STUDY OF HYBRID SEED PRODUCTION TECHNIQUES AND VICINISM IN DESI COTTON

BY

KAMLAKAR ACHUTRAO DESHPANDE

B. Sc. (Agri)

Dissertation

Submitted to the Marathwada Agricultural University
In Partial Fulfilment of the Requirement
for the Degree of

Master Of Science

(Agriculture)

IN

AGRICULTURAL BOTANY

(Seed Technology)

DEPARTMENT OF BOTANY
MARATHWADA AGRICULTURAL UNIVERSITY
PARBHANI (Maharashtra) INDIA

1990

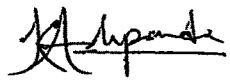
AFFECTIONATELY DEDICATED

TO MY

BELOVED PARENTS

CANDIDATE'S DECLARATION

I, hereby, declare that the dissertation or part of thereof has not been previously submitted by me for a degree of any university.



(K.A.Deshpande)

PARBHANI

Dated : July, 1990.

Dr. L. A. Deshpande
Cotton Breeder,
Cotton Research Station,
M. B. F., M. A. U., Parbhani.

CERTIFICATE I

This is to certify that Shri Kamlakar Achutrao Deshpande has satisfactorily prosecuted his course of research for a period of not less than four semesters and that the dissertation entitled "Study of hybrid cotton seed production techniques and vicinism in desi cotton" submitted by him is the result of original research to warrant its presentation to the examination for the award of the degree of 'MASTER OF SCIENCE' (Agriculture) in Agricultural Botany (Seed Technology). I also certify that dissertation or part thereof has not been previously submitted by him for a degree of any University.

PARBHANI.

Dated: 25th July, 1990.

(Dr. L. A. Deshpande)
Guide

CERTIFICATE II

This is to certify that the dissertation entitled "Study of hybrid cotton seed production techniques and vicinism in *desi* cotton" submitted by Kamlakar Achutrao Deshpande, to the Marathwada Agricultural University, in partial fulfilment of the requirement for the degree of Master of Science (Agriculture) in the subject of Agricultural Botany (Seed technology) has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

External Examiner

(Dr.B.A.Deshpande)
Guide

Advisors

(Dr.V.D.Patil)

(Dr.M.R.Salunke)

(Dr.S.T.Borikar)

(Proff.P.R.Waghmare)

Associate Dean and Principal
Collage of Agriculture
Parbhani.

ACKNOWLEDGEMENT

I, express my deep sense of gratitude to my research guide and chairman of advisoty committee Dr.L.A.Dashpande, Cotton Breeder, Cotton Research Station, Mahboob Baugh, M.A.U., Parbhani for suggesting the problem, offering inspiring scholartic criticism, guidance, constant encouragement, keen interest and help during entire course of study till the finalization of this thesis. The main inspiration and impetus for carrying out this work came from his under whom, I had the previlage to conduct the investigation. Therefore, the major credit for this research work goes to him.

I am indebted to Dr. Y.S. Nerkar, Associate Dean and Principal, College of Agricultural, Parbhani, for his valuable guidance and suggestions during the course of the investigation.

My cordial thanks due to Dr. M.R.Salunke, Head, Department of Genetics and Plant Breeding, for his valuable guidance and suggestions during the course of the investigation.

I wish to place my sincere thanks to advisory committee members Dr. S.T. Borikar, Seed Research Officer, Seed Technology Research Unit, M.A.U., Parbhani and Proff. P.R. Waghmare, Department of Economics and Statistics for their time to time help and suggestions throughout the course of the present investigation.

I am greatful to Dr. P.V. Salvi, Vice Chancellor, M.A.U., Parbhani, Dr. P.A. Deshmukh, Director of Research, Dr. V.K. Patil, Dean, Faculty of Agriculture, Dr. K.R. Pawar, Ex-Vice Chancellor, M.A.U., Parbhani and Dr.K.D. Rajmane, Head, Department of Economics and Statistics, College of Agriculture, Parbhani for providing the facilities for prosecuting the investigation.

My cordial thanks due to Dr. V.D. Patil, Dr.U.G. Kulkarni, Reader, Department of Genetics and Plant Breeding, Dr. M.B. Misal, Dr. V.G. Makhne, Dr. S.R. Singh and Prof. I.A. Madrap, Assistant Professors, Department of Genetics and Plant Breeding for their good wishes and continuous encouragement during course of study.

My cordial thanks are also due to Dr. U.V. Shashtri, Associate Proff., Department of Parasitology, M.A.U., Parbhani, for their good wishes and continuous encouragement during course of study.

My thanks are due to Shri S.S. Ambekar, Assitt. Cotton Breeder, Shri B.B. Gaikwad, R.G. Tammewar, Agril. Asstt. and Shri A.Y. Waghmare, B.N. Shinde, Jr. Clerk, C.R.S. Parbhani for their kind co-operation during the course of investigation.

I am also thankful to my dear colleagues S/Shri A.B. Tikotkar, D.B. Bangale, G.V. Yegaonkar, U.V.Bhalerao, J.M. Joshi, B.U. Khan.

My special thanks are due to Shri S.S. Sawant, for liberal helping in typing of this thesis.

I express my profound and treatiest gratitude to my younger brother Sudhakar due to which I would achieve this goal.

I also express my desp sense of appreciation to Shri Subhashrao Patil, and my wife Sow. Sunita, all family members and relatives for their help as well as keeping patience during the course of this investigation.

PARBHANI

(K.A.Deshpande)

Dated : July, 1990.

CONTENTS

1. INTRODUCTION

1. INTRODUCTION

Cotton is one of the most important commercial fibre crop and it plays an important role in the economy of country. The area under cotton cultivation in India is 70.74 lakh hectares and in Maharashtra it is 26.92 lakh hectares with an annual production of 70.14 and 8.88 lakh bales respectively. The area under cotton in Marathwada region is 6.95 lakh hectares with the production of 2.26 lakhs bales (Anonymous, 1989). The yield level of cotton per hectare in Marathwada region is very low as compared with the other states.

Development and release of intra-hirsutum hybrid-4 during 1971-72 for the first time in India, bestup the cotton production and gap between demand and supply was bridged to a great extent. After release of hybrid-4, number of intra and inter specific tetraploid hybrids were released by various cotton growing states in India. Some of the hybrids like NHH-44, AHH-468, DCH-32 and NHB-12 are worthwhile to mention which increased the production of long and extralong steple cotton and there by making the country self sufficient.

The new world tetraploid cotton hybrids though added to the productivity proved very much susceptible to disease and pest. The cultivation of such hybrids

requires intensive care followed by heavy expenditure. The marginal cultivators cannot affort heavy expenditure for growing successful crop of tetraploid cotton hybrid. These hybrids, therefore are not suitable for low input technology with high production.

To safe guard the producers during the period of falling prices and to develop the hybrids suitable for low input technology, it was thought to develop hybrids of *desi* or Asiatic cotton. Release of productive *desi* cotton hybrids may prove a boon to the marginal cultivater, as *desi* cotton had wider adaptability and inherent ability to resist major pest and diseases. Work to develop Asiatic hybrid cotton have been accelerated in Maharashtra, Gujarat and Karnataka. The hybrids like G. cot. DH-7 and LDH-2 have been already released from Gujarat and Karnataka respectively. These hybrids, though are characterised by high yield potential possesses infevior fibre qualities. The hybrid Pha-46 developed at Parbhani had high productivity and superior fibre qualities than the *desi* cotton hybrids released so far. The hybrid is being released very soon for general cultivation in Marathwada region.

The cultivaters are well adapted with the hybrid seed production technique of tetraploid cotton. This adaption resulted in developing efficient hybrid seed production industry of tetraploid cotton. The hybrid seed

production in case of *desi* cotton is some what tedious and faces some of the problems as follows:

1. The bud size in case of *desi* cotton is smaller than tetraploid cotton and the process of emasculation is tedious.
2. The shading of buds and crossed bolls is higher.
3. The boll size is small and number of seeds per boll are less.

It was therefore, essential to develop a suitable technique of hybrid seed production which will be helpful for commercial exploitation of hybrid vigour in *desi* cotton.

In addition to the development of suitable hybrid seed production technology in *desi* cotton it is also essential to study the extent of cross pollination to deside the isolation distance. Such studies have been already undertaken with regard to tetraploid cotton. The systematic experimentation to study the extent of cross pollination (Vicinism) in *desi* cotton is still lacking.

The present investigations was therefore, undertaken with following objectives.

1. To develop suitable hybrid seed production technique in *desi* cotton.
2. To study the extent of cross pollination (Vicinism) for deciding suitable isolation distance.

2. REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Hybrid cotton seed production involves various steps, like hand emasculation of female flower bud a day before its opening, covering of emasculated bud, pollinating the emasculated bud on the next day with pollens from male flower and covering of pollinated or crossed buds. Research work done on these various aspects of crossing technique particularly in *desi* cotton is rare. However, available literature pertaining to hybrid seed production technique in *desi* cotton and major work done on tetraploid cotton have been briefly presented below under following heads:

1. Time of emasculation and pollination.
2. Pollen behaviour in relation to its germination.
3. Pollen viability and,
4. Shedding of bolls.
5. Hybrid cotton seed production.

1. Time of emasculation and pollination

Fielding (1947), while working with cotton reported that the best set from buds which were cross fertilized was obtained from buds emasculated in the early afternoon and cross pollinated with pollens from flower just opened or fresh pollens. Janki *et al.* (1968) studied the floral biology of cotton in five varieties belonging to the three species of Gossypium viz. G. *hirsutum*, G. *arboreum*

and G. barbadense. The variety of diploid Asiatic species (G. arboreum) had smaller pollen grains in comparison to the two tetraploid American species. They found that the maximum receptivity of stigma was observed between 4.00 and 11.00 A.M. on the day of the opening of the flower. They also stated that the opening of flowers and dehiscense of anthers was markedly influenced by the atmospheric temperature and humidity, the influence of low temperature and high humidity being towards delaying the processes. These three species differed in their commencement and period of flowering. The G. arboreum was earliest to flower, while other two species have very short period flower.

Douglas and Admson (1965), studied the cross pollination technique with cotton G. hirsutum L. and stated that the use of any common method of protecting emasculated flowers requires considerable time in making a cross. Therefore the crossed seed was an expencive and quantities of such seed for experimental use were some times limited.

Capau (1968), observed that when fresh pollen was applied to 87631 (G. barbadense L.) and at intervals of 15 to 63 hours after emasculation, the best boll set was with pollination after fifteen hours. The seeds per boll was found to be highest with pollination after

15 to 21 hours. Meyer (1973) studied the cytoplasmic effects on anther numbers in interspecific hybrids of cotton, G. herbaceum x G. herknessii and suggested that the original cross which produced the tetraploid linted species had shown apposite direction with previous studies. Katarki (1973) while working with tetraploid cotton reported that the best time of pollination would be from 10 A.M. to 1 P.M., whereas Kalse and Garg (1976), found that the best time for pollen application for getting highest boll set was from 10 A.M. to noon. The setting was comparatively low when pollination was done at 9 A.M. Cyapau (1976), observed that the highest number of pollen tubes entered the ovary when the stigma was pollinated 15 and 20 hours after emasculation of the bud.

2. Pollen behaviour in relation to its germination and tube growth

Quite earlier Sankaran (1932), found flowers of cotton contain a much higher percentage of anthers in the abortive condition than the later formed ones.

Mansurov and Shebitchanko (1969), while working with barbadense cotton observed that number of pollen tubes penetrating into style depend mainly on the amount of available pollen. They suggested that the large amount of pollen should be deposited on stigma particularly in the case of hybridization.

Patil and Patil (1973), studied the extent of boll setting in varlaxmi and stated that inadequate pollination might be the major cause for high boll shedding although the mechanical injury caused while emasculation and insect pests may be the several other factors responsible for low boll set.

Shebitchenko (1974), observed that the begining of pollen germination was delayed when pollen grains were placed on the stigmas of another species. In such cases tube growth abnormalities were also predominent.

Khadaiberdyev (1975), observed the germination of additional pollen tubes in interspecific hybridization of cotton (G. hirsutum L. and G. barbadense L.) and reported that additional pollination hed a stimulating effect on pollen germination and the growth of the pollen tubes. Schubert et al. (1976), evidenced that mortality of ovules due to lack of fertilization must have resulted in decreased seed number per boll, which was caused to decrease in seed weight per boll.

3. Pollen viability

Balsubrahmanyan (1948), while studing pollen viability in cotton observed 43 per cent boll set in an experiment in which the pollens from transported buds involving time interval of 44 hours were dusted on emasculated buds between 11 A.M. and 3 P.M.

Arutjunova and Gesos (1964) found that cotton pollen storing at 26 to 28 °C for 24 hours reduced its viability by 40 to 60 per cent and storing for 48 hours resulted into complete loss of viability in G. arboreum G. barbadense and G. hirsutum species.

Janki et al. (1968) depicted that only a small per cent of pollen (0.to 5.6) were viable up to 30 hours of storage at room temperature (22.8°C) with 68 per cent relative humidity. They also observed that 0 to 3.2 per cent of pollens were viable, when stored at low temperature (13°C) and zero per cent RH. There was no appreciable effect of low temperature and relative humidity on the storage of pollengrains towards increasing the longivity. They further observed that with the decrease in relative humidity there was decrease in viability of pollengrains.

Parmeswar (1972) reported that the percentage of viability was more in pollen grains of G. hirsutum L. than in G. barbadense L. Both the species maintained high percentage of pollen germination upto six hours after dehiscense at room temperature.

4. Sheeding of bolls in cotton

Bharadwaj et al. (1968), found that

boll shading was related primarily to the number of flower produced irrespective of temperature and rainfall.

Hoffman and Rawlins (1970) studied infertility of cotton flowers at both high and low relative humidities and reported that at either constantly low (25 per cent) of high (90 per cent) atmospheric relative humidity cotton (G. hirsutum L.) sets very few bolls because the anthers fails to dehisce.

Ehlig and Mc Mert (1972) reported that the fruit load was the primary cause for low boll retention and ceasation of flowering during midseason. No direct relation with maximum or minimum temperature or high relative humidity was observed.

Sherif et al. (1974) obtained 34.97 per cent boll set in varlaxmi seed production, when they emasculated female buds during 3 to 6 P.M. and dusted the pollen on the next day between 10 A.M. to 12 noon. The emasculated buds were not covered with paper packets as they were not likely to be contaminated by bees or by the wind. Approximately six to eight female buds were dusted with one male flower.

Verma (1975) studied on the extent, periodicity and intensity of flower bud and boll sheeding and reported that 31.5 per cent of the buds produced and 51.5 per cent of the buds opened shed at one or other times. He found

that ten day old buds and four day old buds showed the maximum abscission.

Rao et al. (1979) conducted the experiments in varlaxmi seed production and reported the findings as under:

1. The best time for pollination to be 10 A.M. to 12 noon and the time of pollination depended mainly on the prevailing temperature. The maximum seed number and seed weight per boll was obtained when pollinatidn was done between 10 A.M. to 12 noon.
2. Rubbing anthers alround the stigmatic lobes resulted in better boll set, seed number and seed weight per boll. The optimum number of female flowers to be pollinated with single male flower was found to be five.
3. Emasculation : bagging the emasculated bud either before or after crossing resulted in an increase in the boll set. The per cent off types were found to be maximum when emasculated bud was kept naked and minimum when bud was covered before and after crossing. The treatment crossed bud kept naked recorded values within the limits of seed certification standards.

4. 4. Storage of open male flowers for 24 hours under natural condition resulted in reduction of pollen viability.

5. Environmental factors failed to show any influence on boll set and other seed characters. The plant age played a decissive role on these parameters.

5. Hybrid cotton seed production

Mehta et al. (1983) while working on hybrid seed production technique of Asiatic cotton stated that low boll setting percentage and short period of seed viability are the major constraints.

Merawada and Katarki (1986) reported that emasculation and crossing operations in varlaxmi hybrid cotton seed production restricted to first four blooming periods seems to be effective and economical. They also stated that seed recovered from first three pickings had ensured better seed quality characters and germination percentage than the subsequent pickings.

Kadapa et al. (1987) studied the method of crossing in large scale seed production of desi cotton seeds and suggested that "Straw tube" method was the better than "thumbnail" and "pinching off top of corolla" for adoption for commercial desi cotton hybrid seed production.

Vyakaranahal et al. (1987) conducted a field experiment to know the effect of nutrition and hormone application on production in hybrid cotton, and indicated that application of 240 kg N : 180 kg P_2O_5 and 180 kg K_2O per hectare was optimum for hybrid seed production in cotton. Split application of 50 per cent N, P_2O_5 and K_2O at planting : 25 : 25 per cent N, P_2O_5 and 50 per cent K_2O at 45 days after sowing through soil and 25 per cent N and P_2O_5 along with 10 ppm NAA through foliar spray at 90, 100, 110, 120 and 130 days after sowing was desirable than the total fertilizers applying through soil.

Ravindranath et al. (1988) studied various methods of emasculation like doak method, surat method and copper straw method and found that copper straw method was superior than other methods which enhances the setting of more crossed bolls. It was found that there was reduction in cost of desi hybrid cotton seed.

Arutyunova et al. (1989) stated that the tetraploid hybrid G. hirsutum x G. herbaceum x G. harknessii set no seed from selfing under isolators but gave a good set from open pollination. The seed in intraspecific and interspecific crosses were observed 80.85 per cent and 40 + 45 per cent when emasculated flowers were pollinated with cooled pollens.

