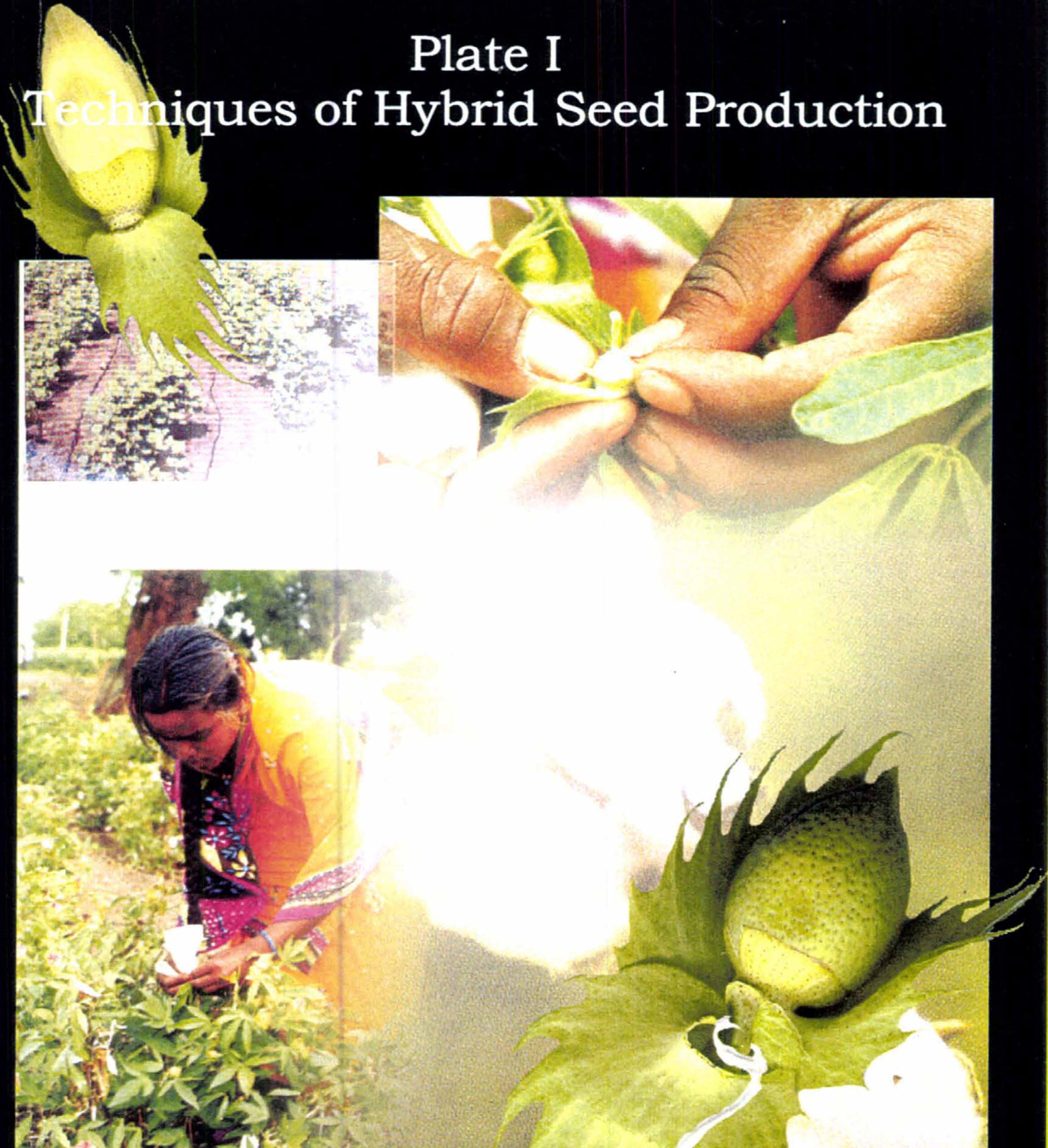
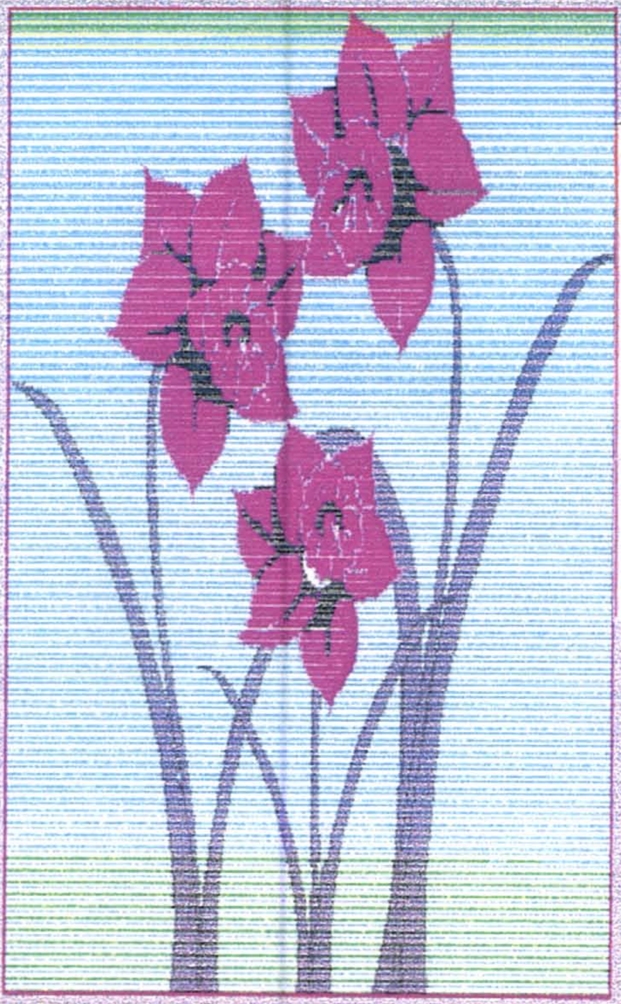
Plate I
Techniques of Hybrid Seed Production



Dedication



This research manuscript is affectionately dedicated to my beloved brother Suraj, Whose high expectations about me have been the highest source of inspiration for me and whose everlasting love is the basis of my progress.

..Dipak

"EFFECT OF DIFFERENT SOWING DATES AND IRRIGATION METHODS ON QUALITY AND QUANTITY OF HYBRID COTTON SEED PRODUCTION"

By

NAGARGOJE DIPAK CHHAGANRAO

(*Reg. No.* 99035)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI - 413722, DIST. AHMEDNAGAR, MAHARASHTRA, (INDIA)

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SEED TECHNOLOGY

DEPARTMENT OF AGRICULTURAL BOTANY

POST GRADUATE INSTITUTE,

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI - 413722, DIST. AHMEDNAGAR (M.S). , INDIA

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Dr. S. S. Mehetre
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DEPARTMENT OF AGRICULTURAL BOTANY
POST GRADUATE INSTITUTE,
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DIST. AHMEDNAGAR (M.S). , INDIA

2001

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 : MPKV., Rahuri

Dated :30/ 06/ 2001

D. C. Nagargoje

(D. C. Nagargoje)

Dr. S. S. Mehetre
Cotton Breeder,
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Maharashtra , India

CERTIFICATE

This is to certify that the thesis entitled, **"Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton seed production"**, submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra state, India, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY,** embodies the results of a piece of *bona fide* research work carried out by **Mr. D. C. Nagargoje**, under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma or publication.

Place :- MPKV, Rahuri
Dated : 30 / 06 / 2001.

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Research Guide

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Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722, Dist. Ahmednagar,
Maharashtra, India.

CERTIFICATE

This is to certify that, the thesis entitled, **"Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton seed production".** submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra state, India, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY,** embodies the results of a piece of *bona fide* research work carried out by **Mr. D. C. Nagargoje**, under the guidance and supervision of **Dr. S. S. Mehetre,** Cotton Breeder, Cotton Improvement Project, MPKV., Rahuri and that no part of this thesis has been submitted for any other degree or diploma or publication.

Place : MPKV, Rahuri.
Dated : / /2001

(S. S. Kadam)
Associate Dean

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It is impossible to mention everyone who helped me to achieve this destination. However, it would be possible to acknowledge who helped me in this project.

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The heartiest blessings of my beloved parents, Pappa and Mammi, brother Suraj and Vahini Chanda are the source of my constant inspiration with which I am stepping up my career.

Place : MPKV, Rahuri
Date : 30 / 06 / 2001

Dipak

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LIST OF ABBREVIATION USED

%	:	Per cent
&	:	and
@	:	At the rate of
°C	:	Degree Celcius
° N	:	Degree North
° S	:	Degree South
C.D.	:	Critical difference
cm	:	Centimeter
CPE	:	Cumulative pan evaporation
Cu	:	Consumptive use
Cv.	:	Cultivar
ER	:	Effective rainfall
et al.	:	Co-workers
ET	:	Evapotranspiration
etc.	:	Et cetera
EU	:	Emission uniformity
Fig.	:	Figure
g	:	Gram (s)
ha	:	Hectare
ha-cm	:	Hectare centimeter
i.e.	:	that is
IR	:	Irrigation Requirement
kg	:	Kilogram (s)
Kg/ha	:	Kilogram (s) per hectare
ml	:	milliliter
mm	:	millimeter
PE	:	Pan evaporation
pp	:	Pages
q/ha	:	Quintal (s) per hectare
RBD	:	Randomised Block Design
S. E.	:	Standard error
t/ha	:	Tonne (s) per ha
viz.	:	Namely
WUE	:	Water use efficiency

ABSTRACT

"EFFECT OF DIFFERENT SOWING DATES AND IRRIGATION METHODS ON QUALITY AND QUANTITY OF HYBRID COTTON (*Gossypium* Sp. L.) SEED PRODUCTION"

by

Dipak Chhaganrao Nagargoje

A candidate for the degree of
MASTER OF SCIENCE (AGRICULTURE)
in
AGRICULTURAL BOTANY
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI -413 722
2001.

Research Guide	:	**Dr. S. S. Mehetre**
Department	:	Agril. Botany
Major Discipline	:	Seed Technology

The present investigation entitled "Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton (*Gossypium sp.* L.) seed production" was carried out at the experimental field of Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during the summer season of 2000. The experiment was laid out in factorial randomised block design with four replications. Eight treatment combinations were formulated involving two irrigation methods *viz.* drip and surface irrigation and four sowing dates *viz.* 16th March, 1st April, 15th April and 1st May. In surface method, irrigations were scheduled at 50 mm CPE. In case of drip irrigation alternate day water application was made.

It was observed that drip irrigation saved 54.51, 51.55, 52.24 and 46.66 per cent of water over conventional surface method of irrigation for the crops sown on 16th March, 1st April, 15th April and 1st May, respectively. Maturity of the crop was delayed due to drip irrigation as compared to surface irrigation. Number of flowers available for emasculation and pollination, percentage of boll setting, number of bolls harvested per plant, average boll weight and average seed weight per boll was higher in drip irrigation treatments as compared to surface irrigation treatments. Seed cotton yield and seed yield was higher in drip irrigation treatments as compared to surface irrigation treatments. Germination percentage, vigour index and seedling dry matter was higher in drip irrigation treatments as compared to surface irrigation treatments but the differences were non-significant. The incidence of pests and diseases was found to be less in drip irrigation treatments as compared to surface irrigation treatments.

It was found that as the sowing was delayed from 16th March to 1st May, the maturity of the crop was earlier. The number of flowers, available for emasculation and pollination, percentage of boll setting, number of bolls harvested per plant, average boll weight and average seed weight per boll were decreased as the sowing was delayed. Seed cotton yield, seed yield were decreased as the sowing was delayed. Germination percentage, vigour index and seedling dry matter of seeds obtained from later sowing dates were found to be less. The incidence of pests and diseases was increased as the sowing was delayed.

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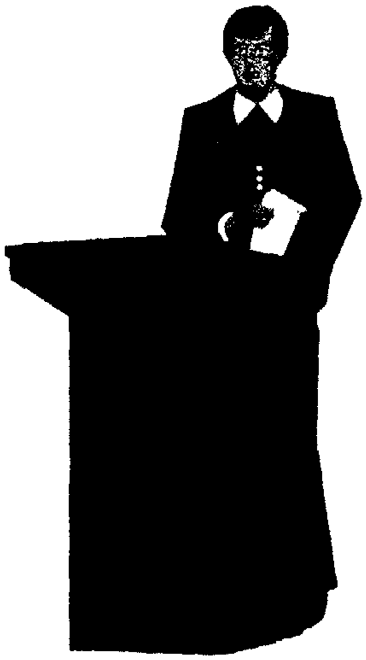


INTRODUCTION

1. INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important cash crop cultivated in India. It is also the most important fibre crop which meets almost 85 per cent of total fibre requirements of textile industry in India. It provides employment to several million people from production of cotton fibre, processing, cotton trade and marketing. Cotton seed is used for extracting edible oil on large scale and has utility in number of industries like cosmetics, rubber, plastics, water proofing material, insecticide and fungicide. Cotton seed hull is a concentrate feed for cattle. The linters are used for surgical dressings, absorbent cotton, twine, wicks, automobile and furniture padding, chemical grade pulp for manufacture of special grade papers, plastics, explosives, paints, cellophane, films, lindeum, etc.

India is one of the major cotton growing countries of the world. The data regarding area, production and yield of cotton in selected countries, regions and world are presented in Table 1.1. India ranks first in area and third in production after China and USA. The area of cotton crop in India was 9.0 million hectares with production of 12.65 million bales in the year 1999-2000 (Anonymous, 1999).

The data pertaining to area, production and productivity of cotton in major cotton growing states of India are presented in Table 1.2

Table 1.1 ***Cotton*** **Area, Production and Yield in selected Countries, Regions and World.**

Country		Area '000' ha		Production '000' bales		Yield Kg/ha	
		98-99	99-2000	98-99	99-2000	98-99	99-2000
A. *Wewstern Hemisphere* Region							
1	United States	4324	5476	13918	18304	701	728
2	Brazil	800	850	2000	2100	544	538
3	Mexico	229	160	1000	650	951	885
4	Argentina	650	500	900	900	301	392
5	Colombia	55	60	170	170	673	617
6	Paraguay	140	200	290	350	451	381
7	Peru	60	85	150	200	544	512
8	Guatemala	2	2	3	3	327	327
9	Nicaragua	4	4	10	10	544	544
10	Venezuela	30	30	50	50	363	633
	Others	75	70	109	97	316	302
	Total	6369	7437	18600	22834	636	668
B. Europe Region							
11	Greece	412	425	1753	1800	926	922
12	Spain	97	100	483	500	1084	1089
13	Others	18	18	33	33	399	399
	Total	527	543	2269	2333	937	935
C. Africa Region							
14.	Egypt	280	260	1050	1000	816	837
15	Sudan	150	225	250	330	363	319
16	Zimbabwe	325	300	450	425	301	319
17	South Africa	150	125	240	200	348	348
18	Tanzania	250	250	135	200	118	174
19	Cameroon	180	180	360	340	435	411
20	Nigeria	300	280	300	250	218	194
21	Chad	420	420	300	440	156	228
22	Others	2625	2664	4058	4198	337	343
	Total	4680	47704	7143	7383	332	342
D. Asia and Oceeania							
23	China	4450	4100	20700	19000	1013	1009
24	FSU-12	2500	2520	6600	7050	575	609
25	Uzbekistan	1485	1500	4600	5000	674	726
26	Turkmenistan	475	475	950	950	435	489
27	Others	540	545	1050	1100	423	439
28	India	9170	9000	12800	12650	304	306
29	Pakistan	2900	3000	6300	7000	473	508
30	Turkey	757	725	3850	3800	1107	1141
31	Australia	525	475	3100	3200	1286	1467
32	Syria	272	240	1539	1400	1232	1270
33	Israel	30	15	235	125	1706	1814
34	Burma	180	180	130	130	157	157
35	Thiailand	14	15	32	30	498	435
36	Afghanistan	60	60	100	100	363	363
37	Others	379	410	868	899	499	477
38	Total	2	1237	20740	56254	499	577
World Total		32813	33424	84266	87934	559	573

Table 1.2 Area, Production and Productivity of Cotton in major Cotton growing states of India.

Sr. No.	States	Years					
		94-95	95-96	96-97	97-98	98-99	99-2000
1. Area (lakh ha)							
1.	Punjab	6.06	7.50	7.42	7.02	5.47	4.75
2.	Haryana	5.52	6.46	6.49	6.55	5.87	5 10
3	Rajasthan	4.61	6.06	6.54	5.80	6.38	4.64
4	Gujarat	13.28	14.10	15.24	14.28	16.97	15.16
5	Maharashtra	27.60	30.70	30.90	31.00	31.99	32.53
6	Madhya Pradesh	5.75	5.37	5.27	5.48	5.32	5.41
7	A.P.	7 28	10 57	10.07	8.50	10.03	9.09
8	Karnataka	5.96	6.74	6.68	6.00	6.09	5.29
9	Chennai	2 72	2 65	2.60	2.65	2.20	2.50
10	Others	0 43	0 53	0.50	0 50	0 80	0 81
	Total	79.21	90.68	91.71	88.08	91.12	85.28
2. Production (lakh bales)							
1	Punjab	14.50	14.35	16	7.5	5.5	9.5
2	Haryana	11.54	11.3	13.5	9.00	7.50	11.00
3	Rajasthan	9.92	13.75	14 00	11.50	12.00	12.50
4	Gujarat	26.59	31.25	34.25	42.00	45.00	35.00
5	Maharashtra	15.84	28.75	33.00	20.50	25.00	38.00
6	Madhya Pradesh	15 85	14.25	18.75	23.00	20.00	15.00
7	A.P.	28.36	27.35	26.50	24.75	25.00	38.00
8	Karnataka	9.30	9.50	9.00	7.50	8.50	8.00
9	Chennai	6.00	5.00	5.50	5.50	5.50	5.50
10	Others	1.00	1.00	1.00	1.00	1.25	1.50
	Loose Supply	-	-	5.00	5.75	6.25	8.00
	Total	138.9	156.5	176.5	158.00	161.500	167 00
Productivity (Kg/ha)							
1	Punjab	407	325	367	182	171	340
2	Haryana	355	297	353	234	217	367
3	Rajasthan	366	386	364	337	320	458
4	Gujarat	340	377	382	490	451	392
5	Maharashtra	98	159	182	112	133	199
6	Madhya Pradesh	469	451	605	714	639	471
7	A.P	662	440	605	714	639	471
8	Karnataka	265	240	229	213	237	257
9	Chennai	375	321	360	353	425	374
	Mean	298	293	327	305	302	333

Maharashtra being major cotton growing state accounting the area of 3.25 million hectares with production of 3.8 million bales (170 Kg each) in the year 1999-2000. (Anonymous, 1999-2000).

The productivity of cotton in India is 306 Kg/ha as against 199 Kg/ha in Maharashtra in terms of lint. The major reasons for low productivity in the state are maximum cotton cultivation is concentrated under rainfed conditions, poor water management, less availability of high yielding cotton varieties/hybrids, heavy insect pests infestation and limited fertilizer application due to high prices. In order to increase the cotton production the newly evolved varieties/hybrids with improved technology must be considered. Hybrids are high yielders over straight varieties. In cotton many new hybrids have been released viz. H_4, H_6, NHH-44, which yield higher than their parents.

Date of sowing has been found to be an important agronomic measure to affect the yield and quality of a crop and is more so in case of cotton. The sowing date should be adjusted in such a way that crop can get favourable weather conditions during its growth period. So it is necessary to study the effect of different sowing dates on quality and quantity of hybrid cotton seed production.

The other most important factor for increasing the production of the crop is water. Irrigation is one of the most essential input for cotton cultivation especially under summer irrigated season. Water being a limited resource, its efficient use is a basis for survival of agriculture all over the world. The limited available water is not being used judiciously through surface method of irrigation due to losses during transit. The use of modern method like drip irrigation system has become widespread in recent years especially in the areas of water scarcity. The method delivers water directly and frequently in the vicinity of root zone, minimizing conveyance losses, due to deep percolation, runoff and soil water evaporation. Thus there is a considerable saving in water to the extent of 40 to 60 per cent. Hybrid cotton being widely planted is ideally suited to drip method of irrigation.

According to availability, quality seed in large quantities a main production factor, limits the production and productivity of cotton. Since hybrid cotton seed is produced manually by hand emasculation and pollination, puts limit on quantity of seed produced. Further many agronomic factors like recommended sowing time and environmental factors also play a significant role in the production of hybrid seed in large quantities.

Though earlier results showed that sowing of summer irrigated cotton in Deccan canal region during 15^{th} March to 15^{th} April gives exceptionally high yield, availability of canal irrigation water during this period is a must. Further during this period the rate of water requirement in well also reduced drastically hence puts limit on the area to be brought under cotton cultivation. To overcome this, the drip irrigation technology is found to be highly effective for uplifting cotton production and productivity under minimum use of irrigation water. Further it has also another advantage like weed control, less occurrence of diseases and pests. Thus the production cost is also reduced.

In view of the above mentioned considerations and necessary improving cotton yield a study was under taken on "Effect of different sowing dates and irrigation methods on the quality and quantity of hybrid cotton seed production" with the following objectives.

1. To study the effect of different sowing dates on the quality and quantity of hybrid cotton seed production as well as on seed storage, germination and seedling vigour etc.

2. To study the effect of drip and surface methods of irrigation on the quality of hybrid cotton seed production as well as on seed storage, germination and seedling vigour etc.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

An account of earlier research workdone in various aspects of growth characters, yield, quality and laboratory studies and also sucking pests, bollworms and diseases has given in this chapter under different headings.

2.1 Effect of sowing dates

2.1.1 Growth

In a field experiment cotton was sown on 5^{th} , 25^{th} March and 25^{th} April. Sowing date affected the total period of the crop maturity but not the boll weight. Late sowing produced more flowers more quickly. Early sowing produced the highest seed cotton yield, more open bolls and the highest percentage of boll set (El-Akkad *et al.,* 1980). It was observed that a delay in sowing from mid April to mid May and mid June increased the percentage of flowers/bolls shed in cotton (Chhabra and Krishnamoorthy, 1981).

When cotton was sown on different dates from March to May, it was observed that number of opened bolls/plant, seed cotton yield/plant, seed cotton yield/Feddan were highest with the earlier sowing dates. Boll weight decreased with later sowing dates (Makram *et al.,* 1982). When cotton was sown on 4 dates at 10 days interval beginning on 10^{th} April and final date 10^{th} May. Plant height, number of fruiting branches, number of bolls/plant decreased with increasing delay in sowing time (Lee *et al.,* 1986).

In another experiment the results of cotton sown on 28-29th March or 10-12th May, revealed that March sown cotton had higher number of bolls and sound bolls per plant than May sown cotton (Shalaby *et al.,* 1989). It was observed that number of days from sowing to 50 per cent emergence, number of days from sowing to 50 per cent flowering, number of days from sowing to first open bolls and number of bolls per plant were all decreased when sowing was delayed from January to April. Boll retention increased with sowing date delay (Eid *et al.,* 1993).

In a field experiment cotton cultivars AKH 081 and LRA 5166 were sown on 15th June, 15th July and 15th August. The study revealed that early planting dates led to enhanced square production and significant decrease in physiological shedding of fruiting parts (Kumara perumal, 2001).

2.1.2 Yield and Yield contributing characters

In a field trial of "Effect of sowing dates on cotton yield" sowing dates 11th and 21th February gave the highest seed cotton yields of 1.10 and 1.09 t/ha respectively (Sastrosupadi and Marlijunadi, 1978). In another field experiment, cotton was sown on 12th, 29th May and 15th June. The seed cotton yield was highest when cotton was sown on 12th May (1.12 t/ha) as compared with yields of 29th May (0.91 t/ha) and 15th June (0.42 t/ha) sowings respectively (Misra and Malik, 1979). It was observed that seed cotton yield of cv. Giza 82, Giza 66 and Giza 67 was 35.61, 23.23 and 22.28 per cent respectively higher when sown early than when sown late (Yousef, 1980).

It was observed that the seed cotton yields of cotton decreased progressively with a delay in sowing from 7th May to 22nd May and 7th June (Shrivastava *et al.*, 1982). It was found that mean seed cotton yields varied from 1.07 t/ha (Sowing date 1 July) to 2.26 t/ha (Sowing date 16th May) (Karim *et al.*, 1983). Cotton was sown on 15th May, 10th June or 21st July 1978. It was observed that boll weights of monopodia decreased from 4.82 to 3.39 gm and those of sympodia from 5.08 to 4.38 gm for early to late sowings respectively (Malik and Malik, 1986). It was observed in a trial that eight cotton cultivars sown on 18-22nd May and 7-12th June gave average seed cotton yields of 2.07 and 1.68 t/ha, respectively (Nehra *et al.*, 1987).

Dhonde and Khade (1988) under Rahuri conditions observed that a delay in sowing of cotton from the 14th to 16th and 18th meteorological week decreased average seed cotton yields from 2.57 to 2.13 and 1.63 t/ha respectively.

It was found in a field trial after sowing of cotton on 15th April, 15th May and 15th June, sowing in April gave highest seed cotton yield in all three years 1984-86 (Khan *et al.*, 1988). *Gossypium hirsutum* cultivars were sown on 4 dates (1 and 15th April, 1st and 16th May) in 1986.

It was observed that sowing in April gave significantly higher seed cotton yield than sowing in May (on average 2.3-2.6 vs 1.8-195 t/ha) (Ansari *et al.,* 1989).

It was observed that the reduction in seed cotton yield took place for cv. NHH-44 as the sowing time was delayed. (Dhoble *et al.*, 1989). It was observed that delayed sowing until June reduced seed cotton yield/ha by 30.5 per cent in respect of cotton (Brar *et al.,* 1990). It was found that seed cotton yield increased when sowing was delayed from January to April. (Eid *et al.*, 1993). It was observed that delayed sowing after 31st July decreased seed cotton yield significantly (Mukundan *et al.*, 1993). It was observed that seed cotton yield was higher from sowing early (5th Feb) to that of late (20th Feb) (2.32 vs. 2.13 t/ha) in case of summer cotton. (Solaippan *et al.,* 1994).

Field experiment was conducted to identify optimum sowing time for cotton on the hill slope. It was found that cotton sown on 5th May, 20th May and 5th June were found high yielding than delayed one 20th June, 5th July and 20th July. A period from 5th May to 5th June proved optimum for upland cotton. (Sarma *et al.,* 1997).

In a field experiment cotton was sown on 15th March, 15th April, 15th May and 15th June. The results revealed that the seed cotton yield and boll weight were significantly higher with 15th April sowing than the succeeding dates. The cotton yield increased from March to April and further decreased by delayed sowing beyond 15th April (Chandrashekhara *et al.*, 1998). It was reported that early planting (1st week of May) gave 7.9 per cent higher seed cotton yield over third week of May (Bishnoi *et al.*, 2001).

In a field experiment, cotton was sown on three different dates viz. 15th June, 15th July and 15th August. The study revealed that early planting dates led to significant increase in seed cotton yield (Kumara perumal, 2001).

2.1.3 Quality

Effect of sowing dates on seed cotton yield was seen in field trials. It was observed that lint quality was not affected by the treatments of sowing dates (Sastrosupadi and Marlijunadi, 1978). In a field experiment cotton was sown on 12th or 29th May or 15th June. It was observed that quality characters were unaffected by sowing date (Misra and Malik, 1979). Cotton was sown in early March and April. It was found that early sowing increased the lint percentage (El-Rahman *et al.*, 1980).

