Practical Manual

on

Crop Improvement-I (*Kharif crops*)

AGP-312 2(1+1)

(For Undergraduate Agricultural students)

Dr. Vishnu Kumar
Dr. Rumana Khan

2020

Department of Genetics & Plant Breeding
College of Agriculture
RANI LAKSHMI BAI CENTRAL AGRICULTURAL UNIVERSITY
Jhansi-284003

Syllabus [AGP-312 2(1+1)]:
Floral biology, emasculation and hybridization techniques in different crop species; *viz*., rice, jute, maize, sorghum, pearl millet, ragi, pigeonpea, urdbean, mungbean, soybean, groundnut, seasame, caster, cotton, cowpea, tobacco, brinjal, okra and cucurbitaceous crops. Maintenance breeding of different *kharif* crops. handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods; study of field techniques for seed production and hybrid seeds production in *kharif* crops; estimation of heterosis, inbreeding depression and heritability; layout of field experiments; study of quality characters, donor parents for different characters; visit to seed production plots; visit to AICRP plots of different field crops.

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Exercise 1

Objective: Floral biology and crossing techniques in rice

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in rice
Materials required: ……

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Botanical name: *Oryza sativa*
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:
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Emasculation and Pollination:
Procedure: ……..…

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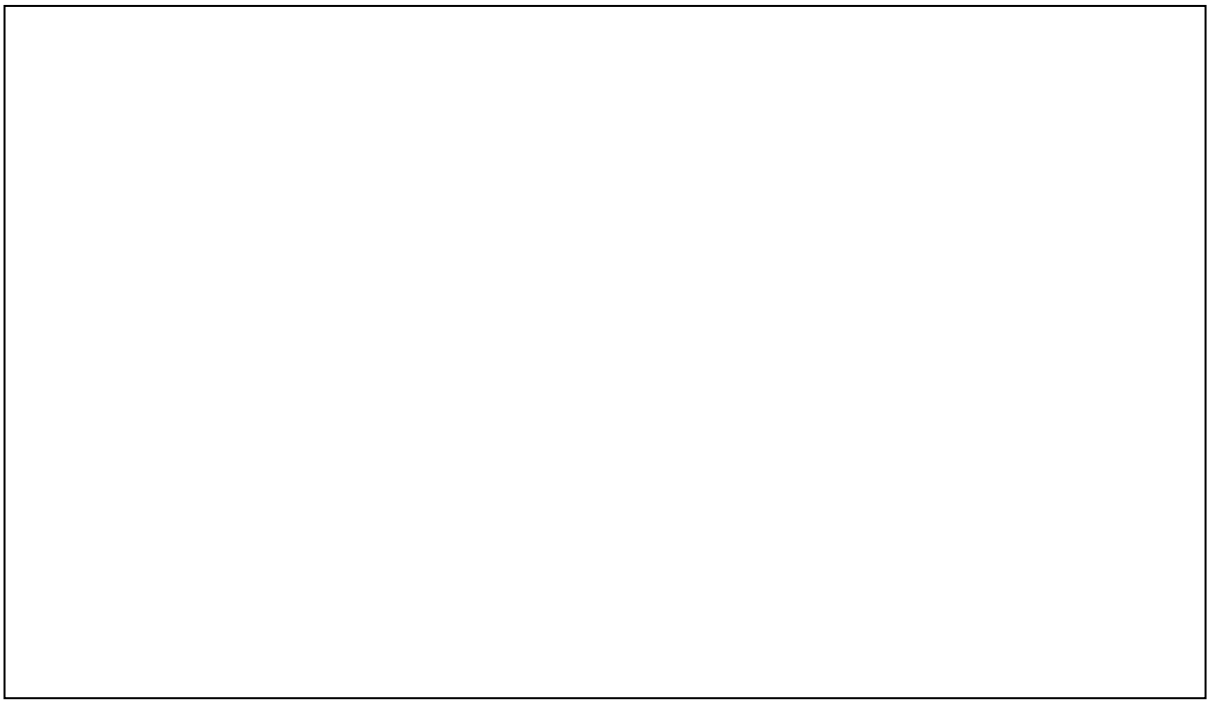

Exercise 2

Objective: Floral biology and crossing techniques in maize

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in maize
Materials required: ……

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Botanical name: *Zea mays*
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:
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Emasculation and Pollination:
Procedure: ……

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Exercise 3

Objective: Floral biology and crossing techniques in pearl millet

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in pearl millet

Materials required: ……………………………………………………………………………………………

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Botanical name: *Pennisetum glaucum*
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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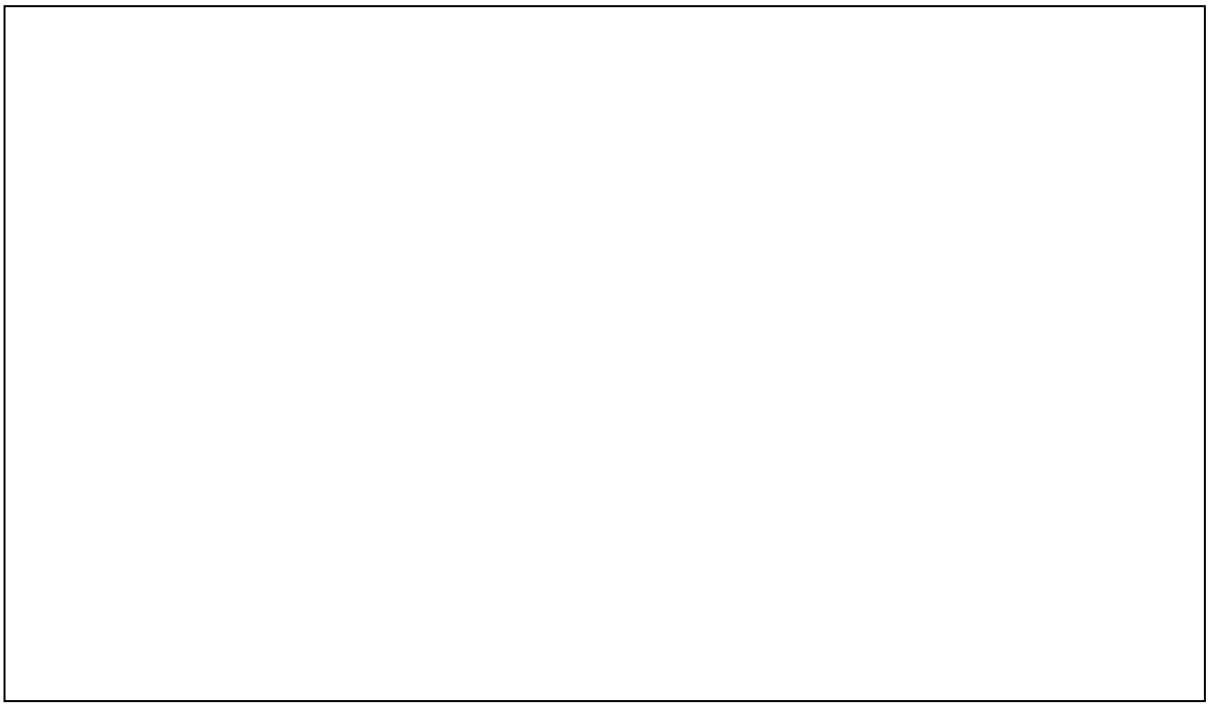
Exercise 4

Objective: Floral biology and crossing techniques in sorghum



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in sorghum

Materials required: ……

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Botanical name: *Sorghum bicolor*
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:

