B.Sc. AGRICULTURE LAB MANUAL

3rd Semester

Prepared By

Biological Science Dept.

Agriculture

MIDNAPORE CITY COLLEGE

AGS (301)

Crop Production Technology-I (*Kharif* crops)

INDEX

Exercise: 1 Identification of kharif crops and seeds

Introduction

Crops and seeds are too often confuses a student, particularly different varieties of a crop, if he/she does not have proper acquaintance previously. Similarities in morphological characters like plant stature, size of the ear head, colour and size of the seed leads to lot of confusion especially for those not having farming back ground or lack of exposure to such crops and seeds. Therefore maintenance of the crop museum is a mandatory for each college farm. In crop museum different crops are sown. In each instructional farm (college farm/ students farm) a piece of land is meant for raising crop cafeteria which includes different crops with recommended package of practices for student instructional purpose (identification).

Different types of field crops like cereals, pulses, oil seeds, commercial crops, fibers etc. are grown in limited area considering the season of growing at a time with the purpose of studying detail characteristics and demonstration is called crop museum. This crop museum serves as an important guide to the students and farmers to know the important characteristics of different kharif crops and offering an opportunity to choose suitable crop or crops.

Objectives:

- To know the crop growth stages of different crops viz. germination stage, tillering stage, flowering stage, maturity stage etc.
- To know the life period of different crops.
- To know the periodical growth habit of the crops viz. height and width of crop plants.
- To know the different stages at which the crops are affected by insects, pests, and diseases and nature of damage.
- To know the climatic effect on different kharif crops.
- To know the method of the sowing, seed rate, fertilizer and irrigation requirement, maturity and time of harvesting.
- To identify two similar crops at initial stage of the crop growth e.g. sorghum and Pearlmillet.

Material required

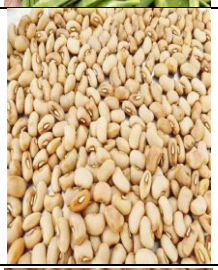
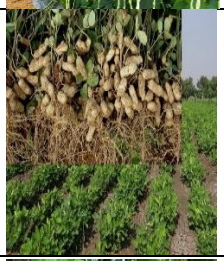
Crop museum, seed museum

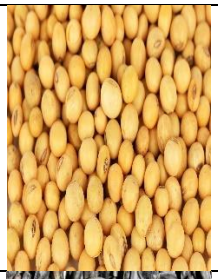
Procedure

Visit the students' farm/college farm; observe the existing crops, their morphological characters for easy identification.

Serial No	Name of the Crops	Botanical name	Family	Picture

1	Rice	*Oryza sativa*	Poaceae	 
2	Maize	*Zea mays*	Poaceae	 
	Sorghum	*Sorghum bicolor*	Poaceae	 
	Pearl millet	*Penisetum glaucum*	Poaceae	 
	Vari	*Penicum milare*	Poaceae	
	Kodomillet	*Paspalum scorbicalatum*	Poaceae	 
	Finger millet	*Elusine coracana*	Poaceae	 
	Pigeonpea	*Cajanus cajan*	Fabaceae	 

	Greengram	*Vigna radiata*	Fabaceae		
	Blackgram	*Vigna mungo*	Fabaceae		
	Clusterbean	*Cyamopsis tetragonoloba*	Fabaceae		
	Cowpea	*Vigna sinensis*	Fabaceae		
	Groundnut	*Arachis hypogaea*	Fabaceae		
	Castor	*Ricinus communis*	Euphorbiaceae		
	Sesame	*Sesamum indium*	Pedaliaceae		

	Soybean	*Glycine max*	Fabaceae		
	Sunflower	*Helianthus annus*	Asteraceae		
	Cotton	*Gossypium hirsutum*	Malvaceae		
	Jute	*Corchorus olitorius, Corchorus capsularis*	Malvaceae		
	Napier hybrid	*Pennisetum purpureum*	Poaceae		
	Tobacco	*Nicotiana tabacum*	Solanaceae		

	Sunhemp	*Crotolaria juncea*	Fabaceae		
	Dhaincha	*Sesbania rostrata*	Fabaceae		

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Exercise: 2 Field lay-out of different methods of rice nursery including SRI

Objectives:

1. To know different methods of raising nurseries for rice crop planted through transplanting.

2. To obtain healthy and robust seedlings to transplant in time for better yield.

Rice has small sized seeds and soft seeds, if sown directly in the field, it will not give uniform and satisfactory germination. To avoid such difficulty, the seeds are not directly sown in the field but seedlings are raised in the nursery with special care and later on they are transplanted in the field. A nursery of succeeding crop is prepared to avoid its delay sowing in case of late harvesting of preceding crop. For example, seedlings of rice are raised in nursery for summer cultivation. In cases of hybrid seeds require in large quantity, where seed material is costly or in limited quantity, crop is grown in raised nursery.

Selection of Nursery site:

• It is desirable that the nursery site is changed every year to minimise the incidence of diseases, pests and weeds.

• Soils of nursery area having good water retention capacity with good amount clay and O.M., well drained, on high elevation to drain excess water.

• It should be near to source of irrigation

• Away from shade of tree.

Wet nursery:

Seed and seed treatment:

➢ Select the certified seed for sowing

➢ For fine grain varieties, 20-25 kg seed and for coarse varieties, 25-30 kg seed would be required to raise seedlingsin 10 Gunthaarea, which is enough for one hectare.

➢ Dry seed treatment:Seeds should be treated with thiram or carbendazim 25 S.D. @ 3 g/kg seed.

➢ Wet seed treatment:Soak the seeds (25 kg) in streptocycline@ 6g/24 lit water for 10 hours.After soaking the seeds, they should be dried for sowing.

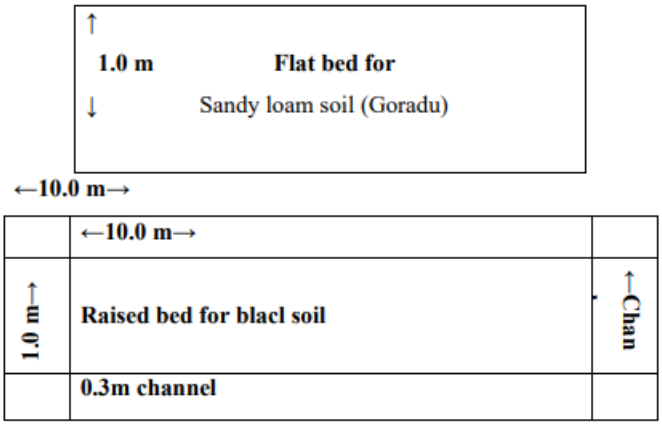
Nursery

➢ Select the well-drained and levelled field having better irrigation facilities

➢ Usually nursery area for rice is about one tenth of the main field area. About 1000 sq. m. area of nursery is sufficient to transplant one hectare.

➢ Flats type of beds are prepared easily in sandy loam type of soils. Whereas, raised type of beds are mostly preferred in heavy black soils which have poor drainage capacity. The basal measurement of beds should be 10 m x 1m. Length of beds should be kept according to the slope of nursery.

In between the raised beds, a drainage channel of about 30 cm width is provided.The surface of the bed is smoothened with gradual inclination towards both sides to facilitate easy drainage of water.



➢ Keep the nursery wet by sprinkling water with water cane or give light irrigation till the germination of seeds.

➢ Weeding in time is the important operation. Spray pendimethalin @ 1.0 kg/ha or oxadiazon o.5 kg/ha or pretilachlor@1kg/ha with sand after 3 days of sowing for control of weeds.

➢ Application of Carbofuran 3G @ 10 kg / 10 Guntha 15 DAS

➢ After care should be taken for plant protection measures.

Dapog Nursery:

• This method of raising nurseries has been introduced in India from Philipines.

• This involves growing seedlings on a concrete floor or on a raised bed of soil covered with polyhtene sheets or banana leaves.

• The polyhtene sheets prevent entry of roots into the soil.

• The dapog beds should be about 1- 1.5 m wide and its length depends on the area to be planted.

• Pre-germinated seeds are sown on the top of the sheets @ 2.0 kg/sq.m.ofnursery.

• Water is sprinkled and the seeds are pressed gently with hand or with a wooden flat board twice a day for the first 3-6 days.

• This helps the roots to remain in contact with water retained on the surface and prevents drying.

• After 6 days, the seed beds are watered upto a depth of 1-2 cm.

• In about 14 days,seedlings are readyfor transplanting. Besides, the seedlings are thin, slender and short in height.

• The main merit of this method is that less area (30-40 sq.m.) is needed to raise seedlings sufficient for planting one hectare.

• By this time,the roots are well developed and interwine with one another so that the nursery can be cut into stripes, rolled and transported easily to the planting site.

• Loosen the interlocked roots carefully before transplanting.

Details of SRI Technology

System of Rice Intensification (SRI) was first developed in MEDAGASKAR in 1980, s.

1.Land preparation		Apply 5 t FYM ha-1and plough the field
2. Suitable varieties 3. Seed rate 4. Nursery raising 5. Age of seedling		Any variety / hybrid 5 kg seed /ha 5 Apply layer of fine manure on seed bed. Distribute pre-sprouted se seeds and cover with them with layer of fine manure.Seed bed 1 should be mulched with paddy straw. About 100 sq. m. area of nursery is sufficient to transplant one hectare 12 -14 days old seedling (Two leaves stage)
6. Transplanting		Transplant one seedling per hill (25 cm x 25 cm). The root of the seedling should not be disturbed. Transplanting should be done a day after puddling the field having no standing water. Transplanting should be done from last fortnight of June to First fortnight of July.
7.Nutrient Management Fertilizer dose		25 % RDN through chemical fertilizer and remain 75 % through organic manure
8.Bio-fertilizer		Liquid biofertilizer @ 1 lit/ ha each of Azotobactor and PBS after mixing with 50 kg well decomposed &

		sieved FYM, broadcast it equally at the time of transplanting.
9. Weed Control		Use cono-weeder/ rotary weeder 4 times at an interval of 10 DAT for weed control.
10. Water Management		A light irrigation should be given after transplanting when hair like crack of soil has been seen. Keep standing water (5 cm) from 50 % flowering to maturity stage. Water should be drained 10-15 days before harvesting

Healthy plants in SRI is because of ……..

➢ Large root volume

➢ Profuse and strong tillers

➢ Non loding

➢ More and well filled spikelets with higher grain weight.

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Exercise: 3 Seed treatment and sowing of major crops

Objectives:

1. To know the different methods of seed treatment.

2. To study about different seed treatment to different field crops.

3. To know the importance of seed treatment.

4. To acquire skill in seed treatment.

The improved seeds play an important role in increasing the crop production. Similarly, the seed treatment is also equally important to boost up the crop yield. Seed treatment is low cost input and the monetary returns realized due to seed treatment are comparatively higher as compared to other inputs in crop production.

Seed treatment refers to the application of fungicide, insecticide, or a combination of both, to seeds before sowing for various purposes to control insects, pests, diseases, improving germination, atmospheric nitrogen fixation and inducing the initial root growth of crop.

Purposes of seed treatment:

1. Easy sowing: When the seed contain fuzzes and cannot be separated from each other at the time of sowing, the physical or chemical method of seed treatment is used for easy sowing. E g. Cotton seed

2. Uniform distribution of seeds during sowing: When the seeds are small in size and light in weight, it is difficult to sow the seeds and maintaining uniform plant population. Therefore, the seeds are mixed either with sand or powder of oil seed cake or FYM. E.g. Sesame and Rajgira seeds.

3. Seed treatment for improving germination: Some crops have hard seed coat or hard layer over the seeds and ultimately, it takes more time for germination. Soaking the seeds in water before sowing will improve the germination percentage. Duration of soaking depends on the nature of the seed coat. E.g. soaking of paddy seeds for 12 hours in water and drying of seed under shade for 4-5 hrs.

4. To prevent the effect of pests: Some of the seed material carries eggs of insects and pests in dormant condition or the pest itself is in the dormant condition in the soil. After sowing of the crop, the pests become active and start to damage the seed and seedling, hence the seed treatment is necessary against the pests e.g. termites.

5. To prevent the seed borne and soil borne diseases: In case of seed borne diseases, the pathogens are carried either on surface of the seed within it. When pathogen externally present, may be destroyed by treating the seeds with chemical viz, captan, thirum and agrosan etc. If pathogens are present internally in the seed, the hot water treatment is effective.

6. Microbial culture treatment to maximize the yield: Pulses crop have ability to fix the atmospheric nitrogen through root nodules which used by crop plant. Similarly, in cereal crops free living bacteria fix the N_2 in soil. The seeds of legumes/ cereals are inoculated with effective bacterial culture for better N_2 fixation the in soil. E.g. *rhizobium* cultural used in pulses and *Azatobecter* and *Azospirillum* culture for cereals.

7. To reduced the seed rate: To reduce the seed rate coriander seeds are rubbed and spited in two halves and these two halves should be sown for easy germination and optimum plant population.

8. To induce the genetic variation: By genetic variation plant breeder can obtain disease resistant variety through the seed treatment create fundamental change in colour, taste, quality etc, By mutation, inducing variation in the progeny by X- rays and gama rays.

9. To break the seed dormancy: Dormancy is a resting period of crop seeds during that time plant completes its physiological process. If temperature and moisture are appropriate for seed germination even though seeds cannot be germinate. For that, seeds should treat with chemical. E.g ethanol is used in spreading variety of groundnut to break the seed dormancy.

10. To safe seed storage: Sun drying reduce the moisture content of seeds. For safe storage of seeds the moisture per cent should be 8-10 %. If the moisture content is more than 8-10 %, there is a chance of diseases and pests for spoiling the seeds. So, seeds should be treated with some pesticides or Neem leaves for safe storage.

11. Seed hardening: The seed hardening may be done for inducing tolerance to adverse weather and soil condition such as drought, frost, cold, salt etc. By dipping in to a solution of chemical, such as potassium chloride, potassium nitrate and calcium chloride.

Equipments used for seed treatment:

4) Slurry Treater 2) Direct Treater 3) Grain auger 4) Home- made drum mixer 5) Shovel

Methods of seed treatment:

1. Rotary seed dressing drum: The fungicide may be applied to small lot of seeds with rotary seed dresser. Sometimes it may be applied in large quantity of seeds also. In this method, the rotary seed dresser is filled up to 2/3 part with seeds and with required quantity of fungicide. The rotary seed dresser is rotated 10-15 minutes with jack in slow motion. Generally, the seeds of cereals, legumes and oil seeds are treated by this method.

2. Planter or Hopper box method: The required quantity of fungicide is mixed with the seed planter or hopper box of seed drill at the time of sowing. The advantages of this method are that only required quantity of seed is used and rest of the seeds may be used for other purposes.

3. Earthen pot method: This is a local method used, where rotary seed dresser is not available and seed is in small quantity. In this method, pot is filled up to 2/3 part with seeds and with required quantity of fungicide, shakes it well for 10 minutes to make seeds ready for sowing.

4. Seed treatment by plastic or paper bag: When the seeds are costly and in small quantity, seed treatment may be applied by plastic or paper bag. The required quantity of fungicide is mixed with seed in plastic or paper bag and treated seeds are then used for sowing.

5. Slurry methods: The required quantity of wettable power is mixed with water and make in to slurry. When the treatment is to be made on larger scale, the slurry method is applied with automatic machinery generally by private- seed growers, government seed farms and Seed Corporation. But when the seeds are to be mixed in small quantity, it is done manually, such as legume seed treatment with rhizobium culture.

6. Soaking seeds/ Dipping roots of seedling: This method is generally adopted vegetatively propagated seed material e.g. sugarcane, potato etc. Some times seeds are also soaked e.g legumes seeds. In some cases, roots of crop seedling are dipped in the fungicidal solution. In this method, required quantity of fungicide is dissolved in water to make the solution of desired concentration. The seed material is soaked in the solution for specific time and dried in shade and used for sowing/ planting.

Seed treatment for different field crops:

Sugarcane:

For the control of Mealy bug and scale insects: Setts should be dipped in the 0.1 % solution of Melathion for five minutes before use.

For seed borne and soil borne diseases: After giving the above treatment, sugarcane setts are dipped into 0.5 % solution (500 gm in 100 litres of water) of Aretan or Amisan or Agallol or Seresan for 5 minutes before planting.If these chemicals are not available, the seed setts are treated with Thiram or Captan.

For better germination: a. Setts should be dipped in 0.5 kg of quick lime in 200 liters of water for 12 hours for softening of the eyes. This treatment ensures better germination and also kills eggs of insects.

Hormones treatment : To obtain good germination and vigorous seedlings treat the setts with 10 ppm solution of Naphthalene Acetic Acid (NAA) or Indole Acetic Acid (IAA) or Gibberellic Acid (GA).

Tobacco :

For uniform distribution of seeds at sowing seed should be mixed with fine sand or oilseed cake or FYM.

Cotton:

Physical method: due to fuze seeds should be rubbed in cow dung slurry/ earth soil for easy sowing.

Chemical Method: Acid delinting of cotton seed @ 1 kg of commercial sulphuric acid with 10 kg of seeds, kept 2-3 minute in 10 liters of water, wash the seeds with fresh water for 2-3 times. Treat the seeds with Thiram /Carbendazim @ 2-3 gm kg seeds.

Ground nut:

For white grub: Treat the seeds with Chlorpyriphos @ 25 ml /kg seeds

For collar rot and root rot: Treat the seeds with fungicide like Thiram/ Captan/ Mencozeb @ 3 gm/ kg of seeds

Sesame:

For uniform distribution at sowing: Seed should be mixed with fine sand or oilseed cake or FYM.

For leaf spot and bacterial blight: Applied hot water treatment at 52 ^{0}c for 10 minutes or Treat the seed with Thirum /Captan @ 3 gm/kg of seed

Castor:

For hastening the germination: Soaking the seeds in water for 12-14 hrs before sowing

For root rot and 13anually13a blight: Treat the seed with Thiram or Ceresan@ 3 gm/ kg of seeds.

Paddy:

For the selection of bold seed: Soak the seeds in to 3.0 % salt solution and remove the unfilled seeds by draining the water, after that wash out the seeds with fresh water and dry it under shade.

For dormancy: Give heat treatment. For that, exposure of seeds which has 11-12 % moisture to a temperature of 47-50 ^{0}c for 4-7 days.

For Stem rot, Foot rot and Brown spot: Treat the seeds with Agrosan @ 2-3 g/ kg of seeds.

For bacterial leaf blight: Soaking in 0.1 % streptocyclin (100 ppm) + wet dressing of Agrosan or Ceresan & Azotobacter or Azospirillum culture treatment.

Pearl millet:

For the selection of bold seeds: Soaking of seed in to salt solution and after that, wash the seeds with fresh water for 2-3 times, dry in the shade and use for sowing.

For ergot and smut: Treat the seeds with organo – mercurial fungicide like Agrosan / Cerasan @ 3 gm /kg of seeds.

For downey mildew, Apron @ 6 gm/kg of seeds.

Sorghum:

For False smut: 4-6 gm Sulphur or organo- mercurial fungicide like Agrosan / Cerasan @ 3 gm /kg of seeds.

For stem borer : Carbofuran 3 G @ 100 gm/ 1 kg of seeds.

Maize:

For seedling blight: Agrosan / Cerasan @ 3 gm /kg of seeds.

Pulses: (Gram, Pigeon pea, Green gram, Black gram, Cluster bean, Kidney bean Indian bean, Pea and Rajmashetc)

Seed borne and fungal diseases: Agrosan / Cerasan/ Captan @ 3 gm / kg of seeds.

For atmospheric nitrogen fixation: Seeds inoculation with Rhizobium and PSB @ one packet (250 gm) / 8-10 kg seeds of each culture.

Objectives of methods of sowing:

• To achieve uniformity in distribution of seeds.

• To sow the seeds at desired seed rate and inter-row and intra-row spacing

• To maintain the depth of seed placement.

• To provide proper compaction over the seed.

The methods include broadcasting manually, opening furrows by a country plough and dropping seeds by hand i.e. behind the plough, drilling, dibbling. Zero tillage technique and transplanting of seedlings.

1.Broadcasting: In this method the seeds are broadcast and then covered with the help of harrowing. However, the seeds are not uniformly distributed in the field. This method of sowing is very insufficient and should not be encouraged. Germination of broadcast seeds is relatively poor and the plant stand is often irregular. Wastage of seeds because, most of the seeds are left on the surface which can not germinate and may picked up and eaten by birds.

2. Behind Local Plough: A majority of farmers uses this method. This method consists of dropping the seeds by hand into the furrows opened with local plough at a depth of 5-6 centimeters. When seeds are dropped in furrows by hand, it is called ‘kera’ method and when it is dropped through a Pora or Naior Hazaraa special attachment with local plough it is called ‘Pora’ method. Germination is satisfactory in this method.

3.Drilling: In this method seeds are sown by seed drill or seed cum fertilizer drill. With the help of this implement seeds drop at proper depth, placement of fertilizers and results in

uniform germination with regular plant stand. Seed bed should be fine and well 15anually, free from clods and weeds for the use of this implement. Seed drills are easily available in the market. They may be either bullock driven or tractor driven.

4.Zero tillage technique: This new method is used in Rice-Wheat cropping system where showing of wheat is delayed due to preparation of field, uncertain rainfall and rice harvesting with traditional method.

Puddling in transplanted rice creates a hard pan in the field. After harvesting of rice crop, field requires at least 6-8 tillage operations in ploughing and harrowing for sowing of wheat, in which generally 10-15 days are required for proper field preparation. A Zero-till-fertizer-seed-drill has been developed at G.B.Pant University of Agriculture and Technology, Pantnagar by which direct sowing of wheat is done in Rice field without ploughing. This helps advancing the sowing of wheat as the time required for field preparation is saved. At the time of sowing there should be proper moisture in the field.

5. Diblling: This method is used when quantity of seed is limited. Sowing is done with the help of dibble. This method cannot be commercialized because it is time consuming and labour intensive.

6. FIRB: The Furrow Irrigated Raised Bed (FIRB) system has been developed and is being promoted by the by the Rice- Wheat Consortium of GIAR Institute. In this method wheat is sown on raised beds accommodating 2-3 rows of wheat. Between the beds are furrows that are used for irrigation.The benefit of overlapping technology under FIRB is that sugarcane is planted at the optimum time i.e. in the month of February.

Tobacco

• Tobacco seedlings are transplanted. The field is line marked with the help of iron or wooden marker at 90 cm apart.

• The furrows are opened with the help of plough as per the line marked in field.

• There after cross marking at 60 cm distance is done at the right angle to the opened furrows.

• Seedlings are transplanted at cross mark at the hedge of the furrow to avoid seeding rot and uprooting of the seedlings due to heavy flow of rainwater.

• If there is no rain, the line-marked field is irrigated in furrows in the morning and cross marking is done for transplanting of the seedlings in the late evening time.

• Healthy disease free seedlings of 8-10 cm height should be used for transplanting.

• If rain is not occur after transplanting, light irrigation at 5-6 days may conveniently be given in furrows for good establishment of the seedlings.

Sugarcane

Sugarcane planting is done by two methods.

4) **Dry method**

The sugarcane setts are placed in furrow in dry soil and setts are covered with 4-5 cm of soil and then irrigation is given.

2) Wet method

In this method, the pre-planting irrigation is given and then the sugarcane setts are placed in furrows and inserted into soil by pressing them under foot. Wet planting method is found more convenient in our state.

• In India sugarcane is planted by adopting two systems viz., (i) Ridges and furrows system

(ii) Flat system.

• There are some special systems also such as Trench system, Deep Trench system, paired-row system, Ring or pit system etc.

4. **Ridges and furrows system**

• In the finely prepared field, ridges and furrows are formed at 60-135 cm between the rows using tractor – drawn or bullock – drawn ridgers. Some small farmers open furrows manually also.

• Depth of furrow should be around 25 cm. and length of 10-15 meter is ideal when guided irrigation is followed.

• Irrigation and drainage channels should be provided appropriately. Drainage channels which are deeper than the furrows and the irrigation channel, should be opened along with field borders as well as within the field at regular intervals.

• The ridge – furrow system is the most ideal system of planting under highly irrigated sugarcane cultivation.

B. Paired row system of planting

• In the paired row system, two cane rows are brought together followed by a wide gap before the next set of two rows (60 cm with 120 cm gap) in which the number of rows per hectare remains same. The paired rows which can be utilized for growing profitableinter crops, also good earthing up is possible and permits better light interception. Thus can give higher yield

B. Flat system

It involves repeated ploughing using a country plough and compacting by planking to conserve soil moisture. For planting, shallow furrows are opened with a wooden country plough and the setts are dropped and again covered by planking. Irrigation does not follow immediately.

C. Trench system

• In this system U-shaped furrows or trenches of 25-30 cm. deep are made mostly using spade and heaping clods 16anually. The system is useful to prevent lodging which is quite common. A specially fabricated implement “Ridgemax” can be used for formation of trenches

D. Deep trench method

• In this system deep trenches of depth 30-45 cm. and width 60 cm. are dugout manually at a spacing of 120 cm. between the centres of two adjacent trenches. That is the gap between the

trenches is 60 cm. Sugarcane setts are planted on either side of the trench bottom and covered with soil slightly.

• As the canes grow, the trench is filled with the soil with each manuring. Finally a small trench is formed in between two setts of paired rows which serves as a drainage channel to remove excess water during the N-E monsoon period

E. **Modified trench system**

• In the modified trench system ridges and furrows are opened at 120 cm. spacing using a tractor drawn ridger. The furrow bottom is dug and widened and the soil is removed to the ridges.

• Thus trenches are formed, basal manures are applied and then setts are planted. As the crop grows while each manuring, only slight earthing up is done so that a trough is maintained through out the crop growth. Here irrigation is given in the cane row itself.

F. Single bud direct planting

• In this system single bud setts are planted directly in the field in the furrow at 30-45 cm. spacing between the setts. This method is highly economical and sowing of seed material. The buds should be healthy.

Planting techniques

4) **End to end technique**

Three budded setts are put in furrow in such a way that end of the other setttouch to the end of the former sett. Eye to eye distance is maintained.

2) Over lapping technique

Three budded setts are put in furrow so that eye of the one sett touch to theeye of another set. This technique requires more seed rate.

3) Slant Technique

Three budded setts are planted slanting with one bud in the soil and two buds above the ground. When the above the ground buds sprout up into shoots of 20- 25 cm length the setts are horizontally pressed down inside and the leaves of the shoots covered with soil.

4) **Transplanting technique**

Seedbeds of 8.0 x 1.5 m are generally prepared to raise seedlings. The germination of bud is complete within a fortnight and seedlings become ready for transplanting after one week of germination. The sprouted setts are taken out from seedbed and are cut into two pieces making one-budded setts. The sprouted setts are thus planted in the field.

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Exercise:4 Effect of seed size on germination and seedling vigour of kharif crops

Plants reproduce sexually by seeds and asexually by vegetative parts. Most crop plants produce viable seed which is used for sowing. Those used for multiplication are called seeds while those used for human or animal consumption are called grains. Those plants which do not produce seeds are multiplied with vegetative parts. Sugarcane is planted with stem cuttings known as setts. Forage grasses like napier grass, guinea grass, paragras etc. are mainly propagated by stem cuttings or rooted slips.Rooted slips are basal two to three internodes of the stem with a few roots. Tubers are used as seed material in potato.The crop sown with vegetative parts need larger quantities of seed material.Grafting, budding and layering methods are used for the propagation of horticultural crops.

Characteristics of good seed material

Establishing a vigorous crop starts with selecting good quality seeds. Quality seed ensures uniform crop stand establishment with uniform vigour and population per unit area.Selectionof good seed is,therefore, of prime importance for remunerative crop production. Major seed quality characteristics include :

(1) Improved variety: It should be superior to existing ones. It should realise its yield potential in the region where it is grown.

(2) Genetic purity: It referes to the trueness to type. It has direct effect on ultimate yield.

(3) Physical purity :It should be free from other varieties of the crop, other crop seeds, weed seeds, broken seeds and inert material.

(4) Maturity :The seed must be from harvested maturity crop.

(5) Free from storage pests and seed born diseases : The seed free from pest and disease pathogens for optimum stand establishment.

(6) Free from dormancy :It should germinate within stipulate time when sown under optimum soil conditions.

(7) Uniformity: Seed must be uniform in size, shape and colour.

(8) High percentage of germination: High percentage of germination (98-99%) for adequate stand establishment.

Quality of seed

Viability and vigour are the two important characters of seed quality. Viability can be expressed by the germination percentage, which indicates the number of seedlings produced by a given number of seeds. Vigour of seed and seedlings is difficult to measure. Low germination percentage, low germination rate and low vigour are often associated. Seeds with low vigour may not be able to withstand unfavourable conditions in the seedbed. The seedlings may lack the strength to emerge if the seeds are planted too deep or if the soil surface is crusted.

