Lecture 07:
SEED PRODUCTION IN MAIZE

Maize is common millet of India with wider industrial and household utility. It is used a feed, food and raw material in soft drink industry. Botanically it is known as *Zea mays* and belongs to the family poaceae.

Floral biology

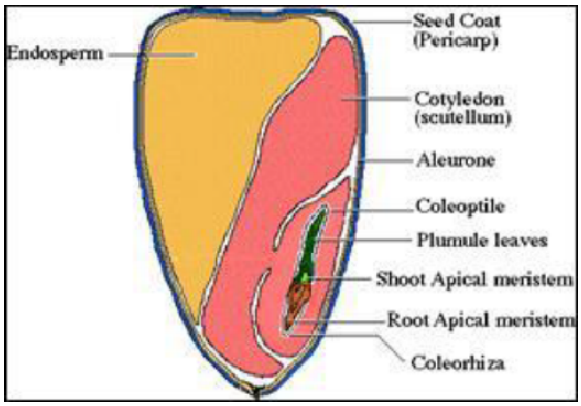
Botanical name	*: Zea mays*
Chromosome number	: 2n=20
Botanical Family	: Poaceae
Inflorescence	: Panicle cob, as the crop is monoceious in nature
Type of flowers	: Female : Cob (axillary inflorescence in the middle portion of plants) Male : Tassel (terminal inflorescence)
Husk	: Enlarged leaf sheaths from each node, forming a protective covering around the inflorescence.
Pollination	: Cross pollination
Special character	: Protandry
Flowering pattern	: Top to bottom (Tassel) Bottom to top (Cob)
Anthesis	: Pollen shedding begins 1 to 3 days before the silk emerge from the cob.
Fertilization	: Within 12 to 18 hrs after silk emergence The entire silk is receptive. Silk will be pinkish and sticky at the beginning (receptive) after fertilization it will be chocolate/ brown colour.
No. of pollen in tassel	: 2,50,00,000
Pollen viability	: 12-18h
Silk receptive	: 8-10 days
Male flower anthesis	: 6.00 am to 8.00 a.m
Duration of flowering	: 2-14 days

Tassel

Cob

Husk

Silk



Seed

Types and Methods of seed production in maize

In maize, open pollinated varieties, synthetics, composites and hybrids are available.

1. Open pollinated varieties

Raise the varieties under isolation of 400 m in foundation seed stage and 200 m in certified seed stage and allow the plants to openly pollinate among themselves and set seed.

1. Synthetics

In cross pollinated species, a variety obtained by in mating in all possible combinations, a number of lines (>5) that combine well with each other. COBC 1 (Baby corn).

1. Composite varieties

These are produced by open pollination among a number of outstanding strains usually not selected for combining ability with each other e.g. K1, Jawahar, Vikram, Sona, Amber, CO 1 and Kisan.

d. Inbreds

It is relatively true breeding strain resulting from repeated selfing (5 times.)

Varietal seed production technique

Open pollination under isolation is the common method of varietal seed production.

Stages of seed multiplication

In maize seed (varieties composites and synthetics) is multiplied adopting three generation system, as breeder seed, foundation seed and certified seed as the crop is highly cross pollinated crop , where the chances for genetic contamination is high.

Popular varieties

In Tamil Nadu, CO1, K1, COH3, COH4, are the popular varieties for grain purpose, while African tall is a fodder maize.COBC1 is a variety identified for salad purpose.

Season

The best season for production is June - July, November- December and January – February and the flowering should not coincide either with rain or high RH and the maturation should coincide with dry weather. The temperature of 37°C is favourable for better seed setting.

Land requirement

The land required for open pollinated variety, composites and synthetics should be fertile and problem soils will lead to low pollen fertility and will adversely affect the quality and the seed set will be poor. The previous crop should not be the same crop to avoid the occurrence of volunteer plants and if to be the same crop it has to be the same variety and should be certified and has to be accepted for certification. The field should not have any volunteer plants.