Vicinism

Though cotton is predominently a self pollinated crop, natural crossing due to insects also occurs to some extent. The earlier work done on extent of natural crossing or vicinism by various workers have been briefly reviewed as follows:

Auther (1938) studied the natural cross pollination in hirsutum cotton and observed that the percentage of natural cross pollination due to artificial contamination ranged from 0 to 18.5 per cent. The cross pollination was mostly due to honey bees visiting the flowers most frequently.

Afzal and Khan (1950) evidenced that, in general there was higher percentage of natural hybrids with decrease in distance from marker plot. A distance of 12.5 feet from the marker plants had the largest number of natural hybrids. Beyond this distance natural crossing seems to have taken place sporadically. They concluded that there was largest number of natural cross pollination upto 12.5 feet.

Afzal and Khan (1950) also reported that the extent of natural cross pollination was about 3 per cent and stated that there was no marked difference in the extent of natural crossing between the local and the acclamatized American cottons.

Thadani (1950) concluded from his experiments that natural crossing in desi cottons in Sindh varied from 5 to 8 per cent.

Hatchison and Lawes (1953) stated the amount of natural crossing by using different pollen and seed parent. By studying the single boll progenies of seed parent they observed the per cent natural cross pollination to the extent of 11.65 per cent.

Thies (1953) studied agents of cross pollination of cotton in Oklahoma and reported that wind was of no importance as a possible means of cross pollination. Natural crossing wad dependent only on the activity of honey bees. Min'kov (1960) studied the nectar bearing cotton plants and the role of bees in cross pollination of cotton plants and stated that, honey bees never collect the pollen of cotton flowers and consequently do not participate in pollination.

Marani and Palvitz (1962) observed that natural hybridization in cotton population varied from 0.5 per cent in dry or hot areas to approximately 15 per cent in cooler or more humid areas. They also observed that cross fertilization in the case of Pima-32 (G. barbadense L.) was consistently less than 0.3 per cent, while in Acala 1517 C (G. hirsutum L.) it ranged from 6 to 16 per cent approximately.

Zahirudding and Menon (1972) studied the natural cross pollination in G. arboreum, and observed that percentage of natural hybrids at various distaces was found to vary from zero to 0.88 per cent, the average being 0.02

per cent. The maximum distance at which natural crossing occured was 42.5 feet.

William et al. (1973) found natural crossing in cotton (G. hirsutum L.) in the Delta of Mississippi, varied from 0 to 6 per cent and average to 2 per cent.

Gururajan and Srinivasan (1975) reported natural cross pollination in cotton ranging from 5 to 6 per cent.

Tanda and Goyal (1979) while studing pollen dispersal in desi cotton (G. arboreum) observed that insect is the main agent of pollen transfer and cross fertilization. They further observed that in open field the insects were able to disperse pollen to a distance of about 12 mts in a day.

Chauhan and Singh (1983) suggested that under normal plant protection measures 5 m is absolutely safe isolation distance for production of foundation and certified seed at Nagpur.

Nadagauder et al. (1985) studied the minimum requirement of isolation distance in cotton and clearly indicated that there is no need of very wide isolation distance as specified in field standards for seed certification of cotton seed crop to produce quality seed.

Waller *et al.* (1986) studied the use of honey bees in production of hybrid cotton seed and concluded that bee management method was usefull for satisfactory fertilization of the cotton flowers.

Wilson and Stapp (1986) studied crossing ( ) in cotton and number of flowers pollinated and time of emasculation and stated that when 30 pistillate flowers were pollinated with one stiminate flower there was decreasing seed yield. They also found that emasculation of flowers early at 0200 h on the day of pollination allowed some self pollination in cotton.

Kalora and Wankhade (1987) stated that out crossing was not observed in cotton grown with isolation distances ranging from 5 to 50 m from all directions, and indicated that distance of 5 m was safe for the production of genetically good quality seeds of cotton grown with recommended practices.

...

3. MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Crossing technique in hybrid seed production

In the present investigation five experiments were conducted to obtain the information pertaining to different aspects of crossing technique and their effect on hybrid seed production of *desi* cotton. All the five experiments were conducted on seed production plot of the *desi* cotton hybrid Pha-46, raised at Cotton Research Station, Mehboob Baugh Farm, Marathwada Agriculture University, Parbhani. The experiment was carried out from 1st Oct., 1989.

3.1.1 Experimental material

The experimental material consist of female parent Ph-1 and male parent PA-140 of the *desi* cotton hybrid Pha-46.

3.1.2 Ph-1 (Female parent)

Ph-1 is a selection from a variety SM-150 from Karnataka. It is a diploid cotton (2n = 26) belonging to *herbaceum* species and is used as a female parent for Pha-46. The strain Ph-1 is monopodial in habit and possesses broad leaves. It requires 80-90 days for flowering. The bud and flower size is medium and had a capacity to bear large

number of flowers. The boll size is medium weighing 1.8 to 2.2 gm. The halo length is 21 to 22 mm. The petal colour is light yellow whereas the anther colour is dark yellow. The seed index is very high ranging from 5 to 6.

3.1.3 PA-140 (male parent)

It is a diploid cotton evolved at cotton Research Station, Mehboob Baugh Farm, M.A.U., Parbhani it belongs to arboreum species and is used as male parent for Pha-46. It is completely sympodial and flowers within 55-60 days. The leaf lobes are deeply serrated. It is long staple arboreum having 25 to 26 mm. halo length like that of American cotton. The ginning outturn is 36 to 37 per cent and seed index is 4 to 5.

3.1.4 Layout and agronomic practices

The total area of the seed plot was 9 x 9 m. The female parent Ph-1 was sown on 5th July, 89. The spacing of 60 x 30 cm was kept between rows and plants within the row respectively.

The male parent PA-140 was sown in three equal instalments i.e. 30, 45 and 60 days after sowing of female parent Ph-1. The spacing of 45 x 22.5 cm was kept between rows and plants within the row respectively.

Fertilizer doses were given at the rate of 50 kg N : 25 kg P_2O_5 : 25 kg K_2O per hectage. Nitrogen was given in two instolments. 25 kg N at the time of sowing and remaining 25 kg N at the time of square formation.

Irrigations were given as and when required. All the recommended plant protection measures were taken up particularly for boll worm control.

For crossing purpose the twelve rows of female parent were grown and distributed amongst five experiments according to number of treatments in each experiment.

3.1.5 Experimental methods

Following five experiments were conducted.

1. Study of time of emasculation and pollination.
2. Method of pollen application.
3. Number of female flower buds to be pollinated with single male flower.
4. Effect of covering stigma on per cent boll set, seed number and seed weight per boll.
5. Pollen storage in relation to pollen viability.

The crossing technique of hand emasculation and pollination was used in all these experiments. The time of

emasculation was from 2 P.M. to 4 P.M. one day before its opening and pollination on the next day in between 10 A.M. to 1 P.M. was the common practice used in all the experiments except for experiment No.1. Similarly the covering of emasculated and pollinated flower buds with straw tube was common in all experiments except for experiment number 4.

The experiments were carried out in seed plot of Pha-46 and each of the experiment was repeated three times with an interval of about 15-16 days. The three periods of crossing were decided and in each period, crossing was done for fifteen days. Of these, three successive days were alloted to each experiment so as to adjust one replication on one day. Repeatations were considered as three seperate periods of crossing and were called as P_1, P_2 and P_3 (P_1 = 1.10.1989 to 15.10.1989, P_2 = 19.10.1989 to 2.11.1989 and P_3 = 6.11.1989 to 21.11.1989). The data on per cent boll set, seed number and seed weight per boll for every experiment, for each date of crossing under each treatment per replication was obtained seperately and analysed statistically following the procedure for Factorial Randomised Block Design (Panse and Sukhatme, 1967).

The procedure for obtaining the above data was as under.

1. Per cent boll set

In each experiment the data for all the dates of crossing under each period of crossing regarding the number of flower buds crossed under each treatment was recorded.

The bolls were harvested having the label indicating the date of crossing, treatment given and experiment number. Finally the harvested bolls were counted and the boll set was calculated as percentage.

2. Seed number and seed weight per boll

From each harvested boll, the seeds were extracted, the number counted and the weight of seeds was taken in grams. According to the label, the entries were made against each date of crossing for each treatment under every experiment and data was obtained by taking average seed number and seed weight per boll.

3.1.5.1 Study of time of emasculation and pollination

The experiment was conducted as Factorial Randomised Block Design with two factors, viz. time of emasculation and time of pollination. For the first factor two levels i.e. emasculation in the morning (EM)

and emasculation in the afternoon and for the second factor four timings of pollination were considered.

This experiment was conducted by using four rows, each having 30 dibbles (two plants per dibble). Of these four rows, two rows were saperately alloted for each of morning (8 to 10 A.M.) and afternoon (2 to 4 P.M.) emasculation.

Each row was divided in two equal number of dibbles (15) and in each row two treatments were carried out according to crossing programme. Like wise emasculation in the morning was done on two row with four treatments of pollination. The time of pollination for these four treatments were 8 to 10 A.M., 10 A.M. to 12 noon, 12 noon to 2 P.M. and 2 to 4 P.M.

Each treatment consists of thirty case studies (crossed flower buds) and all the treatments were replicated three times on three successive days considering one replication on one day. Combinely this was called as the first period of crossing (P_1). With the same procedure the experiment was conducted for second (P_2) and third period of crossing (P_3). Dates of crossing and number of flower buds crossed in this experiment were as under.

Dates of crossing	No.of flower buds crossed
P_1 = 1-10-89, 2-10-89, 3-10-89	720 (240 on each date)
P_2 = 19-10-89, 20-10-89, 21-10-89	720 (240 on each date)
P_3 = 6-11-89, 7-11-89, 8-11-89	720 (240 on each date)

For easy indentification the different coloured tags were used in each period of crossing and were labled with all information pertaining to its treatment, date of crossing and experiment number.

3.1.5.2 Method of pollen application

The experiment was conducted as Factorial Randomised Block Design with two factors, viz. three levels of period of crossing and four treatments. The experiment was conducted on two rows, each having thirty dibbles. Each row was divided in to two (15 dibble each) groups and in each row two treatments were carried out. The four treatments used in this experiment were as under.

T_1 = Touching the anthers only on the tip of stigma.

T_2 = Rubbing anthers on two apposite sides of stigma.

T_3 = Rubbing anthers on four sides of stigma except tip.

T_4 = Rubbing anthers on four sides of stigma and on tip of stigma.

Under each treatment thirty case studies were made and each treatment replicated three times on three successive days, one replication on one day.

The dates of crossing and number of flower buds crossed were as under :

Dates of crossing	No.of flower buds crossed
P_1 = 4-10-89, 5-10-89, 6-10-89	360 (120 on each date)
P_2 = 22-10-89, 23-10-89, 24-10-89	360 (120 on each date)
P_3 = 9-11-89, 10-11-89, 11-11-89	360 (120 on each date)

The required number of buds were emasculated in the afternoon from 2 to 4 P.M. one day before the actual date of crossing. According to the treatment assigned emasculated buds were pollinated in each treatment from 10 A.M. to 1 P.M. on the day of crossing. The crossed flower buds were labled, indicating the date of crossing, treatment given and experiment number.

3.1.5.3 Number of flower buds to be pollinated with single male flower

The experiment was conducted as Factorial Randomised Design with two factors, viz. three levels of periods of crossing and seven treatments.

This experiment was conducted on three rows, each having thirty dibbles. As the number of case studies varies, T_1, T_2, T_3 and T_4 treatments were conducted on first row, T_5 and T_6 on second row and T_7 on third row of the experiment.

The treatments consisted of pollinating varied number of female flower buds starting from $T_1 = 5$, $T_2 = 10$, $T_3 = 15$, $T_4 = 20$, $T_5 = 30$, $T_6 = 40$ and $T_7 = 50$, with single male flower.

In one replication respective number of female flower buds in each treatment were crossed. The treatments were replicated three times on three successive days one replication on one day.

The dates of crossing and number of flower buds crossed are as under :

Dates of crossing	No.of flower buds crossed
P_1 = 7-10-89, 8-10-89, 9-10-89	510 (170 on each date)
P_2 = 25-10-89, 26-10-89, 27-10-89	510 (170 on each date)
P_3 = 12-11-89, 13-11-89, 14-11-89	510 (170 on each date)

One day before the actual date of crossing the required number of female flower buds were emasculated and on the next these were pollinated according to the treatments. One male flower was used for pollinating respective number of flower bud in each treatment and then it was discarded.

Emasculation and pollination time was same as in second experiment. Each crossed flower bud was labled. The lables were indicated with the date of crossing, treatment, and the experiment number.

3.1.5.4 Effect of covering stigma on per cent boll set, seed number and seed weight per boll

The experiment was conducted as Factorial Randomised Block Design with two factors, viz. three levels of period of crossing and four treatments. This experiment was conducted on two rows each having 30 dibbles. Every row

was divided into two and in each row two treatments were allowed. All together four treatments were conducted in these two rows of this experiment. The four treatments used in this experiment are as under :

T_1 = Emasculated flower bud uncovered and crossed flower bud covered.

T_2 = Emasculated flower bud covered and crossed flower bud covered.

T_3 = Emasculated flower bud covered and crossed bud uncovered.

T_4 = Emasculated flower bud uncovered and crossed bud uncovered.

Each treatment consisted of 40 case studies and each treatment was replicated three times on three successive days, one replication on one day.

The dates of crossing and number of flower buds crossed on those dates were as under :

Dates of crossing	No.of flower buds crossed
P_1 = 10-10-89, 11-10-89, 12-10-89	480 (160 on each date)
P_2 = 28-10-89, 29-10-89, 30-10-89	480 (160 on each date)
P_3 = 15-11-89, 16-11-89, 17-11-89	480 (160 on each date)

The required number of flower buds were emasculated a day before the actual date of crossing. Half of these were left uncovered and for their easy identification on the next day they were tagged with coloured tags. On the next day for treatment 1 and 4 the uncovered emasculated buds were utilized. After crossing, the flower buds were covered or left uncovered as per the treatment. Straw tubes were used for covering. Time of emasculation and pollination was same as in experiment 2.

All the crossed flower buds were labled according to treatment, date of crossing and experiment number. The coloured tags used at the time of emasculation were removed after crossing.

3.1.5.5 Pollen viability

The experiment was conducted as Factorial Randomised Block Design with two factors, viz. three levels of period of crossing and four treatments as given below:

T_1 = Pollinating the emasculated flower bud with pollens from male flower opened on the day of crossing (Fresh pollen).

T_2 = Pollinating the emasculated flower bud with pollen from male flower opened on the previous day and stored for 24 hours in wet blotter paper.

T_3 = Pollinating the emasculated flower bud with pollen from male flower opened on the previous day and stored for 24 hours in wet cloth.

This experiment was conducted on one row having thirty dibbles. The total dibbles were divided into three equal number and were used for above three treatments saperately. In each treatment 25 case studies were undertaken for each date of crossing. The dates of crossing and number of flower buds crossed on those dates were as under:

	Date of crossing	No. of flower buds crossed
P_1 =	13-10-89, 14-10-89, 15-10-89	225 (75 on each date)
P_2 =	31-10-89, 1-11-89, 2-11-89	225 (75 on each date)
P_3 =	18-11-89, 19-11-89, 20-11-89	225 (75 on each date)

All the crossed flower buds were labled according to treatment, date of crossing and experiment number.

3.1.5.6 Effect of temperature and relative humidity

The data on maximum and minimum temperature (^{o}C) and relative humidity (%) on each date of crossing was

recorded. The range of maximum and minimum temperature and relative humidity during three periods of crossing was obtained for studying the effect of these environmental factors on per cent boll set, seed number and seed weight per boll.

3.2 Natural crossing (Vicinism)

The present investigation was under taken to know the extent of cross pollination to elucidate the infomation regarding the out crossing due to natural entities like bees, wind and various pollen transmitting agents. The arboreum culture G-27 having red pigmentation as a marker was sown at the centre of the plot surrounded by variety Eknath (PA-32) having green pigmentation. The experiment was conducted at cotton Research Station, M.A.U., Parbhani and sowing was done on 14th July, 1989.

3.2.1 Experimental material

3.2.1.1 G-27 (marker plant)

It is a diploid (G. arboreum) desi cotton variety having red pigmentation. It is used as a marker being pigmented strain. The plant body and flowers are dark red with dark yellow anthers. It flowers within 70-80 days.

The newly opened flowers are attractive for pollinating insects like honey bee, butter fly and various insects. The variety G-27 evolved at Punjab possesses higher yield potential and superior ginning outturn (38.39 %). It possesses short staple length (16-17 mm) which can be used only for blending purpose in woolen industry.

3.2.1.2 Eknath (PA-32)

It is a well known arboreum variety having superior G.O.T. (37-38 %) and staple length ranging from 23 to 24 mm. The seed index is 5 to 6. The plant body is green and flowers are light yellow with dark yellow anthers. It takes 70-80 days for flowering.

3.2.2 Layout and agronomic practices

The total area under experimental plot was 105 x 105 mater including 5 x 5 m marker plot of G-27. The red pigmented marker variety G-27 was sown in the centre of a square field of Eknath (PA-32) being green pigmentation.

The G-27 was sown in the centre with spacing 45 x 22.5 cm between rows and plants within the row respectively.

The Eknath (PA-32) was sown in square surrounded to the centre plot up to the distance of 50 meters. The spacing of 45 x 22.5 cm between the row and plants within the row was maintained and 110 rows were grown in all the directions.

