.28	13.50
125% RDF (50:50% N IF:FYM)	1.31	1.32	4.84	5.08	2.68	2.71	4.65	4.79	13.48	13.90
S.E. ±	0.08	0.09	0.41	0.55	0.15	0.17	0.21	0.28	0.85	1.09
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT										
75% RDF (100% IF)	1.16	1.14	3.78	3.65	2.38	2.33	4.16	4.12	11.49	11.31
100%RDF (100% IF)	1.24	1.26	4.55	4.76	2.53	2.58	4.52	4.56	12.84	12.90
S.E. ±	0.02	0.02	0.16	0.18	0.04	0.04	0.07	0.07	0.11	0.23
C.D. at 5%	0.06	0.06	0.48	0.54	0.12	0.12	0.21	0.21	0.33	0.70
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	1.20	1.20	4.15	4.10	2.46	2.46	4.36	4.36	12.16	12.11

4.2.8.1 Root.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of K in root during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of K in root during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest K uptake (1.24 and 1.26 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.8.2 Stalk.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of K in stalk during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of K in stalk during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest K uptake (4.55 and 4.76 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.8.3 Leaves.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of K in leaves during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of K in leaves during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest K uptake (2.53 and 2.58 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.8.4 Seed.

Effect of kharif treatments.

The kharif treatments did not significantly affect the uptake of K in seed during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the uptake of K in seed during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest K uptake (4.52 and 4.56 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.8.5 Total K uptake.

Effect of kharif treatments.

The kharif treatments did not significantly affect the total uptake of K during both the years.

Effect of rabi treatments.

The rabi treatments significantly affected the total uptake of K during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest total uptake of K (12.84 and 12.90 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.9 Quality studies.

4.2.9.1 Protein studies.

The data regarding protein content in seed at harvest of *isabgol* as influenced by different treatments are presented in Table 75. The mean protein content in seed was 15.42 and 15.40 % during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the protein content of seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the protein content of seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

Table 75. Mean protein content (%), husk percentage and swelling factor (ccg^{-1}) of *isabgol* seed as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Protein content (%)		Husk percentage		Swelling factor (cc g^{-1})	
	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT						
50% RDF (100% IF)	15.44	15.38	24.33	25.50	12.17	12.07
50% RDF (50:50% N IF:FYM)	15.44	15.38	24.83	24.33	12.68	12.82
75% RDF (100% IF)	15.38	15.31	25.33	26.17	13.25	12.75
75% RDF (50:50% N IF:FYM)	15.38	15.44	24.76	24.67	12.83	13.55
100% RDF (100% IF)	15.56	15.50	25.17	25.33	13.40	12.98
100% RDF (50:50% N IF:FYM)	15.31	15.31	25.33	25.83	13.47	13.12
125% RDF (100% IF)	15.38	15.38	25.67	24.50	13.27	13.75
125% RDF (50:50% N IF:FYM)	15.50	15.50	26.17	26.67	13.35	13.13
S.E. ±	0.33	0.32	0.68	0.64	0.47	0.60
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB PLOT						
75% RDF (100% IF)	15.20	15.19	24.96	25.04	12.83	12.82
100%RDF (100% IF)	15.65	15.58	25.46	25.71	13.27	13.22
S.E. ±	0.16	0.17	0.38	0.39	0.23	0.15
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	15.42	15.40	25.20	25.38	13.05	13.02

4.2.9.2 Husk percentage.

The data on husk percentage of seed at harvest of *isabgol* as influenced by different treatments are presented in Table 75. The mean husk percentage of seed was 25.20 and 25.38 during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the husk percentage of seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the husk percentage of seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.9.3 Swelling factor.

The data pertaining to swelling factor of seed at harvest of *isabgol* as influenced by different treatments are presented in Table 75. The mean swelling factor of seed was 13.05 and 13.02 cc g^{-1} during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly affect the swelling factor of seed during both the years.

Effect of rabi treatments.

The rabi treatments did not significantly affect the swelling factor of seed during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.10 Soil status after harvest.

Data pertaining to physical and chemical properties of soil after harvest of *isabgol* crop are presented.

4.2.10.1 Physical properties of soil.

The data regarding pH, electrical conductivity and bulk density of soil after harvest of *isabgol* as influenced by different treatments are presented in Table 76.

4.2.10.1.1 pH.

The mean pH of soil after harvest of *isabgol* was 8.11 during both the years. The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

An application of 125% RDF (100% inorganic fertilizer) and 100% RDF (100% inorganic fertilizer) recorded the highest pH (8.12) during both the years.

Effect of rabi treatments.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest pH (8.12) of soil during 2002-03 while, during 2003-04 both the treatments had a similar pH (8.11).

4.2.10.1.2 Electrical conductivity.

The mean electrical conductivity of soil after harvest of *isabgol* was 0.13 dS m^{-1} during both the years. The data was not statistically analyzed and the inferences are based on mean values only.

Table 76. Mean pH, electrical conductivity (dS m^{-1}) and bulk density (g cc^{-1}) of soil after harvest of *isabgol* as influenced by different treatments during 2002-2003 and 2003-2004.

Treatment	pH				E.C. (dS m^{-1})				B.D. (g cc^{-1})			
	Initial		After harvest		Initial		After harvest		Initial		After harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT												
50% RDF (100% IF)	8.11	8.10	8.11	8.10	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
50% RDF (50:50% N IF:FYM)	8.10	8.09	8.10	8.10	0.12	0.13	0.13	0.13	1.32	1.32	1.32	1.32
75% RDF (100% IF)	8.11	8.10	8.11	8.11	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
75% RDF (50:50% N IF:FYM)	8.10	8.10	8.11	8.11	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
100% RDF (100% IF)	8.11	8.11	8.12	8.12	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
100% RDF (50:50% N IF:FYM)	8.10	8.09	8.11	8.11	0.13	0.13	0.13	0.13	1.31	1.31	1.31	1.31
125% RDF (100% IF)	8.13	8.11	8.12	8.12	0.13	0.14	0.13	0.14	1.32	1.32	1.32	1.32
125% RDF (50:50% N IF:FYM)	8.10	8.10	8.11	8.11	0.13	0.14	0.13	0.14	1.31	1.31	1.31	1.31
SUB PLOT												
75% RDF (100% IF)	8.10	8.10	8.11	8.11	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
100%RDF (100% IF)	8.10	8.10	8.12	8.11	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32
Mean	8.11	8.10	8.11	8.11	0.13	0.13	0.13	0.13	1.32	1.32	1.32	1.32

Effect of kharif treatments.

During 2002-03 there was no change in the E.C. due to the different treatments while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) recorded the highest E.C. (0.14 dS m^{-1}) while, rest of the treatments recorded a similar E.C. of 0.13 dS m^{-1}.

Effect of rabi treatments.

There was no change in the E.C. due to the sub plots during both the years.

4.2.10.1.3 Bulk density.

The mean bulk density of soil after harvest of *senna* was 1.32 gcc^{-1} during both the years. The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

There was not much variation in bulk density due to the various treatments tried.

Effect of rabi treatments.

There was not much variation in bulk density due to the various treatments tried.

4.2.10.2 Chemical properties of soil.

The data regarding organic carbon, total nitrogen and C:N ratio of soil after harvest of *isabgol* as influenced by different treatments are presented in Table 77. The data regarding available nitrogen, available phosphorus and available potassium are presented in Table 78, 79 and 80, respectively.

4.2.10.2.1 Organic carbon.

The mean organic carbon of soil after harvest of *isabgol* was 0.512% during both the years. There was no change from the initial value of organic carbon of the respective years during both the years.

The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest organic carbon (0.515 and 0.518%) during both the years.

Effect of rabi treatments.

An application of 100% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer) recorded a similar value (0.512%) of organic carbon during 2002-03 while, during 2003-04 an application of 100% RDF (100% inorganic fertilizer) recorded the highest organic carbon (0.512%).

Table 77. Mean organic carbon (%), total nitrogen (%) and Carbon:Nitrogen Ratio of soil after harvest of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Organic carbon (%)				Total nitrogen (%)				C:N Ratio			
	Initial		After harvest		Initial		After harvest		Initial		After harvest	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT												
50% RDF (100% IF)	0.509	0.506	0.508	0.505	0.0456	0.0455	0.0455	0.0454	11.16	11.12	11.17	11.12
50% RDF (50:50% N IF:FYM)	0.510	0.508	0.509	0.507	0.0456	0.0455	0.0455	0.0454	11.18	11.17	11.19	11.17
75% RDF (100% IF)	0.511	0.510	0.511	0.509	0.0457	0.0457	0.0456	0.0456	11.18	11.16	11.21	11.16
75% RDF (50:50% N IF:FYM)	0.513	0.513	0.513	0.513	0.0459	0.0460	0.0459	0.0460	11.18	11.15	11.18	11.15
100% RDF (100% IF)	0.513	0.514	0.513	0.514	0.0460	0.0463	0.0461	0.0464	11.15	11.10	11.13	11.08
100% RDF (50:50% N IF:FYM)	0.514	0.515	0.514	0.515	0.0461	0.0463	0.0462	0.0464	11.15	11.12	11.13	11.10
125% RDF (100% IF)	0.514	0.515	0.514	0.515	0.0461	0.0464	0.0462	0.0465	11.15	11.10	11.13	11.08
125% RDF (50:50% N IF:FYM)	0.515	0.518	0.515	0.518	0.0462	0.0465	0.0463	0.0466	11.15	11.14	11.12	11.12
SUB PLOT												
75% RDF (100% IF)	0.512	0.511	0.512	0.511	0.0459	0.0458	0.0459	0.0458	11.16	11.16	11.16	11.16
100%RDF (100% IF)	0.513	0.512	0.512	0.512	0.0460	0.0459	0.0460	0.0462	11.15	11.16	11.15	11.15
Mean	0.512	0.512	0.512	0.512	0.0459	0.0460	0.0459	0.0460	11.16	11.13	11.16	11.12

4.2.10.2.2 Total nitrogen.

The mean total nitrogen of soil after harvest of *isabgol* was 0.0459 and 0.0460% during 2002-03 and 2003-04, respectively. There was no change from the initial value of total nitrogen of the respective years during both the years.

The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest total nitrogen (0.0463 and 0.0466% during 2002-03 and 2003-04, respectively).

Effect of rabi treatments.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest (0.0460 and 0.0462% during 2002-03 and 2003-04, respectively).

4.2.10.2.3 C:N Ratio.

The mean C:N Ratio of soil after harvest of *isabgol* was 11.16 and 11.12 during 2002-03 and 2003-04, respectively.

The data was not statistically analyzed and the inferences are based on mean values only.

Effect of kharif treatments.

An application of 75% RDF (100% inorganic fertilizer) recorded the highest C:N Ratio (11.21) during 2002-03 while, during 2003-04 an application of 50% RDF (50% N through urea and 50% N through FYM) recorded the highest C:N Ratio (11.17).

Effect of rabi treatments.

An application of 75% RDF (100% inorganic fertilizer) recorded the highest C:N Ratio (11.16) during both the years.

4.2.10.2.4 Available nitrogen.

The mean available nitrogen of soil after harvest of *isabgol* was 205.13 and 200.88 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean change in the available nitrogen from the initial value was -0.15 and -0.13 kg ha^{-1} during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the available nitrogen of soil during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available nitrogen (221.85 and 234.77 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest positive change in available nitrogen (+1.74 and +2.12 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 75% RDF (100% inorganic fertilizer) recorded the highest negative change in available nitrogen (-1.80 kg ha^{-1}) during 2002-03 while, during 2003-04 an application of 50% RDF (100% inorganic fertilizer) recorded the highest negative change in available nitrogen (-1.79 kg ha^{-1}).

Table 78. Balance sheet of mean available nitrogen (kg ha^{-1}) of soil after harvest of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil nitrogen		Nitrogen added		Total soil nitrogen		Nitrogen in soil after harvest		Balance of nitrogen in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	188.94	168.28	43.75	43.75	232.69	212.03	187.26	166.49	- 1.68	- 1.79
50% RDF (50:50% N IF:FYM)	191.90	171.15	43.75	43.75	235.65	214.90	190.98	170.38	- 0.92	- 0.77
75% RDF (100% IF)	199.87	188.54	43.75	43.75	243.62	232.29	198.07	186.98	- 1.80	- 1.56
75% RDF (50:50% N IF:FYM)	201.24	192.52	43.75	43.75	244.99	236.27	201.12	191.78	- 0.12	- 0.74
100% RDF (100% IF)	210.45	209.63	43.75	43.75	254.20	253.38	209.32	208.34	- 1.13	- 1.29
100% RDF (50:50% N IF:FYM)	212.54	217.15	43.75	43.75	256.29	260.90	214.12	218.48	+ 1.58	+ 1.33
125% RDF (100% IF)	217.12	228.15	43.75	43.75	260.87	271.90	218.29	229.81	+ 1.17	+ 1.66
125% RDF (50:50% N IF:FYM)	220.11	232.65	43.75	43.75	263.86	276.40	221.85	234.77	+ 1.74	+ 2.12
S.E. ±	–	–	–	–	–	–	1.25	3.12	–	–
C.D. at 5%	–	–	–	–	–	–	3.79	9.46	–	–
SUB PLOT										
75% RDF (100% IF)	205.27	201.01	37.50	37.50	242.77	238.51	202.55	197.51	- 2.72	- 3.50
100%RDF (100% IF)	205.27	201.01	50.00	50.00	255.27	251.01	206.78	204.25	+ 1.51	+ 3.24
S.E. ±	–	–	–	–	–	–	0.51	1.02	–	–
C.D. at 5%	–	–	–	–	–	–	1.53	3.06	–	–
Interaction	–	–	–	–	–	–	N.S.	N.S.	–	–
Mean	205.27	201.01	43.75	43.75	249.02	244.76	205.13	200.88	- 0.15	- 0.13

Effect of rabi treatments.

The rabi treatments significantly affected the available nitrogen of soil during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest available nitrogen (206.78 and 204.25 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer).

An application of 100% RDF (100% inorganic fertilizer) recorded a positive change in available nitrogen (+1.51 and +3.24 kg ha^{-1} during 2002-03 and

2003-04, respectively). An application of 75% RDF (100% inorganic fertilizer) recorded a negative change in available nitrogen (-2.72 and -3.50 kg ha^{-1} during 2002-03 and 2003-04, respectively).

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.10.2.5 Available phosphorus.

The mean available phosphorus of soil after harvest of *isabgol* was 25.19 and 25.67 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean change in the available phosphorus from the initial value was +0.05 and +0.11 kg ha^{-1} during 2002-03 and 2003-04, respectively.

Table 79. Balance sheet of mean available phosphorus (kg ha^{-1}) of soil after harvest of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil phosphorus		Phosphorus added		Total soil phosphorus		Phosphorus in soil after harvest		Balance of phosphorus in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	23.83	20.82	21.88	21.88	45.71	42.70	21.66	19.65	-2.17	-1.17
50% RDF (50:50% N IF:FYM)	24.50	22.87	21.88	21.88	46.38	44.75	23.07	21.84	-1.43	-1.03
75% RDF (100% IF)	24.06	23.12	21.88	21.88	45.94	45.00	23.60	22.27	-0.46	-0.85
75% RDF (50:50% N IF:FYM)	25.11	25.04	21.88	21.88	46.99	46.92	25.62	25.24	+0.51	+0.20
100% RDF (100% IF)	25.75	27.27	21.88	21.88	47.63	49.15	26.39	27.75	+0.64	+0.48
100% RDF (50:50% N IF:FYM)	25.96	28.58	21.88	21.88	47.84	50.46	27.03	29.00	+1.07	+0.42
125% RDF (100% IF)	25.82	27.83	21.88	21.88	47.70	49.71	26.74	29.04	+0.92	+1.21
125% RDF (50:50% N IF:FYM)	26.12	29.00	21.88	21.88	48.00	50.88	27.44	30.61	+1.32	+1.61
S.E. ±	–	–	–	–	–	–	0.60	0.84	–	–
C.D. at 5%	–	–	–	–	–	–	1.82	2.55	–	–
SUB PLOT										
75% RDF (100% IF)	25.27	25.57	18.75	18.75	44.02	44.02	24.65	25.44	-0.62	-0.13
100%RDF (100% IF)	25.27	25.57	25.00	25.00	50.27	50.57	25.89	25.91	+0.62	+0.34
S.E. ±	–	–	–	–	–	–	0.08	0.08	–	–
C.D. at 5%	–	–	–	–	–	–	0.24	0.24	–	–
Interaction	–	–	–	–	–	–	N.S.	N.S.	–	–
Mean	25.14	25.57	21.88	21.88	47.02	47.45	25.19	25.67	0.05	0.11

Effect of kharif treatments.

The kharif treatments significantly affected the available phosphorus of soil during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available phosphorus (27.44 and 30.61 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N

through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM) during 2002-03 while, during 2003-04 it was at par with an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest positive change in available phosphorus (+1.32 and +1.61 kg ha^{-1} during 2002-03 and 2003-04, respectively).

An application of 50% RDF (100% inorganic fertilizer) recorded the highest negative change in available phosphorus (-2.17 and -1.17 kg ha^{-1} during 2002-03 and 2003-04, respectively).

Effect of rabi treatments.

The rabi treatments significantly affected the available phosphorus of soil during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest available phosphorus (25.89 and 25.91 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer).

An application of 100% RDF (100% inorganic fertilizer) recorded a positive change in available phosphorus (+0.62 and +0.34 kg ha^{-1} during 2002-03 and 2003-04, respectively). An application of 75% RDF (100% inorganic fertilizer) recorded a negative change in available phosphorus (-0.62 and -0.13 kg ha^{-1} during 2002-03 and 2003-04, respectively) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.10.2.6 Available potassium.

The mean available potassium of soil after harvest of *isabgol* was 466.21 and 456.82 kg ha^{-1} during 2002-03 and 2003-04, respectively. The mean change in the available potassium from the initial value was -8.75 and -7.60 kg ha^{-1} during 2002-03 and 2003-04, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the available potassium of soil during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest available potassium (482.80 and 488.33 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through

during 2002-03 while, during 2003-04 it was at par with an application of 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM) and significantly superior to rest of the treatments during both the years.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest negative change in available potassium (-13.25 and -10.30 kg ha^{-1} during 2002-03 and 2003-04, respectively).

Table 80. Balance sheet of mean available potassium (kg ha^{-1}) of soil after harvest of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Initial soil potassium		Potassium added		Total soil potassium		Potassium in soil after harvest		Balance of potassium in soil	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
MAIN PLOT										
50% RDF (100% IF)	464.52	445.23	–	–	464.52	445.23	457.35	437.63	-7.17	-7.60
50% RDF (50:50% N IF:FYM)	483.70	482.67	–	–	483.70	482.67	477.64	477.66	-6.06	-5.01
75% RDF (100% IF)	463.24	442.81	–	–	463.24	442.81	456.51	436.48	-6.73	-6.33
75% RDF (50:50% N IF:FYM)	485.28	490.04	–	–	485.28	490.04	479.35	485.39	-5.93	-4.65
100% RDF (100% IF)	459.65	434.38	–	–	459.65	434.38	451.18	426.56	-8.47	-7.82
100% RDF (50:50% N IF:FYM)	490.36	496.11	–	–	490.36	496.11	479.66	486.43	-10.70	-9.68
125% RDF (100% IF)	456.92	425.52	–	–	456.92	425.52	445.20	416.10	-11.72	-9.42
125% RDF (50:50% N IF:FYM)	496.05	498.63	–	–	496.05	498.63	482.80	488.33	-13.25	-10.30
S.E. ±	–	–	–	–	–	–	1.71	2.15	–	–
C.D. at 5%	–	–	–	–	–	–	5.22	6.52	–	–
SUB PLOT										
75% RDF (100% IF)	474.97	464.49	–	–	474.97	464.49	465.76	455.20	-9.21	-9.29
100%RDF (100% IF)	474.97	464.49	–	–	474.97	464.49	465.78	458.45	-9.19	-6.04
S.E. ±	–	–	–	–	–	–	0.03	0.07	–	–
C.D. at 5%	–	–	–	–	–	–	N.S.	0.21	–	–
Interaction	–	–	–	–	–	–	N.S.	N.S.	–	–
Mean	474.97	464.42	–	–	474.97	464.42	466.21	456.82	-8.75	-7.60

Effect of rabi treatments.

The rabi treatments significantly affected the available potassium of soil during both the years.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest available potassium (465.78 and 458.45 kg ha^{-1} during 2002-03 and 2003-04, respectively). It was found to be at par with an application of 75% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 it was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer).

An application of 75% RDF (100% inorganic fertilizer) recorded highest negative change in available potassium (-9.21 and -9.29 kg ha^{-1} during 2002-03 and 2003-04, respectively).

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years.

4.2.11 Economics.

The data regarding gross monetary returns, cost of cultivation, net monetary returns ha^{-1} and Benefit:Cost Ratio of *isabgol* as influenced by different treatments are presented in Table 81.

4.2.11.1 Gross monetary returns.

The mean gross monetary returns were Rs. 28,822, 28,866 and 28,845 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the gross monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest gross monetary returns (Rs. 29,615, 29,978 and 29,797 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with rest of the treatments, except to an application of 50% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the gross monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest gross monetary returns (Rs. 29,559, 29,727 and 29,643 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.11.2 Cost of cultivation.