Isolation distance and Modification of isolation distance

1. Composite, Synthetics and OPV = (FS:CS 400 : 200 m)

Differential blooming dates are permitted for modifying isolation distance provided 5.0% or more of the plants in the seed parent do not have receptive silks when more than 0.50% of

plants in the adjacent field (s) within the isolation distance are shedding pollen.
Distances less than 200 meters may be modified by planting border rows of male parent, if the kernel colour and the texture of the contaminant are the same as that of seed parent. The number of border rows shall be determined by the size of the field and isolation distance from the contaminant.

Selection of Seed

For production of foundation seed, breeder seed is used as the base material, while for certified seed, foundation seed should be used as the base material. The seed used should be from authenticated source with tag and bill. The required seed rate will be 20kg /ha or 8kg/ acre.

Pre sowing seed treatment

The seeds are given with any one of the seed treatment or in combination. Seeds are soaked in 2% KH2PO4 for 16h with a seed to solution ratio of 1:0.06 and are dried back to their original moisture content of 8-9% .This management could be used both for dryland agriculture as well as gardenland.

Seeds are also treated with 5% carbofuran 3G to protect the seed from shoofly infection. Seed treatment with chlorpyriphos @4 ml /kg is also recommended against the attack by shootfly. Seeds are dry dressed with bavistin @2g/kg of seed to protect against seed borne pathogens and soil borne pathogen.

Seeds are also treated with azospirillum @50g/kg of seed to fix atmospheric N. Any one of these treatment or combination of treatment is adopted for better productivity.
Seeds are also treated with polycoat @ 3g/kg of seed diluted in 5ml of water to invigourate the seed towards better marketability and production. Pink coloured polycoat performed better than other colour polymers. On adoption of sequence of treatment physiological should be followed with physical seed treatment.

Sowing

The seed are sown at a spacing of 45 x 10 cm or 60 x 20 cm at a depth of 2-4 cm based on the specific features of the variety. Nursery production will not be suited to this crop. In the main field seeds are sown either in ridges and furrows or under beds and channels. The seedlings are thinned and gap filled should be done 7-8 days after sowing.

Plant spacing

Row spacing

Seed rate
Varieties : 20 kg /ha

Nutrient application
At last ploughing apply 12.5 tonnes of compost per hectare

Fertilizers(varieties) 150:75:75

- Basal 40:75:40 NPK kg/ha
- 1st top 20 DAS 50:0 :0 kg/ha
- 2nd top 40 DAS 60:0:35 kg/ha.

Micronutrients
2% DAP is sprayed at 50% flowering stage to enhance uniform flowering and increased seed set
If Zn deficiency is found apply 20 kg of zinc sulphate / ha.
If Fe deficiency is found apply 12.5 kg /ha micronutrient mixture

- The crop is mostly affected by micronutrient deficiencies by N,P,Mg,Mn,Zn,Fe and K. Apply 12.5kg of micro nutrients in furrows and the mixture in the soil.

Weeding

Application of atrazine @ 500g per ha as pre-emergence herbicide control the growth of weeds upto 20-25 days.(If pulses is used as intercrop do not use atrazine) One hand weeding at 17-18 days after sowing keep the field free of weeds.Weeding after boot leaf stage is not economical and shade will also minimize the weed flora . On organic production, 2 hand weeding at seedling stage and other at boot leaf formation will keep the field weed free.

Irrigation

The crop should be irrigated once in 10-15days for enhanced seed set and formation of bolder grains. The critical stages of irrigation are primordial initiation stage, vegetative stage , flowering, milky and maturation stage. If the irrigation is withheld in these stages seed set will be poor and seed size will be reduced.

Pest and disease management

Shoot fly	Monocrotophos 0.03%
Stem borer	Rogar 0.3% / Carbaryl 50 WP 1kg.per heactre on 20th day
Lesion nematodes	Carbofuran 3 G@30kg./ha.in seed holes at the time of sowing.
Downy mildew	Mancozeb @ 1kg/ha.
Leaf spot	Mancozeb or captan @ 1kg/ha
Cob borer	Apply carbaryl 10% dust @ 25kg/ha. At milky stage repeat it 15 days thereafter.(50 lts. Spray fluid per ha)

Roguing

It is specific to seed crop and is done from seedling stage to harvesting stage based on the phenotypic characters. Off types can be identified through stem colour,plant structure, number of leaves ,auricles, nodal colour, tassel colour,sheath colour ,grain colour etc. The field standard for seed crop is as follows

Seed Certification

Number of Inspections

A minimum of two inspections shall be made at flowering and another during flowering.