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Emasculation and Pollination:
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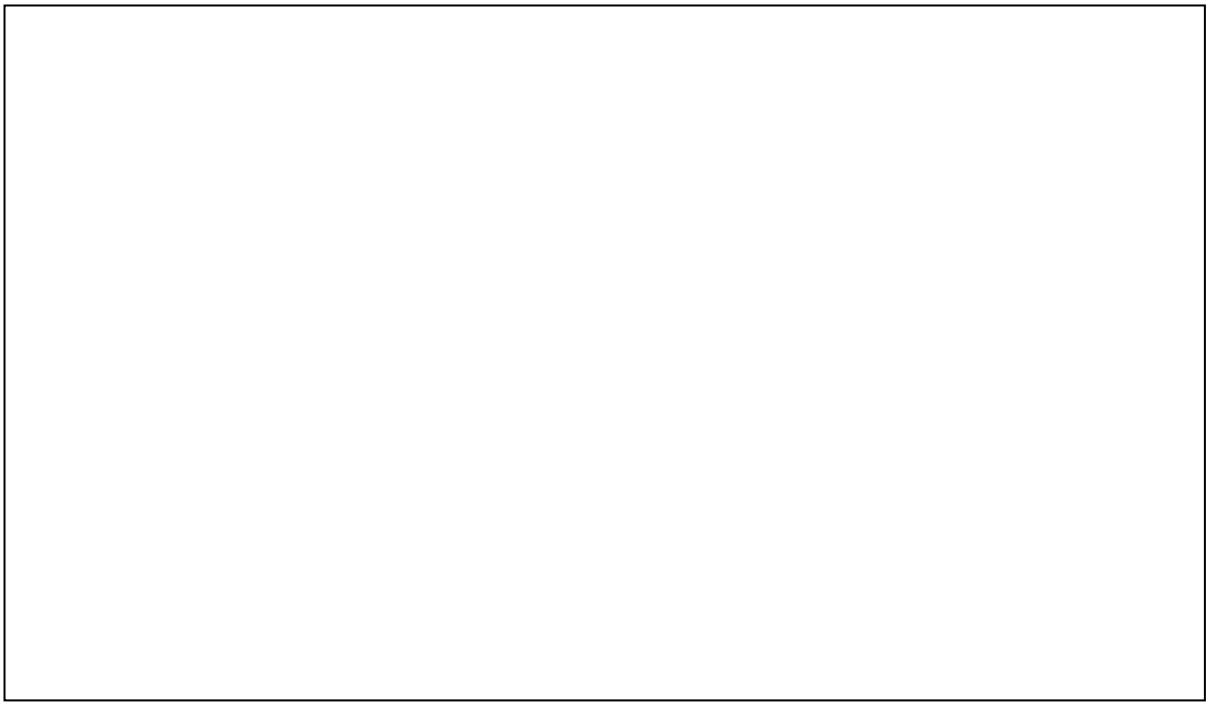
Exercise 5

Objective: Floral biology and crossing techniques in soybean



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in soybean

Materials required: ……

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Botanical name: *Glycine max*
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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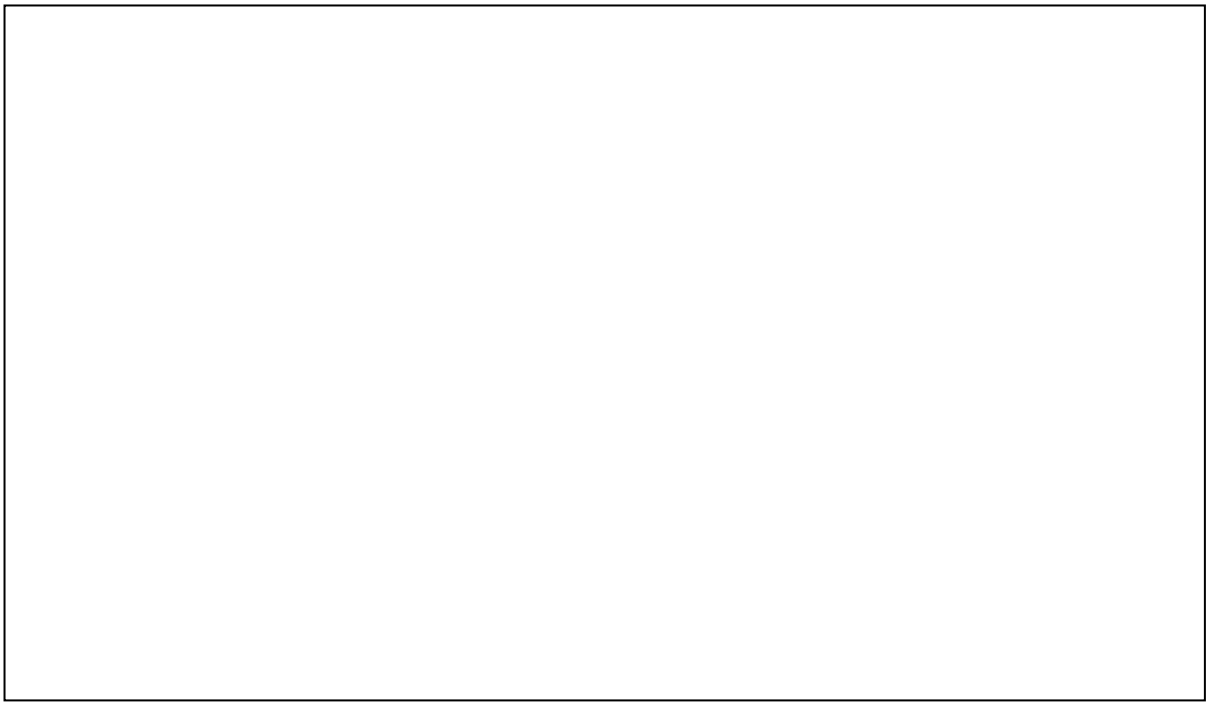
Exercise 6

Objective: Floral biology and crossing techniques in groundnut



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in groundnut

Materials required: ………………………………………………………………………………………………

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Botanical name: *Arachis hypogea*
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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Exercise 7

Objective: Floral biology and crossing techniques in sesame

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in sesame

Materials required: ……

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Botanical name: *Sesamum indicum*
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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Exercise 8

Objective: Floral biology and crossing techniques in cotton

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in cotton

Materials required: ……………………………………………………………………………………………

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Botanical name: *Gossypium hirsutum*
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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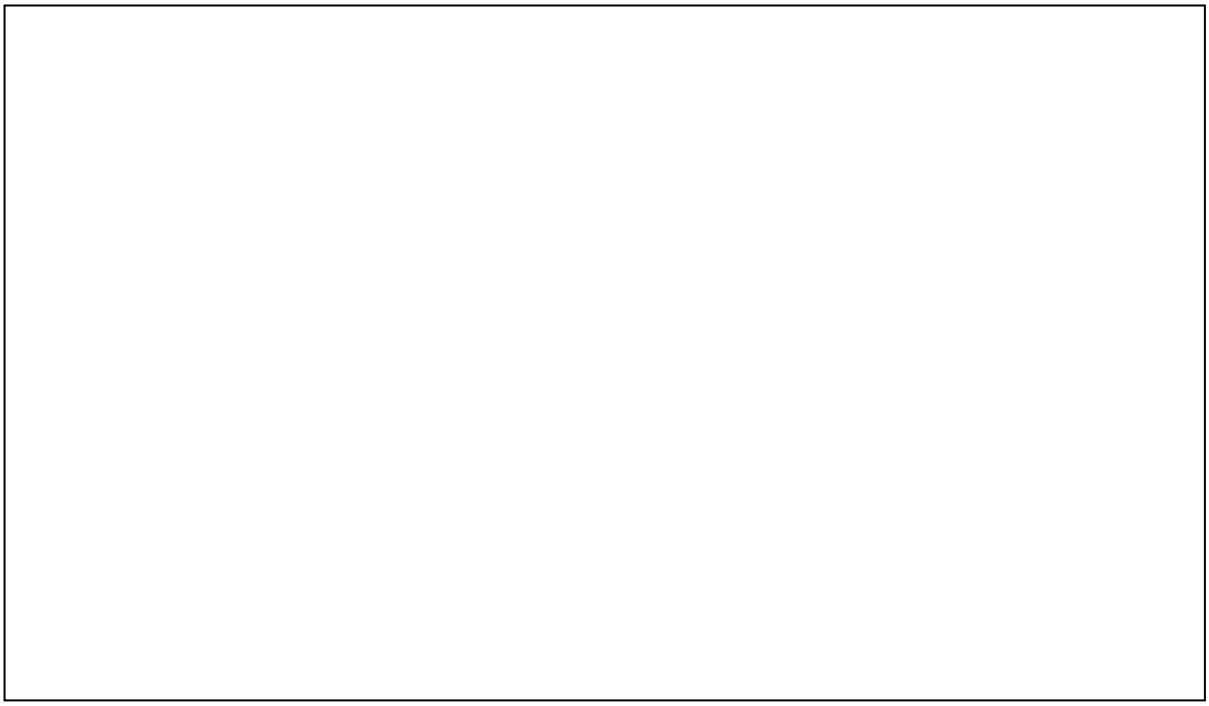
Exercise 9