The mean cost of cultivation was Rs. 17,732, 18,353 and 18,043 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the cost of cultivation ha^{-1} during both the years and on pooled mean basis.

Table 81. Mean gross monetary returns, cost of cultivation, net monetary returns (Rs ha^{-1}), Benefit:Cost Ratio and pooled mean of *isabgol* as influenced by different treatments during 2002-03 and 2003-04.

Treatment	Gross monetary returns (Rs ha^{-1})			Cost of cultivation (Rs ha^{-1})			Net monetary returns (Rs ha^{-1})			Benefit: Cost ratio		
	02-03	03-04	Pooled Mean	02-03	03-04	Pooled Mean	02-03	03-04	Pooled Mean	02-03	03-04	Pooled Mean
MAIN PLOT												
50% RDF (100% IF)	27828	27615	27722	17241	17814	17528	10587	9801	10194	1.61	1.55	1.58
50% RDF (50:50% N IF:FYM)	28004	27803	27904	17274	17849	17562	10730	9954	10342	1.62	1.56	1.59
75% RDF (100% IF)	28377	28156	28267	17344	17915	17630	11033	10241	10637	1.64	1.57	1.61
75% RDF (50:50% N IF:FYM)	28662	28455	28559	17397	17971	17684	11265	10484	10875	1.65	1.58	1.62
100% RDF (100% IF)	29233	29472	29353	17504	18162	17833	11729	11310	11520	1.67	1.62	1.65
100% RDF (50:50% N IF:FYM)	29351	29614	29483	18014	18676	18345	11337	10938	11138	1.63	1.59	1.61
125% RDF (100% IF)	29505	29837	29671	18531	19206	18869	10974	10631	10803	1.59	1.55	1.57
125% RDF (50:50% N IF:FYM)	29615	29978	29797	18552	19232	18892	11063	10746	10905	1.60	1.56	1.58
S.E. ±	548.22	724.61	640.77	109.25	144.85	126.00	474.97	629.75	547.78	0.03	0.03	0.03
C.D. at 5%	1663	2198	1943	331	439	382	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SUB-PLOT												
75% RDF (100% IF)	28085	28005	28045	17394	17984	17689	10690	10021	10356	1.62	1.56	1.59
100%RDF (100% IF)	29559	29727	29643	18071	18722	18397	11488	11005	11247	1.64	1.59	1.62
S.E. ±	197.99	208.14	171.80	37.02	38.92	32.13	160.96	169.22	139.68	0.008	0.008	0.008
C.D. at 5%	594	624	515	111	117	96	483	507	418.72	N.S.	0.02	0.02
Interaction	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. %	5.94	6.29	6.15	4.76	5.00	4.88	9.08	12.20	10.14	4.18	4.76	4.31
Mean	28822	28866	28845	17732	18353	18043	11090	10513	10802	1.63	1.57	1.60

* Price of isabgol seed: Rs. 3000 q^{-1} and straw: Rs. 50 q^{-1}

An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest cost of cultivation (Rs. 18,552, 19,232 and 18,892 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the cost of cultivation ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest cost of cultivation (Rs. 18,071, 18,722 and 18,397 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.11.3 Net monetary returns.

The mean net monetary returns were Rs. 11,090, 10,513 and 10,802 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly influence the net monetary returns ha^{-1} during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the net monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest net monetary returns (Rs. 11,488, 11,005 and 11,247 ha^{-1} during 2002-03 and 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.11.4 Benefit:Cost Ratio.

The mean Benefit:Cost Ratio was 1.63, 1.57 and 1.60 during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments did not significantly influence the Benefit:Cost Ratio during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the Benefit:Cost Ratio during 2002-03 and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest Benefit:Cost Ratio (1.64, 1.59 and 1.62 during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 75% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 and on pooled mean basis it was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer).

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.2.12 Correlation.

Correlation study was carried out on some of the characters observed. The data regarding the correlation study of *isabgol* are presented in Table 82 and 83.

4.2.12.1 Plant height plant^{-1}.

Highly significant relation between number of productive tillers plant^{-1}, total dry matter plant^{-1}, number of productive spikes plant^{-1}, length of spike, girth of spike, thousand seed weight and weight of seed plant^{-1} during both the years, with number of seeds spike^{-1} and number of seeds plant^{-1} during 2003-04 only. Significant relation between number of seeds spike^{-1}, weight of spike^{-1} during 2002-03 while, during 2003-04 with weight of seeds spike^{-1} only. Non-significant relation between number of seeds plant^{-1} during 2002-03.

4.2.12.2 Number of productive tillers plant^{-1}.

Highly significant relation between total dry matter plant^{-1}, number of productive spikes plant^{-1}, length of spike, girth of spike, thousand seed weight, weight of seeds plant^{-1} during both the years while, during 2003-04 between number of seeds spike^{-1}, weight of seeds spike^{-1} and number of seeds plant^{-1}. Significant relation between number of seeds spike^{-1}, weight of seeds spike^{-1} during 2002-03 only. Non-significant relation between number of seeds plant^{-1} during 2002-03 only.

Table 82: Correlation study of *isabgol* during 2002-2003 (1st Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.980**	0.991**	0.958**	0.984**	0.943**	0.820*	0.749*	0.651	0.985**	0.997**
No .of productive tillers plant^{-1}	—	0.976**	0.938**	0.977**	0.971**	0.787*	0.834*	0.544	0.970**	0.980**
Total dry matter plant^{-1}		—	0.951**	0.987**	0.955**	0.860**	0.736*	0.620	0.980**	0.988**
No. of productive spikes plant^{-1}			—	0.975**	0.864**	0.797*	0.604	0.521	0.939**	0.936**
Length of spike				—	0.939**	0.875**	0.703	0.598	0.983**	0.987**
Girth of spike					—	0.799*	0.844**	0.511	0.936**	0.978**
No. of seeds spike^{-1}						—	0.465	0.681	0.862**	0.872**
Wt. of seeds spike^{-1}							—	0.375	0.737**	0.754*
No. of seeds plant^{-1}								—	0.701	0.579
1000-seed weight									—	0.978**
Wt. of seeds plant^{-1}										—

Table 83: Correlation study of *isabgol* during 2003-2004 (2nd Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.985**	0.985**	0.983**	0.991**	0.821**	0.883**	0.802*	0.995**	0.961**	0.984**
No .of productive tillers plant^{-1}	—	0.988**	0.952**	0.951**	0.889**	0.879**	0.846**	0.974**	0.974**	0.981**
Total dry matter plant^{-1}		—	0.940**	0.975**	0.837**	0.925**	0.866**	0.984**	0.957**	0.976**
No. of productive spikes plant^{-1}			—	0.983**	0.736*	0.810*	0.709*	0.976**	0.929**	0.964**
Length of spike				—	0.817*	0.897**	0.801*	0.994**	0.951**	0.991**
Girth of spike					—	0.758*	0.828*	0.802*	0.929**	0.882**
No. of seeds spike^{-1}						—	0.857**	0.916**	0.877**	0.905**
Wt. of seeds spike^{-1}							—	0.796*	0.853**	0.851**
No. of seeds plant^{-1}								—	0.952**	0.983**
1000-seed weight									—	0.980**
Wt. of seeds plant^{-1}										—

Note: *, **: Significant at 5% and 1% level respectively.

4.2.12.3 Total dry matter plant^{-1}.

Highly significant relation between number of productive spikes plant^{-1}, length of spike, girth of spike, number of seeds spike^{-1}, thousand seed weight, weight of seeds plant^{-1} during both the years, with weight of seeds spike^{-1}, number of seeds plant^{-1} during 2003-04 only. Significant relation between weight of seeds spike^{-1} and non-significant relation between number of seeds plant^{-1} during 2002-03.

4.2.12.4 Number of productive spikes plant^{-1}.

Highly significant relation between length of spike, thousand seed weight, weight of seeds plant^{-1} during both the years, with girth of spike during 2002-03 while, during 2003-04 with number of seeds plant^{-1}. Significant relation between number of seeds spike^{-1} during both the years while, during 2003-04 with girth of spike, weight of seeds spike^{-1}. Non-significant relation between weight of seeds spike^{-1}, number of seeds plant^{-1} during 2002-03 only.

4.2.12.5 Length of spike.

Highly significant relation between number of seeds spike^{-1}, thousand seed, weight of seeds plant^{-1} during both the years, between girth of spike during 2002-03 while, during 2003-04 between number of seeds plant^{-1}. Significant relation between girth of spike, weight of seeds spike^{-1} during 2003-04. Non-significant relation between weight of seeds spike^{-1} and number of seeds plant^{-1} during 2002-03.

4.2.12.6 Girth of spike.

Highly significant relation between thousand seed weight, weight of seeds plant^{-1} during both the years, between weight of seeds spike^{-1} 2002-03 only. Significant relation between number of seeds spike^{-1}, weight of seeds spike^{-1} during both the years, between number of seeds plant^{-1} during 2003-04. Non-significant relation between number of seeds plant^{-1} during 2002-03.

4.2.12.7 Number of seeds spike^{-1}.

Highly significant relation between thousand seed weight and weight of seed plant^{-1} during both the years, between weight of seeds spike^{-1}, number of seeds plant^{-1} during 2003-04. Significant relation between weight of seeds spike^{-1}, number of seeds plant^{-1} during 2003-04 only. Non-significant relation between weight of seeds spike^{-1} and number of seeds plant^{-1} during 2002-03 only.

4.2.12.8 Weight of seeds spike^{-1}.

Highly significant between thousand seed weight during both the years, between weight of seeds plant^{-1} during 2003-04. Significant relation between

weight of seeds spike^{-1} during 2002-03, with number of seeds plant^{-1} during 2003-04. Non-significant relation between number of seeds plant^{-1} during 2002-03.

4.2.12.9 Number of seeds plant^{-1}.

Highly significant relation between thousand seed weight and weight of seeds plant^{-1} during 2003-04. Non-significant relation between the two characters during 2002-03.

4.2.12.10 Thousand seed weight.

Highly significant relation between weight of seeds plant^{-1} during both the years.

4.2.13 Regression.

Regression study was carried out on some of the characters observed. The data regarding the regression study of *isabgol* are presented in Table 84, 85, 86, 87, 88 and 89.

4.2.13.1 Plant height plant^{-1}.

Highly significant association with number of productive tillers plant^{-1}, total dry matter plant^{-1}, number of productive spikes plant^{-1}, length of spike, number of seeds spike^{-1}, thousand seed weight, weight of seed plant^{-1} during both the years, with girth of spike during 2002-03 only. Significant association with weight of seeds spike^{-1} during 2002-03 with girth of spike, weight of seeds spike^{-1} during 2003-04. Non-significant association with number of seeds plant^{-1} during 2002-03.

4.2.13.2 Number of productive tillers plant^{-1}.

Highly significant association with total dry matter plant^{-1}, number of productive spikes plant^{-1}, length of spike, girth of spike, thousand seed weight, weight of seeds plant^{-1} during both the years, with number of seeds spike^{-1}, weight of seeds spike^{-1}, number of seeds plant^{-1} during 2003-04 only. Significant association with number of seeds spike^{-1} and weight of seeds spike^{-1} during 2002-03 only. Non-significant association with number of seeds plant^{-1} during 2002-03 only.

4.2.13.3 Total dry matter plant^{-1}.

Highly significant association with number of productive spikes plant^{-1}, length of spike, girth of spike, number of seeds spike, thousand seed weight and weight of seed plant^{-1} during both the years, with weight of seeds spike^{-1} and number of seeds plant^{-1} during 2003-04 only. Significant association with weight of seeds spike^{-1} during 2002-03 only. Non-significant association with number of seeds plant^{-1} during 2002-03 only.

Table 84: Regression study (b co-efficient) of *isabgol* during 2002-2003 (1st Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.432 **	0.459 **	0.989 **	0.249 **	0.236 **	3.121 **	0.011 *	78.213	0.174 **	0.184 **
No .of productive tillers plant^{-1}		1.027 **	2.198 **	0.560 **	0.551 **	6.799 *	0.027 *	148.588	0.389 **	0.420 **
Total dry matter plant^{-1}			2.117 **	0.538 **	0.514 **	7.065 **	0.023 *	160.797	0.374 **	0.402 **
No. of productive spikes plant^{-1}				0.239 **	0.209 **	2.938 *	0.008	60.709	0.161 **	0.171 **
Length of spike				_	0.928 **	13.175 **	0.040	284.294	0.688 **	0.736 **
Girth of spike					_	0.052 *	14.833 **	0.001	1.322 **	1.295 **
No. of seeds spike^{-1}							0.002	21.519	0.040 **	0.043 **
Wt. of seeds spike^{-1}								3167.667	9.167 *	10.000 *
No. of seeds plant^{-1}								_	0.001	0.001
1000-seed weight										1.044
Wt. of seeds plant^{-1}										_

Table 85: Regression study (b co-efficient) of *isabgol* during 2003-2004 (2nd Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.350 **	0.387 **	0.869 **	0.243 **	0.154 *	2.651 **	0.008 *	102.510 **	0.149 **	0.157 **
No .of productive tillers plant^{-1}	_	1.093 **	2.367 **	0.572 **	0.470 **	7.424 **	0.024 **	282.227 **	0.425 **	0.440 **
Total dry matter plant^{-1}			2.113 **	0.609 **	0.400 **	7.064 **	0.022 **	257.697 **	0.377 **	0.396 **
No. of productive spikes plant^{-1}				0.273 **	0.175 *	2.751 **	0.008 *	113.710 **	0.163 **	0.174 **
Length of spike				_	0.626 *	10.973 **	0.033 *	417.128 **	0.601 **	0.643 **
Girth of spike					_	0.047 *	15.467 *	0.001 *	1.126 **	1.042 **
No. of seeds spike^{-1}							0.003 **	31.416 **	0.045 **	0.048 **
Wt. of seeds spike^{-1}								8144.067 *	13.133 **	13.467 **
No. of seeds plant^{-1}									0.001 **	0.002
1000-seed weight										1.006
Wt. of seeds plant^{-1}										_

Note: *, **: Significant at 5% and 1% level respectively.

Table 86: Regression study (a co-efficient) of *isabgol* during 2002-2003 (1st Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	-1.178	1.408	3.693	0.305	-0.345	29.230	-0.037	131.153	-0.686	-0.662
No .of productive tillers plant^{-1}	—	2.820	6.803	1.058	0.276	39.663	-0.014	490.881	-0.150	-0.133
Total dry matter plant^{-1}		—	0.939	-0.425	-1.068	17.675	-0.063	-37.311	-1.183	-1.235
No. of productive spikes plant^{-1}				-0.410	-0.731	21.213	-0.026	146.152	-1.087	-1.098
Length of spike					-0.564	23.102	-0.035	141.988	-0.861	-0.877
Girth of spike					—	70.175	-40.850	1160.825	-2.046	-1.815
No. of seeds spike^{-1}						—	-0.033	-352.362	-1.209	-1.263
Wt. of seeds spike^{-1}								820.303	0.618	0.685
No. of seeds plant^{-1}									0.442	0.599
1000-seed weight									—	0.085
Wt. of seeds plant^{-1}										

Table 87: Regression study (a co-efficient) of *isabgol* during 2003-2004 (2ndYear).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	-0.119	2.333	5.211	0.391	0.747	34.923	0.001	-186.917	-0.357	-0.304
No .of productive tillers plant^{-1}		2.522	6.058	1.024	0.665	36.502	-0.001	-104.063	-0.303	-0.212
Total dry matter plant^{-1}		—	0.986	-0.932	-0.196	17.345	-0.057	-751.629	-1.196	-1.179
No. of productive spikes plant^{-1}			—	-0.963	-0.144	23.940	-0.027	-734.135	-1.114	-1.140
Length of spike				—	0.527	30.420	-0.012	-335.180	-0.554	-0.546
Girth of spike					—	69.779	-42.892	1165.956	-1.521	-1.129
No. of seeds spike^{-1}						—	-0.103	-1030.33	-1.537	-1.588
Wt. of seeds spike^{-1}							—	300.651	0.213	0.336
No. of seeds plant^{-1}									0.442	-0.564
1000-seed weight									—	0.149
Wt. of seeds plant^{-1}										

Table 88: Regression study (r^2) of *isabgol* during 2002-2003 (1st Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.960	0.980	0.917	0.967	0.912	0.672	0.560	0.423	0.970	0.953
No .of productive tillers plant^{-1}	—	0.948	0.878	0.953	0.949	0.618	0.695	0.296	0.941	0.960
Total dry matter plant^{-1}		—	0.895	0.967	0.924	0.730	0.545	0.384	0.956	0.972
No. of productive spikes plant^{-1}				0.950	0.755	0.635	0.364	0.271	0.882	0.875
Length of spike				—	0.893	0.765	0.494	0.357	0.966	0.973
Girth of spike					—	0.654	0.713	0.317	0.904	0.962
No. of seeds spike^{-1}						—	0.216	0.464	0.742	0.759
Wt. of seeds spike^{-1}								0.140	0.543	0.568
No. of seeds plant^{-1}								—	0.490	0.335
1000-seed weight									—	0.956
Wt. of seeds plant^{-1}										—

Table 89: Regression study (r^2) of *isabgol* during 2003-2004 (2nd Year).

	No. of productive tillers plant^{-1}	Total dry matter plant^{-1}	No. of productive spikes plant^{-1}	Length of spike	Girth of spike	No. of seeds spike^{-1}	Wt. of seeds spike^{-1}	No. of seeds plant^{-1}	1000-seed weight	Wt. of seeds plant^{-1}
Plant height plant^{-1}	0.970	0.970	0.952	0.982	0.674	0.779	0.642	0.989	0.924	0.968
No .of productive tillers plant^{-1}	—	0.975	0.876	0.942	0.790	0.772	0.715	0.947	0.948	0.961
Total dry matter plant^{-1}		—	0.870	0.950	0.699	0.855	0.749	0.966	0.915	0.953
No. of productive spikes plant^{-1}				0.955	0.541	0.641	0.471	0.942	0.814	0.902
Length of spike				—	0.668	0.805	0.641	0.989	0.904	0.981
Girth of spike					—	0.574	0.685	0.642	0.862	0.778
No. of seeds spike^{-1}							0.734	0.838	0.768	0.818
Wt. of seeds spike^{-1}							—	0.632	0.726	0.724
No. of seeds plant^{-1}								—	0.904	0.966
1000-seed weight									—	0.959
Wt. of seeds plant^{-1}										—

4.2.13.4 Number of productive spikes plant^{-1}.

Highly significant association with length of spike, girth of spike, thousand seed weight and weight of seed plant^{-1} during both the years, with number of seeds plant^{-1} during 2003-04. Significant association with number of seeds spike^{-1} during 2002-03 with girth of spike and weight of seeds spike^{-1} during 2003-04. Non-significant association with weight of seeds spike^{-1} and number of seeds plant^{-1} during 2002-03.

4.2.13.5 Length of spike.

Highly significant association with girth of spike, number of seeds spike^{-1}, thousand seed weight and weight of seeds plant^{-1} during both the years, with number of seeds plant^{-1} during 2003-04. Significant association with girth of spike and weight of seeds spike^{-1} during 2003-04. Non-significant association with weight of seeds spike^{-1} and number of seeds plant^{-1} during 2002-03.

4.2.13.6 Girth of spike.

Highly significant association with thousand seed weight and weight of seeds plant^{-1} during both the years, with weight of seeds spike^{-1} during 2002-03. Significant association with number of seeds spike^{-1} during both the years, with weight of seeds plant^{-1} and number of seeds plant^{-1} during 2003-04. Non-significant association with number of seeds plant^{-1} during 2002-03.

4.2.13.7 Number of seeds spike^{-1}.

Highly significant association with thousand seed weight and weight of seeds plant^{-1} during both the years, with weight of seeds spike^{-1} and number of seeds plant^{-1} during 2003-04. Non-significant association between weight of seeds spike^{-1} and number of seeds plant^{-1} during 2002-03.

4.2.13.8 Weight of seeds spike^{-1}.

Highly significant association with thousand seed weight and weight of seeds plant^{-1} during 2003-04. Significant association with thousand seed weight and weight of seeds plant^{-1} during 2002-03, with number of seeds plant^{-1} during 2003-04.

4.2.13.9 Number of seeds plant^{-1}.

Highly significant association with thousand seed weight during 2003-04 only. Non-significant association with thousand seed weight and weight of seeds plant^{-1} during 2002-03, with weight of seeds plant^{-1} during 2003-04.

4.2.13.10 Thousand seed weight.

Non-significant association with weight of seeds plant^{-1} during both the years.

4.3 Soil properties after two years of cropping.

The physical and chemical properties of soil after two years of *senna-isabgol* cropping sequence are presented.

4.3.1 Physical properties of soil.

The physical properties of soil after two years of *senna-isabgol* cropping sequence are presented in Table 90.

4.3.1.1 pH.

Effect of kharif treatments.

The pH showed a negative change for an application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). While, no change was observed for an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (100% inorganic fertilizer). The maximum (-0.02) negative change was observed in case of an application of 50% RDF (50% N through urea and 50% N through FYM), and 50% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The pH showed negative change (-0.01) for an application of 100% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer).

4.3.1.2 Electrical conductivity.

Effect of kharif treatments.