Field Standards

General: Maize field should be isolated from contaminants as follows

Contaminants	Minimum distance(meters)	
	Foundation stage	Certified stage
Fields of other varieties	400	200
Fields of same variety not confirming to varietal purity requirements for certification and teosinte	400	200

In maize hybrid alone increasing the border row and minimising the isolation is permitted

Specific standard: These are verified at the final inspection

Factor	Maximum permitted (%)	
	FS	CS
Off types plants that have shed are or shedding pollen at anyone of the inspections during flowering when 5%or more of the plants in the seed field have receptive silks .	1.0	1.0

Preharvest sanitation spray

Spraying of endosulphan @ 0.07% and bavistin@10g /lit 10 days prior to harvest prevent the seed weevil (Sitophilus oryzae) infestation at storage.

Seed maturation

- 14-20 DAA milky stages (starch in fluid stage)
- 35 DAA : Soft dough stage
- 45 DAA : Glazad dough stage
- 55 DAA : Ripe dough stage

Symptom of Physiological maturation

- Cob sheath turn straw yellow colour
- The funicular degeneration
- Formation of dunken layer
- Moisture content of seed 35%

Matured cob

Dunken layer

Harvesting

The crop attains physiological maturity 30-35 days after 50% flowering and the seed moisture at this stage will be around 25-30%. The crop is harvested as cob harvesting when the sheath of cob dries and attains straw yellow color. The crop is harvested as once over harvest for seed purpose.

Dehusking

After harvest manually the sheath are removed, which is known as dehusking.

Cob sorting

Based on the kernel arrangements on the shank as irregular discoloured, diseased and ill filling the Cobs are sorted out and cobs with characteristic kernel colour and shank colour and regular row arrangements are selected for seed purpose. The kernel discolouration should not 10% for certification.

Zenia and metazenia

The discolouration in cobs may be due to disease infection or genetic contamination. The effect of foreign pollen on kernel colour is known as Zenia, metazenia effect which causes genetic contamination in the seed lot. Zenia is the effect of foreign pollen of same generation and metazenia is the effect of foreign pollen in next generation.

Shelling

The cobs are dried under sun and threshed with fliable stick for extraction of seeds the moisture content of seed at the time of threshing will be 15-18%.On large scale production cob shellers are used, but care should be given to avoid mechanical damage, which in turn will reduce the seed quality and storability.

Drying

The seeds are dried to 8 to10 % moisture content either under sun or adopting mechanical driers for long term storage as the seeds is orthodox in nature.

Processing

Mechanical grading can be done with cleaner cum grader, which will remove the undersized immature and chaffy seeds .The middle screen size should be 18/64" round perforated sieves. The size can vary depending on the variety from 14/64 to 20/64 inch round perforated sieves.

Seed treatment

The seeds are infested with several storage pests, to protect against these pests the seeds are given protective treatment with bavistin @2g/kg of seed with carbaryl @200mg/kg of seed as slurry treatment. Bifenthrin @5mg /kg of seed or diflubenzuran @ 200 ppm per kg of seed or imidachlopride @ 3 ml per kg of seed is also recommended for better seeds storage .

Seed packing

Seeds are packed in gunny bag for short term storage while in HDPE and polylined gunny bag for long term storage.

Storage

The treated seed can be stored up to 12 months provided the seeds are not infected with storage pests. Seed can be stored up to 3 years if the seeds are packed in moisture containers and are stored at low temperature .The godown should be kept clean as the possibility of secondary infestation with Trifolium (red flour weevil) is much in these crop. The major problem in storage is incidence of grain weevil which will powder the seed material in a short period.

Seed yield: 3 to 4.0 tones

Seed standard

The processed seed should have the following seed quality characters both for certification and labeling.

A. Seed ears inspected after harvest shall not contains in excess of 1.0% of offtype ears including the ears with off-coloured kernels.