Objective: Floral biology and crossing techniques in pigeon pea

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in pigeon pea



Materials required: ……………………………………………………………………………

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Botanical name: *Cajanus cajan*
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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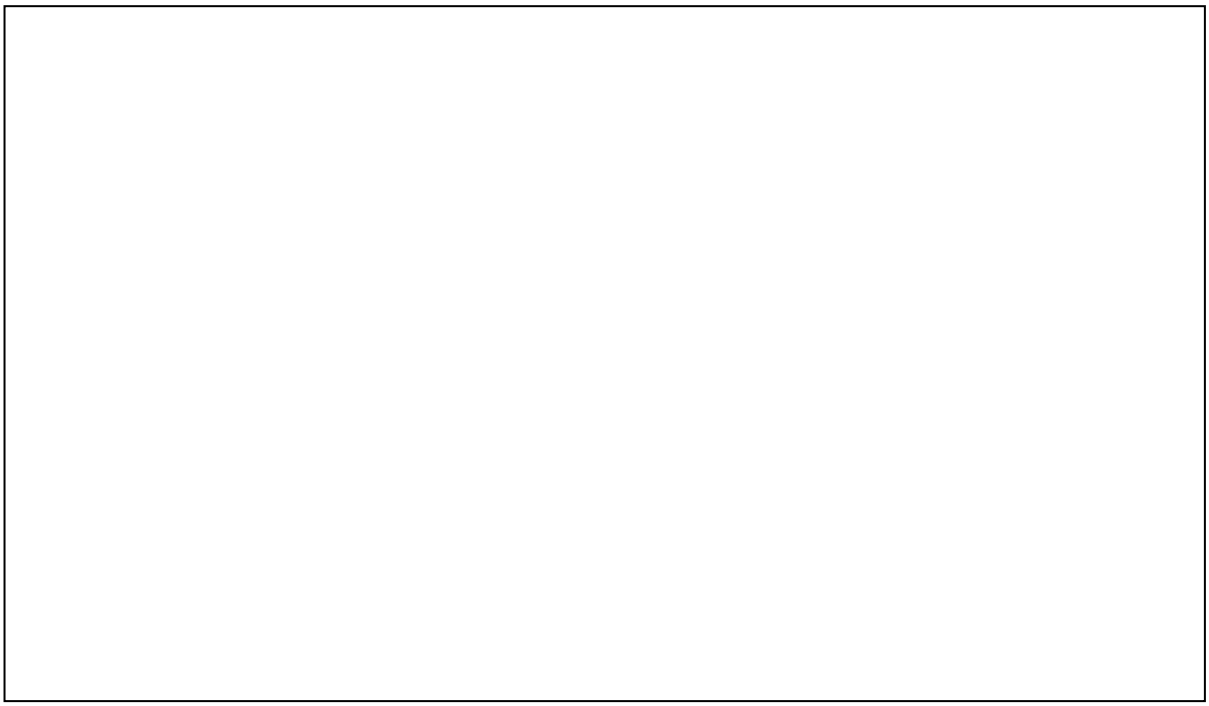
Exercise 10

Objective: Floral biology and crossing techniques in urd bean



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in urd bean

Materials required: ……………………………………………………………………………………………

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Botanical name: *Vigna mungo* (L.)
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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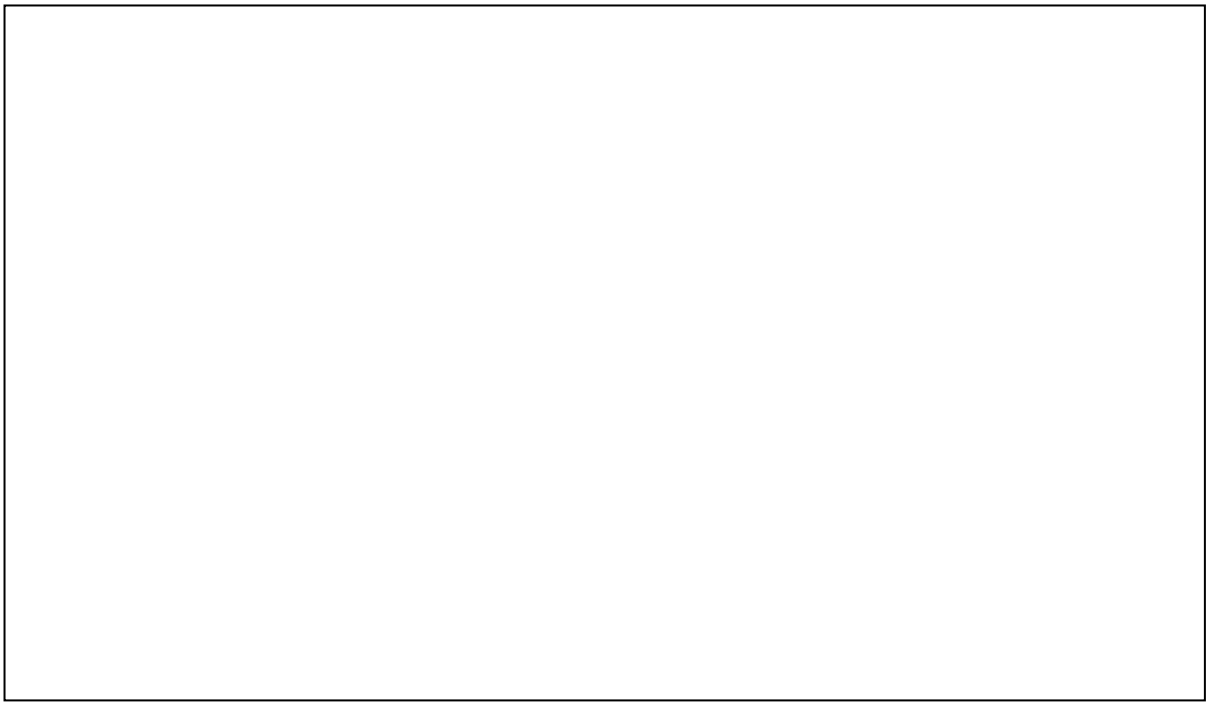
Exercise 11

Objective: Floral biology and crossing techniques in mung bean

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in mung bean



Materials required: ………………………………………………………………………

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Botanical name: *Vigna radiata* (L.)
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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Exercise 12

Objective: Floral biology and crossing techniques in cow pea

Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in cowpea

Materials required: ……

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Botanical name: *Vigna unguiculata* (L.)
Chromosome no.: 2n=…….
Family: ……
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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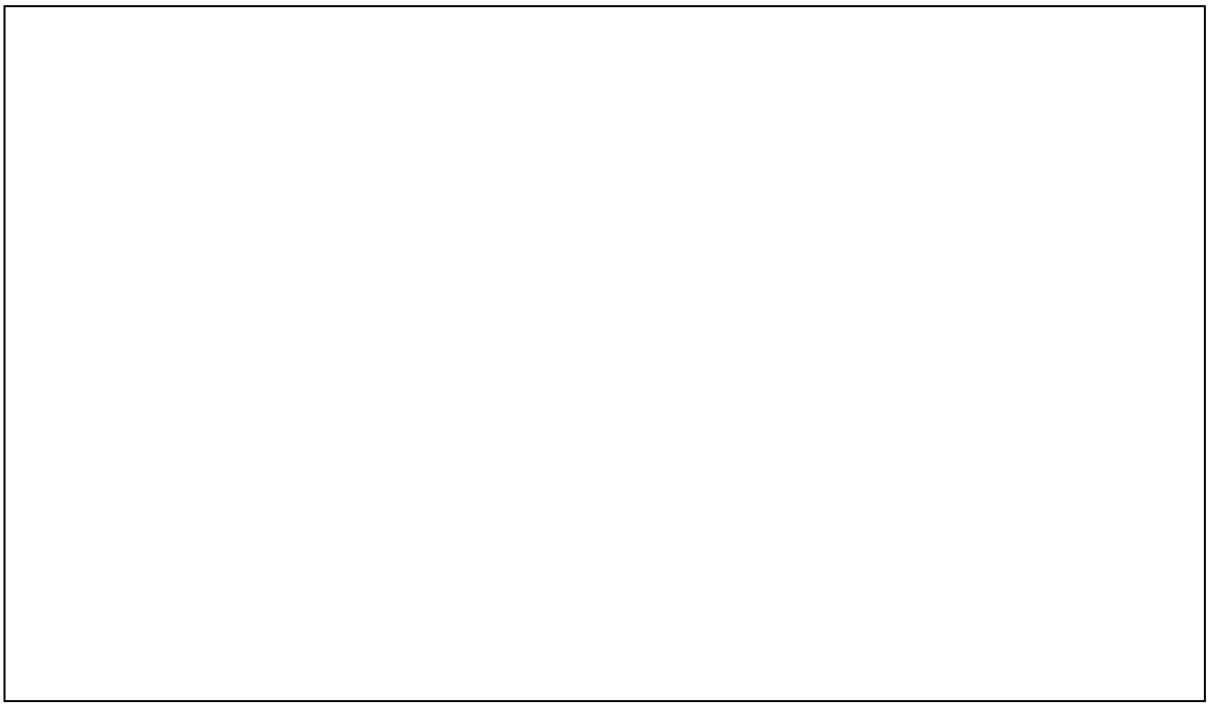
Exercise 13