The layout of the experiment was such that observations on the extent of natural crossing in different directions and distances can be recorded. A diagramatic representation of the layout is shown in figure 7.

Fertilizer doses were given at the rate of 50 kg N : 25 kg P_2O_5 : 25 kg K_2O per hectare. Nitrogen was given in two instolments, 25 kg N at the time of sowing and remaining 25 kg N at the time of square formation.

All the recommended plant protection measures were also taken whenever necessary.

3.2.3 Experimental methods

For obtaining the results the following steps were followed.

3.2.3.1 Picking of each row

The first picking was under taken after attending uniform boll bursting in experimental plot. The produce

from each row was picked separately in cloth bag. These cloth bags were labelled for their row number, direction of the picking and distance from the marker (centre plot).

The same procedure was adopted for second picking also.

3.2.3.2 Ginning of produce (kapas)

All the produce obtained from each row was ginned separately. The 40 gm sample was drawn from each bag (row) as a representative sample.

3.2.3.3 Field test

This test was carried out to test the possibility of presence of natural hybrids in each row.

The raised beds of 6 x 1.5 m size were prepared. The well rotted F.Y.M. was mixed throughly in the soil before preparing raise beds.

The beds were irrigated uniformly and seed samples from each row were sown. The observations were recorded after 25 days of the sowing at seedling stage. The number of natural hybrids having medium red cotyledons in each row was recorded. The percentage of natural crossing in each row was calculated on percentage basis.

4. EXPERIMENTAL FINDINGS

4. EXPERIMENTAL FINDINGS

The results obtained in the present investigations are presented bellow:

4.1 Study of time of emasculation and pollination

4.1.1 Per cent boll set

The results pertaining to per cent boll set have been presented in Table 1 & 2.

4.1.1.1 Per cent boll set in first period of crossing (P_1)

The analysis of variance (Table-1) indicated significant differences due to emasculation time, pollination time (PT) and interaction effect (ET x PT) for per cent boll set in first period of crossing.

Per cent boll set was significantly higher (31.89 %) when emasculation was done in morning (8 to 10 A.M.) than in the afternoon (24.16 %).

As regards time of pollination, maximum boll set (31.11 %) was obtained when pollination was done in the morning (10 A.M. to 12 noon) which was at par with 8 to 10 A.M. time of pollination. There was significant reduction in per cent boll set when pollination was done from 2 to 4 P.M. (22.77 %). The pollination done during

12 noon to 2 P.M. (28.79%) was, however, at par with the pollination timings of 8 to 10 A.M. (29.44 %).

The highest boll set (36.66 %) during the first period of crossing was observed when emasculation was done in the morning and pollination during 10 A.M. to 12 noon next day. This particular treatment (35.36 %) was at par with the treatment of emasculation in the morning and pollination during 12 to 2 P.M. on the next day. It therefore indicated that, emasculation in the morning from 8 to 10 A.M. and next day pollination from 10 A.M. to 2 P.M. was found to be suitable for higher boll set in first period of crossing. The lowest boll set (21.11 %) was observed when emasculation was done during 2 to 4 P.M. and pollination on the next day at 2 to 4 P.M.

4.1.1.2 Per cent boll set in second period of crossing (P_2)

The analysis of variance for boll set in second period of crossing (Table-1) indicated that the differences due to pollination timings (PT) were highly significant, where as they were nonsignificant due to emasculation timings. The differences due to interaction (ET x PT) were also nonsignificant.

During second period of crossing maximum boll set was observed when pollination was done during 10 A.M. to 12 noon (27.77 %) which was at par when pollination was done from 12 noon to 2 P.M. (24.99 %). The effect of emasculation time was however nonsignificant.

In the present investigation maximum boll set was observed when emasculation was done in the after noon from 2 to 4 P.M. and pollination on next day from 10 A.M. to 12 noon (28.88 %). This was at par with the treatment when emasculation was done during morning and pollination on next day from 10 A.M. to 12 noon (EMT_2) and morning emasculation with pollination from 12 noon to 2 P.M. on the next day (EMT_3). This indicated that emasculation in the morning and pollinations during 10 A.M. to 2 P.M. gives the reasonable boll set and was at par with the treatment of after noon emasculation and pollination on nextday from 10 A.M. to 12 noon (EMT_2). Emasculation in the morning and pollination during 2 to 4 P.M. (EMT_4) recorded lowest per cent of boll set (17.77 %) which was at par with emasculation in the afternoon and pollination from 8 to 10 A.M. This indicated that the emasculation timing being nonsignificant, the pollination during 8 to 10 A.M. and 2 to 4 P.M. significantly reduced the per cent boll set. However, pollination during 10 A.M. to 12 noon

Table 1 : Analysis of variance for the experiment to study effect of time of emasculation and pollination on per cent boll set in three periods of crossing P_1, P_2 and P_3.

Source	DF	Mean sum of square		
		P_1	P_2	P_3
Emasculation time (ET)	1	358.67**	1.86	90.71**
Pollination time (PT)	3	79.31**	69.75**	160.53**
ET x PT	3	39.72**	27.27*	11.73
Error	14	3.12	5.55	6.81

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 2 : Effect of time of emasculation and pollination on per cent boll set in three periods of crossing (P_1, P_2 and P_3).

Treatments	Per cent boll set		
	P_1	P_2	P_3
Emasculation time (ET)			
8 to 10 A.M. (EM)	31.89 (a)	23.34	30.27 (a)
2 to 4 P.M. (EA)	24.16 (b)	23.88	26.38 (b)
SE ±	0.510	0.680	0.753
CD (P=0.05)	1.547	N.S.	2.284
Pollination time (PT)			
8 to 10 A.M. (T_1)	29.44 (gq)	21.11 (p)	29.99 (p)
10 A.M. to 12 noon (T_2)	31.11 (p)	27.77 (q)	33.33 (q)
12 noon to 2 P.M. (T_3)	28.79 (q)	24.99 (pq)	28.89 (p)
2 to 4 P.M. (T_4)	22.77 (r)	20.55 (p)	21.11
SE ±	0.721	0.962	1.066
CD (P=0.05)	2.187	2.918	3.233
(ET x PT)			
EMT_1	31.11 (d)	23.33 (d)	32.22
EMT_2	36.66 (a)	26.66 (da)	35.55
MET_3	35.36 (a)	25.55 (da)	28.88
EMT_4	24.44 (f)	17.77 (f)	24.44
EAT_1	27.77 (g)	18.88 (f)	27.88
EAT_2	25.55 (g)	28.88 (e)	31.11
EAT_3	22.22 (fh)	24.44 (d)	28.88
EAT_4	21.11 (h)	23.33 (d)	17.77
SE ±	1.020	1.360	1.507
CD (P=0.05)	3.094	4.125	N.S.

Treatments with same letters in the bracket are at par in each coloumn.

and 12 noon to 2 P.M. seeds to be suitable for getting maximum boll set in second period of crossing.

4.1.1.3 Per cent boll set in third period of crossing (P_3)

The analysis of variance (Table-1) for the third period of crossing indicated significant differences due to emasculation time (ET) and pollination time (PT) for per cent boll set. The interaction effects due pollination and emasculation timings (ET x PT) were found to be nonsignificant.

Per cent boll set was higher (30.27 %) when emasculation was done from 8 to 10 A.M., than in the afternoon from 2 to 4 P.M. The afternoon emasculation recorded lowest per cent of boll set (26.38 %).

The pollination time from 10 A.M. to 12 noon recorded highest boll set and shown superior over all periods of pollination from 8 to 10 A.M., 12 noon to 2 P.M. and 2 to 4 P.M. The pollination time of 12 noon to 2 P.M. recorded 28.89 per cent boll set and was at par with the pollination from 8 to 10 A.M. The lowest boll set was observed when pollination was done from 2 to 4 P.M.

The interaction effects were found nonsignificant.

4.1.2 Seed number per boll

The results pertaining to the effect of time of emasculation and pollination on seed number per boll are presented in Table 3 & 4.

4.1.2.1 Seed number per boll in first period of crossing (P_1)

The analysis of variance (Table-3) indicated the significant differences due to time of pollination (PT) on seed number per boll. The effect of emasculation time (ET) recorded nonsignificant results. The interaction (ET x PT) effects on seed number per boll were also nonsignificant.

Seed number per boll was highest (21.67) when the pollination was done from 10 A.M. to 12 noon (T_2), and was at par with (20.17) when pollination was done from 12 noon to 2 P.M. (T_3). The pollination time from 8 to 10 A.M. (T_1) recorded lowest seed number (16.50) and was at par with T_4 i.e. when pollination was done from 2 to 4 P.M.

4.1.2.2 Seed number per boll in second period of crossing (P_2)

The analysis of the variance (Table-3) indicated significant differences due to time of pollination (PT) for seed number per boll in second period of crossing. The emasculation time (ET) was, however, nonsignificant.

Table 3 : Analysis of variance for the experiment to study the effect of time emasculation and pollination on seed number/boll in three periods of crossing (P_1, P_2 and P_3).

Source	Df	Mean sum of squares		
		P_1	P_2	P_3
Emasculation time (ET)	1	0.17	6.37	0.166
Pollination time (PT)	3	37.22**	35.15**	29.94**
ET x PT	3	0.28	3.37	1.056
Error	14	1.86	2.42	7.54

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 4 : Effect of time of emasculation and pollination on seed number per boll in three periods of crossing (P_1, P_2 and P_3).

Treatments	Seed number per boll		
	P_1	P_2	P_3
Emasculation time (ET)			
8 to 10 A.M. (EM)	18.92	19.42	18.83
2 to 4 PM. (EA)	18.75	18.67	19.00
SE ±	0.394	0.449	0.793
CD (P=0.05)	N.S.	N.S.	N.S.
Pollination time (PT)			
8 to 10 A.M. (T_1)	16.50 (p)	17.33 (p)	17.77 (p)
10 A.M. to 12 noon(T_2)	21.67 (q)	21.67 (q)	21.17 (q)
12 noon to 2 P.M.(T_3)	20.17 (q)	20.50 (q)	20.50 (q)
2 P.M. to 4 P.M. (T_4)	17.00 (p)	16.67 (p)	16.83 (p)
SE ±	0.557	0.635	1.121
CD (P=0.05)	1.689	1.926	3.400
(ET x PT)			
EMT_1	16.33	18.66	17.00
EMT_2	22.00	22.00	21.00
EMT_3	20.33	20.00	20.00
EMT_4	17.00	17.00	17.33
EAT_1	16.66	16.00	17.33
EAT_2	21.33	21.33	21.33
EAT_3	20.00	21.00	21.00
EAT_4	17.00	16.33	16.33
SE ±	0.788	0.899	1.585
CD (P=0.05)	N.S.	N.S.	N.S.

Treatments with same letters in the bracket are at par in each coloumn.

As regards to the pollination time (PT), the pollination time T_2 (10 A.M. to 12 noon) was most (21.67) superior for crossing and was at par with T_3 (pollination from 12 noon to 2 P.M.). The lowest value of seed number (16.67) per boll was recorded when pollination was done from 2 P.M. to 4 P.M. (T_4) and was at par with T_1 when pollination was done from 8 to 10 A.M.

The interaction effects (ET x PT) were non-significant in this second period of crossing.

4.1.2.3 Seed number per boll in third period of crossing (P_3)

The analysis of variance (Table-3) indicated the significant differences due to pollination time (PT). The emasculation time (ET) was nonsignificant for seed number per boll in this period of crossing.

As regards to the time of pollination (PT) T_2 recorded highest (21.17) seed number per boll when pollination was done from 10 A.M. to 12 noon and was at par with the treatment when pollination was done from 12 noon to 2 P.M. (T_3). The lowest seed number per boll was recorded (16.83) when pollination was done from 2 to 4 P.M. and was at par (17.17) with T_1 (8 to 10 A.M.).

The interactions effects (ET x PT) were non-significant for seed number per boll in this period of crossing.

4.1.3 Seed weight per boll(g)

The results pertaining to the effect of emasculation and pollination on seed weight per boll are presented in Table 5 & 6.

4.1.3.1 Seed weight per boll in first period of crossing (P_1)

The analysis of variance (Table-5) indicated the nonsignificant effect of emasculation time for seed weight per boll in first period of crossing. However, differences were significant due to time of pollination time.

The highest seed weight was recorded in T_2, (1.33 gm) when pollination was done from 10 A.M. to 12 noon and was at par with T_3, when pollination was done from 12 noon to 2 P.M. The lowest seed weight per boll was recorded (1.17 g) when pollination was done from 2 to 4 P.M. (T_4) and was at par with T_1 when pollination was done from 8 to 10 A.M.

The interaction effects (ET x PT) were nonsignificant for seed weight per boll in this period of crossing.

Table 5 : Analysis of variance for the experiment to study effect of time of emasculation and pollination on seed weight per boll in three period of crossing (P_1, P_2 and P_3).

Source	Df	Mean sum of square		
		P_1	P_2	P_3
Emasculation time (ET)	1	0.0037	0.0150	0.0009
Pollination time (PT)	3	0.0369	0.0390	0.0201
ET x PT	3	0.0018	0.0069	0.0009
Error	14	0.0025	0.0051	0.0107

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 6 : Effect of time of emasculation and pollination on seed weight per boll in three periods of crossing (P_1, P_2 and P_3)

Treatments	Seed weight per boll		
	P_1	P_2	P_3
Emasculation time (ET)			
8 to 10 A.M. (EM)	1.26	1.28	1.21
2 to 4 P.M. (EA)	1.24	1.23	1.22
SE ±	0.0145	0.0206	0.0298
CD (P=0.05)	N.S.	N.S.	N.S.
Pollination time (PT)			
8 to 10 A.M. (T_1)	1.19 (p)	1.19 (p)	1.22
10 A.M. to 12 noon (T_2)	1.33 (q)	1.35 (q)	1.29
12 noon to 2 P.M. (T_3)	1.30 (q)	1.29 (q)	1.22
2 to 4 P.M. (T_4)	1.17 (p)	1.18 (p)	1.15
SE ±	0.0206	0.0291	0.0422
CD (P=0.05)	0.062	0.088	N.S.
(ET x PT)			
EMT_1	1.18	1.26	1.20
EMT_2	1.35	1.36	1.30
EMT_3	1.33	1.30	1.21
EMT_4	1.18	1.18	1.13
EAT_1	1.20	1.11	1.23
EAT_2	1.32	1.33	1.28
EAT_3	1.27	1.28	1.22
EAT_4	1.16	1.18	1.16
SE ±	0.020	0.0412	0.0596
CD (P=0.05)	N.S.	N.S.	N.S.

Treatments with same letters in the bracket are at par in each coloumn.

4.1.3.2 Seed weight per boll in second period of crossing (P_2)

The analysis of variance (Table-5) indicated the significance differences due to pollination time. The emasculation time was found to be nonsignificant.

As regards to pollination time, pollination from 10 A.M. to 12 noon (T_2) recorded highest value (1.35 g) and was at par with T_3, when pollination was done from 12 noon to 2 P.M. The process of pollination from 2 to 4 P.M. (T_4) recorded lowest seed weight (1.18 g) and was at par with pollination from 8 to 10 A.M. (T_1).

The interaction effects (ET x PT) were nonsignificant for seed weight per boll in this period of crossing.

4.1.3.3 Seed weight per boll in third period of crossing (P_3)

No significant differences were observed in seed weight per boll when emasculation was done in the morning (8 to 10 A.M.) or in afternoon (2 to 4 P.M.).

The results were nonsignificant for pollination timings from 8 A.M. to 4 P.M.

Interaction effects were also nonsignificant.

4.2 Method of pollen application

The results pertaining to the effect of method of pollen application on per cent boll set, seed number and seed weight per boll in all the three periods of crossing (P_1, P_2 and P_3) are presented in Table 7 & 8.Fig.1.

4.2.1 Per cent boll set

The analysis of variance (Table-7) indicated significant differences over periods of crossing (PC) and pollination methods (PM). The interaction effects were also highly significant amongst these three periods of crossing for per cent boll set.

As regards to methods pollination of the treatment, rubbing of pollens on four sides of stigma and on tip (T_4) gave the highest boll set (39.25 %) which was at par with treatment of rubbing anthers on four sides of stigma except tip (T_3). The treatment touching the anthers only on tip of stigma (T_1) resulted in significant reduction in boll set, (25.18 %) and was at par with treatment when rubbing anthers on two sides of stigma (T_2).

As regards to period of crossing P_1 and P_2 (33.88 %) were superior to P_3. P_1 and P_2 were at par with each other (33.88 %). There was significant reduction in per cent boll set in third period of crossing (P_3) (28.88 %).

Table 7 : Analysis of variance for the experiment to study the effect of method of pollen application on per cent boll set, seed number and seed weight per boll in three period of crossing (P_1, P_2 and P_3).

Source	Df	Mean sum of squares		
		Boll set (%)	Seed number per boll	Seed weight per boll
Period (p)	2	100.02**	5.86	0.0026
Treatment (t)	3	363.73**	41.55**	0.0557**
P x T	6	118.11**	3.53	0.0031
Error	22	17.42	4.33	0.0045

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 8 : Effect of method of pollen application on per cent boll set, seed number and seed weight per boll.