B. Shelling

Shelling of the seed ears is to be done after obtaining approval from the Certification Agency

Factor	Standards for each class	
	FOUNDATION	CERTIFIED
Pure seed (maximum)	98.0%	98.0%
Inertmatter(maximum)	2.0%	2.0%
Other crop seed (maximum)	5/kg	10/kg
Weed seed	None	None
Other distinguishable varieties based on kernel colour and texture (max)	10/kg (by number)	20/kg (by number)
Germination (Minimum)	90%	90%
Moisture (maximum)	12.0%	12.0%
For vapour proof container (maximum)	8.0%	8.0%

Mid storage correction

The seeds lose their quality during storage due to deterioration and pest infestation, when the germination falls below 5-10 % of the required standard the seeds are imposed with mid storage correction, where the seeds are soaked in double the volume of 10-4 M solution of potassium di-hydrogen phosphate (3.6mg/lit of water) for 6 hours and the seeds are dried back to original moisture content (8-9%).

Lecture 08:
HYBRID SEED PRODUCTION IN MAIZE

Crossing technique : Manual emasculation by detasseling

Detasseling : Removal of male inflorescence from the monoecious crop

Time for detasseling : The time taken for shedding of pollen from the tassel in 1-2 days after emergence. Hence the tassel should be removed before the shedding of pollen.

Detasseling

Detasseling is the removal of tassel from female parent. Detasseling is done when the tassel emerged out of the boot leaf, but before anthesis have shed pollen. Anthers take 2-4 days to dehisce after complete emergence. Only in few cases, the anthers start dehisce before its complete emergence. In such case detasseling should be done earlier. Detasseling is done every day from the emergence of tassel upto 14 days.

Method

- Hold the stem below the boot leaf in left hand and the base of the basal in right hand and pull it out in a single pull.
- Grasp entire tassel so that all the pollen parts are fully removed.
- Do not break or remove leaves as removal will reduce yields and will result in lower quality of seed.

Precautions to be adopted during detasseling

- No part should be left on the plant as it causes contamination.
- It should be uniform process done daily in the morning in a particular direction.
- Donot break the top leaves as the field may be reduced due to the earning of source material to accumulate in sink [seed] as removal of 1 leaf course 1.5% loss 2 leaves 5.9% loss and 3 leaves 14% loss in yield.
- Detassel only after the entire tassel has come out and immature detasseling may lead to reduced yield and contamination.
- Mark the male rows with marker to avoid mistake in detasseling
- Look out for shedders [shedding tassel] in female rows as the may cause contamination.
- After pulling out the tassel drop it there itself and bury in soil. Otherwise late emerging pollen from detasseled tassel may cause contamination.
- Do not carry the tassel through the field as any fall of pollen may lead to contamination.
- Donot practice, improper, immature and incomplete detasseling.
- **Improper detasseling**: A portion of the tassel is remaining in the plant while detasseling.
- **Immature detasseling:** Carrying out detasseling work when the tassel is within the leaves.
- **Incomplete detasseling**: The tassel is remaining in lower or unseen or unaccounted in within the whole of leaves.
- There should not be any shedding tassel.
- **Shedding tassel**: Either full or part of tassel remain in female line after detasseling and shedding pollen which may contaminate the genetic purity of the crop.

System of Hybrid seed production

- Detasseling (Manual creation of male sterility)

Types of hybrids

Single cross hybrid

It is a cross between 2 inbreds. A x B. A genotype will be detasseled and crossed with B genotypes.

- COH 1- UMI 29 x UMI 51
- COH 2- UMI 810 x UMI 90
- CoH(M) 5-UMI 285 X UMI 61

Double cross

- It is a cross between two single crosses.
- It is a cross between 2 hybrids (A x B) x (C x D) (A x B) single cross hybrid will be produced by detasseling A and by crossing with B (C x D) hybrid will be produced by detasseling C and crossing with D.
- Then (A x B) will be detasseled and crossed with (C x D) hybrid.