Objective: Floral biology and crossing techniques in brinjal



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in brinjal

Materials required: ………………………………………………………………………………………..…

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Botanical name: *Solanum melongena* (L.)
Chromosome no.: 2n=…….
Family: ……………….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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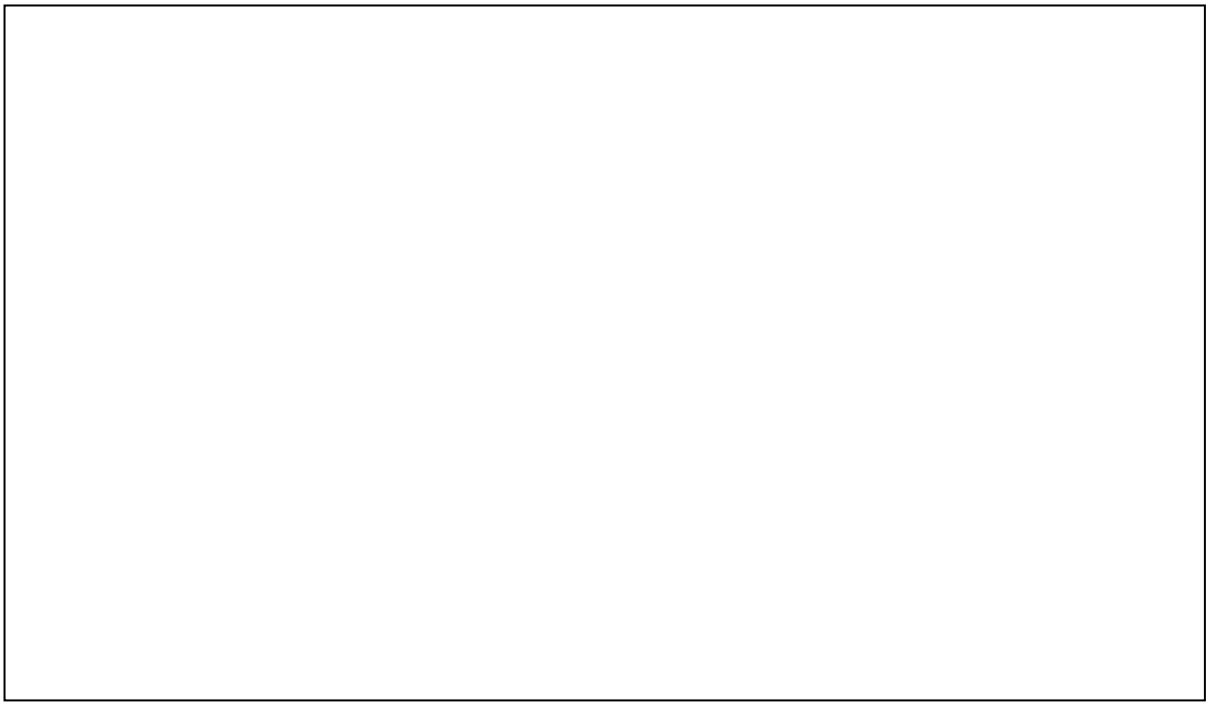
Exercise 14

Objective: Floral biology and crossing techniques in okra



Problem 1: To study floral biology, floral structure, emasculation & pollination techniques in okra

Materials required: ……

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Botanical name: *Abelmoschus esculentus* (L.)
Chromosome no.: 2n=…….
Family: …….
Floral biology and floral structure:

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Emasculation and Pollination:
Procedure: ……

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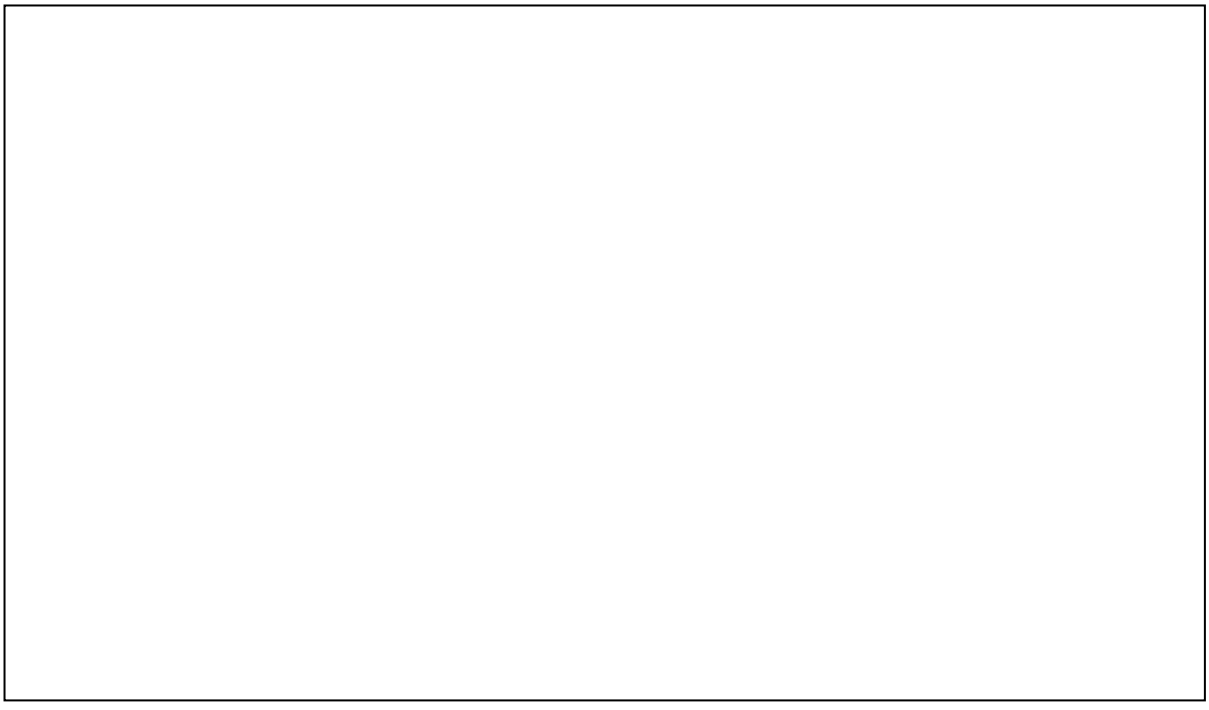
Exercise 15

Objective: Handling of segregating generations



Problem 1: Data recording on various characters and pedigree record maintenance.

Materials required: ……

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Records:

Experiment details

1. Name of the experiment: ……
2. Season: ……..
3. Crop: ……
4. Design of the experiment: ……
5. Replication: ……
6. Size of the plot: ……
7. Spacing: ……
8. Date of sowing/planting: ……..
9. Date of harvest: ……..
10. Comments: ……

Data recording in field notebook for a given crop.

Pedigree……

Data on various characters of ……

S. No.	Strain	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8	Ch9	Ch10
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											
11.											
12.											

13.											
14.											
15.											
16.											
17.											
18.											
19.											
20.											

Exercise 16

Objective: Quality characters for different *kharif* crops

Problem 1: To study the various quality characters of different *kharif* crops.

Sr. No.	Trait	Range & Remarks
Rice		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Maize		
1		
2		
3		
4		
5		
Pearl millet		
1		
2		
3		
4		
5		
Mung bean		
1		
2		
3		
4		
5		

Ground nut		
1		
2		
3		
4		
5		

Exercise 17

Objective: Donor parents for different characters in *kharif* crops

Problem 1: To study of donor parents for different characters in important *kharif* crops

Donor parents of and their contributing characters in crop improvement

Crop	Traits	Donor parents
Rice		
Maize		
Sorghum		
Sesame		
Groundnut		

Exercise 18

Objective: Estimation of heterosis, inbreeding depression and heritability in field experiments

Problem 1: Calculate heritability (h^2) from the following estimates-
Vg = 13.62, Vp = 30.55

Problem 2: The following data for average of ten plants were observed for grain yield per plant (g) in rice. Write down formula(s) and calculate average heterosis, heterobeltiosis and standard heterosis, including inbreeding depression using data of F_2 population.

P_1	P_2	F_1	F_2	Commercial check
12.24	17.25	21.26	19.17	20.10

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FLORAL BIOLOGY AND CROSSING TECHNIQUES

RICE:

Inflorescence- Panicle of spikelets, Spikelet – one loosely arranged on the branches of the panicle. At the base of each spikelet there are two small, membranous, persistent bracts called the empty Glumes; above them lies the single flower which is enveloped in two larger bracts.

The lower one (in the axil of which the flower develops) is the flowering glume, which may or may not have at its apex a narrow-elongated outgrowth called the awn; the upper one inserted at little above the flowering glume is called Palea.

Flower: Bracteate (Lemma or inferior palea) pedicellate, complete, hermaphrodite, zygomorphic, small hypogynous.

Perianth: Represented by 2 scales called lodicules, fleshy and small.

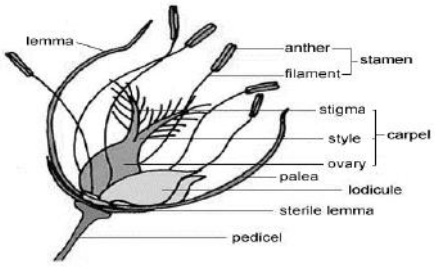
Androecium: Stamens six, polyandrous, anthers linear, versatile, introrse.

Gynoecium: Monocarpellary, ovary superior, unilocular with only one ovule. Style 2, short; stigma 2 feathery and lateral.