Germination is measured with two parameters- the germination percentage and the germination rate. Vigour is indicated by the higher germination percentage, high germination rate and quicker seedlings growth. Germination percentage is the numbers of seeds germinated to numbers of seeds planted and is expressed as percentage. Germination rate is expressed in two ways: (1) the number of days required to produce a given germination percentage and (2) the average number of days required for radicle or plumule to emerge.

Traditionally, seeds used to be sown at a specified weight of seed per unit area irrespective of seed size. Depending on the seed size, the number of seeds per unit area varies considerably. Hence, number of seeds per unit area is more important than the weight per unit area. This requires knowledge of test weight of crop seeds for adjustments in seed rate to obtain required population density. Several conditions viz.; (1) Late seeding (2) Poorly drained soils (3) Rough seedbed (4) Partly undecomposed plant residues (5) Seeds with low test weight than normal (6) Low germination percantage (7) High pest and disease problems (8) Inadequate soil moisture for germination may demand higher seed rate than recommended.

Relationship between vigour, field performance and yield

❖ The germination ability and vigour of a seed lot is directly related to performance in the field.

❖ Seeds low in vigour generally produces weak seedlings that are susceptible to environmental stresses.

❖ High level of vigour in seeds can be expected to provide an early and uniform stands which give the growing seedlings the competitive advantage against various environmental stresses.

❖ Provides a very good estimate of potential field performance and subsequently, the field planting value.

❖ The ability of the germinating seed to continue to grow and survive then determines crop establishment.

❖ Low seed vigour contributes to the development of smaller and uneven seedlings which leads to poor plant stand and growth (weaker seedlings) and uneven time of maturity, resulting in the possibility of yield loss.

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Exercise: 5 Effect of sowing depth and methods on germination of crops

Establishment of a good stand is the essential pre-requisite for attaining high yields. It depends on time, depth and method of sowing and seed treatment. Planting depth of seeds vary according to seed size and available soil moisture. Uneven depth of sowing results in uneven crop stand. Plants will be of different sizes and ages and finally harvesting is a problem as there is no uniformity in maturity. Shallow or deep sowing results in low plant population because all seeds do not germinate. The crops appear with uneven spread of plants with large number of gaps. Weed problem becomes serious under these conditions. It is,therefore, essential to sow the crop at optimum depth for obtaining good stand of the crop.

Crops with bigger sized seeds like groundnut, castor, sunflower etc. can be sown even upto the depth of 6 cm. Whereas, small sized seeds like tobacco, sesamum, bajra, mustard have to be sown as shallow as possible. If the seeds are sown too shallow, the surface soil dries up quickly and germination may not occur due to lack of moisture. Therefore, small sized seeds which are sown shallow should be watered frequently to ensure good emergence of the crop. If the small seeds are sown deep in the soil, the seed reserve food may be inadequate to put

forth long coleoptiles for emergence. Even if the seedling emerges, it is too weak to survive as an autotrophic.

The thumb rule is to sow seeds to a depth approximately 3 to 4 times their diameter. The optimum depth of sowing for most of the field crops ranges between 3 cm to 5 cm. Shallow depth of planting of 2 cm to 3 cm is follow for small seeds like bajra, sesamum, mustard. Whereas, seeds of tobacco are very small in size (0.08-0.09 mg) and the emerging seedlings are tiny and delicate. Hence, the seeds are unsuitable for sowing directly in the field and are sown in nursery at a depth of 1 cm and tended carefully till the seedlings attain a particular size before transplanting in the main field.

For achieving good results from transplanting,the seedlings are transplanted at optimum age and at proper depth. The thumb rule for the optimum age of seedlings is one week for every month of total duration of the crop.the depth of planting should be as shallow as possible for getting more number of tillers in tillering crops. Transplanting of rice seedlings more than 2 cm deep results in poor tillering.

Because of randomness of seed dispersal in broadcasting method, the spacing available for individual plant varies considerably. It results in excess competition at certain areas and no competition at all in some other areas of the field. However, this methods is still used for sowing fodder crops or crops where seeds are cheap or crops which can easily establish and supress weeds. Rice is also sown by broadcasting on puddled soil.

In broadcasting method, seeds cannot be placed in desired depth. Desired depth ensures perfect anchorage. Lodging (falling down) of crops are common in broadcasting. Whereas, drilling or line sowing method facilitates uniform depth of sowing resulting in uniform crop stand. Crops may not be lodged under drilling method. In the same crop, coleoptile length may differ due to varieties. Traditional tall varieties of wheat have long coleoptile. Generally, they are sown deep in the soil with seed drill. Mexican varieties with short coleoptile do not emerge when they are sown deep. These Mexican wheats give higher yields compared to tall varieties only when they are sown at a depth of 4 cm.

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Exercise : 6 Study of various methods of fertilizer application

Objectives:

1. To decide right stage of the crop for fertilizer application

2. To adopt right method for maximizing fertilizer use efficiency.

It is most essential to apply fertilizer at proper time and with proper methods for its efficient use.

Time of fertilizer application:

Time of fertilizer application depends on the type of crop cultivated, its growth stage, nutrient requirement, soil conditions, and nature of fertilizer. The fertilizers are applied (1) prior to sowing (2) at sowing and (3) after sowing the crop.

1. Application of before sowing: Amendments should be applied well in advance to sowing. Some of the water insoluble P fertilizers such as rock phosphate and basic slugs should be applied about 2- 4 weeks before sowing. This enables conversion of water insoluble form of P to soluble form for efficient crop utilization.

2. Application at sowing: Application of fertilizer at the time of sowing or just before sowing is called basal application. Mostly phosphatic and potassic fertilizers are basally applied. A part of recommended N is also applied as basal dose. Micronutrient fertilizers should be applied at the time of sowing on the soil and should not be incorporated in to soil.

3. Application after sowing (Top dressing): Application of fertilizers after the crop establishment is called top dressing. Usually a portion of N is applied as top dressing depending on the stage of crop. In light textured soil, potash is also recommended for top dressing.

4. Spilt application of N: Spilt application increases the nitrogen use efficiency by supplying N at the critical stages of crop when the crop requirement is high. This also avoids large amounts of basally applied N being subjected to various losses. It is the most convenient and easily adaptable technique. Factors such as total amount of N to be applied, soil texture, crop duration, critical stages of growth, crop season and water management practices largely govern the number of splits. In irrigated crops N is generally applied in 2-3 splits. In dry land condition, all the N is applied at sowing as it is difficult toapply N at later stages in the absence of adequate soil moisture. Nitrogen application is recommended at tillering and panicle initiation stages for rice. Basal application of N is sufficient for pulses.

Principles governing selection of proper time of application of fertilizer

1. Nitrogen is taken up by the crop plant slowly in the initial growth stages, rapidly during the grand growth period and slowly at its maturity stage. Thus nitrogen requirement of a crop is less in the early stages, maximum during its peak growth period and very slow at the subsequent stage up to the harvest. But the nitrogen required by the crop through out its growth stages.

2. Nitrogenous fertilizers are highly soluble in water. They are mobile and move rapidly in all direction within the soil. The nitrogen is easily lost through leaching, volatilization and other means. Therefore, it should be applied in split dose at critical growth period.

3. Phosphorus is required during the early root development and early growth of plant. As such crop plant utilizes 2/3 of the total requirement of phosphorus and accumulates 1/3 of their dry weight. Entire quantity of phosphorus should be applied as basal dose before sowing or planting.

4. Potash behaves partly like nitrogen and partly like phosphorus. From the rate of absorption point of view it is like nitrogen being absorbed up to harvest, but available slowly like phosphate fertilizers.

5. In sandy soil nitrogenous fertilizers should be applied after irrigation in to splits, in medium black soil it should be applied before irrigation.

Methods of fertilizer application:

It will vary in relation to

1. The nature of fertilizer
2. The soil type
3. The deferential nutrient requirement
4. Nature of field crops

Fertilizers applied to different crops are of two types

1. Fertilizer in solid form
2. Fertilizer in liquid form

A) Broadcasting

1. It refers to spreading fertilizers uniformly all over the field.

2. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used.

Broadcasting of fertilizers is of two types.

i) Broadcasting at sowing or planting (Basal application)

The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

ii) Top dressing

It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

➢ **Disadvantages of broadcasting**

• The main disadvantages of application of fertilizers through broadcasting are:

• Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.

• The weed growth is stimulated all over the field.

• Nutrients are fixed in the soil as they come in contact with a large mass of soil.

B) Placement

1. It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.

2. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soil have a low level of fertility and to apply phosphatic and potassic fertilizer.

The most common methods of placement are as follows:

i) Plough sole placement

1. In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing.

2. Every band is covered as the next furrow is turned.

3. This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.

ii) Deep placement

It is the placement of ammonical nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammonical nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.

iii) Localized placement

It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:

a) Drilling

In this method, the fertilizer is applied at the time of sowing by means of a seed-cumfertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

b) Side dressing

It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are

1. Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and

2. Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

C) Band placement

If refers to the placement of fertilizer in bands.Band placement is of two types.

i) Hill placement

It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

ii) Row placement

When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

D) Pellet application

1. It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop.

2. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

➢ **Advantages of placement of fertilizers**

The main advantages are as follows:

• When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced.
• The weeds all over the field can not make use of the fertilizers.
• Residual response of fertilizers is usually higher.
• Utilization of fertilizers by the plants is higher.
• Loss of nitrogen by leaching is reduced.
• Being immobile, phosphates are better utilized when placed.

2**. Methods of application of fertilizer in liquid form**:

a**) Starter solutions**

It refers to the application of solution of N, P_2O_5 and K_2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables. Starter solution helps in rapid establishment and quick growth of seedlings.

The disadvantages of starter solutions are

• Extra labour is required, and
• The fixation of phosphate is higher.

b) Foliar application

1. It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.

2. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.

3. The concentration of the spray solution has to be controlled, otherwise serious damage may result due to scorching of the leaves.

4. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

c**) Application through irrigation water (Fertigation**)

1. It refers to the application of water soluble fertilizers through irrigation water.

2. The nutrients are thus carried into the soil in solution.

3. Generally nitrogenous fertilizers are applied through irrigation water.

d) Injection into soil

1. Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types.

2. Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions.

3. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

e) Aerial application

In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc.

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Exercise : 7 Study of growth and yield attributing characters

Objectives :

1. To know the different growth and development stages of crops

2. To manage the various resources according to crop growth stage requirement.

Crop plants are differ in respect to ontology (development of organism), morphology, anatomy, physiology and requirement of particular type of ecology.

Growth: It is an irreversible increase in mass or weight. Growth is attained mainly by photosynthesis loss, what is goes through respiration that is weight, height, length, diameter.

Development: It is defined as change means development of a plant from germination to maturity. It can be considered as the series of discrete periods such asweight, size, and structure of specific organs.

Development Stages:
1. Germination and emergence
2. Seedling growth
3. Vegetative growth
4. Flowering
5. Fruit growth
6. Fruit maturity
7. Physiological maturity
8. Harvest maturity

Factor affecting growth and development of plant:

1. Solar radiation(Light)
2. Temperature
3. Soil moisture
4. Soil aeration

The dry matter production from a crop growth, many factors such as type of soil, fertilizer, water, growing season and variety of crop attribute great variation in crop production.

Yield attribute: Any factor responsible for attributing increase the yield called yield attribute.

❖ Growth analysis

Growth analysis is a mathematical expression of environmental effects on growth and development of crop plants. This is a useful tool in studying the complex interactions between the plant growth and the environment. The basic principle that under lie in growth analysis depends on two values (1) total dry weight of whole plant material per unit area of ground (w) and (2) the total leaf area of the plant per unit area of ground (A).

The total dry weight (w) is usually measured as the dry weight of various plant parts viz, leaves, stems and reproductive structures. The measure of leaf area (A) includes the area of other organs viz, stem petioles, flower bracts, awns and pods that contain chlorophyll and contribute substantially to the overall photosynthesis of the plants

According to the purpose of the data, leaf area and dry weights of component plant parts have to be collected at weekly, fortnightly or monthly intervals. This data are to be used to calculate various indices and characteristics that describe the growth of plants and of their parts grown in different environments and the relationship between assimilatory apparatus and dry matter production. These indices and characteristics are together called as growth parameters. Some of the parameters that are usually calculated in growth analysis are crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and Leaf area index (LAI). Accuracy in calculations of these parameters and their correct interpretation are essential aspect in growth analysis.

Advantages of growth analysis

a) We can study the growth of the population or plant community in a precise way with the availability of raw data on different growth parameters.

b) These studies involve an assessment of the primary production of vegetation in the field i.e. at the ecosystem level (at crop level) of organization.

c) The primary production plays an important role in the energetic of the whole ecosystem.

d) The studies also provide precise information on the nature of the plant and environment interaction in a particular habitat.

e) It provides accurate measurements of whole plant growth performance in an integrated manner at different intervals of time.

Drawbacks of Growth Analysis

In classical growth analysis sampling for primary values consist of harvesting (destructively) representative sets of plants or plots and it is impossible to follow the same plants or plots throughout whole experiment.

❖ Growth Characteristics - Definition and Mathematical Formula

The following data are required to calculate different growth parameters in order to express the instantaneous values and mean values over a time interval. In the following discussion W, WL, WS and WR are used to represent the dry weights of total plant (w), dry leaves (wL), stem (WS) and roots (WR) respectively. Whereas A is the leaf area and P is the land area.

1. Crop Growth Rate (CGR):

D.J. Watson coined the term Crop growth rate. It is defined as the increase of dry matter in grams per unit area per unit time. The mean CGR over an interval of time T1 and T2 is usually calculated as show in the following formula

$$CGR = \frac{W2 - W1}{P\,(T2 - T1)}$$

Where, CGR is the mean crop growth rate, P= ground area, W1 and W2 are the dry weights at two sampling times T1 and T2, respectively and it is expressed in $g/m^2/day^1$.

2. **Relative Growth Rate (RGR):**

The term RGR was coined by Blackman. It is defined as the rate of increase in dry matter per unit of dry matter already present. This is also referred as Efficiency index since the rate of growth is expressed as the rate of interest on the capital. It provides a valuable overall index of plant growth. The mean relative growth rate over a time interval is given below.

$$RGR = \frac{\text{Loge } W2 - \text{Loge } W1}{T2 - T1} \quad (g\ g^{-1}\ day^{-1})$$

Where, Log is natural logarithm, T1= time one (days), T2= time two (days), W1= dry weight of plant at time one (days), W2= dry weight of plant at time two (days) and it is expressed as g/g/day.

3. Net Assimilation Rate (NAR):

The NAR is a measure of the amount of photosynthetic product going into plant material i.e. it is the estimate of net photosynthetic carbon assimilated by photosynthesis minus the carbon lost by respiration. The NAR can be determined by measuring plant dry weight and leaf area periodically during growth and is commonly reported as grams of dry weight increase per square centimeter of leaf surface per week. This is also called as Unit leaf rate because the assimilatory area includes only the active leaf area in measuring the rate of dry matter production. The mean NAR over a time interval from T1 to T2 is given by

$$NAR = \frac{W2-W1}{T2-T1} \times \frac{Log\ e\ L2 - Log\ e\ L1}{L2 - L1}$$

Where L1 and L2 are total leaf are at time t1 and t2 respectively. W1 and W2 are total dry wt. time t1 and t2 respectively. Log e is Logarithum to base 'e' (Log e = 2.3026) and it is expressed as (g cm^{-2} wk^{-1}).

4. **Leaf area index (LAI):**

D.J. Watson coined this term. It is defined as the functional leaf area over unit land area. It represents the leafiness in relation to land area. At an instant time (T) the LAI can be calculated as LAI = Leaf area / ground area. It is expressed as m2/m2

For maximum production of dry matter of most crops, LAI of 4-6 is usually necessary. The leaf area index at which the maximum CGR is recorded is called as 'optimum leaf area index'.

Growth and yield attributing characters and Quality Parameter

Growth and Yield attribute characters and Quality Parameter

1 Number of branches	1 Oil content (%)
2 Number of tiller per plant	2 Protein content(%)
3 Number of leaves	3 Nicotine in tobacco(%)
4 Number of internodes/plant	4 linoleic acid content in Safflower / Sunflower/ cotton(%)
5 Length of internodes	5 Crude protein (In fiber/ forage crops)
6 Length of earhead /fruit/pod size	6 Starch content (%) (Sugar and sucrose content)
7 No. of seed in earhead / pod	7 Fiber content in cotton
8 Test weight(g)	
9 Seed/grain yield (kg/ha)	
10 Straw yield (kg/ha)	
11 Harvest index (%)	

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Exercise : 8 Visit to the agronomic and forage experiments

Agronomy experiments are mainly field oriented. Choice of appropriate design and conduct of the experiments in a proper manner may help to get valid information. Field selection and layout of the experiments also play a vital role.It is always necessary to collect data on ancillary characteristics so as to have better interpretation of the results.Use of appropriate software package makes the job of the scientists/ workers to analyze the data scientifically and interpret the results.

An experiment is designed based on the objectives, availability of experimental material and cost of the experiment.It is important to design the experiment carefully to test the hypothesis with acceptable degree of precision.The choice of treatments, method of assigning treatments to experimental units and arrangement of experimental units in various patterns to suit the requirement of a particular problem are combinedly known as the design of experiment. In an agricultural field experimentation, it is normally aimed to assess the performance of varieties of a crop, effect of manures, irrigation methods, new herbicides,etc. in different crops.All these objects of comparison are known as teatments. Experiment is to be laid out in the field, keeping view of land slope and fertility status to make homogeneous plots within the replication.

Layout :The layout is done before deciding base line of the experimental area. Then right angle is to be taken on the base line by 3 m x 4 m x 5 m triangle to draw straight line on the both sides of base line with the of measuring tape, pegs and rope to obtain uniform plot size.

Thereafter plotting is done as per the predecided size of the plot, keeping border between plots, between replications, space required for irrigation and drainage channels.After plot demarcation, randomization of the treatment is done and experimental field is prepared for sowing and treatments are then imposed as per experimental requirement to fulfill the objectives of the experiment.

Replication :The repetition of the same treatment so that it appears two or more times in an experiment.

Treatments :A single state of some factor being varied and to evaluate the effect in an experiment such as rate of fertilizer, varieties, herbicides etc.

Randomization :The allocation of treatment to the different plots by a random process.In this method each treatment has an equal chances to be allocated to an experimental unit.

Experimental design :Various experimental designs are available for different type of experiments i.e. CRD, RBD, LSD and split plot design etc.

Analysis of variance :Analysis of variance is splitting of the total variation into various factors responsible for variation in a given population.

Critical difference : Value which indicate the significance of the treatment in the experimentation.

Exercise :

Q.1 : Enlist the name of titles of agronomic and forage experiments conducted during current season.

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Q.2 : Draw the field layout of any one experiment with no. of treatments, no. of replications, spacing and gross plot size.

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Exercise 9 : Numerical exercises on fertilizer, seed requirement and plant population

Objectives:

To calculate correct quantity of fertilizer required for sowing per unit area.

Manures and fertilizers are the substances containing fair amount of plant food, which are used for supplementing the nutrients in the soil. On the other hand, indiscreet or excess use of

fertilizers not only increase cost of cultivation, but also deteriorates soil quality: leading to poor productivity. Therefore, use of proper quantity of fertilizer is prime importance for sustainable agriculture.

Fertilizers: are the organic and inorganic materials or natural or synthetic origin which are added to the soil to supply certain elements essential to the growth of plants. The term " fertilizer" is now commonly restricted to commercial products. eg. Urea, DAP, AS etc.

Manures: Manure is a organic substance containing plant nutrients. Therefore manures are defined as the sources of plant nutrients. eg. cattle manure and other bulky natural substance that were applied to land or soil with the objective of increasing the production of crops. On the basis of concentration of nutrient manures can be grouped in to two

1. Bulky organic manures. eg. FYM, Vermicompost, compost and Green manure

2. Concentrated organic manures. eg. Fish manure, Poultry manure, Cakes,blood meal , bone meal and human excreta.

Amendments: are the substances other than manures and fertilizers which are added to soils for the improvement of soil. eg. Gypsum and lime.

Classification of fertilizers:

1. Straight fertilizers: Such fertilizer contains only one major nutrient e.g. Urea

2. Binary fertilizer: Such fertilizer contains two major nutrients. e.g. Potassium Nitrate.

3. Ternary fertilizer: Such fertilizer contains three major nutrients eg. Ammonium Potassium Phosphate.

4. Compound / Complex fertilizer: Such fertilizer content of at least two of the major nutrients obtained chemically and generally granular in form. eg. Nitro- Phosphate, DAP, Ammonium –phosphate.

5. Mix fertilizer: Individual or straight fertilizer materials are blended to gather physically to permit application in the field in one operation such fertilizers supply two or three major nutrients in a definite proportion or grade eg. NPK -15-15-15.

6. Complete fertilizer: Having all three primary major nutrients, viz, N,P,K called complete fertilizer.

7. In complete fertilizer: Containing any two primary major nutrients.

8. Bio- fertilizers:Biofertilizer is a substance which contains living microorganisms, when applied to seed, plant surfaces, or soil it willpromotes the growth by increasing the supply or availability of primary nutrients to the host plant. They are cost effective, eco-friendly and renewable source of plant nutrients. Eg *Rhizobium*, *Azatobecter*, Azospirillum and PSB

9. Green manure: Green undecomposed plant materials grown primarily to add nutrients and organic matter to the soil is called green manure. By growing green manure crops in the field and incorporating it in its green stage in the same field is called green maturing. egsannhemp and dhaincha.

Factors determining quantity of fertilizers:

1. The N-P-K content of the fertilizer 2. Soil type 3. Cropping system 4. Rainfall and its distribution 5. Availability of irrigation 6. Initial fertility status of the soil 7. Use of organic manures 8. Planting density 9. Recommended dose of nutrient for the crop. 10. The total area you will be applying the fertilizer (ha)

Problem:1

Recommended dose of fertilizer for wheat crop is 120: 60: 00 NPK kg/ha and nitrogen is applied in two equal split. The source of fertilizer are Urea and DAP. Calculate the fertilizer requirement in kg for wheat crop.

Solution:

Now , Urea contain 46% N and DAP contain 18% N and 46 % P.

So, First we have to calculate the quantity of DAP

Therefore, required quantity of DAP

For 46 kg P_2O_5, we required 100 kg of DAP

Therefore, for 60 kg P_2O_5, the amount of DAP is required = (100 x 60)/46 = 130 kg DAP/ha.

Now, DAP also contain 18 % N,

Therefore, From 130 kg DAP = (130x 18)/100 = 24 kg N is suppled.

Now, The basal N require. is 60 kg /ha, but 24 kg N is received from DAP,

Therefore remaining 36 kg (60 -24) N should be apply through the urea

To fulfill the remaining quantity of nitrogen:

For 46 kg N, 100 kg urea is required

Therefore, (100x 36)/100 = 78 kg urea is required for N application

Now, remaining 60 kg N as second spilt, which required = (100x 60)/46 = 130 kg urea is required.

Therefore, at the time of sowing the quantity required for basal application = 78 kg Urea + 130kg DAP and for 2nd split application 130 kg Urea is required.

Example: 2.

Calculate the quantity of urea, SSP, and muriate of potash required for one hectare of rice with the N, P_2O_5 and K_2O, The recommended dose of rice is 100-50-50 kg/ha.

Solution:

As mention in above example, we can calculate the fertilizer quantity directly,

For, Urea = 100 / 46 x 100 = 217.4 kg

For, Single Super Phosphate = 100 / 16 x 50 = 312.5 kg

And for, Muriate of Potash = 1 x 60 = 83.3 kg

NB. Requirement of fertilizer can be calculated using the conversion factor.

(The conversion factor of Urea is 2.2, Single super phoshphate is 6.3, Muriate of Potash is 1.67)

Therefore, total Urea required= 100 x 2.2 = 220 kg

Single super phosphate= 50 x 6.3 = 315 kg

Muriate of Potash = 50 x 1.7 = 85 kg

Example: 3

Calculate the quantity of DAP, Urea and muriate of potash required for one ha of rice to meet the nutrient requirement of N, P_2O_5 and K2O at 100- 50-50 kg recommended dose of fertilizer.

Solution:

DAP to meet 50 kg P_2O_5 = 100 / 46 x 50 = 108.7 kg

Now, quantity of N is present in 108.7 kg of DAP = 18 / 100 x 108.7 = 19.6, ie.20 kg

Therefore, the quantity of N to be supplemented with urea = 100-20 = 80 kg

So, requirement of Urea = 100 x 46 x 80 = 173.9 kg

and Muriate of Potash = 100 / 60 x 50 = 83.3 kg.

(Note: Where complex fertilizer is involved, calculate first for the contribution of that fertilizer for the nutrient that is present in higher quantity. For example, in the case of DAP, first calculate for P as DAP contains higher quantity of P. Then calculate the quantity of the next highest quantity of nutrient (in case N) contributed by that quantity of the fertilizer.

Example: 4

Work out the quantity of complex (17:17: 17) and urea required to meet the nutrient requirement of 100: 50: 50 kg N, P_2O_5 and K2O, /ha.

Solution:

Quantity of complex fertilizer = 100 / 17 x 50 = 294 kg

This will supply 50 kg each of N, P_2O_5 and K2O.

Remaining 50 kg N is to be supplemented with urea.

Therefore, quantity of Urea = 100 /46 x 50 = 108.7 kg.

Example. 5

Progressive farmer of Gandhinagar district wishes to apply 100-50-50 kg/ha NPK to one ha crop. The fertilizers available with him are 12-32-16 grade complex fertilizer Urea and MOP. The nitrogen will be applied in two splits. i.e. 50 % basal, 50 % at tillering. Calculate the quantity of fertilizers to be required for basal and for split application.

Solution:

First we should calculate the quantity of fertilizer for P_2O_5:
For 32 kg P_2O_5, 100 kg Complex fertilizer is required
Therefore, for 50 kg P_2O_5, how much complex fertilizer is required ?
= 100 x 50 / 32= 156 kg complex fertilizer is required.
Now for Nitrogen requirement:
From 100 kg complex fertilizer, 12 kg Nitrogen is supplied
Therefore, from 156 kg complex fertilizer, how much N is supplied ?
= 156 x 12 / 100 = 18.7 kg N from complex fertilizer.
Now Basal N requirement is 50 kg and 18.7 kg N is supplied from complex fertilizer
Therefore, remaining N (50.0- 18.7 = 31.3 kg) should applied from Urea
So, for that Urea requirement is 100 x 31.3 / 46 = 68 kg urea is needed.
and for split application of N requirement is 50 kg
For that 100 x 50 / 46 = 109 kg Urea is required.
Now for Potash:
From the complex fertilizer
16 x 156 /100 = 25 kg K will be supplied from the complex fertilizer
While our requirement is 50 kg K2O
Therefore, remaining K (50.0- 25.0 =25.0 kg) should be applied from MOP
Therefore, 100 x 25 / 59 = 42.4 kg MOP is required
Total fertilizer requirement:
156 kg complex fertilizer (12-32-16); 68 kg Urea for basal + 109 Kg Urea for split application
and 42.4 kg MOP for one hectare.

Homework:

Ex. 1. A progressive farmer desired to grow a Rajmah crop. The recommended dose of Rajmah crop is 90-60-30 kg NPK/ha, Nitrogen is applied in to two split. The fertilizers with him are Urea, DAP and Muriate of Potash. Calculate the total quantity of fertilizers for 1.5ha of land.

Ex. 2.A progressive farmer desired to grow Irrigatedhybrid Gujarat cotton -10. The recommended dose of crop is 150-00-00 kg NPK/ha. Nitrogen is applied in to three equal split. The fertilizer with him is Ammonium sulphate. Calculate the total quantity of fertilizer for 2.5 ha of land.

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Exercise 10 : Calculation of seed reqirement and plant population

Objectives: To estimate correct quantity of seeds required for sowing of crop per unit area.

Introduction:

The 1,000 seeds weight is a measure of seed size. It is the weight in grams of 1,000 seeds. Seed size and the weight can vary from one crop to another, between varieties of the same crop and even from year to year or from field to field of the same variety losses.Seeding rate is an important factor when considering all the decisions that need to be made at planting time. For instance, a high seeding rate can result in higher crop yields, better weed competition, earlier maturity, less tillers, smaller seed size and shorter plant height. To calculate the seeding rate in kg per ha, we need the following information: It is a good, if we have a value for the 1000 seed weight (in grams). Otherwise, we will need to count out 1,000 seeds and weigh them (grams).