Treatments &	Boll Set (%)	Seed number per boll	Seed weight per boll (g)
Pollination methods (PM)			
T_1	25.18 (a)	17.11 (a)	1.13 (a)
T_2	28.88 (a)	20.00 (b)	1.25 (b)
T_3	35.55 (b)	21.67 (b)	1.29 (b)
T_4	39.25 (b)	21.67 (b)	1.31 (b)
SE ±	1.391	0.6937	0.0225
CD (P=0.05)	4.079	2.034	0.066
Period of crossing (PC)			
P_1	33.88 (p)	19.75	1.23
P_2	33.88 (p)	20.92	1.26
P_3	28.88 (q)	19.67	1.24
SE ±	1.205	0.6007	0.0195
CD (P=0.05)	3.534	N.S.	N.S.
(PM x PC)			
P_1T_1	26.66 (e)	16.00	1.06
P_1T_2	32.22 (efgh)	20.00	1.25
P_1T_3	37.77 (fg)	21.00	1.30
P_1T_4	38.88 (fg)	22.00	1.31
P_2T_1	35.55(fgh)	19.00	1.17
P_2T_2	28.88 (eh)	20.00	1.25
P_2T_3	21.10 (eh)	23.00	1.30
P_2T_4	39.99 (g)	23.00	1.31
P_3T_1	13.33 (i)	16.33	1.15
P_3T_2	25.55 (eh)	20.00	1.25
P_3T_3	37.77 (fg)	22.33	1.26
P_3T_4	38.88 (fg)	22.00	1.28
SE ±	2.410	1.2015	0.0389
CD (P=0.05)	7.068	N.S.	N.S.

Treatments with same letters in the bracket are at par in each column.

T_1 – TOUCHING ANTHERS ON TIP OF STI

T_2 – RUBBING ANTHERS ON TWO APPOSITE SIDES OF STIGMA.

T_3 – RUBBING ANTHERS ON FOUR SIDES OF STIGMA EXCEPT TIP

T_4 – RUBBIN ANTHERS ON FOUR SIDES OF STIGMA AND ON TIP OF STIGMA

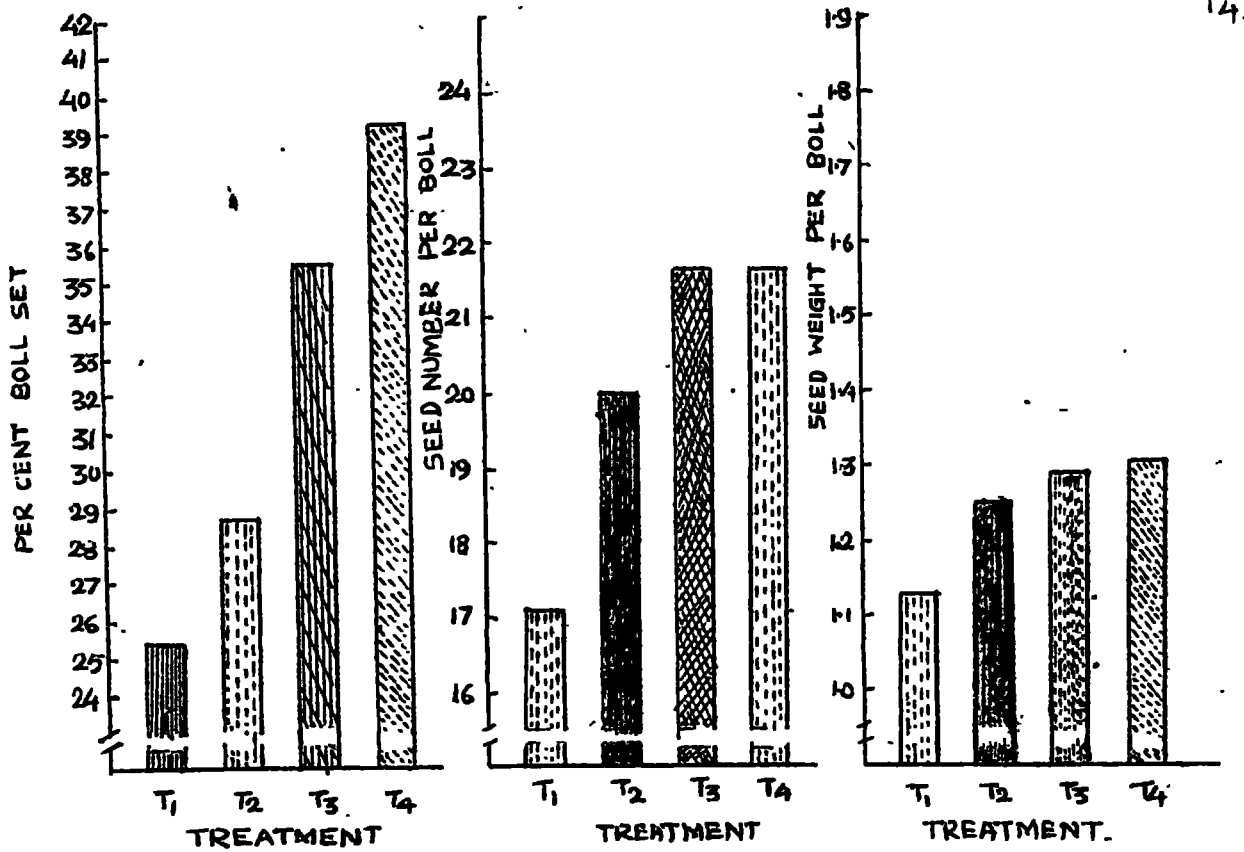


FIG-1. EFFECT OF DIFFERERENT METHODS OF POLLEN APPLICATION ON PER CENT BOLL SET, SEED NUMBER AND SEED WEIGHT PER BOLL.

The interactions effects were significant. In first period of crossing, the treatment of rubbing of burst anthers on four sides of stigma and on tip of stigma i.e. (P_1 T_4) recorded maximum boll set, this particular treatment was at par with P_1T_2 (rubbing authers on two sides of stigma during first period of crossing), P_1T_3 (rubbing anthers on four sides of stigma except tip in first period crossing), P_2T_1 (touching anthers on tip of stigma in second period of crossing), P_3T_3 (rubbing anthers on four sides of stigma except tip in three period of crossing) and P_3T_4 (rubbing anthers on four sides of stigma and on tip of stigma in third period of crossing). The treatment of touching anthers on tip of stigma in first period crossing (P_1T_2) recorded lowest per cent of boll set (26.66 %) which was at par with P_1T_2 (rubbing anthers on two sides of stigma in first period of crossing), P_2T_2 (rubbing anthers on two sides of stigma in second period of crossing), P_2T_3 (rubbing anthers on four sides of stigma except tip in second period of crossing) and P_3T_2 (rubbing anthers on two sides of stigma in third period of crossing).

In second period of crossing the treatment of rubbing anthers on four sides of stigma and tip of stigma (P_2T_4) gave maximum boll set (39.99 %) in second period,

and was at par with P_3T_3 (rubbing anthers on four sides of stigma in third period of crossing), P_3T_4 (rubbing anthers on four sides of stigma and on tip in third period of crossing), P_2T_4 (toughing anthers on tip in second period of crossing), P_1T_4 (rubbing anthers on four sides of stigma and on tip in first period of crossing) and P_1T_3 (rubbing anthers on four sides of stigma except tip in first period of crossing).

In third period of crossing significant reduction in per cent boll was observed in P_3T_1 (13.33 %).

4.2.2 Seed number per boll

The analysis of variance (Table-7) indicated that, differences due to pollinations method were significant, whereas the differences due to period of crossing and interaction effects were nonsignificant.

The method of pollination T_4 (rubbing anthers on four sides of stigma and tip of stigma) recorded highest value (21.67) and was at par with T_2 (anthers rubbing on two sides of stigma and T_3 (rubbing anthers on four sides of stigma except tip). The treatment of pollination T_1 (touching anthers on tip of stigma) showed lowest seed number per boll (17.11).

4.2.3 Seed weight per boll (g)

The analysis of variance (Table-7) indicated

that differences due to effect of pollinations were significant. The period of crossing was nonsignificant for the seed weight per boll in all the three periods of crossing.

As regards to pollinations method, T_4 (rubbing anthers on four sides of stigma and on tip) depicted highest seed weight (1.31 g) per boll and was at par with T_2 (rubbing anthers on two sides of stigma) and T_3 (rubbing anthers on four sides of stigma except tip). The T_1 (touching anthers on tip of stigma) obtained lowest seed weight (1.13 g).

Interaction effects of treatment and period of crossing on seed weight per boll were found to be nonsignificant.

4.3. Number of female flower buds to be pollinated with single male flower

The results pertaining to the per cent boll set, seed number and seed weight per boll affected by pollinating varied number of female flower with single male flower for various periods (P_1, P_2 and P_3) of crossing are presented in Table 9 & 10, Fig. 2.

4.3.1 Per cent boll set

The analysis of variance (Table-9) for per cent boll set in three periods of crossing indicated significant difference due to pollination.

The effect of period of crossing was nonsignificant. The pollination treatment T_1 (when single male flower used to pollinate 5 female flower buds) recorded highest boll set (55.56 %). The lowest boll set (19.33 %) was observed when single male flower was used to pollinate 50 female flower buds (T_7). There was significant reduction in per cent boll set when single male flower was pollinated with increased number of emasculated buds. The treatment T_3 (single male flower used to pollinate 15 female flower buds) showed 39.26 per cent boll set and was at par with T_4 (single male flower used to pollinate 20 female flower buds). Interaction effects for per cent boll set were nonsignificant.

4.3.2 Seed number per boll

The analysis of variance for seed number per boll in three periods of crossing indicated significant differences. The period of crossing was however, found to be nonsignificant.

Table 9 : Analysis of variance for the experiment to study the effect of method of pollen application on per cent boll set, seed number and seed weight per boll in three periods of crossing (P_1, P_2 and P_3).

Source	Ef	Mean sum of squares		
		Boll set (%)	Seed number per boll	Seed weight per boll
Period (p)	2	1.07	5.82	0.0114
Treatment (t)	6	1479.61**	62.27**	0.0480**
P x T	12	61.91	2.19	0.0022
Error	40	40.98	2.93	0.0054

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 10 : Effect of pollinating varied number of female flower buds with single male flower on percent boll set, seed number and seed weight per boll.

Treatments	Boll set (%)	Seed number per boll	Seed weight per boll (g)
Buds pollinated (BP)			
5 T_1	55.56 (a)	23.33 (a)	1.33 (a)
10 T_2	47.78 (b)	22.67 (a)	1.29 (ab)
15 T_3	39.26 (c)	21.00 (b)	1.24 (bc)
20 T_4	33.52 (cd)	19.78 (bc)	1.22 (bcd)
30 T_5	28.15 (de)	18.33 (cd)	1.18 (d)
40 T_6	25.50 (e)	17.89 (d)	1.18 (d)
50 T_7	19.33 (f)	16.11 (e)	1.17 (d)
SE ±	2.137	0.570	0.0244
CD (P=0.05)	6.098	1.629	0.070
Period of crossing (PC)			
P_1	35.36	19.81	1.24
P_2	35.81	20.43	1.23
P_3	35.59	19.38	1.20
SE ±	1.397	0.373	0.0159
CD (P=0.05)	N.S.	NS.S	N.S.
(PC x BP)			
P_1T_1	53.33	23.00	1.35
P_1T_2	46.66	23.00	1.31
P_1T_3	37.77	20.00	1.25
P_1T_4	35.00	20.00	1.25
P_1T_5	28.88	19.33	1.21
P_1T_6	26.50	17.00	1.18
P_1T_7	19.33	16.00	1.13
P_2T_1	60.00	23.66	1.33
P_2T_2	50.00	22.66	1.28
P_2T_3	37.77	21.00	1.26
P_2T_4	30.55	20.33	1.21
P_2T_5	26.66	19.66	1.23
P_2T_6	25.00	18.66	1.16
P_2T_7	20.66	16.00	1.10
P_3T_1	53.33	23.33	1.31
P_3T_2	46.66	22.33	1.26
P_3T_3	42.22	20.66	1.21
P_3T_4	35.00	19.00	1.18
P_3T_5	28.88	16.00	1.10
P_3T_6	25.00	18.00	1.18
P_3T_7	18.00	16.00	1.11
SE ±	3.696	0.988	0.0423
CD (P=0.05)	N.S.	N.S.	N.S.

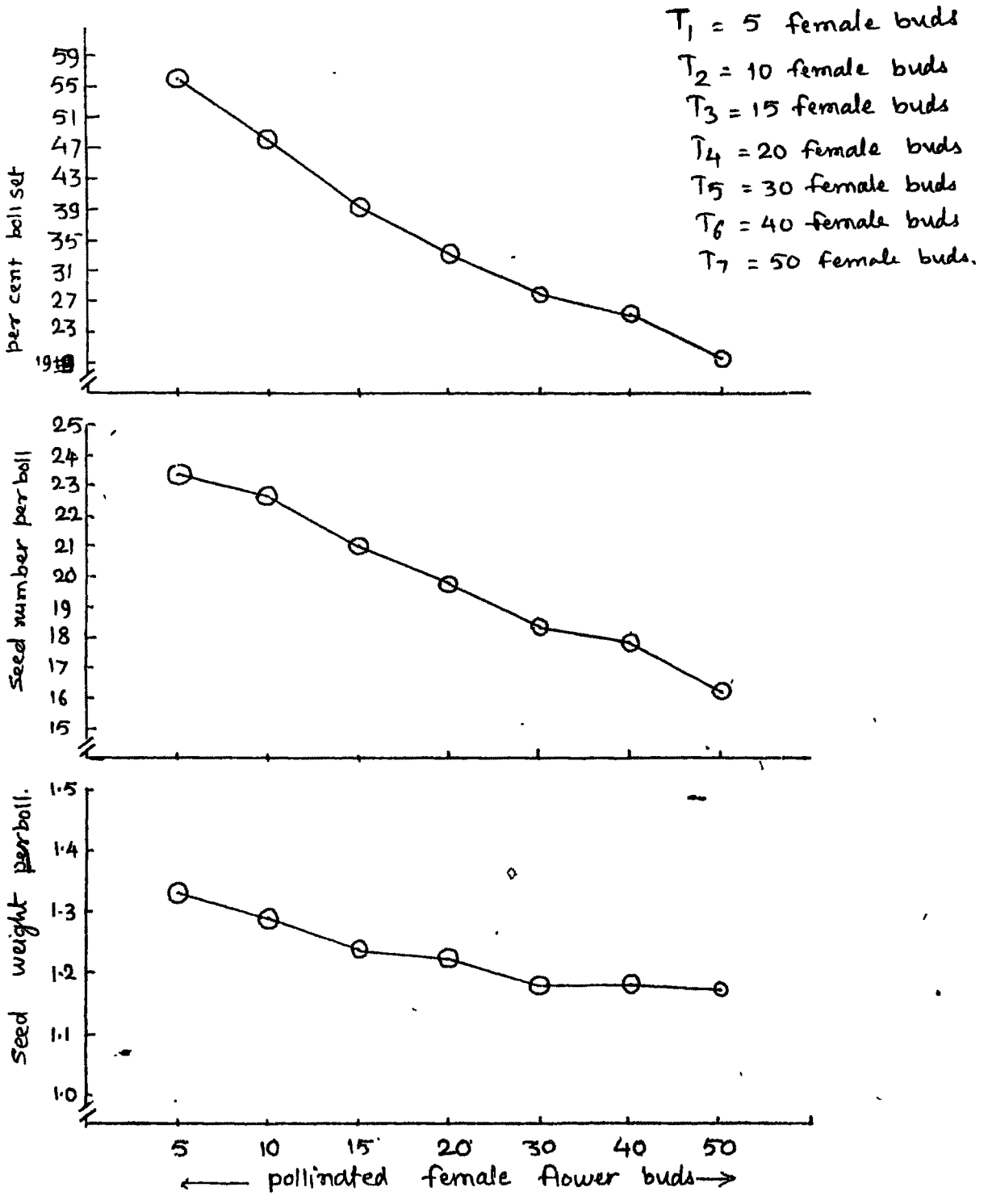


Fig. 2. EFFECT OF POLLINATING VARIED NUMBER OF FEMALE FLOWER BUDS POLLINATED WITH SINGLE MALE FLOWER.

As regards pollination treatments, T_1 was found to be with highest seed number per boll (23.33) which was at par with T_2 (single male flower used to pollinate 10 female flower buds). The treatment T_3 (single male flower used to pollinate 15 female flower buds) obtained 21.00 seeds per boll and was at par wtih T_4 (single male flower used to pollinate 20 female flower buds). T_4 was at par with T_5. The treatment T_7 (single male flower used to pollinate 50 female flower buds) recorded lowest seed number (16.11). The treatment (T_6) where in single male flower was used to pollinate 40 female flower buds recorded 17.89 seed number and was at par with T_5.

4.3.3 Seed weight per boll

The analysis of varience (Table-9) indicated that the differences due to pollination were significant whereas for that of for period of crossing were nonsignificant.

As regards to the pollination of bud, when a single male flower was used to pollinate 5 female flower buds (T_1), the highest seed weight (1.33 g) was obtained. This treatment (T_1) was found to be at par with T_2 (when single male flower was used to pollinate 10 female flower

buds). The treatment (T_7) when single male flower was used to pollinate 50 female flower buds recorded lowest seed weight (1.17) and was at par with T_6, T_5 and T_4.

The interaction effect were observed as non-significant in all the three periods of crossing for seed weight per boll.

4.4 Effect of covering stigma on per cent boll set, seeds number and seed weight per boll

The results pertaining to the effect of covering stigma on per cent boll set, seed number and seed weight per boll for all the three periods of crossing (P_1, P_2 and P_3) are presented in Table 11 & 12, Fig. 3.