Fruit: A caryopsis completely enclosed by the flowering glume and palea.

Emasculation and pollination: In rice anthesis commences shortly after emergence of panicle. Spikelets at the tip bloom first and proceed downwards. Anthesis time 8-10 am. Each spikelet remains open 30 minutes and then closes. The anther dehiscence takes place immediately after the opening of the spikelets. Receptivity remains for one day.

Emasculation is necessarily followed by controlled pollination. Emasculation is done during early morning between 6 and 8 AM in spikelets, due to open on the same day. Emasculation should be over well ahead of the time of anthesis. Crossing techniques in rice differ based on the method of emasculation. Since maximum number of spikelets open on the 3rd or 4th day of anthesis, panicles of that stage are selected for emasculation.

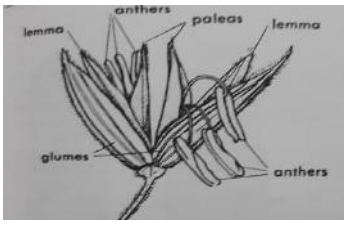


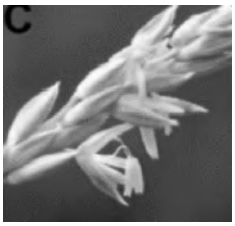
In the previous day evening, top 1/3rd and bottom 1/3rd portions in the panicle of the desired female parent are clipped off by using scissors leaving the middle spikelets. With the help of scissors again, top 1/3 portion in each spikelet is clipped-off in a slanting position. The six anthers present in each spikelet are removed with the help of the needle (Emasculation). Care must be taken during emasculation for not to damage the gynoecium. Then to prevent contamination form the foreign pollen, the emasculated spikelets are covered with a butter paper big. In the next day morning (usually at 9.00AM), the bloomed panicle from the desired male parent is taken. The top portion of the butter paper bag which was originally inserted in the emasculated female parent is now cut to expose the panicle. The male parent panicle is inserted in an inverted position into the butter paper bag and sturned in both ways in order to disperse the pollen. After ensuring the abundant disbursement of pollen, the opened butter paper bag is closed using a pin. Coloured thread may be tied at the base of the panicle to identify the crossed ones. After ensuring pollination, the bag may be removed.

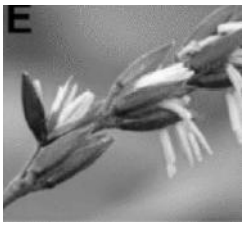
MAIZE:

Maize is proto-androus and monoicous crop. The male inflorescence (tassel) is located at the top of the plant Tassel is branched panicle in which paired spikelets (one sessile and one pedicellate) are produced. Each spikelet consists of two lower most empty bracts called glumes, two staminate florets each having three stamens and enclosed by lemma and palea.

The female inflorescence known as cob or ear is a modified lateral branch originating from an axillary bud on main stem. From the lower node, modified leaves in the form of overlapping sheaths cover the inflorescence called husk. Pistillate spikelets are borne in pairs in longitudinal rows. Each spikelet has two flowers, one fertile and one sterile. This results in an even number of rows of kernels on ears. The hair like structures are called silk. Silk function both as stigma and style as it is receptive to fresh pollen throughout the entire length.

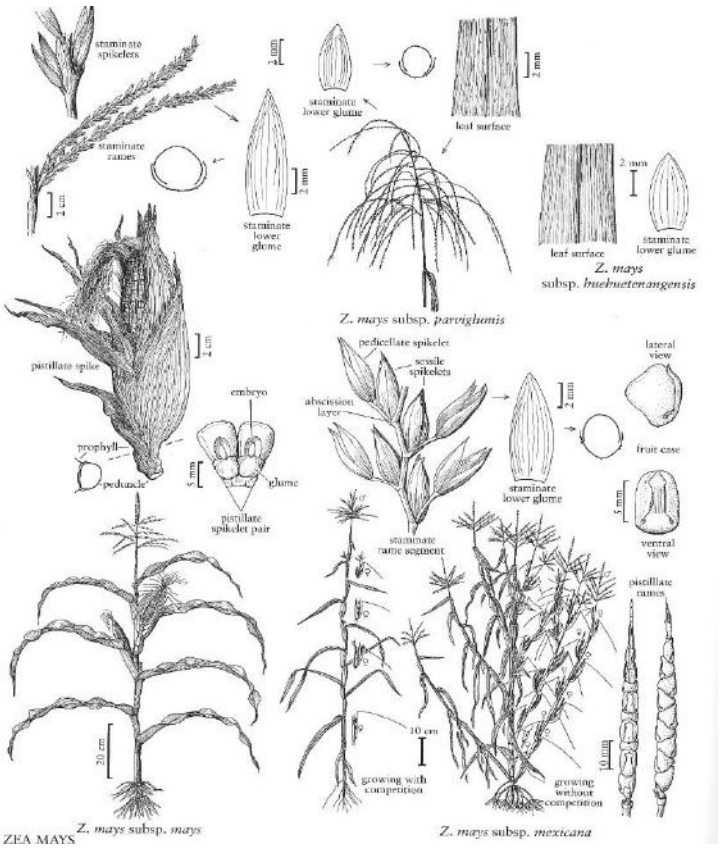






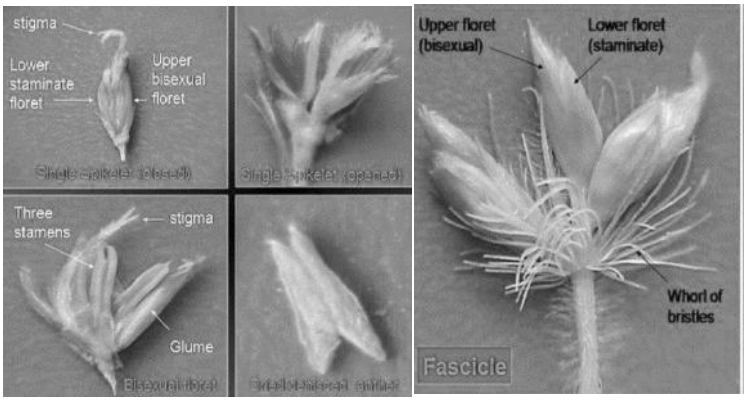
Crossing and pollination: Pollen shedding normally begins 1-3 days before the emergence of silk and continues 3-4 days after the silks are ready to be pollinated. A single tassel may produce as many 25,000,000 pollen grains on an average 25000 pollen grains for each kernel with 800-1000 kernels. Pollen grain remain viable for 12-18 hrs. For crossing, the top of an ear before the emergence of silk is cut by a sharp razor and covered with butter paper bag. The tassel of desired male parent is covered with tassel bag.

Pollination is carried out when a uniform growth of silk is visible. The tassel bag containing freshly shed pollen grains is transferred over the cob after removing the silk bag.

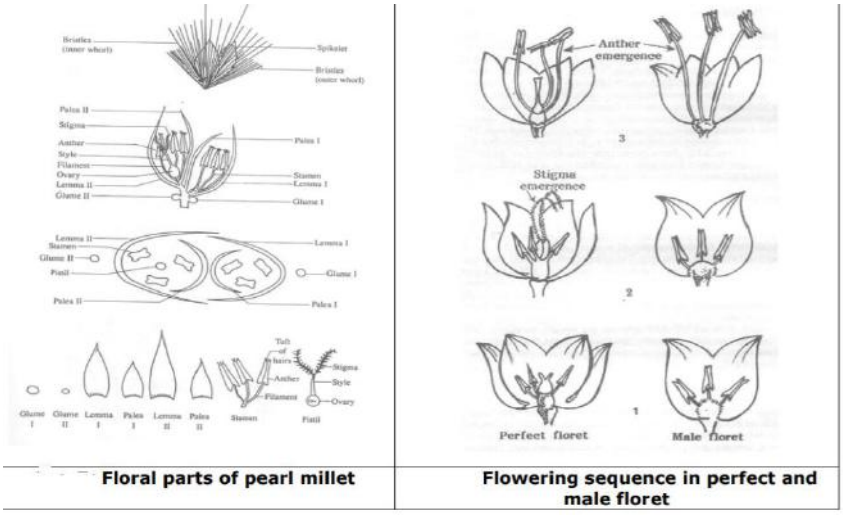


PEARL MILLET

Pearl millet is cross pollinated due to protogyny. The inflorescence is cylindrical spike tapering toward the end and may vary in length from a few centimeters to over meters. A rosette of bracts consisting of bristles and spikelets united at the base known as involucre encloses a flower cluster arising from the central rachis. Each involucre may include one to nine fertile spikelets. The total spikelet per spike may vary from 800 to 3000. Each spikelet contains one upper and one lower floret. The lower floret is staminate and sterile which has a single lemma and three stamens. The upper floret is fertile and lemma, one palea, three anthers and a carpel with two styles terminating in brush like stigmas known as bifurcated feathery stigma.