1. Spacing or Plant density or plants per square metre

2. Germination percentage and Emergence mortality (%)

3. 1000 seeds weight in grams

4. Purity of seed

1.Spacing or Plant density or plants per square metre

Spacing is very important for plant growth. There are many variation in spacing for different crops. It is depend upon type of crop varieties, soil type and purpose of crop. If any crop grown for fodder purpose, close spacing is to be required, but when these crops are grown for grain purpose wider spacing should be maintained. Plant population also depends on seed size.

2. Test weight of seeds or grain:

Test weight means 1000 or 100 seeds weight in gram or on volume base. It varies from one variety to another and from one crop type to another. Bold seeded varieties has higher test weight, which required higher seed rate, while fine or small seeds has low test weight as compared to bold seeds of same crop, which required less quantity of seed/ ha for sowing.

3.Germination & Mortality percentage:

To properly calculate seeding rates, germination tests should be done on all seed lots. Higher germination percentage of seed required less quantity of seeds for sowing, while seeds has low germination percentage, more quantity of seeds is required for sowing. An estimate is also needed of seedling mortality, that is all those seeds that germinate but fail to develop into a plant. The reasons for plant death include disease, insects, rocks and drought. A common value used for mortality is 3%. Unfortunately, seedling mortality can vary greatly from year to year, and field to field. Mortality in cereals typically ranges from 5 to 20 per cent.

4.Purity percentage:

Seed quality is important when using the 1,000 seed weight. Poor seed produces weak plants. To properly calculate seeding rates, purity percentage play vital role. It is decided from different component of purity, such as pure seeds, other crop seeds, weed seeds and inert matter. The seeds having more purity percentage required less quantity of seeds for sowing as compared to less purity percentage of seeds. With the above values, we can use the calculator to get the desired seeding rate.

Plant population

Number of plants in a particular area depends on the canopy coverage of the individual plants. If vigour of the plant is less, canopy coverage is less and requirement of plants per unit area will be more. Thus, spacing is maintained in such a way that its canopy mathematically covers the entire area to intercept maximum sunshine without interfering the neighbouring crop plants.

Plant population = 10,000/[Row to row distance (m) x Plant to plant distance (m)]

Example 1:Calculate the plant population/ha, if the spacing is 20 cm x 20 cm.

Spacing = 20 cm x 20 cm = 0.2 m x 0.2 m =0.04 m^2 i.e. 0.04 m^2 is covered by = 1 plant

10000 m^2 is covered by =10000/0.04 = 2,50,000 plants

Example 1: Find out the seed rate of wheat in kg/ha from the following

details;

1. Spacing- 23 cm x 1 cm, 3.. Test weight: 25. 0 gm

2. Germination % = 90 4. Purity % = 95

Solution:

Seed rate(kg/ha) = [Area to be sown in sq.m. x test wt (g) x 100 x100]/ [1000 x 1000 x germination % x purity % X spacing (m)]

= (10000 x 25 x 100 x100)/(1000 x 1000 x 90 x 95 x 0.23 x 0.01)

= 130 kg/ha

Example 2: Find out the seed rate of maize in kg/ha from the following

details:

1. Spacing- 60 cm x 20 cm, 4 t weight: 350 gm
2. Germination % = 90 5.Purity % = 95
3. Gap filling : 5 % of required seed

Solution:

Seed rate(kg/ha) = [Area to be sown in sq.m. x test wt(g) x 100 x100]/[1000 x 1000 x germination % x purity % X spacing (m)]

= (10000 x 350 x 100 x100)/(1000 x 1000 x 90 x 95 x 0.60 x 0.20) = 34.11 = 35 kg/ha.

Now, seed required for gap filling = 35 x 5/100= 1.75 kg

Therefore, total quantity required = 35 + 1.75 = 36.75 = 37 kg/ ha.

Example 3. Work out the seed requirement of transplanted crop in kg/ha

1. Spacing : 60 x 30 cm, 2. No. of seedling / hill : two, 3. Germination: 80 % 4. Purity: 90 %, 5. Test wt: 30 gm, 6. No. of damaged seedling at the time of uprooting: 20 %, 7. No. seedling required for gap filling: 5 per 5 sq. m.

Solution:

Total No. of seedling required for T.P + No. seedling damaged during uprooting + No. of seedling required for gap filling

The No. seedling required for T.P. /ha =(10000 x no. of seedling/ hill)/spacing

= (10000 x 2)/ 0.60 x 0.30 = 1,11,110 plants

No. of seedling damaged while uprooting = No. seedling required for T.P. x 20/100 = 111110 x 20/100= 22222plants

Now, No. of seedling required for gap filling =10000 x 5/ 5 = 10000 plants

Therefore, total seedling required = 111110 + 22220 +10000= 143330 seedling /ha

Now for seed rate calculation=(No .of seedling /ha x test wt(g) x 100 x100)/(1000 x1000 x GP % x Purity %)

= (143330 x 30 x 10000)/(1000 x 1000 x 80 x 90)= 59.72 kg/ha = 60 kg/ha

Homework:

Ex.1 Work out the seed requirement of transplanted rice crop in kg/ha

1. Spacing : 20 x 10 cm 2. No. of seedling / hill : two
3. Germination: 80 % 4. Purity: 90 %, 5. Test wt: 30 gm
6. No of damaged seedling at the time of uprooting: 25 %
7. No. seedling required for gap filling: 5 per 5 sq. m.

Solution:

Ex.2 Calculate the seed rate of mustard crop in kg/ha and total seed required for 10.5 hectare from the following detail.

1. Test wt.(g) : 5.20 2. Spacing (cm) : 45 x 15
3. Germination % : 80 4. Purity % : 95

Solution:

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A practical manual on Fundamentals of Plant Breeding

Credits: 3(2+1)

Subject code: 302

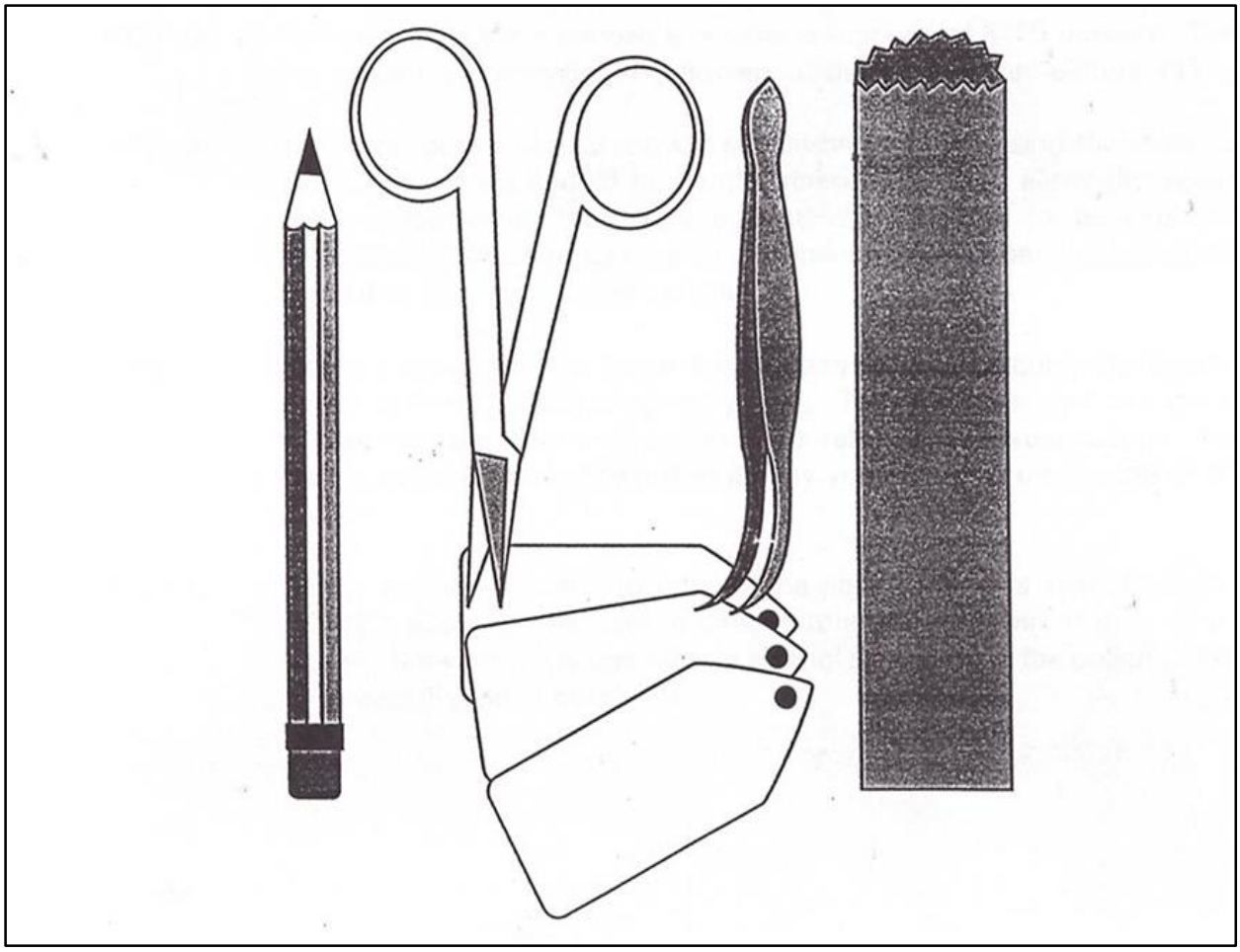
Semester: III

Practical 1. Plant Breeder's kit, Study of germplasm of various crops

Materials required: Forceps, scissors, alcohol, tags, pencil and butter paper bags

Principle: Germplasm is living tissue from which new plants can be grown. It can be a seed or another plant part – a leaf, a piece of stem, pollen or even just a few cells that can be turned intoa whole plant. Various institutes with different objectives are engaged in plant and/or germplasm collecting activities. The collecting of plant genetic resources primarily aims at tapping germplasm variability in different agri-horticultural (crop) plants, their wild relatives and related species. The germplasm so collected reveals the nature and extent of variability in different species, within species, cultigens, etc. as also their agro-ecological/phyto-geographical distribution. Knowledge of agro-ecology, crops and their distribution and harvesting time in areas of survey, local contacts, equipment required, transport arrangements and routes to be followed, distances involved, places of halt/camping sites available, transport of material, besides team-composition etc. is to be acquired before setting out on a collecting expedition. Of equal importance is to acquire knowledge on diversity in crop plants *vis-a-vis* its distribution to tap target areas and/or target species and the variability contained there of.

Plant breeder's kit:



Fine pointed forceps:

Use: it is used for incising the floral buds and for removing the anthers from it. E.g. Tobacco, sesamum etc.

Small/ curved scissor:

Use: for cutting the small florets in cereals and small flowers in the crops like lucerne, guar etc.

Long straight scissor

Use: it is used for clipping, cutting the vegetable parts and large size floral parts in cereals likewheat, sorghum, bajra, and tobacco.

Sharp pointer

Use: it is used for incising the floral parts and for removing the anthers from the crops like bajra.

Eye lens or magnifying lens

Use: For observing the reproductive parts to confirm that there should not be any part of theanther left on the stigma or stigma is free from any foreign pollens.

U-pins (u- clips)

Use: It is used for fasting the bags on earheads or flowers to keep the bag in proper position.

Paint brush

Use: It is used for transferring the pollen grains in crops like Castor, Sorghum etc.
Advantage: Without injuring to stigmas or pollens, pollination is accomplished very smoothly.

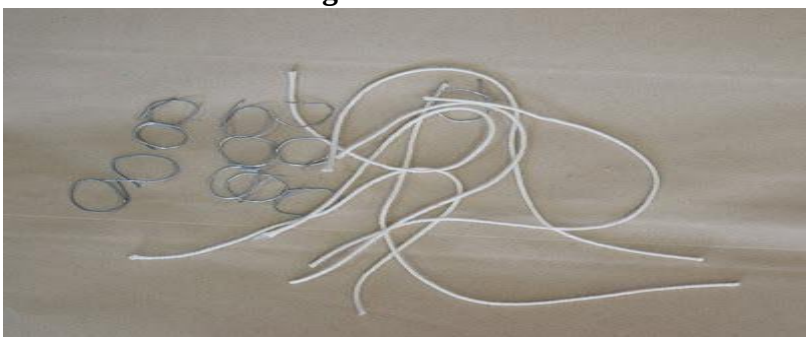
Pencil

Use: It is used for writing field labels or field bags. Sometimes it is also used for emasculating the sorghum flowers. Compared to ink or ball pen writing, pencil writing should be preferred asit will not erase or spread during rains, dew or under intense light.

Washing bottle

Use: It is used for filling sterilizing agent like alcohol or spirit to sterilize the scissors, pointers,forceps and brush during crossing work.

Wire ring and smooth thread



Use: It is used for selfing in crops like Cotton, Okra, Sesamum etc. Thread is used for fastening(tying) the bud, while ring is inserted in axis of flowers to identify it. Compared to bags,this method is more convenient and cheaper.

Small white tag

Use: It is used for identifying the internal flower or a small twig during crossing programme.The detailed information about crossing is written on it with pencil and then it is inserted on pedicel or peduncle e.g. Cotton, Bajra, Wheat, Sorghum, Sesamum etc.

Soda straw tubes

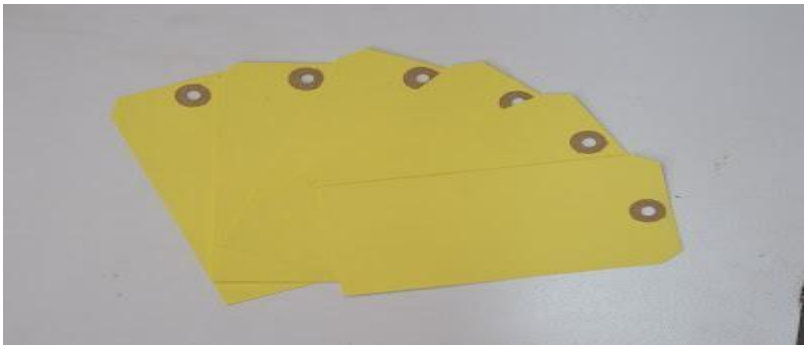
Use: it is used for protecting the emasculated or pollinated flower buds of cotton, tobacco etc.

Advantage: compared to paper bags it is very convenient, easy and cheaper method of selfingand crossing.

Waxy threads

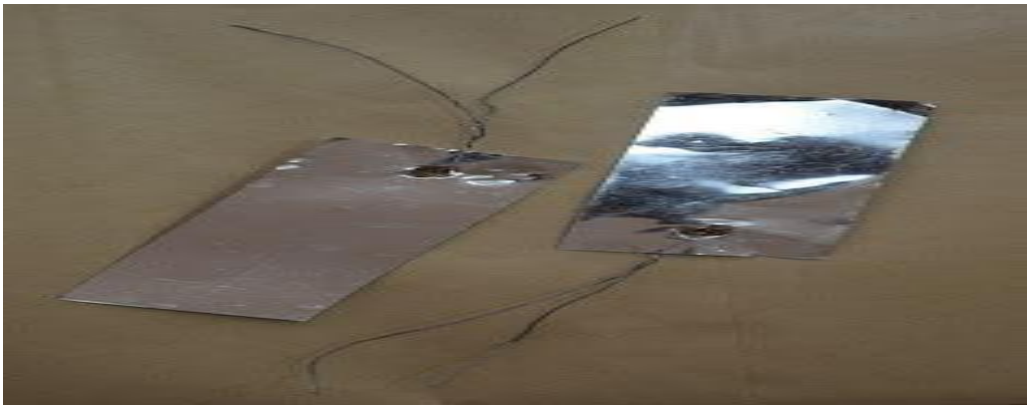
Use: It is used for fastening(tying) the luggage labels on the plants.

Luggage labels (white or yellow)



Use: It is used for tagging the large sized plants like Tur or Castor while rouging or duringselection.

Aluminium label with wire



Use: It is used for tagging the flowers in fruit crops or tree species after crossing. It is also usedfor identification of selected trees.

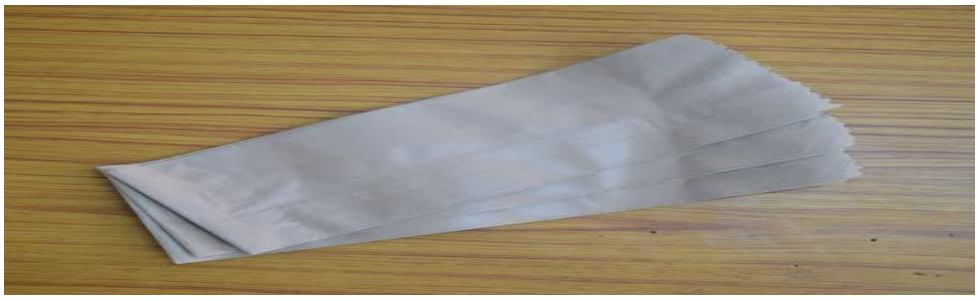
Muslin cloth bag (large size)

Use: To cover the whole plant while selfing or crossing in the crops like Chillies, Brinjal etc. Inlarge sized plants like Tur it can be used for protecting individual branch also.

Yellow sample bag

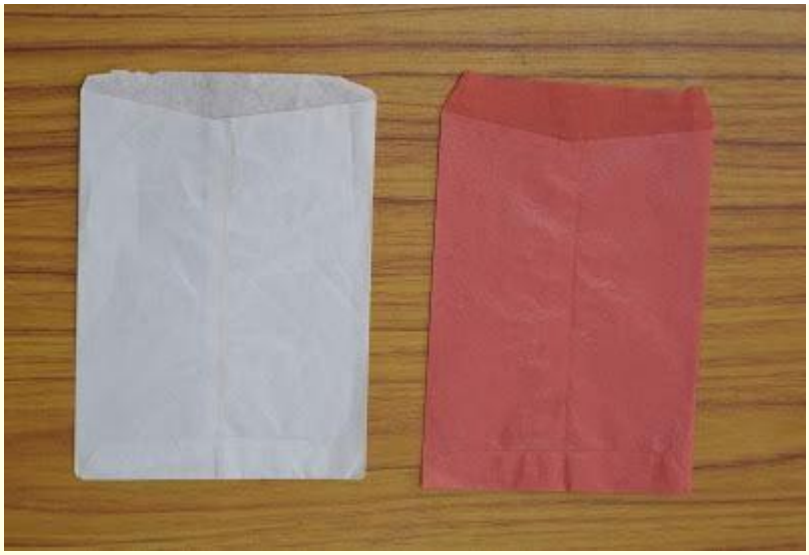
Use: For storing the crossed seeds in small quantity.

Paper Bag



Use: For selfing Bajra, Wheat, Sorghum, Castor etc.

Kite paper bag (white/red)



Use: It is used for protecting small size flowers of Pulses, Oilseeds and Other food crops during selfing and crossing.

Germplasm collecting stratagies

A. For seed collections (*cultivated and wild species*)

1. Collect from (30- 100) individuals per site (50 seeds of each as one sample or less, ifnecessary, at random. One inflorescence per plant is generally suitable.
2. Sample as many sites as possible according to availability of time.
3. Choose sampling sites over as broad an environmental range as possible. This should captureall alleles with frequency of 5 percent or more in the population.
4. Change tactics, where necessary, for wild species, that is, where individuals are scattered, youmay need to consider that a population for sampling spreads over several square kilometres.
5. If considerable morphological variation is present in a population, make separate samples ofeach type.
6. Add biased sampling if some morphotypes are not included in random sampling.
7. Take whole inflorescences, as well as seeds, where necessary, as vouchers.
8. Make herbarium specimens, where possible.
9. Take photographs.
10. Write meticulous field notes.

B. i) For vegetatively propagated cultivated species

1. Sample each distinct morphotype in a village.
2. Repeat at intervals over an area.

3. Supplement with seed collections, where possible, and give same collection numbers if seeds come from the same plants as the vegetative samples. If they do not or are bulked samples, give separate collection numbers.

ii) For collecting wild vegetatively propagated species

Collect just a single propagule from each of 10-15 individuals as a bulk sample (less if organs are very large, more if smaller, from area of about 100 x 100 m).

Germplasm cataloguing, Data storage and Retrieval

Each germplasm accession is given an accession number. This number is pre fixed in India, with either IC (Indigenous collection), EC (exotic collection) or IW (Indigenous wild). Information on the species and variety names, place of origin, adaptation and on its various feature or descriptors is also recorded in the germplasm maintenance records. Catalogues of the germplasm collection for various crops are published by the gene banks. The amount of data recorded during evaluation is huge. Its compilation, storage and retrieval is now done using special computer programmes.

National Bureau of Plant Genetic Resources (NBPGR)

NBPGR establishment in 1976 is the nodal organisation in India for planning, conducting, promoting, coordinating and lending all activities concerning plant.

Practical 2 Study of floral structure of self-pollinated and cross pollinated crops

1. **Floral structure of Rice (*Oryza sativa*): A self pollinated**

cropPanicle

- The inflorescence of rice plant, borne on terminal shoot and thus called as panicle.
- It is determinate type and at maturity, it is droopy in nature.

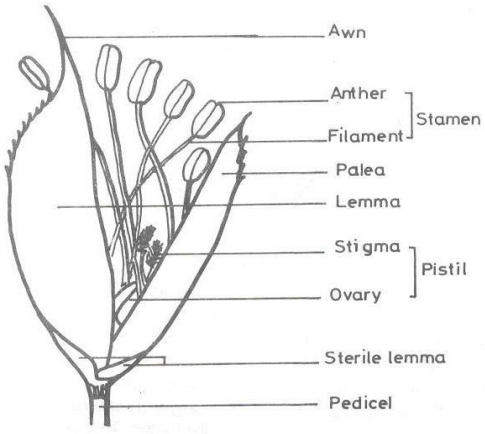


Fig: A flowered rice spikelet

Spikelet

- A spikelet is the floral unit and consists of two sterile lemmas, a lemma, a palea and the flower.
- Its parts are:
    1. Lemma: It is a 5- nerved hardened bract with a filiform extension (of the middle nerve)known as awn.
    2. Palea: IT is a 3- nerved bract slightly narrower than lemma.
    3. Flower: It consists of 6 stamens with two-celled anthers and a pistil with one ovary andtwo stigmas. The pistil contains one ovule.

2. Floral Structure of wheat (*Triticum aestivum*): A self pollinated crop

Floral Biology

The inflorescence of wheat is a spike bearing two opposite rows of lateral spikelets and a single terminal spikelet on the primary axis. The unit of spike is called spikelet. Two to five florets are born in each spikelet, subtended by a pair of glumes. Each floret contains three anthers and a pistil bearing two styles each with feathery stigma and two ovate lodicules which are modified perianth structure. Florets at anthesis are forced open by swelling of the lodicules. Flowering starts several days after the wheat spike emerges from the boot. Florets on the main culm flower first and those on the tillers flowering later. Flowering begins in the early morning and continues throughout the day. Two to three days are required for a spike to finish blooming. A wheat grain is caryopsis, a small dry, indehiscent, one seeded fruit with a thin pericarp consisting of a germor embryo and an endosperm.

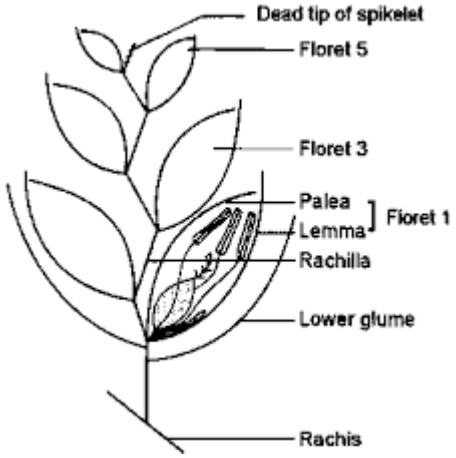


Figure: A wheat Spike

3. Floral structure of Maize (*Zea mays*) A cross pollinated cropFloral biology

It is monoecious plant bearing male flower are the growing tip as tassel and female flower at the axial of the leaf on the shoot. The tassel is terminal with staminate flowers in several roots. Each pairs of flower consist of sessile and pedicillate spiklet. Each spiklet contains two similar
glumes. The flower contains membranous palea with three stamens and two lodicules. The pollens remain viable for 18 to 24 hours.

The female inflorescence is a spadex known as cob or ear. It is modified lateral branch developed from lateral bud. The shoot is composed of compressed internodes from which husk rise and terminates in an ear on which the sessile are borne. Spiklets are in pair. Each spiklet having two flowers, the lower one is reduced to lemma and palea is non-functional, while upper one contained knob shaped ovary surrounded by broad lemma and thin palea. One carpel is provided with long silky hair, which behaves as style and style stigma throughout the length.

Figure 1: Maize plant showingposition of male and female inflorescences

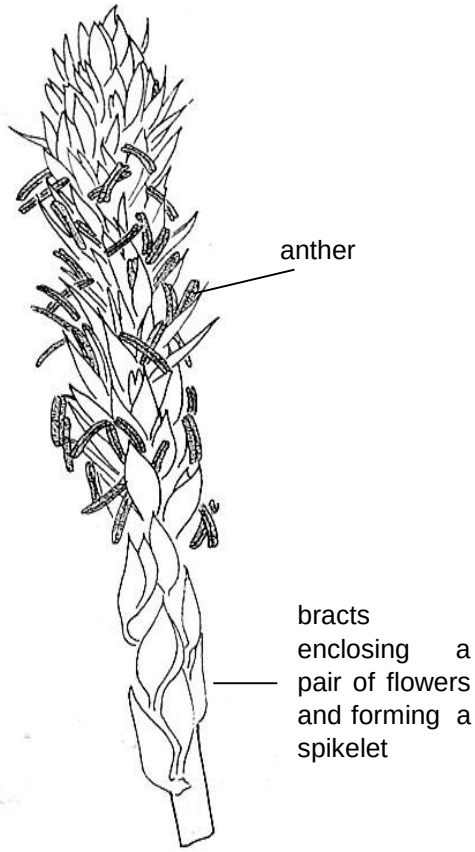


Figure 2: Part of maleinflorescence

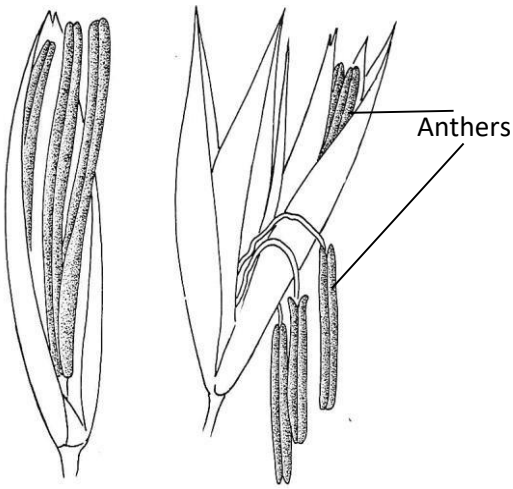


Figure 3: Male flowers

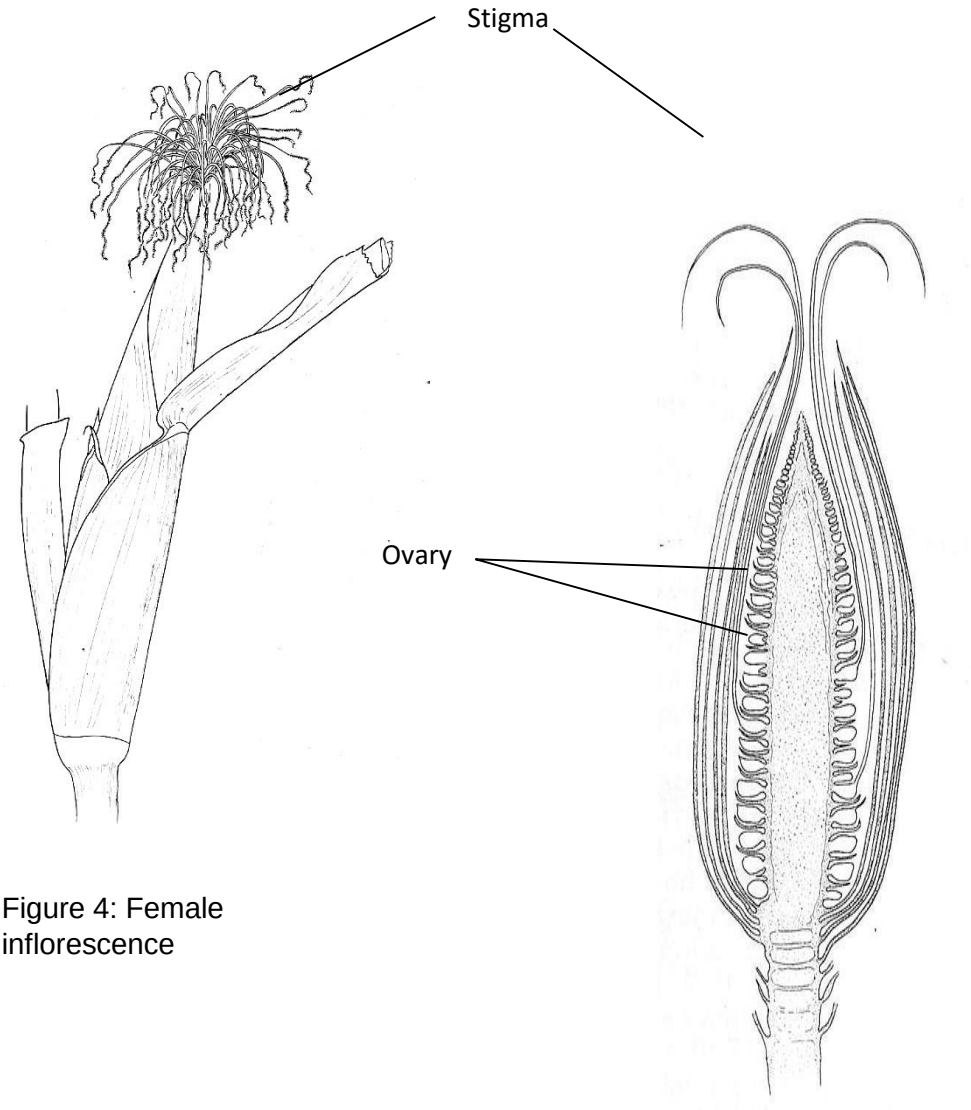


Figure 4: Female inflorescence

Figure 5: Longitudinal section through femaleinflorescence

Practical 3: Emasculation and hybridization techniques in self-pollinated crops

Methods of Emasculation

1. Hand Emasculation

In species with large flowers, removal of anthers is possible with the help of forceps. It is done before anther dehiscence. It is generally done between 4 and 6 PM one day before anthers dehisce. It is always desirable to remove other young flowers located close to the emasculated flower to avoid confusion. The corolla of the selected flower is opened with the help of forceps and the anthers are carefully removed with the help of forceps. Sometimes corolla may be totally removed along with **epipetalous stamens** e.g. gingelly.