The E.C. showed a positive change for all the treatments applied. The maximum positive change (+0.02 dS m^{-1}) was observed in an application of 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) while, rest of the treatments recorded a similar positive change of +0.01 dS m^{-1}.

Effect of rabi treatments.

The E.C. showed positive change (+0.01) for an application of 100% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer).

4.3.1.3 Bulk density.

Effect of kharif treatments.

The bulk density showed negative change for an application of 125% RDF (50% N through urea and 50% N through FYM) and 100% RDF (50% N through urea and 50% N through FYM). While, no change was observed for an

Table 90. Balance sheet of mean pH, electrical conductivity (dS m^{-1}) and bulk density (g cc^{-1}) of soil after two years of *senna – isabgol* cropping sequence as influenced by different treatments during 2002-04.

Treatment	After harvest						Mean			Change over initial						Mean change		
	SUB PLOT									SUB PLOT								
	75% RDF			100% RDF						75% RDF			100% RDF					
	pH	E.C.	B.D.	pH	E.C.	B.D.	pH	E.C.	B.D.	pH	E.C.	B.D.	pH	E.C.	B.D.	pH	E.C.	B.D.
MAIN PLOT																		
50% RDF (100% IF)	8.09	0.13	1.32	8.11	0.13	1.32	8.10	0.13	1.32	-0.03	+ 0.01	0.00	-0.01	+ 0.01	0.00	-0.02	+ 0.01	0.00
50% RDF (50:50% N IF:FYM)	8.10	0.12	1.32	8.10	0.14	1.32	8.10	0.13	1.32	-0.02	0.00	0.00	-0.02	+ 0.02	0.00	-0.02	+ 0.01	0.00
75% RDF (100% IF)	8.10	0.13	1.32	8.12	0.13	1.32	8.11	0.13	1.32	-0.02	+ 0.01	0.00	0.00	+ 0.01	0.00	-0.01	+ 0.01	0.00
75% RDF (50:50% N IF:FYM)	8.12	0.12	1.32	8.10	0.13	1.32	8.11	0.13	1.32	0.00	0.00	0.00	-0.02	+ 0.01	0.00	-0.01	+ 0.01	0.00
100% RDF (100% IF)	8.11	0.13	1.32	8.13	0.13	1.32	8.12	0.13	1.32	-0.01	+ 0.01	0.00	+ 0.01	+ 0.01	0.00	0.00	+ 0.01	0.00
100% RDF (50:50% N IF:FYM)	8.11	0.13	1.31	8.11	0.13	1.31	8.11	0.13	1.31	0.01	+ 0.01	-0.01	-0.01	+ 0.01	-0.01	-0.01	+ 0.01	-0.01
125% RDF (100% IF)	8.13	0.14	1.32	8.11	0.14	1.32	8.12	0.14	1.32	+ 0.01	+ 0.02	0.00	-0.01	+ 0.02	0.00	0.00	+ 0.02	0.00
125% RDF (50:50% N IF:FYM)	8.11	0.14	1.31	8.11	0.14	1.31	8.11	0.14	1.31	-0.01	+ 0.02	-0.01	-0.01	+ 0.02	-0.01	-0.01	+ 0.02	-0.01
Mean	8.11	0.13	1.32	8.11	0.13	1.32	8.11	0.13	1.32	-0.01	+ 0.01	0.00	-0.01	+ 0.01	0.00	-0.01	- 0.01	0.00

Note: Initial pH, E.C. and bulk density at the start of experiment was 8.12, 0.12 $dSm^{-1}$and 1.32 g cc^{-1}, respectively.

fertilizer), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum (-0.01) negative change was observed in an application of 125% RDF (50% N through urea and 50% N through FYM) and 100% RDF (50% N through urea and 50% N through FYM)

Effect of rabi treatments.

The bulk density showed no change for an application of 100% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer).

4.3.2 Chemical properties of soil.

The data regarding the organic carbon, total nitrogen and Carbon:Nitrogen Ratio of soil after two years of *senna-isabgol* cropping sequence are presented in Table 91. The data regarding the available nitrogen, available phosphorus and available potassium of soil after two years of *senna-isabgol* cropping sequence are presented in Table 92.

4.3.2.1 Organic carbon.

Effect of kharif treatments.

The organic carbon showed positive change for an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM). While, a negative change was observed for an application of 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum positive change (+0.006) was observed in case of 125% RDF (50% N through urea and 50% N through FYM) while, a negative change (- 0.007) was observed in case of 50% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The organic carbon showed no change for an application of 100% RDF (100% inorganic fertilizer) while, for an application of 75% RDF (100% inorganic fertilizer) there was a negative change (-0.001).

4.3.2.2 Total nitrogen.

Effect of kharif treatments.

The total nitrogen showed positive change for an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer) and 75% RDF (50% N through urea and 50% N through FYM).

Table 91. Balance sheet of mean organic carbon (%), total nitrogen (%) and Carbon:Nitrogen Ratio of soil after two years of *senna* - *isabgol* cropping sequence as influenced by different treatments during 2002-04.

Treatment	After harvest						Mean			Change over initial						Mean change		
	SUB PLOT									SUB PLOT								
	75% RDF			100% RDF						75% RDF			100% RDF					
	O.C.	T.N.	C:N	O.C.	T.N.	C:N	O.C.	T.N.	C:N	O.C.	T.N.	C:N	O.C.	T.N.	C:N	O.C.	T.N.	C:N
MAIN PLOT																		
50% RDF (100% IF)	0.504	0.0452	11.15	0.505	0.0455	11.09	0.505	0.0454	11.12	-0.008	-0.0006	-0.03	-0.007	-0.0003	-0.09	-0.007	-0.0004	-0.06
50% RDF (50:50% N IF:FYM)	0.506	0.0453	11.17	0.508	0.0455	11.16	0.507	0.0454	11.17	-0.006	-0.0005	-0.01	-0.004	-0.0003	-0.02	-0.005	-0.0004	-0.01
75% RDF (100% IF)	0.508	0.0455	11.16	0.510	0.0457	11.16	0.509	0.0456	11.16	-0.004	-0.0003	-0.02	-0.002	+ 0.0001	-0.02	-0.003	-0.0002	-0.02
75% RDF (50:50% N IF:FYM)	0.512	0.0457	11.18	0.513	0.0461	11.13	0.513	0.0460	11.15	0.000	0.0001	0.00	+ 0.001	+ 0.0003	-0.05	+ 0.001	+ 0.0002	-0.03
100% RDF (100% IF)	0.512	0.0462	11.08	0.515	0.0465	11.08	0.514	0.0464	11.08	0.000	+ 0.0004	-0.10	+ 0.003	+ 0.0007	-0.10	+ 0.002	+ 0.0006	-0.10
100% RDF (50:50% N IF:FYM)	0.514	0.0462	11.12	0.516	0.0465	11.09	0.515	0.0464	11.10	+ 0.002	+ 0.0004	-0.06	+ 0.004	+ 0.0007	-0.09	+ 0.003	+ 0.0006	-0.08
125% RDF (100% IF)	0.514	0.0462	11.12	0.515	0.0467	11.03	0.515	0.0465	11.08	+ 0.002	+ 0.0004	-0.06	+ 0.003	+ 0.0009	-0.15	+ 0.003	+ 0.0007	-0.10
125% RDF (50:50% N IF:FYM)	0.518	0.0465	11.14	0.518	0.0467	11.09	0.518	0.0466	11.12	+ 0.006	+ 0.0007	-0.04	+ 0.006	+ 0.0009	-0.09	+ 0.006	+ 0.0008	-0.06
Mean	0.511	0.0458	11.16	0.512	0.0462	11.15	0.512	0.0460	11.12	- 0.001	0.0000	-0.04	0.000	+ 0.0004	-0.08	0.000	+ 0.0002	-0.06

Note: Initial O.C.,T.N. and C:N ratio at the start of experiment was 0.512%, 0.0458% and 11.18 , respectively.

inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum positive change (+0.0008) was observed in case of an application of 125% RDF (50% N through urea and 50% N through FYM) while, a negative change (-0.0004) was observed in case of an application of 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The total nitrogen showed a positive change (+ 0.0004) for 100% RDF (100% inorganic fertilizer) while, for an application of 75% RDF (100% inorganic fertilizer) there was no change.

4.3.2.3 C:N Ratio.

Effect of kharif treatments.

There was a reduction in the C:N Ratio of the soil in all the treatments applied. The maximum change (-0.10) was observed in an application of 125% RDF (100% inorganic fertilizer) and 100% RDF (100% inorganic fertilizer) while, the lowest change (-0.01) was observed in an application of 50% RDF (50% N through urea and 50% N through FYM).

Effect of rabi treatments.

The C:N Ratio showed a negative change (-0.04) for 100% RDF (100% inorganic fertilizer) while, for an application of 75% RDF (100% inorganic fertilizer) there was a negative change (-0.08).

4.3.2.4 Available nitrogen.

Effect of kharif treatments.

The available nitrogen showed a positive balance for an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM). While, a negative balance was observed for an application of 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum positive balance (+25.63 kg ha^{-1}) was observed in case of 125% RDF (50% N through urea and 50% N through FYM) while, a maximum negative balance (-42.65 kg ha^{-1}) was observed in case of 50% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The available nitrogen showed a negative balance (-4.89 kg ha^{-1}) for an application of 100% RDF (100% inorganic fertilizer) while, for an application of 75%

Table 92. Balance sheet of mean available nitrogen, available phosphorus and available potassium (kgha^{-1}) of soil after two years of *senna* - *isabgol* cropping sequence as influenced by different treatments during 2002-04.

Treatment	After harvest						Mean			Change over initial						Mean change		
	SUB PLOT									SUB PLOT								
	75% RDF			100% RDF						75% RDF			100% RDF					
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
MAIN PLOT																		
50% RDF (100% IF)	164.12	19.11	434.76	168.86	20.19	440.50	166.49	19.65	437.63	-45.02	-5.83	-43.36	-40.28	-4.75	-37.62	-42.65	-5.29	-40.49
50% RDF (50:50% N IF:FYM)	167.24	21.56	474.86	173.51	22.12	480.45	170.38	21.84	477.66	-41.90	-3.38	-3.26	-35.63	-2.82	+ 2.33	-38.77	-3.10	-0.47
75% RDF (100% IF)	183.77	22.19	434.28	190.18	22.35	438.68	186.98	22.27	436.48	-25.37	-2.75	-43.84	-18.96	-2.59	-39.44	-22.17	-2.67	-41.64
75% RDF (50:50% N IF:FYM)	185.41	25.13	484.44	198.15	25.35	486.34	191.78	25.24	485.39	-23.73	+ 0.19	+ 6.32	-10.99	+ 0.41	+ 8.22	-17.36	+ 0.30	+ 7.27
100% RDF (100% IF)	205.85	27.46	425.44	210.83	28.04	427.67	208.34	27.75	426.56	-3.29	+2.52	-52.68	+ 1.69	+ 3.10	-50.45	-0.80	+ 2.81	-51.57
100% RDF (50:50% N IF:FYM)	216.04	28.88	485.83	220.91	29.12	487.03	218.48	29.00	486.43	+ 6.90	+ 3.94	+ 7.71	+ 11.77	+ 4.18	+ 8.91	+ 9.34	+ 4.06	+ 8.31
125% RDF (100% IF)	226.54	28.72	414.18	233.07	29.35	418.01	229.81	29.04	416.10	+ 17.40	+ 3.78	-63.94	+ 23.93	+ 4.41	-60.11	+ 20.67	+ 4.10	-62.03
125% RDF (50:50% N IF:FYM)	231.07	30.45	487.77	238.47	30.76	488.88	234.77	30.61	488.33	+ 21.93	+ 5.51	+ 9.65	+ 29.33	+ 5.82	+ 10.76	+ 25.63	+ 5.67	+ 10.21
Mean	197.51	25.44	455.20	204.25	25.91	458.45	200.88	25.67	456.82	-11.64	+ 0.50	-22.93	-4.89	+ 0.97	-19.68	-8.26	+ 0.73	-21.30

Note: Initial available N, P and K at the start of experiment was 209.14, 24.94 and 478.12 kgha^{-1}, respectively.

4.3.2.5 Available phosphorus.

Effect of kharif treatments.

The available phosphorus showed a positive balance for an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 100% RDF (100% inorganic fertilizer), 75% RDF (50% N through urea and 50% N through FYM). While, a negative balance was observed for an application of 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum positive balance (+5.67 kg ha^{-1}) was observed in case of an application of 125% RDF (50% N through urea and 50% N through FYM) while, a maximum negative balance (-5.29 kg ha^{-1}) was observed in case of 50% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The available phosphorus showed a positive balance (+0.97 kg ha^{-1}) for an application of 100% RDF (100% inorganic fertilizer) while, for an application of 75% RDF (100% inorganic fertilizer) there was a positive balance (+0.50 kg ha^{-1}).

4.3.2.6 Available potassium.

Effect of kharif treatments.

The available potassium showed a positive balance for an application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM). While, a negative balance was observed for an application of 125% RDF (100% inorganic fertilizer), 100% RDF (100% inorganic fertilizer), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer). The maximum positive balance (+10.21 kg ha^{-1}) was observed in case of an application of 125% RDF (50% N through urea and 50% N through FYM) while, a maximum negative balance (-62.03 kg ha^{-1}) was observed in case of 125% RDF (100% inorganic fertilizer).

Effect of rabi treatments.

The available potassium showed negative balance (-19.68 kg ha^{-1}) for an application of 100% RDF (100% inorganic fertilizer) while, for an application of 75% RDF (100% inorganic fertilizer) there was a negative balance (-22.93 kg ha^{-1}).

4.4 Total ecomomics of cropping sequence.

The data regarding the total gross monetary returns, cost of cultivation, net monetary returns, Benefit:Cost Ratio and pooled mean of *senna-isabgol* cropping sequence are presented in Table 93.

4.4.1 Gross monetary returns.

The mean gross monetary returns were Rs. 1,38,008, 1,38,846 and 1,38,427 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the gross monetary returns ha^{-1} during both the years and on pooled mean basis. An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest gross monetary returns (Rs 1,49,482, 1,53,228 and 1,51,355 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 125% RDF (100% inorganic fertilizer) and significantly superior to rest of the treatments during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the gross monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest gross monetary returns (Rs.1,38,746, 1,39,706 and 1,39,226 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.4.2 Cost of cultivation.

The mean cost of cultivation was Rs. 70,716, 71,658 and 71,187 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the cost of cultivation ha^{-1} during both the years and on pooled mean basis. An application of 125% RDF (50% N through urea and 50% N through FYM) recorded the highest cost of cultivation (Rs.77,544, 79,287 and 78,416 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to rest of the treatments during both the years and on pooled mean basis.

Effect of rabi treatments.

The rabi treatments significantly affected the cost of cultivation ha^{-1} during both the years and on pooled mean basis. An application of 100% RDF (100% inorganic fertilizer) recorded the highest cost of cultivation (Rs. 71,054, 72,027 and 71,541 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to

Table 93. Total mean gross monetary returns, total cost of cultivation, total net monetary returns (Rs ha^{-1}), Benefit:Cost ratio and pooled mean of *senna-isabgol* cropping sequence as influenced by different treatments during 2002-04.

Treatment	Gross monetary returns (Rs. ha^{-1})									Cost of cultivation (Rs. ha^{-1})								
	02-03			03-04			Pooled mean			02-03			03-04			Pooled mean		
	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean
	75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF	
MAIN PLOT																		
50% RDF (100% IF)	122554	124067	123311	120774	121089	120932	121664	122578	122122	64677	65239	64958	64947	65300	65123	64812	65269	65041
50% RDF (50:50% N IF:FYM)	124757	126117	125437	123117	123655	123386	123937	124886	124412	66888	57422	67155	67371	67766	67568	67130	67594	67362
75% RDF (100% IF)	132989	133765	133377	130684	131928	131306	131836	132847	132342	67358	67782	67570	67557	68084	67820	67457	67933	67695
75% RDF (50:50% N IF:FYM)	134880	136178	135529	132319	135391	133855	133600	135784	134692	70381	70903	70642	70812	71681	71247	70597	71292	70944
100% RDF (100% IF)	142225	143392	142808	145452	147391	146422	143838	145392	144615	69929	70427	70178	71190	71847	71519	70560	71137	70849
100% RDF (50:50% N IF:FYM)	145516	146687	146101	148724	150437	149581	147120	148562	147841	74085	75560	74822	75716	77307	76512	74901	76433	75667
125% RDF (100% IF)	147366	148677	148022	151402	152705	152054	149384	150691	150038	72597	73121	72859	73921	74459	74190	73259	73790	73525
125% RDF (50:50% N IF:FYM)	147879	151084	149482	151405	155052	153228	149642	153068	151355	77104	77982	77544	78800	79776	79287	77952	78879	78416
S.E. ±	-	-	1045.58	-	-	856.78	-	-	886.61	-	-	195.52	-		160.22		-	165.80
C.D. at 5%	-	-	3171	-	-	2599	-	-	2689	-	-	593	-	-	486	-	-	503
SUB PLOT																		
S.E. ±	-	-	197.99	-	-	208.14	-	-	171.80	-	-	37.02	-	-	38.92	-	-	32.13
C.D. at 5%	-	-	594	-	-	624	-	-	515	-	-	111	-		117	-	-	96
Interaction	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.
C.V. %	-	-	7.01	-	-	8.90	-	-	7.93	-	-	5.61	-	-	6.33	-	-	5.97
Mean	137271	138746	138008	137985	139706	138846	137628	139226	138427	70377	71054	70716	71289	72027	71658	70833	71541	71187

(Table cont'd...)

Table 93 (cont'd.). Total mean gross monetary returns, total cost of cultivation, total net monetary returns (Rs ha^{-1}), Benefit:Cost ratio and pooled mean of *senna-isabgol* cropping sequence as influenced by different treatments during 2002-04.

Treatment	Net monetary returns (Rs. ha^{-1})									Benefit:Cost ratio								
	02-03			03-04			Pooled mean			02-03			03-04			Pooled mean		
	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean	SUB PLOT		Mean
	75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF		75% RDF	100% RDF	
MAIN PLOT																		
50% RDF (100% IF)	57877	58828	58353	55827	55789	55808	56852	57309	57081	1.89	1.90	1.90	1.86	1.85	1.86	1.88	1.88	1.88
50% RDF (50:50% N IF:FYM)	57868	58695	58282	55746	55890	55818	56807	57292	57050	1.87	1.87	1.87	1.83	1.82	1.83	1.85	1.85	1.85
75% RDF (100% IF)	65631	65983	65807	63127	63844	63486	64379	64913	64646	1.97	1.97	1.97	1.93	1.94	1.94	1.95	1.96	1.96
75% RDF (50:50% N IF:FYM)	64499	65275	64887	61507	63710	62609	63003	64493	63748	1.92	1.92	1.92	1.87	1.89	1.88	1.89	1.90	1.90
100% RDF (100% IF)	72295	72965	72630	74261	75544	74903	73278	74255	73767	2.03	2.04	2.04	2.04	2.05	2.05	2.04	2.05	2.05
100% RDF (50:50% N IF:FYM)	71430	71127	71279	73007	73130	73069	72219	72129	72174	1.96	1.94	1.95	1.96	1.95	1.96	1.96	1.95	1.96
125% RDF (100% IF)	74770	75556	75163	77481	78246	77864	76125	76901	76514	2.03	2.03	2.03	2.05	2.05	2.05	2.04	2.04	2.04
125% RDF (50:50% N IF:FYM)	70775	73102	71938	72605	75276	73941	71690	74189	72940	1.92	1.94	1.93	1.92	1.94	1.93	1.92	1.94	1.93
S.E. ±	-	-	850.06	-	-	696.57	-	-	720.81	-	-	0.01	-	-	0.01	-	-	0.01
C.D. at 5%	-	-	2578	-	-	2113	-	-	2186		-	0.03	-		0.03	-	-	0.03
SUB PLOT																		
S.E. ±	-	-	160.96	-	-	169.22	-	-	139.67	-	-	0.002	-	-	0.002	-	-	0.002
C.D. at 5%	-	-	483	-	-	507	-	-	419	-	-	N.S.	-	-	N.S.	-	-	N.S.
Interaction	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.	-	-	N.S.
C.V. %	-	-	9.29	-	-	12.49	-	-	10.84	-	-	3.99	-	-	5.05	-	-	4.48
Mean	66893	67691	67292	66695	67679	67187	66794	67685	67240	1.95	1.95	1.95	1.93	1.94	1.94	1.94	1.95	1.95

be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.4.3 Net monetary returns.

The mean net monetary returns were Rs.67,292, 67,187 and 67,240 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the net monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 125% RDF (100% inorganic fertilizer) recorded the highest net monetary returns (Rs.75,163, 77,864 and 76,514 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be at par with an application of 100% RDF (100% inorganic fertilizer) during 2002-03 while, during 2003-04 and on pooled mean basis it was significantly superior to rest of the treatments applied.

Effect of rabi treatments.

The rabi treatments significantly affected the net monetary returns ha^{-1} during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest net monetary returns (Rs. 67,691, 67,679 and 67,685 ha^{-1} during 2002-03, 2003-04 and on pooled mean basis, respectively). It was found to be significantly superior to an application of 75% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis.

4.4.4 Benefit:Cost Ratio.

The mean Benefit:Cost Ratio was 1.95, 1.94 and 1.95 during 2002-03, 2003-04 and on pooled mean basis, respectively.