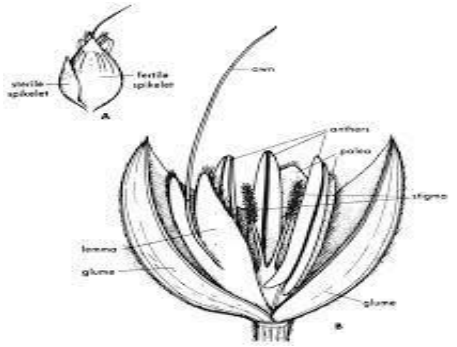
Crossing and pollination: Stigma remain receptive for one to two days. Anther emerges in two waves. First wave- of perfect flowers and second wave of staminate flower after 2-3 days. Anthesis starts for tip Anther dehisce in the morning. Pollen grain remain viable for 5-7 hours. For self-pollination spike is bagged. For crossing, about one fifth upper portion is clipped and left-over portion is bagged. Like-wise panicle of pollen parent if also bagged. As soon as the stigma of female parent emerges, pollen from the male parent are dusted



over it.

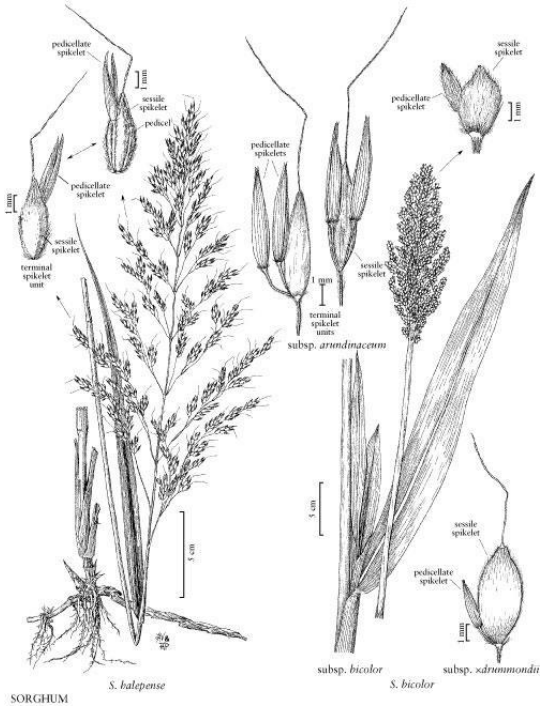
SORGHUM:

The genus sorghum is characterised by spikelets born in pairs. One spikelet is sessile and bisexual and fertile and second one is pedicillate and sterile or occasionally staminate. The sessile spikelet consists of a short central axis or rachilla and two glumes enclosing two florets. The upper floret is fertile while the lower is reduced to a scale called lemma. The fertile floret has a lemma, a palea, 2 lodiclules, 3 stamens and an ovary having 2 small styles both terminating at feathery stigma. The anthers are attached to long thread like filaments.



Sorghum usually flowers in 55 to 70 days in warm climate, but flowering may range from 30 to more than 100 days. The sorghum head begins to flower at its tip and flowers successively downwards over a 4- or 5-day period. Because all heads in a field do not flower at the same time, pollen is usually available for a period of 10 to 15 days. At the time of flowering the glumes open and the three anthers fall free, while the two stigmas protrude each on a stiff style. Flowering frequently occurs just before or after sunrise, but may be delayed on cloudy damp mornings.

The anthers dehisce when they are dry (but not in heavy dew or rain) and a small cloud of pollen blows into the air. The stigmas are receptive before flowering and remain receptive for 6-8 days. Pollen is visible only for a few hours under natural conditions and loses its viability very rapidly. Fertilization is completed within 2-4 hours after pollination. Sorghum is primarily self-pollinated but 2-10 % or even more cross pollination may occur. Therefore, sorghum is classified as often cross pollinated.



SORGHUM

Emasculation and pollination

(I) Hand emasculation- Generally those sections of the panicle are emasculated that will flower the next day. The florets present at the tip of the panicle are trimmed away because pollen dehiscence starts from the top. Similarly, those present close to the rachis are also removed as these are difficult to grasp in fingers and thus to emasculate. Generally, 25 to 50 florets present in the centre of the panicle are left for emasculation because if more florets are left, the probability that one floret is left as such without emasculation will get increased thereby increasing the chance of self-fertilization.

The florets to be emasculated are grasped between the thumb and for-finger. The emasculation needle is inserted just below the middle of the floret and then moved toward the back of the glume, and across the floret. The needle is then rotated slightly and lifted. The anthers come up and are removed. The emasculated panicle is covered by suitable paper bag.

(II) Plastic bag/ mass emasculation technique- Sorghum head is covered with plastic bag. This practice creates high humidity inside the bag. Under such high humidity the anthers emerge out but shed no pollen thus it prevents anther dehiscence. Some percentage of selfing occur in this method, thus marker genes to identify the plants from self-seeds are needed.

(III) Hot water method- The sorghum head is immersed in hot water at 48^0c for 10 minutes (Poehlman, 1987).

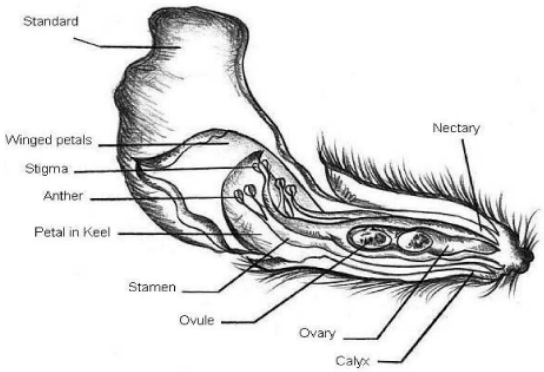
Pollination should be done as soon as almost all the florets come to flower. Pollen shedding in normal sunny day occurs between 6-7 a.m. Pollination delayed in afternoon should be avoided. The pollen is collected in paper bags. Appropriate sorghum heads are covered with paper bags in the evening. In the next morning, these heads are shaken and pollen is collected. The pollen in the bag is viable for only short period (10-20 minutes). The collected pollen is dusted over the emasculated panicle.

SOYBEAN:

Soybean has a typical papilionaceous flower with a tubular calyx of five unequal lobes. The corolla consists of posterior banner petal, two lateral wing petal, and two anterior keel petals. The keel petals touch each other, but are nor fused. The 10 stamens are in diadelphous pattern (9+1). The single pistil is unicarpellate and has one to four campylotropous ovules.

The style is about half the length of ovary and curves backwards towards the free posterior stamen. The stigma is capitate. Hairs are present on the pistil and the outer surface of the calyx tube.

Emasculation and pollination: In freshly opened flower, the diadelphous stamens are elevated and the anthers form a ring around the stigma. The pollen is thus directly shed on stigma resulting into a high percentage of naturals elf-pollination. The pollination may occur a day before full opening of flower i.e. pollination may occur within the bud. Special care is needed while emasculating the flower buds as they are very small. Parental cultivars may be grown in pots so that the plants could be raised to the desired height for emasculation. A floral bud at the appropriate stage is swollen and the corolla is visible through the calyx. Five sepals are removed with the forceps to expose the corolla. Corolla is removed with forceps by jerking-one stroke operation. In this process, 10 stamens are usually removed and is a few are left they are removed.

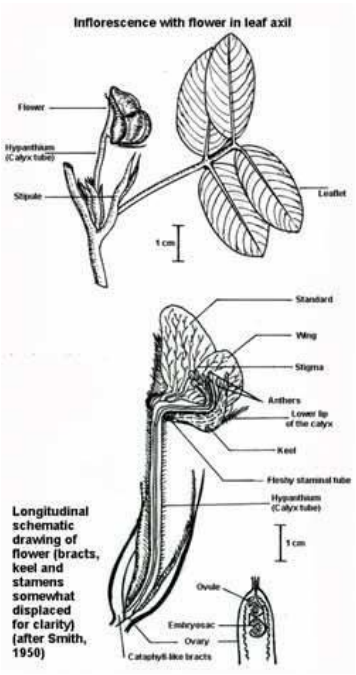


Pollination is carried out immediately after emasculation. Open flowers are collected from male parent. Corolla is removed and the emasculated flower bud stigma is brushed with the anthers of male flowers whose corollas are already removed. In event of a successful pollination, pod is visible in about seven days.

GROUNDNUT

The flowers are produced in the leaf axiles in singles or in clusters of three or more. The flower has a long calyx tube which could be mistaken as a pedicel. The calyx tube ends in five lobs, of which three are united into one big structure and the two are linear lanceolate. The corolla has a standard petal, two wing petals and two keel petals. Corolla is commonly yellow. Androecium and gynoecium are enclosed within keel petals. The stamens are mono-adelphous and 10 in number of which 8 are fertile and two are sterile. The eight fertile stamens are dimorphic with four having long anther lobes, and four with rounded anther lobe. The gynoecium consists of a monocarpellary, unilocular ovary with one to three ovules.