In cereals, one third of the empty glumes will be clipped off with scissors to expose anthers. In wheat and oats, the florets are retained after removing the anthers without damaging the spikelets. In all cases, gynoecium should not be injured. An efficient emasculation technique should prevent self pollination and produce high percentage of seed set on cross pollination.

2. Suction Method

It is useful in species with small flowers. Emasculation is done in the morning immediately after the flowers open. A thin rubber or a glass tube attached to a suction hose is used to suck the anthers from the flowers. The amount of suction used is very important which should be sufficient to suck the pollen and anthers but not gynoecium. In this method considerable self-pollination, upto 10% is like to occur. Washing the stigma with a jet of water may help in reducing self-pollination, However self pollination can not be eliminated in this method.

3. Hot Water Treatment

Pollen grains are more sensitive than female reproductive organs to both genetic and environmental factors. In case of hot water emasculation, the temperature of water and duration of treatment vary from crop to crop. It is determined for every species. For sorghum 42-48^{O}C for 10 minutes is found to be suitable. In the case of rice, 10 minutes treatments with 40-44^{O}C is adequate. Treatment is given before the anthers dehiscence and prior to the opening of the flower. Hot water is generally carried in thermos flask and whole inflorescence is immersed in hot water.

4. Alcohol Treatment

It is not commonly used. The method consists of immersing the inflorescence in alcohol of suitable concentration for a brief period followed by rinsing with water. In Lucerne the inflorescence immersed in 57% alcohol for10 second was highly effective. It is better method of emasculation than suction method.

5. Cold Treatment

Cold treatment like hot water treatment kills the pollen grains without damaging gynoecium. In the case of rice, treatment with cold water 0.6^{O}C kills the pollen grains without affecting the gynoecium. This is less effective than hot water treatment.

6. Genetic Emasculation

Genetic/ cytoplasmic male sterility may be used to eliminate the process of emasculation. This is useful in the commercial production of hybrids in maize, sorghum pearlmillet, onion, cotton, and rice, etc.,

In many species of self-incompatible cases, also emasculation is not necessary, because self-fertilization will not take place. Protogyny will also facilitate crossing without emasculation (e.g.) Cumbu.

7. Use of Gametocide

Also known as chemical hybridizing agents (CHA) chemicals which selectively kills the male gamete without affecting the female gamete. eg. Ethrel, Sodium methyl arsenate, Zinc methyl arsenate in rice, Maleic hydrazide for cotton and wheat.

Bagging

Immediately after emasculation the flower or inflorescence enclosed with suitable bags of appropriate size to prevent random cross-pollination.

Crossing

The pollen grains collected from a desired male parent should be transferred to the emasculated flower. This is normally done in the morning hours during anthesis. The flowers are bagged immediately after artificial crossing.

Tagging

The flowers are tagged just after bagging. They are attached to the inflorescence or to the flower with the help of a thread. The following may be recorded on the tag with pencil.

1. Date of emasculation:
2. Date of pollination
3. Parentage:
4. No. of flowers emasculated:

1. In Paddy

Emasculation:

It is done in the afternoon on preveious day or early in the morning on the day of pollination.

The ear just emerged is selected and all spiklets already opened are clipped the spiklets which

are likely to be opened are selected and six anthers from each spiklet is removed with needle and fine pointed forceps. The emasculated ear after examination with lens covered with perforated butter paper bag and labelled.

In mass emasculation method hot water having temperature 42 to 45 0C is carried in thermos flask in the field. The panicle of the proper stage is selected and inserted in the water for 2 to 3 minutes. The flask is unopened spiklets are clipped off.

Pollination:

It is done on next day morning. Matured anthers are collected from protected male parent in petri dish and dusted on the stigma of emasculated flower with brush and forceps and covered with butter paper bag to protect natural cross pollination.

Practical 4: Emasculation and hybridization techniques in cross pollinated crops

In Maize

Emasculation:

The tassels of the female plants are removed immediately as soon as appeared. The process is called as detasseling. It is always done in the morning. Ear shoot which emerging from the leaf sheath is bagged 1 to 2 days below the tip of the preveious day of pollination.

The tassels of selected male parents is also covered with bag on following day in the morning between 9.00 to 10.00 a.m. pollens from tassel bag is dusted over the silk of the female cob/eat. The bag covered ear shoot is torn and bag from the male parent may be placed over the cob. Care should be taken to avoid contamination of silk with foreign pollens.

Crossing technique

Female parent

a. Detassel
b. Cut the tip of the cob before the silks emerge and cover with a butter paper cover.

Male parent

a. Cover the tassel before anthesis begins or as soon as the tassel emerges.

When the silks emerges in the female parent in the form of a brush, pollination is done by transferring the freshly shed pollen cover form the male parent and inserting it over the cob of the female parent after removing the cover from the cob.

The details like date of pollination, parentage and breeding programme to be carried out are clearly written by water proof pencil. The date or pollination will be one day later than the date of tasselling. Pollination should be completed within one week of silk emergence. Isolation distance for maize = 400M.

Practical 5: Consequences of inbreeding on genetic structure of resulting populations

Inbreeding is a form of mating system in sexual organism. It implies mating together ofindividual that are close to each other by ancestral or pedigree relationship.

When the individuals are closely related E. g Full sib mating, half sib mating. The highest degree of inbreeding is achieved by selfing. The chief effect of inbreeding is to increase homozygosity in the progeny, which is proportionate to the degree of inbreeding. Cross – pollinated and asexually reproducing species are highly heterozygous in nature. These species show a severe reduction in fertility and vigour due to inbreeding (inbreeding depression). It contrast to this hybridization between unrelated strains leads to an increased vigour and fertility (hybrid vigour or heterosis). These two aspects are of great significance in breeding of these species. In fact heterosis and inbreeding depression may be considered as the two opposite sides of the same coin.

Inbreeding Depression:

It refers to decrease in fitness and vigour due to inbreeding or it may be defined as thereduction or loss in vigour and fertility as a result of inbreeding.

The most revealing impact of inbreeding is the loss of vigour and the physiological efficiencyof an organism characterised by reduction in size and fecundity. For example selfing reduces heterozygosity, by a factor ½ in each generation. In fact the degree of inbreeding in any generation is equal to the degree of homozygosity in that generation. Inbreeding depression results due to fixation of unfavourable recessive genes in F2, while in heterosis the unfavourable recessive genes of one line (parent) are covered by favourable dominant genes of other parent.

The primary genetic consequence of inbreeding is increased homozygosity (Falconer and MacKay 1996). Two hypotheses for the genetic basis of inbreeding depression are put forth, both of which depend on the idea that homozygosity wll increase with inbreeding. Either the overdominance or partial dominance hypotheses are invoked to model the negative consequences of inbreeding (Charlesworth and Charlesworth 1987; Lynch 1991; Karkkainenet al. 1999). In the overdominance hypothesis, inbreeding depression is attributable to higher fitness of heterozygotes versus homozygotes for the loci in question (Frankham et al. 2003). For the partial dominance hypothesis, negative fitness consequences for inbred lines are due to the fixation of recessive or partially recessive deleterious alleles (Frankham et al. 2003).
Current thought favors the latter hypothesis, where inbreeding depression is attributable to many genes of small effect (Keller and Waller 2002, Frankham et al. 2003). However, distinguishing between the two genetic mechanisms is complicated by linked sets of deleterious recessives that imitate overdominance effects (Keller and Waller 2002).

Practical 6: Study of male sterility system

1. Palynology

This is the science involving the study of pollens. The pollen has a very minute structure. It is unicellular and usually round although it may be oval, pyramidal, polyhedral etc. It is provided with two coats-an inner, delicate, cellulose layer called **intine** and an outer tough, cutinised layer called exine or **extine**. The exine is often sculptured or provided with spines, warts etc., occasionally, it is smooth. The exine may have a waxy coating to render the pollen more or less waterproof. Very often, there are some definitely thinner circular spots or slits in the exine called **germ pores** or **slits**. These weak spots are utilized during the germination of the pollen.

2. Preparation of Acetocarmine Stain ($C_{22}H_2O_{13}$)

It is one of the most widely used stain for pollen study. A mixture of 4 ml glacial acetic acid and 55 ml of distilled water is boiled. A quantity of 1 g of carmine (according to the strength required) is added to 100 ml of the above mixture at about boiling point and then boiled for few minutes. After boiling, the contents are removed from the flame and allowed to cool and filtered in a clean bottle. The filtrate is reddish in colour and known as 1% acetocarmine. Ferric chloride or ferric acetate may be added if necessary for deep staining and preservation.

Fertility and sterility in A, B, R and TGMS lines

Male sterility is characterized by nonfunctional pollen grains, while female gametes function normally. It occurs in nature sporadically.

Types of male sterility, maintenance and uses:

Male sterility may be conditioned due to cytoplasmic or genetic factors or due to interaction of both. Environment also induces male sterility. Depending on these factors male sterility can be classified in to

a) Cytoplasmic male sterility (CMS)

b) Genetic male sterility (GMS)

c) Cytoplasmic-genetic male sterility (CGMS)

d) Environmental induced male sterility which is again sub divided in to

i) TGMS (Theromosensitive)

ii) PGMS (Photo sensitive)

A line or ms line: It represents a male sterile line belonging to any one of the above categories. The A line is always used as a female parent in hybrid seed production.

B line or maintainer line: This line is used to maintain the sterility of A line. The B line is isogenic line which is identical for all traits except for fertility status.

R line or restorer line: It is other wise known as Restorer line which restores fertility in the A line. The crossing between A x R lines results in F_1 fertile hybrid seeds which is of commercial value.

Pollen fertility count

a. Different crop species

Crop species	Number of pollen grains		Total	Percentage of pollen fertility
	Unstained	Stained		

b) A, B & R Lines of rice, cumbu.

Lines	Number of pollen grains		Total	Percentage of pollen fertility
	Unstained	Stained		
A				
B				
R				

Practical 7: Handling of segregation populations

Maintenance of Records

1. Accession Register
2. germplasm Bank
3. Descriptive blank register
4. Cropping programme
5. Single plant selection register
6. Row test
7. Replicated row test
8. Preliminary/Initial evaluation trial
9. Comparative yield/ yield evaluation trial
10. Multilocation I, II trials.
11. Quality observations Note book
12. Record of crosses
13. F1 generation
14. F2 segregation generation note book.

Accession Register

This will contain the details of the seeds/ planting material with regard to receipt date, source, their number, number assigned at the receiving unit, short description of the planting material, to whom sent for evaluation, date, feed back information about the genotype, now how maintained etc., Accession number given by the serial number followed by the year of entry i.e. serial 145 in 1991. Then accession number will be 145191 or 91145. It will be mentioned as EC = Exotic collection IC = Indigenous collection.

Proforma for Accession Register

Accession No. 1	Name of variety 2	Date of Receipt 3	Source of seed 4	Source No. 5	Pedigree record 6	Description of the material 7	How disposed to whom sent 8	Feed back information 9	Re-marks 10

Standard form of a Field Note Book

Each field note book should contain the following information.

A. Yield Trial

i) First Page

a) Number and title of the project
b) Season of raising the crop

c) Unit under which the trial is being conducted

ii) Second page

a) A full plant of the field showing the location of the trial with the approach path.
b) North East directions should be specified.

iii) Third Page

a) Plan of the experiment
b) Experiment details
1. Name of the experiment
2. Season
3. Number of variants
4. Design of the experiment
5. Replication
6. Size of the plot (Block/Plot/Row., etc.,)
7. Spacing (Between rows and within the row in cm)
8. Date of sowing/planting
9. Date of harvest
10. Name of the Principal Investigator

iv) Fourth page

Details of cultural practices followed for the plot/ field

a. Date of ploughing
b. Date of layout of the trial
c. Manurial schedule adopted
   Basal :
   Topdressing :
d. Irrigation schedules with date from life irrigation onwards
e. Plant protection schedules followed
f. Details of intercultural operations A (hoeing, weeding, and earthing up etc.,)
g. Date of harvest
h. Duration of processing till storage
i. Rainfall received during the crop growth
j. General remarks on the seasonal condition prevailed and its effects on crop growth including the occurrence of pests and disease.

v) Fifth page

One page for each variant per replications allotted.

The following information have to be recorded in each page.

1. Date of germination
2. Date of gap filling
3. Initial stand on
4. Date of first flowering
5. Date of general flowering
6. Date of harvest

7. Final stand
8. Wet weight of grain
9. Wet weight of haulms/ straw etc.,
10. Dry weight of produce after cleaning
11. Yield per ha in kg.

The page will also have additional information on observations about the variant, recorded by the breeder in relation to the object of the project.

The fifth page will also contain the following information and their modification depending upon the crop.

e.g. Rice : Date of earhead emergence in the main shoot number of tillers,
: Date of earhead emergence in tillers and
: Number of tillers.

Cotton : Number of sympodial branches
: Number of monopodial branches

Cumbu : Date of emergence of female flowers
: Date of emergence of male flowers
: Number of tillers

Sunflower : Duration of flower opening etc.,

Generation study

This field note book will contain the following information.

a. Plan for the segregation generation
b. Details of the generation

1. Name of the generation study
2. Number of crosses
3. Details of the cross
   Cross No. Female parent, Male parent, Number of families, number of seed sown.
4. Length of row
5. Spacing (cm)
6. Date of sowing
7. Dates of harvest
8. Name of the Principal Investigator

c. Plan for the segregation generation

d. Details of the generation

1. Name of the generation study
2. Number of crosses
3. Details of the cross
   Cross No. Female parent, Male parent, Number of families, number of seed sown.
4. Length of row
5. Spacing (cm)
6. Date of sowing
7. Dates of harvest
8. Name of the Principal Investigator

Practical No 8: Methods of calculating mean, range, variance, standard deviation, heritability

The Mean

The sample mean is the average and is computed as the sum of all the observed outcomes from the sample divided by the total number of events. We use x bar as the symbol for the sample mean. In math terms,

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x$$

where n is the sample size and the x correspond to the observed valued.

Example

Suppose you randomly sampled six acres in the Desolation Wilderness for a non-indigenous weed and came up with the following counts of this weed in this region:

34, 43, 81, 106, 106 and 115

We compute the sample mean by adding and dividing by the number of samples, 6.

34 + 43 + 81 + 106 + 106 + 115
= 80.83
6

We can say that the sample mean of non-indigenous weed is 80.83. 2.Variance, Standard Deviation and Coefficient of Variation

The mean, mode, median, and trimmed mean do a nice job in telling where the center of the data set is, but often we are interested in more. For example, a pharmaceutical engineer develops a new drug that regulates iron in the blood. Suppose she finds out that the average sugar content after taking the medication is the optimal level. This does not mean that the drug is effective. There is a possibility that half of the patients have dangerously low sugar content while the other half have dangerously high content. Instead of the drug being an effective regulator, it is a deadly poison. What the pharmacist needs is a measure of how farthe data is spread apart. This is what the variance and standard deviation do. First we showthe formulas for these measurements. Then we will go through the steps on how to use the formulas.

We define the variance to be

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})^2$$

and the standard deviation to be

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})^2}$$

Variance and Standard Deviation: Step by StepCalculate the mean, x.

Write a table that subtracts the mean from each observed value.Square each of the differences.

Add this column.

Divide by n -1 where n is the number of items in the sample This is the variance.To get the standard deviation we take the square root of the variance.

Example

The owner of the Ches Tahoe restaurant is interested in how much people spend at the restaurant. He examines 10 randomly selected receipts for parties of four and writes downthe following data.

44, 50, 38, 96, 42, 47, 40, 39, 46, 50

He calculated the mean by adding and dividing by 10 to getx = 49.2

Below is the table for getting the standard deviation:

x	x - 49.2	(x - 49.2)2
44	-5.2	27.04
50	0.8	0.64
38	11.2	125.44
96	46.8	2190.24
42	-7.2	51.84
47	-2.2	4.84
40	-9.2	84.64
39	-10.2	104.04
46	-3.2	10.24
50	0.8	0.64
Total		2600.4

Now

$$\frac{2600.4}{10 - 1} = 288.7$$

Hence the variance is 289 and the standard deviation is the square root of 289 = 17.

Since the standard deviation can be thought of measuring how far the data values lie from the mean, we take the mean and move one standard deviation in either direction. The mean for this example was about 49.2 and the standard deviation was 17. We have:

49.2 - 17 = 32.2

and

49.2 + 17 = 66.2

What this means is that most of the patrons probably spend between $32.20 and $66.20.

49.2 - 17 = 32.2

and

49.2 + 17 = 66.2

What this means is that most of the patrons probably spend between $32.20 and $66.20.

Practical 9: Designs used in plant breeding experiments, analysis of Randomized Block Design

Laying out of Field Experiments

The basic objective of plant breeding is the ultimate crop improvement. It results in development of high yielding varieties hybrids etc., over the existing cultivars and so on. The performance of the new varieties are confirmed from the results obtained from the field experiments. To be explained scientifically the field experiments are laid out following certain rules and the data thus collected are analyzed statistically. The steps involved in this process are explained here under.

Any designing of experiments involves three major steps.

1. Selection of experimental units

The objects on which the treatments are applied is known as experimental units.
Eg. Plots in the field, plant, etc.,

2. Fixing of treatments

The objects of comparison are known as treatmentsEg. Varieties, spacing etc.,

3. Arrangement of treatments in the experimental Units.

It comprises of three basic principles of design

a) **Replication:** repetition of treatments
b) **Randomization:** unbiased allocation of treatments to the experimental units.
c) **Local control:** minimizing the effect of heterogeneity of the experimental units.

The objective of replication, randomization and local control is to minimize the Experimental Error (EE). EE is nothing but differences in the responses from the experimental unit to experimental unit under similar environments. Apart from these, EE

can be reduced further by proper selection of the experimental units and choosing of most appropriate experimental design for a given number of treatment.

Types of basic experimental designs

1. Completely Randomized Design (CRD)
2. Randomized Block Design (RBD)
3. Latin Square Design (LSD)

Among these, RBD is the widely used design.

Laying Out of RBD

A. The experimental material (field) is divided first into blocks consisting of homogenous (uniform) experimental units. Each block is divided into number of treatments equal to the total number of treatments.

B. Randomization should be taken within each block and the treatments are applied following the random number table.

C. Collection and analysis of data: After the collection of data from the individual experimental unit (treatments) ANOVA (Analysis of Variance) table is formed.

The significance of the ANOVA table is that it indicates the sources of variation exhibited by the treatments, the magnitude of variation derived from different sources and their worthiness (significant/ non significant).

D. Computation of Critical Difference (CD)

Critical Difference is the difference between the treatment means, which places the treatments statistically as well as significantly apart. Otherwise if the difference of two treatments mean is less than CD it can be concluded both the treatments are on par.

RT: Row trial

Row trial is generally conducted in F_3 and F_4, when the seeds are not sufficient for replication with individual plant progeny rows. Each row consists of about 20 or more plants. Individual plants with desirable characteristics are selected from superior progeny rows. Pest, Disease and lodging susceptible progenies with undesirable characteristics are eliminated.

RRT – Replicated Row Trial

It is generally conducted from F_3 generation onwards. Depending on availability of seeds, 3-4 more rows are grown for each progeny to facilitate comparison among progenies

adopting suitable replications. Families, which have become reasonably homozygous may beharvested in bulk. From those families showing segregation, single plants are selected for characters under study. The breeder has to visually assess the yielding potential of progenies and reject the inferior ones in the field and the yield potential has to be assessed in the laboratory for confirmation.

PYT – Preliminary Yield Trial Or (IYET) Initial Yield Evaluation Trial

It is conducted from F_5 generation onwards. Preliminary yield trial with three or more replications are conduct to evaluated the comparative performance of the culture and to identity the superior cultures among them. The cultures are evaluated for plant height, lodging, pest and disease resistance, flowering time, duration and yield, etc., Quality tests may also be carried out. Standard commercial varieties must be included as checks for comparison. Ten to fifteen outstanding cultures, if superior to checks, would be advanced to the Advanced yield trails.

AYT – Advanced Yield Trial

Advanced Yield Trial is conducted from F8 generation on wards. The superior cultures identified from Preliminary Yield Trial are tested in Replicated Yield Trial. In this trial, the cultures are evaluated for yield, pest, disease and lodging resistance, duration, quality, etc.

Multi location trial is conducted from F_{13} onwards for 3 years by the Research StationScientists. Multilocation Trial are useful for suitability studies i.e. whether a particular culture is able to perform well in all the locations or not. Stable performance of a culture over all the locations will be promoted to ART.

ART – Adaptive Research Trial

It is conducted after MLT for 3 years by the Department of Agriculture. Nearly 3-4 cultures are tested and based on the performance of 3 Years in the farmers field, the best culture over the check may be proposed to SVRC (State Variety Release Committee) for releasing.

If the SVRC finds that the cultivar is suitable for any particular area or throughout the state, then the variety is released and is notified by the State Department of Agriculture.

Practical 10: To work out the mode of pollination in a given crop and extent of naturalout-crossing

AIM: To work out the mode of pollination in a given crop and extent of out crossing.

1. To work out the mode of pollination in a given crop.

There are several approaches:

a) Morphological examination of flowers:

Mechanism like dioecy , monoecy, protogyny, protandry and cleistogamy are easilydetected. They indicate the mode of pollination.

b) Space isolation:

Growing single plant of a crop in isolation and recording the seed sit, determines the extent of pollination. Failure o set seeds in isolation proves the crop to be cross pollinated and seed set is indicative of self-pollination.

c) Effects of selfing (inbreeding):

Vigour due to inbreeding is common in cross pollinated species while self-pollinated crops show no inbreeding depression.

2) To work out the extent of out crossing:

The amount of cross-pollination is determined by planting two strains of the concerned species in a mixed stand. One of these two strains is homozygous for a dominant character, preferably an easily recognizable seeding or other phenotypic character, while other strain is recessive for that character. The two strains are planted in such a manner that each plant of the recessive strain is surrounded by plants of dominant strain to provide abundant pollen. Seeds produced on the recessive strain are harvested and grown in the next generation. The percentage of plant carrying the dominant allele of the character represents the percentage of cross-pollination

Practical 11: Prediction of performance of double cross hybrids

The performance of double cross hybrids can be predicted by comparative evaluation of the predictions based on the performance of single cross.

The method was developed by Jenkins (1934). According to this method, the predicted performance of any double cross is the average performance of the four non-parental single crosses involving the four parental inbred.

For example:

If the 4 inbred are I1, I2, I3 and I4. The possible single cross among these inbred would be 6,viz I1 × I2, I2 × I3, I3 × I4, I1 × I3, I1 × I4 & I2 × I4.

These single crosses can combine to produce 3 double crosses, Viz,(I1 × I2) × (I3 ×I4)

(I1 × I3) × (I2 ×I4) (I1 × I4) × (I2 × I3)

The performance of any of these double crosses can be predicted from the performance of the four single crosses, not involved in producing that particular double cross.

For example:

The performance of double cross (I1 × I2) × (I3 ×I4) would be the average of the performance of the four single crosses (I1 × I3), (I1 × I4), (bv+I2 × I3) and (I2 ×I4)

FARM MACHINARY AND POWER (AGS-305)

Contents

Practical No. 1. Introduction to various farm machines and equipment used on the farm

Objectives: (i) To make familiar about various farm machines used on farm

Introduction: Crop production requires a number of operations like seed bed preparation, seeding, fertilizing, spraying, dusting, irrigation, harvesting and threshing. The various farm equipment/machines have been used on the farm to perform these operations in order to enhance their output capacity, efficiency, timeliness of operation and to reduce drudgery involved.

1. Seed bed preparation

Seed bed preparation is the first operation in production of crop which is very labour intensive operation. The main objective of seed bed preparation is to provide favourable condition for proper crop growth through mechanical manipulation of soil. Soil tillage consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass so as to enable the roots of the crops to penetrate and spread into the soil.

Tillage operations for seed bed preparations are classified as: i) Primary tillage ii) Secondary tillage.

2. Seeding

Seeding or sowing is an art of placing seeds in the soil to have good germination in the field. A perfect seeding gives

- Correct amount of seed per unit area.
- Correct depth at which seed is placed in the soil.
- Correct spacing between row-to-row and plant-to-plant.

The various Sowing methods are as below:

(i) Broadcasting (ii) Dibbling (iii) Drilling (iv) Seed dropping behind the plough (v) Transplanting (vi) Hill dropping (vii) Check row planting

3. Intercultural operation

Weeds can compete with productive crops or pasture, or convert productive land into unusable scrub. Weeds are also often poisonous, distasteful, produce burrs, thorns or other damaging body parts or otherwise interfere with the use and management of desirable plants by contaminating harvests or excluding livestock. They provide competition for space, nutrients, water and light.

The weeder can be classified as (i) Dry land weeder (ii) Wet land weeder (cono weeder), Sweep, Engine Operated weeder etc.

4. Plant Protection

There is increase in plant pests and diseases as more fields remain covered under crops for longer duration of time due to multiple cropping, intensive farming and better irrigation facilities. So it has become necessary now to use pesticides and fungicides for controlling the pests and diseases. The chemicals are applied on plants in the form of spray and dust. Many types of sprayers and dusters are available in different sizes for plant protection work.

Sprayer

Sprayer is a machine to apply fluids in the form of droplets. Sprayer is used for the following purpose.

- Application of herbicides to remove weeds.
- Application of fungicides to minimize fungus diseases.
- Application of insecticides to control insect pests.
- Application of micro nutrients on the plants.

The main functions of sprayer are

- To break the liquid droplets of effective size.
- To distribute them uniformly over the plants.
- To regulate the amount of liquid to avoid excessive application.

Duster

It is a machine to apply chemical in dust form. Duster make use of air streams to carry pesticides in finely ivided dry form on the plants.

Exercise 1.1 Enlist the name of equipment/machines used for different field operations.

S. No.	Name of field operation	Name of implement/machine used
1.	Seed bed preparation a. Primary tillage b. Secondary tillage	 1. _____ 2. _____ 3. _____ 1. _____ 2. _____ 3. _____
2.	Sowing/Planting/Transplanting	1. _____ 2. _____ 3. _____ 4. _____
3.	Intercultural operation	1. _____ 2. _____ 3. _____

4.	Plant protection	1. _____ 2. _____ 3. _____

Practical. 2. To Measure Field capacity and field efficiency of Farm implements

Objectives:

i. To measure field capacity of farm implements used on farm

ii. To measure field efficiency of farm implements used on farm

Equipment Required:

1. Tractor
2. Disk harrow
3. Cultivator
4. Measuring Tape
5. Stop Watch

Methodology:

Select an area of approximately 10 x 10 m for determination of field capacity and field efficiency of the implement. For theoretical capacity, take a test run of 10 m. Operate the farm machinery at optimum speed and at suitable gear in the field. Note down the average time taken by the implement to cover 10 m run. Also record average width coverage by implement in one pass. Find the theoretical field capacity to be covered by the implement based on width of the implement and speed of the implement using the formula, find the theoretical field capacity of the implement.