Effect of kharif treatments.

The kharif treatments significantly affected the Benefit:Cost Ratio during both the years and on pooled mean basis.

An application of 100% RDF (100% inorganic fertilizer) recorded the highest Benefit:Cost Ratio (2.04 and 2.05 during 2002-03 and on pooled mean basis, respectively) while, during 2003-04 an application of 125% RDF (100% inorganic

fertilizer) and 100% RDF (100% inorganic fertilizer) recorded the highest Benefit:Cost Ratio (2.05). An application of 100% RDF (100% inorganic fertilizer) was found to be at par with an application of 125% RDF (100% inorganic fertilizer) during both the years and on pooled mean basis.

Effect of rabi treatments.

The differences between Benefit:Cost Ratio duc to sub plot treatments given to rabi *isabgol* were found to be non-significant during both the years and on pooled mean basis.

Interaction.

The interaction effects between kharif and rabi treatments were found to be non-significant during both the years and on pooled mean basis

5.DISCUSSION

5. DISCUSSION

A research experiment entitled "Effect of integrated nutrient management in *Senna* (Cassia angustifolia) – *Isabgol* (Plantago ovata) cropping sequence on growth, yield and quality of constituent crops." was conducted at Post Graduate Institute Instructional Farm, in 'B' block of Central Campus, Group No. 6, Survey No.70, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.) during the years 2002-03 and 2003-04. The findings detailed in previous chapter have been discussed here in this chapter.

5.1 Soil.

An analysis of soil (Table 1) of the experimental plot before commencement of present investigation revealed that the soil was clayey in texture, low in available nitrogen (209.14 kg ha^{-1}), medium in available phosphorus (24.94 kg ha^{-1}) and high in available potassium (478.12 kg ha^{-1}). The soil was slightly alkaline in reaction (pH= 8.12). Thus, the soil was suitable for growing *senna* during kharif and *isabgol* in rabi season.

5.2 Weather.

5.2.1 *Senna* (kharif season).

The mean maximum temperature recorded was 30.8 and 31.1°C while, the mean minimum temperature was 16.2 and 16.4°C during 2002-03 and 2003-04, respectively. The mean morning humidity was 86.7 and 82.9% while, the mean evening humidity was 45.4 and 45.2% during 2002-03 and 2003-04, respectively. The wind speed, bright sunshine and mean pan evaporation was 4.1 and 6.6 km hr^{-1} day^{-1}, 7.2 and 7.1 hrs day^{-1}, 4.5 and 4.8 mm day^{-1} during 2002-03 and 2003-04, respectively. Total rainfall of 225.3 and 191.1 mm in 8 and 14 rainy days was recorded during 2002-03 and 2003-04, respectively (Table 2 and 3).

5.2.2 *Isabgol* (rabi season).

The mean maximum temperature recorded was 34.4 and 35.5°C while, the mean minimum temperature was 13.7 and 13.0 °C during 2002-03 and 2003-04, respectively. The mean morning relative humidity was 74.5 and 83.8% while, the mean evening relative humidity was 29.6 and 22.7% during 2002-03 and 2003-04, respectively. The wind speed, bright sunshine and mean pan evaporation was 4.5 and 4.7 km hr^{-1} day^{-1}, 9.4 and 9.8 hrs day^{-1}, 7.6 and 8.3 mm day^{-1} during 2002-03 and 2003-04, respectively. There was no rainfall during the cropping period of *isabgol* during 2002-03 and 2003-04 (Table 2 and 3).

During both the years, crops were irrigated as and when required. The crops were sown with favourable moisture conditions necessary for better germination of the crops and desired plant population was maintained by gap filling and thinning. Thus, it can be seen that weather conditions prevalent during cropping period of both the crops were similar during 2002-03 and 2003-04.

5.3. *Senna*

An experiment on *senna* during kharif season was laid out in randomised block design in three replications with eight treatments comprising of a combination of chemical fertilizer viz., urea and single super phosphate and with or without farmyard manure. The results of present investigation are discussed here.

5.3.1 Growth characters of *senna*

The important growth attributes viz., height, spread, number of branches, leaf area, total fresh matter and total dry matter accumulation plant^{-1} as observed periodically were increased due to an increase in the level of the fertilizer. The differences in these growth characters were observed to be more pronounced from 30 days onwards after sowing.

The plant height (Table 13) increased with an advancement in age of crop and the maximum was recorded at harvest. There was a rapid growth in terms of height during 30 and 120 days after sowing.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the plant height by 1.30, 1.13 and 0.31 percent during 2002-03 while, during 2003-04 the increase was 3.25, 2.59 and 1.37 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the plant height by 6.56, 7.56, 13.10 and 13.20 percent during 2002-03 while, during 2003-04 the decrease was 8.65, 9.79, 15.34 and 15.93 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

The plant spread (Table 14) increased with an advancement in age of crop and the maximum was recorded at harvest. There was a rapid growth in terms of plant spread during 30 and 105 days after sowing.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through

FYM) increased the plant spread by 2.97, 2.26 and 1.38 percent during 2002-03 while, during 2003-04 the increase was 2.14, 1.80 and 1.06 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the plant spread by 4.29, 4.72, 13.73 and 14.82 percent during 2002-03 while, during 2003-04 the decrease was 6.89, 7.69, 16.66 and 17.70 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

This increase might be attributed to the improvement in the nutritional status of plants, which might have resulted in greater synthesis of growth promoting substances, which enhanced meristematic activity and increased cell numbers and their growth. These ultimately increased the plant height and plant spread (Kumavat and Bansal, 1996). Similar results were obtained by Choudhary *et al.* (1979) on *Solanum khasianum*, Pareek *et al.* (1988) on henbane and Ilangovan *et al.* (1990) and Mali (1994) on *senna*.

The number of branches (Table 15) increased with an advancement in age of crop and the maximum was recorded at harvest. There was a rapid growth in terms of number of branches during 45 and 75 days after sowing.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of branches by 6.52, 5.11 and 2.94 percent during 2002-03 while, during 2003-04 the increase was 3.49, 3.49 and 2.11 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the number of branches by 3.59, 6.52, 11.63 and 13.04 percent during 2002-03 while, during 2003-04 the decrease was 7.81, 9.93, 14.15 and 15.52 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An integrated use of nitrogen was found to be beneficial to *senna* in increasing the number of branches. This may be because of an application of nitrogen partly through farmyard manure and urea, might have helped the growth and development of the crop. Similar results were obtained by Hegde (1998) on periwinkle, Pareek *et al.* (1988) on henbane, Mali (1994) on *senna*, Bhaskar *et al.* (2002) on *Solanum viarum* and Krishnamoorthy and Madalagiri (2002) on *Ajowan*.

Leaf area has been considered as a relative index of crop growth to nutrient application. The leaf area (Table 16) increased with an advancement in age

of crop and the maximum was recorded at 90 days after sowing. The leaf area declined at 90 and 120 days after sowing due to picking of the fresh leaves at 90 and 110 days after sowing. Then the leaf area again increased up to harvest.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the leaf area by 4.40, 3.97 and 3.10 percent during 2002-03 while, during 2003-04 the increase was 4.27, 3.64 and 1.32 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the leaf area by 4.09, 5.39, 9.36 and 11.03 percent during 2002-03 while, during 2003-04 the decrease was 7.65, 10.16, 13.80 and 16.56 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An integrated use of nitrogen was found to be positive in increasing the leaf area. The increased leaf area under the farmyard treatments could be attributed to the increased availability of potassium that could have caused cell expansion by regulating solute potential, which may have increased the rate of leaf expansion and the leaf area (Rao and Rao, 1983). Similar results were obtained by Duraisingh and Gopalaswamy (1991) on soybean, Mali (1994) on *senna* and Bhaskar *et al.* (2002) on *Solanum viarum*.

The fresh and dry matter is influenced by the plant height, plant spread, number of branches and leaf area plant^{-1}. The dry matter production is considered as an indicator of the ability of plant to take up nutrients and metabolise them into plant constituents.

The total fresh matter (Table 17) increased with an advancement in age of crop and the maximum was recorded at harvest. There was rapid growth in terms of total fresh matter during 30 and 150 days after sowing. Thereafter, the total fresh matter declined due to drying of plants.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total fresh matter by 4.62, 3.26 and 2.13 percent during 2002-03 while, during 2003-04 the increase was 4.65, 3.57 and 2.11 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total fresh matter by 6.53, 7.98,

16.53 and 18.77 percent during 2002-03 while, during 2003-04 the decrease was 9.10, 11.52, 19.71 and 21.78 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

The total dry matter (Table 18) increased with advancement in age of crop and the maximum was recorded at harvest. There was a rapid growth in terms of dry matter during 30 and 150 days after sowing.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total dry matter by 6.68, 4.71 and 2.46 percent during 2002-03 while, during 2003-04 the increase was 8.22, 6.21 and 3.42 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total dry matter by 6.08, 8.25, 16.83 and 19.23 percent during 2002-03 while, during 2003-04 the decrease was 9.86, 12.46, 21.31 and 23.93 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An overall better growth under farmyard manure treatments could be attributed to the higher microbial population and dehydrogenase activity, which may have influenced higher nutrient uptake, chlorophyll synthesis and plant growth. Further, these microbes could have promoted soil aggregation and thus indirectly influenced the root environment and plant growth (Maheshwarappa *et al.*, 2000). An increase in the leaf surface with each additional dose of fertilizer might have helped in utilizing the radiant energy more effectively thereby resulting in an increased synthesis of carbohydrates. Hence, vigour of the plant was better due to an increase in the level of fertilizer. Similar results were obtained by Mali (1994) on *senna*, Muniramappa *et al.* (1997) on *kalmegh*, Arumugam *et al.* (2001) on *senna* and Krishnamoorthy and Madalageri (2002) on *Ajowan*.

The periodical AGR values of dry matter showed increasing trend due to an increase in the application of fertilizer (Table 19). The periodical RGR values of dry matter showed increasing trend due to an increase in the application of fertilizer (Table 20). In general, it is observed that almost all morphological characters studied exhibited an increasing trend corresponding to an increase in the levels of fertilizer.

Hence, it can be stated that the *senna* crop when fertilized with higher doses of N and P combinations helped to produce superior growth over the recommended dose of fertilizer.

There was a delay in number of days to flower initiation, days to 50% flowering and days to maturity (Table 21) with an increase in the level of fertilizer.

This might be due to an increased availability of nitrogen, which prolonged growth and delayed senescence (Rajput *et al.*, 1983). Similar results were obtained by Ilangovan *et al.* (1989) on *senna*.

5.3.2 Yield contributing characters of *senna*.

The growth attributes were favourably influenced by higher doses of fertilizer. These favourable effects on growth were also reflected on yield contributing characters.

The effect of treatments on crop development for yield contributing characters was measured in terms of number of filled pods, number of unfilled pods, total number of pods, weight of filled pods, weight of unfilled pods, total weight of pods plant^{-1}, length of pod, breadth of pod, number of seeds pod^{-1}, weight of seeds pod^{-1}, thousand seed weight, number of seeds plant^{-1} and weight of seeds plant^{-1}. From these some of the important characters are discussed below,

An improvement in yield contributing characters studied as observed was evident due to an increase in the levels of fertilizer.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of filled pods (Table 22) by 7.56, 6.43 and 3.90 percent during 2002-03 while, during 2003-04 the increase was 7.39, 6.36 and 3.80 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the number of filled pods by 7.02, 9.61, 15.25 and 17.94 percent during 2002-03 while, during 2003-04 the decrease was 12.60, 15.64, 22.51 and 23.32 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the weight of filled pods (Table 22) by 8.79, 6.14 and 2.61 percent during 2002-03 while, during 2003-04 the increase was 8.77, 5.69 and 1.39 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the weight of filled pods by 7.94, 10.94, 18.96 and 22.20 percent during 2002-03 while, during 2003-04 the decrease was 11.44, 14.43, 22.09 and 25.42 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An increase in number and weight of pods plant^{-1} could be due to higher photosynthetic surface as a result of an increased leaf area coupled with an increase in phosphorus availability in soil during vegetative and generative stages of the crop in an increased fertilizer levels might have resulted in enhanced photosynthetic activity and thus more metabolites were directed for the development of more pods plant^{-1} (Singh *et al.*, 1980).

Similar results were obtained by Choudhary *et al.* (1979) on Solanum khasianum, Nimje and Seth (1987) and Duraisingh and Gopalaswamy (1991) on soybean, Bhaskar *et al.* (2002) on Solanum viarum.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of seeds (Table 24) by 7.80, 6.57 and 3.56 percent during 2002-03 while, during 2003-04 the increase was 7.68, 6.23 and 2.75 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the number of seeds by 7.31, 9.90, 15.69 and 18.67 percent during 2002-03 while, during 2003-04 the decrease was 17.06, 19.60, 24.17 and 26.18 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). The efficient transfer of metabolites and subsequent accumulation of these metabolites in the pods would have resulted in an increase in the number of cells.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the weight of seeds (Table 24) by 10.20, 8.65 and 5.10 percent during 2002-03 while, during 2003-04 the increase was 10.26, 8.65 and 5.26 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50%RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the weight of seeds by 12.20, 16.58, 24.32 and 27.69 percent during 2002-03 while, during 2003-04 the decrease was 16.06, 20.87, 27.48 and 30.69 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the thousand seed weight (Table 24) by 5.62, 4.66 and 1.63 percent

during 2002-03 while, during 2003-04 the increase was 5.70, 4.42 and 2.66 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the thousand seed weight by 4.80, 7.20, 10.56 and 12.77 percent during 2002-03 while, during 2003-04 the decrease was 5.89, 6.65, 12.54 and 14.35 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An increase in the number and weight of seeds plant^{-1} and thousand seed weight could be due to the favourable effect of nitrogen application which was directly attributed to higher dry matter accumulation and indirectly through the build-up of sizeable protein pools at vegetative phase and increased supply of assimilates to flowers led to the formation of bold seed.

Similar results were obtained by Muthuvel *et al.* (1985) on red gram, Nimje and Seth (1987) and Duraisingh and Gopalaswamy (1991) on soybean.

5.3.3 Yield of *senna*

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total fresh leaves yield (Table 29) by 4.96, 4.23 and 2.57 percent during 2002-03 while, during 2003-04 the increase was 5.22, 4.59 and 2.49 percent while, on pooled mean basis the increase was 5.09, 4.41 and 2.53 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total fresh leaves yield by 6.42, 8.41, 18.97 and 20.88 percent during 2002-03, during 2003-04 the decrease was 10.38, 12.31, 22.21 and 24.35 percent while, on pooled mean basis the decrease was 8.42, 10.39, 20.61 and 22.63 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total dry leaves yield (Table 30) by 5.69, 4.84 and 3.02 percent during 2002-03 while, during 2003-04 the increase was 4.73, 3.74 and 1.94 percent while, on pooled mean basis the increase was 5.20, 4.29 and 2.49 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100%

inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total dry leaves yield by 6.62, 8.40, 17.69 and 19.73 percent during 2002-03 while, during 2003-04 the decrease was 11.62, 13.34, 21.86 and 23.62 percent while, on pooled mean basis the decrease was 9.14, 10.89, 19.81 and 21.69 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An increase in the fresh and dry leaves yield could be due to the favourable synthesis of growth promoting constituents in plant system as result of better supply of nitrogen, which led to an enlargement in the leaf area due to, increased cell size and cell division in the leaves of the plant (Nandan and Prasad, 1998)

Similar results were obtained by Kalyansundaram *et al.* (1981 a) and Ilangovan *et al.* (1989), Mali (1994) and Arumugam *et al.* (2001) on *senna* .

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the seed yield (Table 31) by 5.23, 3.83 and 2.44 percent during 2002-03 while, during 2003-04 the increase was 6.12, 5.44 and 3.40 percent while, on pooled mean basis the increase was 5.50, 4.47 and 2.75 percent, respectively. An application of lower doses of fertilizer and N substitution through FYMviz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF(100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the seed yield by 5.23, 6.97, 10.80 and 12.20 percent during 2002-03 while, during 2003-04 the decrease was 8.16, 10.20, 14.63 and 16.67 percent while, on pooled mean basis the decrease was 6.87, 8.59, 12.72 and 14.78 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An incorporation of farmyard manure might have helped in improving nutrient availability from soil for a prolonged period on one hand and mitigating the deficiency of different nutrients as well as improving the soil physical conditions on the other leading to better aeration, root activity and nutrient absorption which had a positive effect on increasing the leaf area and the photosynthetic activity which ultimately increased the crop yield (Naphade *et al.*, 1993).

Similar results were obtained by Sharma *et al.* (1999 a) and Ramamoorthy *et al.* (2003) on *senna*.

The harvest index (Table 31) during 2002-03 was increased due to an application of 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM) and 75% RDF (100% inorganic fertilizer) by 0.05, 0.02, 0.14 and 0.43 percent, respectively while, an application of 125% RDF (50% N through urea and 50% N

through FYM), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the harvest index by 0.12, 1.87 and 1.89 percent. During 2003-04, the harvest index was increased due to an application of 125% RDF (100% inorganic fertilizer) by 0.17 percent while, an application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the harvest index by 0.21, 0.24, 0.48, 0.31, 2.76 and 2.40 percent, respectively as compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

On pooled mean basis, the harvest index was increased by an application of 125% RDF (100% inorganic fertilizer) and 75% RDF (100% inorganic fertilizer) by 0.12 and 0.07 percent while, an application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the harvest index by 0.17, 0.10, 0.17, 2.31 an 2.15 percent, respectively as compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

5.3.4 Concentration and uptake of nutrients in *senna*.

The biological yield and concentration of nitrogen, phosphorus and potassium in the various plant parts had a direct bearing on uptake of these elements in the crop.

The concentration of nitrogen (Table 32), phosphorus (Table 33) and potassium (Table 34) in the various plant parts analyzed increased with an increase in an application of higher doses of fertilizer. Similar results were obtained by Bhand (1994) and Prasad and Kumar (1999) on soybean.

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total uptake of nitrogen (Table 35) by 7.98, 6.09 and 3.20 percent during 2002-03 while, during 2003-04 the increase was 8.71, 5.70 and 3.30 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total uptake of nitrogen by 9.55, 12.01, 19.51 and 22.18 percent during 2002-03 while, during 2003-04

the decrease was 12.81, 15.54, 21.68 and 24.99 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An increased uptake of nitrogen under the farmyard manure treatments could be due to the activity of ammonifiers and nitrifiers which helped in increasing the element in the soil solutions and thus enhanced the activity and uptake of the element (Sharma *et al.*, 2002).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total uptake of phosphorus (Table 36) by 11.05, 9.33 and 2.99 percent during 2002-03 while, during 2003-04 the increase was 11.02, 8.90 and 2.86 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total uptake of phosphorus by 9.36, 12.35, 19.25 and 22.66 percent during 2002-03 while, during 2003-04 the decrease was 13.51, 15.58, 22.77 and 26.85 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An uptake of phosphorus is synergistic to the uptake of nitrogen and higher uptake of phosphorus could be due to solubilization effect of organic acids produced during decomposition of farmyard manure, improved aeration and better root proliferation (Murugappan *et al.*, 1998).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total uptake of potassium (Table 37) by 12.57, 10.10 and 5.86 percent during 2002-03 while, during 2003-04 the increase was 11.79, 7.50 and 3.60 percent, respectively. An application of lower doses of fertilizer and N substitution through FYM viz., 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the total uptake of potassium by 8.47, 13.25, 23.52 and 26.27 percent during 2002-03 while, during 2003-04 the decrease was 12.61, 20.02, 27.56 and 31.85 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An application of farmyard manure improved the physical condition of soil resulting in more root growth enabling the plant to explore wider areas and higher depth for absorption of potassium, leading to its higher uptake. (Biswas *et al.*, 1995).

Similar results were obtained by Sharma and Dixit (1987), Reddy *et al.* (1990) and Bachhav (1994) on soybean.

5.3.5 Quality characters of *senna*.

The sennoside percentage in leaf remained unaffected due to varying levels of fertilizer and no specific trend could be observed. Similar observations were recorded in case of sennoside percentage in pod. (Table 38) The results are in conformity with Gupta *et al.* (1977), Pareek *et al.* (1989) and Ilangovan *et al.* (1991) on *senna*.

5.3.6 Soil characters.

5.3.6.1 Physical properties of soil.

There was a slight decrease in the pH of the soil (Table 39). This lowering of the pH values may be due to an addition of several plant acids in soil by the root during its growth and the decomposition of farm yard manure (Newaj and Yadav, 1994). Similar results were obtained by Kwakye, 1988. There was a slight increase in the electrical conductivity of the soil (Table 39). An increase might be due to an application of fertilizer particularly nitrogen due to its high solubility (Prasad *et al.*, 1997). Similar results were obtained by Dahiya (1990).

There was no change in the bulk density of the soil (Table 39) except in case of treatments receiving higher doses of farmyard manure viz., 100% RDF (50% N through urea and 50%N through farmyard manure) and 125% RDF (50% N through urea and 50%N through farmyard manure). This might be due to the process of decomposition wherein, polysaccharides, polynoides, cellulose and humus are produced which are responsible for firm binding between soil particles resulting in more stable aggregates causing a reduction in bulk density (Beresteskii *et al.*, 1986). Similar results were obtained by Bellakki and Badanur, 1997.

