EFFECT OF DATE OF SOWING AND NITROGEN ON GROWTH AND YIELD OF ISABGOL (*Plantago ovata* Forsk.)

BY

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B.Sc. (Horticulture)

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CERTIFICATE

Ms. A. ARUNJYOTHI, has satisfactorily prosecuted the course of research and that the thesis entitled **"EFFECT OF DATE OF SOWING AND NITROGEN ON GROWTH AND YIELD OF ISABGOL (*Plantago ovata* Forsk.)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: -08-2007
Place: Hyderabad

(Dr. G. SATHYANARAYANA REDDY)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF DATE OF SOWING AND NITROGEN ON GROWTH AND YIELD OF ISABGOL (*Plantago ovata* Forsk.)"** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Ms. A. ARUNJYOTHI** under our guidance and supervision. The subject of the thesis has been approved by the Students Advisory Committee.

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

(Dr. G. SATHYANARAYANA REDDY)
Chairman of the Advisory Committee

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DECLARATION

I, **A. ARUNJYOTHI**, hereby declare that the thesis entitled **"EFFECT OF DATE OF SOWING AND NITROGEN ON GROWTH AND YIELD OF ISABGOL (*Plantago ovata* Forsk.)"** submitted to the Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN HORTICULTURE** is a result of original research work done by me. It is further declared that the thesis or part thereof has not been published earlier in any manner.

Date: -08-2007

(A. ARUNJYOTHI)

Place: Hyderabad

C O N T E N T S

LIST OF TABLES

LIST OF PLATES

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Percentage
CD	:	Critical difference
cm	:	centimeter
dSm^{-1}	:	desi simen per meter
DOS	:	Date of sowing
DAS	:	Days after sowing
EC	:	Electrical conductivity
et al	:	and others
Fig.	:	Figure
g	:	gram
q ha^{-1}	:	quintal per hectare
m	:	metres
m^2	:	square meter
mm	:	milli meters
N	:	Nitrogen
P	:	Phosphorus
K	:	Potassium
hr	:	hour (s)
NS	:	Not significant
^oC	:	Degree Celsius
$plant^{-1}$	:	per plant
kg ha^{-1}	:	Kilograms per hectare
SEm$\pm$	:	Standard error mean
viz.,	:	namely

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ABSTRACT

The present investigation on "Effect of date of sowing and nitrogen on growth and yield of Isabgol (*Plantago ovata* Forsk.)" was conducted at Herbal Garden, ANGRAU, Rajendranagar, Hyderabad during the period from October 2004 to March 2005. The experiment was laid out in randomized block design with factorial concept.

In the present study, 5th October sowing proved to be superior over other sowing dates in respect of plant height (42.34 cm), number of tillers per plant (12.26), dry weight of plant (5.05 g), spike length (5.34 cm) and seed yield per hectare (5.49 q ha^{-1}).

Among the different levels of nitrogen, 100 kg ha^{-1} recorded higher plant height (34.58 cm), greater number of tillers per plant (10.34), higher dry weight of plants (4.78 g), spike length (4.44 cm) and seed yield per hectare (41.10 q ha^{-1}) over other levels of nitrogen.

The interaction between sowing dates and nitrogen levels revealed that the plant height (44.27 cm), number of tillers per plant (13.06), dry weight of plant (7.23 g), spike length 96.20 cm) and seed yield per hectare (5.64 q ha^{-1}) were

maximum with 5th October sowing + 100 kg N ha^{-1} over other treatment combinations.

The harvest index was on a par with 5th October sowing (5.15) and 20th October sowing (5.10) but were significantly superior over 5th November sowing (4.46) and 20th November sowing (3.99). Among the nitrogen levels, 75 kg N ha^{-1} recorded higher harvest index (5.37) over other nitrogen levels. The interaction between sowing dates and nitrogen levels revealed that harvest index was maximum with 5th October sowing + 75 kg N ha^{-1} (5.89).

The percentage of husk did not differ significantly because of different sowing dates. Further, the treatment with no nitrogen recorded significantly higher percentage of husk (23.85) over 100 (21.85) and 50 kg N ha^{-1} (21.83) but was on a par with lower levels of nitrogen 75 kg N ha^{-1} (22.30). The treatment combination, 5th October sowing + 75 kg N ha^{-1} (24.50) recorded high percentage of husk but was on a par with all the treatment combinations except at 20th November sowing with all the nitrogen levels.

The present study revealed that 5th October sowing in combination with either 100 kg N ha^{-1} or 75 kg N ha^{-1} recorded higher yield over all other treatment combinations. This could be due to congenial temperature (22.42^{o}C) more sunshine hours (189.60 hrs), higher relative humidity (85%) and high rainfall (112.70 mm) during the crop growth period. Further sowing on 20th November recorded lower growth parameters resulting in lower yield irrespective of nitrogen levels. This might be due to low mean minimum temperature (13.63^{o}C) and low rainfall (36 mm) coupled with short day condition during the plant growth period.

CHAPTER – I

INTRODUCTION

India is termed as the Botanical garden of the world with botanical wealth of more than 2000 medicinal plant species. The developing countries are the leading suppliers of medicinal plants to the world and India is one of them. There is an ever-growing demand for medicinal plants in pharmaceutical and phyto-chemical industries. It is estimated that the world trade in these materials is around 12,000 million US $ and it is expected to rise to 33,000 million US $ (Reddy, 2000). India's contribution is around 1,200 million US $ and is expected to rise to 8,500 million US $ at the end of 2000 AD. In addition to this, the demand of these products in the domestic market is also increasing. There exists a considerable gap between demand and supply of the plant products of medicinal nature.

Plantago ovata commonly known as Isabgol, Psyllium or Indian Plantago belongs to family Plantginaceae. Psyllium seed is in use in medicine since long. The seed husk of psyllium has the property of absorbing and retaining water which accounts of its utility in checking diarrrhoea. In patients suffering chronic dysentery, the ulcered surface of intestinal mucosa is soothed by the demulcent action of the mucilage. The mucilage spreads along the inner wall of intestine and protects it against the irritants present in food. Moreover, the mucilage absorbs toxins from the gut and helps in excerting them from the body. Use of 2 or 3 heaped desert spoonfuls of seed, twice a day, for a couple of months resolves all symptoms of chronic dysentery and eliminates Entamiels a histolytica, if present, from the patients body. The mucilage of the seed husk acts as a lubricant in the large intestine. The husk is consumed alone or is mixed with different chemicals, such as powdered anhydrous dextrose, sodium bicarbonate, citric acid etc. (Virmani *et al*., 1980).

Isabgol is diuretic, it alleviates kidney and bladder complaints, gonorrhea, urethritis and hemorrhoids. It removes burning sensation in feet, relieves polyuria difficult micturition and tones up bladder. It is also effective in checking spermatorea. It is recommended for use by pregnant women.

Seeds soaked in water are recommended for treatment of cancer (Ahmad, Farooqui and Siddiqui, 1985, Hartwell, 1970). The seed husk is also effective in reducing serum cholesterol level. The oil contained in Isabgol embryo is rich in linoleic acid and has the potential dietary hypocholesterolenic agent. The oil content in embryo and endosperm is 14.7 and 8.8 per cent respectively (Atal Kapur and Siddiqui, 1964). Siddiqui, Kapur and Atal (1964) reported that Isabgol oil is more potent than safflower oil for reducing serum cholesterol level. The efficacy is increased when the husk is consumed with metronidazole (Ikrami, 1984). Ingestion of 10 g Isabgol a day for a month reduces serum cholesterol level by 9.6 per cent and triglyceride by 8.6 per cent (Goswami, 1988).

Decoction of *Plantago ovata* with honey is good for treatment of sore throat and bronchitis. The liquid obtained after boiling psyllium seed is chilled and used as eye drops. It is also used to get rid of pimples and check hair fall. Regular use of isabgol makes the skin to remove all kinds of blemishes.

Seed husk of Isabgol is also used in ice cream industry as substitute for sodium alginate (Upadhyay, Patel and Vyas, 1978). The mucilage is used as an ingredient in chocolate making, textile sizing, manufacturing cosmetics (Singh and Virmani, 1982) and setting and dressing hairs (Roia, 1966). The seeds and husk are also used in dyeing. Psyllium is also a source of commercial gum (Farooqi, 1976).

Tribals use Isabgol for several purposes, the snthals use it to relieve pains and treat bronchitis (Jain and Tarafder, 1970). The tribal inhabitants of North Gujarat consume seed decoction of psyllium as a cooling demulcent to cure diarrhea and dysentery.

Isabgol Gola's byproduct of psyllium is used as cattle feed (Shukla *et al.*, 1983). Its consumption has no adverse effect on production and composition of milk and the body weight of milch cows (Desai et al., 1980).

India has been exporting the seeds and husk of Isabgol to several countries and holds a monopoly in its production and trade. However, it is cultivated mainly in the northern parts of the country and its suitability to South Indian conditions has not yet been critically examined.

In view of the increasing demand for Isabgol seed and husk, both in India and abroad, extending its cultivation to the other regions of the country has become inevitable. The Isabgol being photosensitive, a *rabi* crop responds well to time of sowing and application of nitrogen. Hence the present investigation was undertaken to study the effect of sowing dates and nitrogen application on growth and yield of Isabgol at Hyderabad, Andhra Pradesh with the following objectives.

1) To study the effect of sowing dates on seed yield and yield attributes of Isabgol in A.P.

2) To study the effect of nitrogen application on plant growth and seed yield of Isabgol.

3) To study the effect of interaction of sowing dates and nitrogen application on plant growth and seed yield of Isabgol.

CHAPTER – II

REVIEW OF LITERATURE

2.1 Effect of sowing dates on growth and yield

2.1.1 Effect of sowing dates on plant height

Singh *et al.* (1979) reported that sowing of coriander on 12^{th} October resulted in taller plants during first year of the experiment, while no such trend was observed in the second year with sowings between 26^{th} September and 7^{th} November. Similarly, Bhati *et al.* (1989) found that coriander crop attained maximum height of 50.7 cm when it was sown on 18^{th} November, while it attained a height of 41.1 cm when it was sown on 18^{th} December. Coriander attained a maximum height of 124.9 and 134.9 cm during 1987-88 and 1988-89 respectively when sown on 15^{th} October as compared to 94.9 and 96.0 cm during 1987-88 and 1988-89 respectively when sown on 15^{th} November (Sharma and Israel, 1991). While Naghera *et al*. (2000) observed that coriander sown on 30^{th} October recorded highest plant height over 15^{th} October and 15^{th} November.

Plant height in chillies was maximum when planted in August or October months (Gowda and Gowda, 1980 and Malla Reddy *et al.*, 1989). Verna *et al.* (1980) observed maximum plant height (97.7 cm) when planted on 25^{th} March as compared to that planted on 11^{th} March, 18^{th} March and 1^{st} April in chillies.