It was observed that lint percentage was greater from the late sown crop than the early sown crop with cotton (Yousef, 1980). It was found that the values for ginning percentage, number of seeds per boll, seed and lint indices were higher in cotton sown on 30 April than when sown on 20th May, 9th or 29th June (Singh and Warsi, 1985). Cotton was sown on 28-29th March or 10-12th May it was observed that March sown cotton had a higher seed index in 1983 and 1984 than May sown cotton. (Abdalla *et* sown cotton had higher lint percentage than May sown cotton (Shalaby *et al.*, 1989). It was observed that cotton sown earlier was superior to cotton sown late in respect of lint index but not in ginning percentage, mean halo length or seed index (Solanke *et al.*, 1989).

2.1.4 Incidence of sucking pests

In a field experiment average seed cotton yield was higher from April sowing than May sowing and it was reported that early harvests can escape late season insect infestations and contribute to an effective cotton integrated pest management system. (Anonymous, 1983). Field experiment was conducted to see the effect of sowing date (25th April, 9th May and 23rd May) on the incidence of *Amrasca biguttula biguttula, Aphis gossypii* and *Bemisia tabaci* on cotton in Punjab in 1981. It was observed that delayed sowing did not affect the population of *B. tabaci.* The population of *Amrasca b. biguttula* was higher on the crop sown on 9th May than on that sown on 23rd May and the population of *Aphis gossypii* was higher on the crop sown on 25th April than on that of sown on the later two dates (Dhawan *et al.*, 1987).

2.1.5 Incidence of bollworm

It was observed that the incidence of *Pectinophora gossypiella* on flowers and of *Earias vitella* sp. on bolls was greater in the early sown crop than in the late sown crop. The greatest incidence of *Pectinophora gossypiella* on bolls and of dipausing larvae was recorded in the late sown crop (Taneja and Dhindwal, 1982). It was reported that the delayed sowing of the crop (end of June) resulted in reduced bollworm attack and its carryover but it increased suicidal emergence of pink bollworm moths. The number of harvestable bolls per plant was reduced by 50 per cent in late sown crop (end June) as compared with early sown crop (end-April) (Singh and Sidhu, 1983).

It was reported that delayed sowing did not affect the extent of bollworm incidence of three sowing dates 25th April, 9th May and 23rd May (Dhanwan *et al.* 1987). Experiment was conducted to see the effect of pink bollworm incidence in relation to time of planting. It was reported that early (April) and late (June) sowing of cotton crop may be discouraged wherever possible because the early planted crops provide fruiting bodies for pink bollworm moths emerged after mid May whereas the late sown crops produced suitable fresh bolls for diapausing pink bollworm larvae (Singh *et al.,* 1988). It was observed that May 5 and May 15 sown crop had lower bollworm incidence and less stained seed cotton. Late sown crop harboured higher population of dipausing pink bollworm larvae. (Singh *et al.,* 1991).

2.1.6 Incidence of diseases

Experiment to see the effect of sowing dates (April, May, June) on boll rot of cotton was conducted. It was observed that early crop had maximum infection on boll as well as on locule basis whereas minimum incidence was recorded in late sowing in both the varieties (Rathee and Chauhan, 1994).

Three sowing dates were carried out to see the effect of sowing dates on *Alternaria* leaf spot starting from 9th July and at two weekly intervals. Results showed that the later the planting date, the higher the disease epidemics. The incidence (41 per cent) and severity (3.1per cent) of the disease was lower and seed cotton yield was higher with early planting dates when compared with later planting dates in August (Nwanosike and Aedoti, 1998).

2.2 Effect of irrigation methods

2.2.1 Growth

It was observed that drip irrigation delayed maturity by two to nine days for cotton crop (Constable and Hodgson, 1990).

2.2.2 Yield and Yield contributing characters

It was observed that cotton drip irrigated through alkathene pipes with holes protected by sockets or with microtube emitters or furrow irrigated produced on average 69, 65 and 45 bolls per plant and seed cotton yields of 3.25, 2.86 and 2.60 tonnes per hectare respectively. (Padmakumari and Sivanappan, 1979). In a field experiment it was observed that drip system increased yield of cotton by 25 per cent compared with conventional method. (Sivanappan and Padmakumari, 1980). It was observed that trickle irrigation has the advantages which include enhanced crop yield and limited weed growth in comparison to furrow method of irrigation for cotton crop. (Bucks and Nakayama, 1982).

It was reported that yield of cotton was 31.36 q/ha in drip which was 39.5 per cent higher than traditional method of irrigation. (Magar and Sonawane, 1987). It was reported that, use of trickle irrigation increased average lint cotton yields from 685 to 868 lb/acre in Texas (Henggler, 1988). It was observed that drip irrigation increased yields of cotton by 48.7 per cent compared with furrow irrigation. (Ramchadrappa and Havangai, 1988). It was observed that seed cotton yield with drip irrigation were about 5t/ha and significantly higher than those from an adjacent furrow irrigated plot (<3t/ha). (Mateos *et al.*, 1991).

An experiment was conducted on cotton (NHH-44) at Parbhani. Drip irrigation produced 2.62 t/ha of seed cotton with normal planting as compared with flood irrigation (2.32 t/ha). (Anonymous, 1993-94). Drip irrigation method was compared with furrow method of irrigation for cotton crop at Rahuri. It was found that all the treatments in drip method gave significantly higher yield than furrow method. (Anonymous, 1997-98 a).

An experiment was conducted on hybrid cotton at Hisar (Sirsa) during 1997-98. It was observed that drip irrigation with and without mulch produced higher seed cotton yield than surface method of irrigation. (Anonymous, 1997-98 b). It was found that paired row planting in drip irrigation with 100 per cent of recommended dose of solid fertilizer produced higher seed cotton yield (22.66 q/ha) than normal row planting in surface irrigation with recommended dose of solid fertilizer (20.36 q/ha) (Mane *et al.*, 1999).

An experiment comprised levels of solid and liquid fertilizers (50, 75, 100 and 125 per cent of the recommended dose) through fertigation and conventional method. Conventional planting with surface irrigation was compared with paired row planting under drip irrigation. In the ten demonstrations of above technology conducted on farmers fields in the "Pilot Project" on area of 9.00 ha during 1998-99, an average 26.6 q/ha seed cotton yield was recorded that was 34 per cent increase over average yield of 19.85 q/ha obtained in conventional method of irrigation, (Mehetre and Jadhav, 1999).

2.2.3 Incidence of sucking pests

Infestations of immatures of *Bemisia argentifolii* were studied on drip and furrow irrigated field plots. It was observed that the average numbers of immature whiteflies was greater in biweekly furrow irrigated than in drip irrigated plots. (Flint *et al.*, 1955).

2.3 Water management aspects

2.3.1 Emission uniformity and uniformity coefficient

It was reported that uniformity less than 94 per cent within subunit is likely to lower down the performance of overall drip system due to the problem of clogging. They suggested that uniformity should be above 90 per cent. Spacing of microtubes along the lateral has the direct relationship with uniformity coefficient (Karmeli and Keller,1975).

2.3.2 Water use efficiency

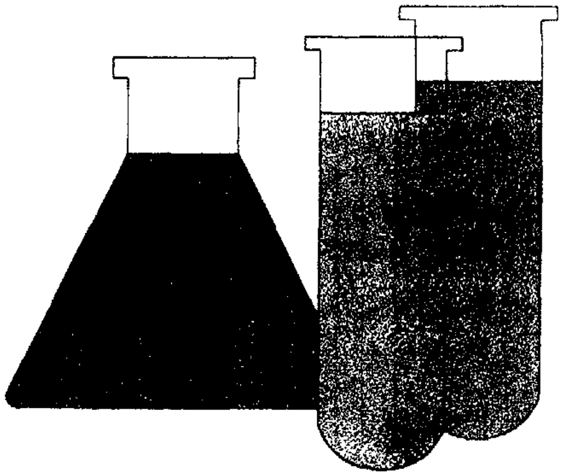
An experiment was conducted on MCU-5 cotton at IARI regional station, Coimbatore to compare the efficiency of drip method of irrigation with conventional method. With two years average of 33.9 ha-cm of water gave 14.5 q of seed cotton/ha in conventional method. While the drip method with only 16.3 ha cm of water gave 13.2 q of seed cotton/ha. Thus drip irrigation system saved the irrigation water to the extent of 50 per cent over furrow irrigation (Shanmugham *et al.*, 1976).

It was observed that cotton drip irrigated through alkathene pipes with holes protected by sockets or with microtube emitters or furrow irrigated used water 15, 15 and 70 cm respectively. (Padmakumari and Sivanappan, 1979). It was reported that for a maximum seed cotton yield under drip irrigation, 630 ± 50 mm of water was required for evapotranspiration and when water supplies were limited, trickle irrigation was much more efficient than furrow irrigation for producing lint cotton. (Phene *et al.*, 1984).

It was observed in experiments, water saving in drip irrigation has cut water use by upto 50 per cent and raised cotton yields by a half bale or more per acre in the southwest USA over a conventional furrow irrigation system. (Wilson *et al.*, 1984). It was reported that water saving in drip was to the extent of 43 per cent as compared with furrow irrigation method. The water use efficiency was almost double i.e. 64.3 Kg/ha-cm due to adoption of drip irrigation method. (Magar and Sonawane, 1987). It was observed that water application efficiency was 30 per cent higher in the drip irrigation treatments over furrow irrigation treatments (Mateos *et al.*, 1991).

It was reported that water use efficiency was more in drip irrigation system as compared to furrow irrigation. (Tarhalkar and Majumdar, 1997-98). Drip irrigation method was compared with furrow method of irrigation for cotton crop at Rahuri. It was found that water requirement under drip method was 49.12 cm compared to 85.14 cm requirement in furrow method and thus 61.2 per cent water could be saved in drip method. (Anon, 1997-98 a).

It was reported that use of drip irrigation for cotton reduced the seasonal water requirement by 47 per cent with maximum water use efficiency (29.44 to 50 Kg/ha-cm). (Mane *et al.*, 1999).



MATERIAL AND METHODS

3. MATERIAL AND METHODS

The present investigation entitled, "Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton seed production" was conducted during summer season of 2000. The details of material used and methods adopted during the course of investigation are described in this chapter under the following heads.

3.1 Experimental site

The present experiment was carried out at the experimental field of Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during summer season of 2000.

3.2 Location, climatic conditions and soil of the experimental field

Geographically, the Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated at 30 Km from Ahmednagar on Ahmednagar - Manmad state highway No. 14. It lies between 19° 48' and 19° 57' North latitude and between 74° 32' and 74° 10' East longitude. The altitude varies from 495 to 569 meters above the mean sea level.

Climatologically, this area falls in the semi-arid tropics with an annual rainfall varying from 307 to 619 mm and the average annual rainfall is 520 mm. The distribution of rains is erratic and most of the rainfall is received from South-West monsoon (June to September) and the remaining is received from North-East monsoon in October and November.

The annual mean maximum and minimum temperatures are 37.9° C and 17.2°C respectively. The mean relative humidity during the morning and evening is 59 and 35 per cent respectively. Agroclimatically, this area falls in scarcity zone.

The meteorological data recorded on the important weather parameters during the cropping season was obtained from meteorological observatory located at Central Campus, MPKV., Rahuri and is presented in Table 3.1.

Physical properties of the soil of experimental field are presented in Table 3.2.

Table 3.2 Physical Properties of Soil

Sr. No.	Characteristics	Results	Method used	Reference
1.	Particle size distribution Clay (per cent) Silt (per cent) Fine sand (per cent) Course sand (per cent)	 37.20 29.50 24.10 9.20	International pipette method	Piper (1966)
2.	Textural class	Clay loam		
3	Bulk density (g/cm^3)	1.33	Core sampler method	Klute *et al.* (1986)
4	Field capacity (per cent)	38.6	Pressure plate apparatus	Black (1965)
5	Permanent wilting point (per cent)	20.03	Pressure plate apparatus	Black (1965)
6	Available soil moisture in 0– 45 on soil depth (cm)	14.00	Pressure plate apparatus	Black (1965)

Table 3.1 Details of meteorological data during the experimental period.

Meteorolo-gical week and date	Mean Temperature (°c)		Mean relative humidity (per cent)		Mean pan evaporation (mm/day)	Rainfall (mm)	No. of rainy days
	Max.	Min.	Morn.	Even.			
Mar. 2000							
11(12-18)	34.1	9.0	73.0	21.4	6.8	-	-
12(19-25)	34.9	10.2	65.4	27.0	7.6	-	-
13(26-1)	35.9	13.5	59.4	19.4	7.4	-	-
April 2000							
14(2-8)	39.1	18.2	53.4	22.0	8.0	-	-
15(9-15)	39.8	16.1	59.1	21.7	9.9	-	-
16(16-22)	38.8	19.4	59.0	22.7	9.3	-	-
17(23-29)	38.9	16.5	56.1	23.9	11.8	-	-
May 2000							
18(30-6)	40.6	18.0	58.6	31.0	11.8	-	-
19(7-13)	36.9	19.3	72.7	39.3	9.1	-	-
20(14-20)	34.5	20.5	75.7	50.6	8.4	2.6	-
21(21-27)	36.1	22.0	76.4	43.3	9.5	-	-
22(28-3)	35.7	21.7	85.6	52.7	7.0	42.1	4
June 2000							
23(4-10)	32.4	20.4	91.4	64.7	4.8	159.4	5
24(11-17)	32.6	21.4	86.5	56.4	6.8	3.8	1
25(18-24)	31.7	21.9	81.7	53.9	5.7	-	-
26(25-1)	31.7	21.9	81.0	57.9	6.3	32.5	2
July 2000							
27(2-8)	29.7	22.0	84.4	63.7	4.0	6.6	1
28(9-15)	28.7	22.8	88.6	75.4	4.1	42.0	3
29(16-22)	29.1	22.2	83.4	57.1	4.9	-	-
30(23-29)	31.9	19.9	82.6	46.1	5.8	1.2	-
Aug. 2000							
31(30-5)	33.3	19.7	75.7	42.1	6.8	-	-
32(6-12)	31.3	21.9	84.0	57.3	5.1	10.2	2
33(13-19)	31.7	21.3	82.4	50.1	6.0	0.7	-
34(20-26)	28.4	21.9	93.3	81.4	2.5	218.8	5
35(27-2)	29.0	21.8	89.7	68.9	4.1	24.3	3
Sept. 2000							
36(3-9)	29.1	20.0	84.6	59.0	4.6	1.5	-
37(10-16)	31.3	18.5	85.4	48.6	4.6	-	-
38(17-23)	32.2	19.5	84.6	50.0	6.2	10.6	2
39(24-30)	32.0	20.6	91.1	54.0	4.5	50.1	4
Oct. 2000							
40(1-7)	33.0	19.8	86.9	45.0	4.3	7.0	1
41(8-14)	30.5	20.4	89.4	60.7	3.3	23.0	3
42(15-21)	32.7	17.0	88.4	33.3	4.5	12.8	1
43(22-28)	33.6	15.7	87.6	28.9	4.8	-	-

3.3 Material

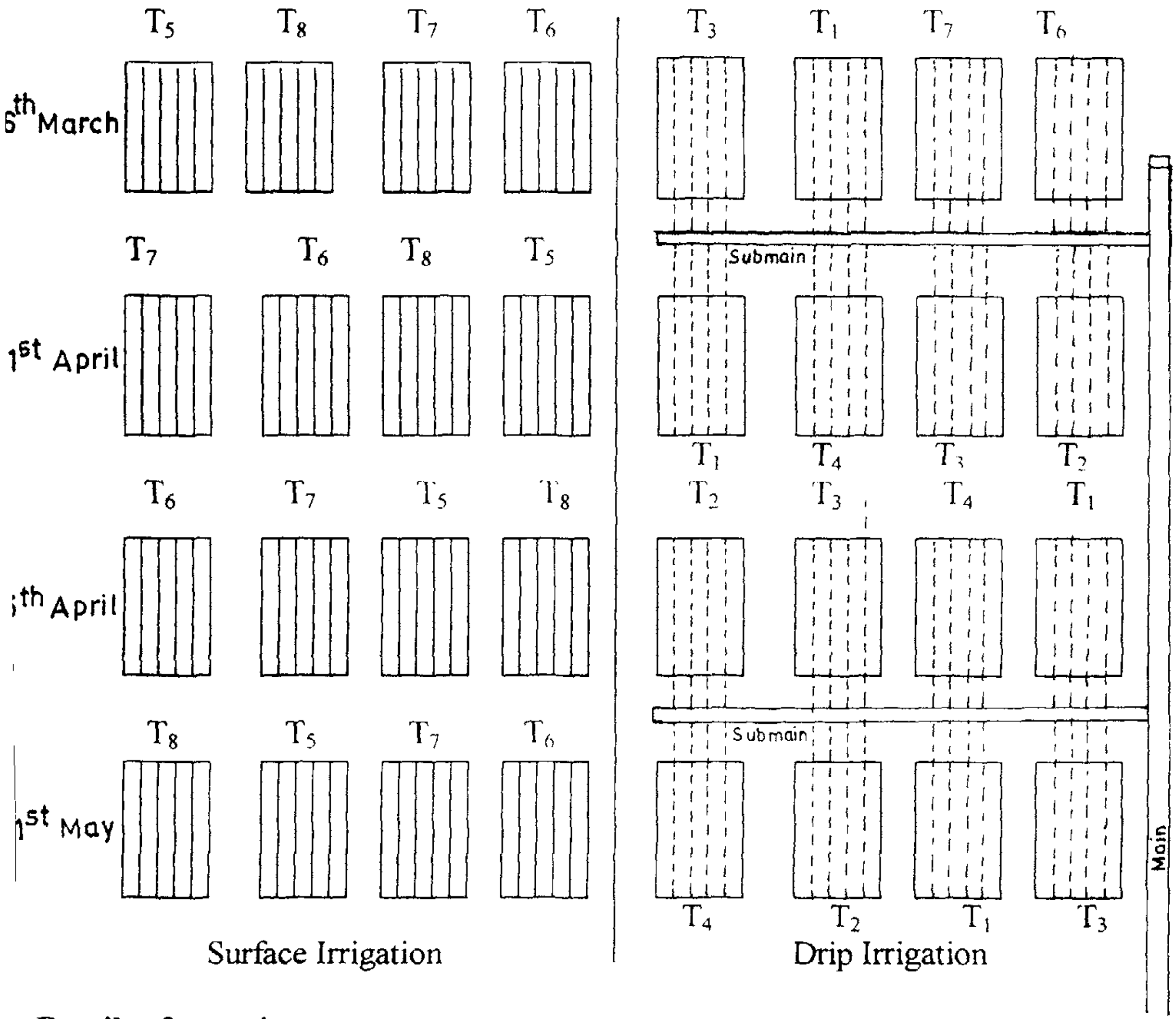
The experiment was conducted for the hybrid seed production of RHB 0388 with combination of RHC- 006 as female parent and RHC-b-001 as male parent. Pure seeds of RHC-006 and RHC-b-001 were obtained from the Cotton Breeder, Cotton Improvement Project , MPKV., Rahuri.

3.4 Methods

A fairly well levelled land was selected at the farm of Cotton Improvement Project, MPKV., Rahuri. The field was prepared by ploughing once and harrowing twice to bring the soil to good tilth. Stubbles and debris of previous crop were removed and burnt.

3.4.1 Experiment layout

1.	Design	-	Factorial RBD
2.	Number of treatment combinations	-	8
3.	Number of replications	-	4
4.	Total number of plots	-	32
5.	Gross plot size	-	8.1 x 7.0 m^2
6.	Net plot size	-	6.3 x 5.0 m^2
7.	Spacing	-	100 x 90 cm
8.	Sowing method	-	Dibbling



Details of experiment

Design	:	Factorial RBD
Gross plot size	:	8.1 x 7.0 m^2
Net plot size	:	6.3 x 5.0 m^2
Spacing	:	100 x 90 cm

Treatment details

$T_1 = I_1\ S_1$ = Drip irrigation + 16th March

$T_2 = I_1\ S_2$ = Drip irrigation + 1st April

$T_3 = I_1\ S_3$ = Drip irrigation + 15th April

$T_4 = I_1\ S_4$ = Drip irrigation + 1st May

$T_5 = I_2\ S_1$ = Surface irrigation+16th March

$T_6 = I_2\ S_2$ = Surface irrigation + 1st April

$T_7 = I_2\ S_3$ = Surface irrigation + 15th April

$T_8 = I_2\ S_4$ = Surface irrigation + 1st May

Fig. 3.1 Layout of Experimental field.

9. Planting ratio - 4:2

3. 4. 2 Treatment details

The details of treatments alongwith symbols used are given below.

a) Sowing dates

1. 16^{th} March - S_1
2. 1^{st} April - S_2
3. 15^{th} April - S_3
4. 1^{st} May - S_4

b) Irrigation methods

1. Drip Irrigation - I_1
2. Surface Irrigation - I_2

3.4.3 Sowing

The crop was sown by dibbling method at the spacing of 100 x 90 cm for both drip and surface irrigation methods. Crop was sown as per the sowing.

3.4.4 Fertilizer dose

At the time of each sowing, the plots were fertilized at the rate of 20 Kg N, 50 Kg P_2O_5 and 50 Kg K_2O per hectare in the form of Urea, Single Super Phosphate and Muriate of Potash respectively. Second dose of 40 Kg N and third dose of 40 Kg N were given one month and two months after sowing per hectare respectively, in the form of urea as top dressing.

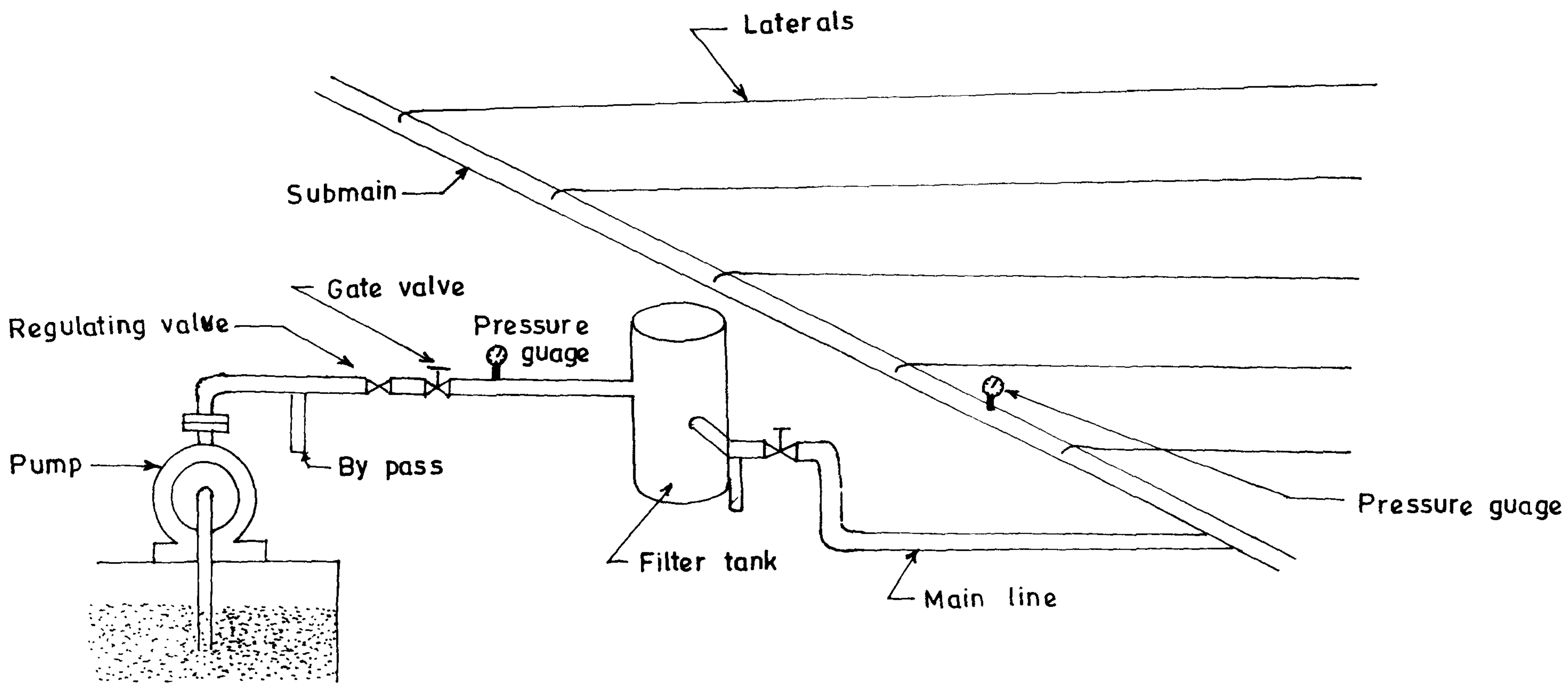


Fig. 3.2 Schematic diagram of components of drip irrigation system.

3.4.5 Plant Protection measures

In order to control the early sucking pests like aphids, jassids, thrips and mites Endosulfan 35per cent EC was used @ 750 ml in 500 litres of water for one hectare. Cypermethrin was used for control of bollworms @ 375 ml in 500 litres of water for one hectare.

3.4.6 Water management aspects

3.4.6.1 Details of drip system

The details of drip irrigation design in experimental field has shown in figure 3.1 and details of drip unit has shown in figure 3.2. One lateral was provided for one row of crop and one emitter for one plant. The distance between two laterals i.e. two rows of crop was 100 cm. Six laterals i.e. four for female parent and two for male parent and 48 drippers were used for each plot. There were eight drippers on each lateral. The operating pressure was 1.00 Kg/cm^2.

An amount of water applied was calculated by recording daily pan evaporation data. Pan evaporation was measured with the help of U.S.W.B. class A pan evaporimeter.

3.4.6.2 Determination of emission uniformity of drip system

To study the emission uniformity as influenced by the length of lateral and dripper spacing, the discharge through the emitters located in 1^{st}, 2^{nd}, 3^{rd} and 4^{th} quadrant of lateral were collected and average values were taken. The uniformity was observed for various operating heads. The discharge through the dripper for one minute was recorded. The emission uniformity was computed with the help of formula given by Nakayama and Bucks (1986).

$$EU = 100 \left(\frac{q\ min}{q\ avg} + \frac{q\ avg}{qx} \right) x \frac{1}{2}$$

Where,

EU - Emission Uniformity

q min - Minimum emitter flow rate (lph)

q avg - Average emitter flow rate (lph)

q x - Average of the highest 1/8th of the emitter flow rates (lph)

The uniformity coefficients were computed for all drip irrigation treatments.

3.4.6.3 Scheduling of drip irrigation

The irrigation was scheduled at alternate day. The pan evaporation of two days was considered for calculating water requirement of plant on alternate day and time of operation. The daily pan evaporation data were recorded form U.S.W.B. class A pan evaporimeter. The quantity of water to be applied per plant on alternate day was estimated by the following formula.

d = CPE x Kc x Kp

Where,

d - Depth of water to be applied (mm)

CPE - Cumulative Pan Evaporation for two days (mm)

Kc - Crop Coefficient depending upon growth stages

Kp - Pan Factor (0.7)

The following Kc values were considered for computing the water need during crop growth period as indicated in FAO paper, 33.

Sr. No.	Crop growth period (days)	Kc values
1.	0-15 days	- 0.4
2.	15-30 days	- 0.5
3.	30-60 days	- 0.7
4.	60-75 days	- 0.8
5.	75-105 days	- 1.05
6.	105-135 days	- 1.25
7.	135-150 days	- 0.8
8.	150-165 days	- 0.9

The volume of water to be applied per emitter was calculated by using following formula.