4.4.1 Per cent boll set

The analysis of variance for the per cent boll set (Table-11) indicated significant differences due to period of crossing and per cent boll set. The treatment effect was also found to be significant.

Per cent boll set was significantly highest in T_2 (29.72 %) i.e. when emasculated and crossed flower bud were covered (20.56 %) by straw tubes.

The lowest boll set was recorded in T_4 (15.28 %) i.e. when emasculated and crossed buds were kept uncovered. T_2 was superior over all the remaining treatments T_1, T_3 and T_4.

As regards to period of crossing highest value of boll set (25 %) was recorded in 1st period of crossing (P_1) and was significantly superior than P_2 and P_3 (second and third period of crossing) for per cent boll set.

The highest boll set was observed in P_2T_2 (33%) i.e. when the emasculated and crossed flower buds were covered in second period of crossing.

The treatment P_1T_3 (when emasculated flower bud uncovered) was superior (28.33 %) and was at par with P_1T_1 (emasculated flower bud uncovered and crossed flower bud covered), P_1T_2 (emasculated flower bud and crossed flower bud covered), P_2T_3 (emasculated flower bud covered and crossed bud uncovered in second period of crossing) and P_3T_2 (emasculated and crossed flower bud covered in third period of crossing). The treatment P_1T_4 (emasculated and crossed flower bud uncovered in first period of crossing) was at par with P_2T_1, P_2T_4, P_3T_1 and P_3T_3. The lowest value for per cent boll set (13.33 %) was observed in P_3T_4.

4.4.2 Seed number per boll

The analysis of variance (Table-11) indicated that treatment effects were significant and period of crossing was nonsignificant for seed number per boll in all the three periods of crossing.

Table 11 : Analysis of variance for the experiment to study the effect of covering stigma on per cent boll set, seed number and seed weight per boll in three periods of crossing (P_1, P_2 and P_3).

Source	Df	Mean sum of squares		
		Boll set (%)	Seed number per boll	Seed weight per boll
Period (p)	2	69.27**	1.33	0.0004
Treatment (t)	3	346.93**	68.69**	0.0360**
P x T	6	35.48**	1.44	0.0012
Error	22	5.26	3.18	0.0018

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 12 : Effect of covering stigma on per cent boll set, seed number and seed weight per boll

Treatments	Boll set (%)	Seed number per boll	Seed weight per boll
Covering modification (CM)			
T_1	20.56 (a)	20.44 (a)	20.22 (a)
T_2	29.72 (b)	22.00 (ab)	1.28 (b)
T_3	25.28 (c)	23.11 (b)	1.29 (b)
T_4	15.28 (d)	16.78 (c)	1.16 (c)
SE ±	0.76	0.595	0.0144
CD (P=0.05)	2.229	1.745	0.042
Period of crossing (PC)			
P_1	25.00 (a)	20.92	1.24
P_2	22.92 (b)	20.58	1.24
P_3	20.21 (c)	20.25	1.23
SE ±	0.66	0.516	0.0125
CD (P=0.05)	1.936	N.S.	N.S.
(PC x CM)			
P_1T_1	26.66 (e)	20.66	1.21
P_1T_2	27.50 (e)	22.33	1.26
P_1T_3	28.33 (e)	23.00	1.31
P_1T_4	17.50 (f)	17.66	1.16
P_2T_1	16.66 (f)	21.00	1.23
P_2T_2	33.00 (h)	22.00	1.28
P_2T_3	26.66 (e)	23.66	1.30
P_2T_4	15.00 (f)	15.66	1.13
P_3T_1	18.33 (f)	19.66	1.20
P_3T_2	28.33 (e)	21.66	1.28
P_3T_3	20.83 (f)	22.66	1.26
P_3T_4	13.33 (g)	17.00	1.16
SE ±	1.32	1.031	0.0250
CD (P=0.05)	3.871	N.S.	N.S.

Treatments with same letters in the bracket are at par in each coloumn.

T_1 = EMASCULATED BUD UNCOVERED AND CROSSED BUD COVERED

T_2 - EMASCULATED AND POLLINATED BUD COVERED

T_3 = EMASCULATED BUD COVERED AND CROSSED BUD UNCOVERED

T_4 = EMASCULATED AND CROSSED BUD UNCOVERED

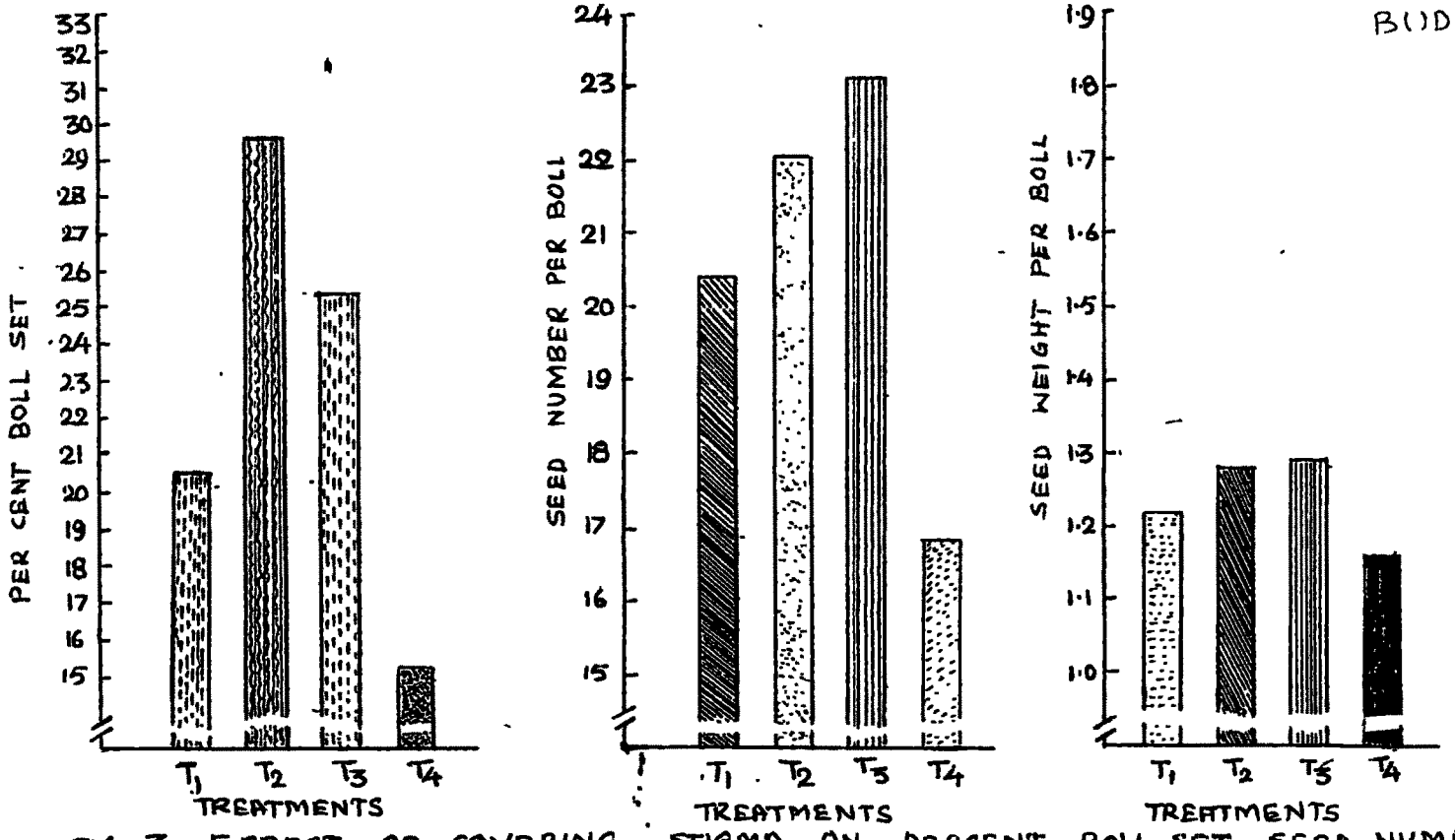


FIG. 3 EFFECT OF COVERING STIGMA ON PERCENT BOLL SET SEED NUMBER AND SEED WEIGHT PER BOLL.

As regards to treatment effect, the treatment T_3 (emasculated flower bud covered and crossed bud uncovered) recorded highest seed number per boll (23.11) and was significantly superior over T_1 and T_4, and was at par with T_2 (emasculated and crossed flower bud covered). Significantly lowest seed number per boll (16.78) was observed in T_4 when emasculated and crossed flower buds were uncovered.

The interaction effects were nonsignificant.

4.4.3 Seed weight per boll

The analysis of variance (Table-11) indicated that treatment differences were significant. The differences due to period of crossing were, however, nonsignificant.

The seed weight was highest in T_3 (1.29 g) when emasculated flower buds were covered and crossed bud were kept uncovered and was at par with T_2 (when emasculated and crossed buds covered). The treatment T_4 (when emasculated and crossed flower buds were uncovered) recorded lowest seed weight (1.16 g).

The interaction effects were nonsignificant for all the three periods of crossing pertaining to seed weight per boll.

4.5 Pollen viability

The results pertaining to the effect of method of pollen application on per cent boll set, seed number and seed weight per boll in all the periods of crossing (P_1, P_2 and P_3) are presented in Table 13 & 14. Fig. 4.

4.5.1 Per cent boll set

The analysis of variance (Table-13) indicated that the treatment effects due to pollen viability were significant. The effects due to period of crossing were also significant.

As regards to the treatment T_1 (when fresh pollens were used for pollination) recorded the highest boll set (36.00 %) which was highly significant over T_2 and T_3.

The treatment T_3, where in the pollens were stored for 24 hours in wet cloth gave the lowest boll set (8.44 %).

The first period of crossing P_1 (20.44 %) recorded highest boll set which was at par with P_2 i.e. second period of crossing. Whereas in P_3 there was lowest boll (16.44 %).

The interaction effects due to storage condition and period of crossing were nonsignificant.

Table 13 : Analysis of variance for the experiment to study the effect of covering stigma on per cent boll set, seed number and seed weight per boll in three periods crossing (P_1, P_2 and P_3).

Sourse	Df	Mean sum of squares		
		Boll set (%)	Seed number per boll	Seed weight per boll
Period (p)	2	39.70*	3.11	0.0017
Treatment (t)	2	2021.93**	64.33**	0.0359**
P x T	4	5.03	1.11	0.0006
Error	16	9.26	4.94	0.0030

*, ** = significant at 5 per cent and 1 per cent level, respectively.

Table 14 : Effect of pollen storage conditions on per cent boll set, seed number and seed weight per boll.

Treatments	Boll set (%)	Seed number per boll	Seed weight per bodl (g)
Storage conditions (SC)			
T_1	36.00 (a)	20.11 (a)	1.24 (a)
T_2	12.00 (b)	17.78 (b)	1.21 (b)
T_3	8.44 (c)	14.78 (c)	1.21 (b)
SE ±	1.0143	0.7411	0.0185
SD (P=0.05)	3.041	2.222	0.055
Period of crossing (PC)			
P_1	20.44 (d)	17.11	1.17
P_2	19.55 (d)	17.33	1.19
P_3	16.44 (e)	18.22	1.20
SE ±	1.0143	0.7411	0.0185
CD (P=0.05)	3.041	N.S.	N.S.
(PC x SC)			
P_1T_1	38.66	19.00	1.21
P_1T_2	13.33	18.00	1.18
P_1T_3	9.33	13.66	1.11
P_2T_1	36.00	20.00	1.25
P_2T_2	12.00	17.00	1.21
P_2T_3	10.66	15.00	1.13
P_3T_1	33.33	20.66	1.25
P_3T_2	10.66	18.33	1.15
P_3T_3	5.33	15.66	1.20
SE ±	1.757	1.284	0.0320
CD (P=0.05)	N.S.	N.S.	N.S.

Treatments with same letters in the bracket are at par in each coloumn.

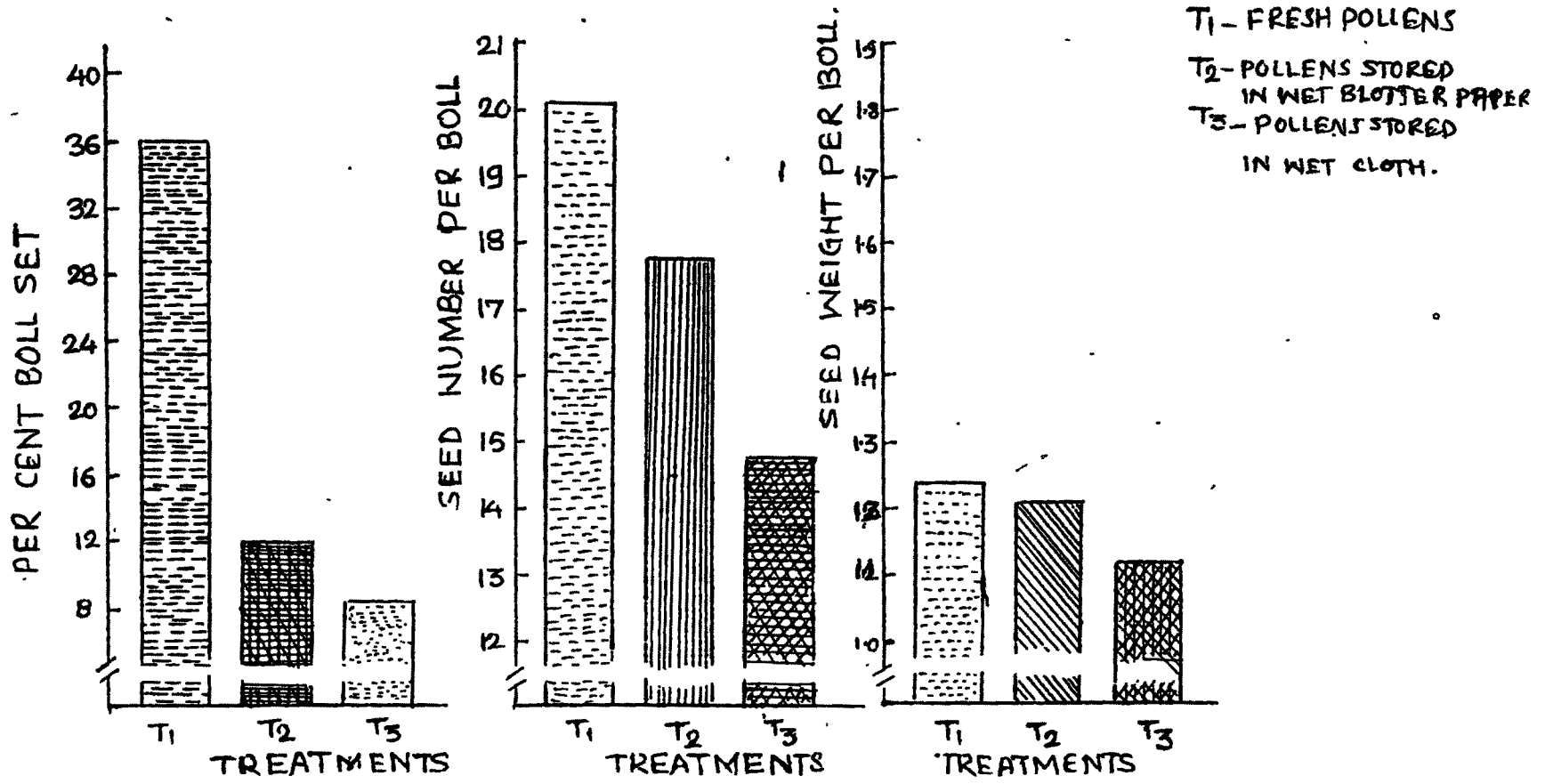


FIG-4: EFFECT OF DIFFERENT POLLEN STORAG CONDITIONS ON PER CENT BOLL SET, SEED NUMBER AND SEED WEIGHT PER BOLL.

4.5.2 Seed number per boll

The analysis of variance (Table-13) indicated that the differences due to treatment effect were highly significant.

The treatment T_1 (when fresh pollen from newly opened flower were used for pollination) recorded the highest seed number 21.11, whereas the T_3 (when emasculated buds were pollinated from male flower opened on the previous day and stored for 24 hours in wet cloth) recorded the lowest seed number (14.78).

As regards to period of crossing the results were nonsignificant.

The interaction effects due to treatment and period of crossing recorded nonsignificant results.

4.5.3 Seed weight per boll (g)

The analysis of variance (Table-13) indicated that the treatment effects were significant whereas, effects due to period of crossing were nonsignificant.

The treatment (T_1), where in the emasculated flower buds were pollinated with pollen from male flower opened on the day of crossing (fresh pollen), indicated the highest seed weight per boll (1.24 g).

When the emasculated buds were pollinated with pollen from flower opened an the previous day and stored for 24 hours in wet blotter paper (T_2) noticed the seed weight 1.21 g which was at par with the treatment T_3.

Period of crossing noticed the nonsignificant results.

As regards to the interaction effects, the differences due to interaction of treatments and period of crossing were nonsignificant.

4.6 Effect of temperature and relative humidity on per cent boll set, seed number and seed weight per boll.

The results pertaining to the effect of temperature and relative humidity during three periods of crossing on per cent boll set, seed number and seed weight per boll are presented in Table 15. Fig. 5 & 6.

The figures indicated that there was little effect of temperature and relative humidity on per cent boal set in third period of crossing P_3) as compared to the first and second period of crossing.