In French bean, Ali and Kushwah (1987) observed that sowing in second fortnight of October gave better vegetative growth. While, Singh and Singh (1987) did not find considerable differences in growth over very narrow sowing period from 1st to 20th September in French bean.

Shadia *et al*. (1998) observed that the vegetative growth significantly increased at the early sowing date of 1st November over 15th November in *Nigella sativa*.

Solanki and Shaktawat *et al*. (1999) recorded highest plant height, when isabgol seeds were sown on 17th November compared with 17th December sowing. Similarly Mann and Vyas (1999) recorded a significant increase in plant height with 15th November sowing over 15th December sown crop in Isabgol. While sowing on 25th October gave highest biological yield over 14th and 24th November sowing in Isabgol (Singh *et al*., 2003).

In fenugreek, Halesh *et al*. (2000) noticed that the crop sown on 1st July recorded the maximum plant height over 15th June, 15th July, 1st September, 15th September and 1st October. Santlal *et al*. (2003) observed maximum plant height with 16th November sowing over 31st October in fenugreek. While, Korla *et al*. (2003) found that the plant height was increased with delay in sowing from 6th September to 6th October, then decreased with further delay in sowing in fenugreek.

Azizi (2000) observed the effect of sowing dates (6th March, 4th April and 5th May) on the growth of anise and found that seeds sown on 6th March showed increased plant height.

Sonia Aggarwal *et al*. (2002) found that sowing of ginger either on 30th April or 15th May gave highest vegetative growth over 30th April.

2.1.2 Effect of sowing dates on number of tillers per plant

Gill *et al.* (2005) reported that number of tillers per plant were highest with 1st February sowing and decreased with delay in sowing in taro (*Colacasia esculenta*).

Kang *et al*. (1989) observed that number of tillers decreased with delay in sowing date from 20th September to 5th October in barley.

Wang *et al*. (1998) conducted a field experiment to study the physiological characteristics and cultivation technology for wheat cultivar Xuzhou No.24. He recommended early sowing in late September as late sowing gave fewer tillers.

Singh *et al*. (2002) found that the number of tillers decreased with delay in sowing from 1st December to 10th January in wheat while Rakesh Kumar and Sharma (2003) reported that delay in sowing from 30th November to 16th December significantly reduced number of tillers in wheat.

Rakesh Kumar and Sharma (2003) observed that delay in sowing from 30 November to 16 December significantly reduced number of tillers in wheat.

2.1.3 Effect of sowing dates on dry matter production

Shindel *et al*. (1982) recorded significantly higher dry matter in the early sown coriander of 6th July than that was sown on 18th, 30th July and 19th August.

Kadam *et al*. (1991) obtained maximum total dry weight per plant from November 15th planting and as the planting was delayed, the dry matter accumulation reduced in tomato.

In Isabgol, Mann and Vyas (1999) recorded a significant increase in dry matter accumulation on 15th November sown crop over 15th December sown crop.

Halesh *et al*. (2000) observed maximum dry weight in fenugreek sown on 1st July over 15th June, 15th July, 1st September, 15th September and 1st October sowing. Sudesh Kumar *et al*. (2000) found maximum dry matter production in dill (*Anethun grameoleus* L.) sown on 7th August and was on a par with the yield of crop sown on 23rd July. However, further delay in sowing significantly decreased the dry matter production.

In Isabgol, Singh *et al*. (2003) observed a significant increase in dry matter accumulation when sown on 25th October over 14th and 24th November sowing.

2.1.4 Effect of sowing dates on spike production and seed yield

Ramesh *et al*. (1989) observed that Isabgol seeds when sown either in mid or late October produced maximum number of spikes over sowing in late December. Similarly, Solanki and Shaktawat (1999) recorded highest number of spikes per plant and spike length when Isabgol seeds were sown on 17th November over 17th December sowing. Spike length decreased with delay in sowing after 4th November (Singh *et al*., 2003).

Moskalenko (1972) observed that the autumn sown coriander gave 30 – 40 per cent extra yield over spring sown coriander. Singh *et al*. (1979) reported that early sown coriander (12th October) produced more yield while the sowings on 23rd November produced lower seed yield in the first year. While no such significant reduction in seed yield was recorded when sown between 26^{th} September and 7^{th} November in the second year in coriander.

Bhati *et al*. (1984) reported that under Rajasthan conditions, early sowing of coriander was congenial to obtain better seed yield and the optimum time of sowing was between 15^{th} October and 15^{th} November. Singh and Singh (1984) observed that late sowing after 2^{nd} week of October reduced the coriander yields and crop sown in the first and second week of October gave maximum seed yield.

Sharma and Israel (1991) reported that the crop sown on 15^{th} October produced higher seed yield as compared to that sown on 15^{th} November.

Shadia *et al*. (1998) observed that seed yield significantly increased in the early sowing on 1^{st} November over 15^{th} November in *Nigella sativa*. While Antuono *et al*. (2002) found decreased seed yield with delayed sowing dates (3 March, 9 April and 7 May) in *Nigella sativa*.

Reddy and Rolston (1999) observed in coriander that the seed yield declined from the first sowing on 17^{th} September to the last sowing on 1^{st} December. Sowing on 30^{th} October recorded the highest seed yield (905 kg ha^{-1}), while earlier sowing on 15^{th} October recorded a 14 per cent lower seed yield and the delayed sowing on 15^{th} November recorded a 12 per cent lower seed yield than sowing on 30^{th} October (Naghera *et al*., 2000). Coriander sown during the first week of November had got the highest yields over last week of October and second week of November (Chellaiah *et al*., 2001). On the other hand, Tiwari *et al*. (2003) found that sowing on 30^{th} October gave the highest seed yield.

Yadav *et al*. (2000) studied the effect of sowing time on seed crop of fenugreek. They found that the seed yields were significantly higher in the first sowing date (31st October and 20th November) whereas each successive 20-day delay in sowing significantly reduced yield. While Halesh *et al*. (2000) found that the crop sown on 1st July significantly increased seed yield followed by 15th July sown crop over 15th June, 1st September, 15th September and 1st October sowing. On the other hand, Satish Siyag *et al*. (2002) observed that sowing on 15th October gave significantly higher seed yield than the later dates of sowing (1st October, 1st November, 15th November and 1st December).

Sudesh Kumar *et al.* (2000) conducted a field experiment to study the effect of sowing time on yield in dill (*Anethum graveolem* L.). The maximum seed yield was recorded when crop was sown on 7th August and was on a par with the yield of crop sown on 23 July. However, further delay in sowing significantly decreased the seed yield. Similarly, in ajwain crop Sharma *et al*. (2000) recorded maximum seed yield when sown on 7th August but the yield was on a par with the crop sown on 23rd July. Aziz (2000) studied the effect of sowing dates (6th March, 4th April and 5th May) on seed yield of anise. He found that sowing on 6th March reported increased seed yields.

In Isabgol, Bist *et al*. (2001) found that crop sown on 21st November performed better in terms of yield than the crop sown on 21st December. Solanki and Shaktawat (1999) reported that sowing on 17th November gave the highest seed yield over 17th December in Isabgol. Mann and Vyas (2001) also recorded maximum seed yields with 15th November sowing over 25th November, 5th December and 15th December sowings in Isabgol. While, Singh *et al*. (2003) found that 25th October sowing gave highest seed yield over 14th and 24th November sowing in Isabgol.

2.2 Effect of nitrogen on growth and yield in isabgol

2.2.1 Effect of nitrogen on plant height

Rai *et al*. (1977) reported that in Japanese mint, the deficiency of N resulted in reduced plant height. Singh and Duhan (1979) reported a significant effect of N at 160 kg ha^{-1} in terms of increased plant height in spearmint.

Jha and Singh (1979) observed linear increase in plant height due to graded doses of nitrogen in spearmint. They recorded significantly higher responses of spearmint in respect of plant height at 160 kg N ha^{-1}. While application of 60 kg N ha^{-1} registered the highest plant height in bergemol mint (Singh *et al.*, 1979).

Shenoy (1980) reported that nitrogen had a marked effect on the plant height in dawana. The plant height increased to a maximum of 45 cm when nitrogen was applied at 120 kg ha^{-1} in davana. While Narayana *et al*. (1982) reported that there was no significant effect of N and P on plant height of main crop, but N significantly increased plant height in ratoon crop. However, maximum plant height does not exceed 45 cm. On the other hand, Panduranga (1983) reported a significant increase in plant height at 120 days N ha^{-1} in davana. Similar results were reported by Prakash Rao *et al*. (1983).

In geranium, Mani *et al*. (1981) reported the maximum plant height of 84.3 cm with the application of 120 kg ha^{-1} N and 60 kg ha^{-1} each of P and K. Pareek *et al*. (1981), while studying the nutritional effect of yield parameters of palmarosa observed that application of N at 40 kg ha^{-1} increased plant height.

Kamala Singh *et al*. (1982) in an experiment on *Mentha arvensis* reported that application of n resulted a significant increase in plant height upto 125 kg ha^{-1}. Kattimani *et al.* (2001) in an experiment on *Mentha arvensis* under semi-arid tropical Andhra Pradesh and reported that maximum plant height was recorded in plant treated with N at 223 kg ha^{-1}. They also reported increased plant height with P_2O_5 at 80 kg ha^{-1}.

Prakasa Rao *et al.* (1983) conducted a trial at Bangalore to study the effect of different rates of nitrogen, phosphorus and potassium on the yield of coriander. From their study they reported increased plant height due to nitrogen application, but the difference between the two rates of nitrogen (50 and 100 kg ha^{-1}) was not significant. Raghavaiah *et al.* (1985) also recorded a significant increase in plant height with increase in the level of N, however, the response of coriander to 45 and 60 kg N ha^{-1} was similar statistically.

Randhawa *et al.* (1984) studied the nitrogen requirements of mentha citrate to exploit its potential for recommending as a commercial crop. The trial was conducted in Ludhiana. The treatments consisted of eight levels of nitrogen (0, 50, 75, 100, 125, 150, 175 and 200 kg ha^{-1}) applied in two splits. The results indicated a positive response in plant height to nitrogen application. The height increased with increase in the level of nitrogen upto 150 kg N ha^{-1} and thereafter it declined. Rajeswara Rao and Kailash Singh (1988) also reported that the plant height in Japanese mint increased with an increase in the levels of nitrogen upto 120 kg ha^{-1}.

Krishnamurthy (1985) reported that plant height increased with the application of N, P and K in davana under Tamil Nadu conditions. He also reported that the plants reached a maximum height of 75 to 77 cm both in main and ratoon crop at higher rates of N, P and K (150, 125 and 75 kg ha^{-1} respectively). Rajeswar Rao *et al.* (1989) concluded that the plant height increased with increased level of N upto 80 kg ha^{-1} beyond which the increase in plant height was not significant. Pasha (1989) reported that davana responded well to fertilizer application and there was a rapid increase in growth with increased levels of nitrogen.