V = d x s x per cent wetted area (60 per cent)

Where,

V - Volume of water to be applied (litres per emitter)

d - Depth of water to be applied (mm)

s - Spacing (m^2) (Distance between laterals x Distance between emitters)

The operating time of system (t) was calculated by

$$t = \frac{V \times 60}{Q \times Ne}$$

Where t - Operating time of system (min-sec)

V - Volume of water to be applied (lit/emitter)

Q - Emitter discharge (lph)

Ne - Number of emitter per plant.

3.4.6.4 Scheduling of surface irrigation

Irrigation was scheduled at 50 mm CPE for surface plots. Evapotranspiration is the function of climatic parameters and is more accurate in estimating short term fluctuations in ET than Emperical formulae. Hence climatological approach was considered for scheduling of irrigation. The U.S.W.B class A pan evaporimeter was used for measurement of daily pan evaporation.

The daily pan evaporation recorded from U.S.W.B. class A pan evaporimeter was summed up for surface. When cumulative pan evaporation (CPE) attained the value of 50 mm CPE, the irrigations were given with requisite depth of irrigation water (7 cm). The depth of irrigation was determined with the help of moisture content monitored before irrigation using the formula suggested by Dastane (1972).

$$d = \frac{\text{MAD \% x AWHC}}{\text{Ea}}$$

Where,

d - Depth of irrigation (cm)

MAD - Maximum Allowable Depletion 50 per cent i.e. (0.5)

AWHC - Available Water Holding Capacity (cm)

Ea - Application efficiency 8 per cent i.e. (0.8)

$$\text{AWHC} = \frac{\text{FC - PWP}}{100} \text{ x B. D. x Effective root zone depth (cm)}$$

Where,

FC - Field capacity (per cent)

PWP - Permanent Wilting Point (per cent)

BD - Bulk Density (g/cm^3)

(The water discharge was measured with the help of portable 90° V notch which installed as per specification described by Michael *et al.*, 1977).

For water application to the field the formula used for fixed depth of water application is given below.

$$T = \frac{A \times D}{Q}$$

Where ,

T - Time of water application (Seconds)

A - Area to be irrigated (m^2)

D - Depth of irrigation (mm)

Q - Discharge of water (lps)

By the above formula, desired amount of water was applied at each irrigation for surface plot.

3.4.6.5 Irrigation studies

3.4.6.5.1 Consumptive use and soil moisture depletion

Moisture content of soil was determined by gravimetric method as described by Klute *et al* (1986). Soil samples were taken prior to each irrigation at soil depth of 0-15, 15-30 and 30-45 cm with the help of screw auger from one place at the centre of the plot and soil moisture loss during each irrigation was estimated.

The consumptive use was estimated by calculating the depth of moisture depleted from each soil layer of 0.15, 15-30 and 30-45 cm. During an irrigation by gravimetric method the water content of different soil layers of profile after receipt of rains and at harvest of the crop was also determined by the equation which is given below (Dastane, 1972).

$$Cu = u$$

$$u = d = \sum_{i=1}^{n} [(M_1 i - M_2 i/100) \times Ai \times Di + PET + ER + S]$$

Where,

$u = d =$ Soil moisture depletion in the root zone or consumptive use during irrigation cycle, (cm).

$M_1 i$ - Soil Moisture content at the time of first sampling i.e. 48 hours after irrigation of I^{th} layer on oven dry weight basis.

$M_2 i$ - Soil Moisture content at the time of second sampling i.e. just before irrigation of i^{th} layer on oven dry weight basis.

Ai - Bulk density of the i^{th} layer of soil gm/cm^3

Di - Depth of i^{th} layer of the soil, cm

PET - Potential Evapotranspiration (EP x 0.7) for the accelerated water for the interval (s) just after irrigation (s) and before soil moisture sampling, i.e. for the 48 hours.

ER - Effective Rainfall during the interval between two soil sampling, cm.
(ER was calculated by soil moisture balance studies)

S - Ground water contribution (not considered as ground water was far below from the soil surface)

Seasonal consumptive use (Cu) is the summation of soil moisture depletion during the entire crop growth period worked out by the equation.

$$Cu = \sum_{i=1}^{n} ui$$

Where,

Cu - Seasonal consumptive use of water by the crop for a given period, (cm).

ui - Consumptive use per irrigation cycle (cm).

3.4.6.5.2 Water requirement of crop

The water requirement of the cotton crop was determined by the procedure described by Michael (1978) and the formula used was,

$$WR = IR + ER + S$$

Where,

WR - Water requirement (cm)

IR - Irrigation requirement (cm)

ER - Effective Rainfall (cm)

S - Soil Moisture contribution 's' is considered as nil as the water table of the experimental field was far below the soil surface.

3.4.6.5.3 Water use efficiency (WUE)

Water use efficiency is defined as the ratio of yield of marketable produce of the crop and amount of total consumptive use of water during the crop growth period. It is given by the formula (Michael, 1978).

$$WUE = \frac{Y\ (Kg/ha)}{Cu\ (cm)}$$

Where,

WUE - Water Use Efficiency (Kg/ha cm)

Y - Marketable produce (Kg/ha)

Cu - Total consumptive use (cm)

3.4.7 Biometric observations

Sampling technique

For recording various growth observations, five plants were selected at random from each net plot. The plastic coated label was tied to each observational plant for easy identification. The details of different observations recorded are given in Table.

3.4.7.1 Growth characters

3.4.7.1.1 Days required for first square formation

The number of days from sowing to the date when 50 per cent of the plants in the plot showed first square formation were recorded.

3.4.7.1.2. Days required for flower initiation

The number of days from sowing to the date when 50 per cent of the plants in the plot showed flower initiation were recorded.

3.4.7.1.3 Flowering period

The date of first flower initiation and date of last flower initiation during the crop growth was observed visually from time to time and the period between date of first flower initiation and date of last flower initiation was recorded as the flowering period in days.

3.4.7.1.4 Number of flowers emasculated

The emasculation process was done either in the previous evening or early in the morning before anthesis. Removal of corolla as well as anther lobe sheath covering the style by pinching at the base of the bud with thumb nail and removing corolla and anther column in one jerk twisting action . The pistil with its stigma allowed to remain entirely intact and the emasculated flower covered with a cotton plugged straw tube (Doak, 1934).

The total number of flowers emasculated were counted and recorded from time to time on five randomly selected plants from each plot.

3.4.7.1.5 Number of flowers pollinated

Pollination was done by dusting the pollen from male parent after anthesis i.e. on the next day of emasculation and the crossed flower was again covered .

The total number of flowers pollinated were counted and recorded from time to time on five randomly selected plants from each plot.

Plate – II

Fig.	**Description**
1.	A Flower Bud Ready For Emasculation
2.	Emasculated Flower Bud
3.	Developing Crossed Boll
4.	A Hybrid Seed Production Plot Ready for Harvest

Plate II

Fig. 1

Fig. 2

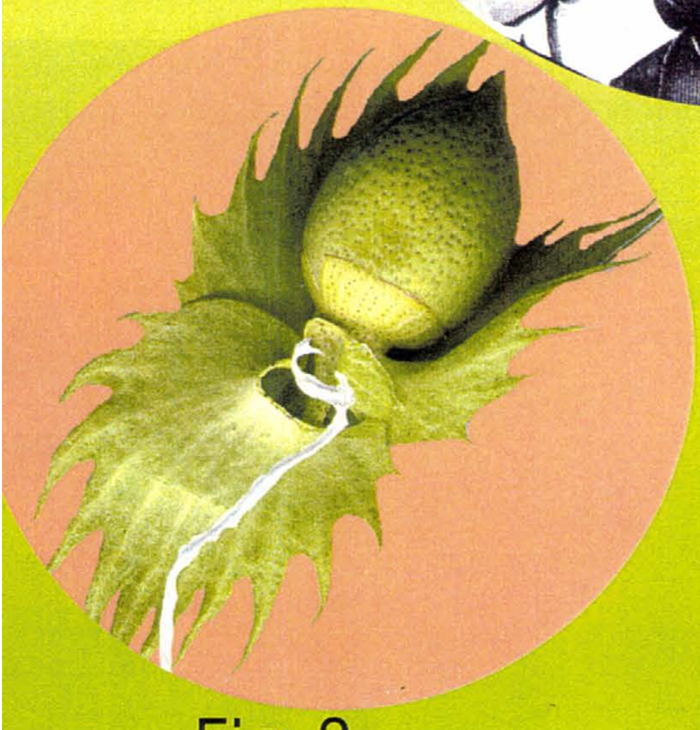


Fig. 3

Fig. 4

3.4.7.1.6 Percentage of boll setting

Number of bolls set out of those pollinated for each plot were recorded from time to time on five randomly selected plants and percentage of boll set was worked out.

3.4.7.1.7 Days required for boll opening after pollination

Date was recorded at the time of pollination and date of boll opening of that pollinated flower was recorded and period between date of pollination and date of boll opening was recorded in days.

3.4.7.1.8 Number of bolls harvested

Number of bolls harvested were counted and recorded from time to time on five randomly selected plants for each plot in every replication.

3.4.7.1.9 Average boll weight (g)

The average weight of bolls of each randomly selected plants from each net plot were recorded in grams.

3.4.7.2 Yield

3.4.7.2.1 Seed cotton yield per plant (g)

At the time of each picking seed cotton of each observation plant was picked and weighed separately for each treatment plot in grams .

3.4.7.2.3 Seed cotton yield per plot (kg)

The seed cotton yield obtained from picking of net plot was recorded in kilograms.

3.4.7.2.4 Seed cotton yield per hectare (q)

The seed cotton yield per hectare was calculated on the basis of actual plant population per net plot at the time of picking in quintals.

3.4.7.2.5 Average seed weight per boll (g)

From five sampled plants bolls were picked, ginned and the weight of seeds/boll in grams was recorded and average seed weight per boll was computed.

3.4.7.2.5 Seed yield per plant (g) , per plot (kg) and per hectare (q)

From the seed cotton of five randomly selected plants, ginning was done and seed yield per plant was weighed and computed for per plot and per hectare.

3.4.7.3 Quality and Laboratory studies

3.4.7.3.1 Ginning percentage

For determining the ginning percentage seed cotton was picked from five randomly selected plants. Ginning was done on ginning machine. Lint and seeds were separated and weighed and ginning percentage was worked out by following formula.

Plate – III

Fig.	**Description**
1.	Fuzzy seed
2.	Delinted seed
3.	Healthy Normal Hybrid Seedling
4.	Adult Hybrid Plant RHB-0388 (Phule 388)

Plate III

Fig.1

Fig.2

Fig.3

Fig.4

3.4.7.3.5 Dry matter content per 10 seedlings (g)

10 randomly selected fresh seedlings from each of the replications of germination test after germination count were taken and dried in hot air oven at constant temperature of 50 °C till the constant weight of dry matter was obtained. After complete drying they were weighed and dry matter content per 10 seedlings recorded in grams.

3.4.8 Effect of sowing dates and irrigation methods on storage of cotton seed

The seeds obtained after harvest were stored in cloth bags under laboratory condition. Germination test was carried out at harvest and 30 days, 60 days, 90 days, 120 and 150 days after storage.

3.4.9 Entomological aspects

The methods for recording observations on sucking pests viz., Aphids (*Aphis gossypii*), Jassids (*Amrasca biguttula biguttula* Ishida), Thrips (*Anaphothrips dorsalis*) and white flies (*Bemisia tabaci)* and bollworm complex consisting of spotted bollworm (*Earias vitella*), American bollworm (*Helicoverpa armigera*) and pink bollworm (*Pectinophora gossypiella*) are as given below .

3.4.9.1 Sucking pests

From each experimental plot, five plants were randomly selected and labelled for recording observations periodically. From each plant three leaves were selected that is one from top, and one from middle and one from bottom portion of the plant. The population of both nymphs and adults for aphid , only adults for white fly and only nymph for Jassid and thrip on the leaves were recorded.

3.4.9.2 Bollworm incidence

3.4.9.2.1 Bollworm infestation to bolls

Number of bollworm attacked bolls per five plants in each treatment were recorded at the time of each picking. From this average percentage of damaged bolls in each treatment was calculated.

3.4.9.2.2 Bollworm infestation to loculi

At the time of picking, total loculi of opened bolls and loculi showing bollworm damage were calculated from observations of the pickings average percentage of damaged loculi in each treatment was calculated.

3.4.10 Pathological aspects

Periodical observations on the incidence grey mildew and boll rot in percentage and severity of bacterial leaf blight, *Alternaria* leaf spot, red leaf blight, grey mildew and boll rot in percentage were recorded for which five plants from each treatment were randomly selected, tagged and used for recording the disease intensity. In the present study 6 most heavily infected leaves, to each from the top, middle and bottom were randomly selected and observations were recorded on the basis of score card developed and described below.

Grading system followed for describing disease intensity of bacterial leaf blight, *Alternaria* leaf spot, Red leaf blight was taken from (Anonymous, 2000-2001).

3.4.10.1 Bacterial leaf blight

For recording the intensity of bacterial leaf blight, five grades were fixed as under

A)	Immune	: Plant completely free from infection
B)	Resistant	: Spots few, scattered nearly 1.0 mm in diameter, dry, not coalescing, reddish, not angular, veins free.
C)	Moderately Resistant	: Spots initially wet but rapidly drying, several, larger, nearly 2.0 mm. Not coalescing, reddish brown, veins and veinlets free and leaf area covered upto 10 per cent.
D)	Moderately susceptible	: Lesions larger, 2.0 mm or more in diameter, angular and turning brown, black, coalescing, spreading linearly along the veins, 11-20 per cent leaf area covered or water soaked vein infection along the main veins.
E)	Susceptible	: Lesions larger, water soaked coalescing as above but covering more than 20 per cent leaf area or vein infected and extending pulvinus and petioles.

3.4.10.2 *Alternaria* leaf spot (ALS)

For recording the intensity of *Alternaria* leaf spot five grades were fixed as under

A)	Immune	:	No infetion
B)	Resistant	:	A few small spots, less than 2.0 mm, scattered, brown in colour, leaf area covered is less than 5 per cent.
C)	Moderately Resi- stant	:	Bigger spots upto 3.0 mm not coalescing, brown in colour 6 to 20 per cent leaf area covered.
D)	Susceptible	:	Spots increasing in size 3-5 mm and irregular in shape tending to coalscing, 21 to 40 per cent leaf area covered.
E)	Highly susceptible	:	Spots coalescing to form bigger lesions irregular in shape and size, more than 40 per cent leaf area covered.

3.4.10.3 Red leaf blight (RLB)

For recording disease intensity of red leaf blight, five grades were fixed as under.

A)	Immune	:	A whole leaf area free from reddening.
B)	Resistant	:	Reddening of leaf margins, leaf area covered upto 25 per cent .

C)	Moderately resistant :	Reddening of inter-veinal leaf area along with margins, leaf area covered upto 50 per cent .
D)	Moderately susceptible :	Reddening extended to entire leaf area and inter-veinal portion covered upto 75 per cent .
E)	Susceptible :	Leaf area covered by reddening more than 75 per cent , drying and defoliation of affected leaves.

3.4.10.4 Grey mildew (GM)

Chidambaran (1994) has suggested following grade of disease intensity of grey mildew.

A)	Highly resistant :	Scattered powdery growth without lesions on lower surface. Mainly lower leaves affected.
B)	Resistant :	Angular reddish spots visible, 50 per cent of lower surface covered by powdery growth. A few powdery spots on the upper suface. Powdery spots present only on middle layer leaves of the plant.
C)	Moderately Resistant:	100 per cent of lower surface and 50 per cent of upper surface covered by powdery growth. Reddish spots coalesce to form brown necrotic areas. Powdery growth present on the top leaves also.

D) Susceptible : More than 50 per cent area covered by reddish spots. Powdery growth on both surfaces, 25 - 50 per cent of the leaf necrotic, leaves get curled.

E) Highly susceptible : Leaves dry up and are shed.

For converting these different grades into numerical values, infection Grade 'A' was multiplied by 1 , Grade B by 2 , Grade C by 3, Grade D by 4 , and Grade E by 5. Frequencies of each infections grade were multiplied by the corresponding numerical values and the total sum of all the numerical values was divided by the total leaf observations and maximum grade to derive disease index.

The disease intensity grades recorded on the randomly selected plants were converted into disease indices by following formula

$$DI = \frac{\text{Sum of observed grades x 100}}{\text{Number of observations taken x Maximum grade}}$$

The disease intensity observations were recorded at various growth stages of cotton mentioned below.

1. Seedling stage
2. Square formation stage
3. Flower initiation stage
4. Boll development stage

5. Boll bursting stage

3.4.10.5 Boll rot (BR)

Observations on boll rot were also recorded from the same plants which were selected for other observations.

The infection percentage of boll rot was worked out by counting the actual number of the affected bolls observed on plants, out of total number number of bolls produced .

3.4.11 Statistical analysis

The standard methods of statistical analysis was followed as per method suggested by Panse and Sukhatme (1967) . Whenever the results were significant the critical difference (C.D.) at 5 per cent level of significance was calculated and compared.

EXPERIMENTAL RESULTS

4. RESULTS

The results of the present investigations are presented with appropriate tables and graphs. The results are interpreted in an integrated manner to draw the appropriate conclusions. These results are broadly categorised under the following heads.

4.1 Water management aspects

4.2 Biometric observations

4.3 Entomological aspects

4.4 Pathological aspects

4.1 Water management aspects

4.1.1 Net Irrigation requirement under drip irrigation system

Daily pan evaporation was taken into consideration for estimating the irrigation requirement. Pan evaporation readings for two days were converted into evaporation of cotton crop using pan factor (KP) and crop coefficient (KC). This concept was developed and adapted by Doorenbose and Pruitt (1977).

The net irrigation requirement of cotton crop during its growth period sown on four different sowing dates viz. 16th March, 1st April, 15th April and 1st May are reported in Appendix – I, II, III, & IV, respectively.

4.1 Profile depletion, total water applied, water requirement, consumptive use, water saving and water use efficiency as affected by different treatments.

Treatment	Profile depletion (mm)	Total water applied (mm)	Effective rainfall (mm)	Seasonal water requirement (mm)	Consumptive use (mm)	Water saving (per cent)	Seed cotton (Kg/ha)	Water use efficiency (Kg/ha-mm)
	A	B	C	(B+C)	(A+C)	D	E	(E / (A+C)
T_1 16 March+ drip	633.27	633.27	100.80	734.07	734.07	54.51	1411	1.92
T_2 1 April + drip	616.85	616.85	105.10	721.95	721.95	51.55	1150	1.59
T_3 15 April +drip	557.98	557.98	129.30	687.28	687.28	52.24	940	1.37
T_4 1 May + drip	504.32	504.32	139.10	643.42	643.42	46.66	742	1.15
T_5 16March surface	1076.56	1400.00	213.40	1613.40	1289.96	-	1216	0.94
T_6 1 April +Surface	1048.65	1260.00	230.20	1490.20	1278.85	-	1020	0.80
T_7 15 April +Surface	948.57	1190.00	249.10	1439.10	1197.67	-	855	0.71
T_8 1 May +Surface	857.34	910.00	296.30	1206.30	1153.64	-	653	0.57

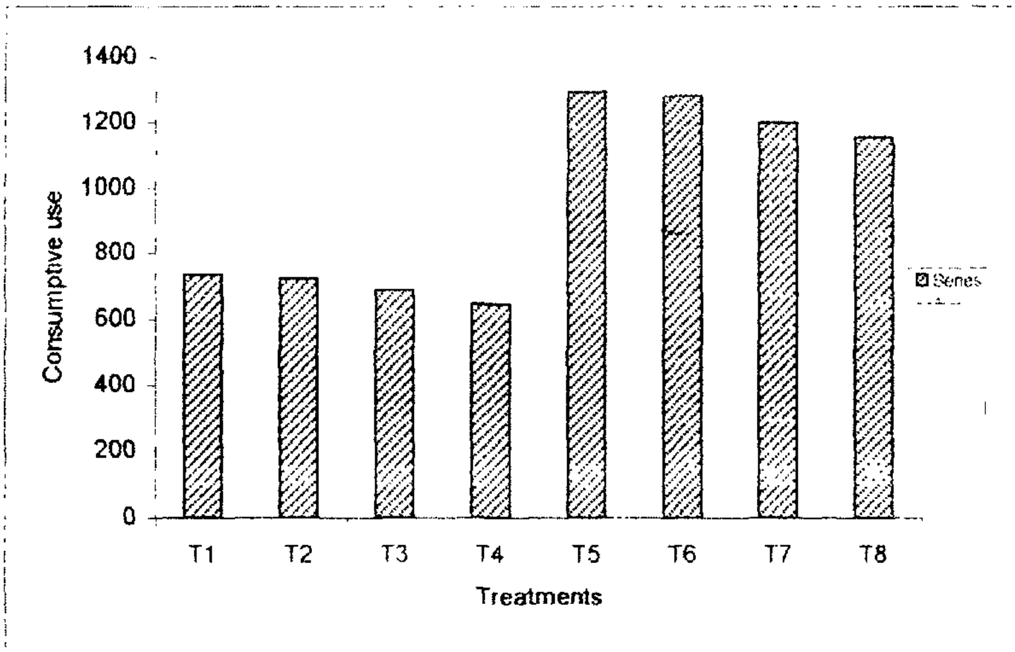
A total of 633.27 mm, 616.85 mm, 557.28 mm and 504.32 mm water was applied during the period of investigatoin through drip irrigation for the crop sown on four different sowing dates i.e. 16th March, 1st April, 15th April and 1st May respectively. The net alternate day water requirement in litres per plant was also estimated and utilised for working out the time for running the drip irrigation system to meet the crop water requirement.

The operating time for each irrigation was changed due to change in water requirement of crop. The operating time of drip irrigation system was decided on the basis of net irrigation requirement in litres per plant, emission uniformity of the system, number of emitters per plant and design discharge rate through each emitter.

The average discharge through each emitter at operating pressure of 1 Kg/cm^2 was 7.71 lph. The seasonal water requirement of cotton crop sown on 16th March, 1st April, 15th April and 1st May was 734.07 mm, 721.95 mm, 687.28 mm and 643.42 mm respectively.

4.1.2 Net irrigation requirement under surface irrigation system

The water requirement of cotton crop under surface irrigation treatment as estimated by climatological approach is presented in Appendix V, VI, VII, and VIII for four sowing dates 16th March, 1st April, 15th April and 1st May respectively. The available soil moisture content in the profile of 45 cm was 14.0, 13.7, 13.1 and 12.9 cm which was calculated as per formula suggested by Dastane (1972). As per management allowable deficit (MAD) concept of 50 per cent of available soil moisture content



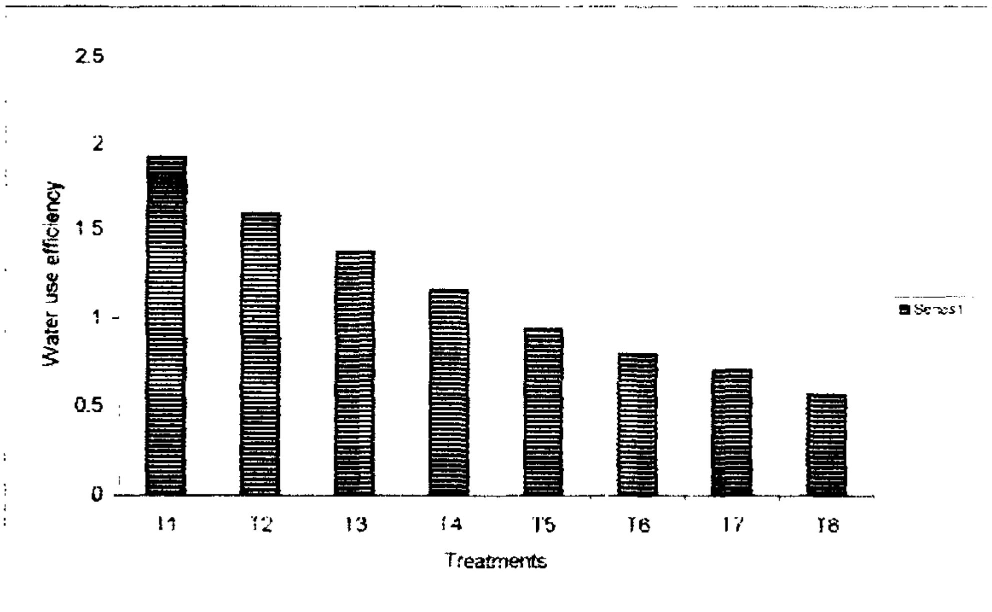


Fig. 4.1 Relation between Cu and WUE as affected by different treatments.

and assuming 0.80 per cent efficiency, the depth of irrigation was worked out to be 7 cm for all sowing dates. Irrigation was scheduled at 50 mm CPE which required 20, 19, 17 and 13 irrigations @ 7 cm depth for four sowing dates 16th March, 1st April, 15th April and 1st May respectively were given during the crop period. Thus, the total water applied throughout the season in surface irrigation treatments was 1613.40, 1490.20, 1439.10 and 1206.30 mm for the sowing dates 16th March, 1st April, 15th April and 1st May respectively including effective rainfall.

4.1.3 Irrigation studies

The data on soil moisture studies viz., profile depletion, effective rainfall, water applied through drip irrigation, seasonal water requirement, consumptive use water saving and water use efficiency are given in Table 4.1. The relationship between Cu and WUE is graphically shown in Fig. 4.1.

4.1.3.1 Consumptive use

From the data in Table 4.1, it is seen that the total water applied for surface irrigation was 1400, 1260, 1190 and 910 mm for the crop sown at 16th March, 1st April, 15th April and 1st May respectively. Total water applied for drip irrigation was 633.27, 616.85, 557.98 and 504.32 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. The profile depletion of surface irrigation was 1076.56, 1048.65, 948.57 and 857.34 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. The profile depletion of drip irrigation was 633.27, 616.85, 557.98 and 504.32 mm for the crop sown at 16th March, 1st April, 15th April and 1st May respectively. In case of drip irrigation quantity of water applied was almost as per need of the crop and hence the quantity of water applied was nearly equal to soil moisture depleted by the crop. The effective rainfall for surface irrigation was 213.40, 230.20, 249.10 and 296.30 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. The effective rainfall for drip irrigation was 100.80, 108.10, 129.30 and 139.10 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. Consumptive use for surface irrigation treatment was 1289.96, 1278.85, 1197.67 and 1153.64 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. Consumptive use for drip irrigation treatments was 734.07, 721.95, 687.28 and 643.42 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively.

4.1.3.2 Water saving

The data presented in Table 4.1 revealed that the depth of water applied in surface irrigation was 1613.40, 1490.20, 1439.10 and 1206.30 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively including effective rainfall. The depth of water applied in drip irrigation was 734.07, 721.95, 687.28 and 643.42 mm for the crop sown on 16th March, 1st April, 15th April and 1st May respectively including effective rainfall. Thus water saving was 54.51, 51.55, 52.24 and 46.66 per cent due to drip irrigation method over conventional method of irrigation for the crop sown at 16th March, 1st April, 15th April and 1st May respectively.