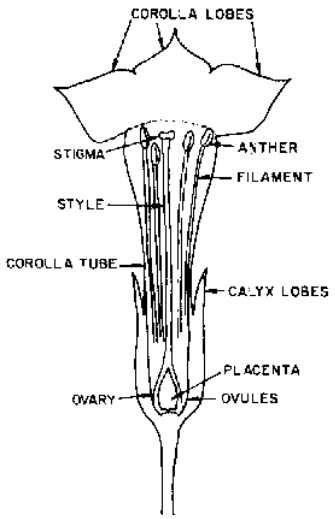
Emasculation and pollination: Before anthesis the flower bud is 6-10 mm long, the day before anthesis 10-20 mm long and at anthesis 50-70 mm long. The stigma become receptive to pollen 24 hrs before and 12 hrs after the flower opens. Anthesis and pollination usually occurs at sunrise. For emasculation, vexillary aestivated corolla of the bud to be emasculated is excised by a circular cut with a sharp blade at about 2 mm form the base (between 4 and 6 pm). The exposed anthers are removed with fine pointed forceps. Following emasculation, an extended style is noticeable by about 8 am the next day. The emasculated flower is pollinated by applying pollen directly from a flower or with a fine brush.



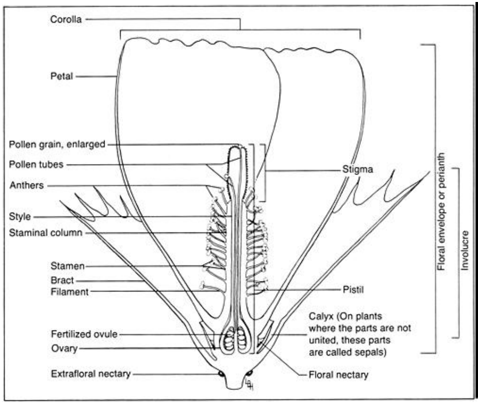
SESAME:

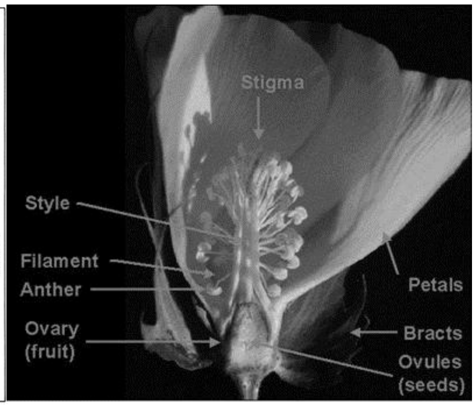
The flowers are complete, gamopetalous, zygomorphic and with a short stalk. The calyx has five fused sepals. One of the petals serves as a landing platform for the visiting insects. The tubular corolla is white, with a lobe upwards and the other downwards. The androceum is didynamous with four stamens, in pairs, one lower than the other, epipetalous, fused at the base of the upper lip of the corolla tube, and anthers longitudinal dehiscence. Anthers are yellowish and 1 mm in length. The pollen grain is yellowish; gynoecium is bicarpelar, with bilocular ovary and axile placentation. ovary is superior and green, and the style is filiform, ending in a bifid stigma.

Emasculation and pollination: The crop come to flowering 3-5 weeks after sowing. 2-3 flowers open in acropetal succession. Flower opening is between 5-8am. Anthers while growing starts bursting and start to dehisce between 2-4 am. Stigma became receptive at the same time as anther dehisce and remain receptive till 8 am. It is predominantly self-pollinated. Emasculation is done in the previous evening between 5-6 pm. It is done by just pulling out the corolla as such by holding it at the tip and protected by covering with paper bag. Pollination is done in the next morning.



COTTON:





There are three triangular bracts at the base of the flower. They completely enclose and protect the tender growing flower parts. Calyx has five sepals which remain attached permanently with the boll. Five petals form the corolla which may be white, yellow or red. The petals turn pink or red, the day after pollination and later fall from the plants. There are numerous stamens which form a tube around the styles. Anthers are arranged in five rows on staminal tube. Pistil has 3-5 carpels. The flower buds appear at first as small green pyramidical structures known as squares.

Emasculation and pollination: Emasculation is done one day earlier of flower opening. Corolla is removed by hand or cut away with small scissors. At this stage the anthers are compressed around the staminal column and the protruding stigma can be seen. Sepals are also cut away. Stamens are removed with forceps. Ripe anthers are collected from the pollen parent in a small cold drink straw whose one end is closed. The straw containing the pollen is slipped over the stigma and this structure is enclosed with the bract by wire. Alternatively. ripe anthers can be rubbed over the stigma of the emasculated flower.

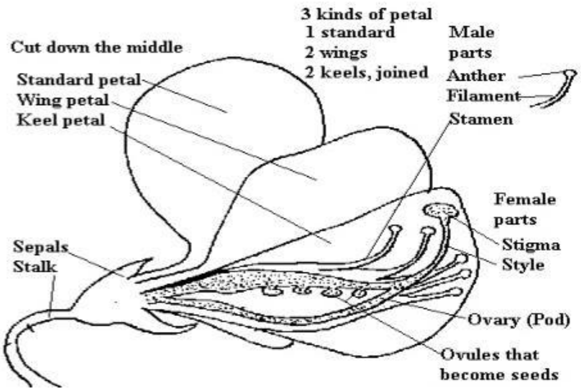
PIGEON PEA:

Inflorescence: Solitary axillary.

Flower: Bracteate, pedicellate, complete, hermaphrodite, zygomorphic pentamerous, hypogynous.

Calyx: Sepals 5, gamosepalous, pentapartite, companulate, odd sepal anterior, imbricate aestivation, green, hairy.

Corolla: Petals 5, polypetalous, papilionaceous, consisting of a large posterior petal – the vexillum or standard, two lateral-alae or wings and two inner fused to form a boat shaped structure the keel or carnia, vexillary aestivation.



Androecium: Stamens 10, diadelphous, nine are fused by the lower halves of their filaments to form a tube round the ovary and tenth posterior one free, anthers basifixed, introrse, dithecous, enclosed in the keel.

Gynoecium: Monocarpellary, ovary superior, unilocular, hairy, elongated, laterally compressed, marginal placentation ovules many, style long, stigma hairy.

Fruit: Legume.

Floral formula: Br, o|o ☿ K(5) C1+2+(2) A(9)+1 $G_{\underline{1}}$

Emasculation and Pollination: For emasculation, the flower bud chosen should have developed to the stage just before anther dehiscence, indicated by extension of petals beyond sepals. Flowers can be emasculated any time. The first step is emasculation is to tear away with the forceps the tip of the sepal from in front of the keel. The fore finger is positioned behind the flower and thumb in front and light pressure is applied. This spread the standard and wings to expose the keel. The exposed keel is slight open by tips of forceps. Pressure can be applied by the thumb and finger on keel for increased exposure of the pistil and stamens. The 10 stamens are pulled out.

Pollen can be obtained throughout the day, preferably from a freshly opened flower. For pollen collection, it is more convenient to pick the male flowers, remove the standard and wings, pull back the keel so that the style protrudes and use the pollen covered styler brush as an applicator to transfer the pollen to the stigma of the emasculated bud. Older flowers and other flower bud not used in crossing and removed the peduncle to increase the pod set after crossing.

URD-BEAN:

The inflorescence is axillary, any have 2-3 branches. There are e5-6 flowers clustered at the top of short hairy peduncle. Bracteoles are longer than calyx. Calyx includes five sepals and calyx lobes are linear. Corolla (5 petals) is pale yellow. The standard petal is 12-16 mm wide. There are two wing and two keel petals. Stamens are diadelphous (9+1). Style is spirally twisted.

Emasculation and pollination: It is essentially self-pollinated crop. For emasculation the flower bud is held between thumb and forefinger. The dissecting needle is inserted just under the standard obliquely along the top of the bud. The left side of the standard and the left wing are pushed outward away from the bud and the left keel is removed in pieces. Exposed anthers are removed. For pollination, the staminal column having stamens and anthers intact is taken out from the freshly opened flowers and rubbed against the stigma of emasculated bud.

MUNG-BEAN:

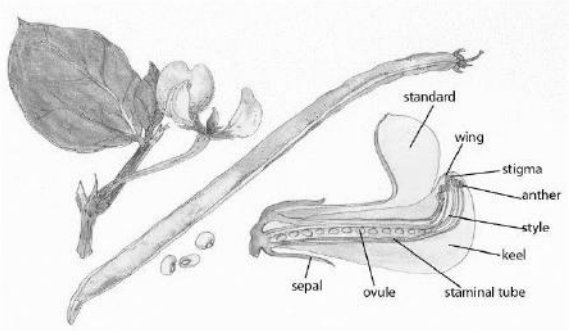
The inflorescence is terminal or axillary raceme. With about more than 10 flowers per peduncle. The flower is typical papilionaceous with 5 sepals, 5 petals, 10 diadelphous (9+1 stamens), and monocarpellary ovary with hairy style.