Singh and Dhankar (1987) observed the plant height increased with increasing levels of N, being highest at 160 kg N ha^{-1} in combination with 100 kg K_2O ha^{-1} and 25 kg $ZnSO_4$ ha^{-1}. Singh *et al*. (1989) also reported that with increase in N levels from 0 to 120 kg ha^{-1} increasedthe plant height in onion cv. Pusa Red from 47.5 cm to 69.18 cm.

Sudheera *et al*. (1990) conducted a study on celery, which revealed the highest plant height was recorded at highest dose of N at 200 kg ha^{-1} (87.33 cm and 76.06 cm). Ilangovan *et al*. (1990) found a significant increase in plant height with increase in application of nitrogen from 0 to 100 kg N ha^{-1}. Farooqui *et al.* (1991) also revealed that application of nitrogen at 180 kg N ha^{-1} resulted in maximum plant height (45.99) in *Artenisia pallens.*

Muniramappa *et al*. (1997) recorded highest plant height with the application of 78.5 kg N, 75 kg P_2O_5 and 50 kg K_2O ha^{-1} in Kalmegh. While Chauhan *et al*. (2002) reported that in Kalmegh, the application of nitrogen at 40 kg ha^{-1} resulted in highest plant height.

Solanki *et al*. (1999) recorded highest plant height in Isabgol with the application of 30 kg N ha^{-1} over control. Application of 45 kg N ha^{-1} also recorded maximum plant height over control (Mann *et al*., 1999). Singh *et al*. (2003) also observed that nitrogen at 30 kg ha^{-1} increased plant height over the control and 15 kg N ha^{-1} in Isabgol.

Azizi (2000) found that application of N at 100 kg ha^{-1} recorded maximum plant height over control and 200 kg N ha^{-1} in ginger. While, Pradeep Kumar *et al.* (2001) reported that N fertilizer significantly affected plant height upto 75 kg N ha^{-1}, while K fertilizers had no significant effect in ginger.

2.2.2 Effect of nitrogen on tiller production

In rice, increased tiller number with increase in nitrogen application have been reported by Ramaiah *et al.* (1987).

Kaushik *et al.* (1973) reported significant increase in total number of tillers over control but all fertilizer sources viz., SSP, Ammonium phosphate, and NP found to be equally effective in increasing the total number of tillers m^{-2} in rice variety TN-1.

At Bhubaneswar, all the varieties of rice produced more tillers due to higher levels of nitrogen application (Pandhi and Misra, 1968). On sandy loam soils of Coimbatore, higher levels of nitrogen also increased tiller production (Kalyanikutty *et al*., 1969).

Four varieties of rice tested at three levels of nitrogen (50, 100 and 150 kg ha^{-1}) indicated significant increase in number of tillers with increase in nitrogen levels (Prasad *et al*., 1982).

2.2.3 Effect of nitrogen on dry matter production

Singh and Duhan (1979) reported a significant effect with N at 160 kg ha^{-1} in terms of enhanced dry matter accumulation in spearmint. Similarly Jha and Singh (1979) observed a linear increase in dry matter accumulation at 160 kg N ha^{-1}.

Ilangovan *et al*. (1989) found that application of nitrogen at 100 kg ha^{-1} increased the dry leaf and dry pod yields of senna.

Mann *et al*. (1999) recorded a significant increase in dry matter accumulation in Isabgol with the application of 45 kg nitrogen per hectare over control. Application of 30 kg N ha^{-1} increased dry matter accumulation per plant over the control and 15 kg N ha^{-1} in Isabgol (Singh *et al.*, 2003).

Maryada *et al*. (2001) reported that in Ashwagandha (*Withania somnifera*), application of 30 kg N ha^{-1} produced maximum dry weight of stems.

2.2.4 Effect of nitrogen on spikes production

Ramesh *et al*. (1989) observed that application of nitrogen at the rate of 75 kg ha^{-1} in combination with 25 kg ha^{-1} of phosphorus produced the highest number of spikes per plant over 50 kg ha^{-1} with no phosphorus in Isabgol. Contrary to this, application of 30 kg N ha^{-1} gave the maximum spike length over control in Isabgol (Solanki and Shaktawat, 1999). Singh *et al*. (2003) also observed that application of 30 kg N ha^{-1} significantly increased a spike length over the control and 15 kg N ha^{-1}.

2.2.5 Effect of nitrogen on yield

Maheshwari and Yadav (1981) reported highest root yield in Ashwagandha with the application of 20 kg N and 40 kg P_2O_5. While, Nigam *et al*. (1984) reported that NPK at 30:30:30 kg ha^{-1} recorded highest dry root yield in Ashwagandha and with the increase in the dose of fertilizers had no effect on the dry root yield.

Raghavaiah *et al*. (1985) recorded a significant increase in number of seeds per plant with increase in the level of N in coriander. However, the response to 45 and 60 kg N ha^{-1} was similar statistically. On the other hand, Naghera *et al*. (2000) observed that application of 40 kg N ha^{-1} recorded more seed yield than treatment with 20 and 60 kg N ha^{-1}.

Veeraraghavathatham *et al*. (1988) reported that in *Coleus forskohlii*, a combination of 40 kg N, 60 kg P_2O_5 and 50 kg K_2O ha^{-1} was found to be optimum for maximum fresh and dry tuber yields. Increase in the levels of fertilizers beyond this was found to reduce the tuber yield significantly. Hedge (1988) reported that in Periwinkle, 100 kg N, 40 kg P_2O_5 and 50 kg K_2O ha^{-1} gave maximum root yield.

In *Papaver somniferum*, Bhandari *et al*. (1989) reported that as the rate of nitrogen increased from 30 to 90 kg ha^{-1}, latex yield increased from 56.7 kg to 67.4 kg ha^{-1}. In *Hyoscyanus albus*, dry herbage yield increased from 12.38 q ha^{-1} with 80 kg N ha^{-1} (Maheshwari *et al*., 1989).

Solanki and Shaktawat (1999) recorded highest seed yield with the application of 30 kg N ha^{-1} over control.

Azizi (2000) observed that the effect of N fertilizer (0, 100, 200 kg N ha^{-1}) on the growth, development and seed yield of anise. He found that application of N at 100 kg ha^{-1} recorded increase in seed yield.

In Isabgol, Mann and Vyas (2001) recorded higher seed yields with the application of 45 kg N ha^{-1} over control.

Nataraja *et al*. (2003) found that application of nitrogen at 100 kg ha^{-1} resulted in the highest number of seeds per pod in black cumin (*Nigella sativa* L.).

CHAPTER – III

MATERIAL AND METHODS

The material used and the methods followed during the course of present investigation are furnished hereunder.

3.1 Location of the experiment

The field experiment entitled "Effect of sowing date and nitrogen on growth and yield of Isabgol (*Plantago ovata* Fossk)" was carried out from October, 2004 to March, 2005 at Herbal Garden, College of Agriculture, Rajendranagar, Hyderabad. The experimental site is situated at an altitude of 542.3 m above mean sea level with a geographical bearing $17^{o}19'$ North latitude and $79^{o}23'$ East longitude.

3.2 WEATHER CONDITIONS DURING THE CROP PERIOD

Hyderabad falls under arid sub-tropical climate zone with an average annual rainfall of 800 mm. Meteorological data pertaining to rainfall, mean minimum and maximum temperatures, relative humidity and sunshine hours are presented in weekly averages from the first week of October 2004 to March 2005 in Appendix .

3.3 Soil characteristics of experimental site

The soil was red sandy loam with uniform texture and topography. The soil samples from experimental field were collected before sowing from five randomly selected spots at a depth of 30 cm. The soil was air-dried and ground to pass through 2 mm sieve before analysis. The composite soil sample was analysed for its physico-chemical properties and the results are furnished below.

1) Textural class : Red sandy loam

2) Soil fraction

Property	Quantity (%)	
Sand	71.9	International pipette method (Piper, 1950)
Silt	7.8	
Clay	18.5	
Chemical composition		
Soil pH	7.0	Digital pH meter (D_1-707) (Jackson, 1967)
Electrical conductivity (dSm^{-1})	0.24	Conductivity bridge (Jackson, 1967)
Organic carbon (%)	0.57	Walkley and Black (1934)
Available N (kg ha^{-1})	192	Alkaline permanganate method (Subbaiah & Asija, 1956)
Available P (kg ha^{-1})	11.8	Olsen's method (Olsen *et al.*, 1954)
Available K (kg ha^{-1})	30.8	Flame photometer method (Muhr *et al.*, 1965)

3.4 Experimental details

3.4.1 Variety

The variety selected for the present experiment was Gujarat Isabgol-II which is under cultivation in Gujarat and Rajasthan because of its higher husk yield.

3.4.2 Layout

The experiment was laid out in a factorial randomized block design with 16 treatment combinations and replicated thrice.

3.4.3 Plot size

A plot size of 2.0 x 1.5 m^2 (3 sq.m) was used for all the treatments.

3.4.4 Treatments

The details of the treatments are furnished below.

Dates of sowing	-	4	(D_1 : 5th October, 2004), (D_2 : 20th October 2004), D_3 : 5th November, 2004) and (D_4 : 20th November 2004)
Levels of N	-	4	N_0 : Control, N_1 : 50 kg ha^{-1}, N_2 : 75 kg ha^{-1} and N_3 : 100 kg ha^{-1}

Treatment combinations : 16

T_1	-	$D_1 + N_0$
T_2	-	$D_1 + N_1$
T_3	-	$D_1 + N_2$
T_4	-	$D_1 + N_3$
T_5	-	$D_2 + N_0$
T_6	-	$D_2 + N_1$
T_7	-	$D_2 + N_2$
T_8	-	$D_2 + N_3$
T_9	-	$D_3 + N_0$
T_{10}		$D_3 + N_1$
T_{11}		$D_3 + N_2$
T_{12}		$D_3 + N_3$
T_{13}		$D_4 + N_0$
T_{14}		$D_4 + N_1$
T_{15}		$D_4 + N_2$
T_{16}		$D_4 + N_3$

Note: Recommended P and K were applied uniformly to all the treatments at P – 50 kg ha^{-1} and K – 30 kg ha^{-1}

Design	-	FRBD
Replications	-	3
Spacing	-	15 x 6 cm
Plot size	-	2.0 x 1.5 m^2 (3 sq.m.)

3.4.5 Spacing

A spacing of 15 x 6 cm between the rows and within the row was adopted for all the treatments.

3.5 Cultivation details

3.5.1 Preparatory cultivation

The whole experimental plot was brought to a fine tilth by repeated ploughings followed by harrowing. Finally, it was leveled and divided into plots as per the layout.