Example
Ganga 2 : (CM 109 x CM 110) x (CM 202 x CM 111)
Ganga 101 : (CM 103 x CM 104) x (CM 201 x CM 206)
COH3 : (UMI 101 x UMI 130) x (UMI 90 x UMI 285)

Three way cross

- It is a cross between a single cross and an inbred.
- It is first generation resulting from the crossing of on approved inbred line and a certified open pollinated variety A x variety)
- A will be detasseled and allowed for crossing in the variety.

Example Ganga -5 (CM 202 x CM 111) x CM 500.
COH (M) 4 : (UMI 90 x UMI 285) x UMI 112

Double top crosses : The first generation resulting from the controlled crossing of a certified single cross and a certified open pollinated variety. : (A x B) x variety : (Ax B) will be detasseled and crossed with a variety

Seed production technology

Season - November- December, Mid July, Jan. Feb and Sep. Oct

Isolation distance

	Foundation seed (m)	Certified seed (m)
1. Inbreds	400	-
2. Single cross hybrid	400	-

Field standards for isolation (modification based on situation)
For (foundation single crosses and hybrid of certified class)

	Foundation stage	Certified stage
• Same kernal color	400	200
• Different kernal colour	600	300
• Field of single cross / inbreds not confirming to varietal purity	400	200
• Single cross with same male parent confirming to varietal purity	5	5
• Single cross with other male parent not confirming to varietal purity	400	200

- Differential blooming dates are permitted for modifying isolation distance provided 5.0% or more of the plants in the seed parent do not have receptive silk when more than 0.20% of the plants in the adjacent field within the prescribed isolation distance are having shedding pollen.
- In hybrid seed production (certified seed stage) alone the isolation distance (less than 200 meter) can be modified by increasing the border rows of male parent, if the kernal colour and texture of the contaminant are the same as that of the seed parent.

The number of border rows to be planted all around the seed field to modify isolation distance less than 200 m shell also be determined by the size of the field and its distance from the contaminant as shown below.

Area in ha.	Isolation distance (m)	Border rows
< 4 ha	200	1
< 4 ha	150	5
< 4 ha	100	9
< 4 ha	50	13
10-12 ha	180	1
10-12 ha	130	5
10-12 ha	80	9
10-12 ha	30	13
> 16 ha	165	1
> 16 ha	115	5
> 16 ha	65	9
> 16 ha	15	13

Seed production stages and production of parental lines / hybrids

Stage of seed	**Single cross**	**Double cross**	**Three way cross**	**Double top cross**	**Top cross**
Breeder seed	A, B	A, B, C, D	A, B, C	A, B, variety	A, variety
Foundation seed	A, B	(AxB) (CxD)	(AxB), C	(AxB) variety	A, variety
Certified seed	A X B	(AxB) x (CxD)	(AxB) x variety	(AxB) x variety	Ax variety

Spacing

Seeds are sown in ridges and furrows

Hybrids	:	60x 25 cm
Seed rate	:	Female : 7 -10 kg ha-1
		Male : 3 -4 kg ha-1
Spacing	:	Female : 60 x 20 to 75 x 30 depending on the area.
		Male :45 x 30 cm

Planting ratio:

Single cross	:	4:2
Double cross	:	6:2
3 way cross	:	6:2
Border rows	:	a. Inbreds & single cross - 4 rows
		b. Others - 3 rows

Fertilizer

NPK kg / ha	:	200 : 100 : 100
Basal	:	100 : 100 : 50
1st Top	:	50 : 0 : 0 (20th days -vegetative phase)
2nd Top	:	50 : 0 : 50 (Boot leaf stage at 45 days)
Foliar	:	DAP 2% at 50% flowering
In Zn deficient soil	:	ZnSO4 @ 25 kg ha-1

Roguing

Should be done periodically based on position of cob, colour of silk, arrangements of seeds in cob, leaves etc. Shedding tassels are to be removed in roguing . It refers to the tassels in female parents rows, shedding pollen or that has shed pollen in hybrid maize plots. During field inspection a tassel whose main spike or any side branch or both have shed pollen or shedding pollen in more than 5 cm of branch length is counted as a shedding tassel during inspection the shedding tassels are taken into count for acceptance or rejection of production plot.