4.1.3.3 Water use efficiency

From the table 4.1 it can be seen that the water use efficiency for surface irrigation treatment was 0.94, 0.80, 0.71 and 0.57 for the crop sown 16th March, 1st April, 15th April and 1st May respectively and for drip irrigation treatment it was 1.92, 1.59, 1.37 and 1.15 for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. It can be seen that WUE was more in drip irrigation method as compared to surface irrigation method for all the four sowing dates.

4.1.3.4 Average discharge and emission uniformity of drip irrigation

The uniform distribution of water throughout the experimental field is necessary for better crop development. Emission uniformity is one of the important criterion for evaluating the performance of drip irrigation system.

The average discharge obtained according to the method reported in Table 4.2 it is revealed that the average discharge in the system was 7.71 lph at 1.0 Kg cm^{-2} pressure. The observations on average discharge were used to calculate emission uniformity (Eu).

Emission uniformity obtained in the system was 96.65 per cent at the operating pressure of 1.0 Kg cm^{-2}. The Eu observed in the system was above 90 per cent and considered as excellent.

Table 4.2. Average discharge and emission uniformity of drip irrigation system.

Mean of two successive emitters discharge (lph)/Lateral	L_1	L_2	L_3	L_4	Mean
E_1	7.80	7.92	7.75	7.90	7.84
E_2	7.72	7.82	7.68	7.76	7.74
E_3	7.70	7.80	7.67	7.73	7.72
E_4	7.6	7.50	7.40	7.70	7.55
Mean total	7.70	7.76	7.62	7.77	30.84

$$\text{Average discharge} = \frac{30.84}{4} = 7.71 \text{ lph}$$

$$\text{Emission uniformity} = Eu = 100\left(\frac{q\ min}{q\ av.} + \frac{q\ av.}{qx}\right) \times \frac{1}{2}$$

$$= 100\left(\frac{7.40}{7.71} + \frac{7.71}{7.91}\right) \times \frac{1}{2}$$

$$= 96.65 \text{ per cent}$$

4.2 Biometric observations

4.2.1 Mean number of days required for first square formation

Table 4.3 Mean number of days required for first square formation as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	39.65	38.05	37.00	35.95	37.66
I_2	38.00	36.50	35.50	34.00	36.00
Mean	38.83	37.28	36.25	34.98	36.83

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.185	0.261	0.369
C.D. at 5 per cent	0.543	0.768	N.S.

The data on days required for first square formation are presented in Table 4.3. From the Table 4.3, it can be seen that the mean number of days required for first square formation was 36.83.

4.2.1.1 Effect of irrigation methods

It is clear from the Table 4.3 that the crop with drip irrigation treatments required significantly more number of days (37.66) for first square formation and led to delayed maturity than the crop with surface irrigation treatments (36.00).

4.2.1.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on number of days required for first square formation. The crop sown on 16th March (S_1) required significantly more period (38.83) than the crop sown on all other dates. It can be seen from the Table 4.3 that the crop required less number of days for first square formation as the sowing was delayed. The minimum period (34.98) was required for first square formation when the crop was sown on 1st May (S_4).

4.2.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean number of days required for first square formation was found to be non-significant.

4.2.2 Mean number of days required for flower initation

Table 4.4 Mean number of days required for flower initiation as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	60.40	59.60	56.75	55.50	58.06
I_2	59.05	57.10	55.75	54.00	56.08
Mean	59.73	58.35	56.25	54.75	57.27

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.335	0.474	0.670
C.D. at 5 per cent	0.985	1.393	N.S.

The data pertaining to mean number of days required for flowering initiation of the crop are presented in Table 4.4. The mean number of days required for flowering initiation was 57.27.

4.2.2.1 Effect of irrigation methods

It can be seen from the Table 4.4, that the mean number of days required for flowering initiation was significantly more in the crop with drip irrigation treatments (58.06) as compared to the crop with surface irrigation treatments (56.08).

4.2.2.2 Effect of sowing dates

The mean number of days required for flower initiation was significantly influenced by different dates of sowing. The crop sown on 16^{th} March (S_1) which was at par with the crop sown on 1^{st} April (S_2) required significantly more number of days (59.73) and (58.35) respectively for flower initiation than the crop sown on all other dates. It can be seen from the Table 4.4 that flower initiates early as the sowing was delayed. The minimum number of days (54.75) were required for flower initiation when the crop was sown on 1^{st} May (S_4).

4.2.2.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean number of days required for flower initiation was found to be non-significant.

4.2.3 Flowering period

The data regarding mean flowering period of the crop as influenced by various treatments are presented in Table 4.5. The mean flowering period of the crop was 58.33.

Table 4.5 Mean flowering period (in days) of the crop as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	58.40	59.78	57.40	58.75	58.58
I_2	59.40	57.05	57.50	58.35	58.08
Mean	58.90	58.41	57.45	58.55	58.33

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.553	0.781	1.105
C.D. at 5 per cent	N.S.	N.S.	N.S.

4.2.3.1 Effect of irrigation methods

Irrigation methods did not significantly influence the flowering period of the crop. However flowering period was found to be more in case of crop with drip irrigation treatments (58.58) as compared to the crop with surface irrigation treatments (58.08).

4.2.3.2 Effect of sowing dates

There was no definite trend in the effect of different sowing dates on flowering period of the crop. However, maximum flowering period (58.90) was noticed when the crop was sown on 16th March (S_1) and minimum flowering period (57.45) was noticed when the crop was sown on 15[th] April (S_3).

4.2.3.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean flowering period of the crop was not significant.

4.2.4 Mean number of flowers emasculated and pollinated

The data on mean number of flowers emasculated and pollinated during the growth of the crop as influenced by different treatments are presented in Table 4.6. The mean number of flowers emasculated and pollinated was 48.89.

Table 4.6 Mean number of flowers emasculated and pollinated as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	59.55	54.70	48.30	40.55	50.78
I_2	55.35	50.40	45.10	37.15	47.00
Mean	57.45	52.55	46.70	38.85	48.89

	Irrigation methods	Sowing dates	Interaction
S.E. ±	1.206	1.705	2.411
C.D. at 5 per cent	3.543	5.011	N.S.

4.2.4.1 Effect of irrigation methods

From the Table 4.6, it can be seen that significantly more number of flowers were available for emasculation and pollination during the growth period of the crop with drip irrigation treatments (50.78) as compared to the crop with surface irrigation treatments (47.00) .

4.2.4.2 Effect of sowing dates

It can be seen from the Table 4.6, that the number of flowers available for emasculation and pollination was significantly reduced as the sowing was delayed. Significantly more number of flowers were available for emasculation and pollination when the crop was sown on 16th March (S_1) (57.45) than the crops sown on all other dates except the crop which was sown on 1st April (S_2) (52.55) which was at par with it. Significantly less number of flowers were available for emasculation and pollination during the growth period of the crop sown on 1st May (S_4) (38.85) than the crops sown on all other dates.

4.2.4.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean number of flowers available for emasculation and pollination during the growth period of the crop was found to be non significant.

4.2.5 Mean percentage of boll setting

The data regarding mean percentage of boll setting as influenced by different treatment are presented in Table 4.7. The mean percentage of boll setting was 55.89.

Table 4.7 Mean percentage of boll setting as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	60.92 (51.31)	57.32 (49.20)	54.86 (47.80)	53.70 (47.12)	56.70 (48.86)
I_2	58.49 (49.90)	56.34 (48.65)	54.13 (47.37)	51.40 (45.80)	55.09 (47.93)
Mean	59.70 (50.60)	56.83 (48.92)	54.50 (47.59)	52.55 (46.46)	55.89 (48.40)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.246	0.348	0.492
C.D. at 5 per cent	0.723	1.023	N.S.

*Figures in parentheses indicate arcsin transformation.

4.2.5.1 Effect of irrigation methods

It can be seen from the Table 4.7, that the irrigation methods significantly influenced mean percentage of boll setting during the crop growth. Mean percentage of boll setting was found to be significantly higher in drip irrigation treatment (56.70) as compared to the surface irrigation treatment (55.09).

4.2.5.2 Effect of sowing dates

It is clear from the Table 4.7, that the mean percentage of boll setting was significantly reduced as the sowing was delayed. The crop sown on 16th March (S_1) had significantly higher percentage of boll setting (59.70) than the crops sown on all other dates. However the crop sown on

1st May (S_4) had significantly lower percentage of boll setting (52.55) than the crops sown on all other dates.

4.2.5.3 Effect of interaction

The effect of interaction between irrigation methods and sowing dates on mean percentage of boll setting was found to be non-significant.

4.2.6 Mean number of days required for boll opening after pollination

The data pertaining to mean number of days required for boll opening after pollination as influenced by different treatments are presented in Table 4.8. Mean number of days required for boll opening after pollination was 44.14.

Table 4.8 Mean number of days required for boll opening after pollination as influenced by different treatments of irrigation method and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	49.85	46.60	43.70	42.15	45.58
I_2	47.20	43.15	41.00	39.45	42.70
Mean	48.53	44.88	42.35	40.80	44.14

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.362	0.511	0.723
C.D. at 5 per cent	1.063	1.503	N.S.

4.2.6.1 Effect of irrigation methods

From the Table 4.8, it can be seen that the crop with drip irrigation treatments required significantly more number of days (45.58) for boll opening after pollination as compared to the crop with surface irrigation treatments. (42.70).

4.2.6.1 Effect of sowing dates

The number of days required for boll opening after pollination was significantly decreased as the sowing was delayed. The crop sown on 16th March (S_1) required significantly more number of days (48.53) for boll opening after pollination than the crops sown on all other dates. While the crop sown on 1st May (S_4) required significantly less number of days (40.80) for boll opening after pollination than the crop sown on all other dates.

4.2.6.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean number of days required for boll opening after pollination was not found to be significant.

4.2.7 Mean number of bolls harvested per plant

The data on mean number of bolls harvested per plant as influenced by different irrigation methods and sowing dates are presented in Table 4.9. The mean number of bolls harvested per plant was 27.50.

Table 4.9 Mean number of bolls harvested per plant as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	37.00	31.30	26.45	21.25	29.00
I_2	32.40	28.35	24.25	19.00	26.00
Mean	34.70	29.83	25.35	20.13	27.50

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.720	1.019	1.441
C.D. at 5 per cent	2.117	2.994	N.S.

4.2.7.1 Effect of irrigation methods

From the Table 4.9, it can be seen that mean number of bolls harvested per plant was significantly higher (29.00) in the crop with drip irrigation treatments as compared to the crop with surface irrigation treatments (26.00).

4.2.7.2 Effect of sowing dates

It can be seen from the Table 4.9 that the mean number of bolls harvested per plant was significantly reduced as the sowing was delayed. Mean number of bolls harvested per plant was significantly more (34.70) in the crop sown on 16th March (S_1) that the cross sown on all other dates. While the crop sown on 1st May(S_4) had significantly less number of bolls harvested per plant (20.13) than the crops sown on all other dates.

4.2.7.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean number of bolls harvested per plant was found to be non-significant.

4.2.8 Average boll weight in (g)

The data pertaining to average boll weight as influenced by different treatment are presented in Table 4.10. The average boll weight was 3.56 gms.

Table 4.10 Average boll weight in gms as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	3.75	3.62	3.52	3.45	3.59
I_2	3.70	3.56	3.48	3.40	3.54
Mean	3.73	3.59	3.50	3.43	3.56

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.012	0.017	0.023
C.D. at 5 per cent	0.035	0.049	N.S.

4.2.8.1 Effect of irrigation methods

From the Table 4.10, it can be seen that the crop with drip irrigation treatment had significantly higher average boll weight (3.59 g) as compared to the crop with surface irrigation treatments (3.54 g).

4.2.8.2 Effect of sowing dates

Average boll weight of cotton was significantly decreased as the sowing was delayed. The crop sown on 16th March (S_1) had significantly higher average boll weight (3.73 g) than the crop sown on all other dates. While the crop sown on 1st May (S_4) had significantly lower average boll weight (3.43 g) than the crop sown on all other dates.

4.2.8.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average boll weight of cotton was found to be non-significant.

4.2.9 Mean seed cotton yield per plant (g) per plot (kg) and per hectare (q)

Table 4.11 a) Mean seed cotton yield per plant (g) as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	138.94	113.37	93.11	73.28	104.67
I_2	119.92	100.69	84.42	64.62	92.41
Mean	129.43	107.03	88.77	68.95	98.54

	Irrigation methods	Sowing dates	Interaction
S.E. ±	2.742	3.878	5.484
C.D. at 5 per cent	8.060	11.398	N.S.

Table 4.11 b) Mean seed cotton yield in per plot (kg) as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	4.45	3.63	2.97	2.34	3.35
I_2	3.83	3.22	2.70	2.06	2.95
Mean	4.14	3.42	2.83	2.20	3.15

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.088	0.125	0.177
C.D. at 5 per cent	0.259	0.367	N.S.

Table 4.11 c) Mean seed cotton yield per hectare (q) as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	14.11	11.50	9.40	7.42	10.61
I_2	12.16	10.20	8.55	6.53	9.36
Mean	13.14	10.85	8.98	6.98	9.98

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.280	0.396	0.560
C.D. at 5 per cent	0.824	1.165	N.S.

The data pertaining to mean seed cotton yield per plant, per plot and per hectare as influenced by different treatments are presented in

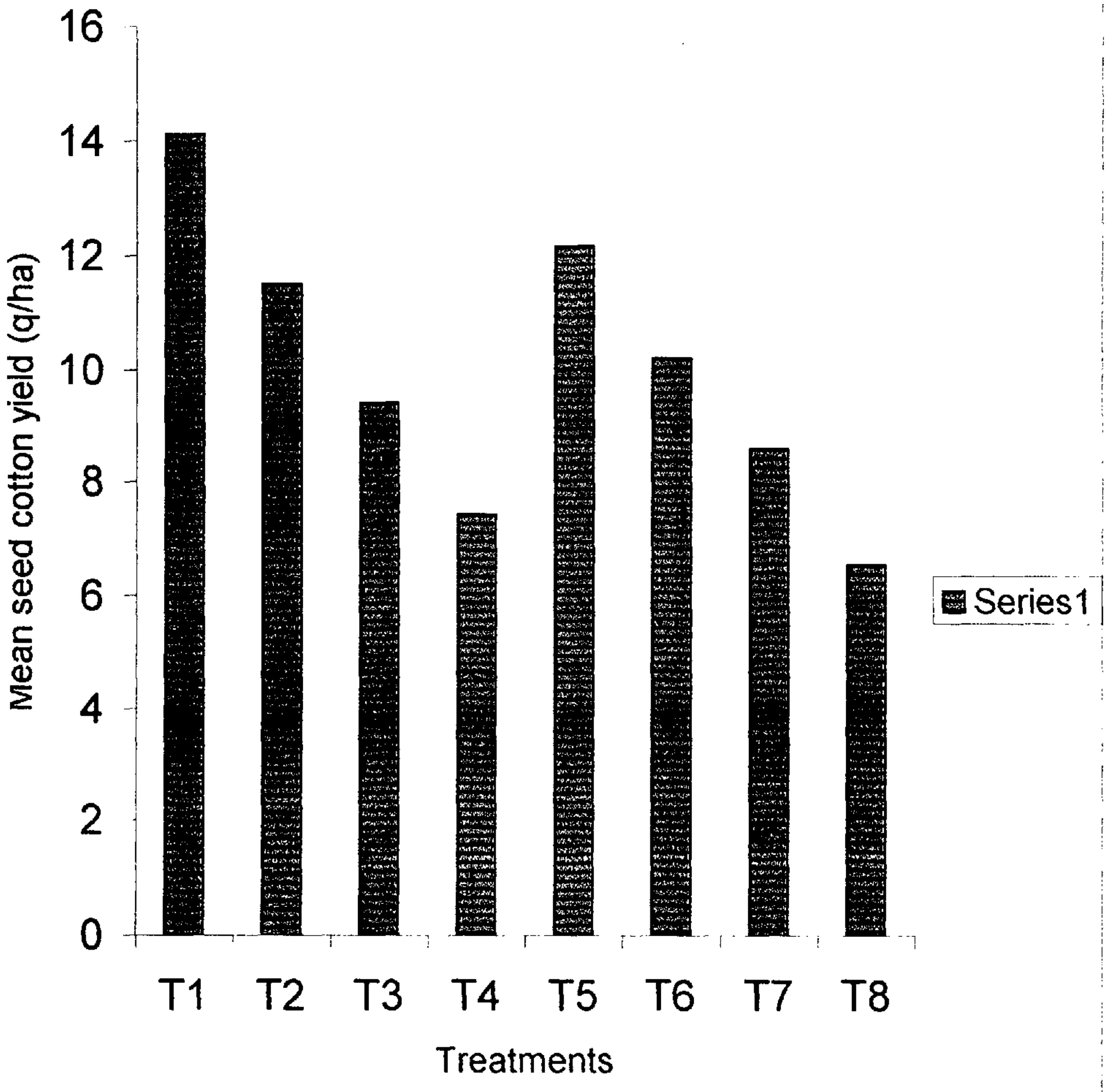


Fig. 4.2 Mean seed cotton yield per hectare in (q) as influenced by different treatments of irrigation methods and sowing dates

Table 4.11 (a), (b) and (c) respectively. The mean seed cotton yield was 98.54 gms per plant, 3.15 Kg per plot and 9.98 qtls per hectare.

4.2.9.1 Effect of irrigation methods

From the Table 4.11 (a), (b), and (c) it can be seen that the crop with drip irrigation treatment produced significantly higher mean seed cotton yield per plant (104.67 g), per plot (3.35 kg) and per hectare (10.61 q) as compared to the crop with surface irrigation treatment which produced mean seed cotton yield of 92.41 gms per plant 2.95 Kg per plot and 9.36 qtls per hectare.

4.2.9.2 Effect of sowing dates

From the Table 4.11 (a), (b) and (c) it can be seen that mean seed cotton yield per plant, per plot and per hectare was significantly reduced as the sowing was delayed. The crop sown on 16th March (S_1) produced significantly higher mean seed cotton yield per plant (129.43 g), per plot (4.14 Kg) and per hectare (13.14 q) than the crops sown on all other dates. While the crop sown on 1st May (S_4) produced significantly lower mean seed cotton yield per plant (68.95 g) per plot (2.20 kg) and per hectare (6.98 q) than the crops sown on all other dates.

4.2.9.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean seed cotton yield per plant, per plot and per hectare was found to be non-significant.

4.2.10 Average seed weight per boll (g)

The data on average seed weight per boll in gms as influenced by different irrigation methods and sowing dates are presented in Table 4.12. The average seed weight per boll was 2.24 gms.

Table 4.12 Average seed weight per boll in (g) as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	2.36	2.29	2.21	2.17	2.26
I_2	2.32	2.25	2.18	2.14	2.22
Mean	2.34	2.27	2.20	2.15	2.24

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.009	0.013	0.018
C.D. at 5 per cent	0.027	0.038	N.S.

4.2.10.1 Effect of irrigation methods

From the Table 4.12, it can be seen that average seed weight per ball was significantly higher in the crop with drip irrigation treatment (2.26 g) as compared to the crop with surface irrigation treatments (2.22 g).

4.2.10.2 Effect of sowing dates

From the Table 4.12, it can be seen that average seed weight per boll was significantly higher when the crop was sown on 16th March (S_1) (2.34 g) than the crop sown on all other dates. While the average seed weight per boll was significantly lower when the crop was sown on 1st May (S_4) (2.15 g).

4.2.10.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average seed weight per boll was found to be non-significant.

4.2.11 Mean seed yield per plant (g), per plot (kg) and per hectare (q).

Table 4.13 a) Mean seed yield per plant (g) as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	87.17	71.73	58.46	45.98	65.83
I_2	74.92	63.65	52.89	40.71	58.04
Mean	81.04	67.69	55.68	43.34	61.94

	Irrigation methods	Sowing dates	Interaction
S.E. ±	1.758	2.487	3.517
C.D. at 5 per cent	5.169	7.310	N.S.

Table 4.13 b) Mean seed yield per plot (kg) as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	2.89	2.39	1.98	1.57	2.21
I_2	2.41	2.16	1.69	1.52	1.94
Mean	2.65	2.28	1.84	1.55	2.08

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.066	0.093	0.131
C.D. at 5 per cent	0.192	0.273	N.S.

Table 4.13 C) Mean seed yield per hectare (q) as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	8.85	7.28	5.93	4.67	6.68
I_2	7.61	6.47	5.37	4.12	5.89
Mean	8.23	6.87	5.65	4.39	6.29

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.178	0.252	0.356
C.D. at 5 per cent	0.524	0.741	N.S.

The data pertaining to mean seed yield per plant, per plot and per hectare are presented in Table 4.13 (a), (b), and (c). From the Table it can be seen that the mean seed yield of cotton was 61.94 g/plant, 2.08 kg/plot and 6.29 q/hectare.

4.2.11.1 Effect of irrigation methods

From the Table 4.13 (a), (b), and (c) it is clear that the crop with drip irrigation treatments produced significantly higher mean seed yield per plant (65.83 g), per plot (2.21 kg) and per hectare (6.68 q) as compared to the crop with surface irrigation treatments which had mean seed yield of 58.04 g/plant 1.94 kg/plot and 5.89 q/ha.

4.2.11.2 Effect of sowing dates

The mean seed yield of cotton per plant, per plot and per hectare was significantly reduced as the sowing was delayed. The crop

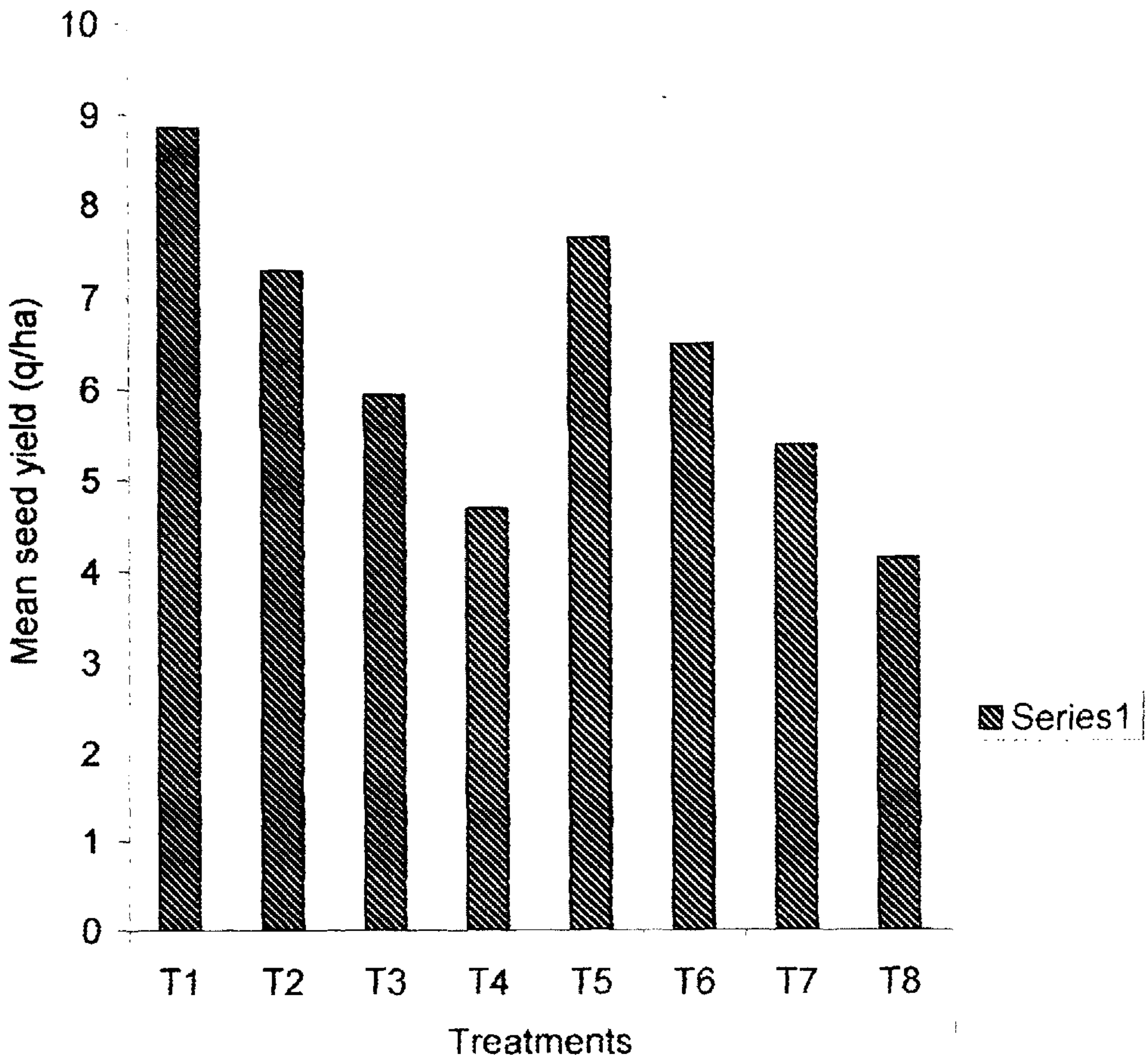


Fig. 4.3 Mean seed yield per hectare in (q) as influenced by different treatments of irrigation methods and sowing dates

sown on 16th March (S_1) produced significantly higher mean seed yield per plant (81.04 g) per plot (2.65 kg) and per hectare (8.23 q) than the crop sown on all other dates. While the crop sown on 1st May (S_4) produced significantly lower mean seed yield per plant (43.34 g), per plot (1.55 kg) and per hectare (4.39 q) than the crop sown on all other dates.

4.2.11.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean seed yield was found to be non significant.

4.3 Quality and Laboratory studies

The harvested bolls were ginned with the help of ginning machine. After ginning process fuzzy seeds were obtained which were delinted with the help of Conc. H_2SO_4 solution.

4.3.1 Mean ginning percentage

Table 4.14 Mean ginning percentage as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	37.06 (37.51)	36.75 (37.30)	37.21 (37.58)	37.24 (37.61)	37.06 (37.50)
I_2	37.30 (37.64)	36.79 (37.36)	37.36 (37.67)	37.20 (37.60)	37.16 (37.57)
Mean	37.18 (37.57)	36.77 (37.33)	37.28 (37.63)	37.22 (37.61)	37.11 (37.53)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.074	0.105	0.149
C.D. at 5 per cent	N.S.	N.S.	N.S.

- Figures in parentheses indicate arcsin transformation.

The data regarding the value of mean ginning percentage as influenced by different treatments are presented in Table 4.14. The value of mean ginning percentage was 37.11.

4.3.1.1 Effect of irrigation methods

Irrigation methods did not significantly influence the value of mean ginning percentage. However the value of mean ginning percentage was found to be more in the crop with surface irrigation treatments (37.16) as compared to the crop with drip irrigation treatments (37.06).

4.3.1.2 Effect of sowing dates

Sowing dates also did not significantly influence the value of mean ginning percentage. However the value of mean ginning percentage was found to be more when the crop was sown on 15th April (S_3) (37.28) than the crop sown on all other dates. While the value of mean ginning percentage was found to be minimum when the crop was sown on 1st April (S_2) (36.77).

4.3.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on the value of mean ginning percentage was found to be non-significant.

4.3.2 Mean seed index

The data regarding the value of mean seed index as influenced by different treatments are presented in Table 4.15. The mean seed index was 7.70 g.

Table 4.15 Mean seed index in gms as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	8.18	7.89	7.62	7.37	7.76
I_2	7.99	7.75	7.52	7.29	7.64
Mean	8.08	7.82	7.57	7.33	7.70

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.035	0.049	0.069
C.D. at 5 per cent	0.102	0.144	N.S.