3.5.2 Fertilizers

Among nutrients, phosphorus and potassium were applied to all treatments before sowing as a basal dressing, whereas nitrogen was applied in two split doses viz., at sowing and one month later. Nitrogen, phosphorus and potash were applied in the form of urea, single superphosphate and muriate of potash respectively.

3.5.3 Irrigation

The first irrigation was given immediately after sowing. The subsequent irrigations were given as and when required depending upon soil moisture and weather conditions.

3.5.4 Interculture

The experimental plots was kept weed free for better growth and development of plants.

3.5.5 Plant protection

No plant protection measures were practiced as no serious insect pest and disease problems were noticed.

3.5.6 Harvesting

The crop was harvested at 135 days after sowing when the spikes have turned to reddish brown in colour. Harvesting was done by cutting the crop 5 cm above the ground level. The spikes were separated from the plants and threshing was done with the help of the sticks to separate the seeds from the spikes.

3.6 Sampling procedure

Ten plants were selected at random from the net plot of each treatment and tagged for recording biometric observations such as plant height and number of tillers per plant. For the estimation of dry weights of shoots, sampling was done at 30, 60, 90 days and at harvest. Ten plants were utilized from each sampling plot leaving border rows. The plants were dried at 60 $\pm$ 5^{o}C till constant dry weights were obtained.

3.7 Observations

The observations recorded and the methods followed during the course of investigation are furnished below.

3.7.1 Plant height (cm)

Plant height from base of the plant to the tip of the longest leaf was measured from 10 randomly tagged plants in each treatment at 30, 60, 90 days after sowing (DAS) at harvest and their mean values were worked out and presented.

3.7.2 Number of tillers per plant

Number of leaves per plant was recorded at 30, 60, 90 DAS and at harvest from 10 randomly tagged plants and their mean values were computed and presented.

3.7.3 Dry weight of plants (g plant^{-1})

Ten randomly selected plants from each plot were pulled out at 30, 60, 90 DAS, at harvest and the plants were dried in hot air oven at 60^{o}C $\pm$ 5^{o}C temperature till constant dry weights were obtained.

3.7.4 Spike length (cm)

Spike length was recorded at 60, 90 days after sowing (DAS) and at harvest from 10 randomly tagged plants and their mean values were computed and presented.

3.7.5 Days taken for 50% flowering

Time taken for 50 per cent flowering was observed in each treatment and their mean values were worked out and presented.

3.7.6 Seed yield (q ha^{-1})

After the harvest, the spikes were separated from the plants in each treatment and the spikes were threshed manually to separate the seeds from the spikes. The seed yield values were computed and presented.

3.7.7 Harvest Index (%) (HI)

Economic yield and biological yield of the plants were recorded and HI was arrived and presented in percentages with the following equation.

$$HI = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100$$

3.7.8 Husk yield (%)

Economic part of Isabgol is seed husk. It is estimated through chemical analysis and their values were computed and presented (Jhanki and Talati, 1983).

3.7.9 Chemical analysis of husk

It involves adding of 10 ml of 0.04 to 0.1 N HCl to 1 gm of seed sample and heating the mixture at 70°C for 10 min. Subsequently, the mixture is filtered through a previously weighed sintered gooch crucible, grade I. The dehusked seed is washed 3 to 4 times with excess of hot (70°C) water. The crucible is dried at 110°C for 2 h and weighed. Percentage of husk is calculated by using the formula.

% husk = (1 – weight of dehusked seed) x 100

3.8 Statistical analysis

The design adopted was randomized design with factorial concept.

The data were subjected to analysis of variance as given by Panse and Sukhatme (1989). Significance was tested by ‘F’ values at 5 per cent level of probability. Critical difference (CD) values were calculated at 5 per cent whenever ‘F’ test was found to be significant.

CHAPTER – IV

RESULTS

Experiment was conducted during the *rabi* season of 2004 to study the effect of dates of sowing and nitrogen on growth and yield of Isabgol (*Plantago orata* Forsk.) on growth and yield attributes. The pooled data of results obtained on various parameters is presented under the following headlines.

4.1 Growth characters

4.1.1 Plant height (cm)

Plant height was significantly affected with different dates of sowing, N levels and their combinations (Table 1).

Plant height increased with the age of the crop reaching maximum at harvest. Rapid increase in plant height was observed between 30-90 DAS and thereafter the increase in plant height was marginal in the sowings D_3 (5^{th} November) and D_4 (20^{th} November) while in D_1 (5^{th} October) and D_2 (20^{th} October) still a marked increase was observed from 90 DAS to harvest.

Among the sowing dates, the plant height decreased significantly with each delay in sowing from D_1 (5^{th} October) to D_4 (20^{th} November) at all the stages of crop growth. The maximum plant height was observed at D_1 (5^{th} October) sowing followed by D_2 (20^{th} October) and D_3 (5^{th} November). The lowest plant height observed at D_4 (20^{th} November) sowing at all the stages of crop growth.

The plant height increased significantly with increase in the level of nitrogen from N_0 (Control) to N_3 (100 kg ha^{-1}) at different stages of crop growth except at 60 DAS wherein no significant difference in plant height was observed between N_1 (50 kg ha^{-1}) and N_2 (75 kg ha^{-1}) levels. The maximum plant height was recorded with N_3 (100 kg ha^{-1}). The minimum plant height was observed in Control (N_0).

The interaction between sowing dates and nitrogen levels was found significant at all the stages of crop growth. At 30 DAS, D_1N_3 (15.53 cm) recorded significantly higher plant height than the rest of the treatment combinations but was on a par with D_1N_2 (14.73 cm). Further D_1N_2 (14.73 cm) was on a par with D_2N_3 (14.23) but they were significantly superior over rest of treatment combinations. The treatment combination D_2N_2 (13.30 cm) recorded significantly higher plant height which was on a par with D_1N_1 (12.56 cm) but they were significantly superior over rest of the treatment combinations. The lowest plant height was recorded with D_4N_0 (5.93 cm).

At 60 DAS D_1N_3 (28.86 cm) recorded higher plant height than the rest of the treatment combinations. This was followed by D_1N_2 (26.53 cm) which was on a par with D_1N_1 (26.86 cm) but they were significantly superior over rest of the treatment combinations. Further the treatment combination, D_1N_0 (23.80 cm) recorded significantly higher plant height over rest of the treatment combinations. The lowest plant height was observed with D_4N_0 (12.20 cm) but was on a par with D_4N_1 (12.76 cm).

At 90 DAS higher plant height was observed with D_1N_3 (38.36) over rest of the treatment combinations followed by D_1N_2 (37.13), D_1N_1 (36.06), D_1N_0 (35.36), D_2N_3 (29.13), D_3N_3 (28.16), D_2N_2 (28.13) and D_2N_1 (27.66). The lower plant height was recorded with D_4N_0 (16.23) and D_4N_1 (16.66) which were on a par.

At harvest, among the different treatment combinations, D_1N_3 (44.27) recorded significantly higher plant height over rest of the treatment combinations but was on a par with D_1N_2 (43.50). These were followed by D_1N_0 (40.63), D_1N_1 (40.97) which were on a par but were significantly superior over rest of the treatment combinations. Further D_2N_3 (38.33) recorded significantly higher plant height over rest of the treatment combinations followed by D_2N_2 (34.13), D_2N_1 (32.17), D_3N_3 (30.33) and D_2N_0 (30.23) which were significantly superior over rest of the treatment combinations. The lower plant height was recorded with $D4N_0$ (18.27).

4.1.2 Number of tillers per plant

The number of tillers per plant was also significantly affected at different dates of sowing, nitrogen levels and their combinations at all stages (Table 2).

The number of tillers per plant increased with age from 30 days onwards and registering maximum at harvest. But the rate of increase in number of tillers per plant was maximum between 60 – 90 DAS.

The maximum number of tillers were reported with 5th October (12.26) and minimum with 20th November (8.26) at all the stages of crop growth.

The number of tillers increased with increasing level of nitrogen at all stages of crop growth. The greater number of tillers per plant was recorded with N_3 (100 kg ha^{-1}) at harvest and lower at 30 DAS with N_0.

The interaction between sowing dates and nitrogen levels was found to be significant at 60 and 90 DAS while at 30 DAS and harvest it was found not significant.

At 60 DAS among the treatment combinations, D_1N_3 (7.73) recorded significantly greater number of tillers over all other treatment combinations. This was followed by D_1N_2 (7.13) which recorded greater number of tillers over rest of the treatment combinations. Further no significant difference was observed among D_1N_1 (6.13), D_2N_3 (6.06) and D_3N_3 (5.80). These were followed by D_2N_3 (6.06) and D_3N_3 (5.80). The lowest number of tillers per plant was observed with D_4N_0 (3.16).

At 90 DAS, more number of tillers per plant was observed with D_1N_3 (11.53) over rest of the treatment combinations but was on a par with D_1N_2 (11.20). These were followed by D_1N_1 (10.43), D_1N_0 (9.30), D_3N_3 (8.76), D_2N_3 (8.56) and D_3N_2 (8.36). The lower number of tillers per plant was observed with D_4N_0 (6.20) which was on a par with D_4N_1 (6.50) which was on a par.

4.1.3 Dry weight of plant (g)

The dry weight was lowest at 30 DAS and thereafter increased significantly with the age of the crop reaching maximum at harvest due to the effect of different dates of sowing (Table 3). The dry weight was significantly higher due to the effect of D_1 (5^{th} October) sowing over rest of the sowing dates at all the stages of crop growth. This was followed by D_2 (20^{th} October), D_3 (5^{th} November) and D_4 (20^{th} November) sowing dates. The lower dry weight was observed in D_4 (20^{th} November) sowing at all the stages of crop growth.

The residual effect due to the application of nitrogen from N_0 (Control) to N_3 (100 kg ha^{-1}) was also significantly increased the dry weight at all the stages of crop growth. The higher dry weight was recorded with N_3 (100 kg ha^{-1}) at all the stages of crop growth followed by N_2 (75 kg ha^{-1}), N_1 (50 kg ha^{-1}) and N_0 (Control).

A significant interaction was observed between sowing dates and nitrogen due to their effect on dry weight at all the stages of crop growth.

Among various treatment combinations at 30 DAS D_1N_3 (0.46) recorded significantly higher dry weight than the rest of the treatment combinations. This was followed by D_1N_2 (0.40) which also recorded significantly higher dry weight than the rest of the treatment combinations. This was followed by D_1N_2 (0.40) which also recorded significantly higher dry weight compared with rest of the treatment combinations. Further no significant difference in dry weight was observed between D_2N_3 (0.34) and D_1N_1 (0.32). Similarly D_1N_0 (0.24) recorded higher dry weight than the rest of the treatment combinations but was on a par with D_2N_2 (0.24) and D_3N_3 (0.23). The lower dry weight was observed with D_4N_0 (0.02).