5.3.6.2 Chemical properties of soil.

The organic carbon content of the soil (Table 40) was more after the harvest of *senna* crop. An increased organic carbon content might be due to an enhanced root growth, which leads to an accumulation of organic residues and direct incorporation of organic matter in the soil (Nambiar *et al.*, 1992). The total nitrogen content of soil (Table 40) was improved after the harvest of *senna*. This build up in total nitrogen could be attributed to an increase in the nitrogen fixing bacteria under FYM treatments and also due to an application of fertilizer N thereby, resulting in higher accumulation of nitrogen in soil (Miller *et al.*, 1987). The decrease in C:N Ratio of the soil (Table 40) might be due to an increase in the total nitrogen content of the soil. Similar results were obtained by Badanur *et al.* (1990) and Patil *et al.* (1996 b)

There was a slight increase in available nitrogen (Table 41), available phosphorus (Table 42) and available potassium (Table 43) status of soil. This buildup may be attributed to the mineralization of organic manures and solubilization of nutrients

from the native sources during the process of decomposition (Bhandari *et al.*, 1992). The continuous decrease in available potassium status in non-farmyard manure treatments may be due to its higher uptake by the crop compared to no direct application. Similar results were obtained by Balasubramaniyan (1997) on groundnut and Navale *et al.* (2000) on soybean.

5.3.7 Economics of *senna*.

An application of 125% RDF (100% inorganic fertilizer) increased the net monetary returns (Table 44) by 5.40 percent during 2002-03 while, during 2003-04 the increase was 5.72 percent while, on pooled mean basis the increase was 5.57 percent, respectively. An application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the net monetary returns by 0.04, 1.58, 11.91, 10.06, 21.92 and 21.57 percent during 2002-03 while, during 2003-04 the decrease was 0.63, 2.30, 18.01, 16.27, 27.88 and 27.65 percent while, on pooled mean basis the decrease was 0.34, 1.95, 15.03, 13.23, 24.96 and 24.68 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

An application of 125% RDF (100% inorganic fertilizer) increased the Benefit:Cost Ratio (Table 44) by 0.93 percent during 2002-03, during 2003-04 the increase was 1.37 percent while, on pooled mean basis the increase was 1.38 percent, respectively. An application of 125% RDF (50% N through urea and 50% N through FYM), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the Benefit:Cost Ratio by 6.02, 4.63, 6.95, 3.24, 9.72 and 7.41 percent during 2002-03, during 2003-04 the decrease was 6.39, 5.48, 9.59, 5.48, 12.33 and 10.05 percent while, on pooled mean basis the decrease was 5.99, 5.07, 8.30, 4.15, 10.60 and 8.30 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer).

The decrease in net monetary returns and Benefit:Cost Ratio could be due to an increase in cost of cultivation as a result of higher cost of farmyard manure per unit of nitrogen and also due to less yield obtained in lower doses of application of nutrients.

The correlation (Table 45 and 46) and regression (Table 47 and 48) coefficients showed a positive and significant association amongst most of the

characters studied. Similar results were obtained by Lal *et al.* 1992, Sankaranarayanan *et al.* (1992) and Sankaranarayanan (1995) on *senna*.

In general, an application of higher levels of fertilizer showed an increase in the values of vegetative and yield contributing characters as well as yield of *senna*. This indicates the responsiveness of *senna* to fertilization.

5.4 *Isabgol* (Rabi).

An experiment on *isabgol* during the rabi season was laid out in split plot design in three replications with eight main plot treatments comprising of a combination of chemical fertilizer viz., urea and single super phosphate and with or without farmyard manure given to kharif *senna* and two sub plot treatments of fertilizer levels viz., 75% RDF and 100% RDF to *isabgol*. The results of the present investigation are discussed here.

5.4.1 Growth characters of *isabgol*.

The plant height (Table 54) increased with an advancement in the age of crop and maximum was recorded at harvest. There was rapid growth in terms of height during 30 and 60 days after sowing.

In main plots, the differences in plant height due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the plant height by 3.32, 1.66 and 0.38 percent during 2002-03 while, during 2003-04 the increase was 4.18, 2.84 and 0.52 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the plant height by 3.58 and 3.50 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An increase in the plant height due to an application of nitrogen and phosphorus fertilization may be due to an increase in cell division (Rajput *et al.*, 1983). Similar results were obtained by Singh and Chouhan (1994), Mann and Vyas (1999), and Maheshwari *et al.* (2000 b) on *isabgol*.

The number of leaves (Table 55) increased with an advancement in the age of the crop and maximum was recorded at harvest. There was a rapid growth in terms of number of leaves during 30 and 60 days after sowing.

In main plots, the differences in number of leaves due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through

urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of leaves by 3.29, 0.61 and 0.24 percent during 2002-03 while, during 2003-04 the increase was 9.39, 3.97 and 3.18 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the number of leaves by 5.34 and 5.59 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An increase in the number of leaves might be due to an application of nitrogen and phosphorus fertilization. Similar results were obtained by Mann and Vyas (1999), Singh *et al.* (2003 a) and Utgikar *et al.* (2003) on *isabgol.*

The number of productive tillers (Table 56) increased with an advancement in the age of crop and maximum was recorded at harvest. There was a rapid growth in terms of number of productive tillers during 30 and 60 days after sowing. Productive tiller number is one of the dominant factors responsible for the yield as it has a direct bearing on the number of productive spikes plant^{-1}.

In main plots, the differences in number of productive tillers due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of productive tillers by 3.75, 3.09 and 0.88 percent during 2002-03 while, during 2003-04 the increase was 2.83, 2.17 percent and no change, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer) in case of main plots. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the number of productive tillers by 1.99 and 3.06 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An increase in the number of productive tillers may be due to an improvement of plant hydrature due to an application of nitrogen (Singh, 1974). Similar results were obtained by Singh *et al.* (1996) on wheat, Rai *et al.* (2002) on Foenicum vulgare and Utgikar *et al.* (2003) on *isabgol.*

The total dry matter (Table 59) increased with an advancement in the age of the crop and maximum was recorded at harvest. There was a rapid growth in terms of dry matter during 30 and 60 days after sowing.

In case of main plots, the differences in dry matter due to the treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and

100% RDF (50% N through urea and 50% N through FYM) increased the total dry matter by 2.27, 1.47 and 0.27 percent during 2002-03 while, during 2003-04 the increase was 1.59, 1.32 and 0.40 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the total dry matter by 3.98 and 4.21 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

This may be due to the presence of large number of functional leaves which were instrumental in utilizing the radiant energy more effectively thereby increasing the synthesis of carbohydrates and in turn increasing the vigour of the plant resulting in more plant height, number of leaves and total number of tillers plant^{-1}.

Similar results were obtained by Mann and Vyas (1999), Singh *et al.* (2003 a) and Utgikar *et al.* (2003) on *isabgol.*

The periodical AGR values (Table 60) of dry matter showed increasing trend due to an application of fertilizer. The periodical RGR values (Table 61) of dry matter did not show a specific trend due to an application of fertilizer. In general, it is observed that almost all the morphological characters studied were increased due to an increase in an application of nutrient levels.

There was a delay in the number of days to flower initiation, days to 50% flowering and days to maturity with an increase in the level of fertilizer (Table 62).

5.4.2 Yield contributing characters of *isabgol*

The growth attributes were favourably influenced by higher doses of nutrients. These favourable effects on growth attributes were also reflected on yield contributing characters.

The effect of treatments on the crop development for yield contributing characters was measured in terms of number of productive spikes, number of unproductive spikes, total number of spikes, length of spike, girth of spike, number of seeds spike^{-1}, number of seeds plant^{-1}, weight of seeds plant^{-1} and thousand seed weight.

The number of productive tillers produced by the plant indicates the potentiality of the plant for growth, but from production point of view number of productive spikes are very important.

In main plots, the differences in number of productive spikes (Table 63) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of productive spikes by 3.60, 3.00 and 0.36 percent during 2002-03 while, during 2003-04 the increase was 3.59, 3.23 and 0.60 percent, respectively compared to

an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the number of productive spikes by 15.41 and 15.57 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

This might be due to close association between the photosynthetic rate, which must have increased due to an increase in nitrogen and phosphorus fertilization and the potential sink strength (Basuchaudhari and Dasgupta, 1987). Similar results were obtained by Singh and Chouhan (1994), Mann and Vyas (2001), Deore *et al.* (2002), Sharma *et al.* (2003 b) and Utgikar *et al.* (2003) on *isabgol.*

In main plots, the differences in number of seeds spike^{-1} (Table 64) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of seeds spike^{-1} by 2.92, 1.89 and 2.42 percent during 2002-03 while, during 2003-04 the increase was 1.61, 0.64 and 2.60 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the number of seeds spike^{-1} by 0.67 and 1.08 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An increase might be due to an abundance of phosphorus in the soil, which stimulated the formation of filled seeds and an increase in seed number spike^{-1}. (Mishra *et al.*, 1995)

In main plots, the differences in number of seeds plant^{-1} (Table 65) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of seeds plant^{-1} by 6.15 and 1.79 percent, respectively during 2002-03 while, during 2003-04 an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the number of seeds plant^{-1} by 5.34, 3.55 and 2.05 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the number of seeds plant^{-1} by 16.33 and 16.68 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

In main plots, the differences in weight of seeds plant^{-1} (Table 65) due to the different treatments were found to be non-significant. However, an application

of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the weight of seeds plant^{-1} by 3.96, 3.39 and 1.70 percent during 2002-03 while, during 2003-04 the increase was 5.62, 4.49 and 2.25 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the weight of seeds plant^{-1} by 7.45 and 5.88 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

In main plots, the differences in thousand seed weight (Table 65) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the thousand seed weight by 5.59, 2.49 and 1.24 percent during 2002-03 while, during 2003-04 the increase was 4.88, 2.44 and 0.61 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the thousand seed weight by 5.39 and 7.78 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

This might be due to an increase in the photosynthetic activity due to nitrogen and phosphorus fertilization which had a positive effect in maintaining plant-water balance in the leaves, resulting in increased production of photosynthates and their proper partitioning to the developing seeds (Lal and Sharma, 1976) and (Basuchaudhari and Dasgupta, 1987). Similar results were obtained by Singh and Chouhan (1994), Intodia and Tomar (1998), Sharma *et al.* (2003 b), Singh *et al.* (2003 a) and Utgikar *et al.* (2003) on *isabgol.*

5.4.3 Yield of *isabgol.*

In main plots, the differences in seed yield (Table 68) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the seed yield by 1.24, 0.87 and 0.37 percent during 2002-03 while, during 2003-04 the increase was 1.73, 1.23 and 0.49 percent while, on pooled mean basis the increase was 1.49, 1.11 and 0.50 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the seed yield by

5.04, 5.75 and 5.39 percent during 2002-03, 2003-04 and on pooled mean basis, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

In main plots, the differences in straw yield (Table 68) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the straw yield by 4.09, 3.57 and 1.79 percent during 2002-03 while, during 2003-04 the increase was 4.28, 3.58 and 1.86 percent while, on pooled mean basis the increase was 4.21, 3.60 and 1.82 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer). In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the straw yield by 4.74, 5.54 and 5.14 percent during 2002-03, 2003-04 and on pooled mean basis, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

The positive impact on seed and straw yield might be due to an improvement in the growth and yield attributes due to nitrogen and phosphorus application which promoted synthesis of proteins for the development of tissues and consequently increased the rate of photosynthesis by rapid rate of carbon-dioxide utilization by leaves and increased absorption of mineral nutrient with lesser plant energy finally led to an increase in seed and grain yield. (Tomar *et al.*, 1996). Similar results were obtained by Parihar and Singh (1995), Jadhav *et al.* (2000), Singh *et al.* (2001 a) and Singh and Pal (2003) on psyllium.

In main plots, an application of higher doses of fertilizer and N substitution through FYM viz., 50% RDF (100% inorganic fertilizer) increased the harvest index (Table 68) by 0.26 percent during 2002-03 while, during 2003-04 the increase was 0.55 percent while, on pooled mean basis the increase was 0.40 percent. The treatment of an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer), 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and decreased the harvest index by 1.93, 1.86, 1.02, 0.77, 0.66 and 0.07 percent during 2002-03 while, during 2003-04 the decrease was 1.53, 1.46, 1.02, 0.51, 0.22 and 0.18 percent while, on pooled mean basis the decrease was 1.75, 1.68, 1.02, 0.66, 0.44 and 0.04 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer) in case of main plots. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the harvest index by 0.18, 0.15 and 0.18 percent during 2002-03, 2003-04 and on pooled mean basis, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

5.4.4 Concentration and uptake of nutrients in *isabgol.*

The concentration of nitrogen (Table 69), phosphorus (Table 70) and potassium (Table 71) in the various plant parts analyzed increased with an increase in an application of higher fertilizer doses. The total biological yield of the crop and the concentration of the nitrogen, phosphorus and potassium in the various plant parts have a direct bearing on the uptake of these elements in the plant.

In main plots, the differences in total uptake of nitrogen (Table 72) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total uptake of nitrogen by 3.76, 2.55 and 0.22 percent during 2002-03 while, during 2003-04 the increase was 4.37, 2.87 and 0.52 percent, respectively. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the total uptake of nitrogen by 10.53 and 9.27 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

In main plots, the differences in total uptake of phosphorus (Table 73) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 100% RDF (50% N through urea and 50% N through FYM) increased the total uptake of phosphorus by 5.40, 3.61 and 2.38 percent during 2002-03 while, during 2003-04 the increase was 7.28, 5.24 and 2.69 percent, respectively. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the total phosphorus uptake by 6.43 and 7.48 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

In main plots, the differences in total uptake of potassium (Table 74) due to the different treatments were found to be non-significant. However, an application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM) and 125% RDF (100% inorganic fertilizer) increased the total uptake of potassium by 10.13 and 8.50 percent and an application of 100% RDF (50% N through urea and 50% N through FYM) decreased the potassium uptake by 0.57 percent during 2002-03 while, during 2003-04 an application of 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) and 125% RDF (50% N through urea and 50% N through FYM) increased potassium uptake by 12.28, 9.05 and 0.89 percent, respectively. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the total uptake of potassium by 10.51 and

12.33 percent during 2002-03 and 2003-04, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An increase in the uptake of nitrogen, phosphorus and potassium in the plant may be attributed to the fact that the pool of available nutrient increased in the soil (Patel and Chandravanshi, 1996), coupled with an increase in root hairs, root volume and surface area resulting in more uptake (Mehrotra and Saxena, 1970). Similar results were obtained by Mann and Vyas (1999) and Singh *et al.* (2001 b) on *isabgol.*

5.4.5 Quality characters of *isabgol.*

The protein content of *isabgol* seed (Table 75) was not significantly affected due to the main plot or sub plot treatments. Similar results were obtained by Matai *et al.* (1980) on pearl millet. The husk percentage and swelling factor (Table 75) remained unaffected due to the varying levels of fertilizer and it did not show any specific trend. Similar results were obtained by Maheshwari *et al.* (2000 b) and Rathore and Chandawat (2003) on *isabgol.*

5.4.6 Soil characters.

5.4.6.1 Physical properties of soil.

There was a slight increase in pH (Table 76). This might be due to the presence of calcium in the single super phosphate fertilizer which increased the pH (Vig *et al.*, 1999). Similar results were obtained by Badanur *et al.* (1990). There was also an increase in the electrical conductivity of the soil (Table 76). There was no change in the bulk density of soil (Table 76). Similar results were obtained by Badanur *et al.* (1990).

5.4.6.2 Chemical characters of soil.

There was a slight decrease in the organic carbon content (Table 77). The different applications of N and P did not affect the organic carbon content of the soil (Sharma and Sharma, 2002). However, there was a slight increase in the total nitrogen (Table 77). The continuous application of nitrogen resulted in a higher total N status of the soil (Mandal *et al.*, 2001). There was a slight decrease in the C:N Ratio of the soil (Table 77). This might be due to an increase in the total nitrogen status of the soil. There was an increase in the available nitrogen (Table 78), available phosphorus (Table 79) and available potassium (Table 80) status of the soil.

5.4.7 Economics of *isabgol.*

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF

(100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the net monetary returns (Table 81) by 5.68, 6.44, 3.34, 3.96, 5.94, 8.52 and 9.74 percent during 2002-03 while, during 2003-04 the decrease was 4.98, 6.01, 3.29, 7.31, 9.46, 12.00 and 13.35 percent and on pooled mean basis the decrease was 5.34, 6.23, 3.32, 5.60, 7.67, 10.23 and 11.51 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer) in case of main plots. In sub plots, an application of 75% RDF (100% inorganic fertilizer) decreased the net monetary returns ha^{-1} by 6.95, 10.90 and 7.92 percent during 2002-03, 2003-04 and on pooled mean basis, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

An application of higher doses of fertilizer and N substitution through FYM viz., 125% RDF (50% N through urea and 50% N through FYM), 125% RDF (100% inorganic fertilizer) 100% RDF (50% N through urea and 50% N through FYM), 75% RDF (50% N through urea and 50% N through FYM), 75% RDF (100% inorganic fertilizer), 50% RDF (50% N through urea and 50% N through FYM) and 50% RDF (100% inorganic fertilizer) decreased the Benefit:Cost Ratio (Table 81) by 4.19, 4.79, 2.40, 1.20, 1.80, 2.99 and 3.59 percent during 2002-03, during 2003-04 the decrease was 3.70, 4.32, 1.85, 2.47, 3.09, 3.70 and 4.32 percent and on pooled mean basis the decrease was 4.24, 4.85, 2.42, 1.82, 2.42, 3.64 and 4.24 percent, respectively compared to an application of recommended dose of fertilizer i.e. 100% RDF (100% inorganic fertilizer) in case of main plots. In sub plots an application of 75% RDF (100% inorganic fertilizer) decreased the Benefit:Cost Ratio by 1.83, 1.89 and 1.85 percent during 2002-03, 2003-04 and on pooled mean basis, respectively compared to an application of 100% RDF (100% inorganic fertilizer).

This decrease may be due to the fact that there was reduction in net monetary returns due to lesser yield in lower nutrient levels.

The correlation (Table 82 and 83) and regression (Table 85 and 86) coefficients showed a positive and significant association amongst most of the characters studied. Similar results were obtained by Singh *et al.* (1995 c) on *isabgol.*

6.SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

A field experiment to study the effect of graded levels of nitrogen and phosphorus fertilization alongwith and without farmyard manure on growth, yield and quality of *Senna* (*Sonamukhi*) (Cassia angustifolia) – *Isabgol* (Plantago ovata) sequence cropping was conducted at the Post Graduate Institute Instructional Farm, Rahuri during kharif and rabi seasons of 2002-03 and 2003-04 on the same site. The experimental soil was clayey in texture, low in available nitrogen (209.14 kg ha^{-1}) medium in available phosphorus (24.94 kg ha^{-1}) and high in available potash (478.12 kg ha^{-1}) with 8.12 pH. It was fairly medium in fertility and well drained, hence suitable for growing the *senna* (*sonamukhi*) and *isabgol* crops.

In kharif season, the experiment was laid out in randomised block design with eight treatments i.e. 50% RDF, 75% RDF, 100% RDF (75:50:0 NPK $kgha^{-1}$) and 125% RDF with and without farmyard manure combination. In rabi season, an experiment was laid out in split plot design with 75% RDF and 100% RDF (50:25:0 NPK $kgha^{-1}$) for *isabgol*. The treatments were randomly allocated to each plot and replicated thrice. The important findings emerged from this investigation are summarized below.

6.1 *Senna* (*sonamukhi*).

The *senna* (*sonamukhi*) (kharif) showed linear and significant response to the levels of fertilizer. Beneficial effects were realized on all the growth and yield contributing characters. The favourable effects of increased levels of fertilizer were more pronounced from 30 days onwards after sowing. The application of 100% RDF (75:50:0 NPK $kgha^{-1}$)(50% N through urea and 50% N through FYM) was at found to be significantly superior to 100% RDF (75:50:0 NPK $kgha^{-1}$) (100% inorganic fertilizer) and the lower levels of fertilizers and at par to the higher levels of fertilizers.

1) The growth attributes viz., plant height, plant spread, number of branches, leaf area, total fresh matter, total dry matter were increased by the application of 100% RDF (75:50:0 NPK $kgha^{-1}$) (50% N through urea and 50% N through FYM) over 100% RDF (75:50:0 NPK $kgha^{-1}$) (100% inorganic fertilizer) by 0.31 and 1.37, 1.38 and 1.06, 2.94 and 2.11, 3.10 and 1.32, 2.13 and 2.11, 2.46 and 3.42 percent during 2002-03 and 2003-04, respectively.
2) The yield contributing characters viz., number of filled pods, weight of filled pods, number of seeds $plant^{-1}$, weight of seeds $plant^{-1}$, thousand seed weight, total fresh and dry leaves yield ha^{-1} and seed yield ha^{-1} were increased by the

application of 100% RDF (75:50:0 NPK kgha^{-1}) (50% N through urea and 50% N through FYM) over 100% RDF (75:50:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 3.90 and 3.80, 2.61 and 1.39, 3.56 and 2.75, 5.10 and 5.26, 1.63 and 2.66 percent during 2002-03 and 2003-2004, respectively.