4.3.2.1 Effect of irrigation methods

From the Table 4.15, it can be seen that the crop with drip irrigation treatment recorded significantly higher seed index (7.76 g) as compared to the crop with surface irrigation treatments (7.64 g).

4.3.2.2 Effect of sowing dates

From the Table 4.15, it can be seen that the value of mean seed index was significantly reduced as the sowing was delayed. The crop sown on 16th March (S_1) had significantly higher value of mean seed index (8.08 g) than the crop sown on all other dates. While the crop sown on 1st May (S_4) had significantly lower value of mean seed index (7.33 g) than the crop sown on all other dates.

4.3.2.3 Effect of interaction

Interaction effect between different irrigation methods and sowing dates on the value of mean seed index was found to be non-significant.

4.3.3 Germination percentage

The seeds obtained after ginning process were germinated at 30 ± 1°C temperature by using between paper method (Anonymous, 1985). Germination count was taken on 12th day. Normal and abnormal seedlings were counted and germination percentage was calculated on the basis of percentage of normal seedlings.

4.3.3.1 Mean germination percentage of fuzzy cotton seed

Table 4.16 Mean germination percentage of fuzzy cotton seed as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	76.00 (60.69)	73.50 (59.71)	72.50 (58.40)	71.50 (57.76)	73.38 (59.14)
I_2	75.00 (60.05)	73.50 (59.03)	72.00 (58.06)	71.50 (57.76)	73.00 (58.72)
Mean	75.50 (60.37)	73.50 (59.37)	72.25 (58.23)	71.50 (57.76)	73.19 (58.93)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.465	0.658	0.930
C.D. at 5 per cent	N.S.	1.993	N.S.

* Figures in parentheses indicate arcsin transformation.

Plate – IV

Germination of seeds

Fig.	**Description**
1.	a. Normal Seedlings
	b. Abnormal Seedlings

Plate IV

Fig. 1

The data pertaining to the mean percentage of germination of fuzzy cotton seed as influenced by different treatments are presented in Table 4.16. The mean value of germination percentage was 73.19.

4.3.3.1.1 Effect of irrigation methods

Irrigation methods did not significantly influence the mean value of germination percentage. However, mean value of germination percentage was found to be more with the seeds obtained from the crop with drip irrigation treatment (73.38) as compared to the seeds obtained from the crop with surface irrigation treatments (73.00).

4.3.3.1.2 Effect of sowing dates

From the Table 4.16 it can be seen that the mean value of germination percentage of fuzzy cotton seed was significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) had significantly higher value of mean germination percentage (75.50) than the seeds obtained from crop sown on other dates except the seeds obtained from the crop sown on 1st April (S_2) (73.50) which was at par with it. The treatments S_2, S_3 and S_4 were at par with each other. The seeds obtained from the crop sown on 1st May (S_4) had significantly lower value of mean germination percentage (71.50) than the seeds obtained from the crop sown on 16th March (S_1).

4.3.3.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on value of mean germination percentage was found to be non-significant.

4.3.3.2 Mean germination percentage of delinted cotton seed

Table 4.17 Mean germination percentage of delinted cotton seed as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	81.00 (64.20)	79.00 (62.76)	78.50 (62.51)	75.50 (60.43)	78.50 (60.47)
I_2	80.00 (63.45)	77.00 (61.37)	76.50 (61.08)	74.00 (59.35)	76.88 (61.31)
Mean	80.50 (63.82)	78.00 (62.06)	77.50 (61.80)	74.75 (59.89)	77.69 (61.89)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.597	0.845	1.194
C.D. at 5 per cent	N.S.	2.483	N.S.

* Figures in parentheses indicate arcsin transformation.

The data pertaining to the mean value of germination percentage of delinted cotton seed are presented in Table 4.17. The mean value of gemination percentage was 77.69.

4.3.3.2.1 Effect of irrigation methods

Irrigation methods did not significantly influence the value of mean germination percentage of delinted cotton seed. However the mean germination percentage was found to be higher in case of seeds obtained from the crop with drip irrigation treatments (78.50) as compared to the seeds obtained from crop with surface irrigation treatments (76.88).

4.3.3.2.2 Effect of sowing dates

Mean value of germination percentage of delinted cotton seed was significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) recorded significantly higher value of germination percentage (80.50) than the crop sown on 1st May (S_4) and was at par with treatments S_2 and S_3. The seeds obtained from the crop sown on 1st May (S_4) recorded significantly lower value of germination percentage (74.75) than the seeds obtained from the crop sown on 16th March (S_1) (80.50) and was at par with treatments S_2 and S_3.

4.3.3.2.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean germination percentage of delinted cotton seed was found to be non-significant.

4.3.4 Mean vigour index of fuzzy cotton seed

Table 4.18 Mean vigour index of fuzzy cotton seed as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	2447.20	2343.00	2243.30	2057.50	2272.75
I_2	2393.65	2269.90	2184.35	1992.80	2210.18
Mean	2420.43	2306.45	2213.83	2025.15	2241.46

	Irrigation methods	Sowing dates	Interaction
S.E. ±	35.942	50.830	71.885
C.D. at 5 per cent	N.S.	149.410	203.702

The data pertaining to the mean value of vigour index of fuzzy cotton seed as influenced by different treatments are presented in Table 4.18. The mean vigour index was 2241.46.

4.3.4.1 Effect of irrigation methods

From the Table 4.18, it can be seen that the irrigation methods did not significantly influence the mean vigour index of fuzzy cotton seed. However, the seeds obtained from the crop with drip irrigation treatments recorded higher mean vigour index (2272.75) as compared to the seeds obtained from the crop with surface irrigation treatments (2210.18).

4.3.4.2 Effect of sowing dates

The value of mean vigour index of fuzzy cotton seed was significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) recorded significantly higher value of mean vigour index (2420.43) than the seeds obtained from the crops sown on other dates except the seeds obtained from the crop sown on 1st April (S_2) (2306.45) which was at par with it. Treatments S_2 and S_3 were at par with each other. The seeds obtained from the crop sown on 1st May (S_4) recorded significantly lower value of mean vigour index (2025.15) than the seeds obtained from the crops sown on all other dates.

4.3.4.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean vigour index of fuzzy cotton seed was found to be non-significant.

4.3.5 Mean vigour index of delinted cotton seed

The data regarding the value of mean vigour index of delinted cotton seed as influenced by different treatments are presented in Table 4.19. The value of mean vigour index was 2377.59.

Table 4.19 Mean vigour index of delinted cotton seed as influenced by different treatments of irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	2500.80	2487.55	2470.15	2175.95	2408.61
I_2	2483.35	2396.15	2350.25	2156.55	2346.58
Mean	2492.08	2441.15	2410.20	2166.25	2377.59

	Irrigation methods	Sowing dates	Interaction
S.E. ±	36.238	51.248	72.476
C.D. at 5 per cent	N.S.	150.638	N.S.

4.3.5.1 Effect of irrigation methods

Irrigation methods did not significantly influence the value of mean vigour index of delinted cotton seed. However, the seeds obtained from the crop with drip irrigation treatments recorded higher value of mean vigour index (2408.61) as compared to the seeds obtained from the crop with surface irrigation treatments (2346.58).

4.3.5.2 Effect of sowing dates

The value of mean vigour index was found to be significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) recorded significantly higher value of mean vigour index (2492.08) than the seeds obtained from the crop sown on 1st May (S_4) (2166.25). However, it (S_1) was found to be at par with treatments S_2 and S_3. The seeds obtained from the crop sown on 1st May (S_4) recorded significantly lower value of vigour index (2166.25) than the seeds obtained from the crops sown on all other dates.

4.3.5.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean vigour index of delinted cotton seed was found to be non-significant.

4.3.6 Mean seedling dry matter of fuzzy cotton seed (mg)

Table 4.20 Mean seedling dry matter (mg) of fuzzy cotton seed as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	445.00	432.50	422.50	415.50	428.88
I_2	455.00	430.00	422.50	416.50	430.88
Mean	450.00	431.25	422.50	415.75	429.88

	Irrigation methods	Sowing dates	Interaction
S.E. ±	3.331	4.710	6.661
C.D. at 5 per cent	N.S.	13.846	N.S.

The data on mean seedling dry matter weight (mg) of fuzzy cotton seed are presented in Table 4.20. It can be seen that mean seedling dry matter weight of fuzzy cotton seed was 429.88 mg.

4.3.6.1 Effect of irrigation methods

Irrigation methods did not significantly influence the mean value of seedling dry matter weight of fuzzy cotton seed. However the seeds obtained from the crop with surface irrigation treatments recorded significantly higher value of mean seedling dry matter weight (430.88 mg) as compared to the seeds obtained from the crop with drip irrigation treatments (428.88 mg).

4.3.6.2 Effect of sowing dates

Mean value of seedling dry matter weight was significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) produced significantly higher seedling dry matter weight (450.00 mg) than the seeds obtained from the crop sown on all other dates. Treatments S_2 and S_3 were at par with each other. The seeds obtained from the crop sown on 1st May (S_4) produced significantly lower seedling dry matter weight (415.75 mg) than the seeds obtained from the crops sown on other dates except seeds obtained from the crop sown on 15th April (S_3) (422.50 mg) which was at par with it.

4.3.6.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean seedling dry matter weight of fuzzy cotton seed was found to be non-significant.

4.3.7 Mean seedling dry matter of delinted cotton seed (mg)

The data regarding the mean value of seedling dry matter weight of delinted cotton seed in mg as influenced by different treatments are presented in Table 4.21. The mean seedling dry matter weight of delinted cotton seed was 457.19 mg.

Table 4.21 Mean seedling dry matter (mg) of delinted cotton seed as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	475.00	467.50	455.00	447.60	461.13
I_2	477.50	465.00	437.50	433.00	453.25
Mean	476.25	466.25	446.25	440.60	457.19

	Irrigation methods	Sowing dates	Interaction
S.E. ±	3.691	5.220	7.383
C.D. at 5 per cent	N.S.	15.345	N.S.

4.3.7.1 Effect of irrigation methods

The irrigation methods did not significantly influence the mean seedling dry matter weight of delinted cotton seed. However, the seeds obtained from the crop with drip irrigation treatments produced higher seedling dry matter weight (461.13 mg) as compared to that of seeds obtained from the crop with surface irrigation treatments (453.25 mg).

4.3.7.2 Effect of sowing dates

The mean seedling dry matter weight of delinted cotton seed was significantly reduced as the sowing was delayed. The seeds obtained from the crop sown on 16th March (S_1) produced significantly higher seedling dry matter weight (476.25mg) than that of seeds obtained from the crops sown on other dates except that of seeds obtained from the crop sown on 1st April (S_2) (466.25 mg) which was at par with it. The seeds obtained from the crop sown on 1st May (S_4) produced significantly lower seedling dry matter weight (440.60 mg) than that of seeds obtained from the crops sown on all other dates.

4.3.7.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean seedling dry matter weight of delinted cotton seed was found to be non-significant.

4.4 Effect of irrigation methods and sowing dates on storage of delinted cotton seed

Table 4.22 Mean germination percentage after harvest (3 days of storage) as influenced by different irrigation methods and sowing dates (Delinted cotton seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	85.0 (67.27)	83.5 (66.06)	83.5 (66.06)	80.5 (63.83)	83.13 (65.81)
I_2	85.0 (67.23)	82.5 (65.30)	82.0 (64.93)	80.0 (63.45)	82.38 (65.22)
Mean	85.0 (67.25)	83.0 (65.68)	82.75 (65.49)	80.25 (63.64)	82.76 (65.51)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.405	0.572	0.809
C.D. at 5 per cent	N.S.	1.682	N.S.

* Figures in the parentheses indicate arcsin transformation

Table 4.23 Mean germination percentage at 30 days of storage as influenced by different irrigation methods and sowing dates (Delinted seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	84.5 (66.87)	83.5 (66.06)	83.0 (65.70)	80.5 (63.83)	82.88 (65.61)
I_2	84.5 (66.42)	81.5 (64.55)	81.0 (64.23)	78.5 (62.06)	81.38 (64.31)
Mean	84.5 (66.64)	82.5 (65.30)	82.0 (64.96)	79.5 (62.94)	82.13 (64.96)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.460	0.650	0.920
C.D. at 5 per cent	N.S.	1.911	N.S.

* Figures in the parentheses indicate arcsin transformation

Table 4.24 Mean germination percentage at 60 days of storage as influenced by different irrigation methods and sowing dates (Delinted seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	83.5 (66.06)	82.5 (65.32)	82.0 (64.98)	79.5 (63.14)	81.88 (64.88)
I_2	83.5 (66.04)	80.5 (63.82)	80.0 (63.51)	77.5 (61.70)	80.38 (63.77)
Mean	83.5 (66.05)	81.5 (64.57)	81.0 (64.24)	78.5 (62.42)	81.13 (64.32)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.439	0.621	0.828
C.D. at 5 per cent	N.S.	1.825	N.S.

*Figures in the parentheses indicate arcsin transformation

Table 4.25 Mean germination percentage at 90 days of storage as influenced by different irrigation methods and sowing dates (Delinted seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	83.0 (65.70)	81.0 (64.20)	80.5 (63.96)	77.0 (61.41)	80.38 (63.81)
I_2	82.0 (64.91)	79.0 (62.76)	78.5 (62.47)	76.0 (60.68)	78.88 (62.70)
Mean	82.5 (65.30)	80.0 (63.48)	79.5 (63.21)	76.5 (61.05)	79.63 (63.26)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.457	0.646	0.913
C.D. at 5 per cent	N.S.	1.898	N.S.

* Figures in the parentheses indicate arcsin transformation

Table 4.26 Mean germination percentage at 120 days of storage as influenced by different irrigation methods and sowing dates (Delinted seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	81.0 (64.20)	79.0 (62.76)	78.50 (62.51)	75.50 (60.43)	78.50 (62.47)
I_2	80.0 (63.45)	77.0 (61.37)	76.50 (61.08)	74.00 (59.35)	76.88 (61.31)
Mean	80.50 (63.82)	78.0 (62.06)	77.50 (61.80)	74.75 (59.89)	77.69 (61.89)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.597	0.845	1.194
C.D. at 5 per cent	N.S.	2.483	N.S.

*Figures in the parentheses indicate arcsin tansformation

Table 4.27 Mean germination percentage at 150 days of storage as influenced by different irrigation methods and sowing dates (Delinted seed)

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	80.5 (63.82)	78.0 (62.06)	77.5 (61.82)	74.5 (59.61)	77.63 (61.82)
I_2	79.0 (62.73)	76.0 (60.68)	75.5 (60.42)	73.0 (58.70)	75.88 (60.63)
Mean	79.75 (63.27)	77.0 (61.37)	76.5 (61.12)	73.75 (59.15)	76.76 (61.23)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.557	0.787	1.114
C.D. at 5 per cent	N.S.	2.315	N.S.

* Figures in the parentheses indicate arcsin transformation

To see the effect of irrigation methods and sowing dates on storage of cotton seed, germination test of delinted cotton seed was carried out after 3, 30, 60, 90, 120, 150 days of storage. The data pertaining to mean germination percentage of delinted cotton seed after 3, 30, 60, 90, 120, 150 days of storage are presented in Table 4.22, 4.23, 4.24, 4.25, 4.26 and 4.27 respectively. The mean germination percentage of delinted cotton seed after 3, 30, 60, 90, 120, 150 days of storage was 82.76, 82.13, 81.13, 79.63, 77.69 and 76.76 respectively. It can be seen that the mean germination percentage of delinted seed was decreased as the storage period of seeds was increased.

4.4.1 Effect of irrigation methods

From the Table 4.22, 4.23, 4.24, 4.25, 4.26 and 4.27, it can be seen that mean germination percentage was not significantly influenced by irrigation methods at any stage of storage period. However, mean germination percentage was higher due to drip irrigation treatments 83.13, 82.88, 81.88, 80.38, 78.50 and 77.63 as compared due to surface irrigation treatments 82.38, 81.38, 80.38, 78.88, 76.88 and 75.88 at 3, 30, 60,90,120 and 150 days of storage respectively.

4.4.2 Effect of sowing dates

Sowing dates significantly influenced mean germination percentage at all the 3, 30, 60, 90, 120, 150 days of storage period of seeds. It can be seen that at 3 days of storage period 16th March sowing date recorded significantly superior mean germination percentage (85.0) than the other sowing dates except 1st April sowing dates (83.0) which was at par with it. At 30 days of storage period 16th March sowing date recorded significantly superior mean germination percentage (84.5) than 1st May sowing date (79.5) while it was at par with 1st April and 15th April sowing date. At 60 days of storage period 16th March sowing date recorded significantly superior mean germination percentage (83.5) than 1st May sowing date (78.5) while it was at par with 1st April and 15th April sowing dates. At 90 days of storage period 16th March sowing date recorded significantly superior mean germination percentage (82.5) than the other sowing dates except 1st April sowing date (80.0) which was at par with it. At 120 days of storage 16th March sowing date recorded significantly superior mean germination percentage (80.50) than 1st May sowing date

(74.75) while it was at par with 1st April and 15th April sowing dates. At 150 days of storage 16th March sowing date recorded significantly superior mean germination percentage (79.75) than 1st May sowing date (73.75) while it was at par with 1st April and 15th April sowing dates.

4.4.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean germination percentage of delinted seed was not found to be significant at any stage of storage period of seeds.

4.5 Entomological aspects

4.5.1 Sucking pests

The population of sucking pests on cotton was very negligible at seedling stage and after flowering stage the attack of sucking pests to the crop was not harmful. Hence the observations on the population of sucking pests are taken only at two stages of growth viz, square formation stage and flowering stage.

4.5.1.1. White flies

4.5.1.1.1. Square formation stage

The data on average population of adults of white fly on 15 leaves of cotton plant as influenced by various treatments are presented in Table 4.28 The mean population of adults of white fly was 19.44 at square formation stage.

Table 4.28 Mean population of white flies per 15 leaves as influenced by different irrigation methods and sowing dates at square formation stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	19.00	14.75	12.25	24.75	17.69
I_2	22.25	17.25	16.25	29.00	21.19
Mean	20.63	16.00	14.25	26.88	19.44

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.676	0.955	1.351
C.D. at 5 per cent	1.986	2.809	N.S.

4.5.1.1.1.1. Effect of irrigation methods

It is clear from the Table 4.28 that the average population of white fly was significantly less on the crop with drip irrigation treatments (17.69) as compared to the crop with surface irrigation treatments (21.19).

4.5.1.1.1.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on average population of whitefly on the crop. Significantly less population of white fly was observed when the crop was sown on 15th April (S_3) (14.25) which was at par with the crop sown on 1st April (S_2) (16.00) as compared to the crop sown on other dates. The highest average population was recorded when the crop was sown on 1st May (S_4) (26.88)

4.5.1.1.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average population of white fly on the crop was found to be non-significant.

4.5.1.1.2 Flowering stage

Table 4.29 Mean population of whiteflies per 15 leaves as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	13.00	25.50	34.25	38.50	27.81
I_2	16.50	30.25	38.75	41.25	31.69
Mean	14.75	27.88	36.50	39.88	29.75

	Irrigation Methods	Sowing dates	Interaction
S.E. ±	0.813	1.150	1.627
C.D. at 5 per cent	2.391	3.381	N.S.

The data pertaining to the average population of white fly at flowering stage influenced by different irrigation methods and sowing dates are presented in Table 4.29 . The mean population of white fly was 29.75 at flowering stage of the crop.

4.5.1.1.2.1 Effect of irrigation methods

From the Table 4.29, it can be seen that the average population of whitefly was significantly less on the crop with drip irrigation treatments (27.81) as compared to the crop with surface irrigation treatments (31.69)

4.5.1.1.2.2 Effect of sowing dates

The average population of white fly was significantly influenced by different dates. The crop sown on 16 th March (S_1) recorded significantly less population of white fly (14.75) as compared to the crop sown on all other dates. The highest average population of white fly was recorded (39.88) when the crop was sown on 1st May (S_4) which was at par with the crop sown on 15 th April (S_3) (36.50).

4.5.1.1.2.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average population of white fly on the crop was found to be non-significant.

4.5.1.2 Thrips

4.5.1.2.1 Square formation stage

Table 4.30 Mean population of thrips per 15 leaves as influenced by different irrigation methods and sowing dates at square formation stage

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	8.75	6.00	2.75	13.00	7.63
I_2	14.75	5.50	7.25	19.25	12.69
Mean	11.75	7.75	5.00	16.13	10.16

	Irrigation Methods	Sowing dates	Interaction
S.E. ±	0.596	0.843	1.192
C.D. at 5 per cent	1.752	2.478	N.S.

The data pertaining to the average population of thrips on 15 leaves of cotton crop as influenced by various treatments are presented in

Table 4.30. The mean population of thrips was 10.16 at square formation stage.

4.5.1.2.1.1 Effect of irrigation methods

From the Table 4.30, it can be seen that the crop with drip irrigation treatments recorded significantly lower population (7.63) of thrips as compared with the crop with surface irrigation treatments (12.69).

4.5.1.2.1.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on average population of thrips on the crop. The crop sown on 15th April (S_3) recorded significantly lower population (5.00) of thrips as compared to the crop sown on all other dates. The crop sown on 1st May (S_4) recorded significantly highest population (16.13) of thrips on the crop at flowering stage.

4.5.1.2.1.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on average population of thrips on the crop was found to be non-significant.

4.5.1.2.2 Flowering stage

The data on average population of thrips on the crop as influenced by various treatments are presented in Table 4.31. The mean population of thrips was 15.59 at flowering stage.

Table 4.31 Mean population of thrips per 15 leaves as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	3.75	12.75	14.50	19.50	12.63
I_2	7.00	19.00	22.25	26.00	18.56
Mean	5.38	15.88	18.38	22.75	15.59

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.700	0.990	1.400
C.D. at 5 per cent	2.058	2.910	N.S.

4.5.1.2.2.1 Effect of irrigation methods

From Table 4.31, it is clear that the average population of thrips was significantly less on the crop with drip irrigation treatments (12.63) as compared to the crop with surface irrigation treatments. (18.56).

4.5.1.2.2.2 Effect of sowing dates

The average population of thrips on the crop at flowering stage was significantly influenced by sowing dates. Significantly less population of thrips was observed when the crop was sown on 16th March (S_1) (5.38) than the crop sown on all other dates. The treatments S_2 and S_3 were found to be on par with each other. The highest average population was observed when the crop was sown on 1st May (S_4) (22.75).

4.5.1.2.2.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on the average population of thrips at flowering stage was found to be non-significant.

4.5.1.3 Jassids

4.5.1.3.1 Square formation stage

Table 4.32 Mean population of Jassids per 15 leaves as influenced by different irrigation methods and sowing dates at square formation stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	20.00	19.25	16.25	23.75	19.81
I_2	28.50	25.25	21.00	33.00	26.94
Mean	24.25	22.25	18.63	28.38	23.38

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.902	1.275	1.804
C.D. at 5 per cent	2.651	3.749	N.S.

The data on average population of jassids on 15 leaves of the crop as influenced by various treatments are presented in Table 4.32. The mean population of jassids was 23.38 at square formation stage.

4.5.1.3.1.1 Effect of irrigation methods

The crop with drip irrigation treatments recorded significantly less population of jassids (19.81) than the crop with surface irrigation treatments (26.94).

4.5.1.3.1.2 Effect of sowing dates

The average population of jassids was significantly influenced by the effect of sowing dates. The crop sown on 15th April (S_3) recorded significantly lower population of jassids (18.63) than the crop sown on other dates except the crop sown on 1st April (S_2) (22.25) which was at par with it. Similarly treatment S_1 and S_2 are at par with each other. However the crop sown on 1st May (S_4) recorded significantly highest population of jassids (28.38) than the crop sown on all other dates.

4.5.1.3.1.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on average population of jassids at square formation stage was found to be non-significant.

4.5.1.3.2 Flowering stage

The data on average population of jassids on the crop as influenced by various treatments at flowering stage are presented in Table 4.33. The mean population of jassids on the crop was found 35.91.

Table 4.33 Mean population of jassids per 15 leaves as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	18.75	32.25	34.75	40.75	31.63
I_2	25.50	41.50	44.50	49.25	40.19
Mean	22.13	36.88	39.63	45.00	35.91

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.972	1.375	1.945
C.D. at 5 per cent	2.858	4.042	N.S.

4.5.1.3.2.1 Effect of irrigation methods

From the Table 4.33, it can be seen that the average population of jassids was significantly lower on the crop with drip irrigation treatments (31.63) as compared to the crop with surface irrigation treatments (40.19).

4.5.1.3.2.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on average population of jassids on the crop at flowering stage. The crop sown on 16th March (S_1) recorded significantly lower population of jassids (22.13) than the crop sown on all other dates. While the treatments S_2 and S_3 were found to be at par with each other. The crop sown on 1st May (S_4) recorded significantly highest population of jassids (45.00).

4.5.1.3.2.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on average population of jassids at flowering stage was found to be non-significant.

4.5.1.4 Aphids

4.5.1.4.1 Square formation stage

The data on average population of aphids of 15 leaves as influenced by various treatments at square formation stage are presented in Table 4.34. The mean population of aphids was 90.84.

Table 4.34 Mean population of aphids per 15 leaves as influenced by different irrigation methods and sowing dates at square formation stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	73.25	69.25	59.75	78.75	70.25
I_2	117.25	105.25	100.75	122.50	111.44
Mean	95.25	87.25	80.25	100.63	90.84

	Irrigation methods	Sowing dates	Interaction
S.E. ±	1.755	2.481	3.509
C.D. at 5 per cent	5.157	7.294	9.944

4.5.1.4.1.1 Effect of irrigation methods

From Table 4.34, it can be seen that the crop with drip irrigation treatments recorded significantly lower population of aphids (70.25) at square formation stage as compared to the crop with surface irrigation treatments (111.44).

4.5.1.4.1.2 Effect of sowing dates

The average population of aphids was significantly influenced by the effect of different sowing dates. The crop sown on 15th April (S_3) recorded significantly lower population of aphids (80.25) than the crop sown on other dates except the crop sown on 1st April (S_2) (87.25) which was at par with it. The crop sown on 1st May (S_4) recorded significantly higher population of aphids (100.63) than the crop sown on other dates except the crop sown on 16th March (S_1) (95.25) which was at par with it.

4.5.1.4.1.3 Effect of interaction

The effect of interaction between irrigation methods and sowing dates on average population of aphids at square formation stage was found to be non-significant.

4.5.1.4.2 Flowering stage

Table 4.35 Mean population of Aphids per 15 leaves as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	63.75	122.00	140.25	149.00	118.75
I_2	101.75	135.00	172.75	179.75	147.31
Mean	82.75	128.50	156.50	164.38	133.03

	Irrigation methods	Sowing dates	Interaction
S.E. ±	2.297	3.248	4.594
C.D. at 5 per cent	6.751	9.548	N.S.

The data pertaining to the average population of aphids on the crop at flowering stage are presented in Table 4.35. The mean population of aphids found was 133.03.

4.5.1.4.2.1 Effect of irrigation methods

From Table 4.35, it can be seen that the average population aphids on the crop with drip irrigation treatments was significantly lower (118.75) than the crop with surface irrigation treatments (147.31).

4.5.1.4.2.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on average population of aphids on the crop at flowering stage. The crop sown on 16th March (S_1) recorded significantly lower population of aphids (82.75) than the crop sown on all other dates. Significantly higher population of aphids was recorded when the crop was sown on 1st May (S_4) (164.38) which was at par with the crop sown on 15th April (S_3) (156.5).