Emasculation and pollination: It is essentially self-pollinated crop. For emasculation the flower bud is held between thumb and forefinger. The dissecting needle is inserted just under the standard obliquely along the top of the bud. The left side of the standard and the left wing are pushed outward away from the bud and the left keel is removed in pieces. Exposed anthers are removed. For pollination, the staminal column having stamens and anthers intact is taken out from the freshly opened flowers and rubbed against the stigma of emasculated bud.

COWPEA:

Inflorescence is unbranched axillary raceme bearing several flowers at terminal end of peduncle. The peduncle varies from 5 to 60 cm in length and are slightly twisted and ribbed. Calyx is longitudinally ribbed, tubular with 2-15 mm long sub equal lobes. The corolla is papilionaceous with an erect standard petal spreading at the time of flower opening. The pigmentation pattern of corolla varies from white to solid mauve with yellow spots near the base of the standard petal.

The wings are adherent to the boat shaped keel, enclosing the androecium. The stamens are diadelphous (9+1). Anthers are bright yellow. Ovary is monocarpellary, unilocular with many ovules.



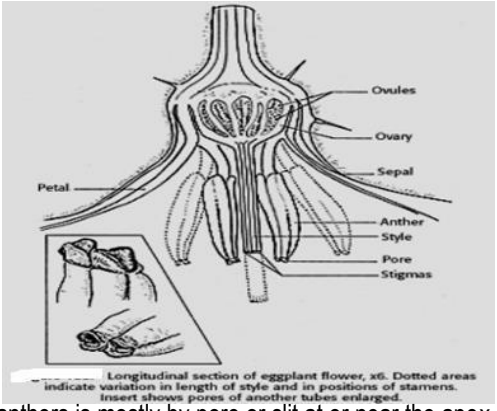
Flowering shoot, seed pod, seeds, and longitudinal section of flower of *Vigna unguiculata*, cowpea

Emasculation and pollination: Cowpea flowers are large and showy. Mostly flowers open between 7 and 9 am. Though the flowers open late in the morning, the dehiscence of anthers is much earlier. It may vary from 10 pm to 0.45 am. Since the dehiscence of anthers is much in advance of blooming the emasculation needs to be carried out in mature flower buds in the preceding evening. The bud likely to bloom the next day is selected for emasculation. The bud is held between thumb and forefinger with the keel side upper most. A needle is run along the ridge where the two edges of standard unite. One side of standard is brought down and secured in position with thumb. Same thing is done with one of the wings. After this, the exposed keel is slit on the exposed side about 1/16 inch of stigma. A section of keel is also brought down and secured in position under the end of thumb. Now 10 stamens are seen. They are removed with pointed forceps. Pollination is done the next morning from a freshly opened flower. The standard and wing of male flower are removed. By slight depression of the keel stigma covered with pollen grains protrudes out.

BRINJAL:

Brinjal flowers are large, violet coloured and solitary or in clusters of two or more. Flower consists of calyx: sepals 5, united, persistent; corolla: petals 5, united, usually cup shaped; Androecium: stamens 5, alternate with corolla; Gynoecium: carpels are united, ovary superior. The hypogynus gynoecium is syncarp located obliquely in relation to the median. In most varieties the perfect flowers are borne singly and opposite the leaves. In brinjal, heterostyly is a common feature. Four types of flowers have been reported depending on the length of styles, viz. (i) long-styled with large ovary, (ii) medium-styled with medium size ovary, (iii) Pseudoshort-styled with rudimentary ovary and (iv) true short-styled with very rudimentary ovary. It has been reported that long and medium-styled flowers produce fruits whereas pseudo-short and short-styled flowers do not set any fruits. Further, chances of cross pollination are more in long style flowers. The percentage of long and medium styled flowers is a varietal character. Fruit setting of long styled flowers varies from 70% to 86.7% in different varieties. In medium styled flowers, fruit set ranges from 12.5% to 55.6%. All varieties have flowers with different style length. The position of the stigma in relation to stamens varies with the cultivars and can also vary in different flowers of same cultivar. Stigmas are either found above, on the same level as or below the stamens and the highest percentage of fruit set is found where the stigma is above the stamens. In short-styled flowers the androecium is fertile but the stigma is smaller with

underdeveloped papillae and lower sugar content than that in long-styled flowers. There is no pollen germination on the stigma or penetration of pollen tube into short styles.

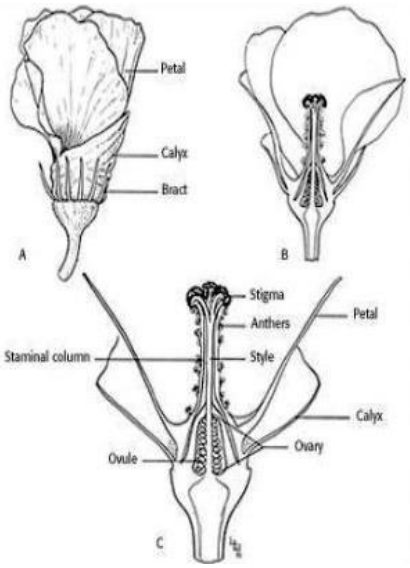


Longitudinal section of eggplant flower, x6. Dotted areas indicate variation in length of style and in positions of stamens. Insert shows pores of another tubes enlarged.

Emasculation and pollination: Flowers generally emerge 40-45 days after transplanting. The anthesis and dehiscence in brinjal are mainly influenced by the daylight, temperature and humidity and therefore the exact timing for every area should be determined by observation and experience. Usually anthesis starts from 6 to 7.30 AM and continues up to 11 AM Peak time for anthesis is 8.30 to 10.30 AM The pollen dehiscence starts from 9.30 to 10 AM Stigma receptivity is highest during anthesis. The receptivity of the stigma could be observed from the plump and sticky appearance which gradually turns brown with the loss of receptivity. The stamens dehisce at the same time stigma is receptive so that self-pollination is a rule, although there is some cross pollination by insects also. The period of effective receptivity ranges from a day prior to flower opening. Pollen is most fertile immediately after the anther dehiscence. Pollen remains viable for a day. Opening of anthers is mostly by pore or slit at or near the apex. Repeated pollination and pollen from different plants increases both fruit and seed set.

For emasculation, use sharp use sharp pointed forceps to force open the selected bud. Then slpit open the anthers and remove them. Collect the pollen from male parent during early morning hours and pollinate the stigma.

OKRA:



The flowers are borne vertically, and its axillary and solitary, on a peduncle 2.0 – 2.5 cm long. The flowers are about 2 inches in diameter, with five white to yellow petals with a red or purple spot at the base of each petal. The flowers were almost actinomorphic. The perianth consisted of 5 sepals and 5 distinct petals. The androecium consisted of very many monadelphous stamens which bears filaments. The gynoecium was a single pistil consisting of several carpels, and a superior ovary. The calyx, corolla and stamens are fused together at the base and fell off as one piece after anthesis.

Emasculation and pollination: flower buds are initiated at 22-26 days and the first flower opened 41-48 days after sowing. Once, initiated flowering continues for 40-60 days. Anthesis was observed between 6 a.m. and 10 a.m. Anthers dehisce before flower opening, and hence self-pollination may occur at anthesis. The dehiscence of anthers is transverse and complete dehiscence occurs in 5-10 minutes. flower opening was initiated between the hours of 6:00am - 6:30am and closes between 11:30am -12:00 pm. At anthesis, self-fertilization is far from complete and only a few ovules are then fertilized. Ovules continue to be fertilized during the morning and allogamy may be possible. The possibility of allogamy decreases rapidly and a pollen grain deposited on the style after midday has no impact on progeny. In okra, stigmas are exposed to allow pollination at anthesis, and only anthers in the upper ring come into contact with stigmas.

Hand emasculation is done by giving a slight ring cut at the base. Remove the anthers with care and bag the flower. Pollen from freshly opened bud are collected in the morning and dusted directly on the emasculated stigma with the help of camel hair brush. Then cover the flower with butter paper.

ESTIMATION OF HETEROSIS, INBREEDING DEPRESSION AND HERITABILITY IN FIELD EXPERIMENTS

Heterosis = $\frac{\overline{F1} - \overline{MP}}{\overline{MP}}$ x 100	Heterobeltiosis = $\frac{\overline{F1} - \overline{BP}}{\overline{BP}}$ x 100	Economic heterosis = $\frac{\overline{F1} - \bar{C}}{\bar{C}}$ x 100
Inbreeding depression = $\frac{\overline{F1} - \overline{F2}}{\overline{F1}}$ x 100	Heritability = $\frac{Vg}{Vp}$ x 100	