At 60 DAS, D_1N_3 (4.10) recorded significantly lower dry weight over rest of the treatment combinations. The treatment combination D_1N_2 (8.23) recorded significantly higher dry weight over rest of the treatment combinations, but was on a par with D_3N_3 (3.10). These were followed by D_3N_3 (3.10), D_2N_3 (2.87), D_2N_3 (2.87) and D_1N_1 (2.63). The lower dry matter was observed with $D3N_0$ (0.82) which was on a par with D_4N_0 (0.62).

At 90 DAS, among the various treatment combinations D_1N_3 (6.80) recorded higher dry weight than the rest of the treatment combinations. This was followed by D_2N_3 (5.10) also recorded higher dry weight than the rest of the treatment combinations. Similarly D_1N_2 (4.67) recorded higher dry matter than the rest of the treatment combinations. Further no significant difference was observed among the treatment combinations D_1N_1 (3.90), D_3N_3 (3.80) and D_2N_2 (3.60). The lower dry weight was observed at D_4N_0 (0.96).

Among various treatment combinations, at harvest, D_1N_3 (7.23) recorded maximum dry weight over rest of the treatment combinations, followed by D_1N_2 (5.00) also recorded significantly greater dry weight over rest of the treatment combinations. However, no significant difference was observed between D_2N_3 (4.53) and D_1N_1 (4.20). Similarly, the treatment combination D_1N_1 (4.20) recorded greater dry weight over other treatment combinations but was on a par with D_2N_2 (4.07), D_3N_3 (4.00) and D_1N_0 (3.77). The lower dry weight was found with D_4N_0 (1.20).

4.1.4 Spike length (cm)

Sowing at different dates and nitrogen at different levels and their combinations, significantly affected the spike length (Table 4).

Among the sowing dates D_1 (5th October) recorded maximum spike length over other treatments at all the stages of crop growth, followed by D_2 (20th October), D_3 (5th November) and D_4 (20th November).

Application of nitrogen at different levels significantly increased the spike length from N_0 – N_3. N_3 (100 kg ha^{-1}) recorded significantly higher spike length than the other treatments at all the stages of crop growth, followed by N_2 and N_1. The lowest spike length was recorded with control (N_0).

The interaction between sowing dates and nitrogen levels revealed that among the various treatment combinations at 60 DAS, D_1N_3 (5.33 cm) recorded significantly higher spike length over rest of the treatment combinations. This treatment was followed by D_1N_2 (4.80 cm) also recorded significantly higher spike length over rest of the treatment combinations. Similarly D_1N_1 (4.33 cm) recorded higher spike length than the rest of the treatment combinations but was on a par with

D_1N_0 (4.13 cm). Further no significant difference was observed between D_2N_3 (3.90 cm) and D_2N_2 (3.86 cm). The lower spike length was observed with D_4N_0 (1.16 cm) which was on a par with D_4N_1 (1.36 cm).

At 90 DAS, spike length significantly increased at D_1N_3 (6.16 cm) over rest of the treatment combinations. So also D_1N_2 (5.50 cm) recorded maximum spike length over rest of the treatment combinations. These treatments were followed by D_2N_3 (4.86 cm), D_1N_1 (4.86 cm) and D_1N_0 (4.60 cm). The lower spike length was recorded at D_4N_1 (1.83 cm) but was on a par with D_4N_0 (1.63 cm).

Among the various treatment combinations at harvest, significantly higher spike length was recorded at D_1N_3 (6.20 cm) than the rest of the treatment combinations. This was followed by D_1N_2 (5.63 cm) also recorded higher spike length than the rest of the treatment combinations. However no significant difference was observed between D_2N_3 (4.93 cm) and D_1N_1 (4.83 cm). Further D_1N_1 (4.83 cm) recorded higher spike length than the rest of the treatment combinations but was on a par with D_1N_0 (4.70 cm). The lower spike length was recorded at D_4N_1 (1.93 cm) and D_4N_0 (1.80 cm) which was on a par.

4.2 Yield characters

4.2.1 Time taken for 50 per cent flowering

Different sowing dates and nitrogen levels had a significant effect on 50 per cent flowering in Isabgol plants (Table 5).

The time taken for 50 per cent flowering was found to delay with extended dates of sowing. The early sowing (i.e.,) 5^{th} October (D_1) was significantly taken more time in attaining 50 per cent flowering over 20^{th} October (D_2), 5^{th}

November (D_3) and 20th November (D_4). The delayed sowing (i.e.,) (D_4) 20th November resulted in early flowering over the other days of sowing.

The interaction between sowing dates and nitrogen levels was found not significant.

4.2.2 Seed yield (q/ha)

The seed yield per hectare in Isabgol plants was also significantly affected with different dates of sowing and nitrogen levels (Table 6).

It is evident from the table that delay in sowing from D_1 (5th October) to D_4 (20th November) significantly reduced the seed yield per hectare. The highest and lowest seed yield per hectare were recorded with D_1 (5th October) and D_4 (20th November) sowing dates respectively.

The seed yield per hectare increased significantly with increase in the level of nitrogen from N_0 (Control) – N_3 (100 kg ha^{-1}). The highest seed yield per hectare was recorded with N_3 (100 kg ha^{-1}) which was significantly superior over rest of the nitrogen levels. The lowest seed yield per hectare was recorded with N_0 (Control) which was on a par with N_1 (50 kg ha^{-1}).

The interaction between sowing dates and nitrogen levels was found significant. The seed yield per hectare increased significantly with increase in level of nitrogen from N_0 (Control) to N_3 (100 kg ha^{-1}) at all dates of sowing. Similarly, the seed yield per hectare decreased significantly with delay in sowing from D_1 (5th October) – D_4 (20th November) at all the levels of nitrogen.

Among the different treatment combinations D_1N_3 (5.64 q ha^{-1}) recorded significantly higher seed yield per hectare than the rest of the treatment combinations but was on a par with D_1N_2 (5.58 q ha^{-1}). Further D_1N_1 (5.41 q ha^{-1}) recorded significantly higher seed yield per hectare over rest of the treatment combinations. These were followed by D_1N_0 (5.32 q ha^{-1}), D_2N_2 (4.63 q ha^{-1}) and D_2N_0 (4.64 q ha^{-1}). The lowest seed yield per hectare was observed with D_4N_0 (2.53 q ha^{-1}) which was on a par with D_4N_1 (2.58 q ha^{-1}).

4.2.3 Harvest index (%)

The data on harvest index in Isabgol plants as affected by the effect different sowing dates and levels of nitrogen and their combinations are furnished in Table 7. Different dates of sowing significantly reduced the harvest index as the sowing was delayed from D_1 (5th October) to D_4 (20th November). D_1 (5th October) recorded significantly higher harvest index than the rest of the treatment combinations. This was followed by N_1 (50 kg ha^{-1}), N_2 (75 kg ha^{-1}) and N_0 (Control). At D_3 (5th November) sowing N_1 (50 kg ha^{-1}) recorded significantly higher harvest index but was on a par with N_2 (75 kg ha^{-1}) followed by N_0 (Control) and N_3 (100 kg ha^{-1}). At D_4 (20th November) higher harvest index was recorded at N_2 (75 kg ha^{-1}) followed by N_1 (50 kg ha^{-1}), N_0 (Control) and N_3 (100 kg ha^{-1}).

A significant interaction between sowing dates and nitrogen levels was also found in respect of harvest index in Isabgol plants. Among various treatment combinations D_1N_2 (5.89) recorded significantly higher harvest index than the rest of the treatment combinations. Further D_1N_1 (5.64) recorded significantly higher harvest index than the rest of the treatment combinations. These were followed by D_2N_1 (5.51), D_2N_2 (5.38), D_3N_1 (5.36), D_3N_2 (5.34) and D_1N_3 (4.73). The lower harvest index was observed at D_4N_3 (2.91).

4.2.4 Percentage of husk

Percentage of husk was significantly affected with different dates of sowing, nitrogen levels and their combinations (Table 8).

At different dates of sowing percentage of husk did not differ significantly. Similarly no significant difference in percentage of husk was observed with increase in nitrogen level from N_0 (Control) – N_2 (75 kg ha^{-1}) but increase in nitrogen dose beyond N_2 (75 kg ha^{-1}) significantly reduced the percentage of husk.

The interaction between sowing dates and nitrogen levels was found significant. The percentage of husk did not differ significantly at D_1 (5th October), D_2 (20th October) and D_3 (5th November) sowing dates with increase in the level of nitrogen from N_0 (Control) – N_3 (100 kg ha^{-1}). At D_4 (20th November), N_1 (50 kg ha^{-1}) recorded higher percentage of husk over rest of the levels of nitrogen. Further increase in nitrogen beyond N_1 (50 kg ha^{-1}) did not increase in percentage of husk at D_4 (20th November) sowing.

Among the different treatment combinations, D_4N_1 (24.56) recorded higher percentage of husk over D_4N_2 (18.30) and D_4N_3 (18.30) but was on a par with rest of the treatment combinations.

Table 1: Effect of dates of sowing and N levels on plant height (cm) in Isabgol plants at different days after sowing

	Days after sowing			
	30	60	90	Harvest
Sowing dates				
D_1	13.80	26.51	36.73	42.34
D_2	12.68	21.25	27.64	33.72
D_3	8.27	18.38	25.67	27.77
D_4	7.00	13.03	18.05	20.97
SEm$\pm$	0.15	0.20	0.13	0.20
CD at 5%	0.45	0.58	0.38	0.57
N levels				
N_0	9.15	17.97	25.10	28.67
N_1	9.90	19.77	26.43	29.82
N_2	10.85	19.92	27.35	31.73
N_3	11.85	21.51	29.22	34.58
SEm$\pm$	0.15	0.20	0.13	0.20
CD at 5%	0.45	0.58	0.38	0.57
D x N interactions				
D_1 N_0	12.37	23.80	35.36	40.63
D_1 N_1	12.56	26.86	36.06	40.97
D_1 N_2	14.73	26.53	37.13	43.50
D_1 N_3	15.53	28.86	38.36	44.27
D_2 N_0	10.86	19.60	25.63	30.23
D_2 N_1	12.33	21.48	27.66	32.17
D_2 N_2	13.30	21.53	28.13	34.13
D_2 N_3	14.23	22.40	29.13	38.33
D_3 N_0	7.43	16.30	23.16	25.53
D_3 N_1	8.20	17.96	25.33	26.57
D_3 N_2	8.30	18.56	26.03	28.63
D_3 N_3	9.16	20.70	28.16	30.33
D_4 N_0	5.94	12.20	16.23	18.27
D_4 N_1	6.50	12.76	16.66	19.57
D_4 N_2	7.10	13.06	18.10	20.67
D_4 N_3	8.46	14.10	21.23	25.37
SEm$\pm$	0.31	0.40	0.26	0.39
CD at 5%	0.91	1.17	0.77	1.14