4.5.1.4.2.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average population of aphids was found to be non-significant at flowering stage.

4.5.2 Bollworm incidence

To determine the attack of bollworm complex on the crop during its growth period. The percentage of damaged bolls and loculi due to the bollworm infection were taken into consideration.

4.5.2.1 Average percentage of damaged bolls due to bollworm attack

The comparative infestation of bollworms as influenced by various treatment was recorded by the actual counting of infested bolls on the plant. The data on average percentage of damaged bolls due to bollworms as influenced by various treatments are presented in Table 4.36. The mean average percentage of damaged bolls was 35.19.

Table 4.36 Average percentage of damaged bolls due to bollworm attack as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	22.25 (26.93)	28.75 (32.62)	35.00 (36.62)	40.00 (39.55)	31.50 (33.93)
I_2	28.75 (32.55)	37.25 (37.81)	42.00 (40.70)	47.50 (43.83)	38.88 (38.72)
Mean	25.50 (29.74)	33.00 (35.21)	38.50 (38.66)	43.75 (41.69)	35.19 (36.33)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.639	0.904	1.278
C.D. at 5 per cent	1.878	2.656	N.S.

* Figures in parentheses indicate arcsin transformation.

4.5.2.1.1 Effect of irrigation methods

From the Table 4.36, it can be seen that the average percentage of damaged bolls due to bollworms was significantly less in crop with drip irrigation treatments (31.50) as compared to the crop with surface irrigation treatment (38.88).

4.5.2.1.2 Effect of sowing dates

Significant differences were observed in respect of effect of sowing dates on average percentage of damaged bolls due to bollworms. The average percentage of damaged bolls due to bollworm attack was significantly reduced when the crop was sown 16^{th} March (S_1) (25.50) as compared to the crop sown on all other dates. It can be seen that percentage of damaged bolls was increased as the sowing was delayed.

However, the crop sown on 1st May (S_4) recorded significantly highest percentage of damaged bolls due to bollworm attack (43.75).

4.5.2.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on average percentage of damaged bolls due to bollworm attack was found to be non significant.

4.5.2.2 Average percentage of damaged loculi due to bollworm attack

Table 4. 37 Average percentage of damaged loculi due to bollworm attack as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	12.75 (21.36)	17.25 (24.88)	19.25 (26.37)	24.75 (30.05)	18.50 (25.66)
I_2	15.50 (23.62)	21.00 (27.66)	23.75 (29.56)	28.75 (32.60)	22.25 (28.36)
Mean	14.13 (22.49)	19.13 (26.27)	21.50 (27.97)	26.75 (31.33)	20.38 (27.01)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.595	0.842	1.191
C.D. at 5 per cent	1.750	2.475	N.S.

*Figures in parentheses indicate arcsin transformation.

The comparative infestations of bollworms as influenced by various treatments was recorded by the actual counting of infested loculi of bolls on the plant. The data pertaining to the average percentage of damaged loculi due to bollworm attack as influenced by irrigation methods and sowing dates are presented in Table 4.37. The average percentage of damaged loculi due to bollworm attack was 20.38.

4.5.2.2.1 Effect of irrigation methods

It can be seen from the Table 4.37 that the crop with drip irrigation treatments recorded significantly lower average percentage of damaged loculi (18.50) due to bollworm attack as compared to the crop with surface irrigation treatments (22.25).

4.5.2.2.2 Effect of sowing dates

The average percentage of damaged loculi due to bollworm attack was significantly influenced by the effect of sowing dates. The crop sown on 16th March (S_1) recorded significantly lower average percentage of damaged loculi (14.13) due to bollworm attack than the crop sown on all other dates. Treatments S_2 and S_3 were at par with each other. The crop sown on 1st May (S_4) recorded significantly highest average percentage of damaged loculi (26.75) due to bollworm attack.

4.5.2.2.3 Effect of interaction

The effect of interaction between irrigation methods and sowing dates on average percentage of damaged loculi due to bollworm attack was found to be non-significant.

4.6 Pathological aspects

4.6.1 Bacterial leaf blight

All the trial plots were observed for bacterial leaf blight disease incidence. But all they were found to be free from the incidence of bacterial leaf blight disease at seedling, square formation, flowering, boll development and boll bursting stages.

4.6.2 *Alternaria* leaf blight

The data on disease index of *Alternaria* leaf spot as influenced by various treatments were recorded at flowering, boll development and boll bursting stage. All the trial plots were free from *Alternaria* leaf spot incidence at seedling and square formation stage.

4.6.2.1 Flowering stage

Table 4.38 Mean disease index of *Alternaria* leaf spot as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	13.91	14.52	15.95	18.17	15.63
I_2	16.59	15.77	17.75	19.38	17.37
Mean	15.25	15.14	16.85	18.77	16.50

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.392	0.555	0.785
C.D. at 5 per cent	1.153	1.631	N.S.

The data on mean disease index of *Alternaria* leaf spot as influenced by different irrigation methods and sowing dates at flowering stage are presented in Table 4.38. The mean disease index of *Alternaria* leaf spot was 16.50.

4.6.2.1.1 Effect of irrigation methods

From the Table 4.38, it can be seen that the crop with drip irrigation treatments recorded significantly less mean disease index (15.63) when compared with the crop with surface irrigation treatments (17.37).

4.6.2.1.2 Effect of sowing dates

The mean disease index of *Alternaria* leaf spot was significantly influenced by different sowing dates. The crop sown on 1st April (S_2) recorded significantly less mean disease index of *Alternaria* leaf spot (15.14) than the crop spot sown on other dates except the crop sown on 16th March (S_1) which was at par with it (15.25). The treatments S_1 and S_3 were at par with each other. The crop sown on 1st May (S_4) recorded significantly higher mean disease index (18.77) of *Alternaria* leaf spot.

4.6.2.1.3 Effect of interaction

The interaction effect between irrigation methods and sowing dates on mean disease index of *Alternaria* leaf spot was found to be non significant at flowering stage.

4.6.2.2 Boll development stage

The data pertaining to mean disease index of *Alternaria* leaf spot influenced by various treatments at boll development stage are presented in Table 4.39. The mean disease index of *Alternaria* leaf spot was 26.49.

Table 4.39 Mean disease index of *Alternaria* leaf spot as influenced by different irrigation methods and sowing dates at boll development stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	22.17	24.22	25.48	28.41	25.07
I_2	24.92	26.30	28.15	32.25	27.90
Mean	23.54	25.26	26.81	30.33	26.49

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.473	0.669	0.946
C.D. at 5 per cent	1.391	1.966	N.S.

4.6.2.2.1 Effect of irrigation methods

It is clear from the Table 4.39 that the crop with drip irrigation treatments recorded significantly less disease index (25.07) as compared to the crop with surface irrigation treatments (27.90) at boll development stage.

4.6.2.2.2 Effect of sowing dates

Significant differences were observed due to the effect of sowing dates on disease index of *Alternaria* leaf spot at boll development stage. The crop sown on 16th March (S_1) recorded significantly less disease index (23.54) of *Alternaria* leaf spot than the crop sown on other dates except the crop sown on 1st April (S_2) (25.26) which was at par with it. Treatments S_2 and S_3 are at par with each other. However significantly highest mean disease index (30.33) of *Alternaria* leaf spot was observed when the crop was sown on 1st May (S_4).

4.6.2.2.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on the mean disease index of *Alternaria* leaf spot at boll development stage was found to be non-significant.

4.6.2.3 Boll bursting stage

The data on mean disease index of *Alternaria* leaf spot influenced by various treatments at boll bursting stage are presented in Table 4.40. The mean disease index of *Alternaria* leaf spot was 33.92.

Table 4.40 Mean disease index of *Alternaria* leaf spot influenced by different irrigation methods and sowing dates at boll bursting stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	31.00	31.94	32.96	36.60	33.12
I_2	32.42	33.17	35.57	37.69	34.71
Mean	31.71	32.55	34.27	37.15	33.92

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.438	0.620	0.877
C.D. at 5 per cent	1.289	1.823	N.S.

4.6.2.3.1 Effect of irrigation methods

From the Table 4.40, it is clear that the crop with drip irrigation treatments recorded significantly less mean disease index of *Alternaria* leaf spot (33.12) as compared to the crop with surface irrigation treatments (34.71).

4.6.2.3.2 Effect of sowing dates

The mean disease index of *Alternaria* leaf spot was significantly affected by the effect of different sowing dates at boll bursting stage. The crop sown on 16th March (S_1) recorded significantly less mean disease index (31.71) of *Alternaria* leaf spot than the crop sown on other dates except the crop sown on 1st April (S_2) (32.55) which was at par with it. Similarly treatments S_2 and S_3 were at par with each other. The crop sown on 1st May (S_4) recorded significantly higher mean disease index of *Alternaria* leaf spot (37.15).

4.6.2.3.3 Effect of interaction

The effect of interaction between irrigation methods and sowing dates on the mean disease index of *Alternaria* leaf blight at boll bursting stage was found to be non-significant.

4.6.3 Red leaf blight at flowering stage

Table 4.41 Mean disease index of Red leaf blight as influenced by different irrigation methods and sowing dates at flowering stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	20.41	23.37	25.07	25.61	23.62
I_2	21.94	24.34	26.01	26.07	24.59
Mean	21.18	23.85	25.54	25.84	24.10

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.506	0.715	1.011
C.D. at 5 per cent	N.S.	2.102	N.S.

The data on mean disease index of red leaf blight as influenced by different irrigation methods and sowing dates were recorded at flowering stage and are presented in Table 4.41. The mean disease index of red leaf blight at flowering stage was 24.10.

4.6.3.1 Effect of irrigation methods

Irrigation methods did not significantly influence the mean disease index of red leaf blight. However the crop with drip irrigation treatments recorded significantly lower mean disease index (23.62) of red leaf blight as compared to the crop with surface irrigation treatments (24.59) at flowering stage.

4.6.3.2 Effect of sowing dates

Sowing dates significantly influenced the mean disease index of red leaf blight at flowering stage. The crop sown on 16th March recorded significantly lower value of mean disease index (21.18) than that of crops sown on all other dates. Treatments S_2, S_3 and S_4 were at par with each other. The crop sown on 1st May (S_4) recorded significantly higher mean disease index (25.84) than the crops sown on all other dates except sown on 1st April and 15th April which were at par with it.

4.6.3.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean disease index of red leaf blight at flowering stage was found to be non-significant.

4.6.4 Grey mildew

The data on the mean disease index of grey mildew as influenced by different irrigation methods and sowing dates were recorded at boll development stage and boll bursting stage. All the trial plots were free from grey mildew incidence at seedling, square formation and flowering stage.

4.6.4.1 Boll development stage

Table 4.42 Mean disease index of Grey mildew as influenced by different irrigation methods and sowing dates at boll development stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	9.87	12.30	16.06	16.19	13.60
I_2	10.77	15.14	18.41	18.87	15.80
Mean	10.32	13.72	17.23	17.52	14.70

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.381	0.538	0.761
C.D. at 5 per cent	1.119	1.582	N.S.

The data pertaining to mean disease index of grey mildew influenced by various treatments boll development stage are presented in Table 4.42. The mean disease index was 14.70.

4.6.4.1.1 Effect of irrigation methods

From the Table 4.42, it can be seen that the disease index of grey mildew was significantly lower in the crop with drip irrigation treatments (13.60) as compared to the crop with surface irrigation treatments (15.80).

4.6.4.1.2 Effect of sowing dates

It can be seen from the Table 4.42 that the mean disease index of grey mildew was significantly influenced by the effect of different sowing dates. The crop sown on 16th March (S_1) recorded significantly less mean disease index of grey mildew (10.32) than the crop sown on all other dates. The crop sown on 1st May (S_4) recorded significantly higher mean disease index of grey mildew (17.52) than the crop sown on all other dates except the crop sown on 15th April (S_3) (17.23) which was at par with it.

4.6.4.1.3 Effect of interaction

The effect of interaction between irrigation methods and sowing dates on mean disease index of grey mildew at boll development stage was found to be non-significant.

4.6.4.2 Boll bursting stage

Table 4.43 Mean disease index of Grey mildew as influenced by different irrigation methods and sowing dates at boll bursting stage.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	16.35	18.23	21.95	24.40	20.23
I_2	19.73	24.19	25.82	29.03	24.69
Mean	18.04	21.21	23.89	26.71	22.46

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.259	0.367	0.519
C.D. at 5 per cent	0.762	1.078	N.S.

The data pertaining to mean disease index of grey mildew influenced by different treatments at boll bursting stage are presented in Table 4.43. The mean disease index was 22.46.

4.6.4.2.1 Effect of irrigation methods

From the Table 4.43, it can be seen that the mean disease index of grey mildew at boll bursting stage was significantly lower in the crop with drip irrigation treatment (20.23) as compared to the crop with surface irrigation treatment (24.69).

4.6.4.2.2 Effect of sowing dates

Mean disease index of grey mildew at boll bursting stage was significantly influenced by different sowing dates. The crop sown on 16th March (S_1) recorded significantly less mean disease index (18.04) than the crops sown on all other dates. While the crop sown on 1st May (S_4) recorded significantly higher mean disease index of grey mildew (26.71) than that of crops sown on all other dates.

4.6.4.2.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean disease index of grey mildew at boll bursting stage was found to be non-significant.

4.6.5 Boll rot percentage at harvest

The data on mean boll rot percentage at harvest as influenced by different irrigation methods and sowing dates are presented in Table 4.44. The mean percentage of boll rot at harvest was 6.98.

Table 4.44 Mean boll rot percentage at harvest as influenced by different irrigation methods and sowing dates.

Irrigation methods	Sowing dates				Mean
	S_1	S_2	S_3	S_4	
I_1	3.90 (11.41)	4.82 (12.69)	5.60 (13.68)	7.94 (16.35)	5.56 (13.53)
I_2	6.50 (14.76)	7.33 (15.70)	9.04 (17.50)	10.75 (19.13)	8.40 (16.77)
Mean	5.20 (13.08)	6.07 (14.19)	7.32 (15.59)	9.34 (17.74)	6.98 (16.77)

	Irrigation methods	Sowing dates	Interaction
S.E. ±	0.201	0.285	0.403
C.D. at 5 per cent	0.592	0.837	N.S.

*Figures in parentheses indicate arcsin transformation.

4.6.5.1 Effect of irrigation methods

From the Table 4.44, it can be seen that mean percentage of boll rot was found to be significantly lower in the crop with drip irrigation treatment (5.56) as compared to the crop with surface irrigation treatments (8.40).

4.6.5.2 Effect of sowing dates

Sowing dates significantly influenced the mean percentage of boll rot at harvest. The crop sown on 16th March (S_1) recorded significantly lower mean percentage of boll rot (5.20) than that of crops sown on all other dates. While the crop sown on 1st May (S_4) recorded significantly higher mean percentage of boll rot (9.34) than that of crops sown on all other dates.

4.6.5.3 Effect of interaction

Interaction effect between irrigation methods and sowing dates on mean percentage of boll rot at harvest was found to be non – significant.

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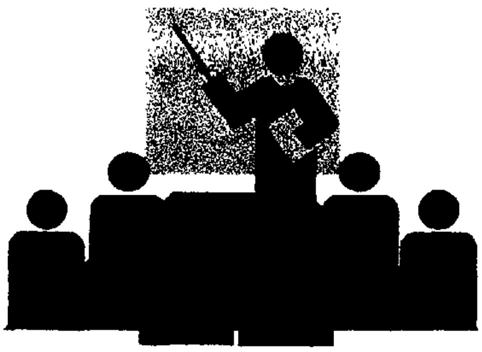


DISCUSSION

5. DISCUSSION

Cotton (*Gossypium* spp L.) is one of the most important fibre cash crops of India. Though most of the crop is grown as rainfed, in certain pockets of irrigation command, the crop is cultivated during summer to realise high yields. A field experiment with a view to study the "Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton seed production" was conducted during summer 2000.

The findings of the investigation reported in the previous chapter are discussed in this chapter under the following heads.

5.1 Irrigation studies

5.2 Effect of irrigation methods on the growth, yield, quality, germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

5.3 Effect of sowing dates on the growth, yield, quality, germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

5.4 Effect of interaction on the growth, yield, quality, germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

5.1 Irrigation studies

5.1.1 Soil of the experimental field

The soil of the experimental plot was clay loam in texture. The soil was medium deep and bulk density of soil was 1.33 g/cm^3. The field capacity and permanent wilting point were 38.6 and 20.03 per cent on w/w basis respectively.

5.1.2 Irrigation water management studies

Water being important parameter in crop production demand of water is increasing day by day. However, in Maharashtra due to limited irrigation the available water must be economically and judiciously utilized for crop production. Traditional furrow irrigation is water intensive method. The adoption of efficient irrigation method is one of the possible ways to improve the situation. Drip (trickle) irrigation system appears to be an important system to use water economically. Several workers through their studies have reported saving in water due to drip irrigation method as compared to traditional method of irrigation (Shanmugham *et al.* 1976; Wilson *et al.* 1984).

5.1.3 Irrigation water applied

In the present studies for surface irrigation total of 1400, 1260, 1190 and 910 mm water was applied through 20, 19, 17 and 13 irrigations for the crop sown on 16th March (S_1), 1st April (S_2), 15th April (S_3) and 1st May (S_4) respectively. As against this, only 633.27, 616.85, 557.98 and 504.32 mm water was applied through drip irrigation treatment for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. Thus there was water saving of 54.51, 51.55, 52.24 and 46.66 per cent in drip irrigation treatments as compared to surface irrigation treatments. Similar results were reported by Magar and Sonawane (1987) and Anonymous (1997-98 a). The reduction in water applied was mainly due to application to limited wetted area. The calculations for estimating effective rainfall (ER) showed that ER was 213.40, 230.20, 249.10 and 296.30 mm in surface irrigation compared with 100.80, 105.10, 129.30 and 139.10 mm in drip irrigation for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. In drip irrigation alternate day water was applied, resulting in less ER.

The computation of seasonal water need showed that for surface irrigation it was 1613.40, 1490.20, 1439.10 and 1206.30 mm and for drip irrigation it was 734.07, 721.95, 687.28 and 643.42 mm which amounts to 54.51, 51.55, 52.24 and 46.66 per cent saving for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. Thus, it is possible to almost double the area under assured water supply through drip irrigation. Several workers have also indicated this possibility (Shanmugham *et al.* 1976; and Magar and Sonawane, 1987).

5.1.4 Water balance studies

Moisture use pattern based on soil moisture depletion showed that in surface irrigation, about 1076.56, 1048.65, 948.57 and 857.34 mm water was estimated to have depleted as against 633.27, 616.85, 557.98 and 504.32 mm in drip irrigation for the crop sown on 16th March, 1st April, 15th April and 1st May respectively. This showed that higher application of water and percolation beyond the root zone added to the higher depletion. In the case of drip irrigation, a limited water application helped to conserve water. Besides water was actually delivered to root zone reducing the losses during the transit. Thus the water depleted was nearly equal to water applied.

5.1.5 Water use efficiency

Water use efficiency is the number of marketable units produced per unit of water used. Thus, yield obtained and the water saving have very close relation with water use efficiency.

Because of adequate and continuous water supply, the plant growth was favoured in the drip irrigation treatments. Number of flowers available for emasculation and pollination (Table 4.6), number of bolls harvested per plant (Table 4.9), seed cotton yield per plant (Table 4.11 a), seed yield per plant (Table 4.13 a) were favourably affected due to drip irrigation. This resulted in higher yield in drip irrigation. Thus, increase in the yield over the surface irrigation method and reduction in water used resulted in higher water use efficiency.

Better growth was due to no stress of water available situation due to alternate day application of water. The water uptake by plant is related to energy concept. Due to continuous non stressed condition, plants could take up water without much expenditure of energy. This ultimately improved WUE which was almost two times in case of drip irrigation treatments (Table 4.1).

5.1.6 Average discharge and emission uniformity of drip irrigation system

Uniform application of water is very important for growth and development of crop. Therefore, it is necessary to study the emission uniformity of the system. Karmelli and Keller (1976) suggested that EU as the design criteria should be around 90 per cent for practical purpose. Examined on this background the emission uniformity (EU) recorded in all the drip irrigation treatment was more than 90 per cent which was excellent. The average discharge calculated was 7.71 lph at 1 Kg/cm^2 pressure in drip irrigation system (Table 4.2).

5.2 Effect of irrigation methods on the growth, yield, quality and germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

Regarding the growth of the crop, it was revealed from the data (Table 4.3, 4.4 and 4.8) that drip irrigation treatments required significantly more number of days for first square formation, flowering initiation and boll opening after pollination as compared to the surface irrigation treatments. This led to delay in maturity in drip irrigation treatments due to delayed nitrogen fertilizer uptake. Similar results were reported by Constable and Hodgson (1990). Mean flowering period

(Table 4.5) was not significantly influenced by drip or surface irrigation treatments.

Mean number of flowers available for emasculation and pollination was significantly more in drip irrigation treatments as compared to surface irrigation treatment (Table 4.6). This may be due to more number of squares produced due to better vegetative growth which result in more number of flower production in drip irrigation treatments. This might be due to better soil air water equilibrium condition in drip irrigated plots. Also optimum moisture level near to field capacity allowed plants to take nutrient at uniform rates in drip irrigation plots as compared to surface irrigation plots.

Mean percentage of boll setting was significantly higher in drip irrigated treatments as compared to surface irrigated treatments (Table 4.7). This may be due to less shedding of crossed flowers, bolls in drip irrigation treatments as compared to surface irrigation treatments. Because there is less attack of bollwoms also boll rot percentage is less in drip irrigation treatments. Also the harmful effect of soil moisture stress is less in drip irrigation treatments as compared to surface irrigation treatments. These all factors led to higher percentage of boll set in drip irrigation treatments.

Number of bolls harvested per plant was significantly higher in drip irrigation treatment as compared to surface irrigation treatments

(Table 4.9) similar results were reported by Padmakumari and Sivanappan (1979). This higher number of bolls per plant was due to higher number of flower production and higher percentage of boll setting in drip irrigation plots as compared to surface irrigation treatments.

Mean boll weight was significantly higher in drip irrigation treatments as compared to surface irrigation treatments (Table 4.10) because in drip irrigation treatments optimum moisture level near to field capacity allowed plants to take nutrients at uniform rates, also there is better soil air water equilibrium condition which favoured vigourous and healthy growth of the crop. Also less incidence of sucking pests and diseases favoured the crop growth in drip irrigation treatments which resulted higher boll weight as compared to the surface irrigation treatments.

Mean seed cotton yield per plant, per plot and per hectare was significantly higher in drip irrigation treatments as compared to surface irrigation treatments (Table 4.11 a, b and c). It can be seen that drip irrigation system increased mean seed cotton yield per hectare by 13.55 per cent compared with conventional method. Similar results were reported by Padmakumari and Sivanappan (1979) , Magar and Sonawane (1987) and Mateos *et al.* (1991). This increased yield in drip irrigation treatments was mainly due to higher number of bolls harvested and higher mean boll weight as compared to surface irrigation treatments.

Mean seed weight per boll was significantly higher in drip irrigation treatments as compared to surface irrigation treatments (Table 4.12). This was mainly due to higher boll weight which was resulted due to healthy and vigourous growth of crop in drip irrigation treatment as compared to surface irrigation treatments.

Mean seed yield per plant, per plot and per hectare was significantly higher in drip irrigation treatment as compared to surface irrigation treatments (Table 4.13 a, b and c). This higher mean seed yield in drip irrigation treatment was mainly due to the higher number of bolls harvested and higher mean seed weight in drip irrigation treatments as compared to conventional method of irrigation.

Mean ginning percentage was not significantly affected by irrigation methods. Mean seed index was significantly higher in drip irrigation treatments as compared to surface irrigation treatment (Table 4.15). This higher mean seed index in drip irrigation treatment was mainly due to big sized and heavier seeds as compared to small and lighter seeds obtained in surface irrigation treatments.

Germination percentage, vigour index, and seedling dry matter of seeds stored for 120 days obtained from 2nd picking of crop was not significantly influenced by irrigation method treatments.

To see the effect of sowing dates and irrigation methods on the storage of seeds only delinted seeds were germinated. It can be seen that the mean germination percentage of the delinted seeds was decreased from 82.76 to 76.76 as the storage period was increased from 3 days to 150 days. Irrigation methods did not significantly influence the germination percentage of delinted seed at any of the stage of storage period of seeds. However, drip irrigation treatments recorded comparatively better germination percentage as compared to surface irrigation treatments. This might be due to that drip irrigation treatments produced more healthy seeds as the insect, disease damage was less as compared to the surface irrigation treatments.

Regarding the sucking pests of cotton during the crop growth at seedling stage, the population of them was very negligible and after flowering stage the attack of these sucking pests to the crop was not harmful, hence the population of these pests were recorded only at square formation stage and flowering stage.

It can be seen that the mean population of whiteflies, thrips, jassids and aphids was significantly less in drip irrigation treatments as compared to surface irrigation treatments at both square formation and flowering stage. In case of whiteflies Flint *et al.* (1995) recorded the similar observations. This might be due to that in drip irrigation treatments weed intensity was less as compared to surface irrigation treatments. Weeds are the host and place for egg laying of insects. Due to drip irrigation optimum soil moisture in the field plot was maintained. While in case of surface irrigation treatments due to flooding of irrigation water excess soil moisture developed in the field plot which is favourable for increasing the population of sucking pests as compared to drip irrigation treatments.

In case of bollworm infestation it can be seen that the mean percentage of damaged bolls and loculi due to bollworm attack was significantly less in drip irrigation treatments as compared to surface irrigation treatments. This might be due to that in surface irrigation treatments there is flooding of water and when infested bolls fall on the ground the eggs of these pests are carried from one place to another with flooding water, which does not happen in case of drip irrigation treatments because water is not flooded and is given in optimum quantity with the drippers at the root zone of plants. And due to egg transfer in surface irrigated plots the intensity of bollworms population increased due to which percentage of damaged bolls and loculi was more in surface irrigation treatments as compared to drip irrigation treatments.

Regarding the diseases of cotton, Bacterial leaf blight was not found at any stage of the growth of the crop. While the disease index of alternaria leaf spot, grey mildew and per cent age of boll rot was found minimum in drip irrigation treatments as compared to surface irrigation treatments at the respective growth stages of cotton. This might be due to that in surface irrigation due to the flooding of water the spores of microorganisms responsible for the disease were carried from one place to another due to which there was more intensity of disease in surface irrigation treatments. While in case of drip irrigation the water is not flooded from one place to another and is given in optimum quantity at the root zone of the crop hence disease was not spread in drip irrigation treatment as compared to surface irrigation treatment.

5.3 Effect of sowing dates on the growth, yield, quality and germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

Among the improved practices sowing time has a predominating effect on cotton cultivation because weather conditions during different stages of growth and maturity vary according to the time of planting. It was revealed from the data (Table 4.3, 4.4 and 4.8) that number of days required for first square formation, flowering initiation and boll opening after pollination was significantly reduced as the sowing was delayed from 16th March to 1st May. Similar result were reported by Eid *et al.* (1993). The seeds sown on 1st May required less number of days for first square formation and flowering intiation. This might be probably due to relatively higher atmospheric temperature during this period. As the sowing was delayed from 16th March the atmospheric temperature during the crop growth period was increased which resulted in less number of days required for first square formation and flower initiation.