Field standard (%)

FS		CS	
Off types		0.2	0.5
Shedding tassel		0.5	1.0 (when receptive silk is 5% or more)
Inseparable other crop	:	Nil (both stage)	
Objectionable weed	:	Nil (both stage)	
Designated diseases	:	Nil (both stage)	

Field standards –specific

Specific factors	Certified stage
Off types shedding pollen when 5 % or more of seed parent in receptive silk	0 .50 %
Seed parent shedding pollen when 5 % of the seed parent is having receptive silk	1.0 %
Total of pollen shedding tassel including tassel that had shed pollen for all 3 inspections conducted during flowering on different dates	2 .0 %
Off types in seed parent at final inspection	0 .5 %

Number of inspection : Four
(Seed certification officers) : One : Before flowering
: Three : During flowering

Harvest

- Harvest when the moisture content falls to 20-25%
- Harvest male first and remove from the field and then harvest female

Threshing

a. Dehusking - The husks are removed manually.
b. Cob sorting - Remove ill filled, diseased cobs and cobs having kernel colour variation.

Zenia

The direct/visible effects of pollen on endosperm and related tissues in the formation of a seed colour. e.g. seed colour. In maize, the gene present in sperm cell contributes in the expression of colour of hybrid seeds.

Matazenia

Is the effect of pollen on the maternal tissues of fruit.

Shelling

Cob sorting should be the first operation it is a post harvest, evaluation for genetic purity. The sheath is removed and check for kernel colour, shank colour, diseased cobs, kernel arrangement. The cobs are shelled either mechanically or manually at 15-18% moisture content. Improper shelling leads to48% damage to kenel Growth of storage fungal Pericarp damage. Crack on pericarp can be identified by FeCl3 or Tz test. Shelling is done mechanically using cob sheller and manually by rubbing with stones.

Drying

Seeds are dried to 12% moisture content.

Grading

Grade the seeds using 18/64" (7.28 mm) sieve.

Seed treatment

Slurry treat the seeds with 8% moisture content either with captan or thiram 75% W.P. @ 70 g/100 kg with 0.5 litre of water. Treated seeds can be stored for 1 year in cloth bag.

Others: As in varietal seed production

Seed yield : 2.5 - 3.6 t/ha

Seed standard inbred, varieties and hybrids

Hybrids

Parameters	Inbreds	FS	CS
1. Physical purity (%) (min)	98	98	98
2. Inert matter (%) (max)	2	2	2
3. Other crop seed (max)	5 /kg	5 kg-1	10 kg-1
4. ODV seeds (max)	5/kg	5 kg-1	10 kg-1
5 Germination % (min)	80	80	90
6. Moisture content (%) (max)			
a. Moisture pervious	12	12	12
b. Moisture vapour proof	8	8	8

Production of Synthetic cultivars

Breeding of cereal and other agronomic crops has contributed significantly to the growth of agribusiness worldwide. In normally self fertilized crops, new variability may be created by hybridisation, followed by the selection of desired cultivars in which desirable characteristics from two or more parents are combined. The type of hybrid cultivar obtained will depend upon the genetic background of the chosen parents as well on the method of selection used. A similar situation arises when new variability is artificially induced through mutations.

In pure-line theory of classic plant breeding, a pure line is defined as all the descendants of single homozygous individual by continued self-fertilization, resulting in a homogeneous cultivar. Hybridization, however, results in significant heterogenity. The multiplication of such heterogenous progeny in bulk to select homozygous individuals would be gigantic task. Most modern hybrid cultivars are, therefore, selected at an early stage (F2) as subsequent lines and probably released at the F8 and F12 generations. These are obviously not as homogeneous as a pure line.

Cultivars can also be selected by producing multilines. Whereas normal line selection seeks to produce a new cultivar on the basis of one line or a few lines that are very similar, multiline cultivars are essentially different from each other in their characteristics, such as resistance to pests and diseases or environmental stresses. Thus, by incorporating different sources of resistance, the newly synthesized cultivar is buffered against changes brought about by virulent pathognes. These cultivars are however, not very stable compared to those produced by the conventional methods of selection. A change in the prevalence of a virulent pathogen may eliminate certain lines from the cultivar. It is, therefore, necessary to return the cultivar to the plant breeder for its reconstitution. This may be advantageous, because it enables plant breeders to substitute new sources of resistance in the material.