Similarly the effect of temperature and humidity on seed number and seed weight per boll was also negligible during all the three periods of crossing. The meteorological

Table 15 : Effect of temperature and relative humidity during three periods of crossing onper cent boll set, seed number and seed weight per boll.

Period of crossing	Boll set (%)	Seed number per boll	Seed weight per boll(g)
P_1	28.54	19.28	1.22
P_2	27.15	19.66	1.23
P_3	25.88	19.28	1.21

Table 16 : Meteorological data showing range of temperature (^oC) and relative humidity (%) during three periods of crossing.

Periods of crossing	Range of temperature ^oC Maximum	Minimum	Range of RH (%)
P_1	31.8 to 36.00	20.5 to 22.9	52.0 to 91.0
P_2	31.7 to 34.00	16.3 to 21.2	44.0 to 86
P_3	30.6 to 32.6	15.5 to 20.2	49.0 to 69

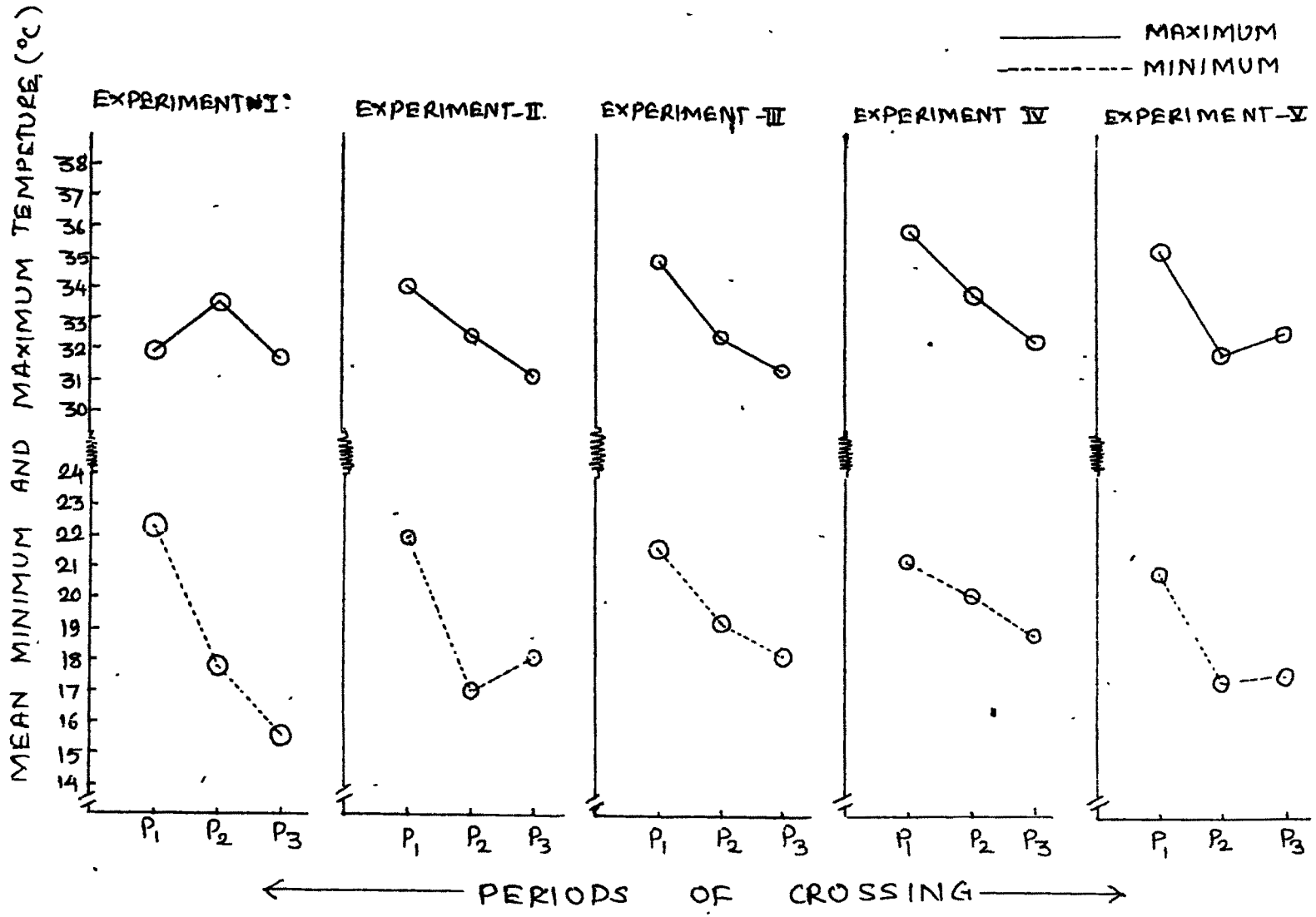


Fig-5. MEAN MINIMUM AND MAXIMUM TEMPERATURE (°C) DURING THREE PERIODS OF CROSSING IN EACH OF THE FIVE EXPERIMENTS.

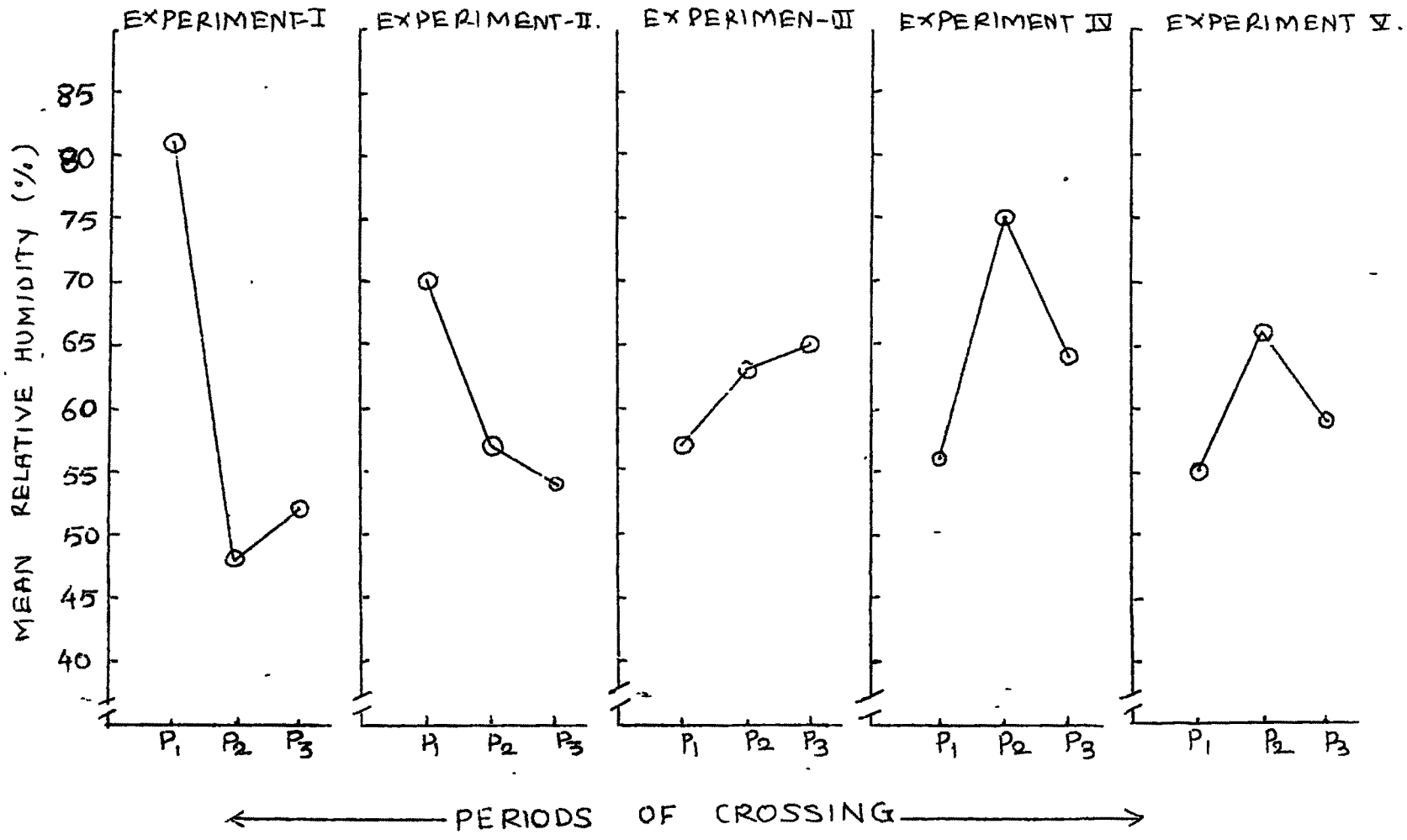


Fig - 6 :. MEAN RELATIVE HUMIDITY DURING THREE PERIODS OF CROSSIN IN EACH OF THE FIVE EXPERIMENTS

data pertaining to these three periods of crossing (P_1, P_2 and P_3) with regards to range of maximum and minimum temperature and relative humidity is presented in Table 16.

4.2 Natural crossing (Vicinism)

The extent of natural crossing was judged from the number of plants with light red colour of cotyledonary leaves and shoot of the seedlings. The data pertaining to natural crossing for different distances and directions is presented in Table 17. Fig. 7.

4.2.1 Extent of natural crossing at different distances

The observations pertaining to per cent of natural crossing at different distances, directions for two pickings have been presented in Table 17.

The observations pertaining to the produce of first picking indicated that the 1st row at a distance of 0.45 meter from marker plot of G-27 recorded 2.69 per cent of natural crossing in south direction, 1.42 in north direction, 1.89 in east direction and 2.12 per cent in west direction. The extent of natural crossing was 1.78 per cent in South, 2.67 per cent in North, 1.45 per cent in East and 1.80 per cent in West direction at a distance of 0.9 meter. The third row at the distance of 1.35 meter in south, North, East and West direction recorded 1.82,

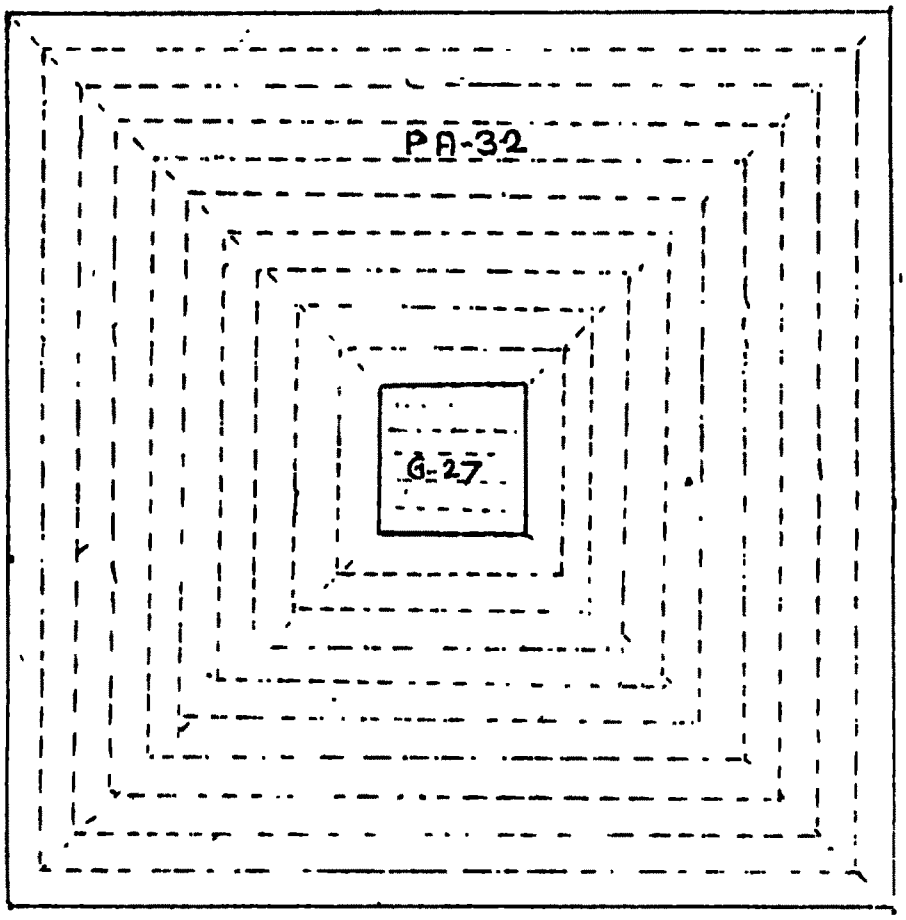


FIG. 7: VICINISM: A DIAGRAMATIC REPRESENTATION OF THE LAYOUT.

Table 17 : Natural crossing in desi Cotton at different distances and directions (Percentage).

Row No	Distance from marker Plot (Meter)	Seedling under study raised on Nursery beds								Cross pollinated F_1's observed (natural hybrids)								Percentage of natural Crossing.							
		Ist Picking				IInd Picking				Ist Picking				IInd Picking				Ist Picking				IInd Picking			
		South	North	East	West	South	North	East	West	South	North	East	West	South	North	East	West	South	North	East	West	South	North	East	West
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	0.45	408	490	370	517	390	382	405	472	11	7	7	11	8	6	9	7	2.69	1.42	1.89	2.12	2.05	1.57	2.22	1.48
2.	0.90	503	411	411	500	505	507	411	490	9	11	6	9	9	5	8	9	1.78	2.67	1.45	1.80	1.78	0.98	1.94	1.83
3.	1.35	383	403	503	495	380	491	390	506	7	9	4	9	8	7	8	5	1.82	2.23	0.79	1.81	2.10	1.42	2.05	0.98
4.	1.80	370	400	414	392	372	419	395	428	8	7	6	7	7	4	5	5	2.16	2.50	1.44	1.78	1.88	0.95	1.26	1.16
5.	2.25	382	385	370	428	402	382	420	434	5	4	3	3	4	5	4	3	1.30	1.03	0.81	0.70	0.99	1.33	0.95	0.69
6.	2.70	301	307	412	403	415	307	292	400	3	2	3	2	3	3	1	1	0.99	0.65	0.72	0.49	1.92	0.97	0.34	0.25
7.	3.15	407	490	390	382	411	402	375	392	1	1	1	3	-	1	2	-	0.24	0.20	0.25	0.78	---	0.24	0.53	-
8.	3.60	409	391	409	401	353	501	382	485	-	2	-	-	3	2	-	2	-	0.51	-	-	0.84	0.39	-	0.41
9.	4.05	350	407	406	332	343	493	319	395	1	-	1	1	1	1	-	-	0.28	-	0.24	0.30	0.29	0.20	-	-
10.	4.50	342	322	317	377	509	320	412	391	-	-	-	-	-	-	-	1	-	-	-	-	0.19	-	-	0.25
11.	4.95	503	341	385	482	318	315	480	402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	5.40	401	382	418	492	415	419	419	372	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	5.85	402	407	372	390	312	501	515	501	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14.	6.30	404	391	501	500	291	328	419	413	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.	6.75	405	418	497	467	272	392	370	471	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.	7.20	502	437	415	378	295	504	461	417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17.	7.65	311	372	498	419	309	318	502	391	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.	8.10	290	503	415	502	321	419	418	395	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.	8.55	271	428	312	403	487	315	392	503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20.	9.00	293	401	501	512	281	490	428	396	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.	9.45	319	392	510	392	403	428	419	493	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.	9.90	328	417	360	411	505	372	405	387	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23.	10.35	285	503	472	503	291	415	395	419	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24.	10.80	272	312	328	427	305	419	372	318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25.	11.25	340	509	503	391	411	450	415	402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26.	11.70	372	419	488	401	381	392	488	413	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Raw number 27 to 110 i.e. at the distances of 12.15 to 50 meters there was zero percentage of natural crossing.

2.23, 0.79 and 1.81 per cent natural crossing respectively. In general there was decrease in natural crossing with the increase in distance of rows from marker plot. Ninth row of the south direction at a distance of 4.05 meter from market plot recorded 0.28 per cent natural crossing. There was 'Zero' per cent natural crossing at same distance in the North direction, 0.24 per cent at East direction and 0.30 per cent at west direction.

As regards to second picking, the 1st row at a distance of 0.45 meter recorded 2.05, 1.57, 1.22 and 1.48 per cent natural cross pollination in South, North, East and West direction respectively. Similarly second row at distance of 0.90 meter in South, North, East and West direction depicted 1.78, 0.98, 1.94 and 1.83 per cent of natural crossing respectively. The third row at a distance of 1.35 meter gave 2.10, 1.42, 2.05 and 0.98 per cent of natural crossing in South, North, East and West direction respectively. The lowest per cent of natural hybrids were found in 10th row at a distance of 4.50 meter in South, North, East and West direction. The per cent of natural crossing at a distance of 4.5 meter was hardly 0.19, 0.00, 0.00 and 0.25 per cent respectively.

...

5. DISCUSSION

5. DISCUSSION

Inspite of previous efforts to replace *desi* cotton (*G. arboreum* L.) with *hirsutum* or American cotton, *desi* cottons are still cultivated on large area of the country. The share of *desi* cotton in increasing the production can not be over looked. The majority of the marginal cultivators had attraction towards the cultivation of *desi* cotton mainly because of their drought tolerance and registance to pest and diseases. Their morphological characteristics such as deep root system, smaller leaf size, thin stem and smaller bolls coupled with effecient physiological system unable them to stand seviour moisture stress during prolong drought. Becauss of this advantage *desi* cottons are largely grown under rainfed condition in perference to *hirsutums*.