Table 2: Effect of dates of sowing and N levels on number of tillers per plant in Isabgol at different days after sowing

	Days after sowing			
	30	60	90	Harvest
Sowing dates				
D_1	4.03	6.62	10.61	12.26
D_2	3.41	5.06	7.89	9.21
D_3	2.82	4.98	7.86	8.26
D_4	2.98	3.87	7.86	8.26
SEm±	0.08	0.06	0.08	0.12
CD at 5%	0.25	0.19	0.23	0.36
N levels				
N_0	2.65	4.26	7.41	8.51
N_1	3.15	4.85	7.96	9.30
N_2	3.54	5.40	8.62	9.70
N_3	3.90	6.03	9.06	10.34
SEm±	0.08	0.06	0.08	0.12
CD at 5%	0.25	0.19	0.23	0.36
D x N interactions				
D_1 N_0	3.33	5.50	9.30	11.26
D_1 N_1	4.00	6.13	10.43	12.13
D_1 N_2	4.30	7.13	11.20	12.60
D_1 N_3	4.50	7.73	11.53	13.06
D_2 N_0	2.56	4.30	7.06	7.93
D_2 N_1	3.20	4.76	7.70	9.16
D_2 N_2	3.73	5.13	8.23	9.60
D_2 N_3	4.16	6.06	8.56	10.10
D_3 N_0	2.53	4.10	7.10	7.66
D_3 N_1	2.76	4.63	7.23	7.96
D_3 N_2	2.86	5.40	8.36	9.40
D_3 N_3	3.13	5.80	8.76	9.03
D_4 N_0	2.20	3.16	6.20	7.20
D_4 N_1	2.66	3.86	6.50	7.93
D_4 N_2	3.26	3.93	6.70	8.20
D_4 N_3	3.80	4.53	7.40	9.10
SEm±	0.17	0.13	0.16	0.25
CD at 5%	NS	0.39	0.47	NS

Table 3: Effect of dates of sowing and N levels on dry weight (g) in Isabgol at different days after sowing

	Days after sowing			
	30	60	90	Harvest
Sowing dates				
D_1	0.36	2.98	4.62	5.05
D_2	0.22	1.93	8.24	3.40
D_3	0.13	1.79	2.30	2.72
D_4	0.10	1.29	1.81	2.15
SEm$\pm$	0.00	0.04	0.06	0.07
CD at 5%	0.01	0.13	0.17	0.21
N levels				
N_0	0.11	1.09	1.81	2.24
N_1	0.17	1.64	2.42	2.77
N_2	0.22	2.10	3.11	3.53
N_3	0.31	3.14	4.64	4.78
SEm$\pm$	0.00	0.04	0.06	0.07
CD at 5%	0.01	0.13	0.17	0.21
D x N interactions				
D_1 N_0	0.24	1.93	3.10	3.77
D_1 N_1	0.32	2.63	3.90	4.20
D_1 N_2	0.40	3.23	4.67	5.00
D_1 N_3	0.46	4.10	6.80	7.23
D_2 N_0	0.12	0.97	1.80	2.10
D_2 N_1	0.18	1.80	2.47	2.90
D_2 N_2	0.24	2.10	3.60	4.07
D_2 N_3	0.34	2.87	5.10	4.53
D_3 N_0	0.08	0.82	1.37	1.90
D_3 N_1	0.10	1.23	1.87	2.17
D_3 N_2	0.13	1.93	2.17	2.80
D_3 N_3	0.23	3.10	3.80	4.00
D_4 N_0	0.02	0.62	0.96	1.20
D_4 N_1	0.08	0.89	1.43	1.80
D_4 N_2	0.10	1.13	2.00	2.27
D_4 N_3	0.20	2.50	2.87	3.33
SEm$\pm$	0.01	0.09	0.12	0.15
CD at 5%	0.02	0.25	0.34	0.43

Table 4: Effect of sowing dates and N levels on spike length (cm)in Isabgol at different days after sowing

	Days after sowing		
	60	90	Harvest
Sowing dates			
D_1	4.66	5.28	5.34
D_2	3.57	4.00	4.03
D_3	2.55	3.48	3.55
D_4	1.42	2.10	2.20
SEm±	0.38	0.04	0.03
CD at 5%	0.11	0.12	0.10
N levels			
N_0	2.68	3.25	3.35
N_1	2.88	3.49	3.51
N_2	3.20	3.75	3.80
N_3	3.45	4.37	4.44
SEm±	0.38	0.04	0.03
CD at 5%	0.11	0.12	0.10
D x N interactions			
D_1 N_0	4.13	4.60	4.70
D_1 N_1	4.33	4.86	4.83
D_1 N_2	4.86	5.50	5.63
D_1 N_3	5.33	6.16	6.20
D_2 N_0	3.16	3.66	3.70
D_2 N_1	3.36	3.86	3.86
D_2 N_2	3.86	3.60	3.63
D_2 N_3	3.90	4.86	4.93
D_3 N_0	2.26	3.13	3.23
D_3 N_1	2.46	3.40	3.43
D_3 N_2	2.60	3.60	3.63
D_3 N_3	2.86	3.80	3.90
D_4 N_0	1.16	1.63	1.80
D_4 N_1	1.36	1.83	1.93
D_4 N_2	1.46	2.30	2.33
D_4 N_3	1.70	2.66	2.73
SEm±	0.07	0.08	0.07
CD at 5%	0.22	0.24	0.21

Table 5: Effect of dates of sowing and N levels on time taken for 50 per cent flowering in Isabgol plants

N levels	Sowing dates				Mean
	D_1	D_2	D_3	D_4	
N_0	85.67	82.50	72.50	71.50	78.04
N_1	86.37	83.50	74.50	73.57	79.48
N_2	87.40	84.50	76.50	74.50	80.72
N_3	89.40	85.50	79.19	76.50	82.64
Mean	87.21	84.00	75.67	74.02	80.22

	Sowing dates	**N levels**	**Sowing dates x N levels**
CD at 5%	0.11	0.11	NS
SEm$\pm$	0.38	0.38	0.77

Table 6: Effect of dates of sowing and N levels on seed yield (q/ha) in Isabgol plants

N levels	Sowing dates				Mean
	D_1	D_2	D_3	D_4	
N_0	5.32	4.64	3.29	2.53	3.95
N_1	5.41	4.54	3.31	2.58	3.96
N_2	5.58	4.63	3.35	2.63	4.05
N_3	5.64	4.68	3.38	2.69	4.10
Mean	5.49	4.62	3.33	2.61	4.01

	Sowing dates	**N levels**	**Sowing dates x N levels**
CD at 5%	0.03	0.03	0.06
SEm$\pm$	0.01	0.01	0.03

Table 7: Effect of dates of sowing and N levels on harvest index (%) in Isabgol plants

N levels	Sowing dates				Mean
	D_1	D_2	D_3	D_4	
N_0	5.24	4.58	4.52	3.49	4.78
N_1	5.64	5.51	5.36	3.89	4.96
N_2	5.89	5.38	5.34	4.01	5.37
N_3	4.73	5.10	3.90	2.91	3.59
Mean	5.15	5.10	4.46	3.99	4.67

	Sowing dates	**N levels**	**Sowing dates x N levels**
CD at 5%	0.06	0.06	0.12
SEm±	0.03	0.03	0.06

Table 8: Effect of dates of sowing and N levels on percentage of husk yield in Isabgol plants

N levels	Sowing dates				Mean
	D_1	D_2	D_3	D_4	
N_0	23.83	23.00	23.26	18.30	23.85
N_1	22.76	23.00	23.26	18.30	21.83
N_2	24.50	23.16	23.26	18.30	22.30
N_3	22.83	23.00	23.26	18.30	21.85
Mean	23.23	23.04	23.26	19.86	22.35

	Sowing dates	**N levels**	**Sowing dates x N levels**
CD at 5%	2.39	2.39	4.78
SEm±	1.17	1.17	2.34

CHAPTER – V

DISCUSSION

Twenty first century is hailed as a century of natural products and biotechnology. Among the natural products, the products obtained from a number of medicinal plants are commanding demand both in national and international market for their extensive use in pharmaceutical and neutraceutical industries. Among them, *Plantago ovata* is one of the potential medicinal crop. *Blond psyllium* or isabgol (*Plantago ovata* Forsk) is an important winter-season crop grown commercially grown in India for seed and husk. It is being a photosensitive crop responds well to the time of sowing. Delay in sowing causes in reduced yield. Nitrogen is considered as a major nutrient for growth and development of plants and its requirement greatly varies according to the soil in the cultivation of Isabgol (Kalyansundaram *et al*., 1987).

Keeping the above facts in view, the present investigation was conducted to study the effect of dates of sowing and levels of nitrogen on growth and yield of isabgol (*Plantago ovata* Forsk.). The results obtained from the experiments are discussed hereunder.

5.1 Plant height (cm)

Growth is an irreversible increase in size shape of the plant and it is affected by the complex interaction between environmental factors and physiological processes which are influenced by the application of external inputs like water and nutrients. In the present experiment, different dates of sowing and nitrogen levels exerted a significant affect on plant height (Table 1).

Irrespective of sowing dates, the plant height increased progressively from 30 to 90 days with the age of crop registering maximum at harvest. The highest plant height was noticed in early sowing on 5th Oct (42.34 cm) and decreased markedly with delay in sowing with 20th November (20.97 cm). The prolonged growing period coupled with more sunshine hours (189) and higher rainfall (112 mm) conditions might have promoted luxuriant vegetative growth in early sowing on 5th October which is a passing period of both rainy and winter seasons. The early sown crop which has passed through higher light duration (22.42 hr) and more humidity (85.04%), long days coupled with optimum temperature (22.42^{o}C) relatively might have encouraged more vegetative growth before the actual onset of short day periods. On the other hand, the poor vegetative growth in winter in late sown crop was due to short day conditions and cold temperatures (13.6^{o}C) and experiencing summer season during the later part of its growth. Similar results were reported by Singh *et al*. (2003), Mann and Vyas (2001) and Solanki and Shaktawat (1999) in Isabgol.

Balanced nutrition is an important factor which optimizes the growth of crop. In the present study, the vegetative growth of crop in terms of plant height increased with increase in nitrogen level from 0 – 100 kg ha^{-1}. The highest plant height was recorded with 100 kg N ha^{-1} (42.34 cm). The increase in plant height at higher level of nitrogen could be due to higher availability and uptake of more nitrogen (Maynard and David, 1987). Mann and Vyas (1999) also reported increased plant height with increase in N levels in Isabgol. Nitrogen is very important constituent of protoplasm and its favourable effect on chlorophyll content of leaves at high level might have increased the synthesis of carbohydrates, amino acids etc., from which phytohormones such as auxins, gibberellins, cytokinins and ethylene have been synthesized resulting in increased plant height (Maynard and David, 1987).