3) The total fresh leaves yield, total dry leaves yield and seed yield ha^{-1} were increased by the application of 100% RDF (75:50:0 NPK kgha^{-1}) (50% N through urea and 50% N through FYM) over 100% RDF (75:50:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 2.57 and 2.49, 3.02 and 1.94, 2.44 and 3.40 percent during 2002-03 and 2003-04, respectively.

4) The N, P, K, concentration in the various plant parts was increased due to increase in the level of fertilizer but the increase in concentration was not significant.

5) The uptake of N, P and K in the various plant parts was increased due to increase in the level of fertilizer. The application of 100% RDF (75:50:0 NPK kgha^{-1}) (50% N through urea and 50% N through FYM) increased the total uptake on N, P, K over 100% RDF (75:50:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 3.20 and 3.30, 2.99 and 2.86, 5.86 and 3.60 percent during 2002-03 and 2003-04, respectively.

6) The sennoside content in the leaves and pods was not altered due to the levels of fertilizers applied.

7) There was a slight decrease in pH (0.01), increase in electrical conductivity (0.01 dSm^{-1}) and no appreciable change in bulk density of the soil.

8) The organic carbon and total nitrogen increased (0.001 and 0.0002%, respectively) and the C:N ratio decreased (0.05) in treatments having higher levels of fertilizer.

9) The available N, P and K was significantly influenced and the application of 100% RDF (75:50:0 NPK kgha^{-1}) (50% N through urea and 50% N through FYM) resulted in higher (212.54 and 217.15, 25.96 and 28.58, 490.36 and 496.11 NPK kgha^{-1} during 2002-03 and 2003-04, respectively) over 100% RDF (75:50:0 NPK kgha^{-1}) (100% inorganic fertilizer) (210.45 and 209.63, 25.75 and 27.27, 459.65 and 434.88 NPK kgha^{-1} during 2002-03 and 2003-04, respectively).

10) There was an increase in net monetary returns (Rs. 65,711/- ha^{-1}) and B:C ratio (2.20) on pooled mean basis due to the application of 125% RDF (93.75:62.50:0 NPK kgha^{-1}) (100% inorganic fertilizer).

11) The plant attributes viz., plant height, plant spread, number of branches, total dry matter, number of filled pods, weight of filled pods, number of seeds pod^{-1}, weight of seeds pod^{-1}, number of seeds plant^{-1}, thousand seed weight and dry leaves weight were positively and significantly correlated, the regression also showed a positive and significant association with weight of seeds plant^{-1}.

6.2 *Isabgol*

Effect of main plot treatments.

The growth, yield contributing characters, yield, concentration and nutrient uptake, quality characters and economical aspects were found to be non-significant due to treatments for the kharif crop of *senna* (*sonamukhi*). There was slight increase in pH (0.01), no change in electrical conductivity, bulk density and organic carbon, increase in the total nitrogen content (0.0001 %), decrease in C:N ratio (0.02). There was improvement in the available nitrogen (+2.12 kgha^{-1}) and phosphorus (+1.61 kgha^{-1}) status. A decrease in the available potassium (-10.30 kgha^{-1}) status. The net monetary returns (Rs.11,520/-) and B:C ratio (1.65) was found to be non- significant.

Effect of sub plot treatments.

The application of 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) to *isabgol* was found to be significantly superior to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer).

1) The growth attributes viz., plant height, number of leaves, number of productive tillers and total dry matter were decreased due to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer) compared to 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 3.58 and 3.50, 5.34 and 5.59, 1.99 and 3.06, 3.98 and 4.21 percent during 2002-03 and 2003-04, respectively.
2) The yield contributing characters viz., number of productive spikes, number of seeds spike^{-1}, number of seeds plant^{-1}, weight of seeds plant^{-1}, thousand seed weight were decreased due to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer) compared to 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 15.41 and 15.57, 0.67 and 1.08, 16.33 and 16.68, 7.45 and 5.88, 5.39 and 7.78 percent during 2002-03 and 2003-04, respectively.
3) The seed and total straw yield was decreased due to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer) compared to 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) by 5.04 and 5.75, 4.74 and 5.54 percent during 2002-03 and 2003-04, respectively.
4) The N, P and K content in the various plant parts was increased due to increase in the level of fertilizer, but the increase in concentration was not significant.
5) The uptake of N, P and K in the various plant parts was decreased due to decrease in the level of fertilizer. The decrease due to the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer) compared to 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) was by 10.53 and 9.27, 6.43 and 7.48, 10.51 and 12.33 during 2002-03 and 2003-04, respectively.

6) The protein content, husk percentage and swelling factor was not altered due to the levels of fertilizers applied.
7) There was no change in the pH, electrical conductivity and bulk density of the soil.
8) The organic carbon was not changed, the total nitrogen content of the soil was increased (0.0003%) and the C:N ratio decreased (0.01) due to the application of 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer).
9) The available N, P, and K of soil were significantly influenced and the application of 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer) resulted in higher i.e. (206.78 and 204.25, 25.89 and 25.91, 465.78 and 458.45 N, P, K kgha^{-1} during 2002-03 and 2003-04, respectively) over the application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) (100% inorganic fertilizer) (202.55 and 197.51, 24.65 and 25.44, 465.76 and 455.20 N, P, K kgha^{-1} during 2002-03 and 2003-04, respectively).
10) There was a increase in net monetary returns (Rs. 11,247/- ha^{-1}) and Benefit:Cost Ratio (1.62) on pooled mean basis due to the application of 100% RDF (50:25:0 NPK kgha^{-1}) (100% inorganic fertilizer).
11) The plant attributes viz., plant height, number of productive tillers, total dry matter, number of productive spikes, length of spike, girth of spike, number of seeds spike^{-1}, weight of seeds spike^{-1}, number of seeds plant^{-1} and thousand seed weight were positively and significantly correlated, the regression also showed a positive and significant association with weight of seeds plant^{-1}.

Interaction effects.

There was no significant interaction effect of main and sub plot treatments for the characters of growth, yield contributing characters, yield, uptake and economics.

6.3 Conclusions.

From the present investigation the following conclusions are drawn.

1) Application of 100% RDF (75:50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) to *senna* (*sonamukhi*) during kharif season was found superior in respect of growth, yield contributing characters, dry leaves (23.44 qha^{-1}) and seed yield (2.99 qha^{-1}) over 100% RDF applied through inorganic fertilizer.
2) Similarly, the application of 100% RDF (75:50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) registered higher uptake of nitrogen (79.30 and 80.81 kgha^{-1}), phosphorus (54.78 and 56.20 kgha^{-1}) and potassium (23.49 and 23.91 kgha^{-1}) by *senna* (*sonamukhi*) during 2002-03 and 2003-04, respectively over 100% RDF applied through inorganic fertilizer.
3) Regarding *isabgol* (rabi season crop), application of 100% RDF (50:25:0 NPK kgha^{-1}) applied through inorganic fertilizer registered maximum growth, yield contributing

characters and seed yield (8.16 qha^{-1}) over 75% RDF (37.50:18.75:0 NPK kgha^{-1}) applied through inorganic fertilizer.

4) Similarly, application of 100% RDF (50:25:0 NPK kgha^{-1}) applied through inorganic fertilizer recorded higher uptake of nitrogen (48.24 and 47.90 kgha^{-1}), phosphorus (22.38 and 22.58 kgha^{-1}) and potassium (12.84 and 12.90 kgha^{-1}) by *isabgol* during 2002-03 and 2003-04, respectively.
5) The sennoside content in leaves and pods of *senna* (*sonamukhi*), protein content, husk percentage and swelling factor of *isabgol* seed remained unaffected by the application of different fertilizer levels.
6) Application of 75% RDF (37.50:18.75:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* crop preceded by the use of 50% RDF (37.50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *senna* (*sonamukhi*) during kharif season decreased the pH of soil from 8.12 to 8.09 at the end of two years of cropping.
7) Application of 100% RDF (50:25:0 NPK kgha^{-1}) and 75% RDF (37.50:18.75:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* preceded by the use of 125% RDF (93.75:62.50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) to *senna* (*sonamukhi*) increased the organic carbon of soil from 0.512 to 0.518% and total nitrogen from 0.0458 to 0.0467% only in application of 100% RDF to *isabgol*.
8) *Senna* (*sonamukhi*) – *isabgol* cropping sequence recorded maximum gain in nitrogen (29.33 kgha^{-1}), phosphorus (5.82 kgha^{-1}) and potassium (10.76 kgha^{-1}) with the application of 125% RDF (93.75:62.50:0 NPK kgha^{-1} in which 50% N through urea and 50% N through FYM) to *senna* (*sonamukhi*) and 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol*.
9) Application of 125% RDF (93.75:62.50:0 NPK kgha^{-1}) through inorganic fertilizer to *senna* (*sonamukhi*) and 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* registered higher net monetary returns (Rs. 76,901/- ha^{-1}) and Benefit:Cost ratio (2.04) at the end of two years of experimentation.
10) The correlation and regression association between the different plant characters with weight of seeds plant^{-1} for *senna* (*sonamukhi*) and *isabgol* was positive and significant.

Thus, after two years of experimentation it could be concluded that application of 125% RDF (93.75:62.50:0 NPK kgha^{-1}) through inorganic ferilizer to *senna* (*sonamukhi*) during kharif season followed by application of 100% RDF (50:25:0 NPK kgha^{-1}) through inorganic fertilizer to *isabgol* during rabi season was found to be the most remunerative proposition for achieving maximum monetary returns and improving soil health.

7. LITERATURE CITED

7. LITERATURE CITED

Anonymous. 1994. Indian medicinal plants. A compodeium of 500 species. Eds. Warrier, P.K., Nambiar,V.P.K., Ramankutty, C.© Orient Longman. 2: pp.23.

Anonymous. 2005 a. Department of Ayurveda, Yoga, Naturopathy, Unani, Siddha and Homeopathy (AYUSH). http//www.indianmedicine.nic.in/ht.

Anonymous.2005b.Exportprospectusofmedicinalplantsfrom India.http://www.techno-preneur.net/new-times/sciencetechmag/Oct.05/export_prospects.pdf.

A.O.A.C. 1975. Official Methods of Analysis. Association of Official Analytical Chemists. 12th Ed. Washington D.C., U.S.A. pp.16.

Arumugam, T., Doraipandian A., Premlakshmi, V. and Vijaykumar M. 2001. Studies on the effect of bio fertilizer on biomass production in senna (*Cassia angustifolia* Vahl.). Changing scenario in the production systems of horticultural crops. Proc. Nat. Sem., Coimbatore, Tamil Nadu, India. 28-30 August, 2001, South Indian Hort.49: special. 178-180.

Auti, A.K. 1996. Response of wheat (Triticum aestivum L.) HD-2189 to different levels and sources of fertilizer. M.Sc. (Agri.) Thesis submitted to M.P.K.V. Rahuri, M.S., India.

Bachhav, P.R. 1994. Study of nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of soybean (*Glycine max* (L.) Merrill) (*kharif*) and to study the residual effect to find out reduction in nitrogen requirement of wheat (*rabi*). M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri, M.S., India.

Bachhav, P.R. and Sabale R.N. 1996. Effects of different sources of nitrogen on growth parameters, yield and quality of soybean. J. Maharashtra agric. Univ., 21(2): 244-247.

Badanur, V.P., Poleshi, C.M. and Naik, K. and Balachandra. 1990. Effect of organic matter on crop yield and physical and chemical properties of a vertisol. J.Indian. Soc. Soil. Sci. 38(3): 426-429.

Balasubramaniyan. P. 1997. Integrated nutrient management in irrigated groundnut (*Arachis hypogea*). Indian J. Agron.42 (4): 683-687.

Banait, D.M. 1991. Effect of application of borax with and without FYM on the yield and quality of groundnut grown on medium black calcareous and non-calcareous soil. M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri, M.S., India.

Bansode, B.D. 1995. Studies on nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of pigeonpea (*Cajanus cajan* L. Millsp) (*kharif*) and to study the residual effect to find out reduction in nitrogen requirement of wheat (*rabi*). M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri, M.S., India.

Basuchaudhari, P. and Dasgupta, D.K. 1987. Photosynthetic rate and yield relationships in some late duration high yielding rice. Indian J. Plant. Physiol. XXX (4): 400-403.

Bellakki, M.A. and Badanur.V.P. 1997. Long-term effect of integrated nutrient management on soil properties of vertisol under dryland agriculture. J.Indian Soc. Soil. Sci. 45(3): 438-442.

*Beresteskii, O.A., Andreeva, N.A. and Patyak, V.K. 1986. Nitrogen fixing cynaobacteria in the rhizosphere of rice grown continuously and in crop rotation. Soviet agriculture. Biology l, Plant Biology. 3: 120-124.

Bhakare, B.D. and Sonar, K.R. 2000. Forms of phosphorus in soil as influenced by phosphate application to soybean. J. Maharashtra agric Univ. 25(1): 85-86.

Bhand, S.S. 1994. Studies on nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of groundnut (*Arachis hypogea* L.) (*kharif*) and to study the residual effects to find out reduction in requirement of wheat (*rabi*). M.Sc. (Agri) Thesis, submitted to M.P.K.V. Rahuri, M.S., India.

Bhandari, A.L., Sood, Anil, Sharma, K.N. and Rana, D.S. 1992. Integrated nutrient management in rice-wheat system. J. Indian Soc.Soil Sci. 40(4): 742-747.

Bhaskar, S. Vasantha Kumar, T. and Shivananda, T. N. 2002. Response of *Solanum viarum* to phosphorus and potassium application. Indian. J. Agron. 47 (2): 294-297.

Bhattacharya, P. and Mittra Bhaskar. 2002. The healing touch. M.P. case study of sustainable medicinal plants conservation in JFM areas. Wasteland News, XVII (2): 32-38.

Bhojvaid, P.P. 2003. Medicinal plants based forest management: Problems and prospects. Ind. For. 129 (1): 25-26.

Bist, L.D., Singh, A.K and Kewalanand. 2000. Growth and yield of isabgol (*Plantago ovata* Forsk.). cv. Gujarat Isabgol-2 in response to nitrogen levels. Prog. Hort. 32(2): 202-203.

Bist, L.D., Singh, A.K. and Kewalanand. 2001. Effect of nitrogen doses on growth and yield of blond psyllium (*Plantago ovata.*). Indian J. agric. Sci. 71(11): 709-710.

Biswas, D.R., Ali, S.A. and Kheera, M.S. 1995. Response of *gobhi sarson* (Brassica hapus L.) to nitrogen and sulphur. J.Indian Soc.Soil Sci. 43(2): 220-223.

Brasher, B.R. Franzmeier, D.P., Valassis, V. and Davidson, S.E. 1966. Use of saran resin to coat natural soil clods for bulk density and water-retention measurements. Soil Sci. 101(2): 108.

Burman Uday, Garg, B.K., Kathju, S. and Burman, U. 2002. Interactive effects of saline water irrigation and nitrogen fertilization on growth and metabolism of isabgol (*Plantago ovata.* Forsk.). J. Plant biology. 29(3): 249-255.

Chawla, K.L. and Chabra, R. 1991. Physical properties of a gypsum amended sodic soil as affected by long term use of fertilizers. J.Indian Soc. Soil. Sci. 39(1): 40-45.

Choudhary, S. N., Balyan, S.S. and Kaul, B.L. 1979. Effect of nitrogen on the growth and yield of *Solanum khasianum* Clarke. Indian Drugs 16(7): 229-230.

Cochron, W.G. and Cox.G.M. 1967. Experimental design 2nd Edn. London, Oliver and Boyd.

Dahiya, D.P. 1990. Effect of chloride and sulphate of copper on salinity, pH and nitrogen mineralization of soil during growing of wheat. J.Indian Soc.Soil. Sci. 38(3): 555-557.

Dalal, K.C. and Sriram, S. 1995. Psyllium. *In.* Advances in Horticulture. Vol.11 - Medicinal and Aromatic Plants (1995).Eds: K.L. Chadha and Rajendra Gupta. Malhotra Publishing House, New Delhi, India. pp. 575-604.

De Silva, T. 1995. Medicinal plants for conservation and health care; Industrial utilization of medicinal plants in developing countries. In: Non-wood Forest Products Bulletin No. 11: Non-wood forest products for rural income and sustainable forestry. ISBN 92-5-104063-X. © FAO. pp. M-37.

Deore, G.N., Ghule, S.T., Bhuse, V.H. and Mahajan, R.S. 2002. Effect of sowing methods, seed rates and nitrogen levels on seed yield of isabgol. New Botanist. 29 (1-4): 21-26.

Dhar, U., Rawal, R.S. and Upreti. 2000. Setting priorities for conservation of medicinal plants as a case study in the Indian Himalayas. Biological conservation, 95: 57-65.

Donald, C.M.1962. In search of yield. J. Aust. Inst. Agril. Sci.28(3):171-178.

Duraisingh, R. and Gopalaswamy, N. 1991. Effect of plant geometry and levels of nitrogen and phosphorus on the productivity of soybean (*Glycine max*). Indian J. Agron. 36(4): 545-548.

Fisher, R.A. and Yates. F. 1963. Statistical tables for biological, agricultural and medical research. 6th Edn. Oliver and Boyd. London. pp. 63.

Fisher, R.A. 1970. Statistical methods for research workers. 14th Edn. London. Oliver and Boyd.

Flavido, H. and Grant W. Thomas. 1998. Phosphorus nutrition effects wheat response to water deficit. Agron. J. 90(2): 166-171.

Gaidhane, S.T. 1994. Response of nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of groundnut (*Arachis hypogea* L.) (*kharif*) and to study the residual effect to find out reduction in nitrogen requirement of wheat (*rabi*). M.Sc. (Agri) Thesis, submitted to M.P.K.V. Rahuri, M.S., India.

Gee, G.W and Boudar, J.W. 1986. Particle size analysis. *In* Methods of soil analysis. Part-1. Kulte, A (ed.) Amer. Soc. Agron. Inc., Soil Sci. Soc.Amr. Inc., Madison. Wisconin, USA. pp. 383.

Gupta, R. 1967 a. Medicinal and aromatic plants - Isabgol. *In* Handbook of Agriculture (3rd ed.) ICAR. New Delhi. pp.1192-1193.

Gupta, R. 1967 b. Medicinal and aromatic plants - Senna. *In* Handbook of Agriculture (3rd ed.) ICAR. New Delhi. pp.1196-1197.

Gupta,R., Srivastava, V.K. and Maheshwari.M.L. 1977. Sennoside content in senna leaves and pods as influenced by growth and nutrition. Indian J. Pharm. 39(5): 109-111.

Hegde, D.M. 1988. Response of periwinkle (*Catharanthus roseus* (L.) G. Don) to nitrogen, phosphorus and potassium fertilization. Agric. Res. J. Kerala 28(2): 227-233.

Hooda, I.S. and Agarwak, S.K. 1987. Studies on irrigation, weed control and fertility levels on growth and yield of wheat. Indian J. Agron. 32(3): 261-264.

Huang, C.L. and Shuttle, E.E. 1985. Digestion of plant tissue for analysis by ICP emission spectroscopy. Column. Soil Sci. Plant Anal., 16: 943-958.

Ilangovan, R., Subbiah, R. and Natarajan, S.-1989. Flowering and yield in senna (*Cassia angustifolia* Vahl.) as influenced by spacing, nitrogen and phosphorus. South Indian Hort. 37(2): 103-107.

Ilangovan, R., Subbiah, R. and Natarajan, S. 1990. Effect of spacing, nitrogen and phosphorus on certain growth parameters of senna (*Cassia angustifolia* Vahl.). South Indian Hort. 38(1): 53-54.

Ilangovan, R., Subbiah, R. and Natarajan, S. 1991. Influence of spacing, nitrogen and phosphorus on sennoside content in senna (*Cassia angustifolia* Vahl.). South Indian Hort. 39(2): 113-116.

Intodia, S.K. and Tomar, O.P. 1998. Response of psyllium (*Plantago ovata*) genotypes to nitrogen and phosphorus on heavy soil. J. Med. Arom. Pl. Sci. 20(4): 1042-1044.

Jackson, M.L. 1973. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi. pp.489.

Jadhav, C.N., Sukhadia, N.M. and Ramani, B.B. 2000. Effect of sowing dates, nitrogen and phosphorus on growth and yield of isabgol (*Plantago ovata* Forsk.). Gujarat Agril. Univ.Res. J. 25(2): 84-87.

Jadhav, A.S., Verma, O.P.S., Yadav, M.V. and Shaikh, A.A. 1996. Response of pearl millet hybrid to nitrogen in intercropping systems. J. Maharashtra agric Univ. 21(3): 412-415.

Jagtap, J.B. 1993. Response of nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of soybean (*Glycine max* L. Merrill) (*kharif*) and to study the residual effect to find out reduction in nitrogen requirement of wheat (*rabi*). M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri, M.S., India.

Kala, C.P. 2003. Commercial exploitation and conservation status of high value medicinal plants across the borderline of India and Nepal in Pittoragarh. Ind. For.129 (1): 80-84.

Kalyansundaram, M.N., Amin, D.K., Patel, A. I. and Dalal, K.C. 1981 a. Effect of nitrogen and phosphorus on yield and quality of *senna* leaflets. Indian J. Pharm. Sci. 43(3): 100-102.

Kalyansundaram, N.K. and Dalal, K.C. 1981 b. Correlation between yield components and seed yield in isabgol (*Plantago ovata* Forsk.). Agric. Sci.Digest, 1(2): 85-86.