For effective field capacity, operate the farm machinery to cover 10 x 10 m area taking into consideration of various time losses turning, refueling, adjustment, if any or any other time loss in the field. Operate the farm machinery in the selected field and note down the total time taken by the implement to cover 100 m^2 area.

Theoretical Field capacity:

It is the rate of field coverage of the implement, based on 100 percent of the time at the rated speed and covering 100 percent of its rated width.

$$\textbf{Theoretical Field capacity (ha/h)} = \frac{\text{width of implement(m) x speed of implement (m/h) x}}{1000}$$

Effective field capacity:

It is actual area covered by the implement based on its total time consumed and its width. Effective field capacity is calculated as

$$\text{Effective field capacity} = \frac{\text{width of coverage(m) x speed of implement (m/h) x } \eta}{1000}$$

Where η = field efficiency

Field efficiency (η) :

It is the ratio of effective field capacity anf theoretical field capacity expressed in per cent.

$$\text{Field efficiency} = \frac{ctive\ field\ capacity}{Theoretical\ field\ capacity} \text{ x } 100$$

Numerical 2.1. A three bottom 40 cm Disc plough has a working depth of 20 cm, field efficiency is 80 % and working speed is 4 km/h. Find the actual field capacity of the plough.

Sol.

Exercise 2.1: Measure the field capacity and field efficiency of Tractor drawn disk harrow.

Observations to be recorded:

Particulars	**1**	**2**	**3**	**4**	**5**	**Average**
Time taken to cover 10 m length (min)						
Width of coverage (m)						

Exercise 2.2: Measure the field capacity and field efficiency of Tractor drawn cultivator.

Observations to be recorded:

Particulars	**1**	**2**	**3**	**4**	**5**	**Average**
Time taken to cover 10 m length (min)						
Width of coverage (m)						

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Practical 3. Draft & fuel consumption measurement for different implements under different soil conditions.

Objective:

1. To measure the draft of different tillage implements under different soil conditions.
2. To measure fuel consumption of different tillage implements under different soil condition.

Equipment required:

1. Tractor
2. Tillage implement (plough, Harrow, cultivator etc)
3. Load cell/ spring dynamometer (1000 kgf)
4. Fuel flow meter
5. Measuring tape, scale

Methodology

Draft (D): It is the horizontal component of the pull, parallel to the line of motion.

$D = P \cos \theta$

Where,

D = draft (kgf)

P = pull (kgf)

θ = angle between line of pull and horizontal

Pull (P) : It is the total force required to pull an implement.

Metric hp = $\frac{\boldsymbol{Draft\ (kgf)\ Speed\ (m/s)}}{\mathbf{75}}$

Side Draft: It is the horizontal component of the pull perpendicular to the direction of motion. Side draft is developed if the centre of resistance is not directly behind the centre of pull.

Unit draft: It is the draft per unit cross sectional area of the furrow.

Fuel Consumption

The fuel consumed by an engine can be measured by determining the volume of flow of fuel in a given time interval and multiplying it by the specific gravity of the fuel.

Continuous flow meters like Flotron are also used to measure fuel consumption which give instantaneous readings.

Experiment: Determine the fuel consumption of different engines under different load conditions

S.No	Name of engine/machine	Operation	Fuel consumed (lit/h)			
			1	2	3	4
1.	Power Tiller	Rotalling				
		Transportation				
2.	Tractor	ploughing				
		Intercultural operation				
		Harrowing				

Practical 4. Study of construction details, adjustments and working of M.B. plough

Objectives:

i) To study the various components of M.B. plough and their function

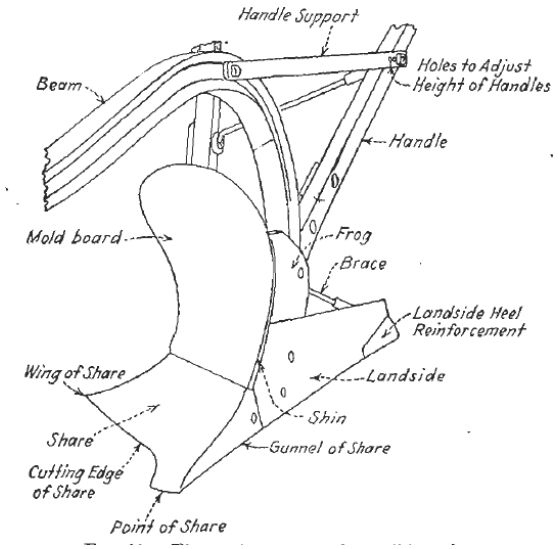
ii) To study the various adjustments of M. B. Plough

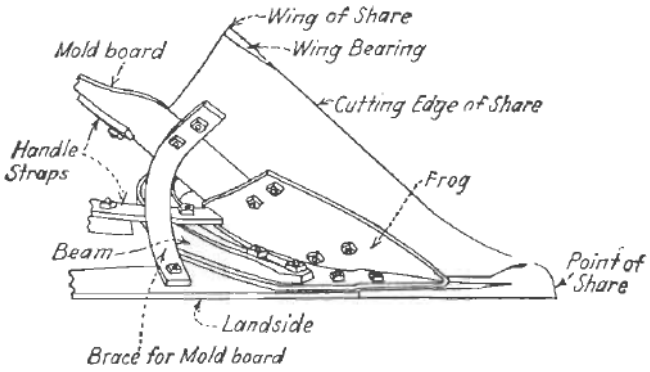
Introduction: Mould board plough cuts, loosen, invert the furrow slice and provide a deep seed bed of good structure for seed bed preparations. The main functions of M.B. plough are:

Main Function: (i) cutting the furrow slice (ii) lifting the soil (iii) Turning the furrow slice and (iv) pulverising the soil.

Components

M.B. plough consists of Share, Mould board, Land side, Frog and Tail piece.





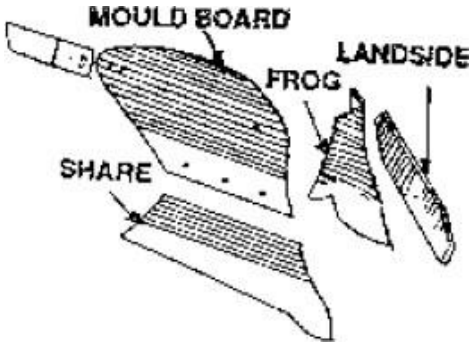


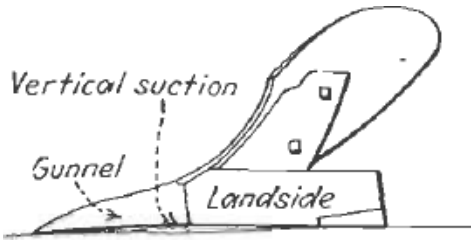
Fig. 4.1 Components of M. B. Plough

Various Adjustment of M.B. Plough

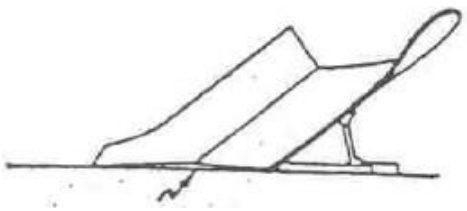
1. **Vertical clearance or suction:** It is the maximum clearance under the land side and the horizontal surface when the plough is resting on a horizontal surface in the working position. It is the vertical distance from the ground, measured at the joining point of share and land side. It helps the plough to penetrate into the soil to a proper depth. This clearance varies according to the size of the plough.

2. **Horizontal Clearance or suction**: It is the maximum clearance between the land side and a horizontal plane touching point of share at its gunnel side and heal of land side. This suction helps the plough to cut the proper width of furrow slice. This clearance varies according to the size of the plough. It is also known as side clearance.

3. **Throat clearance**: It is the perpendicular distance between point of share and lower position of the beam of the plough.



Vertical Suction



Horizontal Suction

Fig. 4.2. Vertical and Horizontal clearance in M.B. Plough

Plough size : The size of the mouldboard plough is expressed by width of cut of the soil.

Exercise 4.1 Measure the following parameters of a M.B. Plough

S. No.	Parameters	Value (mm)			Mean (mm)
		R_1	R_2	R_3	
1	Plough size				
2.	Vertical clearance				
3.	Horizontal clearance				
4.	Throat clearance				
5.	Depth of cut				

Exercise 4.2 Write down the functions of following components of M. B. Plough

Components	Function
1. Share:	
2. Mouldboard:	
3. Landside:	
4. Frog:	
5. Tail Piece:	
6. Jointer	
7. Coulter:	
8. Gauge wheel:	
9. Land wheel	
10. Furrow wheel:	

Practical 5. Study of construction details, adjustments and working of Disc plough

Objectives:

i) To study the various components of disc plough and their function

ii) To study the various adjustments of disc Plough

Introduction: It is a plough, which cuts, turns and in some cases breaks furrow slices by means of separately mounted large steel discs. A disc plough is designed with a view of reduce friction by making a rolling plough bottom instead of sliding plough bottom. A disc plough works well in the conditions where mould board plough does not work satisfactorily. It consists of steel disc of 60 to 90 cm diameter, set at a certain angle to the direction of travel. Each disc revolves on a stub axle in a thrust bearing, carried at the lower end of a strong stand which is bolted to the plough beam. The angle of the disc to the vertical and to the furrow wall is adjustable. In action, the disc cuts the soil, breaks it and pushes it sideways. There is little inversion of furrow slice as well as little burying of weeds and trashes. The disc plough may be mounted type or trailed type. In mounted disc plough, the side thrust is taken by the wheels of the tractor. Disc is made of heat treated steel of 5 mm to 10 mm thickness. The amount of concavity varies with the diameter of the disc. The approximate values being 8 cm for 60 cm diameter disc and 16 cm for 95 cm diameter.

Various Adjustments in a Disc Plough

1. **Penetration**: Penetration can be improved by (a) increasing the disc angle (b) decreasing the tilt angle (c) by adding additional weight on the plough

2. **Width of cut**: It can be adjusted by adjusting the angle between the land wheel axle and the frame.

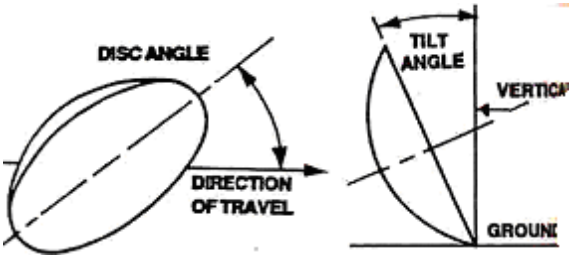


Fig.5.2 Angles of disc plough

Exercise 5.1 Label the various components of following disc plough

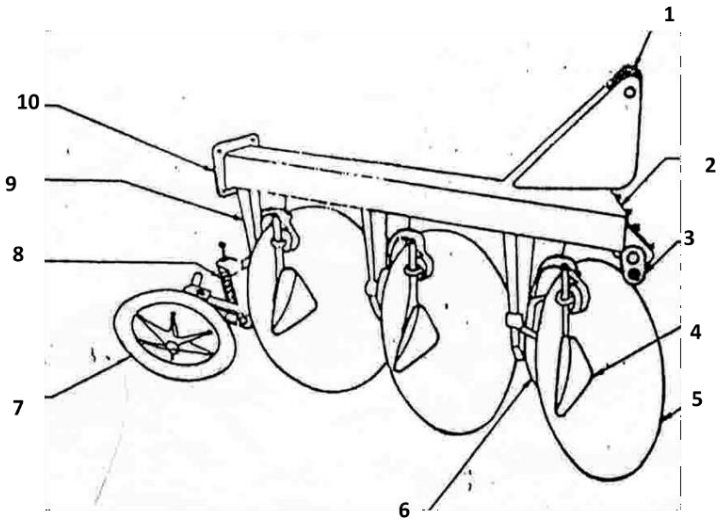


Fig. 5.1 Standard disc plough

Number	Name of component	Number	Name of component
1.	_____	6.	_____
2.	_____	7.	_____

3. _____ 8. _____

4. _____ 9. _____

5. _____ 10. _____

Exercise 5.2 Write down the functions of following components of disc Plough

Components	Function
1. Disc:	
2. Main Frame:	
3. Standard:	
4. Rockshaft:	
5. Scraper:	
6. Concavity:	
7. Furrow wheel:	

Practical 6. Study of construction details, adjustments and working of Disc Harrow

Objectives:

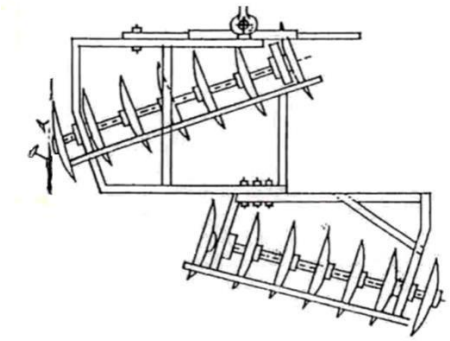
i) To study the various components of disc harrow and their function

ii) To study the various adjustments of disc harrow

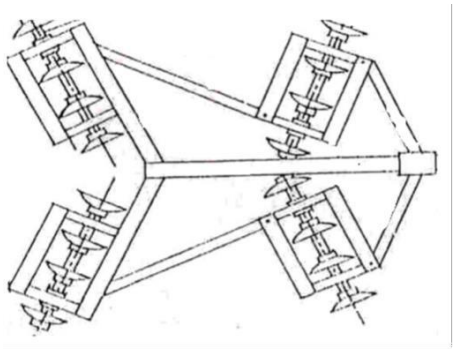
Introduction: It is a harrow, which performs the harrowing operation by means of a set, or a number of sets of rotating slat discs, each set being mounted on a common shaft. Disc harrow is found very suitable for hard ground, full of stalks and grasses. It cuts the lumps of soil, clods and roots. Disc are mounted on one, two or more axles which may be set at a variable angle to the line of motion. As the harrow is pulled ahead, the discs rotate on the ground. Depending upon the disc arrangements, disc harrows are divided into two classes a) Single action and b) Double action.

Exercise 6.1 Write the name of following types of disc harrow

1. _____ 2. _____ 3. _____



4._____

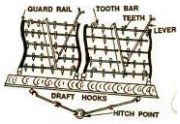
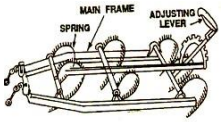
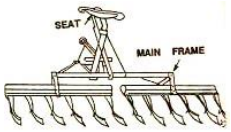
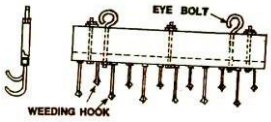
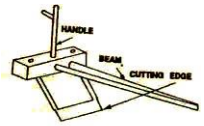
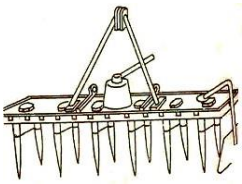


5._____

Exercise 6.2 write down the functions of different components of disc harrow

Components	Function
1. Disc:	
2. Gang:	
3. Arbor bolt:	
4. Gang axle:	
5. Gang control lever:	
6. Weight box:	
7. Spool/spacer:	
8. Transport wheel:	
9. Bearing:	
10. Scraper:	

Exercise 6.3. Write down the name of following types of harrow and their special use.

Picture	Name of harrow	Special use
		
		
		
		
		
		
		

Practical 7. Study of construction details, adjustments and working of Cultivator

Objectives:

i) To study the various components of a cultivator and their function

ii) To study the different types of shovel and sweep used in a cultivator

Introduction: It is an implement for inter cultivation with laterally adjustable tines or discs to work between crop rows. The cultivator stirs the soil, and breaks the clods. The tines fitted on the frame of the cultivator comb the soil deeply in the field. A cultivator performs functions intermediate between those of plough and the harrow. Destruction of weeds is the primary function of a cultivator.

Functions:

- Interculture the fields.
- Destroy the weeds in the field.
- Aerate the soil for proper growth of crops.
- Conserve moisture by preparing mulch on the surface.
- To sow seeds when it is provided with sowing attachments.
- To prevent surface evaporation and encourage rapid infiltration of rain water into the soil.

The cultivator can be 1) Disc cultivator, 2) Rotary cultivator, 3) Tine cultivator.

Exercise 7.1 Label the parts of following cultivator and write their function.

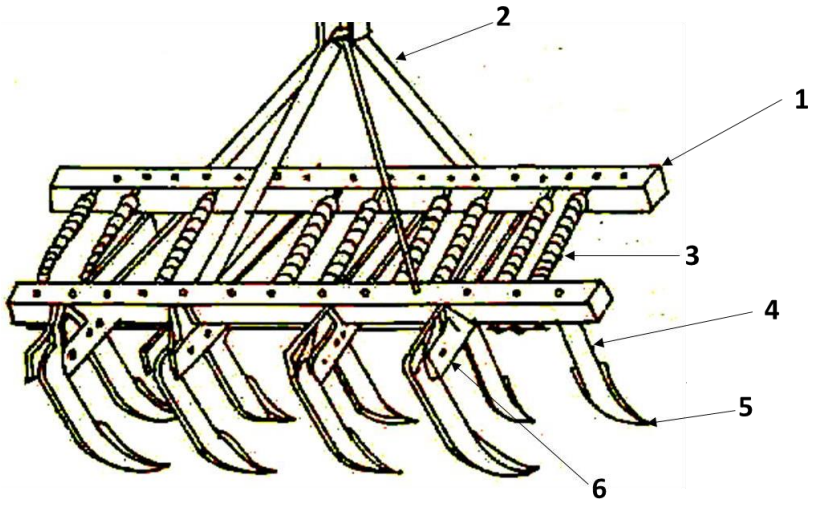
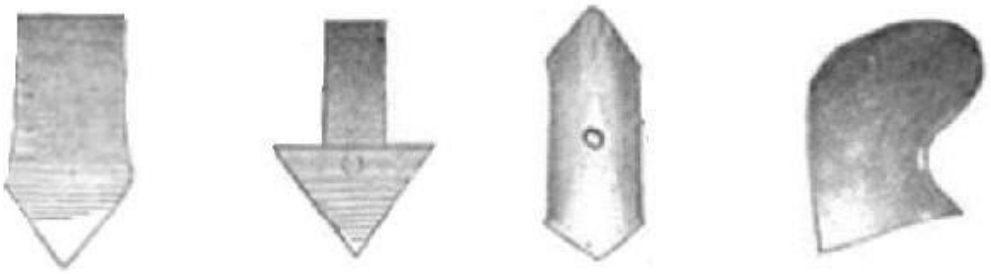


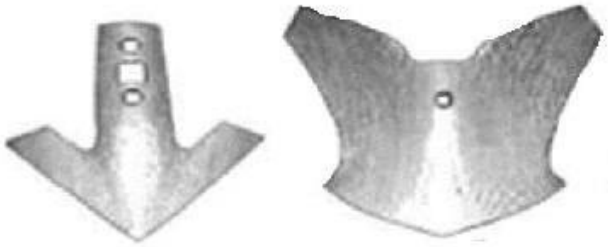
Fig. 7.1 Cultivator with spring loaded tynes

S. No.	Components	Function
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____

Exercise 7.2 Write the name of following types of shovel /sweep alongwith their specific use.



1._____ 2._____ 3._____ 4._____



5._____ 6._____ 7._____

S. No. Name	Use
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
6. _____	_____
7. _____	_____

Practical 8. To study the Construction details and working of earth moving machinery

Objectives:

i) To study the various components of a earth moving machinery and their function

ii) To study the working of earth moving machinery

Introduction: Earth moving equipments are generally used for digging and mowing the unwanted soil from one place to another. The major benefits of earth moving equipments are to reduce the workload of the human resource, save time as well as money.

1. **Excavator**

An excavator consists of an articulated arm (backhoe), bucket and cab mounted on a pivot (a rotating platform, like a Lazy Susan) a top and undercarriage with tracks or wheels. Excavators are intended for excavating rocks and soils. It digs, elevates, swings and dumps material by the action of its mechanism, which consists of boom, arm, bucket and hydraulic cylinders. Bucket is used for trenching, in the placement of pipe and other under-ground utilities, digging basements or water retention ponds, maintaining slopes and mass excavation.

2. **Backhoe Loaders**

Backhoe loaders share many similarities with tractors. The main difference is they contain a shovel at the front which can be adjusted and a bucket at the rear which is used to dig. Backhoe loaders are usually the best choice for smaller jobs which need to be completed in a more restrained space. Backhoe loaders shift dirt, shovel trenches and position pipes into place.

3. **Bulldozers**

Generally Bulldozers are believed to be the most heavy-duty machines in farm machineries. Bulldozers are used for shifting large amounts of dirt on sites where there are wide open spaces, rough grading, and grinding rock. Bulldozers are

easily identified by the huge blade at the front of the equipment that is controlled with the use of hydraulic pistons.

4. Trencher

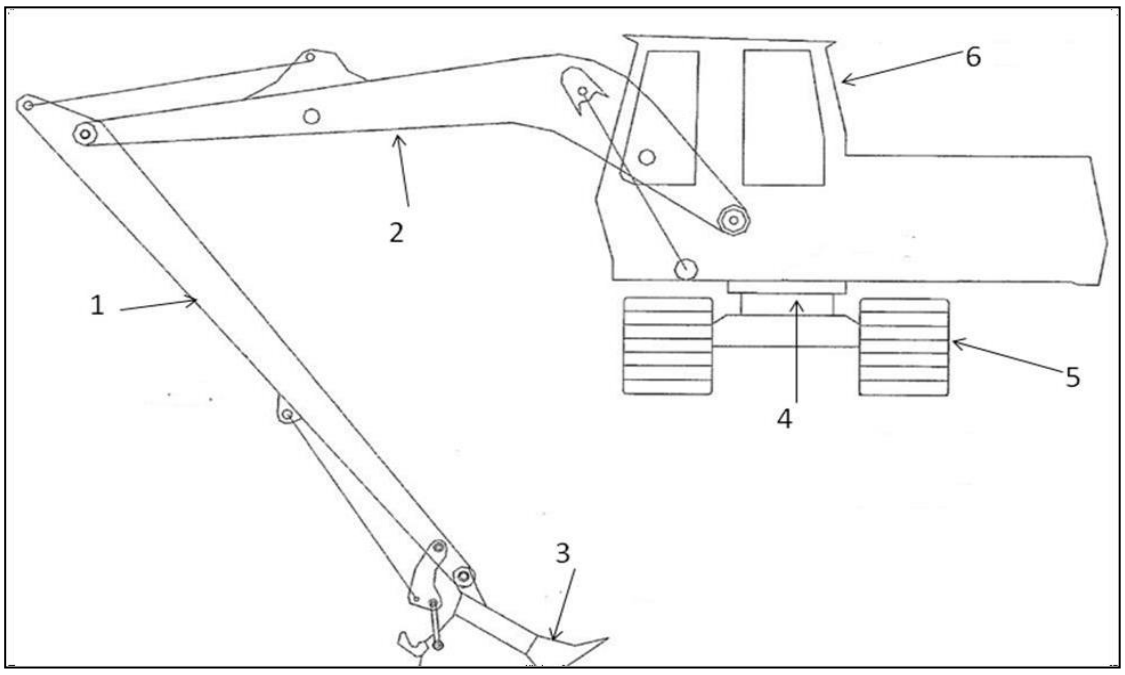
Trenchers are mostly used to dig trenches before pipes are laid down. A range of different trencher machines are available including walk-behind modules, smaller-sized trenchers or heavier equipment used to trench firmer ground.

Exercise 8.1: Enlist the following types of earth moving machine

S.No.	Sketch of machine	Name of machine
1.		
2.		
3.		
4.		

Exercise 8.2. Label the components and write their function in the following

Backhoe loader



S. No. Name	Function
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
6. _____	_____
7. _____	_____

Practical 9. To study the Construction details and working of rotavator

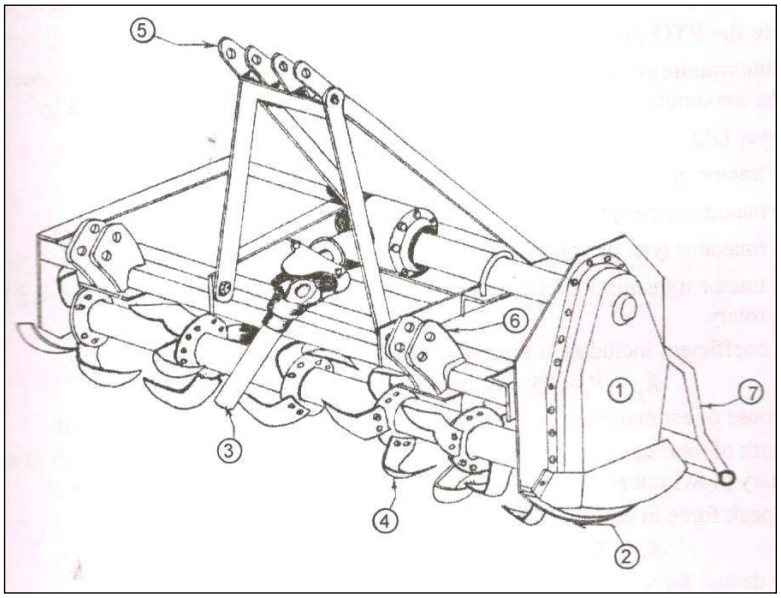
Objectives:

i) To study the various components of a rotavator and their function

ii) To study the working of a rotavator

Introduction: A rotavator is a secondary tillage implement especially designed for seed bed +preparation in a single pass. It gives excellent pulverization of soil and mixes the trash, crop residues, weeds etc. into the soil. It works on the principle of rotary motion. It takes its drive from tractor PTO shaft and transmits to the tynes through the reduction gear so that its tynes rotates at 250-350 rpm while in operation. It consists of steel frame, a rotary shaft on which blades are mounted, power transmission system and gear box. Rotary motion of the PTO is transmitted to the shaft carrying the blades through gear box and transmission system. The main components of tractor drawn rotavator are (i) Hitch point (ii) PTO shaft attachment (iii) Tyne (iv) Chain sprocket driver cover (v) Depth control plate (vi) Hydraulic linkage hitch (vii) Leveller

Exercise 9.1. Label the components and their functions in the following rotavator



S. No.	Components	Function
1.		
2.		
3.		
4.		
5.		
6.		
7.		

Practical 10. Study of seed cum fertilizer drill and its calibration

Objectives:

i) To study the various components of seed cum fertilizer drill

ii) To study the calibration method of seed cum fertilizer drill

Introduction: Seeding or sowing is an art of placing seeds in the soil to have good germination in the field. A perfect seeding gives (a) Correct amount of seed per unit area. (b) Correct depth at which seed is placed in the soil. (c) Correct spacing between row-to-row and plant-to-plant.

Seed cum fertilizer drill : Seed cum fertilizer drill consists of dropping seeds in furrow lines in a continous flow and covering them with soil.

Components of Seed Drill : A seed drill with mechanical seed metering device mainly consists of: (i) Frame (ii) Seed box (iii) Seed metering mechanism (iv) Furrow openers (iv) Covering device (vi) Transport wheels.

Seed Metering Mechanism: The mechanism of a seed drill or fertilizer distributor which delivers seeds or fertilizers from the hopper at selected rates is called *seed metering mechanism*. Seed metering mechanism may be of several types:

(a) Fluted feed type (b) Internal double run type (c) Cup feed type (d) Cell feed mechanism (e) Brush feed mechanism (f) Auger feed mechanism (g) Picker wheel mechanism (h) Star wheel mechanism.

Calibration of seed drill: The procedure of testing the seed drill for correct seed rate is called calibration of seed drill. It is necessary to calibrate the seed drill before putting it in actual use to find the desired seed rate. It is done to get the pre determined seed rate of the machine. The following steps are followed for calibration of seed drill.