Mean flowering period was not affected significantly by different sowing dates. Mean number of flowers available for emasculation and pollination was significantly reduced as the sowing was delayed (Table 4.6) 16th March sowing produced maximum number of flowers available for emasculation and pollination as compared to later dates of sowing. This might be due to that the early sown crop produced better growth and taller plants and long duration available to the crop in 16th March sowing favoured for more number of square production which resulted in more number of flowers available for emasculation and pollination. Misra and Malik (1979) reported that early sowing produced higher number of flowers per plant than that of later sowing.

Mean percentage of boll setting was significantly reduced as the sowing was delayed (Table 4.7). Misra and Malik (1979) reported similar results. The crop sown on 16th March recorded the highest percentage of boll setting as compared to later sowing dates. This more percentage of boll setting with early sowing dates was due to higher number of flowers emasculated and pollinated with earlier sowing dates and also there was less attack of bollworms and less boll rot percentage which resulted in higher boll setting percentage in earlier sowing dates as compared to later sowing dates.

Mean number of bolls harvested per plant was significantly reduced as the sowing was delayed (Table 4.9). The crop sown on 16th

March produced highest number of bolls for harvest per plant as compared to the crops sown on later dates. Crop with earlier sowing was helped in completion of their life period in comparatively more favourable environment. These results are collaborative with the findings of Singh *et al.* (1969). Also the crops with earlier sowing dates had taller plants and more vigourous and healthy growth due to longer duration available which produced more squares and thereby more flowers available for emasculation and pollination. Also the boll setting percentage was higher with earlier sowing dates which totally resulted in maximum number of bolls harvested per plant with earlier sowing dates as compared to later sowing dates.

Mean boll weight was significantly reduced as the sowing was delayed (Table 4.10). Similar results were reported by Malik and Malik (1986)and Shalaby *et al.* (1989). The crop sown on 16th March recorded significantly higher boll weight than the crops sown on later dates. This higher boll weight with earlier sowing dates might be due to the vigourous and healthy growth of the crop than the crop with later sowing dates.

Mean seed cotton yield per plant, per plot and per hectare was significantly reduced as the sowing was delayed (Table 4.11 a, b and c). The crop sown on 16th March produced the highest seed cotton yield as compared to later sowing dates. 16th March sowing produced 21.1, 46.3 and 88.2 per cent higher seed cotton yield per hectare than 1st April, 15th

April and 1st May sowing respectively which was mainly due to higher plant height, more number of flowers per plant, more number of bolls per plant and higher boll weight. The results confirm the findings of Shrivastava *et al.* (1982), Karim *et al.* (1983) and Sarma *et al.* (1997).

Mean seed weight per boll was significantly reduced as the sowing was delayed (Table 4.12). The crop sown on 16th March recorded the highest mean seed weight than the crops sown on later dates. This might be due to more number of seeds per boll. The results confirm the findings of Singh and Warsi (1985).

Mean seed yield per plant, per plot and per hectare was significantly reduced as the sowing was delayed (Table 4.13 a, b and c). The crop sown on 16th March (S_1) recorded significantly highest seed yield than the crops sown on later dates. This increased yield with earlier sowing dates might be due to higher number of bolls per plant, more number of seeds per boll and higher seed weight per boll with earlier sowing dates.

Ginning percentage was not significantly affected by sowing dates. Mean seed index was significantly reduced as the sowing was delayed. (Table 4.15) The crop sown on 16th March recorded the highest mean seed index. Agarwal (1984) found that hundred seed weight was decreased as the sowing was delayed in case of lentil. This higher mean seed index with earlier sowing dates was due to big sized and heavier seeds with earlier sowing dates as compared to smaller and lighter seeds obtained with later sowing dates.

Germination percentage vigour index, seedling dry matter of both fuzzy and delinted seeds stored for 120 days which were obtained from 2nd picking of the crop were significantly reduced as the sowing was delayed. Grewal *et al.* (1973) found that germination percentage declined gradually with delay in sowing. Harper and Obied (1967) reported that dry matter content in seedlings was declined as the sowing was delayed in case of oilseeds. Seeds obtained from crop sown on 16th March recorded significantly higher values of germination percentage, vigour index and seedling dry matter as compared to later sowing dates. Because during the growth period of the crop sown on earlier dates, there was minimum attack of pests and diseases and the crop favoured with good environmental conditions than that of sown later. Hence seeds obtained from the crop sown earlier were more healthy and better than the seeds obtained from the crop sown later. Hence the seeds produced in earlier sowing dates recorded higher values of germination percentage, vigour index and seedling dry matter.

Also it can be seen that the delinted seed recorded the higher value of germination percentage, vigour index and seedling dry matter than that of fuzzy seeds.

To see the effect of sowing dates on the storage of seeds only delinted seeds were germinated. It can be seen that mean germination percentage of the delinted seeds was decreased from 82.76 to 76.76 as the storage period was increased from 3 days to 150 days. Sowing dates significantly influenced the germination percentage of delinted seed at all the 3, 30, 60, 90, 120 and 150 days of storage of seeds. The crop sown on 16th March produced the seeds which recorded the highest germination percentage than that of seeds obtained from the crops sown on later dates. This might be due to that the earlier sown crop had more favourable environmental conditions and less attack of pest and diseases than the crops sown later. Hence early sown crops produced more healthy seeds than the later one which helped in recording the maximum germination percentage with earlier sown crops.

Regarding sucking pests of cotton viz white flies, thrips, jassids and aphids it can be seen that the mean population of sucking pests was decreased as the sowing was delayed from 16th March but increased in the crop sown on 1st May at square formation stage. The crop sown on 1st May recorded the highest mean population of sucking pests at square formation stage as compared to the crops sown on other dates. Dhawan *et al.* (1987) reported that mean population of jassids and aphids was higher on the crop sown earlier (25th April) as compared to the crop sown on later dates viz (9th May and 23rd May). This might be due to that when the crop was sown on 15th March i.e. earlier then at square formation stage temperature was lower which is favourable for sucking pests as compared to 1st April and 15th April sowing dates which had the higher temperatures during the square formation stage which was unfavourable for sucking pests. And in case of last sowing i.e. 1st May temperature was lowered due to rains and humid environment at square formation stage favoured for the highest population of sucking pests as compared to the crops sown earlier.

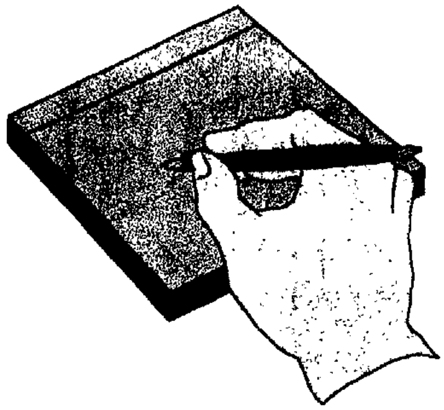
Mean population of sucking pests was significantly increased as the sowing was delayed from 16th March at flowering stage. The crop sown on 16th March recorded the minimum while the crop sown on 1st May recorded the maximum population of sucking pests. This might be due to that with later sowing dates there is more humid climate which is favourable for sucking pests at flowering stage of the crop.

Mean percentage of damaged bolls and loculi due to bollworm attack was significantly increased as the sowing was delayed from the 16th March to 1st May. This might be due to that the attack of bollworms was increased on the crop sown on later dates. The crop sown on 16th March recorded minimum percentage of damaged bolls and loculi than the crops sown on later dates. Singh and Sidhu (1983) reported that number of harvestable bolls per plant was reduced by 50 per cent in late sown crop (end-June) as compared with early sown crop (end-April). Taneja and Dhindwal (1982) reported that the greatest incidence of *P. gossypiella* on bolls and of dipausing larvae was recorded in the late sown crop as compared to early sown one.

Regarding the diseases of cotton the crop sown earlier was found to be less affected by diseases viz *Alternaria* leaf spot, grey mildew, red leaf blight and boll rot. The crop sown on 16th March recorded the minimum infestation of diseases as compared to later sown crops. This might be due to that in later sown crops there was more humid climate which favoured for the activities of microorganisms responsible for diseases and rapid spread of diseases while in case of early sown crops maximum growth stages of crop were escaped from disease attack which was more in later sown crops which have more humid climate than the early sown crop.

5.4 Effect of interaction on the growth, yield, quality, germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases.

It was observed that the interaction effect between irrigation methods and sowing dates on growth, yield, quality, germination, vigour, seedling dry matter, storage of seed and incidence of pests and diseases at any stage of the growth of the crop was found to be non-significant.



SUMMARY AND CONCLUSIONS

6. SUMMARY AND CONCLUSIONS

6.1 Summary

A field experiment to study "Effect of different sowing dates and irrigation methods on quality and quantity of hybrid cotton seed production". was conducted at the experimental field of Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during summer season of 2000.

The experiment was laid out in factorial randomised block design with four replications. Eight treatment combinations were formulated involving two irrigation methods viz. drip and surface and four sowing dates viz. 16th March, 1st April, 15th April and 1st May.

Field observations on number of days for first square formation, flower initiation, boll opening after pollination, number of flowers emasculated and pollinated, percentage of boll setting, number of bolls harvested, average boll weight, seed cotton yield per plant and per plot, seed weight per boll, seed yield per plant and per plot, seed index, mean population of sucking pests on the crop, average percentage of damaged bolls and loculi due to bollworm attack, disease index of *Alternaria* leaf spot, red leaf blight, grey mildew and percentage of boll rot were recorded.

Laboratory analysis was carried out in the seed testing laboratory of Seed Technology Research Unit, Mahatma Phule Krishi Vidyapeeth, Rahuri. Quality of seed was determined by percentage of germination, vigour index and dry matter content in seedlings.

The important findings of present investigation are summarised below.

6.1.1 Irrigation studies
6.1.2 Effect of irrigation methods
6.1.3 Effect of sowing dates

6.1.1 Irrigation studies

1. The soil under study was clay loam in texture. Bulk density of soil was 1.33 g/cm^3. The field capacity and permanent wilting point were 38.6 and 20.03 per cent on w/w basis respectively.

2. In conventional furrow irrigation method the irrigations were scheduled at 50 mm CPE. The total depth of water applied was 1400, 1260, 1190 and 910 mm in 20, 19, 17 and 13 irrigations for the crop sown on 16^{th} March, 1^{st} April, 15^{th} April and 1^{st} May respectively. In drip irrigation method, the irrigations were scheduled on the basis of daily pan evaporation and irrigation water was applied on alternate day. The total depth of water applied was 633.27, 616.83, 557.98

and 504.32 mm for the crops sown on 16th March , 1st April , 15th April and 1st May respectively . The effective rainfall was 213.40, 249.10 and 296.30 mm in surface irrigation and 100.80 , 105.10, 129.30 and 139.10 mm in drip irrigation for the crop sown on 16th March , 1st April , 15th April and 1st may respectively . Thus there was water saving to the extent of 54.51, 51.55, 52.24 and 46.66 per cent in case of drip irrigation method over surface irrigation method for the crops sown on 16th March , 1st April , 15th April and 1st May respectively.

3. The consumptive use of water was found to be 1289.96, 1278.85, 1197.67 and 1153.64 mm in surface irrigation treatments and 734.07, 721.95, 687.28 and 643.42 mm in drip irrigation treatments for the crops sown on 16th March , 1st April, 15th April and 1st May respectively. The maximum water use efficiency was found to be associated with drip irrigation.

4. The emission uniformity in all the drip irrigation treatments was more than 90 per cent which was excellent indicating uniform water application.

6.1.2 Effect of irrigation methods

1. First square formation, flowering initiation and boll opening after pollination i.e. the maturity of the crop was earlier due to surface irrigation methods as compared to drip irrigation method.

2. The yield components viz., number of flowers available for emasculation and pollination, percentage of boll setting, number of bolls harvested per plant, average boll weight and average seed weight per boll were maximum in the crop with drip irrigation treatments as compared to surface irrigation treatments.

3. Seed cotton yield and seed yield per plant, per plot and per hectare was found to be higher in the crop with drip irrigation treatments as compared to surface irrigation treatments.

4. Seeds obtained from drip irrigation treatments recorded the higher percentage of germination, vigour index and dry matter content than that of seeds obtained from surface irrigation treatments but the differences were non-significant.

5. The mean population of sucking pests viz, white flies, thrips, jassids and aphids was found less in drip irrigation treatments as compared to surface irrigation treatments.

6. The percentage of damaged bolls and loculi due to bollworm attack was less in drip irrigation treatments as compared to surface irrigation treatments.

7. The incidence of bacterial leaf blight was not found in any of irrigation method at any stage of crop. While the disease intensity of *Alternaria* leaf spot and grey mildew was found to be lower in drip irrigation treatments as compared to surface irrigation treatments. Boll rot percentage also was found minimum in drip irrigation treatments as compared to surface irrigation treatments.

6.1.3 Effect of sowing dates

1. First square formation, flowering initiation and boll opening after pollination i.e. the maturity of the crop was earlier as the sowing was delayed from 16th March to 1st May.

2. The yield components viz., number of flowers available for emasculation and pollination, percentage of boll setting, number of bolls harvested per plant, average boll weight and average seed weight per boll were decreased as the sowing was delayed from 16th March to 1st May.

3. Seed cotton yield and seed yield per plant, per plot and per hectare were decreased as the sowing was delayed from 16th

March to 1st May. The crop sown on 16th March recorded the maximum seed cotton yield and seed yield per plant and per plot than that of crops sown on later dates.

4. Germination percentage vigour index, dry matter content of seedling reduced as the sowing was delayed from 16th March to 1st May. While the seeds obtained from the crop sown on 16th March recorded the highest germination percentage, vigour index, dry matter content of seedlings.

5. The mean population of sucking pests decreased from 16th March sowing to 15th April sowing crop and then increased in the crop sown on 1st May. The crop sown on 15th April recorded the minimum population of sucking pests viz. White flies, thrips, jassids and aphids at square formation stage.

   While at flowering stage mean population of sucking pests was increased as the sowing was delayed from 16th March to 1st May. The crop sown on 16th March recorded minimum population of sucking pests at flowering stage.

6. The mean percentage of damaged bolls and loculi was increased as the sowing was delayed from 16th March to 1st May. The crop sown on 16th March recorded the minimum percentage of damaged bolls and loculi than the crops sown on later dates.

7. The incidence of bacterial leaf blight was not found at any of sowing date. However, the disease intensity of *Alternaria* leaf spot, grey mildew was increased as the sowing was delayed from 16th March to 1st May. The percentage of boll rot also increased as the sowing was delayed. The 16th March sown crop recorded the minimum disease intensity of *Alternaria* leaf spot and grey mildew and minimum percentage of boll rot.

6.2 Conclusions

On the basis of one season experiment the following conclusions have been drawn.

1. Drip irrigation method in summer cotton gave the higher percentage of seed cotton yield as compared to conventional method of irrigation.

2. Drip irrigation saved the water by 54.51, 51.55, 52.84 and 46.66 per cent over surface method of irrigation for the crop sown on 16th March, 1st April, 15th April and 1st May respectively and water use efficiency was maximum when drip irrigation was adopted.

3. Less attack of pests and diseases was found on cotton growth with drip irrigation method as compared to surface method of irrigation.

Thus drip irrigation method was found to beneficial as compared to surface irrigation method in case of cotton crop.

4. The crop sown on 16th March gave the highest yield and it was decreased as the sowing was delayed.

5. Incidence of pests and diseases was less in the crop sown on 16th March and it was increased as the sowing was delayed.

Hence the sowing of crop on 16th March i.e. earlier sowing was found to be beneficial than the crops sown later.

In order to have meaningful recommendations there is a need to conduct further experiments over number of locations and seasons.

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7. LITERATURE CITED

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APPENDICES

8. APPENDICES

Appendix - I

Net water requirement in drip irrigation system

(1st Sowing 16 March, 2000)

Month and date	Rainfall (mm)	Pan evaporation PE (mm)	Cumulative pan evaporation CPE (mm)	Crop coefficient KC	Crop evapotranspiration ETC	Vol. of water to be applied (lit/emitter)	Operating time of drip system (min-sec)
March 2000							
15	-	6.6					
16	-	6.2					
17	-	7.3					
18	-	7.2	14.5	0.4	4.06	2.19	17.04
19	-	7.4	-				
20	-	7.4	14.8	0.4	4.14	2.23	17.35
21	-	7.5	-				
22	-	7.4	14.9	0.4	4.17	2.25	17.51
23	-	8.0	-				
24	-	7.2	15.2	0.4	4.26	2.30	17.90
25	-	8.1	-				
26	-	7.6	15.7	0.4	4.40	2.38	18.52
27	-	7.2	-				
28	-	6.9	14.1	0.4	3.95	2.13	16.57
29	-	7.4	-				
30	-	8.3	15.7	0.4	4.40	2.38	18.52
31	-	6.7	-				
April, 2000	-						
1	-	8.1	14.8	0.5	5.18	2.80	21.79
2	-	7.2	-				
3	-	8.4	15.6	0.5	5.46	2.95	22.96
4	-	7.0	-				
5	-	6.9	13.9	0.5	4.87	2.63	20.46
6	-	8.2	-				
7	-	8.8	17.0	0.5	5.95	3.21	24.98
8	-	9.4	-				
9	-	8.8	18.2	0.5	6.37	3.44	26.77
10	-	11.7	-				
11	-	9.9	21.6	0.5	7.56	4.08	31.75
12	-	10.2	-				
13	-	8.5	18.7	0.5	6.55	3.54	27.55
14	-	10.2	-				
15	-	10.2	20.4	0.5	7.14	3.86	29.76

Appendix I Contd ..

16	-	9.4	-				
17	-	10.4	19.8	0.7	9.70	5.24	40.78
18	-	9.4	-				
19	-	8.9	18.3	0.7	8.97	4.84	37.66
20	-	8.7	-				
21	-	8.6	17.3	0.7	8.48	4.58	35.64
22	-	9.4	-				
23	-	9.6	19.0	0.7	9.31	5.03	39.14
24	-	10.2	-				
25	-	11.4	21.6	0.7	10.58	5.71	44.43
26	--	12.4	-				
27		12.2	24.6	0.7	12.05	6.51	50.66
28	--	12.7	-				
29		14.4	27.1	0.7	13.28	7.33	57.04
30	-	13.4	-				
May 2000	-						
1	-	12.0	25.4	0.7	12.45	6.72	52.29
2	--	12.9	-				
3	--	10.0	22.9	0.7	11.22	6.07	47.16
4	--	11.6	-				
5	--	11.0	22.6	0.7	11.07	5.98	46.54
6	-	11.9	-				
7	-	10.0	21.9	0.7	10.73	5.79	45.06
8	-	10.0	-				
9	-	10.5	20.5	0.7	10.04	5.42	42.18
10	-	7.9	-				
11	--	6.9	14.8	0.7	7.25	3.91	30.43
12	-	8.2	-				
13	--	9.9	18.1	0.7	8.87	4.78	37.20
14	-	9.4	-				
15	-	9.7	19.1	0.7	9.36	5.05	38.94
16	-	8.4	-				
17	-	10.8	19.2	0.8	10.75	5.80	45.14
18	-	9.2	-				
19	-2.0	5.0	12.2	0.8	6.83	3.69	28.71
20	0.6	6.6	-				
21	-	9.5	15.5	0.8	8.68	4.69	36.50
22	-	9.4	-				
23	-	8.6	18.0	0.8	1.08	5.44	42.33
24	-	10.0	-				
25	-	9.4	19.4	0.8	10.86	5.86	45.60

Appendix I Contd ..

26	-	10.0	-				
27	-	9.9	19.9	0.8	11.14	6.01	46.77
28	3.4	6.4	-				
29	-	5.5	8.5	0.8	4.76	2.57	20.00
30	-	7.2	-				
31	0.4	8.9	15.7	1.05	11.54	6.23	48.48
June 2000							
1	9.2	9.2	-				
2	10.6	6.2	15.4	1.05	-	-	-
3	18.5	5.7	-				
4	4.4	7.4	12.1	1.05	-	-	-
5	7.8	6.5	-				
6	52.2	5.0	11.5	1.05	-	-	-
7	6.2	4.2	-				
8	88.6	4.5	8.7	1.05	-	-	-
9	-	4.0	-				
10	0.2	2.0	6.0	1.05	-	-	-
11	3.8	5.0	-				
12	-	4.9	6.1	1.05	4.48	2.42	18.83
13	-	7.7	-				
14	-	7.78	15.5	1.05	11.39	6.15	47.86
15	-	6.8	-				
16	-	8.2	15.0	1.05	11.02	5.95	46.30
17	-	7.5	-				
18	-	7.5	15.0	1.05	11.02	5.55	46.30
19	-	7.0	-				
20	-	4.0	11.0	1.05	8.08	4.36	33.93
21	-	2.7	-				
22	-	4.5	7.2	1.05	5.29	2.86	22.25
23	-	7.5	-				
24	-	7.0	14.5	1.05	10.66	5.76	44.82
25	-	8.0	-				
26	-	7.9	15.9	1.05	11.69	6.31	49.10
27	-	7.8	-				
28	-	8.6	16.4	1.05	12.05	6.51	50.19
29	-	5.0	-				
30	24.1	2.7	7.7	1.05	-	-	-
July 2000							
1	5.4	3.9	-				
2	0.5	3.4	1.4	1.25	1.23	0.66	5.14
3	5.3	3.7	-				

Appendix I Contd ..

4	0.4	3.8	1.8	1.25	1.57	0.85	6.61
5	-	3.3	-				
6	-	4.7	8.0	1.25	7.00	3.78	29.42
7	0.4	4.9	-				
8	-	4.1	8.6	1.25	7.52	4.06	31.59
9	-	6.3	-				
10	-	6.1	12.4	1.25	10.85	5.86	45.60
11	1.5	4.3	-				
12	3.5	2.0	1.3	1.25	1.14	0.61	4.75
13	32.0	1.8	-				
14	5.0	1.8	3.6	1.25	-	-	-
15	-	6.5	-				
16	-	6.0	12.5	1.25	10.94	5.91	45.99
17	-	5.2	-				
18	-	4.7	9.9	1.25	8.66	4.68	36.42
19	-	3.8	-				
20	-	3.4	7.2	1.25	6.3	3.40	26.46
21	-	5.1	-				
22	-	6.4	11.5	1.25	10.06	5.40	42.02
23	-	6.0	-				
24	-	7.1	13.1	1.25	11.46	6.19	48.17
25	-	6.0	-				
26	1.2	4.8	9.6	1.25	8.4	4.54	35.33
27	-	5.3	-				
28	-	5.2	10.5	1.25	9.19	4.96	38.60
29	-	5.9	-				
30	-	7.2	13.1	1.25	11.46	6.19	48.17
31	-	7.6	-				
Aug. 2000							
1	-	7.0	14.6	0.8	8.18	4.42	34.40
2	-	7.2	-				
3	-	6.5	13.7	0.8	7.68	4.15	32.29
4	-	6.0	-				
5	-	6.1	12.1	0.8	3.42	1.85	14.39
6	-	6.8	-				
7	-	7.0	13.8	0.8	7.73	4.17	32.45
8	-	5.8	-				
9	2.5	6.7	10.0	0.8	5.6	3.02	23.50
10	1.2	5.6	-				
11	5.9	1.6	0.1	0.8	-	-	-
12	0.6	2.5	-				

Appendix I Contd ..

13	-	4.2	6.1	0.8	3.42	1.84	14.35
14	-	4.5	-				
15	-	5.1	9.6	0.8	5.38	2.90	22.59
16	-	8.9	-				
17	-	8.0	16.9	0.9	10.65	5.75	44.74
18	0.7	4.5	-				
19	-	6.5	10.3	0.9	6.49	3.50	27.24
20	-	6.3	-				
21	3.7	1.3	3.9	0.9	2.46	1.33	10.35
22	2.2	2.2	-				
23	3.8	2.9	5.1	0.9	3.21	1.73	13.46
24	95.5	0.5	-				
25	110.8	1.3	1.8	0.9	1.13	0.61	4.74
26	2.8	2.8	-				
27	14.5	3.7	6.5	0.9	-	-	-
28	5.8	2.3	-				
29	1.2	4.2	6.5	0.9	-	-	-

Total water applied = 633.27 mm

Effective rainfall = 100.80 mm

Appendix II

Net water requirement in drip irrigation system

(2nd Sowing 1 April, 2000)

Month and date	Rainfall (mm)	Pan evaporation PE (mm)	Cumulative pan evaporation CPE (mm)	Crop coefficient KC	Crop evapotranspiration ETC	Vol. of water to be applied (lit/emitter)	Operating time of drip system (min-sec)
April 2000							
1	-	8.1					
2	-	7.2					
3	-	8.4	15.6	0.4	4.37	2.36	18.36
4	-	7.0	-				
5	-	6.9	13.9	0.4	3.89	2.10	16.34
6	-	8.2	-				
7	-	8.8	17.0	0.4	4.76	2.57	20.00
8	-	9.4	-				
9	-	8.8	18.2	0.4	5.10	2.75	21.40
10	-	11.7	-				
11	-	9.9	21.6	0.4	6.05	3.27	25.45
12	-	10.2	-				
13	-	8.5	18.7	0.4	5.24	2.83	22.02
14	-	10.2	-				
15	-	10.2	20.4	0.4	5.71	3.08	23.97
16	-	9.4	-				
17	-	10.4	19.8	0.5	6.65	3.59	27.94
18	-	9.4	-				
19	-	8.9	18.3	0.5	6.40	3.46	26.93
20	-	8.7	-				
21	-	8.6	17.3	0.5	6.05	3.27	25.45
22	-	9.4	-				
23	-	9.6	19.0	0.5	6.65	3.59	27.94
24	-	10.2	-				
25	-	11.4	21.6	0.5	7.56	4.08	31.75
26	-	12.4	-				
27	-	12.4	24.6	0.5	861	4.65	36.19
28	-	12.7	-				
29	-	14.4	27.1	0.5	9.48	5.12	39.84
30	-	13.4	-				
May 2000							
1	-	12.0	25.4	0.7	12.45	6.72	52.29
2	-	12.9	-				

Appendix II Contd ..

3	-	10.0	22.9	0.7	11.22	6.06	47.16
4	-	11.6	-				
5	-	11.0	22.6	0.7	11.07	5.98	46.54
6	-	11.9	-				
7	-	10.0	21.9	0.7	10.73	5.79	44.36
8	-	10.0	-				
9	-	10.5	20.5	0.7	10.04	5.42	42.18
10	-	7.9	-				
11	-	6.9	14.8	0.7	7.25	3.91	30.43
12	-	8.2	-				
13	-	9.9	18.1	0.7	8.87	4.79	37.28
14	-	9.4	-				
15	-	9.7	19.1	0.7	9.36	5.05	39.30
16	-	8.4	-				
17	-	10.8	19.2	0.7	9.41	5.08	39.53
18	-	9.2	-				
19	2.0	5.0	12.2	0.7	5.98	3.23	25.14
20	0.6	6.6	-				
21	-	9.5	15.5	0.7	7.59	4.10	31.91
22	-	9.4	-				
23	-	8.6	18.0	0.7	8.82	4.76	37.04
24	-	10.0	-				
25	-	9.4	19.4	0.7	9.51	5.13	39.92
26	-	10.0	-				
27	-	9.9	19.9	0.7	9.75	5.26	40.93
28	3.4	6.4	-				
29	-	5.5	8.5	0.7	4.16	2.25	17.51
30	-	7.2	-				
31	0.4	8.9	15.7	0.8	8.79	4.70	36.57
June 2000							
1	9.2	9.2	-				
2	10.6	6.2	15.4	0.8	-	-	-
3	18.5	5.7	-				
4	4.4	7.4	12.1	0.8	-	-	-
5	7.8	6.5	-				
6	52.2	5.0	11.5	0.8	-	-	-
7	6.2	4.2	-				
8	88.6	4.5	8.7	0.8	-	-	-
9	-	4.0	-				
10	0.2	2.0	6.0	0.8	-	-	-
11	3.8	5.0	-				

Appendix II Contd ..