The production of these cottons can be increased through *desi* cotton hybrids involving *Gossypium herbaceum* and *Gossypium arboreum* species (Padaki 1980). Previous work on large scale trials conducted at Surat, Dharwad and Parbhani indicated that interspecific *desi* cotton hybrids had potential to give 50 to 78 per cent higher yield than the best local variety.

The work on developing *desi* hybrids was started at Parbhani during mid eighties. A large number of

promising interspecific herbaceum x arboreum hybrid combinations were tested and a hybrid Pha-46 have been indentified. The hybrdd Pha-46 is likely to be released for general cultivation very soon. Though the desi cottons had higher yield potential under rainfed condition and can be cultivated with low inputs by the marginal cultivaters possesses some problems of hybrid seed production. The seed production of desi hybrids cannot made much headway mainly because of (i) low boll set, (ii) short period of seed viability and (iii) high cost of seed production.

The present investigation is therefore a sincere effort to indentify suitable seed production technique which will be helpful for commercial exploitation of hybrids vigour in desi cotton with low input technology.

In the present investigation result obtained from five experiments pertainingg to the hybrid seed production technique in desi cotton hybrid Pha-46 are discussed in relation to important traits, viz. per cent boll set, seed number per boll and seed weight per boll.

5.1 Hybrid seed production technique

5.1.1 Per cent boll set

5.1.1.1 Emasculation and pollination timings

The process of emasculation in desi cotton is

already tedious because of smaller bud size. The reduction in per cent boll set can be avoided by suitable technique and proper time of emasculation. In addition to suitable time of emasculation, it is also essential to assess proper time of pollination for getting maximum boll set in successful and remunerative hybrid seed production programme of desi cotton.

In the present investigation, the per cent boll set was significantly higher when emasculation was done in morning (8 to 10 A.M.) in first period of crossing (31.89 %). In second period of crossing the per cent bolls for morning and afternoon emasculation were at par with each other. These observations suggested that morning emasculation from 8 to 10 A.M. is suitable for obtaining higher boll set. As regards to time of pollination, the highest boll set was observed when the pollination was done during 10 A.M. to 12 noon in all the crossing periods. It was 31.11 per cent during first period of crossing, 27.77 per cent in second period of crossing and 33.33 per cent during third period of crossing. Amongst the crossing periods, the third period of crossing (P_3 = 6-11-89, 7-11-89, 8-11-89) recorded highest boll (31.11 %) set when the pollination was done during 10 A.M. to 12 noon. This suggested that the stigma

of the Ph-1 (female parent) remains receptive as well as pollen of PA-140 remains viable upto 12 noon giving maximum boll set. There was significant reduction in per cent boll set when pollination was done in between 12 noon to 2 P.M. in all the period of crossing. This indicate that there is a reductions in the viability of the pollangrains of PA-140 after 12 noon and decrease in receptivity of stigma of Ph-1 because of drying resulting in significant reductions in per cent boll set. Charekar (1983) while studying the hybrid seed production technique in intra hirsutym hybrid Godavari, observed that the 10 A.M. to 12 noon is the effective pollination time for higher boll set.

Rao et al. (1979) also reported that 10 A.M. to 12 noon is the effective time of pollination for maximum boll set in varlaxmi seed production. He further stated that, the temperature at the time of pollination had greater effect on boll set. He suggested that pollination has to be delayed when temperatures are low and advanced when temperatures are high. Ravindranath et al. (1988) while studying hybrid seed production technique in desi cotton observed that, the pollination between 10 A.M. to 1 P.M. resulted in obtaining higher percentage of boll set.

Shariff and Shivandaiah (1974) stated that pollination time from 10 A.M. to 12 noon was suitable for better boll set in varlaxmi hybrid seed production. Kalsey and Garg (1976) found that the best time of p pollination for getting higher boll setting to be 10 A.M. to 12 noon. Katarki (1973) reported that the best pollination time in varlaxmi seed production was from 10 A.M. to 1 P.M. The findings of these investigations are in close agreement with the present study.

The study further indicated that pollination between 12 noon to 2 P.M. was also found to be suitable for adequate boll set (35.36 %) in first period of crossing. This suggested that the pollination timings cna be extended upto 2 P.M. in seed production programme of desi cotton hybrid. Charekar (1983) also observed that the pollination time can also be extended upto 2 P.M. Ravindranath et al (1988) reported that the pollination can be done till 1 P.M.

Thus the present investigation clearly indicated that the proper time of emasculation in desi cotton hybrid seed production programme may be 8 to 10 A.M. and next day pollination between =0 A.M. to 12 noon is suitable for effective boll set. The pollination timings can be extended upto 2 P.M.

5.1.1.2 Method of pollen application

Proper method of pollination of emasculated bud is an important operation for effective boll setting particularly in desi cotton hybrid seed production programme. As the cotton flower possesses a stigma having four distinct side and a broad tip, the method of application of pollen grains plays important role for effective fertilization. Mansurovand shabit chenko (1969) clearly indicated that number of pollen tube penetrating into the style of stigma depends mainly on the amount of available viable pollen and the process of pollinations which deposits large amount of pollens on the suffaca of stigma is desirable for getting maximum boll set.

In the present investigation, rubbing the burst anthers on the four sides of stigma and on the tip resulted in significantly higher boll set (39.25 %) than rubbing the burst anthers only on the tip or on two or four sides excluding tip of stigma in first and second period of crossing. This clearly indicated that application of pollen all around the stigma including its tip is more effective in a process of pollination. The study further indicated that, for successful pollination the maximum stigmatic area should come in contact with pollen grain which helps to develop maximum number of pollen tubes

passing towards the ovary and will help in effective fertilization of all the ovules.

Charekar (1983) while working with hirsutum cotton also reported that the treatment of rubbing anthers on four sides of stigma and on tip was most effective for development of pollen tube. The touching anthers on tip of stigma only or two or four sides of stigma except tip, resulted in low setting of bolls due to inconquence of pollen grains for penetration into style.

Rao et al.(1979) also reported that the superiority of rubbing the anthers alround the stigma for obtaining better boll set in varlaxmi seed production. The treatment touching the anthers only on the tip of stigma deposits less amount of pollens as compared to the amount of pollens deposited by rubbing the burst anthers alround the stigma along with tip. They also reported that scope for the pollens which are deposited on tip of stigma is limiting for their entry into the style as compared to the pollens which are deposited on the sides of the stigma. Similar observations were noted by Mansurov and Shabit Chenko (1969) while studying the growth of pollen tube under different methods of pollination.

These observations are in confirmity with the results obtained in the present investigation.

5.1.1.3 Effect of number of female flower buds to be pollinated with single male flower

In the present study single male flower was used to pollinate with varied number of buds from 5 to 50 and indicated a decreasing trend for per cent boll set in all the three periods of crossing. The highest boll set of 55.56 per cent was obtained when single male flower was used to pollinate 5 female flower buds.

Therefore it can be concluded that a single male flower used to pollinate five female buds is effective for maximum boll set. However, a single flower used to pollinate 10 female flower bud also gave significantly higher boll set. (47.78 %) than rest of the treatments except previous where a single male flower was used to pollinate 5 female flower buds. This suggested that under a situation of scaracity of male flower a single male flower can be used for pollination upto 10 female flower buds.

Patil and Patil (1973) reported that adequate supply of male flowers is essential to pollinate limited number of female flower buds for achieving high boll set. Sheriff and Shivandaih (1974) reported that 6-8 female flowers can be effectively pollinated with a single male

flower in varlaxmi seed production. Charekar (1983) also reported that a single male flower can be pollinated upto 5 female flower buds and can be extended upto 10 female flower bud for getting higher boll set.

5.1.1.4 Effect of covering stigma

Though the cotton is predominantly a self pollinated crop, natural crossing also occurs to certain extent due to insects like bees. Number of workers like Zahiruddin and Memon (1972), Mungomery and Gdossob (1970) and Gururajan and Srinivasan (1975) reported evidence of natural crossing in cotton.

Because of certain extent of cross pollination, it is essential to cover the stigma of emasculated bud by straw tube to eliminate foreign pollen contamination and to maintain purtty of crossed seed. A covering of stigma after emasculation and pollination with covering means like straw tube adds to the cost of seed production which becomes a major constraint particularly in hybrid seed production programme of desi cotton. In an effort to accumulate information on the effect of eliminating such covering stigma either after emasculation or pollination on boll set, it was observed that both covering of stigma after emasculation and pollination only gives higher boll set in hybrid seed production programme of desi cotton.

However, Rao *et al.* (1979) and Charekar (1983) while working with hybrid seed production technique in *hirsutum* cotton reported increased boll set when buds were covered after emasculation and kept uncovered after pollination.

In the present investigation this particular treatment of covering the bud after emasculation and uncovering after pollination (T_3) was next best (25.28 %) for getting maximum boll set. Covering the stigma after emasculation and pollination (T_2) being costly, the process of covering the buds after emasculation and leaving uncovered after pollination is more economic (T_3), less time and labour consuming and also effective in getting reasonable boll set (25.28 %). As a matter of fact it is not essential to cover the stigma after pollination as the chances of foreign pollen contaminations are less because of immediate start of pollen germination and fertilization. Covering of stigma after emasculation helps in avoiding the drying of the stigma and maintain its receptivity till pollination.

It the present study the per cent boll set (15.28) was significantly reduced when buds were left uncovered after emasculation and pollination (T_4).

Similarly there was significant reduction in per cent boll set (20.56) when the buds were left uncovered after emasculation and covered after pollination (T_1). This may be due to inability of the stigma to maintain its receptivity when exposed to natural conditions. In later treatment though the buds were covered after pollination, the application of pollen was on nonreceptive stigma which might have resulted in failure of fertilization and consequently reducing the boll set. Significant reduction in both of these treatments, therefore, indicate lack of natural cross pollination. Patil (1974) found that emasculated buds of variety JK-97 when left open to nature without artificial pollination were shaded due to lack of fertilization. Charekar (1983) observed that in Godavari seed production programme that this situation was due to drying of the stigma lossing its receptivity. He further observed that, this effect was not so pronounced in H_4.

Though the process of covering the stigma after emasculation and keeping uncovered after pollination is economical and gives reasonable boll set, needs confirmation before its wide application. Similarly attention has to be paid on the possibility of insect attack directly on the stigma (Charekar, 1983). Further it is also essential to undertake genetic purity test of the seed material so obtained by covering stigma

after emasculation and eleminating the process of covering it after pollination.

5.1.1.5 Effect of pollen storage in relation to pollen viability

The study indicated that utilization of fresh pollen immediately after bursting of anthers gives maximum boll set (36.00 %) than the application of pollen stored in wet blotter paper and wet cloth for 24 hours. There was drastic reduction in per cent boll set when the pollens were stored in wet blotter paper (12.00 %) and wet cloth (8.44 %) for 24 hours were used for pollination purpose.

Rao et al. (1979) reported that the mean reduction in per cent boll set due to usage of stored pollen in crossing as against fresh pollens, was about 50 per cent. Charekar (1983) reported that the fresh pollens gave higher boll set than pollen stored in blotter paper and wet cloth for 24 hours. Significant reduction in per cent boll set may be due to the effect of temperature on viability of pollengrains under stored conditions. Arutjunova and Gasos (1964) found that the storing cotton pollen at 26 ^{o}C to 28 ^{o}C for 24 hours reduced in viability by 40 to 60 per cent. Parmeswar (1972) reported that pollen grains of G. hirsutum L. and G. barbadense L. maintained high percentage of pollen germination upto six hours after dehiscense at room temperature.

5.1.2 Number of seeds and seed weight per boll

In certified hybrid seed production programme the traits like seed number and seed weight per boll plays an important role andneeds consideration for higher and quality seed production. These traits are directly related to economy of seed production programme. Therefore, it is necessary to study the effect of different techniques of hybrid seed production on these traits. The increase in per cent boll set associated with increase in seed number par boll may result in highest production of crossed seed. In addition to increase in seed number, the higher seed weight per boll will indicate improvement in quality of seed.

5.1.2.1 Time of emasculation and pollination

In the present investigation the time of emasculation had no significant effect on seed number as well as seed weight per boll in all the three periods of crossing. The process of pollination from 10 A.M. to 2 P.M. however, significantly increased the seed number and seed weight par boll than the pollination from 8 A.M. to 10 A.M. and 2 to 4 P.M. This observation indicated that, irrespective of emasculation timings, the process of po pollination from 10 A.M. to 2 P.M. is desirable for higher

and healthy hybrid seed production. The pollination on the nextday before 10 A.M. and after 2 P.M. deteriorate the quantity and quality of hybrid seed.

Charekar (1983), however, while working with intraspecific hybrid seed production programme of American cotton indicated that the next day pollination from 8 A.M. to 12 noon was suitable for more seed per boll and higher seed weight. In hybrid seed production programme of desi cotton the pollination timings can be extended upto 2 P.M. This may be due to ability of pollen grains of desi cotton to remain viable for longer period than hirsutum.

5.1.2.2 Method of pollen application

Inadiquate pollen supply during the process of pollination may be the major cause of low boll and seed setting (Patil, 1973). The method of pollen application in the seed production programme, therefore needs consideration. In the present study, when burst anthers were rubbed on four sides and tip of stigma resulted in significant increase in seed number and seed weight per boll. There was significant reduction in these two traits when the anthers were rubbed only on the tip and two sides of stigma. These observations are in

confirmity with Rao et al. (1979), who rightly pointed out that, better seed number and seed weight per boll can be obtained by rubbing the anthers all around the stigma. Charekar (1983) also indicated that rubbing the burst anthers on four sides and tip of stigma gives higher seed number and seed weight.

5.1.2.3 Number of flower buds to be pollinated with single male flower

For obtaining maximum number of seeds per boll with better seed weight, it is essential to know the information regarding the number of female flower buds to be pollinated with single male flower.

In present study, significant increase in seed number and seed weight per boll was observed when single male flower was used to pollinate five female buds. As number of female flower buds pollinted with single male flower increases, there was consequent reduction in the seed number and seed wiight per boll. Rao et al. (1979) also observed the significant reduction in seed number and seed weight per boll with the increase in number of female flower buds to be pollinated with single male flower.

Schubert et al. (1976) pointed out that mortality of ovules due to lack of fertilization because of indequate pollination results in decrease in seed number which in turn decreases seed weight per boll.

This study further indicated that there was no significant difference between 10 and 5 female flower buds pollinated with single male flower on seed number and seed weight per boll. There was significant reduction in these traits when number of female flower buds to be pollinated with single male flower were increased beyond 10. Charekar (1983) also observed the same trait of significant reduction in seed number and seed weight with increased number of female flower buds pollinated with single male flower beyond ten.

Arutyunova et al.(1989) reported good seed set from intra and interspecific crosses reached to 40-45 per cent when emasculated flowers were pollinated with single male flower.

5.1.2.4 Effect of covering stigma

The effect of covering stigma had significant effect on seed number and seed weight per boll. It was observed that there was significant reduction in seed

number and seed weight per boll when the emasculated and pollinated buds were kept uncovered with straw tube. It was interesting to note the covering of the stigma after emasculation and leaving uncovered after pollination recorded highest seed number and seed weight per boll and was at par with emasculated and pollinated buds to be covered. It therefore, suggested that the process of covering the stigma after pollination can be eleminated for economic hybrid seed production as it had not indicated any drastic effect on seed number and seed weight per boll. Charekar (1983) also made similar observation while working with hybrid seed production programme of Godavari.

5.1.2.5 Pollen storage conditions

The application of fresh pollens proved tube significantly superior over stored pollen application for both of the traits i.e. seed number and seed weitht per boll. Rao et al.(1979) reported that mean reduction due to usage of stored pollen was around 25 per cent for seed number and seed weight per boll in varlaxmi. In the present study there was significant reduction in seed number and seed weight when pollens stored in blotter paper 17.78 and in wet cloth (14.78) for 24 hours

were used for pollination purpose. In adiquate pollination and fertilization due to such pollan grains results in drastic reduction in seed number and seed weight per boll. It is therefore indicated that use of fresh pollen is always beneficial for successful hybrids seed production. The pollen stored in wet blotter paper or cloth for 24 hours losses its viability.

Arutjunova and Gasos (1964) found that cotton pollens storing at 26 to 28°C for 24 hours reduced its viability by 40 to 60 per cent and storing for 48 hours resulted into complete loss of viability in G. arborcum and G. barbadense and G. hirsutum species of cotton.

5.1.2.6 Effect of temperature and relative humidity on per cent boll set, seed number and seed weight per boll during three periods of crossing.

No significant effect of temperature or relative humidity was observed on per cent boll set, seed number and seed weight per boll in all the three periods of crossing.

Ehlig and Mc Mert (1972) reported that there was no direct relationship between low boll set and maximum or minimum temperature or high relative humidity.

5.2 Natural crossing (Vicinism)

Thogh the cotton is predominantly a self pollinated crop the out crossing due to insects also takes place to some extent. Therefore, the knowledge of isolation distance in such oftenly cross pollinated crop is useful for maintaining genetic purity in hybrid as well as variatal seed production programme. Desi cotton (G. arboreum) is an insect pollinated crop (Tanda and Goyal, 1979). Therefore, it was essential to assess the extent of pollen disposal by insect in this crop.

The present study is a little effort to workout minimum requirement of isolation distance in hybrid as well as variatal seed production programme of desi cotton under Marathwada condition.