Procedure:

i. Determine the nominal width (W) of seed drill

W = M x S,

Where,

M = Number of furrow openers, and

S = Spacing between the openers, m

ii. Find the length of the strip (L) having nominal width (W) necessary to cover 1 ha (10000 m^2) area

L = 10000/W, meter

iii. Determine the number of revolutions (N) of the ground wheel of the seed drill required to cover the length of the strip (L)

L = π x D x N = 10000/W

N = 10000/ π x D x W revolutions per minute

iv. Jack the seed drill so that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the ground wheel

v. Fill the selected seed in the seed hopper. Place a container under each boot for collecting the seeds dropped from the hopper

vi. Set the seed rate control adjustment for maximum position and mark this position on the control for reference

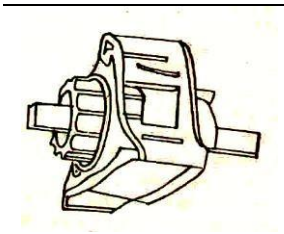
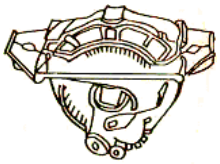
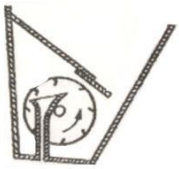
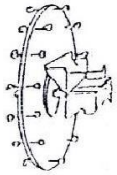
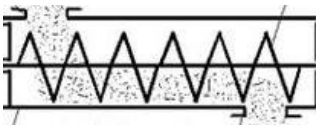
vii. Engage the clutch and rotate the ground wheel for N = 10000/ π x D x N, revolutions per minute

viii. Weigh the quantity of seed collected in the container and record the observation.

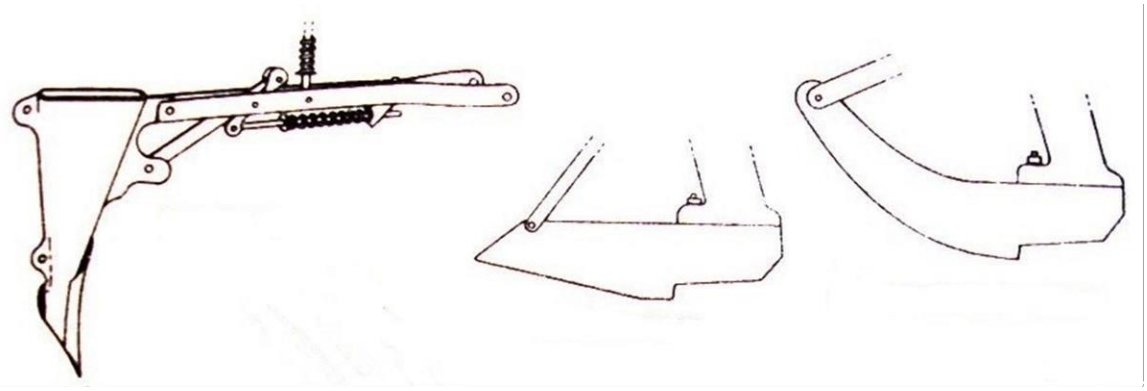
ix. Calculate the seed rate in kg/ha

x. If the calculated seed rate is higher or lower than the desired rate of selected crop, repeat the process by adjusting the seed rate control adjustment till the desired seed rate is obtained.

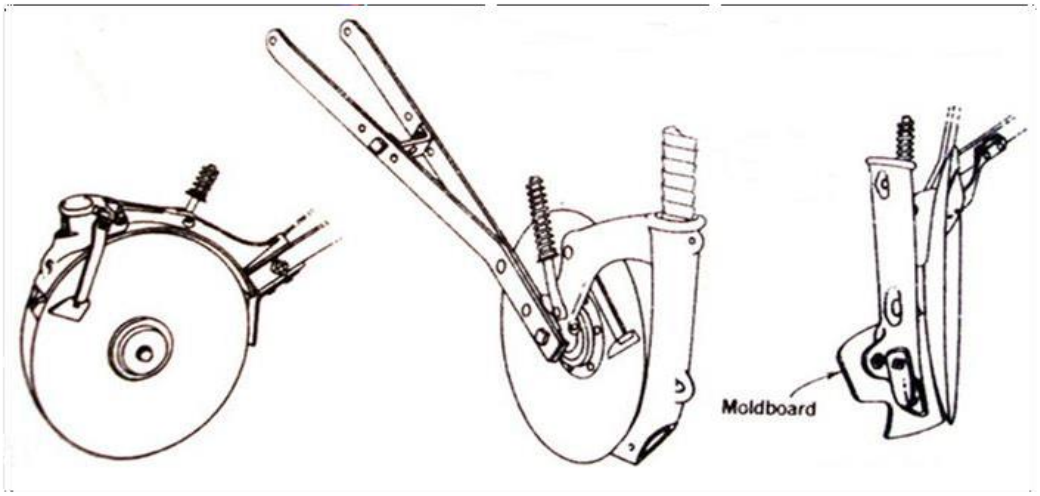
Exercise 10.1 Identify the following seed metering mechanism.

Sketch of metering mechanism	Name of metering mechanism
	_____
	_____
	_____
	_____
	_____
	_____

Exercise 10.2 Identify the type of furrow openers used in seed cum fertilizer drill as shown below.

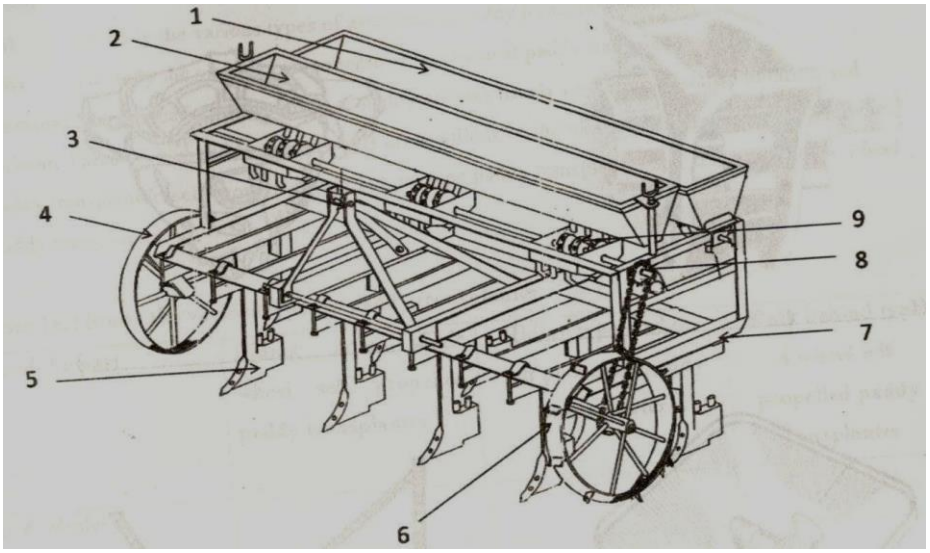


1._____ 2._____ 3._____



4._____ 5._____ 6._____

Exercise 10.3 Label the component of the seed cum fertilizer drill and write their main function



S. No.	Components	Function
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

9. _____	_____

Practical. 11. Study of different type of mechanical paddy transplants

Objectives:

1) To study the various types of mechanical paddy transplanters

2) To study the various components of mechanical paddy transplanters

Introduction: Mechanical transplantation of paddy ensure timely operation of transplantation saves labour. Three type of paddy transplanters are available in the market - self-propelled single wheel type paddy transplanters, self-propelled walk behind paddy transplanter and self-propelled 4-wheel type paddy transplanter.

Exercise 11.1 study the various types of paddy transplanter

Name of the part	**Manual paddy transplanter**	**Riding type single wheel self propelled paddy transplanter**	**Riding type 4 wheel self propelled paddy transplanter**
Make & Model			
Type of Engine			
Number of rows			
Total width			
Steering handle			
Seedling platform			
Seedling picking fingers			
Float			

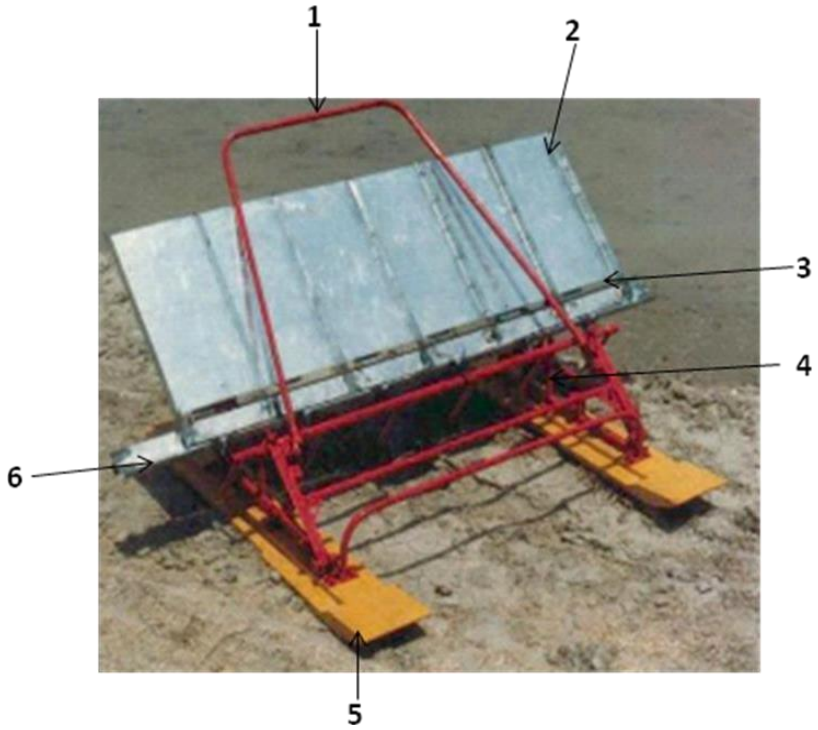
Covering device			
Towing bar			
Driving wheel			

Exercise 11.2 Label the major components of self-propelled riding type single wheel paddy transplanter and write their function.

S. No. Components	Function
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____

5. _____	_____
6. _____	_____
7. _____	_____

Exercise 11.3 Label the components of Manual paddy transplanter alongwith their function



S. No.	Components	Function
1.	_____	_____
2.	_____	_____
3.	_____	_____

4. _____	_____
5. _____	_____
6. _____	_____

Practical 12. Study of different weeding equipments and their use

Objective:

i. To study the various types of weeding/ intercultural equipments

Introduction:

Weeds can compete with productive crops or pasture, or convert productive land into unusable scrub. Weeds are also often poisonous, distasteful, produce burrs, thorns or other damaging body parts or otherwise interfere with the use and management of desirable plants by contaminating harvests or excluding livestock. They provide competition for space, nutrients, water and light.

Manually weeding is done by khurpi, sickle, kudali, tangaroo, wheel hand hoe, cono weeder etc. whereas mechanical weeding is done by self propelled power weeder and tractor operated rotary weeder.

The various types of weeders are

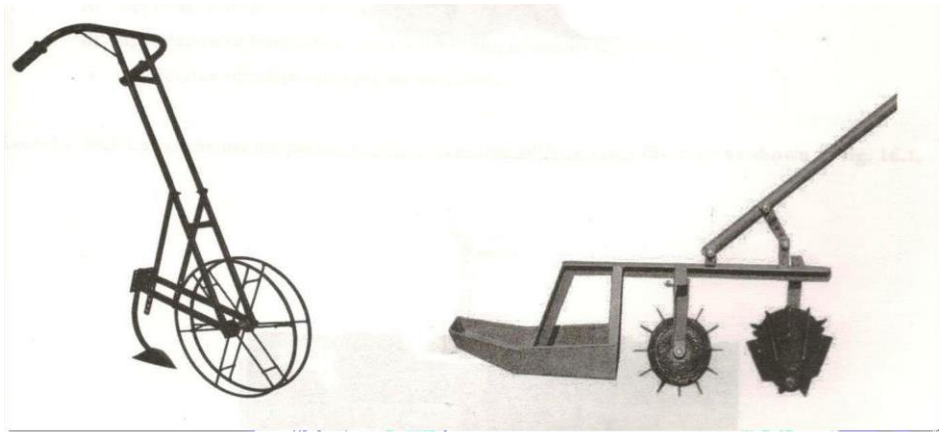
(i) Dry land weeder

(ii) Cono weeder for rice

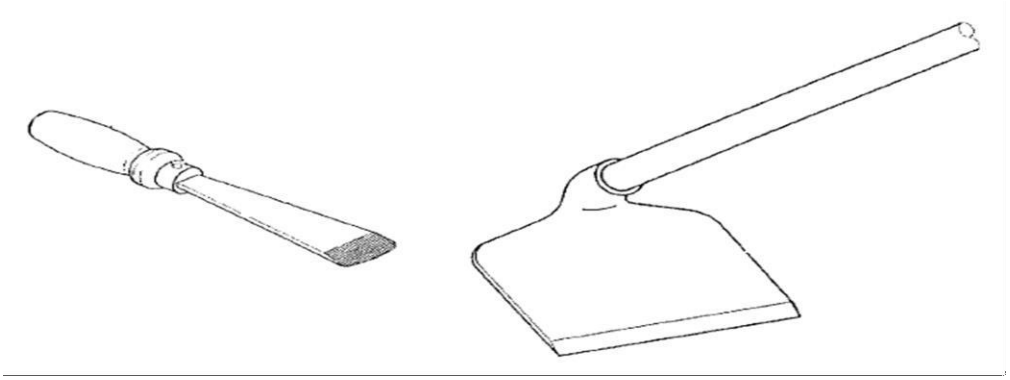
(iii) Selfpropelled weeder

(iv) Tractor operated rotary weeder

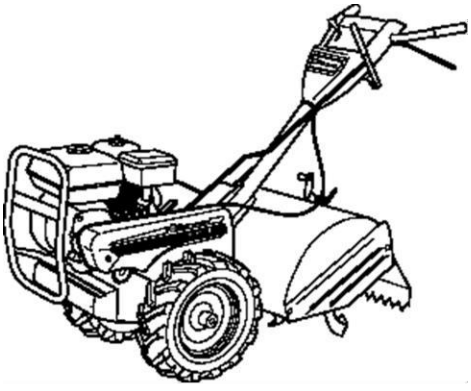
Exercise 12.1 Identify the types of weeding equipments



1._____ 2._____

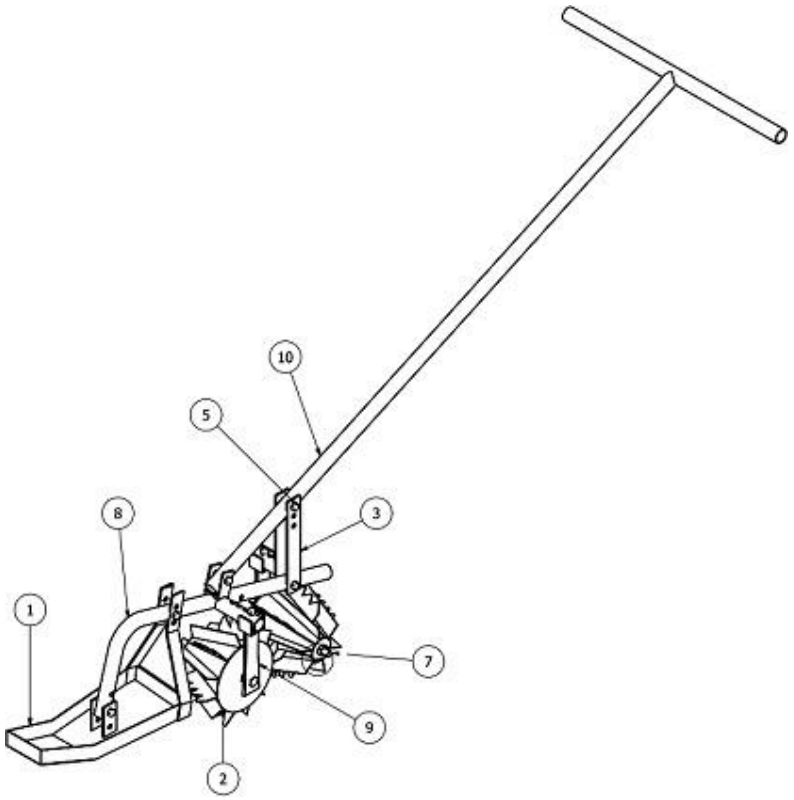


3._____ 4._____



5._____ 6._____

Exercise 12.2. Label the components of cono weeder along with their function.



S. No.	Components	Function
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____

8. _____	_____
9. _____	_____
10. _____	_____

Practical 13. Study of sprayers & dusters and measurement of nozzle discharge

Objectives:

1. To study the major components and their functions
2. To study the various types of sprayer and their application
3. To study the various types of nozzles and their applications

Introduction: Sprayer is a machine to apply fluids in the form of droplets. Sprayer is used for the following purpose.

- Application of herbicides to remove weeds.
- Application of fungicides to minimize fungus diseases.
- Application of insecticides to control insect pests.
- Application of micro nutrients on the plants.

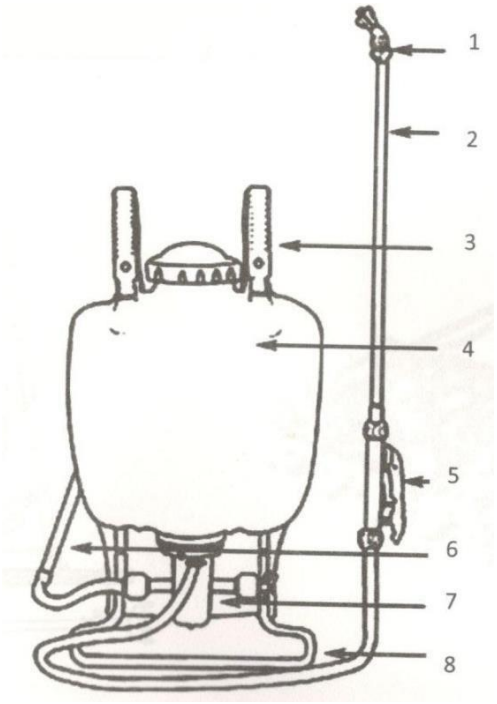
The main function of a sprayer are

(1) To break the liquid droplets of effective size. (2) To distribute them uniformly over the plants. (3) To regulate the amount of liquid to avoid excessive application.

Basic Components of Sprayer: Components of a sprayer are as follows

(1) Nozzle body (2) Swirl plate (3) Filter (4) Over-flow pipe (5) Relief valve (6) Pressure regulator (7) Cut-off valve (8) Spray boom (9) Drop legs (10) Nozzle boss (11) Nozzle disc (12) Nozzle cap (13) Nozzle tip (14) Spray lance (15) Spray gun.

Exercise 12.1 Label the major parts of knapsack sprayer shown below and write their function.

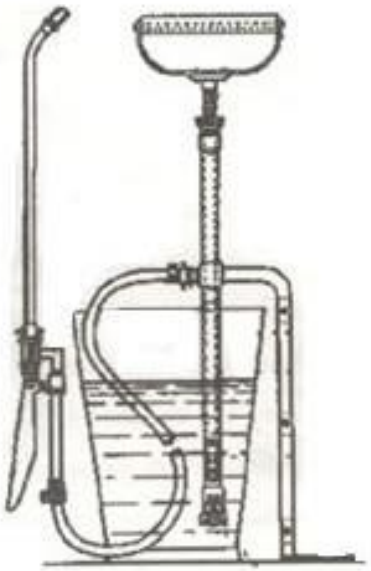


S. No.	Components	Function
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____

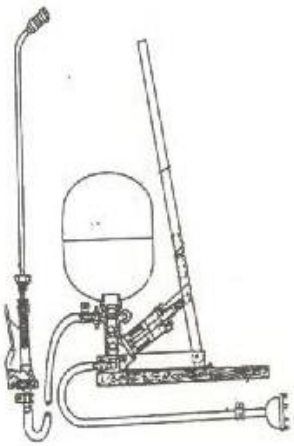
8. _____	_____

Exercise 13.2 Identify the following sprayers and write their specific use.

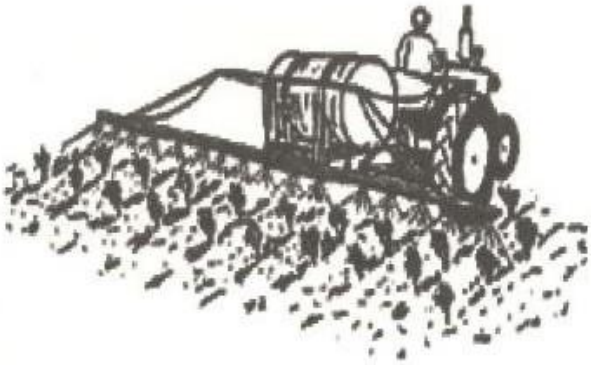
1._____



2._____



3._____



4. _____

Exercise 13.3 Identify the following nozzle and their spray pattern being used in agriculture

1._____ 2._____ 3._____

Exercise 13.4 Measure the discharge of different types of nozzle used in sprayers

Nozzle Type	Discharge (*l*/min)			Average discharge (*l*/min)
1._____				
2._____				
3._____				

AGS-306

PRODUCTION TECHNOLOGY FOR VEGETABLE AND SPICES

B. Sc 3rd semester

Practical Manual

INDEX

Exercise No. 1

Objective: Preparation of Nursery Beds and Seed Sowing for Raising Healthy Seedlings of Horticultural Crops

Introduction: Horticultural crops are propagated either through seeds or vegetative plant parts. Vegetable crops propagated through seeds are either directly seeded or are transplanted in the field by raising the seedlings in the nursery beds. A nursery could be considered as a location where plants are cared for during the early stages of growth by providing optimum conditions forgermination and subsequent growth until they become strong enough for planting in the open field conditions

Theory:

Factors to be taken into consideration for

raising nurseryLocation of the nursery:

- Nursery should be situated near the main field for transplanting.
- Nursery area should receive sunlight right from morning till evening *i.e.* south-westaspect is most suitable as this aspect is very sunny.
- Area must be free from water stagnation *i.e.* proper drainage must be provided.
- Area should be well protected from stray animals and strong winds.
- The area should be near the water source for continuous supply of good quality water.

Soil

- Soil should have good organic matter.
- Soil texture should be neither too coarse nor too fine.
- Soil should be sufficiently porous and adequately aerated.
- It should have a fair degree of water holding capacity.
- Soil pH of nursery bed should be in the range of 6 to 7.
- Acidic and alkaline soils are not suitable for raising nursery rather, neutral soils aresuitable.

- Soil should normally be rich in all essential nutrient elements. Preferably soil testing of nursery area should be done so as to mix additional nutrients accordingly for improving its soil fertility status.

Procedure for nursery bed preparation:

● The soil of the nursery area should be fine and fertile with good water holding capacity. For the preparation of beds, the field should be ploughed and levelled well. Soil should be worked thoroughly to obtain a fine textured soil free of clods and debris.

● Prepare raised beds to facilitate proper drainage of excess water. The level of the bed surface should be made little slanting on the two sides.

● The length of nursery bed should be 3-5 m but it can be increased or decreased according to the availability of land and requirement of plants but the breadth of the beds should not be more than 1.00 -1.2 m and the beds should be 15-20 cm raised from the ground surface.

● The standard size of nursery bed is 3m × 1m × 15 cm.

● A space of 30-45 cm should be left between two beds. This space can be utilized to perform intercultural operations such as weeding, disease and insect-pest management and also fordraining out the excess rain water from the nursery beds.

● Add 20-25 kg well rotten farmyard manure in each standard size nursery bed along with 200g single super phosphate and 15-20 g each of fungicides and insecticides such as mancozeb and dusts like methyl parathion.

● The number of nursery beds depends on the particular crop, season and growing area of crop for transplanting.

● The beds should be prepared in the east and west direction and lines/ rows for sowing of seeds should be made from north to south direction on the beds.

Seed Sowing in nursery bed

- Treat the seed with fungicides like bavistin or thiram or captan @ 3g/kg of seed to checkthe infection of soil borne diseases.
- Make rows at a spacing of 5 cm.
- Sow the seeds at 1 cm depth. The general rule for sowing depth is 2-3 times of the thickness of seed.
- Mix a little of sand in the seed for uniform distribution in the rows and cover it with soil or farmyard manure.

- Avoid broadcasting seeds in the nursery-bed. Thick sowing or sowing with broad castingalso leads to increase in an incidence of damping off disease
- If seeds are sown too deep, nutrient reserves will be exhausted before the plant emerges or emerging plants will be weak or liable to die. If sown too shallow, then it is likely tobe eaten by birds or washed away by the splash of rains or irrigation water.

Exercise No.2

Objective: Identification of Important Vegetable Crops on the Basis of Different Morphological Traits

Theory: Vegetables are the products of herbaceous plants which are annuals, biennial and perennials (mostly annual) whose plant parts such as fruits, leaves, roots, stems, petiole, flower *etc.* are used for culinary purposes or consumed as raw. The vegetable plants differ with respect to each other in their morphologicalcharacters. Keen and frequent observations on vegetative and reproductive parts of the plants help in easyand clear identification. It is essential to know the different parts of the plants before undertaking theidentification. The knowledge of different plant parts serve as the foundation for identifying the vegetable crop plants at different growth stages. In this practical you will learn how to identify a vegetable keepingin mind their characteristic morphological features. The important distinguishing characters of importantvegetable crops have been discussed here under which may help the students in distinguishing them even atearly stages of their growth. It takes time and exposure to learn to identify vegetable plants.

Materials Required: Forceps, hand lens, paper sheet,

paper and pen.Procedure:

1. Critically observe the morphological characteristics of the specimen. To identify plants in garden,look for morphological features such as size, shape and color of the leaves as wellas unusual characteristicslike aroma or hair.

   i) Root system:
   - Adventitious
   - Tap root system.

   ii) Stem characteristics:
   - Hollow or pithy
   - Number and length of internodes
   - Branched or single stem
   - Smooth or ridged
   - Leaf arrangement on the stem- alternate or paired
   - Presence or absence of any specific characters like tendrils, spines *etc.*

   iii) Leaf characteristics: Identify vegetables by their leaves. Vegetables with large and succulent leavesthat emerge directly from the ground and are eaten as greens include lettuce, cabbage, kale and spinach.Fruiting vegetables, such as tomatoes, peppers, eggplant and melons, produce clusters of leaves on thestems. Root vegetables usually have straight and vertical leaves. Vegetables of the cole group, such ascabbage and

cauliflower, produce leaves close to the ground followed by a single head/curddevelopingin the center of the plant. Broccoli produces multiple heads.

- Shape of leaf- long narrow or ovate or lanceolate
- Presence or absence of pubescence
- Type of leaf – simple or compound leaf, petiolated or sessile
- Presence or absence of leaf sheath
- Leaf margins: serrated or smooth
- Texture of leaf- smooth or rough.

iv) Inflorescence: Fruiting vegetables such as melons, squash, beans, tomatoes,eggplants and peppers produce flowers followed by fruits.

- Colour of flowers
- Type of inflorescence.

v) Economic part

- Colour
- Size
- Shape

2. Draw the sketch of each plant.
3. Record the observations with respect to root, stem, leaf, inflorescence and fruitcharacteristics in thedata sheet.
4. Identify the vegetable crop on the basis of morphological characters discussed as under.

Tomato *(Solanum lycopersicum)*

- Examine the stems of the plant. They have short, fine, white hair on them *i.e.* slightly fuzzy. Observe the growth habit of plants which may be determinateor indeterminate. Indeterminate type bears inflorescence cluster at every thirdinternode.
- Notice the leaves on the tomato plant. Tomato bears compound leaves with multiple leaflets (5-9) growing along a common stem (called rachis). Leaves aregreen, hairy, serrated/oval/pointed and have visible veins.
- Sniff your fingers after touching a tomato plant leaf. Tomato leaves have a pungent odour that remain on the skin.
- Observe the flowers on the plant. Tomato flowers are bright yellow with pointed petals.
- Notice the fruits growing on the plant. After pollination, a flower of tomato grows as a single small, round, green fruit. Colour of the fruit changes with the onset of maturity.
- Cut open the fruit you will see the locules filled with jelly like substance containing seeds.

Brinjal *(Solanum melongena)*

● See the stem of the plants. They are branched, erect, have fine hair and some varieties may have spines.
● Notice the leaves which are usually large, lobed, ovate, thin and relatively hairy on the under surface. Leaves also bear sharp spines. Petiole is about one fourthas long as the leafblade.
● Observe the flowers of the plant. Flowers are violet in colour, borne solitary and forms cluster of two or more in lateral cymes. Flowers are deeply lobed with toothed calyx. Calyx is five lobed and covers thebase of the fruit on enlargement. Fruit is berry with numerous seeds.

Bell pepper *(Capsicum annuum)*

● Observe the plants. They have straight main stem which bear secondary branches forming „V". Flowers are white in colour and star shaped. Fruitsare juiceless berries which vary in shape and size.
● Observe the shape of the peppers. A standard bell pepper form blocky fruits in shape with three or four lobes at the bottom of the fruit. Skin of fruit (pericarp) is thick and glossyin appearance.
● Check color of the fruits. Bell peppers are usually green in colour and change color to red, orange or yellow on maturity.