Kalyansundaram, N.K., Patel, P.S. and Dalal, K.C. 1982. Nitrogen need of *Plantago ovata* Forsk. In relation to the available nitrogen in soil. Indian J. agric. Sci.52 (4): 240-242.

Kalyansundaram, N.K., Sriram, S., Patel, B.R., Patel, R.B., Patel, D.H., Dalal, K.C. and Gupta, R. 1984. Psyllium: A monopoly of Gujarat. Indian Hort. 28(4): 35-37 and 41.

Kamble, B.M. and Mohite, A.V. 1996. Effects of phosphate and biophos culture inoculation on nutrients concentration, quality of groundnut and yield of subsequent wheat crop. J. Maharashtra agric Univ. 21(3): 324-327.

Kasturikrishna, S and Ahlawat, I.P.S. 1999. Growth and yield response of pea (*Pisum sativum*) to moisture stress, phosphorus, sulphur and zinc fertilizers. Indian J. Agron. 44 (3): 588-596.

Knudsen, D. and Peterson, G.A. 1982. Lithium, sodium and potassium. *In* Methods of soil analysis. Part 2. A.L. Page (ed.). Agronomy monogram No. 9: 225-246. Amer. Soc. Agron. Inc., Soil Sci. Soc. of Amr., Inc Madison. Wisconsin, USA.

Krishnamoorthy, V. and Madalageri, M.B. 2002. Effect of nitrogen and phosphorus nutrition on growth of *ajowan* genotypes (Trachyspermum ammi). J. Med. Arom Pl. Sci. 24(1): 45-49.

Kumar, D., Jha, B.K. and Kumar, D. 2000. Studies on performance of *isabgol* (Plantago ovata Forsk.) genotypes in Middle Gujarat conditions. Indian J. Horticulture. 57(3): 264-267.

Kumawat, S.M. and Bansal, K.N. 1996. Residual effect of sulphur sources in combination with nitrogen and plant-growth regulator on sorghum (*Sorghum bicolor*). Indian J. Agron. 41 (4): 647-649.

Kumawat, S.K., Gaur, B.L. and Nepalia, V. 2002. Weed dynamics and NPK uptake by blonde psyllium (*Plantago ovata*. Forsk.) as influenced by sowing methods, nitrogen and weed management. Indian J. Weed. Sci.34 (3-4): 254-258.

*Kwakye, P.K. 1988. The influence of organic matter in combination with mineral fertilizer on crop yield and soil properties on a Savana soil in Ghana under continuous cropping. J. Trop. Agri.6: 56-57.

Lal, R.K., Mishra, H.O., Singh, S.P., Sharma, S. and Sharma J.R. 1992. Choice and improvement of superior genetic stocks of senna (*Cassia angustifolia*). Intern. J. Pharma. 30(1): 56-60.

Lal, P. and Sharma, K.C. 1976. Water studies in two dwarf varieties of wheat grown at different levels of soil moisture and nitrogen under shallow water table conditions. Indian J.Agron.21(2): 453-459.

Lambert, J., Srivastava, J. and Vietmeyer, N. 1997. Medicinal plants- Rescuing a global heritage. World Bank Technical paper no.355. pp.ix.

Lange, D.1997. Trade figures for botanical drugs world-wide. Med. Plant Cons. Newsletter, 3: 16-17.

Maheshwarappa, H.P., Nanjappa, H.V. and Hegde, M.R. 2000. Dry matter production and accumulation in different parts of *galangal* (Kaempferia galanga) as influenced by agronomic practices when grown as an intercrop in coconut garden. Indian J. Agron. 45 (4): 698-706.

Maheshwari, S.K., Sharma, R.K. and Gangrade, S.K. 2000 a. Response of ashwagandha (*Withania somnifera*) to organic manures and fertilizers in a shallow black soil under rainfed condition. Indian J. Agron. 45(1): 214-216.

Maheshwari, S.K., Sharma, R.K. and Gangrade, S.K. 2000 b. Performance of isabgol or blond psyllium (*Plantago ovata*) under different levels of nitrogen, phosphorus and bio-fertilizers in shallow black soil. Indian J. Agron. 45(2): 443-446.

Mahimaraja, S., Helkiash, J. and Gopalaswamy, A. 1986. Long-term effects of graded doses of fertilizers and manures on soil physical conditions. Madras Agric.J. 73(6): 340-347.

Mali, L.B.1994.Effect of sowing dates and nitrogen levels on yield of green foliage of senna (*Cassia angustifolia* Vahl.) during *kharif* season.M.Sc.(Agri.) thesis submitted to M.P.K.V.,Rahuri,M.S.,India.

Maliwal, G.L. 1990. Response of phosphorus application in different phases of groundnut (*Arachis hypogea*) - wheat (*Triticum aestivum*) system on the crop productivity and phosphorus uptake. Indian J. agric. Sci. 60(2): 145-147.

Mandal, S.S., Pramanik, C.K. and Das, J. 2001. Effect of nitrogen and potassium on yield, nutrient uptake and soil fertility in soybean (*Glycine max*) – sesame (*Sesamum indicum*) intercropping system. Indian J. agric. Sci. 71(1): 44-46.

Manjkhola, S. and Dhar, V. 2002. Conservation and utilization of *Arnebia benthamii* (Wall. Ex. G. Don) Johnston- A high value Himalayan medicinal plant. Curr. Sci. 83(4): 484-488.

Mann, P.S. and Vyas, A.K. 1999. Effect of sowing dates and nitrogen levels on growth and nutrient uptake by isabgol (*Plantago ovata* Forsk.). Ann. agric. Res. 20(4): 517-518.

Mann, P.S. and Vyas, A.K. 2001. Effect of sowing dates and nitrogen levels on yield, quality and net returns of blond psyllium (*Plantago ovata* Forsk.). Ann. agric. Res. 22(3): 425-428.

Matai, S., Banerjee, A. and Bagchi, D. 1980. Effect of nitrogen on fodder and extracted protein yield of Bajra in Gangetic alluvium soil. Indian J. agril. Chem. XIII (2): 81-85.

*Mehrotra, C.L. and Saxena, U.P. 1970. Cation exchange capacity of plant roots as an index of fertility status of soils. Indian J. agril. Sci.40(10): 889-893.

*Miller, M.H., Mitchell, W.A., Stypa, M. and Barry D.A. 1987. Effects of nutrient availability and subsoil bulk density on corn yield and nutrient adsorption. Canadian J. Soil Sci. 67: 281-292.

Mishra, A., Dash, P. and Paikaray, R.K. 1995.Yield and nutrient uptake by winter sunflower (*Helianthus annus*) as influenced by nitrogen and phosphorus. Indian J. Agron. 40 (1): 137-138.

Motsara. 1999. Need for the right mix. The Hindu Survey of Agric.pp.169-173.

Muhr, G.R., Datta, N.P., Sankarasubramoney, H., Leley, V.K. and Donahure, R.L. 1965. Soil Testing in India, 2nd Ed. USAID, Mission to India, New Delhi.pp.120.

Muniramappa, R.P., Farooqi, A.A., Rudre Gowda, H.G. and Maricapu, S. 1997. Influence of macro nutrients on yield and active principle content in Kalmegh. J.Med. Arom. Pl. Sci. 19: 1039-1042.

Murugappan, V., Santhy, P., Selvi, D and Peramal Rani. 1998. *In.* Long term soil fertility management through integrated plant nutrient supply. (Swarup, A., Pamodar Reddy, D. and Prasad, R.N. Eds.). Indian Institute of Soil Science, Bhopal. pp.194-205.

Muthuvel, P., Subramanian, V. and Sivaswamy, R. 1985. Effect of organic, inorganic and bio fertilizer on rainfed redgram. Madras agric.J.72(3):167-177.

Nambiar, K.K.M., Soni, P.N., Vats, M.R., Sehgal, D.K. and Mehta, D.K. 1992. Annual report 1987-88,1988-89. All India co-ordinated Research Project on long term fertilizer experiment, ICAR, New Delhi.

Nandan Ravi and Prasad, U.K. 1998. Effect of irrigation and nitrogen on growth, yield, nitrogen uptake and water-use efficiency of fresh bean (*Phaseolus vulgaris*). Indian J. agric. Sci. 67 (11): 75-80.

Nandi, R.P. and Chatterjee, S.K. 1981. Senna cultivation in West Bengal. I. Effects of spacings and fertilizers. Ind. For. 107 (2): 111-114.

Naphade, K.T., Deshmukh, V.N., Rawatkar, S.S. and Solanki, B.U. 1993. Grain and nutrient uptake by irrigated wheat grown on vertisol under various nutrient levels. J. Indian Soc. Soil Sci. 41(2): 370-371.

Navale, K.B., Gaikwad, C.B. and Tamboli, B.D. 2000. Effect of integrated nutrient management on yield, nutrient availability and uptake of nutrients by soybean. J. Maharashtra agric Univ. 25(1): 105-107.

Nelson, D.W. and Sommers.L.E. 1982. Total carbon, organic carbon and organic matter. *In* Methods of soil analysis. Part 2. A.L. Page (ed.). Agronomy monogram No. 9: 539-579. Amer. Soc. Agron. Inc., Soil Sci. Soc. of Amr. Inc., Madison. Wisconsin, USA.

Newaj, Ram and Yadav, D.S. 1994. Changes in physico-chemical properties of soil under intensive cropping system. Indian J. Agron. 39(3): 373-378.

Nimje, P.M. and Seth, J. 1987. Effect of phosphorus and farmyard manure on soybean and their residual effect on succeeding winter maize. Indian J. agric. Sci. 57 (6): 404-409.

Nimje, P.M. and Seth, J. 1988. Effect of phosphorus and farmyard manure on nutrient uptake by soybean. Indian J. Agron. 33(2): 139-142.

Olsen, S.R. and Sommers, L.E. 1982. Phosphorus. *In* Methods of soil analysis. Part 2. A.L. Page (ed.). Agronomy monogram No.9: 403-430. Amer. Soc. Agron. Inc., Soil Sci. Soc. of Amer. Inc., Madison. Wisconsin, USA.

Panse, V.G. and Sukhatme, P.V.1978. Statistical methods for agricultural methods. Third revised Edn. ICAR, New Delhi. pp.157-165.

Pareek, S.K., Kidwai, M.A., Saxena, R.K. and Gupta, R. 1988. Investigation on some agronomic inputs influencing yield of henbane. Indian J. Agron. 33(3): 249-252.

Pareek, S.K., Srivastava, V.K. and Gupta, R. 1989. Effect of source and mode of nitrogen application on senna (*Cassia angustifolia* Vahl.). Tropical agric. 66(1): 69-72.

Parihar, G. N. and Singh Rajender. 1995. Response of psyllium (*Plantago ovata*) to nitrogen and phosphorus fertilization. Indian J. Agron. 40(3): 529-531.

Patel, B.S., Patel J.C. and Sadaria S.G. 1996. Response of blond psyllium (*Plantago ovata*) to irrigation, nitrogen and phosphorus. Indian J. Agron. 41(2): 311-314.

Patel, R.M. and Upadhyay, P.N. 1993. Response of wheat (*Triticum aestivum*) to irrigation under varying levels of nitrogen and phosphorus. Indian J. Agron. 38(1): 113-115.

Patel, S.R. and Chandravanshi, B.R. 1996. Nitrogen and phosphorus nutrition of soybean (*Glycine max*) grown in vertisol. Indian J. Agron. 41 (4): 601-603.

Patel, S.R., Naik, M.L. and Chandravanshi, B.R. 1992. Effect of nitrogen and phosphorus level on growth, yield and protein content of soybean (*Glycine max* (L.) Merrill). J. Oil Seed Res. 9(2): 202-208.

Patel, A.M. 1994. Response of nitrogen through manures and fertilizers alone and their combinations on the growth, yield and quality of pigeon pea (*Cajanus cajan* (L.) Millsp.) (*kharif*) and the residual effect to find out reduction requirement of wheat (*rabi*). M.Sc. (Agri.) Thesis, submitted to M.P.K.V., Rahuri, M.S., India.

Patel, J.R. and Shelke, V.B. 2000. Effect of organic and inorganic fertilizers on yield of mustard. J. Maharashtra agric Univ. 25(1): 70-71.

Patil, V.R., Khopade, A.J., More, H.N., Mahadik, K.R. and Kadam, S.S. 1996 a. An alternative method of analysis of senna leaves and pods. Indian J. Nat. Prod. 12(1): 9-12.

Patil, J.D., Patil, A.J., Gaikwad, B.G. and Sonawane, S.S. 1996 b. Recycling of crop residue in soil and its effect on performance of *rabi* sorghum under dryland condition. J. Maharashtra agric Univ. 21(2): 186-189.

Patil, M.N., Zade, K.B., Naphade, K.T. and Kharkar, P.T. 1993. Decomposition of organic materials in soil in relation to nutrient mineralization. J. Maharashtra agric. Univ., 18(3): 348-351.

Pattar, P.S., Nadagouda, V.B., Salakinkop, S.R., Kannur, V.S. and Gaddi, A.V. 1999. Effect of organic manures and fertilizer levels on nutrient uptake, soil nutrient status and yield of groundnut (*Arachis hypogea* L.). J. Oilseeds Res. 16(1): 123-127.

Piper, C.S. 1966. Soil and plant analysis. Inter Science Pub. Inc., New York, 4th Ed. pp.135-200.

Prasad, Arun, Patra, D.D., Anwar, M. and Singh, D.V. 1997.Interactive effects of salinity and nitrogen on mineral N status in soil and growth and yield of German chamomile (*Matricaria chamomilla*). J.Indian Soc.Soil. Sci. 45(3): 537-541.

Prasad, N.K. and Kumar, S. 1999. Nutrient harvest and soil fertility as influenced by legume-wheat (*Triticum aestivum*) sequences. Indian J. agric. Sci. 69(3): 167-171.

Purakayastha, T.J., Katyal, J.C. and Goswami, N.N. 1997. Evaluation of ammonia volatilization from some modified urea fertilizers. J. Indian Soc. Soil Sci. 45(1): 9-14.

Radford, P.J. 1967. Growth analysis formulae. Their uses and abuses. Crop Sci. 7: 171-175.

Rai, S.K., Katiyar, R.S. and Singh, S.P. 2002. Effect of nitrogen and phosphorus on the growth and yield of *Foeniculum vulgare* on the sodic soil. J. Med. Arom. Pl. Sci. 24: 65-67.

*Rajput, F.K., Arain, A.S., Rajput, M.S. and Khawaja, K.B. 1983. Effect of row spacing and fertilizer levels on the yield and growth of sorghum. Pakistan J. Agric. Res. 4:166-170.

Raju, R.A. and Reddy, M.N. 2000. Integrated management of green leaf, compost, crop residues and inorganic fertilizers in rice (*Oryza sativa*) rice system. Indian J.Agron. 45(4): 629-635.

Ramamoorthy, K., Krishnaveni, K. and Aruna, N. 2003. Effect of manure, fertilizer and spacing on herbage and seed yield in senna (*Cassia angustifolia* Vahl.). Plant Archives. 3(2): 287-290.

Ramesh, M. N., Farooqi, A.A. Thilak, Subbaiah and Subbaiah T. 1989. Influence of sowing date and nutrients on growth and yield of isabgol (*Plantago ovata* Forsk.). Crop Res. Hisar. 2(2): 169-174.

Rao Venkateshwara, K and Rao Madhava, K.V. 1983. Influence of potassium nutrition on stomatal behaviour, transpiration rate and leaf water potential of pigeonpea. (*Cajanus cajan* (L.) Millsp) in sand culture. Proc. Indian Academy of Sci.92: 323-330.

Rathore, B.S. and Chandawat M.S. 2003. Influence of irrigation, row orientation and nitrogen on downy mildew of blond psyllium. Ind. Phytopath. 56 (4): 453-456.

Rayer, A.J. 1984. Response of groundnut (*Arachis hypogea*) to application of farmyard manure and N and P on light sandy loam savanna soil of northern Nigeria. Int. J. Tropical Agric. 41(1): 46-54.

Reddy, T.R., Rao, M. and Rao, K.R. 1990. Response of soybean (*Glycine max* (L.) Merrill.) to nitrogen and phosphorus. Indian J. Agron. 35(3): 308-310.

Richards, L.A. 1948. Power plate apparatus for the moisture retention and transmission of soil. Soil Sci 66:105-110.

Sagare, B.N., Guhe, Y.S., Deshmukh, B.A. and Deshmukh, A.B. 1992. Biological yield and uptake of nutrients by peanuts as enfluenced by enriched FYM products. J. Maharashtra agric. Univ. 17(1): 100-102.

Sahu, G.C., Sahu, S.K. and Dash, A.K. 1993. Direct and residual effect of phosphate on rice-groundnut and groundnut-wheat cropping sequence in acid soils of Orissa. Abstract for 58th Conv. Indian Soc. Soil Sci.8-12: pp. 104.

Sankaranarayanan, R., Muthusamy, S. and Khader, M.A. 1992. Variability studies in senna. South Indian Hort. 40(2): 93-95.

Sankaranarayanan, R. 1995. Evaluation of senna. Madras agric. J. 82(12): 643-645.

Sarma, T.C., Chaudhuri, S.B. and Bordoloi, D.N. 1982. Response of different levels of N, P and K on herb yield and Digoxin content of *Digitalis lanata* Ehrh. Indian Drugs 19(7): 267-270.

Sengar, S.S. Wade, L.J., Baghel, S.S., Singh, R.K. and Singh G. 2000. Effect of nutrient management on rice (*Oryza sativa*) in rainfed lowland of southeast Madhya Pradesh. Indian J.Agron.45 (2): 315-322.

*Shakhela, R.R., Patel, C. A. and Tikka, S.B.S. 1984. Effect of nitrogen application on the yield, nitrogen content and uptake by isabgol. Garcia-de-Irta-Estudos-Agronomicos.11(1-2): 1-4.

Sharma, S.R., Bhandari, S.C. and Purohit, H.S. 2002. Effect of organic manure and mineral nutrients on nutrient uptake and yield of cowpea. J. Indian Soc. Soil. Sci. 50(4): 475-480.

Sharma, R.A. and Dixit, B.K. 1987. Effect of nutrient application on rainfed soybean (*Glycine max* (L.) Merrill.) J. Indian Soc.Soil.Sci. 35(3): 452-455.

Sharma, A.K. and Garg, D.K. 2002. Correlated response and correlations in isabgol (*Plantago ovata* Forsk.). Crop Improvement 29(1): 110-112.

Sharma, A.K., Goyal, R.K. and Gupta, J.P.1999 a. Senna-the best choice for sandy wastelands. Indian Fmg. 49(3): 18-20.

Sharma, S.S. and Gupta, S. 1988. Effect of nitrogen and phosphorus on growth and alkaloid content of *Tylophora indica* Burm F. (Mer). Indian Drugs 25 (7): 263-265.

Sharma, S.K. and Sharma, S.N. 2002. Integrated nutrient management for sustainability of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian J. agric. Sci. 72(10): 573-576.

Sharma, R.K., Shrivasatva, U.K., Tomar, S.S., Tiwari, P.N. and Yadav, R.P. 1999 b. Nutrient management in soybean (Glycine max) – mustard (Brassica juncea) crop sequence. Indian J. Agron. 44(3): 493-498.

Sharma, M.P., Wali, P. and Gupta, J.P. 2003 a. Long term effect of chemical fertilizers on rice-wheat productivity and fertility of an inceptisol. Ann. Agric. Res. New Series. 24(1): 91-94.

Sharma, P.K., Yadav, G.L., Kumar Sudesh, Singh, M.M. and Kumar, S. 2003 b. Effects of methods of sowing and nitrogen level on the yield of psyllium (*Plantago ovata*). J. Med. Arom. Pl. Sci. 25(3): 672-674.

Shelke, R.B. 1994. Effect of different levels of plant densities and fertilizers on growth and yield of soybean (*Glycine max* (L.) Merrill) variety MACS-58. M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri, M.S., India.

Singh, D.P. 1974. Relation of refractometer value of cell sap to growth and yield of cereals. Indian J. Plant Physiol. 17 (1&2): 28-35.

Singh, R.A. 1999 a. Integrated input management in groundnut (Arachis hypogea) – wheat (Triticum aestivum) cropping system under drought prone areas of semi-arid regions. Indian J. Agron. 44(4): 673-676.

Singh, A. Awashti, R.P. and Singh, R.D. 1995 a. Effect of fertilizers, manure and lime on soybean (*Glycine max*) growth in mid-hills of Sikkim. Indian J. Agron. 40(4): 613-615.

Singh, A.K., Amgain, L.P. and Sharma S.K. 2000. Root characteristics, soil physical properties and yield of rice (*Oryza sativa*) as influenced by integrated nutrient management in rice-wheat (*Triticum aestivum*) system. Indian J. Agron. 45(2): 217-222.

Singh, Ishwar and Chouhan G.S. 1994. Effect of mixatol and different combinations of nitrogen and phosphorus fertilizer on growth and yield of blond psyllium (*Plantago ovata*). Indian J. Agron. 39(4): 711-712.

Singh, P., Jain, K.K. and Sharma, S.K. 2003 a. Response of isabgol (*Plantago ovata*) to sowing time and nitrogen. J.Maharashtra agric.Univ.28(3): 322-323.