Rapid elongation of cells because of adequate nitrogen seems to be the favourable influence of nitrogen on plant growth. In the present experiment, the increased plant growth with higher levels of nitrogen could be due to production of higher levels of auxins (Torroy, 1950) and cytokinins (Marschner, 1983), while reduced plant height with low levels of nitrogen could be due to very low production of plant hormones. Nitrogen has also prominent effect on GA levels also. Krauss and Marschner (1982) reported that an interruption of nitrogen supply induces a sharp increase in ABA levels. Reduced plant growth under lower nitrogen supply might be due to increase in ABA and decrease in production and export of cytokinins to shoot and leaf. Further inadequate N supply coupled with low nitrogen status of soil and uptake might have resulted in shorter plants at lower levels of nitrogen.

A growth is a function of environmental and nutritional factors. Uptake and utilization of N in plants is controlled by environmental factors like temperature and light intensity. A significant interaction was observed between sowing dates and nitrogen on plant height. Among the various treatment combinations, Oct 5th sowing + 100 kg N ha^{-1} recorded significantly higher plant height compared with rest of the treatment combinations. In general, nitrogen at 100 kg ha^{-1} in combination with 5th October, 20th October, 5th November and 20th November recorded higher plant height compared with rest of the treatment combinations. Solanki and Shaktawat (1999) also reported a positive interaction between environment and nitrogen. This indicates that nitrogen at higher level has got profound effect on the plant height in combination with all sowing dates. In the present experiment, the treatment combination 20th November + Control recorded the lowest plant height. This could be due to low temperatures and highest intensity during the plant growth period during the winter coupled with shortage of nitrogen.

5.2 Tillers per plant

Tillering character is a function of gene and environmental interaction.

The tiller production was significantly reduced with delay in sowing from 12.26 on 5th October date to 8.26 on 20th November. The poor tillering under late planting might be due to low temperatures, reduced uptake of nutrients reduction in the height and number of leaves per plant.

The study revealed that early sowings, 5th October (12.76) and 20th October (9.21) recorded more number of tillers compared to late sowing, 5th November (8.26) and 20th November (8.26). The production of more tillers in early sowing, 5th October could be attributed to longer growing periods, better dry matter production, favourable weather conditions resulting in better vegetative growth. Ramesh *et al*. (1989) also reported that sowing in mid and late October resulted in significantly higher tiller production in Isabgol.

Higher levels of nitrogen increased number of tillers per plant from 8.51 with control to 10.34 with 100 kg N ha^{-1}. Irrespective of the sowing dates, application of 100 kg N ha^{-1} (10.34) recorded higher number of tillers over 75 kg N ha^{-1} (9.70), 50 kg N ha^{-1} (9.30) and control (8.51). Nitrogen being the constituent of protoplasm and its favourable effect on chlorophyll content of leaves might have resulted in increased synthesis of carbohydrates (Tisdale *et al*., 1985). Further, nitrogen being a constituent of nucleotides, enzymes etc., has great importance in plant metabolism (Marschner, 1983). Probably these factors might have enhanced more tiller production. Similar results were also reported by Mahabaleswar *et al*. (1984) in palmarosa.

Early sowing on 5th October with 100kg N ha^{-1} recorded more number of tillers per plant. More number of tillers, in this treatment combination might be due to higher uptake of nitrogen and favourable weather conditions during the crop growth period.

5.3 Dry weight $plant^{-1}$ (g)

Increase in dry weight is a function of optimum growth and development.

Dry weights of plants were significantly influenced due to sowing dates. The dry weight of plants ranged from 5.05 g on 5th October sowing to 2.15 g on 20th November sowing. Irrespective of the levels of nitrogen, 5th October sowing continuously resulted in maximum accumulation of dry matter in the plant portions during all crop growth stages and reached a maximum of 5.05 g at harvest compared to 20th October (3.40 g), 5th November (2.72 g) and 20th November (2.15 g) sowings.

The weather parameters viz., low temperature (13.63oC) and low sunshine hours (133.80 hrs) associated with cloudy days might be responsible for slow and restricted vegetative growth which might have contributed for decreased dry matter production with delayed sowings. Maximum dry matter accumulation in the early sown crop was perhaps due to production of more number of tillers as well as more plant height i.e., more vegetative growth. Similar results were also reported by Singh *et al*. (2003) in Isabgol.

Irrespective of the sowing dates, application of 100 kg N ha^{-1} has produced more dry weight in plants at all crop growth stages. Plant height, tiller number are the growth attributes which might have significantly affected the dry weight of plants. In the present experiment, the treatments which recorded higher plant height and more number of tillers per plant might have resulted in higher plant dry weights. The possible reason for the increase in these growth parameters might be due to influence of nitrogen on protein synthesis, essential for the formation of protoplasm which might have lead to cell division and cell enlargement. Moreover nitrogen is an important component of amino acids and co-enzymes which are of considerable biological importance (Bably, 1974). These results are in conformity with the findings of Maitra *et al*. (1998) in Ashwagandha and Selvaraj *et al*. (2003) in Rosemary and Thyme.

Early sowing on 5th October with higher levels of N 100 kg ha^{-1} recorded higher dry weight over all other treatment combinations and decreased with delay in sowing. More dry weight in early sowing might be due to higher plant height and more number of tillers per plant.

5.4 Spike length

In the present experiment, irrespective of the nitrogen levels, 5th October sowing recorded maximum spike length (5.34 cm) at harvest compared to 20th October (4.03 cm), 5th November (3.55 cm) and 20th November (2.20 cm) sowings (Table 4). Isabgol is a photosensitive crop, increase in day length from February onwards might have caused early conversion of vegetative phase resulting less time to the plants to achieve full growth. Therefore plants from late sowing can not effectively use the production resources. Early sowing coupled with congenial climatic conditions might have encouraged more spike length before the onset of short day periods. Late sown crop which has passed through only short day conditions (133 sunshine hours) and cold temperatures (13.63^{o}C) has entered into summer season during the later part of its growth resulting in less spike length. Similar results were obtained by Solanki and Shaktawat (1999) and Singh *et al*. (2003) in Isabgol.

Nitrogen application significantly influenced the spike length. Irrespective of the sowing dates, application of 100 kg N ha^{-1} produced higher spike length at all stages of crop growth (4.44 cm) over 75 kg N ha^{-1} (3.80 cm), 50 kg N ha^{-1} (3.51 cm) and control (3.35 cm) (Table 4). The favourable effect of nitrogen on spike length could be attributed to the fact that nitrogen is one of the most dispensable plant nutrient for improving growth and development. Solanki and Shaktawat (1999) and Singh *et al*. (2003) also reported that spike length increased with increase in the levels of nitrogen in Isabgol.

The interaction revealed that among the treatment combinations, 5th October sowing + 100 kg N ha^{-1} recorded higher spike length. This might be due to congenial climatic conditions, increase in plant height and number of tillers and leaves per plant.

5.5 Days taken for 50% flowering

A significant influence in days taken for 50 per cent flowering was observed due to dates of sowing, levels of nitrogen and their combination. The number of days taken for 50 per cent flowering ranged from 87.21 to 74.02 from 5th October to 20th November sowing. Isabgol crop is a cold season crop and it requires cool climate for flowering. Delayed flowering in early sown crop may be due to availability of long day periods for longer duration and higher mean maximum temperature (22.42^{o}C) and greater number of sunshine hours (189 hrs) (Appendix I). These results are in line with the findings of Mann and Vyas (1999) wherein 50 per cent flowering occurred early as the sowings were delayed in Isabgol. The early flowering with delayed sowings might be due to low temperatures (13.63^{o}C) and onset of short day conditions.

Days taken for 50 per cent flowering was significantly influenced due to N application. Irrespective of the sowing dates, application of 100 kg N ha^{-1} increased the days taken for 50 per cent flowering (82.64) compared to other treatments (Table 5). In general the days taken to 50 per cent flowering increased with increase in nitrogen levels. This might be due to the fact that the low levels of nitrogen might have resulted in quick cessation of vegetative growth and forcing the plants to flower early. Further, application of higher levels of nitrogen might have enhanced vegetative growth for prolonged period thereby might have delayed 50 per cent flowering. Mann and Vyas (1999) reported similar trend with increase in the levels of nitrogen on 50 per cent flowering in Isabgol.

The interaction between sowing dates and nitrogen levels on 50 per cent of flowering was found not significant indicating that their effect is independent.

5.6 Seed yield (q ha^{-1})

Irrespective of the levels of nitrogen, early sowing on 5th October sowing recorded maximum seed yield. The yield decreased from 5.49 q ha^{-1} to 2.61 q ha^{-1} by delaying sowing from 5th October to 20th November. Higher seed yield in the early sown crop could be due to the longer growing period, production of taller plants, more number of tillers per plant, spike length and more dry weight of plants. Randhawa *et al*. (1978) under Punjab conditions reported that sowing date has significant and a linear effect on yield in Isabgol. Ramesh *et al*. (1989) also observed that sowing Isabgol seeds in the month of October under South Indian conditions resulted in better vegetative growth and enhanced seed yield. Enhanced seed yields were also obtained when Isabgol seeds were sown in October over sowing in November (Singh *et al*., 2003). The decrease in seed yield with delay in sowing was due to shorter growing period, decreased plant height and production of less number of tillers per plant. Iyengar *et al*. (1968) also observed that sowing Isabgol late in December reduced the seed yield.

Seed yield was significantly influenced due to nitrogen application. Irrespective of sowing dates, application of 100 kg N ha^{-1} recorded higher seed yield (4.10 q ha^{-1}) (Table 6). This could be due to the reason that increase in plant height, number of tillers, dry matter production and increase in spike length at higher levels of nitrogen might have resulted higher seed yield. Joshi *et al*. (1968) also observed increased seed yield in Isabgol due to nitrogen applications at rates ranging from 20 to 250 kg ha^{-1}.

The interaction between sowing dates and nitrogen levels revealed that among various treatment combinations, 5^{th} October sowing + 100 kg N ha^{-1} recorded highest seed yield compared ot other treatment combinations but was on a par with 5^{th} October + 75 kg N ha^{-1}. The higher seed yield in these treatments might be due to existing favourable weather conditions during October month and increased uptake of nitrogen at 100 kg ha^{-1} resulting in better vegetative growth in terms of plant height, number of tillers per plant, dry matter production and spike length. The lowest seed yield was observed with 20^{th} November sowing + control. This could be due to lower temperature (13.63^{o}C) during growing period and shortage of nitrogen.

5.7 Harvest index (%) (HI)

A significant influence on harvest index was observed due to sowing dates and levels of nitrogen. Irrespective of nitrogen levels, 5^{th} October sowing recorded higher harvest index and it decreased with delay in sowing dates from 5.15 on 5th October sowing to 3.99 on 20th November sowing. No significant difference in HI was observed between 5th October sowing and 20th October sowing. Harvest index represents increased sink capacity to metabolized photosynthates and translocate them to organs of economic value. It is a convenient index to express numerically what proportion of total dry matter of plant apportioned to economic part. Higher harvest index in early sown crop might be due to higher seed yield. Further, with delay in sowing from 20th October to 20th November significantly reduced the HI. This could be due to less production of biological yield at later dates of sowing.