In the present investigation, it was observed, that with the increase in distance from marker plot there was decrease in natural crossing. The extent of natural crossing was hardly 0.28 per cent in south direction, zero per cent in North direction, 0.24 per cent in East and 0.30 per cent in West direction at a distance of 4.05 meter. These observations were recorded from produce of first picking. Similar type of low per cent of out crossing i.e. 0.19, 0.00, 0.00 and 0.25 per cent in South, North, East and West direction was observed

respectively at a distance of 4.5 meter, in the produce obtained from second picking.

From these observations it can be concluded that 4.5 meter distance is absolutely safe isolation distance for production of foundation and certified varietal as well as hybrid seed production prggramme of desi cotton. Chauhan and Singh (1983) suggested that normaly 5 meter is absolute isolation distance for desi cotton. Nadagouder et al. (1985) studied the minimum requirement of isolation distance in cotton and clearly indicated that there is no need of very wide isolation distance as specified in field standards for seed certification of cotton seed crop to produce quality seed.

In the present study it was interesting to note that, there was same trend of natural cross with regard to distance and direction for both the pickings. It was also suprising to note that, per cent of natural crossing was more or less similar in all direction at the same distance. This was helpful to fix a limit of extent of natural crossing upto 2.60 per cent under Marathwada conditions. Afzal and Khan (1950) stated that the extent of natural crossing in desi cotton was about 2 per cent. In the present study, 4.5 meter was observed as safe isolation distance. These

observations agree with the predecided safe distance of 5 meter recorded by various workers. Kalora and Wankhade (1987) stated that out crossing was not observed in cotton grown with isolation distance ranging from 5 to 50 meter from all directions and indicated that 5 meter was safe isolation distance for production of genetically good quality seeds of cotton grown with recommended practices.

***

6. SUMMARY

6. SUMMARY

The present investigation was carried out to collect pracise information regarding hybrid seed production technique and to study the extent of natural crossing in desi cotton. Both the experiments were carried out at cotton Research Station, Mehboob Baugh Farm, Marathwada Agricultural University, Parbhani during 1989-90. The experimental findings are briefly summarised below:

6.1 Hybrid seed production technique

Five experiments were conducted to study technique of hybrid seed production in desi cotton. They are as follows :

1. Study of time of emasculation and pollination.
2. Method of pollen application.
3. Number of female flower buds to be pollinated with single male flower.
4. Effect of covering stigma on per cent boll set, seed number and seed weight per boll.
5. Pollen storage in relation to pollen viability.

The findings, in brief, are summerized as follows :

1. Morning emasculation from 8 to 10 A.M. was observed suitable for obtaining higher boll set. The

highest boll set was observed when the pollination was done from 10 A.M. to 12 noon. The per cent boll set during this particular period of pollination was 33.11 per cent in first period of crossing, 27.77 in second period of crossing and 33.33 per cent in third period of crossing.

2. The study further indicated that pollination between 12 noon to 2 P.M. was suitable for adequate boll set (35.36 %) in first period of crossing. This suggested that pollination time can be extended up to 2 P.M. in hybrid seed production programme of desi cotton. As regards to seed number and seed weight the same trend was observed as that of per cent boll set.

3. The method of rubbing the anthers on all the four sides of stigma alongwith its tip was the best for obtaining maximum boll set, increased seed number and seed weight per boll in all the three periods of crossing.

There was significant reduction in these parameters when bursted anthers were touched only on the tip of stigma. Similarly when the bursted anthers were rubbed only on the two sides of stigma except tip recorded the lowest value of boll set, seed number and seed weight per boll.

4. A single male flower used to pollinate 5 female flower buds recorded maximum boll set, higher seed number and better seed weight per boll. However, when 10 female flower buds were pollinated with single male flower also recorded maximum boll set, seed number and seed weight par boll and was next best treatment.

There was decreasing trend for per cent boll set, seed number and seed weight per boll with increase in number of female flower buds being pollinated with a single male flower.

5. In an experiment of covering of stigma with straw tube, the treatment, ( ) covering of emasculated and pollinated buds recorded maximum boll set, seed number and seed weight per boll. However, when the emasculated buds were covered but pollinated bud were kept uncovered also reocrded higher value of per cent boll set, seed number and seed weight per boll.

Lowest per cent boll set, seed number and seed weight per boll was observed when both emasculated and pollinated buds were left uncovered.

6. Application of fresh pollens for pollination purpose recorded the maximum value for per cent boll set, increased seed number and higher seed weight per boll.

6.2 Natural crossing (Vicinism)

The present investigation was under taken to know the extent of cross pollination in desi cotton. The experiment was carried out under field conditions in a square design by sowing G-27 being a pigmented strain in the centre of the plot, surrounded by Eknath (PA-32) a desi strain having green pigmentation. The surrounding plot (PA-32) was sown upto a distance of 50 meter.

The findings are summarised as under :

1. There was decrease in natural crossing with the increase in distance from marker plot in all the directions.

2. The per cent of natural crossing at various distance and directions were mostly similar for both first and second picking.

3. Higher per centage of natural crossing to the extent of 2.69 per cent in south direction, 1.42 per cent in North direction, 1.89 per cent in East direction and 2.12 per cent in West direction was observed at a distance of 0.45 meter for first picking.

4. The lowest extent of natural crossing at a distance of 4.05 meter was 0.28 per cent at South direction, zero per cent at North direction, 0.24 per cent at East direction and 0.30 per cent at West direction in the produce of first picking.

5. As regards to second picking, high per cent of natural crossing observed at a closer distance of 0.45 meter was 2.05, 1.57, 1.22 and 1.48 per cent in South, North, East and West direction respectively.

6. For second picking, the lowest percentage of natural crossing was observed at a distance of 4.5 meter in all direction. It was hardly 0.19, 0.00, 0.00 and 0.25 per cent in South, North, East and West direction respectively.

7. It was therefore, concluded that irrespective of directions and pickings 4.5 meter is the safe and minimum isolation distance for hybrid as well as varietal seed production of <u>desi</u> cotton.

...

LITERATURE CITED

LITERATURE CITED

Afzal, M. and Khan, A.H. 1950a. Natural crossing in cotton in Western Punjab. I Natural crossing in continuous plants and row. Agron. J. 42 : 14-19.

Afzal, M. and Khan, A.H. 1959 b. Natural crossing in cotton in Western Punjab. II, Natural crossing in under field conditions. Agron. J. 42 : 89-93.

Anonymous, 1989. Agricultural situation in India. 43 (12) : 1071-73.

*Arutjunova, L.G. and Gesos, K.F. 1964. Improving selective capacity for parental pollen in seed production. Cott. Gr., 6 : 22-25.

*Arutyunova, L.G., Akhmedov, D., Pulatov, M. 1989. Self incompatibility and cross fertility following intraspecific and interspecific hybridization in cotton (G.L.). Pl. Bredg. Abst., 59 (5) : 432.

*Auther, Tu, C.P. 1938. A study of natural crossing in cotton. Pl. Bredg. Abst., 8 : 551.

Balsubrahmanyam, R. 1948. Pollen viability in cotton. Research note. Indian Cott. Gr. Rev. 2 (3) : 145.

*Capau, A. 1968. Influence of age of reproductive organs on making crosses, on boll set and on heritability in fine linted cotton. Pl. Bredg. Abst., 38 : 962.

*Capau, A. 1976. The influence of pollination time on the rate at which pollen tubes penetrate the ovary of the cotton flower. Pl. Bredg. Abst., 46 : 2601.

Charekar, C.C. 1982. Study of Hybrid seed production technique in cotton (G. hirsutum L.). M.A.U. Univ. Lib.

Chauhan, D.S. and Phundan Singh. 1983. Isolation distance in upland cotton under Nagpur conditions. Cott. Dev., 13 (1) : 22.

Douglas, A.G. and Adamson, W.C. 1965. Cross pollination techniques with cotton (G. hirsutum L.). Crop. Sci., 5 (6) : 598.

Ehlig, C.F. and McMert, R.D. 1972. Effect of fruit load, temperature, and relative humidity on boll retension of cotton. Crop. Sci., 13 : 168-171.

Fielding, W.L. 1947. Hybridization technique with cotton. The Emp. Cott. Gr. Rev., 24 (4) : 267-269.

Gururajan, K.N. and Srinivasan, K. 1975. Estimation of natural cross pollination in male sterile upland cotton. Indian J. Agric. Sci., 45 : 352-355.

Hatchison, J.B. and Lawes, D.A. 1953. A note on the estimation of natural crossing in cotton. The Emp. Cott. Gr. Rev., 30 (3) : 192-194.

Hoffman, G.J. and Rawlins, S.L. 1970. Infertility of cotton flowers at both high and low relative humidities. Crop. Sci., 10 (6) : 721.

Janki, Singh, R.P., Prakash, R., Haque, M.F. 1968. Floral biology of cotton (Gossypium spp.). Indian J. Agric. Sci., 38 (3) : 528-538.

Kadapa, S.N., Khadi, B.M. and Eshanna, M.R. 1987. Developing a suitable method of crossing in large scale production of desi hybrid cotton seeds. ISCI Jr. 12 (2) : 91-94.

Kalora, R.M. and Wankhade, S.T. 1987. Studies on isolation distances in cotton (G. hirsutum M.) for vidarbha region. Ann. Pl. Physiol., 1 (1): 107-110.

Katarki, S.H. 1978. Guidelines for varlaxmi hybrid seed production. Cott. Dev., 3 : 23-26.

Kalsey, H.S. and Garg, H.R. 1976. Boll setting in hybrid cotton seed production in Punjab. Cott. Dev., 5 (4) : 27.

*Khudaibandyev, C.H. 1975. The germination of additional pollentubes in interspecific hybridization of cotton (G. hirsutum L., G. barbadense L.). Pl. Bredg. Abst., 45 : 5590.

*Mansurov, N.I., Shebitchenko, V. Yu. 1969. Pollen tube germination on applying different methods of pollination. Cott. Gr., 6 : 25-28.

*Marani, A. and Palevitz, D. 1962. Natural cross fertilization of cotton in israel. Pl. Bredg. Abst., 32 : 891.

Mehta, N.P., Bedaya, S.N. and Patel, G.S. 1983. A modified hybrid seed production technique for Asiatic co cottons. Cott. Dev., 13 (1) : 21-22.

Meyer, V.G. 1973. A study of reciprocal hybrids between upland cotton and experimental lines with cytoplasm from seven other species. Crop.Sci. 13 :439-44.

*Mungomery, V.E. and Glossop, A.J. 1970. Natural cross pollination in central queensland Cott. Gr. Rev., 47 (1) : 69.

*Min'kov, S.G. 1960. Nectar bearing cotton plants and the role of bees in cross pollination of these plants. Biol. Abst., 35 : 11377.

Marwade, M.N. and Katarki, B.H. 1986. Studies on flowering pattern and it's impact on yield andquality of varalaxmi cotton seed. Seed Res., 14 (1) :89-95.

Nadagoudar, B.S., Joshi, V.R. and Katarki, B.H. 1985. Isolation distance in cotton seed production. Cott. Dev., 15 (1) : 9-9.

Padaki, G.R., Ravindranath, K., Balikondappa, D., Dastigiriah. 1980. Research note on interspecific desi cotton hybrids. Cott. Dev., 10 (3 & 4) : 21.

Parmeswar, N.S. 1972. Studies on pollen viability in cotton. Indian J. Agric. Sci., 6 (1) : 47.

Patel, R.D. and Dholaria, M.G. 1981. Costs and returns of hybrid cotton seed production in Gujarat. seeds and farms. 7 (1) : 59-64.

Patil, M.S. and Patil, V.R. 1973. A note on extent of boll setting in varlaxmi seed production cott. Dev., 3 (2) : 15-17.

Rao, D.V.M., Rao, K.J., Reddy, B.M.M. 1979. Studies on different practices of hybrid seed production in varlaxmi cotton. Seeds and farms. 5 (8) : 31-35, (9) : 25-29, (10) : 59-61, (11 & 12) : 17-21.

Ravindranath, K., Sudarsanam, M.R., Reddy, A.S. 1988. Hybrid cotton seed production : A new technique. ISCI Jr. 13 (1) : 54-56.

Sankaran, R. 1932. A preliminary note on the contabescense of anthers in cotton. Agri. and Livstock in India., 11 (3) : 297.

Schubert, A.M., Benedict, C.R., Gates, C.E. and Kohel, R.M. 1976. Growth and development of the lint fibres of the pima S-4 cotton. Crop. Sci., 16 : 539-543.

*Shebitchenkco, V. Yu. 1974. Growth of cotton plant pollen tubes as observed in live material. Cott. Gr. Rev., 51 (1) : 79.

Shefiff, R.A. and Shivandaiah, M.P. 1974. Production of varlaxmi hybrid cotton seeds. Cott. Dev., 4 (2) : 12-14.

Tanda, A.S. and Goyal, N.P. 1979. Pollen dispersal by insects in desi cotton (G. arboreum L.). Seeds and farms., 5 (5 & 6) : 56-59.

*Thadani, K.I. 1920. Some notes on cotton in sind. Agri. Jr. Ind., 15 : 393-397.

Thies, S.A. 1953. Agents concerned with natural crossing of cotton in Oklahoma., Agron. J. 45 (10) : 481-484.

*Tu, C.P. 1938. A study of natural crossing in cotton. Pl. Bredg. Abst., 8 : 551.

Vamma, S.K. 1975. Studies on the extent periodicity and intensity of flower bud and boll shading in cotton (G. hirsutum L.) cott. Dev., 5 (1) : 10.

Vyakaranahal, B.S., Patil, S.D., Shashidhar, S.D. and Kulkarni, G.N. 1987. Effect of nutrition and hormone application on seed production in hybrid cotton. Seed Research, 15 (1) : 43-47.

*Waller, G.D., Loper, G.M., Martin, J.H. 1986. The use of honey bees in production of hybrid cotton seed. Seed Abst., 9 (5) : 169.

William, R. Meredith, and Brddge, R.R. 1973. Natural crossing in cotton (G. hirsutum L.) in the Delta of Mississippi. Crop. Sci., 13 (4) : 551-552.

*Wilson, S.D., Stapp, B.R. 1986. Crossing success in cotton in Arizona as affected by irrigation, number of flowers pollinated and time of emasculation. Pl. Bredg. Abst., 15 (1) : 52.

*Zahiruddin, Md. S., Memon, A.M. 1972. A note on natural cross pollination studies in G. arboreum. Pl. Bredg.Abst., 42 : 2995.

*Original not seen.

...

APPENDIX - I

Meteorological data showing maximum, minimum temperature and relative humidity during three periods of crossing and on each date of crossing in each experiment.

Period of crossing	Experiment number	Date of crossing	Temperature (°C)		Relative humidity (%)
			Maximum	Minimum	
P_1	1	1-10-89	31.8	22.9	67
		2-10-89	32.0	21.6	91
		3-10-89	31.8	22.3	84
P_1	2	4-10-89	33.0	21.7	77
		5-10-89	34.4	22.3	70
		6-10-89	34.7	21.9	62
P_1	3	7-10-89	34.2	22.2	62
		8-10-89	34.6	21.7	58
		9-10-89	35.6	21.0	52
P_1	4	10-10-89	36.0	20.5	56
		11-10-89	36.0	21.6	58
		12-10-89	35.8	21.6	53
P_1	5	13-10-89	35.8	21.0	52
		14-10-89	34.4	20.8	58
		15-10-89	35.2	21.0	54
P_2	1	19-10-89	33.2	18.9	49
		20-10-89	34.0	17.6	44
		21-10-89	33.4	17.1	51
P_2	2	22-10-89	32.8	17.0	55
		23-10-89	32.4	16.8	57
		24-10-89	32.2	17.1	59
P_2	3	25-10-89	32.2	17.0	56
		26-10-89	32.7	20.2	68
		27-10-89	32.2	20.8	64

Contd...

1.	2.	3.	4.	5.	6.
P_2	4	28-10-89	33.5	21.2	72
		29-10-89	34.0	19.8	67
		30-10-89	33.8	19.3	86
P_2	5	31-10-89	31.7	18.8	70
		1-11-89	31.8	16.7	69
		2-11-89	31.8	16.3	60
P_3	1	6-11-89	32.6	15.6	51
		7-11-89	31.4	15.7	51
		8-11-89	31.0	15.5	54
P_3	2	9-11-89	31.0	16.8	61
		10-11-89	30.6	18.9	49
		11-11-89	31.6	18.5	53
P_3	3	12-11-89	32.2	15.9	54
		13-11-89	31.0	18.3	71
		14-11-89	30.6	20.2	69
P_3	4	15-11-89	31.6	19.8	68
		16-11-89	32.6	18.6	65
		17-11-89	32.6	18.1	58
P_3	5	18-11-89	32.6	17.5	57
		19-11-89	32.6	17.1	61
		20-11-89	32.4	17.9	59

APPENDIX - II

Pooled data on per cent boll set, seed number and seed weight per boll during three periods of crossing (P_1, P_2 and P_3) irrespective of the treatments of all the five experiments.

Expt. No.	Boll set percentage			Seed number per boll			Seed weight per boll (g)		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
1.	28.03	23.60	28.34	18.83	19.04	18.92	1.25	1.25	1.22
2.	33.88	33.88	28.88	19.75	20.92	19.67	1.23	1.26	1.24
3.	35.36	35.81	35.59	19.81	20.43	19.38	1.24	1.23	1.20
4.	25.00	22.92	20.21	20.92	20.58	20.25	1.24	1.24	1.23
5.	20.44	19.55	16.44	17.11	17.33	18.22	1.17	1.19	1.20