Singh, P., Jain, K.K. and Sharma, S.K. 2003 b. Effect of sowing dates and nitrogen levels on nutrient uptake and quality of isabgol (*Plantago ovata* Forsk.). Ann. agric. Res. 24(1): 197-199.

Singh, J. N. and Kewalanand. 1988. Effect of nitrogen levels and row spacing on seed yield of psyllium. Indian Drugs. 25(11): 459-461.

Singh, J.N. and Kewalanand. 1989. Effect of nitrogen and phosphorus on yield and quality of sarpagandha (*Rauvolfia serpentina* Benth) Indian Drugs. 26(9): 461-464.

Singh, A. K. and Kumar Sushil. 1998. Editorial: Inter-relationship between mediculture and agriculture.J.Med.Arom.Pl.Sci.20 (3): 671-672.

Singh, Y.V. and Mandal, B.K. 1997. Nutrition of rice (*Oryza sativa*) through *Azolla*, organic materials and urea. Indian J. Agron.42 (4): 626-633.

Singh, R., Menna, N.L. and Godara, A.S. 1996. Growth and yield attributes of wheat (*Triticum aestivum* L.) as influenced by phosphorus, zinc sulphate and plant growth regulator. Ann. agri. Bio. Res. 1(1&2): 133-135.

Singh, R.P., Mundra, M.C., Gupta, S.C. and Agarwal, S.K. 1999 b. Effect of integrated nutrient management on productivity of pearlmillet (*Pennisetum glaucum*) – wheat (*Triticum aestivum*) cropping system. Indian J. Agron. 44(2): 250-255.

Singh Laxman, Pal, B. and Singh, L. 2001 a. Effect of saline water and fertility levels on the yield, potassium and zinc content and uptake by blonde psyllium (*Plantago ovata* Forsk.) Crop Res. Hisar.22 (2): 210-216.

Singh, Laxman, Pal, B. and Singh, L. 2001 b. Influence of saline water and fertility levels on nutrient composition and it's uptake by isabgol (*Plantago ovata* Forsk.). Res. on Crops. 2(2): 174-178.

Singh Laxman and Pal, B. 2003. Effect of saline water irrigation and fertility levels on yield and nitrogen, calcium and zinc contents of blonde psyllium. Ann. Arid Zone.42 (2): 131-135.

Singh, G.R., Parihar, S.S., Chaure, N.K., Choudhary, K.K. and Sharma, R.B. 1997. Integrated nutrient management in summer sesame (*Sesamum indicum*). Indian J. Agron.42 (4): 699-701.

Singh Harphool, Sharma, O.L., Kumar Rakesh, Singh, H. and Kumar, R. 1995 b. Economics of nitrogen and phosphorus fertilization in isabgol (*Plantago ovata* Forsk.). Crop Res. Hisar.11 (2): 246-247.

Singh Harphool, Sharma, O.L., Kumar Rakesh, Singh, H. and Kumar, R. 1995 c. Correlation and regression studies in isabgol (*Plantago ovata* Forsk.). Annals of Biology, Ludhiana.11 (1-2): 210-211.

Singh, T., Singh, K.N., Amarjit, S.B. and Bhatt, G.N. 1995 d. Response of wheat (*Triticum aestivum*) genotypes to nitrogen and phosphorus. Indian J. Agron. 40(1): 99-101.

Singh, K.B., Singh Daulat and Singh D.N. 1980. Response of field pea to population density and phosphorus levels. Indian J. Plant Physiol. XXIII (2): 185-191.

Snecdor, G.W. and Cochron, W.G. 1967. Statistical methods VIth Edn. The IOWA State Univ. Press IOWA. USA.

Solanki, N. S. and Shaktawat, R.P.S. 1999. Effect of date of sowing and nitrogen on growth and yield of isabgol (*Plantago ovata*). Indian J. agric. Sci. 69(7): 528-529.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25(8): 259-260.

*Thanki, R.J. and Talati, J.G. 1983. Review of work done on quality evaluation of isabgol seed at Anand. Presented at Vth All India Workshop on Medicinal and Aromatic Plants held at Solan, H.P.

Tomar, S.K., Singh, H.P. and Ahlawat, I.P.S. 1996. Response of wheat based legume intercropping system to nitrogen fertilizer. Indian J. Agron. 41(4): 515-521.

Utgikar Swarupa, Sadawarte K.T., Wankhade, S.G. and Utgikar, S. 2003. Growth and yield of isabgol (*Plantago ovata* Forsk.) as influenced by nitrogen and phosphorus levels. Agric. Sci. Digest.23 (1): 77-78.

Varavipor, M., Hasan, R. and Singh, D. 1999. Effect of applied phosphorus, sulphur and zinc on yield and uptake parameters of wheat (*Triticum aestivum* L.) and soybean (*Glycine max*) grown on a loamy sand. Indian J. agric Sci. 69 (1): 1-4.

Verma, U and Rajput, O.P. 1999. Effect of N P and K on productivity and soil fertility in pearlmillet (*Pennisetum glaucum*)–wheat (*Triticum aestivum*) cropping system. Indian J. Agron. 44(3): 483-487.

Vig, A.C., Bhal, A.C. and Milapchand. 1991. Phosphorus - Its transformation and management under rice-wheat system. Fert. News. 44 (11): 33-46.

---

* Originals not seen

8. VITA

8. VITA

KHARBADE SWAPNIL HEMRAJ

A candidate for the degree of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

In

AGRONOMY

Title of thesis: "Effect of integrated nutrient management in *senna* (Cassia angustifolia) – *isabgol* (Plantago ovata) cropping sequence on growth, yield and quality of constituent crops."

Major field: Agronomy.

Biographical information:

Personal: Born at Pune, Dist: Pune (Maharashtra) on 4th October 1976.

Education: Passed S.S.C. from J.N. Petit Technical High School, Pune in 1992 and H.S.C. from Nowrosjee Wadia College, Pune in 1994. Received the Bachelor of Science (Agriculture) degree in 1998 and Master of Science (Agriculture) in Agronomy degree in 2001 from College of Agriculture, Pune of M.P.K.V. Rahuri, Dist: Ahmednagar (Maharashtra). Joined Ph.D. in the discipline of Agronomy at the Post Graduate Institute, M.P.K.V. Rahuri, Dist: Ahmednagar (Maharashtra) in 2001.

M.P.K.V. Rahuri LIBRARY

T 6219

9.APPENDICES

APPENDIX A: PROCEDURES.

1) Sennoside estimation.

The procedure adopted for estimation of sennoside is presented here.

1) 250 mg of *senna* leaves powder was weighed for estimation of sennoside from leaf and 300 mg of *senna* pod powder was weighed for estimation of sennoside from pod
2) The appropriate powder was added into a 100 ml volumetric flask. 30 ml of distilled water was added to the flask. Five drops of NaOH (10%) were added and volume adjusted upto the mark with distilled water. After mixing it was kept aside until undissolved material had settled.
3) The supernatant liquid (5 ml) was transferred to a conical flask and heated over boiling water bath for 15 min with 32 ml of HCL (d=1.19). The resultant suspension was kept on ice-bath and dissolved in minimum quantity of 40% NaOH solution. The colour change from yellow to brown was noticed.
4) The ice-cold solution was extracted with 70 ml of pure ether containing 2 ml of 20% H_2SO_4, followed by vigorous shaking in a 300 ml separating funnel for 0.5 hrs. The acidified aqueous layer was separated from ether layer and extracted again with 50 ml portions of acidified ether. The combined ether extracts were extracted with 3 X 10 ml portions of 1/N $NaHCO_3$ solution.
5) The bicarbonate extracts were re-extracted with 50 ml ether acidified with 4 ml of 50% H_2SO_4, with shaking to remove carbon-dioxide and the ether layer was transferred to a volumetric flask.
6) The aqueous phase was extracted with 30 ml and 20 ml of acidified ether after rendering aqueous phase alkaline with 3 ml 40% NaOH in each step. The ether layer was transferred to the same volumetric flask.
7) The ether aglycone solution (5 ml) was mixed with 10 ml of 1 N NaOH with vigorous shaking and when the alkaline aqueous layer (reddish yellow coloured) had separated, 0.2 ml of hydrogen peroxide solution (3%) was added and heated for 4 min on boiling water bath. The solution was cooled immediately, which became wine red.
8) From the extract 0.2, 0.4, 0.6 ml aliquots were taken in 10 ml volumetric flasks. The volumes were made upto the mark with distilled water. The absorbance was measured within 10 min at 520 nm on spectrophotometer using water as a blank.
9) Calibration curve was prepared by subjecting 100 mg ml^{-1} solution of pure sennoside to extraction procedure as described above. From the extracted solution 0.05, 0.1, 0.2, 0.3, 0.4, 0.6 and 0.8 ml aliquots were taken in 10 ml volumetric flasks. The colour was developed as mentioned previously and analysis was done spectrophotometrically.

2) Husk percentage estimation.

1) 1g of *isabgol* seed was weighed and add to 50 ml beaker.
2) 10 ml of 0.1 N HCL was added to the beaker and the mixture heated at 70°C for 10 minutes. Subsequently the mixture was filtered through a previously weighed sintered gooch crucible, grade I.
3) The dehusked seed was washed 3 times with excess of hot (70°C) distilled water. The crucible was dried at 110°C for 3 hrs. and weighed. Percentage husk was calculated by using the formula.

$$\% \text{ husk} = (1 - \text{weight of dehusked seed}) / 100$$

3) Swelling factor estimation.

1 g of *isabgol* seed was placed in a 25 ml graduated cylinder and distilled water was added upto 20 ml, then agitated for through wetting of the seed. The cylinder was allowed to stand for 20 min, then agitated for uniform distribution of swollen seeds and allowed to stand for 6 hrs. After which the volume of swollen seeds was recorded.

APPENDIX B: MEAN MAXIMUM VALUE.

Table 1. Influence of various treatments on the performance of characters of *senna* (kharif) during 2002-03 and 2003-04.

Sr. No. (1)	Character (2)	Mean max value	
		2002-03 (3)	2003-04 (4)
A.	**Growth characters.**		
1.	Plant height at harvest (cm plant^{-1}).	105.07	108.60
2.	Plant spread at harvest (cm plant^{-1}).	104.04	105.71
3.	Number of branches at harvest (plant^{-1}).	9.80	9.80
4.	Leaf area at harvest (dm^2 plant^{-1}).	16.65	16.62
5.	Total fresh matter at harvest (g plant^{-1}).	193.51	196.42
6.	Total dry matter at harvest (g plant^{-1}).	74.11	76.98
7.	Absolute growth rate (g plant^{-1}).	5.56	5.85
8.	Relative growth rate (plant^{-1}).	0.42	0.42
9.	Days to flower initiation.	56.67	56.67
10.	Days to 50% flowering.	60.00	60.67
11.	Days to maturity.	174.67	175.33
B.	**Yield contributing characters.**		
12.	Number of filled pods (plant^{-1}).	73.57	75.53
13.	Number of unfilled pods (plant^{-1}).	9.53	9.53
14.	Total number of pods (plant^{-1}).	82.42	84.73
15.	Weight of filled pods (g plant^{-1}).	30.82	31.37
16.	Weight of unfilled pods (g plant^{-1}).	2.35	2.41
17.	Total weight of pods (g plant^{-1}).	33.17	33.78
18.	Length of pod (cm).	5.16	5.21
19.	Breadth of pod (cm).	2.12	2.16
20.	Number of seeds (pod^{-1}).	7.73	7.83
21.	Weight of seeds (g pod^{-1}).	0.16	0.17
22.	Number of seeds (plant^{-1}).	568.78	591.51
23.	Weight of seeds (g plant^{-1}).	12.10	12.36
24.	Thousand seed weight (g).	22.00	22.25
25.	Root weight (g plant^{-1}). a) Fresh root weight.	11.62	12.73
	b) Dry root weight.	3.78	4.11
26.	Stalk weight (g plant^{-1}). a) Fresh stalk weight.	119.70	120.10
	b) Dry stalk weight.	28.27	30.02
27.	Fresh leaves weight (g plant^{-1}). a) First picking (90 DAS).	23.48	24.66
	b) Second picking (110 DAS).	15.92	16.51
	c) Third picking (at harvest).	29.03	29.81
	d) Total.	68.43	70.98
28.	Dry leaves weight (g plant^{-1}). a) First picking (90 DAS).	7.25	7.68
	b) Second picking (110 DAS).	4.91	5.25
	c) Third picking (at harvest).	8.90	9.07
	d) Total.	21.06	22.00
29.	Pod shell weight (g plant^{-1}).	21.06	21.42

(cont'd...)

(1)	(2)		(3)	(4)
C.	**Yield.**			
30.	Root yield (q ha^{-1}).	a) Fresh root yield.	12.51	12.60
		b) Dry root yield.	3.91	4.00
31.	Stalk yield (q ha^{-1}).	a) Fresh stalk yield.	79.09	80.70
		b) Dry stalk yield.	29.11	29.64
32.	Fresh leaves yield (q ha^{-1}).	a) First picking (90 DAS).	30.24	30.95
		b) Second picking (110 DAS).	10.75	11.03
		c) Third picking (at harvest).	36.48	37.41
		d) Total.	77.47	79.39
33.	Dry leaves yield (q ha^{-1}).	a) First picking (90 DAS).	9.39	9.69
		b) Second picking (110 DAS).	3.23	3.31
		c) Third picking (at harvest).	11.16	11.34
		d) Total.	23.78	24.34
34.	Seed yield (q ha^{-1}).		3.02	3.12
35.	Pod shell yield (q ha^{-1}).		4.34	4.36
36.	Harvest index (%).		42.00	42.11
D.	**Chemical analysis studies.**			
	I. Plant studies.			
37.	Concentration of nutrients (%).			
	I) Nitrogen.	a. Root.	0.96	0.97
		b. Stalk.	1.25	1.25
		c. Leaves. i. First picking (90 DAS).	1.38	1.39
		ii. Second picking (110 DAS).	1.33	1.34
		iii. Third picking (at harvest).	1.34	1.35
		d. Seed.	1.65	1.66
		e. Pod shell.	1.30	1.31
	II) Phosphorus.	a. Root.	0.67	0.68
		b. Stalk.	0.81	0.82
		c. Leaves. i. First picking (90 DAS).	1.06	1.07
		ii. Second picking (110 DAS).	1.05	1.06
		iii. Third picking (at harvest).	1.04	1.04
		d. Seed.	1.27	1.28
		e. Pod shell.	0.94	0.96
	III) Potassium.	a. Root.	0.50	0.52
		b. Stalk.	0.31	0.32
		c. Leaves. i. First picking (90 DAS).	0.44	0.45
		ii. Second picking (110 DAS).	0.43	0.44
		iii. Third picking (at harvest).	0.45	0.44
		d. Seed.	0.50	0.51
		e. Pod shell.	0.42	0.42
38.	Uptake of nutrients (kg ha^{-1}).			
	I) Nitrogen.	a. Root.	3.75	3.88
		b. Stalk.	36.39	37.05

(cont'd...)

(1)	(2)	(3)	(4)
	c. Leaves. i. First picking (90 DAS).	12.96	13.47
	ii. Second picking (110 DAS).	4.30	4.44
	iii. Third picking (at harvest).	14.95	15.31
	d. Seed.	4.98	5.18
	e. Pod shell.	5.64	5.71
	f. Total uptake.	82.97	85.04
	II) Phosphorus. a. Root.	2.62	2.72
	b. Stalk.	23.58	24.09
	c. Leaves. i. First picking (90 DAS).	9.95	10.37
	ii. Second picking (110 DAS).	3.39	3.51
	iii. Third picking (at harvest).	11.61	11.79
	d. Seed.	3.84	3.99
	e. Pod shell.	4.08	4.19
	f. Total uptake.	59.07	60.66
	III) Potassium. a. Root.	1.96	2.08
	b. Stalk.	9.02	9.48
	c. Leaves. i. First picking (90 DAS).	4.26	4.36
	ii. Second picking (110 DAS).	1.39	1.46
	iii. Third picking (at harvest).	5.02	4.99
	d. Seed.	1.51	1.60
	e. Pod shell.	1.82	1.83
	f. Total uptake.	24.98	25.80
	II. Quality studies.		
39.	Sennoside content (%).		
	I) Leaves. i. First picking (90 DAS).	2.34	2.32
	ii. Second picking (110 DAS).	2.35	2.31
	iii. Third picking (at harvest).	2.32	2.30
	II) Pod. i. First picking (90 DAS).	3.38	3.35
	ii. Second picking (110 DAS).	3.33	3.33
	iii. Third picking (120 DAS).	3.34	3.34
	III. Soil studies.		
40.	Available nitrogen (kg ha^{-1}).	220.11	232.65
41.	Available phosphorus (kg ha^{-1}).	26.12	29.00
42.	Available potassium (kg ha^{-1}).	496.05	498.63
E.	**Economics.** a. Net monetary returns (Rs. ha^{-1}).	64188	67232
	b. Benefit:Cost Ratio.	2.18	2.22

Table 2. Influence of various treatments on the performance of characters of *isabgol* (rabi) during 2002-03 and 2003-04.

Sr. No. (1)	Character (2)	Mean max. value	
		2002-03 (3)	2003-04 (4)
A.	**Growth characters.**		
1.	Plant height at harvest (cm plant^{-1}).	13.69	13.95
2.	Number of leaves at harvest (plant^{-1}).	30.48	31.22
3.	Number of productive tillers at harvest (plant^{-1}).	4.70	4.73
4.	Number of unproductive tillers at harvest (plant^{-1}).	1.37	1.40
5.	Total number of tillers at harvest (plant^{-1}).	5.50	5.53
6.	Total dry matter at harvest (g plant^{-1}).	7.67	7.68
7.	Absolute growth rate (g plant^{-1}).	1.30	1.32
8.	Relative growth rate (plant^{-1}).	0.83	0.99
9.	Days to flower initiation.	58.61	58.74
10.	Days to 50% flowering.	61.17	62.17
11.	Days to maturity.	87.83	89.17
B.	**Yield contributing characters.**		
12.	Number of productive spikes (plant^{-1}).	18.11	18.11
13.	Number of unproductive spikes (plant^{-1}).	3.38	3.36
14.	Total number of spikes (plant^{-1}).	21.26	21.29
15.	Length of spike (cm).	3.85	3.86
16.	Girth of spike (cm).	2.85	2.87
17.	Number of seeds (spike^{-1}).	71.98	72.19
18.	Weight of seeds (g spike^{-1}).	0.11	0.11
19.	Number of seeds (plant^{-1}).	1277.66	1272.13
20.	Weight of seeds (g plant^{-1}).	1.88	1.88
21.	Thousand seed weight (g).	1.70	1.72
22.	Root weight (g plant^{-1}).	0.38	0.39
23.	Stalk weight (g plant^{-1}).	4.54	4.52
24.	Leaf weight (g plant^{-1}).	0.91	0.92
C.	**Yield.**		
25.	Root yield (q ha^{-1}).	1.46	1.48
26.	Stalk yield (q ha^{-1}).	17.30	17.51
27.	Leaves yield (q ha^{-1}).	3.39	3.43
28.	Seed yield (q ha^{-1}).	8.15	8.25
29.	Total straw yield (q ha^{-1}).	22.15	22.42
30.	Harvest index (%).	27.52	27.55
D.	**Chemical analysis studies.**		
	I. Plant studies.		

(1)	(2)		(3)	(4)
31.	Concentration of nutrients (%).			
	I) Nitrogen.	a. Root.	1.12	1.11
		b. Stalk.	1.21	1.22
		c. Leaves.	1.49	1.51
		d. Seed.	2.50	2.49
	II) Phosphorus.	a. Root.	0.38	0.40
		b. Stalk.	0.63	0.64
		c. Leaves.	0.75	0.76
		d. Seed	1.11	1.11
	III) Potassium.	a. Root.	0.90	0.89
		b. Stalk.	0.28	0.29
		c. Leaves.	0.79	0.79
		d. Seed	0.57	0.58
32.	Uptake of nutrients (kg ha^{-1}).			
	I) Nitrogen.	a. Root.	1.64	1.64
		b. Stalk.	20.44	20.84
		c. Leaves.	5.15	5.13
		d. Seed	20.61	20.46
		e. Total.	47.21	48.05
	II) Phosphorus.	a. Root.	0.56	0.59
		b. Stalk.	10.90	11.21
		c. Leaves.	2.54	2.61
		d. Seed.	9.05	9.16
		e. Total.	23.05	23.57
	III) Potassium.	a. Root.	1.31	1.32
		b. Stalk.	4.84	5.08
		c. Leaves.	2.68	2.71
		d. Seed.	4.65	4.79
		e. Total.	13.48	13.90
	II. Quality studies.			
33.	Protein content of seed (%).		15.65	15.58
34.	Husk percentage of seed (%).		26.17	26.67
35.	Swelling factor (cc g^{-1}).		13.47	13.75
	III. Soil studies.			
36.	Available nitrogen (kg ha^{-1}).		221.85	234.77
37.	Available phosphorus (kg ha^{-1}).		27.44	30.61
38.	Available potassium (kg ha^{-1}).		482.80	488.33
E.	**Economics:**	a. Net monetary returns (Rs. ha^{-1}).	11729	11310
		b. Benefit:Cost Ratio	1.67	1.62