Potato *(Solanum tuberosum)*

● The potato plant is leafy, herbaceous and spreading type. The leaves are compoundwith 7-15 leaflets.
● Study the flower of the potato. Potato flowers are star-shaped, white, lavender, pink orlight blue with yellow centers and borne in clusters.
● Look at the fruits of the potato plant. The fruits are like small green tomatoes, about aninch in diameter and contain several hundred seeds.
● Dig out the potato plant, you will see tubers growing underground which are round tooval in shape and in general light brown in colour.

Cucurbits:

Cucumber *(Cucumis sativus)*

● Observe the growth habit of the plant in question. Summer and winter squash plants grow very fast in the early days of summer while cucumber plants take afew days more togrow.

● Cucumber plants along with its leaves are usually smaller than squash plants and thestems are not as thick as squash plant.
● A cucumber vines grow vertically with the help of strong tendrils that make grip withstaking material and provide upward growth.
● Cucumber leaves are triangular in shape with pointed lobes. The leaves are large, darkgreen and have a slightly rough texture.
● See the stem of cucumber, it is delicate and has tender spines.
● Cucumber bears male and female flowers separately on the same plant (monoecious flowers). Flowers are small and yellowish coloured. Cucumbers usually form long thin fruits.

Bitter gourd *(Momordica charantia)*

● Observe the growth habit of the plant. Plant vine may grow upto the height of 15 feet.The stems have twining tendrils and are slender, green and hairy.
● The leaves are green, hairy, alternate, deeply palmate and lobed with 5 coarsely toothedlobes.
● The flowers are monoecious and yellow in colour with 5 erect, egg-shaped petals.
● The fruits may be egg-shaped to oblong (10-20 cm long), green, tapering at the endsand covered with blunt tubercles (swellings).
● Taste the fruit. It is bitter in taste.

Bottle gourd: *(Lagenaria siceraria)*

● Observe the plant habit. The bottle gourd is a vigorous, annual, running or climbing vine with large leaves and lush in appearance. The vine is branchedand climb by means of tendrils along the stem. The foliage is covered with softhair and has a foul muskyodour when crushed.
● Look at the leaves. The leaves are circular in overall shape with smooth margins, a few of them may have broad lobes or undulating margins. Leaves have a velvety texture because of thefine hair, especially on the undersurface.
● Look at the flower of bottle gourd. The bottle gourd flowers are borne singly on the axils of the leaves, the males on long peduncles and the females on short peduncles. The flowers are white and attractive withspreading petals. The ovary is in the shape of the fruit. The anthers are borne on short filaments groupedat the center of the flower.
● It bears two types of fruits namely, long and round. The size of the fruit varies from 2to 12 inches in diameter and from 4 to 40 inches in length.

Summer squash:

● The summer squash plant has bush type growth and no vine formation is there.

● The plant has separate male and female flowers on the same plant. The female flowers can be easily identified as they bear miniature fruit (ovary) at the base.Flowers are showyand yellow in colour.
● Feel the outside skin of summer squash fruit which is tender (not hard).
● Look at the color of the squash. It looks bright green and have a shiny gloss.

Musk melon *(Cucumis melo)*

● A muskmelon plant has trailing prostrate stems generally upto 10 m in length and often forming large mats. Stems are viny, herbaceous, slender, angled incross-section, branched near the base and rough in texture with short stiff hair.
● Observe the leaves of the plants. Leaves are alternate more or less palmate, angled or shallowly 3-7 lobed and covered with very short stiff hair (scabrous). Tendrils are unbranched and borne singly per node fromthe base of the leaf petioles.
● Flowers are axillary, monoecious, with 1 or more male flowers per node and single female flowers at few nodes. Corolla is yellow and deeply 5-lobed, with petals fused at the base to form a shallow cup-like tube.Male flowers have 3 separate stamens. Female flowers have an inferior ovary.
● The fruits of the musk melon are oblong to round. Surfaces are net-veined or covered with minute stiff hair and lack prickles. Immature fruits are green, but become mottled or striped with yellow or orange, or aresolid yellow or orange at maturity.

Water melon *(Citrullus lunatus)*

● Watermelon grows on vines which usually sprawl across the ground in a sunny location. At maturity, each vine is 10 to 15 feet in length and has tiny tendrils orthread- like curling stems at leaf bases.
● Look at the vine‟s foliage and feel its texture. Watermelon leaves are light green with silvery white tinge. The leaves are deeply lobed having three to five fingerlikelobes that have coarse rounded teeth.
● The flowers are yellow and occur singly, with five united petals. Flowers appear on the young vines, usually at the tips. Fruits are large in size, green, smooth and round.
● Cut open a fruit. The flesh of a water melon fruit is easily recognizable both at mature and immature stages. Mature or near ripening fruits have red flesh and black seeds while the flesh of young developingfruits is pale green to white with small white seeds.

Root vegetables:

Carrot *(Daucus carota)*

● Note the stem of the plant. The stem at its vegetative state is just above

ground and is greatly compressed as a result internodes are not visible.The stem apex is slightly convex.

● Observe the leaves. Leaves are dark green and shiny, the lowest being broadly linear- lanceolate toothedleaflets. Leaf blades are two to three pinnate, the leaflets being repeatedly divided - pinnatifid. Leaves andthe basal rosette are alternate and compound.

● Uproot the plant and observe the roots. The root length of most of the cultivars ranges between 10 to 25 cm. Roots are orange, yellow, red, purple and white - fleshed. Root shape of many carrot cultivars isconical, but the extent of tapering varies as per cultivars.

● Generally carrot flowers are perfect, small or white or occasionally greenish white or light yellow. Flowers consist of five petals, five stamens and an entire calyx. Flowers usually open first at the periphery of theprimary umbel. The primary umbel is produced at the terminal end of the main floral stem.

Radish *(Raphanus sativus)*

● The plant of the radish is erect, herbaceous that grow up to 40 inches.

● Leaves are arranged in a rosette, with size ranging from 10–15 cm in small cultivars to up to 45 cm in large cultivars. Leaves have a lyrateshape *i.e.* divided pinnately with an enlarged terminal lobe and smallerlateral lobes.

● Radishes make the swollen part of the roots which is edible. Roots are round to cylindrical with a color ranging from white to red.

● The white flowers are borne on a racemose inflorescence. The flower of the radish has four white petals with rose, purple, or yellowish veins. The flower are usually bisexual with four sepals, four petals, sixstamens (2 outer shorter than the 4 inner ones *i.e.* tetradynamous), two carpels and superior ovary withparietal placentation.

● The fruit of the radish is a round pod-like structure called as siliqua.

Turnip *(Brassica rapa)*

● The leaves grow directly from the above-ground shoulder of the root, with little or no visible crown or neck. The edge of leaf blade has lobes. Leaves are lightto medium green,hairy or bristly and lyrate-pinnatifid.

● Turnip root is mostly white-skinned apart from the upper portion which protrudes above the ground and are purple, red, or greenish wherever sunlighthas fallen. This above-ground part develops from stem tissue, but is fused withthe root. The root is roughly conical to globular with interior white flesh.

● Flowers are yellow in colour. Sepals are spreading with petals. Sex form is similar as that of radish.

● Fruit bearing seed is called as siliqua which is 4–6.5 cm long with long tapering beak.

Cole vegetables:

Cauliflower *(Brassica oleracea var. botrytis)*

● Look at the cauliflower plant. The stem/stalk varies from short to medium in length. Leaves are produced close to the ground which are longer, narrowerand brighter green in color than cabbage and broccoli leaves. The leaf petioleis long and broad that looks flat on the upper surface and is little raised on thelower side.

● The edible portion of cauliflower is called curd which is formed in the centre of the leaves. The inner leaves curve inwards to cover the curd in mid and late group varieties and keep curd blanched (white).

● Curd is white to creamish in colour and compact.

Cabbage *(Brassica oleracea var. capitata):*

● Cabbages have very short stem joints and in some varieties the heads are practically coreless. It grows rosette on a short stalk with the broad outer leavesclose to the ground and the "wrapper" leaves form the heads. The leaves havewavy edges. Upper leaves are sessile while those on the base are much fleshierand petiolated with lobules.

● As the plant grows, the leaves increase in number and form a ball-shaped "head" in the center of the plant.

● The leaves of cabbages can range from smooth to crinkled, green to red. They are usually very broad and cupped, with a network of veins that connect to a large central mid-vein.

● Observe the head of the plant. The head of the cabbage plant is made up of several layers of overlapping leaves. Head cabbage and head lettuce are similar in appearance, but cabbage leaves are usually moretightly wrapped to form the head. The head is very solid. The cabbage heads are glossy light green incolour. The red cabbage is purple in colour.

● Flowers are yellow in colour, grouped in loose racemes.

Broccoli *(Brassica oleracea var. italica)*

● Broccoli leaves have elongated petiole, somewhat round in shape. Leaves are green grey in colour with very curly deep lobes. Broccoli leaves are alsobroader than cauliflower leaves and have a lobe-like structure(s) at the base ofthe leaf.

● It has succulent, loose, leafy edible stem, which support large and compact heads of thickly clustered flower buds which are green in colour.

● The main group of florets or "head" grows in the centre of the leaves. After the harvest of the main head, shoots may arise from the stem which is called as spears.

Bulb crops:

Onion *(Allium cepa):*

● Observe the leaves of the onion. Leaves arise from underground part of the stem. The leaves are bluish green and grow alternately in a flattened fan-shaped swathe.

● Leaves are fleshy, hollow and cylindrical with one flattened side. The base of each leaf is a flattened usually white sheath that grows out ofa basal disc.

● From the underside of the disc, a bundle of fibrous roots extends to ashallow depth intothe soil.

● As the onion plant grows, food reserves begin to accumulate in the leaf bases and the bulb of the onion swells.

● Look at the inflorescence of the onion. Inflorescence of onion is called cyme. Each individual flower is made up of six stamens, three carples, united with one pistil and six perianth segments. The pistil containsthree locules, each containing two ovules.

● Onion bulbs are pungent when chopped and contain certain chemical substances whichirritate the eyes.

● At maturity, the foliage dries up and the outer layers of the bulb become dry and brittle.

Garlic *(Allium sativum)*

● Observe the garlic plant. The leaves are long, narrow and flat like grass. This plant has narrow foliage with long, narrow and flat grasslike leaves.

● Taste the plant parts. All parts of this vegetable have a very strong taste and it is widelyused for culinary purposes.

● Look at the bulb of the plant. The bulb is of a compound nature, consisting of numerous „cloves,“ which are grouped together between the membraneous scales and enclosed within a whitish skin, which holds themas in a sac.

Leafy vegetables:

Amaranthus *(Amaranthus tricolor or Amaranthus bicolor)*

● Observe the plant of amaranthus. They are erect-growing plants.

● Its stems are vigorous, cylindrical and fibrous. On maturity, stems becomes hollow inside. The plant has the stripes on the stem and shades of green, red, pink, brownor purple depending upon the variety.

● Look at the leaves of the amaranthus plant. The leaves are stalked, compound, alternate, long or oval and green or dark red at the base and bright yellow, orange orflorescent pink at the top.

● You will find tiny green, red or purple flowers clustered densely together, sometimes slightly drooping at the head of the plant. The flowers last for a long time.

Fenugreek- *Trigonella foenum-graecum* (Common methi) and *Trigonella*

corniculata
(Kasuri methi)

● Fenugreek is of two types *viz.*, common *methi* and *kasuri methi*. The common *methi* has quick growing upright plants whereas *kasuri methi* is slow growing andremains in rosette condition.

● Carefully observe the leaves they are alternate, trifoliate and lanceolate and leaflets areshortly stalked blunt and oblong.

● Leaves of common *methi* are light green in colour and that of *kasuri methi* aredarkgreen in colour.

● Observe the flowers of the fenugreek. Flowers are sessile, solitary in the axils of the leaves. Flowers of *kasuri methi* are yellow in colour and that of common *methi* are whiteor light violet.

● Taste of the leaves is bitter with peculiar odour.

● The pods of common *methi* are straight, long and slender with a prominent beak andthat of *kasuri methi* are sickle shaped.

Spinach *(Spinacia oleracea)*

● Observe the plant of the spinach. It forms clumps of long-stemmed leaves that can grow up to 12 inches long and 18 inches wide at maturity.

● Look at the leaves of the spinach. The edible leaves are arranged in a rosette from which a seed-stalk emerges. The leaves are alternate, simple, ovate to triangular-based with very variablein size

● Observe the flowers of the spinach. The flowers are inconspicuous, yellow-green, 3-4 mm diameter, maturing into a small, hard, dry, lumpy fruit cluster 5-10 mm across containing several seeds.

Legume vegetables:

French bean *(Phaseolus vulgaris)*

● Observe the plant of the French bean. It is erect or twine annual herb.

● Look at the leaves of the plant. The leaves are trifoliate, compound. The edge of theleaf blade is entire (has no teeth or lobes).

● Study the flowers of French bean. Flowers white to violet-purple. Flowers arebilaterally symmetrical. There are 5 petals and 5 sepals in the flower ofFrench beans.

● Look at the pods of the French beans. Pods are slender, 10-26 cm long, straight orslightly curved, the surface may be glabrous or faintly pubescent with prominent beak.

Garden pea *(Pisum sativum)*

● Observe the plant. Garden pea plant may be dwarf or vining/ tall types.

● Stem of pea plant is round and hollow covered with a waxy bloom.

● Observe the leaves of garden pea. The leaves are compound (made up of two or more discrete leaflets). The edge of leaf blade has teeth. Leaves consist of oneor more pairs of opposite leaflets borne on petioles together with several pairsof tendrils (which are essentially modified leaves) and a single or compoundterminal tendril.

● Leaflets are broad and ovate with distinct ribs which may be slightly toothed or entire.

● The two (pseudo) stipules at the base of the leaf are also ovate but much larger than theleaflets.

● In semi-leafless types, the leaflets are replaced by tendrils but the stipules are still present while in leaflesstypes the leaflets are also replaced by tendrils but the stipules are stunted.

● Study the flower of the plant. Flower is white coloured which consists of five petals, five sepals, 10 stamens (9 fused in a staminal tube and 1 stamen is free), and one carpel, which develops into a pod. Petalsare separate.

Cluster bean

● Study the pods of the pea. Pods containing several seeds, flattened when young but becoming roundish at later stages and are dehiscent along two sides.

Cowpea *(Vigna unguiculata)*

● Observe the growth habit of the plant. Plants are herbaceous annual with twining stemsvarying in erectness and bushiness.

● Study the leaves of the plant. Leaves are alternate and trifoliolate. The lateral leafletsare opposite and asymmetrical, while the central leaflet issymmetrical and ovate.

● Look at the flowers of the plant. Flowers are white, cream, yellow, mauve or purple incolour.

● Look at the pods of the cowpea. Pod is pendulous, smooth, 10-23 cm long with a thickdecurved beak and contains10- 15seeds.

Guar or cluster bean *(Cyamopsis tetragonoloba)*

● Study the growth habit of the plant. Plant grows upright, reaching a maximum height of up to 2–3 m. It has a main single stem with eitherbasal branching or fine branching along the stem.

● Look at the leaves of the plant. Leaves are elongated oval in shape (5 to 10 cm length) and borne on alternate position. The leaves and stems aremostly hairy.

● Check the flowers of the plant. Clusters of flowers grow in the plant axil and are white to bluish in colour.

● Look at the pods of the cluster bean. The developing pods are rather flat and slim containing 5 to 12 small oval seeds.

Okra *(Abelmoschus esculentus)*

● Observe the growth habit of the plant. The plant is erect herb up to 2 m tall. Stems aresucculent with scattered stiff hair.

● Observe the leaves. Leaves are about 50 cm wide and 35 cm long, deeply lobed with toothed margins, hairy on both surfaces especially, on the nerves.Each leaf is borne on a petiole.

● Look at the flower of the okra. Flowers are showy, usually yellow with a darkred, purple or mauve centre, borne on a stout peduncle. Stamens (male parts) are united into a white, hairless column up to 2.5 cm long. Stigma (female part) is dark purple. Both calyx (whorl of sepals) andepicalyx (whorl of bracts) are present.

● The fruits of okra are 6–20 cm long (at harvesting stage), roughly circular in cross- section with a pointed end, usually 5-ribbed, borne at the leaf axils. Immature fruit is darkgreen or pale green.

Exercise No. 5

Objective: Study of Maturity Indices, Harvesting, Grading and Packing of Horticultural Crops

Introduction: The time of harvest, among other factors is determined by maturity and quality. Good quality of fruits and vegetables is a combination of flavour, texture appearance and food value which given pleasure or satisfaction to the consumer. Good quality in ornamentals is dependent on appearance and longevity. Good quality is thus extremely important to all phasesof the harvest and post-harvest period.

Theory:

Maturity and time of harvest: Maturity can be described as the state of ripeness. However, it may have different meanings. For uniformity of definition maturity can be considered the stage of development which results in maximum quality of the product.

Fruits such as peaches will have a different standard of maturity if picked for shipment to a distant market. For immediate use fully ripe or tree ripened fruits are harvested. L If the same peaches are shipped to a distant market, even under good refrigeration and handling theirchanges of reaching the consumer in good quality are quite remote. They must therefore be harvested under a different standard of maturity, for maximum quality at the destination. Therefore, they are harvested at an earlier state of ripeness. Sweet potatoes or yams may be harvested over a relatively long period. They are not marketed immediately. Since they must be “curved” to make the skin more firm, less easily bruised and more resistant to invading disease organisms. Flowers for sale or for home bouquet and arrangements are cut before fully opened to

prolong their period of beauty. Fruits, vegetables and ornamentals thus vary widely in their maturity standards at harvest.

Fruits: Fruits maturity can be determined by firmness, coloration, tasting sample fruits and by familiar varietal characteristics. Each of these factors will vary with the kind or type of fruit.

Firmness in peach or plum can be readily detected by feel and is a reliable guide to maturity. Theapple and pear are more difficult to judge by hand pressure. Since they are quite firm up to the point of ripeness. A pressure tester is sometimes used to determine maturity of representative fruits, (Avocado). Colour is the sole guide in the harvest of many fruits. Grapes for fresh market are harvested as they acquire complete coloration. However, for juice, jams, jellies, raisin and wine the sugar content is sampled and the grapes may be left on the vines for increase sugar content even after full colour development.

Citrus fruits are harvested for market when there are still traces of green colour in the skin. If the green colour persists they may be artificially colored before being placed on the retail market. Strawberries may be picked before they have turned completely and for less spoilage on distant shipments. Colour of seeds is a guide of maturity in pears and certain winter apples. Similarly, in

mango, papaya and pine apple. Tasting of sample fruits can be used effectively with apples, plums and white grapes.

Vegetables: Vegetables may be harvested as mature or immature depending on which is considered the edible stage. The salad crops depend on rapid growth under favourable conditionsfor their tender. Cauliflwer left in the field beyond the full head stage will discolour and become more fibrous.

The root crops should be harvested when minimum acceptable retail size is reached if an early market is the goal. If high yields of late crop are desired, they can be left to grow until greatersize is attained, provided the quality remains at an acceptable level. White Potatoes should be mature when harvested to avoid skinning (to remove skin) and bruising.

Pumpkins and winter squash are harvested when they mature on vine. Immature fruits are harvested in respect of summer squash, beans, bhendi, cowpea, ridge gourd, radish, cucumber, carrot etc. Musk melons (cantaloupes) are ready for eating at the full slip stage of the item. For shipping the half slip stage and refrigeration in transit is the best combination. Water melons are harvested for shipping when a metallic sound results from thumping. For immediate use, a dull hollow sound indicates ripeness.

Sweet corn and peas should be harvested at their peak sugar content and before toughening of theseed coat occurs. The use of an instrument called the Tenderometer or Puncture Tester is a guide to processors.

Ornamentals: Ornamentals may be divided into flowers and nursery stock. Since these are not food crops, maturity and quality have different meaning. Flowers are usually ready for harvest before the blooms are fully opened. Rose buds with the colour showing, but yet in a tight whorl is ideal for shipping or holding. For immediate use, they may be picked as the bloom expands to show individual petals. They will finish opening in the vase or arrangements and last for several days. Nursery stock should be mature in that the tissue is hardened to water loss and shrinkage. Similarly, other maturity indices are;

1. Number of days after fruit setting (Banana)

2. Shape of transversely cut fruit (Banana)

3. Ratio between sugar and acids

4. Minimum juice volume (Citrus)

5. Loss of chlorophyll (Banana)

6. TSS – Grapes (TSS – Total soluble solids) are the maturity indices for deciding the harvestingtime.

In some crops the time required to reach the harvestable stage may be expressed with temperature time values called heat units by calculating time in relation to temperatures above a certain minimum. For example if the minimum temperature for growth of a particular crop is 50oF (10oC) then day with an average temperature of 68oF (20oC) would provide 18 degreedays F (10 degree days C) of heat units. KA day with an average temperature of 40oF (5oC) would provide 0 degree days of heat units. The harvest date can be ascertained by an accounting of accumulated heat units. Assuming that, all temperature above a minimum has similar effects on growth

Limitation: Soil temperature more accurately indicates early growth than do air temperature. Difference between day and night stages of plant growth also affects the results. Temperature above a minimum may not have similar effect on growth. Every 10oC rise in temperature may double many physiological processes. The precise determination of harvest date by the accumulation of temperature data depends upon knowledge of the general climate of an area and upon experience.

Exercise No- 3

Objective: To Study Economics of Vegetables and Spices Cultivation

Theory:

Crop	Field preparation	Nursery and planting / sowing	Weeding	Plant protection	Fertilizers	Wages	Staking, transport & other expenses	Total
Tomato	6000	7000	10000	12000	8000	13000	5000	61000
Chilli	6000	7000	10000	12000	6000	5000	-	46000
Paprika	6000	8000	10000	12000	8000	5000	-	49000
Capsicum	6000	8000	10000	12000	8000	5000	-	49000
Brinjal	6000	7000	10000	10000	7000	10000	-	50000
Bhendi	6000	12000	5600	5000	6000	6000	-	40600
Cabbage	6000	10000	10000	12000	8500	5000	-	51500
Cauliflower	6000	10000	10000	12000	8500	5000	-	51500
Tapioca	6000	5000	8000	2000	3000	6000	-	30000
Watermelon	6000	10000	10000	8000	8000	8000	-	50000
Muskmelon	6000	14000	10000	8000	8000	8000	2000	56000
Ribbed gourd	6000	8000	8000	8000	7000	5000	-	42000
Bottle gourd	6000	8000	8000	8000	7000	5000	-	42000
Gherkins	6000	8000	7000	9000	7000	6000	5000	48000
Turmeric	6000	10000	8000	8000	8000	5000	-	45000
Coriander	6000	6000	6000	6000	4000	4000	-	32000
Banana	6000	8000	8000	10000	10000	6000	8000	56000

Cost & Benefits of
Vegetables & Spices

Crop	Cost of cultivation	Yield (MT/ha)	Net income (Rs.) (at the lowest price)	Market price range (Rs.)
Tomato	61000	50	39000 (@ Rs. 2/kg)	2 - 30/kg
Chilli	46000	22	64000 (@ Rs.5/kg)	5 - 15/kg
Paprika	49000	37	136000 (@ Rs. 5/kg)	5 - 20/kg
Capsicum	49000	18	95000 (@ Rs. 8/kg)	8 - 25/kg
Brinjal	50000	60	70000 (@ Rs. 2/kg)	2 - 30/kg
Bhendi	40600	10	19400 (@ Rs.6/kg)	6 - 15/kg
Cabbage	51500	75	173500 (@ Rs. 3/kg)	3 - 10/kg
Cauliflower	51500	32000 flowers	108500 (@ Rs. 5/flower)	5 - 15/flower
Tapioca	30000	30	54000 (@ Rs. 2.8/kg)	2.8 - 5/kg
Watermelon	50000	40	50000 (@ Rs. 2.5/kg)	2.5 - 10/kg
Muskmelon	56000	22	54000 (@ Rs.5/kg)	5 - 25/kg
Bottle gourd	42000	40	78000 (@ Rs. 3/kg)	3 - 15/kg
Gherkins	48000	20	72000 (@ Rs. 6/kg)	6 - 12/kg
Turmeric	45000	5	55000 (@ Rs. 2000/Q)	2000 - 4000/Q

Exercise No. 4

Objective: To study the methods of Vegetable seed extraction.

Theory:

Methods of seed extraction in tomato

1. **Juice and seed extraction**:
   - The whole lot of tomato fruits of a particular variety is taken to some processing unit, wherein juice is removed for other processing purposes and seed is extracted separately.
   - This is the method being followed by National Seed Corporation and other seed companies asthe seed cost is reduced in this way.

2. Fermentation method:
- The selected ripe fruits are crushed by hand.
- Keep entire mass for 24-72 hours depending upon the temperature conditions.
- The pulp will float at the top and the seed will settle at the bottom.
- Remove the fermented mass and clean the seeds with fresh water.
- Dry the seeds.
- Long fermentation period may damage the seed.
- Seed cost is very high in this method and usually followed for nucleus seed or maintenanceof seed stocks by the institutions.

3. Acid treatment:
- Cut the selected fruits into two halves and scoop out the slimmy mass containing seed in avessel.
- Treat the mass with HCl @ 75-100ml/12 kg of material. Seed is separated in 15-30 minutesfrom the slimmy mass.
- Wash the seeds and dry them.

4. Alkali method:
- Cut the selected fruits into two halves and scoop out the slimmy mass containing seed in avessel.
- Treat the mass with equal volume of washing soda (300g dissolved in 4 litres of water).
- The mixture is allowed to stand overnight.
- Next day all the seeds will settle down at the bottom.
- Seeds are washed thoroughly and dried.

Seed Extraction in Brinjal :
- **Isolation distance:** 50-100m.
- Fully Ripe fruits are harvested for seed extraction.
- The outer covering is peeled off and the flesh with the seed is cut into thin slices.

- These are then softened by soaking till the seed is separated from the pulp to which water isadded gradually.
- Keep the material to stand overnight which make the separation of seed from the pulp easier.
- After separation, dip the seed into the water and reject those seeds which float on the water.
- Seeds should be dried in partial shade before storing.
- **Seed Yield**: 100-120kg/ha

Exercise No. 5

Objective: Fertilizer doses for various vegetable crops as per recommendation for N, P and K

Handouts/material required: Paper sheet and pen to note down the calculation procedure.

Introduction:

Vegetable crops require nutrients for its growth and development which are absorbed from the soil. The most important nutrients are nitrogen (N), phosphorus (P) and potassium (K) and soils do not have enough of these three nutrients to meet the crop requirement. Hence, these are required in relatively large amounts for plant growth. The recommendation of these nutrients is available from various sources. Recommendations are always made in terms of nutrients and not in terms of fertilizers directly because different fertilizers contain nutrients in different amounts. We have to calculate the amount of a particular fertilizer based on the recommended dose of N- P-K nutrients to a particular crop on the basis of nutrient status of the soil of a particular area/state. It is always advisable to go for soil testing and accordingly N-P-K or other additional nutrient requirement can be made. Fertilizer bags are labelled by providing information with regards to percentage of nitrogen (N), available phosphate (as P2O5) and soluble potash (as K2O) and represent nitrogen, phosphorous and potassium, commonly referred to as N-P-K. These elements are symbolically represented as N-P2O5-K2O.

Table: Represents recommended dose of nutrient for important vegetable crops (the doses may vary according to growing area, varieties and cultural practices).