12	-	4.9	6.1	0.8	2.74	1.48	11.51
13	-	7.7	-				
14	-	7.8	15.5	0.8	8.68	4.69	36.50
15	-	6.8	-				
16	-	8.2	15.0	1.05	11.02	5.95	46.30
17	-	7.5	-				
18	-	7.0	15.0	1.05	11.02	5.95	46.30
19	-	7.0	-				
20	-	4.0	11.0	1.05	8.08	4.36	33.93
21	-	2.7	-				
22	-	4.5	7.2	1.05	5.29	2.86	22.26
23	-	7.5	-				
24	-	7.0	14.5	1.05	10.66	5.76	44.82
25	-	8.0	-				
26	-	7.9	15.9	1.05	11.69	6.31	49.10
27	-	7.8	-				
28	-	8.6	16.4	1.05	12.05	6.51	50.66
29	-	5.0	-				
30	24.1	2.7	7.7	1.05	-	-	-
July 2000							
1	5.4	3.9	-				
2	0.5	3.4	1.4	1.05	1.03	0.56	4.36
3	5.3	3.7	-				
4	0.4	3.8	1.8	1.05	1.32	0.71	5.52
5	-	3.3	-				
6	-	4.7	8.0	1.05	5.88	3.17	24.67
7	0.4	4.9	-				
8	-	4.1	8.6	1.05	6.32	3.41	26.54
9	-	6.3	-				
10	-	6.1	12.4	1.05	9.11	4.92	38.29
11	1.5	4.3	-				
12	3.5	2.0	1.3	1.05	0.95	0.51	3.97
13	32.0	1.8	-				
14	5.0	1.8	3.6	1.05	-	-	-
15	-	6.5	-				
16	-	6.0	12.5	1.25	10.94	5.91	45.99
17	-	5.2	-				
18	-	4.7	9.9	1.25	8.66	4.68	36.42
19	-	3.8	-				
20	-	3.4	7.2	1.25	6.30	3.40	11.56
21	-	5.1	-				

Appendix II Contd ..

22	-	6.4	11.5	1.25	10.06	5.43	42.26
23	-	6.0	-				
24	-	7.1	13.1	1.25	11.46	6.19	48.17
25	-	6.0	-				
26	1.2	4.8	9.6	1.25	8.40	4.54	35.33
27	-	5.3	-				
28	-	5.2	10.5	1.25	9.19	4.96	38.60
29	-	5.9	-				
30	-	7.2	13.1	1.25	11.46	6.19	48.17
31	-	7.6	-				
Aug. 2000							
1	-	7.0	14.6	1.25	12.77	6.89	53.62
2	-	7.2	-				
3	-	6.5	13.7	1.25	11.99	6.47	50.35
4	-	6.0	-				
5	-	6.1	12.1	1.25	10.59	5.72	44.51
6	-	6.8	-				
7	-	7.0	13.8	1.25	12.07	6.52	50.74
8	-	5.8	-				
9	2.5	6.7	10.0	1.25	8.75	4.72	36.73
10	1.2	5.6	-				
11	5.9	1.6	0.1	1.25	-	-	-
12	0.6	2.5	-				
13	-	4.2	6.1	1.25	5.34	2.88	22.41
14	-	4.5	-				
15	-	5.1	9.6	1.25	8.90	4.54	35.30
16	-	8.9	-				
17	-	8.0	16.9	0.8	9.46	5.11	39.77
18	0.7	4.5	-				
19	-	6.5	10.3	0.8	5.77	3.11	24.20
20	-	6.3	-				
21	3.7	1.3	3.9	0.8	2.18	1.18	9.18
22	2.2	2.2	-				
23	3.8	2.9	5.1	0.8	2.86	1.54	11.98
24	25.5	0.5	-				
25	110.8	1.3	1.8	0.8	-	-	-
26	2.8	2.8	-				
27	14.5	3.7	6.5	0.8	-	-	-
28	5.8	2.3	-				
29	1.2	4.2	6.5	0.8	-	-	-
30	-	3.6	-				

Appendix II Contd ..

31	-	5.3	8.9	0.9	5.61	3.03	23.58
Sept. 2000							
1	-	5.4	-				
2	2.8	3.9	6.5	0.9	4.09	2.21	17.20
3	0.5	4.0	-				
4	-	3.8	7.3	0.9	4.60	2.48	19.30
5	-	4.4	-				
6	-	5.2	9.6	0.9	6.05	3.27	25.45
7	-	5.2	-				
8	-	5.0	10.2	0.9	6.43	3.47	27.00
9	1.0	4.4	-				
10	-	4.2	7.6	0.9	4.79	2.59	20.12
11	-	4.6	-				
12	-	4.5	9.1	0.9	5.73	3.10	24.09
13	-	4.2	-				
14	-	4.6	8.8	0.9	5.54	2.99	23.30

Total water applied = 616.85 mm

Effective rainfall = 105.10 mm

Appendix - III

Net water requirement in drip irrigation system

(3rd Sowing 15 April, 2000)

Month and date	Rainfall (mm)	Pan evaporation PE (mm)	Cumulative pan evaporation CPE (mm)	Crop coefficient KC	Crop evapotranspiration ETC	Vol. of water to be applied (lit/emitter)	Operating time of drip system (min-sec)
April 2000							
15	-	10.2					
16	-	9.4					
17	-	10.4	1.98	0.4	5.54	2.99	23.27
18	-	9.4	-				
19	-	8.9	18.3	0.4	5.12	2.76	21.48
20	-	8.7	-				
21	-	8.6	17.3	0.4	4.84	2.61	20.31
22	-	9.4	-				
23	-	9.6	19.0	0.4	5.32	2.87	22.33
24	-	10.2	-				
25	-	11.4	21.6	0.4	6.05	3.27	25.44
26	-	12.4	-				
27	-	12.2	24.6	0.4	6.89	3.72	28.94
28	-	12.7	-				
29	-	14.4	27.1	0.4	7.59	4.10	31.91
30	-	13.4	-				
May 2000							
1	-	12.0	25.4	0.5	8.89	4.80	37.35
2	-	12.9	-				
3	-	10.0	22.9	0.5	8.01	4.32	33.62
4	-	11.6	-				
5	-	11.0	22.6	0.5	7.91	4.27	33.23
6	-	11.9	-				
7	-	10.0	21.9	0.5	7.66	4.14	32.21
8	-	10.0					
9	-	10.5	20.5	0.5	7.17	3.87	30.12
10	-	7.9	-				
11	-	6.9	14.8	0.5	5.18	2.80	21.79
12	-	8.2	-				
13	-	9.9	18.1	0.5	6.33	3.42	26.61
14	-	9.4	-				
15	-	9.7	19.1	0.5	6.69	3.56	27.74
16	-	8.4	-				

Appendix III Contd ..

17	-	10.8	19.2	0.7	9.41	5.08	39.53
18	-	9.2	-				
19	2.0	5.0	12.2	0.7	5.98	3.23	25.14
20	0.6	6.6	-				
21	--	9.5	15.5	0.7	7.59	4.10	31.91
22	--	9.4	-				
23	--	8.6	18.0	0.7	8.82	4.76	37.04
24	--	10.0	-				
25	--	9.4	19.4	0.7	9.51	5.13	39.92
26	-	10.0	-				
27	-	9.9	19.9	0.7	9.75	5.26	40.93
28	3.4	6.4	-				
29	-	5.5	8.5	0.7	4.16	2.25	17.51
30	-	7.2	-				
31	0.4	8.9	15.7	0.7	7.69	4.15	32.29
June 2000							
1	9.2	9.2	-				
2	10.6	6.2	15.4	0.7	-	-	-
3	18.5	5.7	-				
4	4.4	7.4	12.1	0.7	-	-	-
5	7.8	6.5	-				
6	52.2	5.0	11.5	0.7	-	-	-
7	6.2	4.2	-				
8	88.6	4.5	8.7	0.7	-	-	-
9	-	4.0	-				
10	0.2	2.0	6.0	0.7	-	-	-
11	3.8	5.0	-				
12	-	4.9	6.1	0.7	2.99	1.61	12.53
13	-	7.7	-				
14	-	7.8	15.5	0.7	7.60	4.10	31.92
15	-	6.8	-				
16	-	8.2	15.0	0.8	8.4	4.54	7.78
17	-	7.5	-				
18	-	7.0	15.0	0.8	8.4	4.54	35.33
19	-	7.0	-				
20	-	4.0	11.0	0.8	6.16	3.33	25.91
21	-	2.7	-				
22	-	4.5	7.2	0.8	4.03	2.18	16.96
23	-	7.5	-				
24	-	7.0	14.5	0.8	8.12	4.38	34.02
25	-	8.0	-				

Appendix III Contd ..

26	-	7.9	15.9	0.8	8.90	4.81	37.43
27	-	7.8	-				
28	-	8.6	16.4	0.8	9.18	4.96	38.60
29	-	5.0	-				
30	24.1	2.7	7.7	0.8	-	-	-
July 2000							
1	5.4	3.9	-				
2	0.5	3.4	1.4	1.05	1.03	0.56	4.36
3	5.3	3.7	-				
4	0.4	3.8	1.8	1.05	1.32	0.71	5.52
5	-	3.3	-				
6	-	4.7	8.0	1.05	5.88	3.17	24.67
7	0.4	4.9	-				
8	-	4.1	8.6	1.05	6.32	3.41	26.54
9	-	6.3	-				
10	-	6.1	12.4	1.05	9.11	4.92	38.29
11	1.5	4.3	-				
12	3.5	2.0	1.3	1.05	0.95	0.51	3.97
13	32.0	1.8	-				
14	5.0	1.8	3.6	1.05	-	-	-
15	-	6.5	-				
16	-	6.0	12.5	1.05	9.19	4.96	38.60
17	-	5.2	-				
18	-	4.7	9.9	1.05	7.28	3.93	30.58
19	-	3.8	-				
20	-	3.4	7.2	1.05	5.29	2.86	22.26
21	-	5.1	-				
22	-	6.4	11.5	1.05	8.45	4.56	35.49
23	-	6.0	-				
24	-	7.1	13.1	1.05	9.63	5.20	40.47
25	-	6.0	-				
26	1.2	4.8	9.6	1.05	7.06	3.81	29.65
27	-	5.3	-				
28	-	5.2	10.5	1.05	7.72	4.17	32.43
29	-	5.9	-				
30	-	7.2	13.1	1.05	9.63	5.20	40.46
31	-	7.6	-				
Aug. 2000							
1	-	7.0	14.6	1.25	12.77	6.89	53.62
2	-	7.2	-				
3	-	6.5	13.7	1.25	11.99	6.47	50.35

Appendix III Contd ..

4	-	6.0	-				
5	-	6.1	12.1	1.25	10.59	5.72	44.51
6	-	6.8	-				
7	-	7.0	13.8	1.25	12.07	6.52	50.74
8	-	5.8	-				
9	2.5	6.7	10.0	1.25	8.75	4.72	36.73
10	1.2	5.6	-				
11	5.9	1.6	0.1	1.25	-	-	-
12	0.6	2.5	-				
13	-	4.2	6.1	1.25	5.34	2.88	22.41
14	-	4.5	-				
15	-	5.1	9.6	1.25	8.4	4.54	35.33
16	-	8.9	-				
17	-	8.0	16.9	1.25	14.79	7.97	62.02
18	0.7	4.5	-				
19	-	6.5	10.3	1.25	9.01	4.86	37.82
20	-	6.3	-				
21	3.7	1.3	3.9	1.25	3.41	1.84	10.89
22	2.2	2.2	-				
23	3.8	2.9	5.1	1.25	4.46	2.41	18.75
24	95.5	0.5	-				
25	110.8	1.3	1.8	1.25	-	-	-
26	2.8	2.8	-				
27	14.5	3.7	6.5	1.25	-	-	-
28	5.8	2.3	-				
29	1.2	4.2	6.5	1.25	-	-	-
30	-	3.6	-				
31	-	5.3	8.9	0.8	4.98	2.69	20.93
Sept. 2000							
1	-	5.4	-				
2	2.8	3.9	6.5	0.8	3.64	1.96	3.84
3	0.5	4.0	-				
4	-	3.8	7.3	0.8	4.09	2.21	17.20
5	-	4.4	-				
6	-	5.2	9.6	0.8	5.38	2.90	22.57
7	-	5.2	-				
8	-	5.0	10.2	0.8	5.71	3.08	23.97
9	1.0	4.4	-				
10	-	4.2	7.6	0.8	4.26	2.30	17.89
11	-	4.6	-				
12	-	4.5	9.1	0.8	5.10	2.75	21.42

Appendix III Contd ..

13	-	4.2	-				
14	-	4.6	8.8	0.8	4.93	2.66	20.71
15	-	4.3	-				
16	-	6.1	10.4	0.9	6.55	3.54	27.53
17	-	6.8	-				
18	-	6.5	13.3	0.9	8.38	4.52	35.17
19	-	9.0	-				
20	-	4.0	13.0	0.9	8.19	4.42	34.40
21	1.0	6.2	-				
22	4.5	5.1	5.8	0.9	3.65	1.97	15.33
23	5.1	5.6	-				
24	20.0	4.8	10.4	0.9	-	-	-
25	-	5.0	-				
26	-	5.8	10.8	0.9	6.80	3.67	28.59
27	12.0	4.5	-				
28	15.4	4.3	8.8	0.9	-	-	-

Total water applied = 557.98 mm

Effetctive rainfall = 129.30 mm

Appendix - IV

Net water requirement in drip irrigation system

(4th Sowing, 1 May, 2000)

Month and date	Rainfall (mm)	Pan evaporation PERCENT (mm)	Cumulative pan evaporation CPE (mm)	Crop coefficient KC	Crop evapotranspiration ETC	Vol. of water to be applied (lit/emitter)	Operating time of drip system (min-sec)
May 2000							
1	-	12.0					
2	-	12.9	-				
3	-	10.0	22.9	0.4	6.41	3.46	26.93
4	-	11.6	-				
5	-	11.0	22.6	0.4	6.33	3.42	26.61
6	-	11.9	-				
7	-	10.0	21.9	0.4	6.13	3.31	25.76
8	-	10.0	-				
9	-	10.5	20.5	0.4	5.74	3.10	24.12
10	-	7.9	-				
11	-	6.9	14.8	0.4	4.14	2.23	17.35
12	-	8.2	-				
13	-	9.9	18.1	0.4	5.07	2.74	21.32
14	-	9.4	-				
15	-	9.7	19.1	0.4	6.35	2.89	22.49
16	-	8.4	-				
17	-	10.8	19.2	0.5	6.72	3.63	28.25
18	-	9.2	-				
19	2.0	5.0	12.2	0.5	4.27	2.30	17.90
20	0.6	6.6	-				
21	-	9.5	15.5	0.5	5.42	2.93	42.18
22	-	9.4	-				
23	-	8.6	18.0	0.5	6.30	3.40	49.03
24	-	10.0	-				
25	-	9.4	19.4	0.5	6.79	3.67	28.56
26	-	10.0	-				
27	-	9.9	19.9	0.5	6.96	3.76	29.26
28	3.4	6.4	-				
29	-	5.5	8.5	0.5	2.97	1.60	12.45
30	-	7.2	-				
31	0.4	8.9	15.7	0.7	7.69	4.15	32.29
June 2000							
1	9.2	9.2	-				

Appendix IV Contd ..

2	10.6	6.2	15.4	0.7	-	-	-
3	18.5	5.7	-				
4	4.4	7.4	12.1	0.7	-	-	-
5	7.8	6.5	-				
6	52.2	5.0	11.5	0.7	-	-	-
7	6.2	4.2	-				
8	88.6	4.5	8.7	0.7	-	-	-
9	-	4.0	-				
10	0.2	2.0	6.0	0.7	-	-	-
11	3.8	5.0	-				
12	-	4.9	6.1	0.7	2.99	1.61	23.27
13	-	7.7	-				
14	-	7.8	15.5	0.7	7.59	4.10	59.07
15	-	6.8	-				
16	-	8.2	15.0	0.7	7.35	3.97	57.20
17	-	7.5	-				
18	-	7.5	15.0	0.7	7.35	3.97	30.89
19	-	7.0	-				
20	-	4.0	11.0	0.7	5.39	2.91	22.65
21	-	2.7	-				
22	-	4.5	7.2	0.7	3.53	1.91	14.86
23	-	7.5	-				
24	-	7.0	14.5	0.7	7.10	3.83	29.80
25	-	8.0	-				
26	-	7.9	15.9	0.7	7.79	4.21	32.76
27	-	7.8	-				
28	-	8.6	16.4	0.7	8.04	4.34	33.77
29	-	5.0	-				
30	24.1	2.7	7.7	0.7	-	-	-
July 2000							
1	5.4	3.9	-				
2	0.5	3.4	1.4	0.8	0.78	0.42	3.27
3	5.3	3.7	-				
4	0.4	3.8	1.8	0.8	1.01	0.55	4.28
5	-	3.3	-				
6	-	4.7	8.0	0.8	4.48	2.42	18.83
7	0.4	4.9	-				
8	-	4.1	8.6	0.8	4.82	2.60	20.23
9	-	6.3	-				
10	-	6.1	12.4	0.8	6.94	3.75	29.18
11	1.5	4.3	-				

Appendix IV Contd ..

12	3.5	2.0	1.3	0.8	0.73	0.39	3.03
13	32.0	1.8	-				
14	5.0	1.8	3.6	0.8	-	-	-
15	-	6.5	-				
16	-	6.0	12.5	1.05	9.19	4.96	38.60
17	-	5.2	-				
18	-	4.7	9.9	1.05	7.28	3.93	30.58
19	-	3.8	-				
20	-	3.4	7.2	1.05	5.29	2.86	22.26
21	-	5.1	-				
22	-	6.4	11.5	1.05	8.45	4.56	35.49
23	-	6.0	-				
24	-	7.1	13.1	1.05	9.63	5.20	40.47
25	-	6.0	-				
26	1.2	4.8	9.6	1.05	7.06	3.81	29.65
27	-	5.3	-				
28	-	5.2	10.5	1.05	7.72	4.17	32.45
29	-	5.9	-				
30	-	7.2	13.1	1.05	9.63	5.20	40.47
31	-	7.6	-				
Aug. 2000							
1	-	7.0	14.6	1.05	10.73	5.79	45.06
2	-	7.2	-				
3	-	6.5	13.7	1.05	10.07	5.44	42.33
4	-	6.0	-				
5	-	6.1	12.1	1.05	8.89	4.80	37.35
6	-	6.8	-				
7	-	7.0	13.8	1.05	10.14	5.47	42.57
8	-	5.8	-				
9	2.5	6.7	10.0	1.05	7.35	3.97	30.89
10	1.2	5.6	-				
11	5.9	1.6	0.1	1.05	-	-	-
12	0.6	2.5	-				
13	-	4.2	6.1	1.05	4.48	2.42	18.83
14	-	4.5	-				
15	-	5.1	9.6	1.05	7.06	3.81	29.65
16	-	8.9	-				
17	-	8.0	16.9	1.25	14.79	7.99	62.18
18	0.7	4.5	-				
19	-	6.5	10.3	1.25	9.01	4.87	37.90
20	-	6.3	-				

Appendix IV Contd ..

21	3.7	1.3	3.9	1.25	3.41	1.84	14.32
22	2.2	2.2	-				
23	3.8	2.9	5.1	1.25	4.46	2.41	18.75
24	95.5	0.5	-				
25	110.8	1.3	1.8	1.25	-	-	-
26	2.8	2.8	-				
27	14.5	3.7	6.5	1.25	-	-	-
28	5.8	2.3	-				
29	1.2	4.2	6.5	1.25	-	-	-
30	-	3.6	-				
31	-	5.3	8.9	1.25	7.79	4.21	32.76
Sept. 2000							
1	-	5.4	-				
2	2.8	3.9	6.5	1.25	5.69	3.01	23.89
3	0.5	4.0	-				
4	-	3.8	7.3	1.25	6.39	3.45	26.85
5	-	4.4	-				
6	-	5.2	9.6	1.25	8.40	4.54	35.33
7	-	5.2	-				
8	-	5.0	10.2	1.25	8.92	4.82	37.51
9	1.0	4.4	-				
10	-	4.2	7.6	1.25	6.65	3.59	27.94
11	-	4.6	-				
12	-	4.5	9.1	1.25	7.96	4.30	33.46
13	-	4.2	-				
14	-	4.6	8.8	1.25	7.70	4.16	32.37
15	-	4.3	-				
16	-	6.1	10.4	0.8	5.82	3.14	24.43
17	-	6.8	-				
18	-	6.5	13.3	0.8	7.45	4.02	31.28
19	-	9.0	-				
20	-	4.0	13.0	0.8	7.28	3.93	30.58
21	1.0	6.2	-				
22	4.5	5.1	11.3	0.8	6.33	4.16	32.37
23	5.1	5.6	-				
24	20.0	4.8	10.4	0.8	-	-	-
25	-	5.0	-				
26	-	5.8	10.8	0.8	6.05	3.27	25.44
27	12.0	4.5	-				
28	15.4	4.3	8.8	0.8	-	-	-
29	2.7	3.1	-				

Appendix IV Contd ..

30	-	4.2	4.6	0.8	2.58	1.39	10.82
Oct. 2000							
1	-	4.4	-				
2	7.0	3.6	1.0	0.9	0.63	0.34	2.64
3	-	4.6	-				
4	-	4.8	9.4	0.9	5.92	3.20	10.24
5	-	4.5	-				
6	-	3.8	8.3	0.9	5.23	2.82	21.95
7	-	4.3	-				
8	-	4.7	9.0	0.9	5.67	3.06	23.81
9	3.0	3.7	-				
10	17.2	4.0	7.4	0.9	-	-	-
11	-	2.7	-				
12	2.8	3.5	3.4	0.9	2.14	1.16	9.03
13	-	1.2	-				
14	-	3.4	4.6	0.9	2.90	1.57	12.22
15	12.8	3.5	-				
16	**-**	**5.0**	**8.5**	**0.9**	**-**	**-**	**-**

Total water applied = 504.32 mm

Effective rainfall = 139.10 mm

Appendix - V

Irrigation requirement in surface irrigation

(1st Sowing – 16 March, 2000)

Sr. No.	Pan evaporation (mm)	Date of irrigation	Depth of water applied (cm)	
			Actual	Cumulative
1	-	16.3.2000	7	7
2	50.4	23.3.2000	7	14
3	52.4	30.3.2000	7	21
4	52.6	6.4.2000	7	28
5	56.8	12.4.2000	7	35
6	58.9	18.4.2000	7	42
7	54.6	24.4.2000	7	49
8	58.9	29.4.2000	7	56
9	52.7	3.5.2000	7	63
10	54.5	8.5.2000	7	70
11	52.8	15.5.2000	7	77
12	56.6	22.5.2000	7	84
13	60.3	29.5.2000	7	91
14	51.6	15.6.2000	7	98
15	55.7	24.6.2000	7	105
16	50.6	5.7.2000	7	112
17	54.2	19.7.2000	7	119
18	51.9	29.7.2000	7	126
19	53.5	6.8.2000	7	133
20	52.8	17.8.2000	7	140

Total water applied = 1400 mm

Effective Rainfall = 213.4 mm

Appendix - VI

Irrigation requirement in surface irrigation

(2nd Sowing – 1 April, 2000)

Sr. No.	Pan evaporation (mm)	Date of irrigation	Depth of water applied (cm)	
			Actual	Cumulative
1	-	1.4.2000	7	7
2	54.6	8.4.2000	7	14
3	50.0	13.4.2000	7	21
4	58.1	19.4.2000	7	28
5	55.4	25.4.2000	7	35
6	63.1	30.4.2000	7	42
7	59.9	5.5.2000	7	49
8	53.4	10.5.2000	7	56
9	52.0	16.5.2000	7	63
10	56.3	23.5.2000	7	70
11	50.9	29.5.2000	7	77
12	51.6	15.6.2000	7	84
13	55.2	24.6.2000	7	91
14	50.6	5.7.2000	7	98
15	54.2	19.7.2000	7	105
16	51.9	29.7.2000	7	112
17	53.5	6.8.2000	7	119
18	52.8	17.8.2000	7	126
19	53.1	11.9.2000	7	133

Total water applied = 1260 mm

Effective Rainfall = 230.2 mm

Appendix- VII

Net water requirement in surface irrigation

(3rd Sowing , 15 April, 2000)

Sr. No.	Pan evaporation (mm)	Date of irrigation	Depth of water applied (cm)	
			Actual	Cumulative
1	-	14.4.2000	7	7
2	57.0	21.4.2000	7	14
3	61.6	27.4.2000	7	21
4	52.7	1.5.2000	7	28
5	57.5	6.5.2000	7	35
6	50.3	11.5.2000	7	42
7	52.5	17.5.2000	7	49
8	56.5	24.5.2000	7	56
9	55.0	31.5.2000	7	63
10	53.9	17.6.2000	7	70
11	55.2	26.6.2000	7	77
12	52.2	9.7.2000	7	84
13	56.3	23.7.2000	7	91
14	53.9	1.8.2000	7	98
15	56.7	12.8.2000	7	105
16	50.1	11.9.2000	7	112
17	50.6	20.9.2000	7	119

Total water applied = 1190 mm

Effective Rainfall = 249.1mm

Appendix - VIII

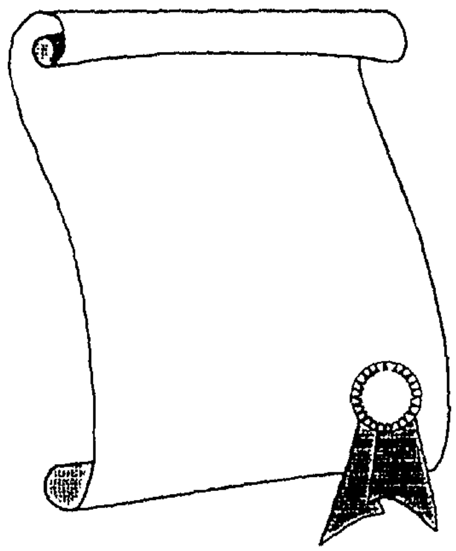
Net water requirement in surface irrigation

(4th Sowing , 1st May, 2000)

Sr. No.	Pan evaporation (mm)	Date of irrigation	Depth of water applied (cm)	
			Actual	Cumulative
1	-	30.4.2000	7	7
2	57.5	6.5.2000	7	14
3	50.3	11.5.2000	7	21
4	52.5	17.5.2000	7	28
5	56.5	24.5.2000	7	35
6	55.0	31.5.2000	7	42
7	57.4	19.6.2000	7	49
8	56.4	28.6.2000	7	56
9	55.8	25.7.2000	7	63
10	55.5	4.8.2000	7	70
11	51.7	16.8.2000	7	77
12	53.1	11.9.2000	7	84
13	50.6	20.9.2000	7	91

Total water applied = 9100 mm

Effective Rainfall = 296.3 mm



VITA

9. VITA

DIPAK CHHAGANRAO NAGARGOJE

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SEED TECHNOLOGY

2001

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