The harvest index ranged from 3.59 with 100 kg N ha^{-1} to 4.96 with 75 kg N ha^{-1}. The significant reduction in HI with 100 kg N ha^{-1} could be due to production of more vegetative growth compared with other levels of nitrogen. Further, 75 kg N ha^{-1} appears to be optimum which has produced more of economic yield than that of biological yield. Further decreased HI in 50 kg N ha^{-1} could be due to production of less biological yield.

The interaction between sowing dates and nitrogen revealed that irrespective of sowing dates, 75 kg N ha^{-1} produced higher HI over others. Further, among the different treatment combinations, 5th October sowing + 75 kg N ha^{-1} recorded higher HI over rest of the treatment combinations. This could be because of the production of lesser biological yield compared with rest of treatment combinations. This could be also due to the fact that the congenial climatic conditions after October sowing and higher uptake of nitrogen might have resulted in HI.

5.8 Percentage of husk

Irrespective of dates of sowing, the per cent of husk did not differ significantly. This indicated that the date of sowings did not have any influence on percentage of husk in Isabgol seeds. This might be due to the fact that though the vegetative characters are differed significantly at each delay in 15 days sowing but the per cent of husk yield did not differ.

The percentage of husk ranged from 22.35 with 100 kg N ha^{-1} to 23.23 with control. Further, the treatment with no nitrogen recorded significantly higher percentage of husk over 100 kg N ha^{-1} but was on a par with lower levels of nitrogen 75 g N ha^{-1} and 50 kg N ha^{-1}. The decreased percentage of husk with the application of 100 kg N ha^{-1} could be due to production of more vegetative growth and higher yield because of more utilization of nitrogen. This might have improved the vegetative characters but not the percentage of husk.

The percentage of husk ranged from 18.30 to 24.50 with different treatment combinations. Further, 5th October sowing + 75 kg N ha^{-1} recorded high percentage of husk but was on a par all other treatment combinations except with 20th November sowing + control, 20th November sowing + 100 kg N ha^{-1}. This indicates that irrespective of level of nitrogen, sowing on 5th October and 20th November had a significant effect which has reduced the percentage of husk significantly. It also revealed that the percentage of husk did not change either sowing date or application of nitrogen at different levels.

CHAPTER – VI

SUMMARY

Plantago ovata commonly known as Isabgol, Psyllium or Indian plantago belongs to family plantaginaceae. It is an important medicinal plant. The husk of the seed is the economic part and is separated by a physical process. The seed husk contains a colloidal mucilage (30%), mainly consisting of xylose, arabinose, galacturonic acid with rhamnose, galactose etc. The seed also contains oil and small amounts of glycoside a cubin and tannin.

The husk of Isabgol has the property of absorbing and retaining water and therefore, it works as anti-diarrhoel drug, beneficial in chronic dysenteries of anoebic and bacillary origin, treating for constipation and intestinal disorders, relieves from sore throat and bronchitis. Till to day, it is cultivated mainly in the northern parts of the country and its suitability to south Indian conditions has not yet been critically examined. Hence, an experiment was carried out to study the effect of date of sowing and nitrogen on growth and yield of Isabgol.

A field experiment entitled "Effect of date of sowing and nitrogen on growth and yield of Isabgol (*Plantago ovata* Forsk.)" was carried out from October, 2004 to April, 2005 at Herbal Garden, College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad. The experimental soil was of red sandy loam with uniform texture and topography.

The treatments consisted of four dates of sowing viz., 5th October 2004, 20th October 2004, 5th November 2004 and 20th November 2004, and four levels of nitrogen, 50 kg N ha^{-1}, 75 kg N ha^{-1}, 100 kg N ha^{-1} and control. A common dose of recommended phosphorus (50 kg ha^{-1}) and potassium (30 kg ha^{-1}) were applied uniformly to all the treatments. A factorial randomized block design was adopted with three replications. The results of the present investigation are summarized hereunder.

6.1 The study revealed that the plant height decreased significantly with each delay in sowing from 5th October – 20th November. While it increased significantly with increase in nitrogen levels from 0 – 100 kg ha^{-1} and registering maximum at 5th October (42.34 cm) and 100 kg N ha^{-1} (34.58 cm) at all stages of crop growth. Further among the various treatment combinations, 5th October + 100 kg N ha^{-1} recorded significantly higher plant height (44.27 cm) at all the stages of crop growth.

6.2 Number of tillers per plant also decreased significantly with delay in sowing from 5th October – 20th November and increased significantly with increase in nitrogen levels from 0 – 100 kg ha^{-1}. The maximum number of tillers per plant was recorded with 5th October and 100 kg N ha^{-1} at all stages of crop growth (12.26 and 10.34 respectively). The interaction between the sowing dates and nitrogen levels revealed that among the various treatment combinations, 5th October + 100 kg N ha^{-1} (13.06) recorded significantly more number of tillers compared with rest of the treatment combinations, but was on a par with 5th October + 75 kg N ha^{-1} (12.60).

6.3 The dry matter per plant and length of the spike decreased significantly with every delay in sowing from 5th October 20th November and increased significantly with increase in nitrogen levels from 0 – 100 kg ha^{-1} and recorded maximum at 5th October (5.05 g dry matter and 5.34 cm spike length) and 100 kg N ha^{-1} (4.78 g dry matter and 4.44 cm spike length) at all the stages of crop growth. The interaction between sowing dates and nitrogen levels revealed that the dry matter and length of the spike increased significantly with 5th October sowing + 100 kg N ha^{-1} over all other treatment combinations.

6.4 The time taken for 50 per cent flowering was found to delay with extended dates of sowing from 5th October – 20th November and increased with increase in the level of nitrogen from 0 – 100 kg N ha^{-1} and recorded maximum at 5th October and 100 kg N ha^{-1} (87.21 and 82.64 respectively). The interaction between the sowing dates of nitrogen levels was found not significant.

6.5 Seed yield per hectare decreased significantly with each delay in sowing from 5th October – 20th November and increased with increasing levels of nitrogen from 0 – 100 kg ha^{-1}. The maximum seed yield was observed at 5th October and 100 kg N ha^{-1} (5.49 q ha^{-1} and 4.10 q ha^{-1} respectively) at all the stages of crop growth. The interaction between the sowing dates and nitrogen levels revealed that 5th October + 100 kg N ha^{-1} recorded maximum seed yield per hectare (5.64 q ha^{-1}) over rest of the treatment combinations but was on a par with 5th October + 75 kg N ha^{-1} (5.55 q ha^{-1}).

6.6 The harvest index significantly affected with the sowing dates, application of N and their combinations. Among the sowing dates, 5th October recorded significantly higher harvest index followed by 20th

October, 5th November and 20th November. On the other hand, harvest index increased with increase in the levels of nitrogen from 0 – 75kg ha^{-1} but decreased at 100 kg N ha^{-1}. Further, sowing on 5th October + 75 kg N ha^{-1} (5.89) recorded significantly higher harvest index compared with rest of the treatment combinations.

6.7 Sowing on 5th October (23.85) recorded higher percentage of husk but was on a par with all the sowing dates. The percentage of husk increased with increase in the levels of nitrogen from 0 – 75 kg ha^{-1} and was on a par with each other but decreased at 100 kg ha^{-1}. Sowing on fifth October in combination with 75 kg N ha^{-1} recorded higher percentage of husk compared with other treatment combinations.

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* Originals not seen

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APPENDIX

WEEKLY METEOROLOGICAL DATA RECORDED AT ARI, RAJENDRANAGAR DURING 2004 AND 2005

WEEK NO.	PERIOD	TEMPERATURE (°C)		RELATIVE HUMIDITY (%)		RAIN-FALL (mm)	RAINY DAYS	SUN-SHINE (hrs.)	WIND SPEED (km/hr0	EVAPO-RATION (mm)	MEAN TEMP. (°C)
		MAX.	MIN	I	II						
40	01-07 OCT	30.5	21.4	93	72	74.7	5	4.3	2.0	2.9	26.0
41	08-14	31.5	21.3	94	59	2.0	0	6.1	1.8	3.7	26.4
42	15-21	30.7	15.9	86	47	0.0	0	8.2	1.3	3.4	23.3
43	22-28	30.5	20.2	91	52	0.0	0	7.9	2.7	3.4	25.3
44	29-04 NOV	29.4	17.9	89	49	0.0	0	5.7	3.4	3.2	23.7
45	05-11	29.1	18.1	87	47	0.6	0	6.1	2.9	3.2	23.6
46	12-18	31.1	17.0	90	42	0.0	0	7.9	2.7	3.5	24.1
47	19-25	30.0	11.4	82	29	0.0	0	9.6	2.5	3.4	20.7
48	26-02 DEC	29.0	10.7	84	29	0.0	0	9.6	2.8	3.5	19.9
49	03-09	28.7	9.2	86	31	0.0	0	9.6	2.2	3.5	18.9
50	10-16	28.8	10.7	85	33	0.0	0	9.3	1.9	2.8	19.8
51	17-23	30.2	11.0	87	30	0.0	0	9.4	1.6	3.2	20.6
52	24-31	29.0	12.4	84	37	0.0	0	8.8	2.5	3.9	20.7
1	01-07 JAN	29.6	15.9	85	36	0.0	0	8.0	3.2	3.6	22.8
2	08-14	30.2	12.5	80	27	0.0	0	9.3	1.6	3.1	21.4
3	15-21	29.4	14.8	72	33	0.0	0	9.3	3.0	2.9	22.1
4	22-28	30.7	19.6	91	43	4.2	1	6.9	4.2	3.2	25.2
5	29-04 FEB	27.9	17.4	88	47	19.6	2	6.5	4.3	3.0	22.7
6	05-11	31.3	15.4	88	25	0.0	0	9.1	3.4	4.1	23.4
7	12-18	35.1	14.9	70	17	0.0	0	10.0	2.3	4.6	25.0
8	19-25	34.3	18.8	80	26	0.0	0	9.3	3.3	5.3	26.6
9	26-03 MAR	35.0	17.3	75	17	0.0	0	9.6	3.4	6.0	26.2
10	05-11	35.0	19.5	89	28	11.6	1	9.6	5.2	6.6	27.3
11	12-18	34.2	18.4	78	19	0.0	0	9.4	2.3	5.7	26.3
12	19-25	37.0	20.7	58	21	0.0	0	9.5	3.3	8.4	28.9
13	26-01 APR	37.5	18.1	70	21	0.0	0	9.8	2.7	9.2	27.8