Alternatively, the plant breeder can create a composite cross by bulking the F2 generations of several crosses. The composite is allowed to develop for several generations during which natural selection may occur. If the composite is grown at more than one location, a locally adapted cultivar may be developed in time. The composite constitutes a gene pool from which the plant breeder can select a cultivar with desirable characteristics for further multiplication.

An alternative to the composite is the synthetic or artificial method of plant breeding in which a number of lines are put together by the plant breeder in predetermined proportions. A synthetic line generally has a limited life, because the proportions of the constituent lines are likely to change over number of generations. The plant breeder must plan for seed production of limited generation basis. This system can be extended by using mixtures of cultivars claimed to be advantageous in some species over a single cultivar, especially if different resistant genes are present in each cultivar. This method adds to the cost of mixing, which can be reduced by growing a seed crop for one or two generations after mixing before using it for crop production.

A hybrid cultivar results from a controlled cross between a male and female parent, the seed being harvested from female parent only and used for crop production. In self fertilized crop species, it is easy to produce hybrid cultivars if male sterile lines are available that can be used as female parents. There are certain substsnces that act as a gametocides, destroying the pollen of desired female parent, or as inhibitors that prevent

pollen produced by the female parent from effecting fertilization. The advantage of the synthetic hybrid cultivar lies in heterosis. Special expensive measures are required to produce seed that is harvested from the female parent only. The resultant heterosis therefore must have a profitable effect to compensate for the cost of production of synthetic hybrid cultivars in the self pollinating crop species.

In the cross pollinated crop species, plant breeders look for parent plants that have good combining ability. These plants, when allowed to multiply together, produce a desirable combination of characteristics. Cross fertilization results in greater heterozygosity in these plants than in the self fertilized plants and therefore less homogeneity. Each generation of an open pollinated cultivar is thus a mixture of hybrids. The open pollinated cultivars are generally grown for a limited number of generations and returned to the plant breeder's maintenance material after each cycle of seed production to produce commercial quantities of seeds.
Putting together a large number of parent plants and allowing random pollination to occur can create composites. A composite in a cross fertilized species is generally the product of the first generation of such random pollination.

Production of synthetic cultivars begins with a limited number of specific parents, which are permitted to interpollinate. The number of generations of multiplication is strictly limited so as to recreate the synthetic/artificial cultivar at the end of each multiplication cycle. As with the self fertilized species, synthetic hybrid cultivars of cross fertilized species are created by controlling pollination to ensure that seed is produced from a desired crossing. This can be achieved by the following methods.

1) By emasculating the female parent, as is done in monoecious plants like maize, by removing the male flowers before the release of pollens.

2) By using male sterility in the female line, so as to avoid the physical removal of male flowers.

3) By using self incompatibility. In this system, the seed crop is harvested as a whole, since all plants are contributing and receiving pollen. The self incompatibility, however, is not always complete, and there may be production of some inbred plants. With the excessive production of such plants, the advantage of heterosis in the subsequent crop is diminished. The advantage of the synthetic hybrid cultivar in cross pollinated species is not restricted only to heterosis. Most hybrids are based upon inbred lines. Normally, cross fertilized plants require inbreeding for several generations to reduce heterozygosity and to include desirable genes in synthetic cultivars. A controlled cross between two such inbreds produces heterosis

and desirable combination of genes in the form of a synthetic cultivar. The major disadvantage of the production of synthetic cultivars is the higher cost of plant breeding and seed production, requiring considerable time consuming work to produce desirable inbreds, which alone can be used to synthesize new artificial hybrids. The final seed crop is not fully productive when male sterility or emasculation is used, because only the female parent is harvested for seed.

Therefore various other hybrids have been produced. The hybrid resulting from the cross of two inbred lines is a single cross, whereas the F1 resulting from the cross of two single cross hybrids as parents is known as a double cross. In a three way cross, an inbred is mated with an f1 hybrid. A top cross is the F1 resulting from a cross between an inbred or a single cross and an open pollinated cultivar. All of the forms of hybrid cultivars require a particular cycle of seed production to produce the seed used in crop production.