Table : Recommendation of primary nutrients (NPK) for different vegetable crops

Crop	Recommended dose of primary nutrients (kg/ha)		
	N	**P_2O_5**	**K_2O**
Solanaceous vegetables	75-100	50-75	50-60
Potato	120	80	60
Onion	60-150	35-150	25-120
Pea	20-50	30-60	30-60
Cole Crops	120-180	75-80	60-75
Cucurbits	60-100	50-75	50-85
French Bean	30-50	60-100	30-60
Root Vegetables	50-90	40-80	40-80
Leafy Vegetables	40-70	30-50	30-50
Okra	60-75	50-60	50-60

Procedure/methodology:

Before calculating the fertilizer dose, one should have the knowledge about

1. The recommended dose of N-P2O5-K2O for a crop for which the fertilizer doses have to becalculated.

2. Different growth stages of the crop at which fertilizers are to be applied.

3. The source of fertilizers from which the N-P-K requirements have to be met e.g. CAN/Urea,SSP, MOP *etc.*

4. Per cent nutrient available in that fertilizer *e.g.* urea contain 46% N.

Source of fertilizers supplying nutrients: Different fertilizer grade refers to the guaranteedminimum percentage of N, P2 O5, and K2O contained in the fertilizer material. For example

Fertilizer	**Composition (%)**		
	N	**P_2O_5**	**K_2O**
Urea	46	-	-
Calcium ammonium nitrate	25	-	-
Single super phosphate	-	16	-
Double super phosphate	-	32	-
Diammonium phosphate	16	48	-
Muriate of potash	-	-	60

Calculation

If the recommended dose of nutrient and the percentage content of that nutrient in the fertilizerare known,

the quantity of fertilizer required can be calculated by using following formula. Quantity of

fertilizer required (kg) = $\frac{\text{(Recommended dose of nutrient application)} \times 100}{\text{(\% Nutrient content present in the fertilizer)}}$

INDEX

Practical.1

Diagrammatic and graphic representation – simple, multiple, component and percentage bar diagram – pie chart – histogram. Frequency polygon, frequency curve

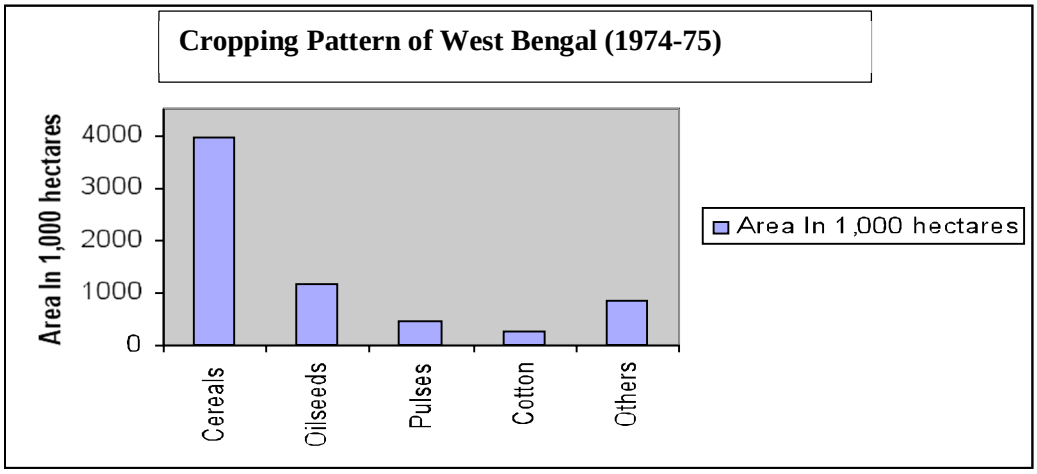
Simple Bar Diagram

Example

The cropping pattern in West Bengal in the year 1974-75 was as follows

Crops	Area In 1,000 hectares
Cereals	3940
Jute	1165
Oilseeds	464
Pulses	249
Others	822

The simple bar diagram for this data is given below:

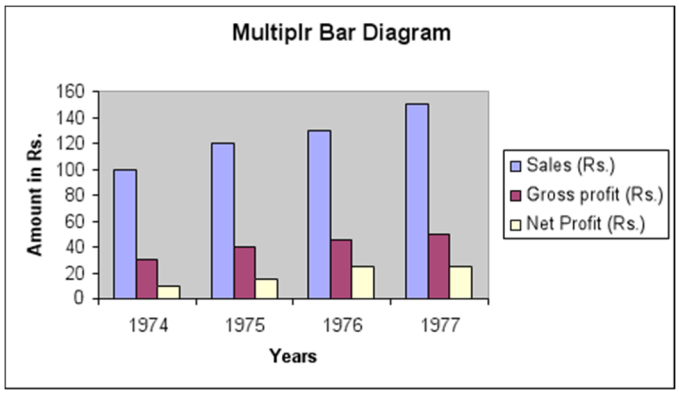


Multiple bar diagram

Example 1

Draw a multiple bar diagram for the following data

Year	Sales (Rs.)	Gross Profit (Rs.)	Net Profit (Rs.)
1974	100	30	10
1975	120	40	15
1976	130	45	25
1977	150	50	25
Total	**500**	**165**	**75**

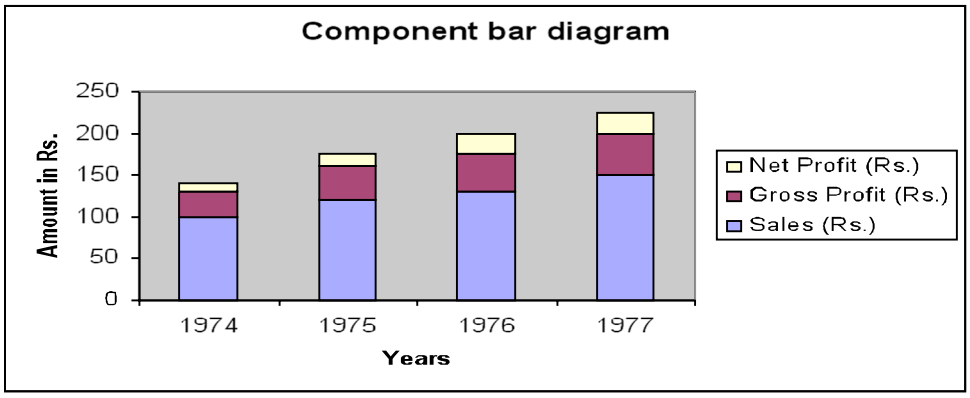


Component bar diagram

Example 2

Draw a component bar diagram for the following data

Year	Sales (Rs.)	Gross Profit (Rs.)	Net Profit (Rs.)
1974	100	30	10
1975	120	40	15
1976	130	45	25
1977	150	50	25



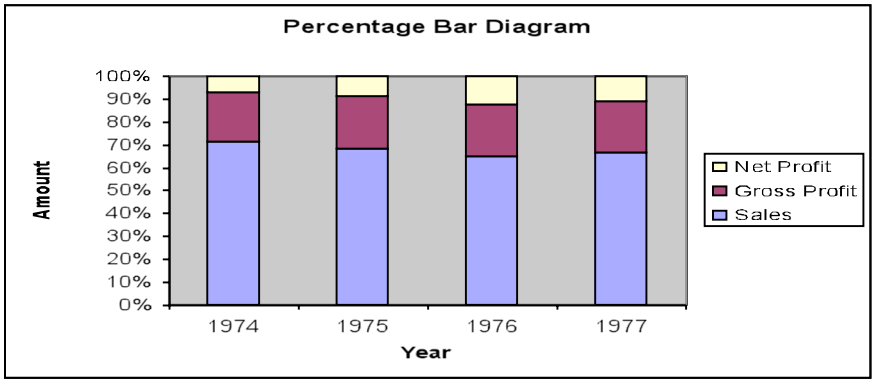
Percentage bar diagram

Example 3

Draw a Percentage bar diagram for the following data

Using the formula Percentage = $\frac{Actual\ value}{Total\ of\ the\ actual\ value} * 100$, the above table is converted.

Year	Sales (Rs.)	Gross Profit (Rs.)	Net Profit (Rs.)
1974	71.43	21.43	7.14
1975	68.57	22.86	8.57
1976	65	22.5	12.5
1977	66.67	22.22	11.11



Pie chart / Pie Diagram

Example 4

Given the population of 1991 of four southern states of India. Construct a pie diagram for the following data

State	Population
Andhra Pradesh	663
Karnataka	448
Kerala	290
Tamil Nadu	556
Total	**1957**

Using the formula

$$\text{Angle} = \frac{\text{Actual value}}{\text{Tota lof the actual value}} \times 360^0$$

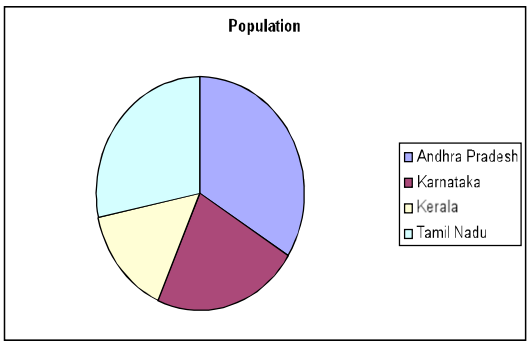
(or)

$$\text{Angle} = \frac{\text{Percentage}}{100} \times 360^0$$

The table value becomes,

State	Population
Andhra Pradesh	121.96
Karnataka	82.41
Kerala	53.35
Tamil Nadu	102.28

Radius = πr2
Here πr^2 =1957
r^2= 1957/π = 623.24
r= 24.96 =25 (approx.)

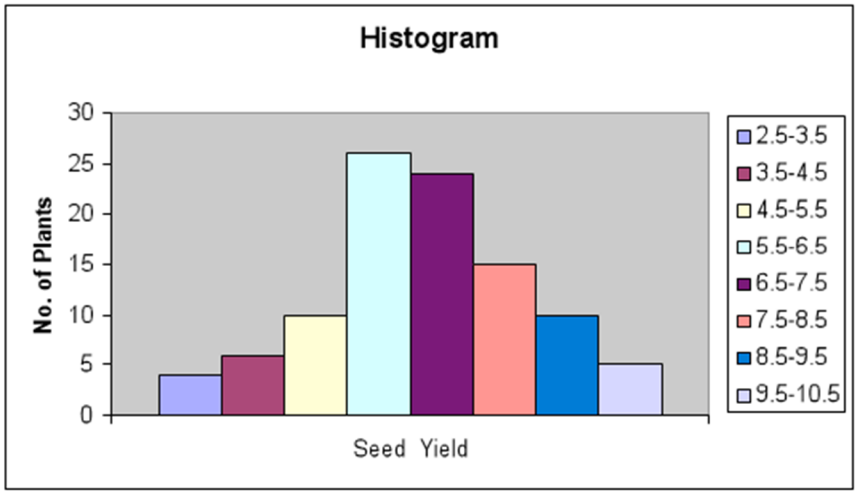


Histogram

Example 5

Draw a histogram for the following data

Seed Yield	No. of Plants
2.5-3.5	4
3.5-4.5	6
4.5-5.5	10
5.5-6.5	26
6.5-7.5	24
7.5-8.5	15
8.5-9.5	10
9.5-10.5	5

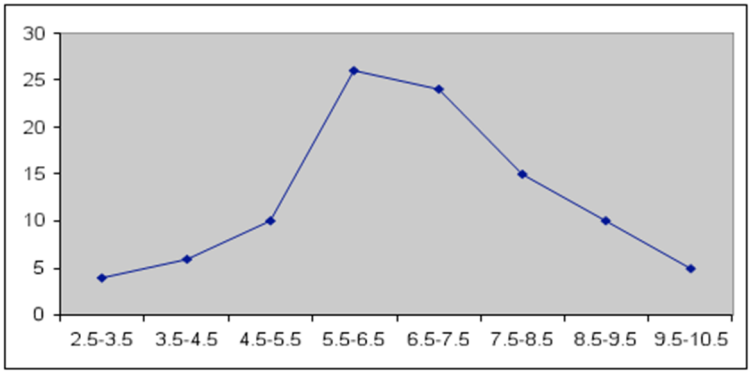


Frequency polygon

Example 6

Draw frequency polygon for the following data

Seed Yield	No. of Plants
2.5-3.5	4
3.5-4.5	6
4.5-5.5	10
5.5-6.5	26
6.5-7.5	24
7.5-8.5	15
8.5-9.5	10
9.5-10.5	5

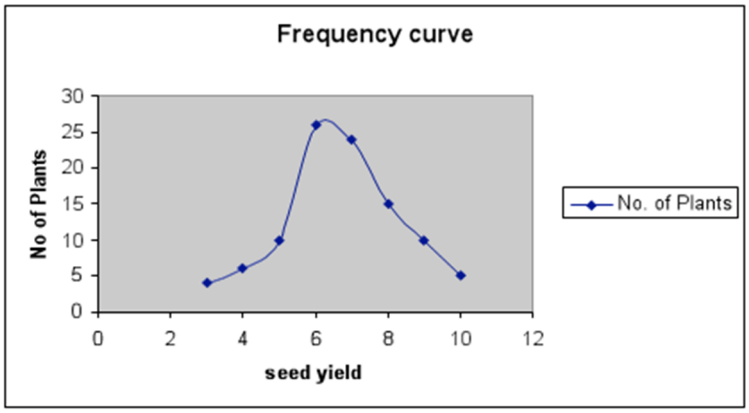


Frequency curve

Example 7

Draw frequency curve for the following data

Seed Yield	No. of Plants
2.5-3.5	4
3.5-4.5	6
4.5-5.5	10
5.5-6.5	26
6.5-7.5	24
7.5-8.5	15
8.5-9.5	10
9.5-10.5	5

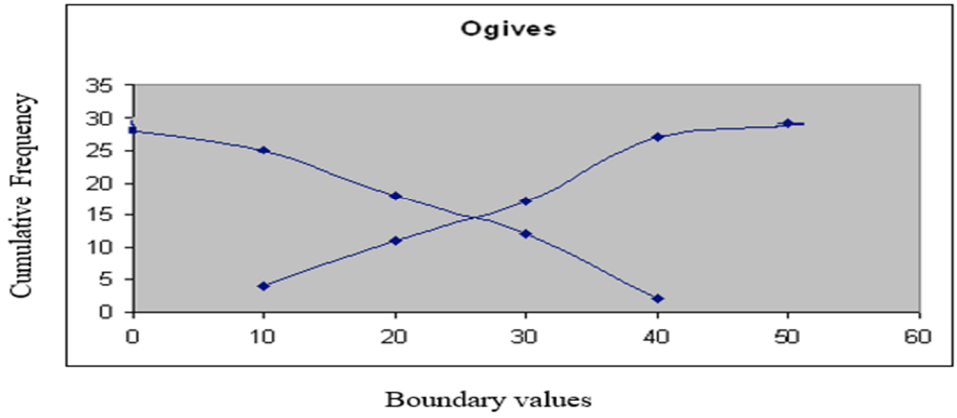


Ogives

Example 8

Draw ogives for the following data

Continuous Interval	Mid Point	Frequency	< cumulative Frequency	> cumulative frequency
0-10	5	4	4	29
10-20	15	7	11	25
20-30	25	6	17	18
30-40	35	10	27	12
40-50	45	2	29	2



Learning Exercise

1. The mean yields of green gram (Kg/hectare) under different weedicide treatment were as follows.

Herbicide	Yield (Kg/ha)
Oxadiazon	1382
Fluchloralin	1117
Isoprofuron	1066
Unweeded Control	767

Draw the simple bar diagram.

2. The cropping pattern of Tamil Nadu in 3 different years was as follows

Crops	Area		
	2002	2003	2004
Cereals	3600	3650	3950
Oilseeds	1000	1150	1100
Pulses	400	450	460
Cotton	200	230	240
Others	800	820	820

Draw the multi bar diagram, Component diagram, percentage bar diagram and pie chart.

3. The yields of a crop sorghum from 100 experimental plots are given below. Construct histogram, frequency polygon, frequency curve and ogives.

Grain Yield	No. of Plants
65-85	3
85-105	5
105-125	7
125-145	20
145-165	24
165-185	26
185-205	12
205-225	02
225-245	01

Exercise 2

Measures of central tendency- mean, median, mode, geometric mean, harmonic mean for raw data

Arithmetic mean or mean

Example 1

Calculate the mean for 2, 4, 6, 8, 10.

Solution

$$\bar{x} = \frac{2+4+6+8+10}{5} = \frac{30}{5} = 6$$

Short-cut method

Example 2

A student's marks in 5 subjects are 75, 68, 80, 92, 56. Find his average mark.

Solution

X	d=x-A
75	7
68	0
80	12
92	24
56	-12
Total	**31**

$$\bar{x} = A + \frac{\sum d}{n}$$

$$= 68 + \frac{31}{5}$$

$$=68+6.2$$

$$=74.2$$

Median

Ungrouped or Raw data

Example 3

If the weights of sorghum ear heads are 45, 60, 48, 100 and 65 grams. Calculate the median.

Solution

Hera n = 6;

Median = Average of (n/2) and $\{(n/2)+1\}^{th}$ value

n/2 = 3^{rd} value = 60 and (n/2)+1 = 3+1= 4^{th} value = 65

Median = (60+65)/2 = 62.5 g

Mode

Ungrouped or Raw data

Example 5

Find the mode for the following seed weight 2, 7, 10, 15, 10, 17, 8, 10 and 2 grams.

Mode = 10

In some cases the mode may be absent while in some cases there may be more than one mode.

Example 6

1, 12, 10, 15, 24, 30 (no mode)

2, 7, 10, 15, 12, 7, 14, 24, 10, 7, 20, 10

The modes are 7 and 10.

Geometric mode

Example 7

If the weights of sorghum ear heads are 45, 60, 48, 100, 65 grams. Find the geometric mean for the following data.

N = 5

G.M = $(45 \times 60 \times 48 \times 100 \times 65)^{1/5}$

= 60.968

Harmonic mean

Example 8

Calculate the harmonic mean from the given data: 5, 10, 17, 24, 30

H.M = $n / (\sum 1/x_i)$

$$= \frac{5}{\left[\left(\frac{1}{5}\right)+\left(\frac{1}{10}\right)+\left(\frac{1}{17}\right)+\left(\frac{1}{24}\right)+\left(\frac{1}{20}\right)\right]}$$

= 11.526

Home work:

The weight of 15 earheads of sorghum are 100, 102, 118, 124, 126, 98, 100, 100, 118, 95, 113, 115, 123, 121, 117.Find

(i) Average of weight
(ii) Median
(iii) Mode
(iv) Harmonic mean
(v) Geometric mean

Practical 3
Measures of central tendency- mean, median, mode, G.M. and H.M. for grouped data

Arithmatic mean or mean
Grouped data
Example 1
Given the following frequency distribution, calculate the arithmetic mean

Marks	64	63	62	61	60	59
Number of Students	8	18	12	9	7	6

Solution

X	**f**	**Fx**	**d = x-A**	**Fd**
64	8	512	2	16
63	18	1134	1	18
62	12	744	0	0
61	9	549	-1	-9
60	7	420	-2	-14
59	6	354	-3	-18
	60	3713		-7

Direct method

$$\bar{x} = \frac{\sum fx}{N}$$

$$\bar{x} = \frac{3713}{60} = 61.88$$

Short-cut method

$$\bar{x} = A + \frac{\sum fd}{N} x\ c$$

Here A = 62

$$\bar{x} = 62 - \frac{7}{60} x\ 1 = 61.88$$

Home work

For the frequency distribution of seed yield of sesamum given in table calculate the mean yield per plot.

Yield per plot (g)	64.5-84.5	84.5-104.5	104.5-124.5	124.5-144.5
No of plots	3	5	7	20

Median

Grouped data

Example 3

The following data pertains to the number of members in a family. Find the median size of the family.

Numbers of members x	1	2	3	4	5	6	7	8	9	10	11	12
Frequency f	1	3	5	6	10	13	9	5	3	2	2	1

Solution

X	F	cf
1	1	1
2	3	4
3	5	9
4	6	15
5	10	25
6	13	38
7	9	47
8	5	52
9	3	55
10	2	57
11	2	59
12	1	60
	60	

$$\text{Median} = \text{size of } \left(\frac{N+1}{2}\right)^{th} item$$

$$= \text{size of } \left(\frac{60+1}{2}\right)^{th} item$$

$$= 30.5^{th} \text{ item}$$

The cumulative frequency just greater than 30.5 is 38.and the value of x corresponding to 38 is 6. Hence the median size is 6 members per family.

Example 4

For the frequency distribution of weights of sorghum ear-heads given in the table below. Calculate the median.

Weights of earheads (in g)	No of earheads (f)	Cumulative frequency (m)
60-80	22	22
80-100	38	60
100-120	45	105
120-140	35	140
140-160	20	160
Total	160	

Solution

$$\text{Median} = l + \frac{\frac{N}{2} - m}{f} \times c$$

$$\left(\frac{N}{2}\right) = \left(\frac{160}{2}\right) = 80$$

Here l = 100, N=160, f = 45, c = 20, m =60

$$\text{Median} = 100 + \frac{80 - 60}{45} \times 20 = 108.8 \ gms$$

Geometric mean

Example 5

Find the G.M for the following

Weight of sorghum (x)	No. of ear head(f)
50	4
65	6
75	16
80	8
95	7
100	4

Solution

Weight of sorghum (x)	No. of earhead(f)	Log x	flog x
50	5	1.699	8.495
63	10	10.799	17.99
65	5	1.813	9.065
130	15	2.114	31.71
135	15	2.130	31.95
Total	**50**	**9.555**	**99.21**

Here N= 60

$$\text{GM} = \text{Antilog}\left[\frac{\sum f \log x_i}{N}\right]$$

$$= \text{Antilog}\left[\frac{99.21}{50}\right]$$

$$= \text{Antilog } 1.9842 = 96.43$$

Example 6

For the frequency distribution of weights of sorghum ear-heads given in table below. Calculte the G.M.

Weights of earheads (in g)	No of earheads (f)
60-80	22
80-100	38
100-120	45
120-140	35
140-160	20
Total	**160**

Solution

Weights of ear heads (in g)	No of ear heads (f)	Mid x	Log x	f log x
60-80	22	70	1.845	40.59
80-100	38	90	1.954	74.25
100-120	45	110	2.041	91.85
120-140	35	130	2.114	73.99
140-160	20	150	2.176	43.52
Total	**160**			**324.2**

Here, N= 160

$$GM = \text{Antilog}\left[\frac{\sum f \log x_i}{N}\right]$$

$$= \text{Antilog}\left[\frac{324.2}{160}\right]$$

$$= \text{Antilog}\,[2.02625]$$

$$= 106.23$$

Harmonic mean

Example 7

The marks secured by some students of a class are given below. Calculate the H.M.

Marks	20	21	22	23	24	25
Number of Students	4	2	7	1	3	1

Solution

Marks X	No of Students f	**1/x**	$f\left(\frac{1}{x}\right)$
20	4	0.0500	0.2000
21	2	0.0476	0.0952
22	7	0.0454	0.3178
23	1	0.0435	0.0435
24	3	0.0417	0.1251
25	1	0.0400	0.0400
	18		0.8216

$$\text{H.M} = \frac{N}{\sum f\left(\frac{1}{x_i}\right)} = \frac{18}{0.1968} = 21.91$$

Homework

For the following frequency distribution find the mean, median, mode, G.M and H.M

Weight of earheads in g	No. of earhead
40 - 60	6
60 - 80	8
80 – 100	35
100 -120	55
120 -140	30
140 – 160	15
160 – 180	12
180 – 200	9

Practical 4

Measures of dispersion – variance, standard deviation and coefficient of variation for raw data

Variance

The square of the standard deviation is called variance (i.e) variance = $(SD)^2$

Standard deviation

It is defined as the positive square-root of the arithmetic mean of the Square of the deviations of the given observation from their arithmetic mean.

Example 1

Raw data

The weights of 5 ear-heads of sorghum are 100, 102, 118, 124, 126 g. Find the SD.

Solution

x	x^2
100	10000
102	10404
118	13924
124	15376
126	15876
$\Sigma x = 570$	$\Sigma x^2 = 65580$

$$SD = S = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{65580 - \frac{(570)^2}{5}}{5-1}} = \sqrt{150} = 12.25\ gms$$

Variance= $(12.25)^{1/2} = 3.5$

Coefficient of variation

C.V= (SD/mean) x 100

Example

Consider the measurement on yield and plant height of a paddy variety. The mean and standard deviation for yield are 50 kg and 10 kg respectively. The mean and standard deviation for plant height are 55 am and 5 cm respectively.

Here the measurements for yield and plant height are in different units. Hence the variabilities can be compared only by using coefficient of variation.

For yield, CV= (10/50) x 100 = 20%

For plant height, CV= (5/55) x 100 = 9.1%

The yield is subject more variation than the plant height.

Homework

1. The weights of 8 earheads of sorghum are 14, 29, 9, 15, 20, 17, 12, and 11. Find Standard Deviation and Variance and coefficient of variation.
2. Find out which of the following batsmen is more consistent in scoring.

Batsman A	5 7	16	27	39	53	56	61	80	101	105
Batsman B	0 4	16	21	41	43	57	78	83	93	95

Practical 5

Measures of dispersion – variance, standard deviation and coefficient of variation for grouped data

Standard deviation and Variance

Example 1

The frequency distributions of seed yield of 50 *Seasamum* plants are given below. Find the standard deviation.

Seed yield in g (x)	3	4	5	6	7
Frequency (f)	4	6	15	165	10

Solution

Seed yieldin gms (x)	**f**	**fx**	**fx^2**
3	4	12	36
4	6	24	96
5	15	75	375
6	15	90	540
7	10	70	490
Total	**50**	**271**	**1537**

Here N = 50, Standard deviation =

$$S = \sqrt{\frac{\sum fx^2}{N} - \left(\frac{\sum fx}{N}\right)^2} = \sqrt{\frac{1537}{50} - \left(\frac{271}{50}\right)^2}$$

$= \sqrt{30.74 - 29.3764}$ =1.1677g

Variance = $(1.1677)^{1/2}$ = 1.081

Example 2

The Frequency distributions of seed yield of 50 *seasamum* plants are given below. Find the standard deviation.

Seed yield in gms (x)	2.5-35	3.5-4.5	4.5-5.5	5.5-6.5	6.5-7.5
No. of plants (f)	4	6	15	165	10

Solution

Seed yield (g) x	**No. of plants f**	**Mid x**	**d=$\frac{x-A}{C}$**	**df**	**d^2f**
2.5-3.5	4	3	-2	-8	16
3.5-4.5	6	4	-1	-6	6
4.5-5.5	15	5	0	0	0
5.5-6.5	15	6	1	15	15
6.5-7.5	10	7	2	20	40
Total	**50**	**25**	**0**	**21**	**77**

A= Assumed mean= 5, N= 50, C= 1

$$S = C \times \sqrt{\frac{\sum fd^2}{N} - \left(\frac{\sum fd}{N}\right)^2}$$

$$= 1 \times \sqrt{\frac{77}{50} - \left(\frac{21}{50}\right)^2}$$

$$= \sqrt{1.54 - 0.1764}$$

$$= \sqrt{1.3636} = 1.1677$$

Variance = $(1.1677)^{1/2}$ = 1.081

Coefficient variation

Example 3

Consider the measurement on yield and plant height of a paddy variety. The mean and standard deviation for yield are 50 kg and 10 kg respectively. The mean and standard deviation for plant height are 55 am and 5 cm respectively.

Here the measurements for yield and plant height are in different units. Hence the variabilities can be compared only by using coefficient of variation.

For yield, CV= (10/50) x 100 = 20%

For plant height, CV= (5/55) x 100 = 9.1%

The yield is subject more variation than the plant height.

Homework

1. From the data given below, find which series is more consistent

Variable	10-20	20-30	30-40	40-50	50-60	60-70
Series A	10	16	30	40	26	18
Series B	22	18	32	34	18	16

2. The yield of a crop sorghum from 31 experimental plots are given below. Find the Range, Standard deviation, Variance, Coefficient of variation.

Grain yield	No. of plots
130	3
135	4
140	6
145	6
146	3
148	5
149	2
150	1
157	1

3. The following table gives the protein intake of 400 families. Find the Range, Standard deviation, Variance, Coefficient of variation.

Protein intake / Consumption unit Per day in grams	No. of Families
15 - 25	30
25 – 35	40
35 – 45	100
45 – 55	110
55 – 65	80
65 –75	30
75 - 85	10

Practical 6

Selection of simple random sampling using lottery method and random numbers

Home work

The following data refers to the Cotton yield of 96 plants.

82	102	88	93	97	38	103	92
102	62	63	72	64	68	59	69
73	65	46	79	87	84	29	52
28	36	37	53	49	51	30	37
56	66	42	37	35	97	32	35
89	99	54	72	26	67	18	27
60	72	33	42	52	82	14	22
57	73	63	61	63	92	40	58
62	61	43	25	42	36	17	30
75	87	47	56	76	36	35	44
56	51	111	73	93	58	49	89
50	80	54	55	91	12	82	76

Select a sample of 25 plants by using simple random sampling method. Also calculate the mean of the 25 samples and verify whether the mean is equal to the mean of the 96 plants.

Practical 7

Students's t test – Paired and Independent t test

Test for single mean (n<30)

Example 1

Based on field experiments, a new variety green gram is expected to give a yield of 12.0 quintals per hectare. The variety was tested on 10 randomly selected farmers' fields. The yield (quintals/hectare) were recorded as 14.3,12.6,13.7,10.9,13.7,12.0,11.4,12.0,12.6,13.1. Do the results conform the expectation?

Solution:

Null hypothesis H_0: $\mu=12.0$

i.e., the average yield of the new variety of green gram is 12.0 q/ha.

Alternate hypothesis: $H_1= \mu \neq 12.0$

i.e., the average yield of the new variety of green gram is not 12.0 q/ha

Level of significance: 5%

Test statistic

$$t_{cal} = \left| \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} \right| \sim t_{(n-1)}\ d.f$$

From the given data

$$\sum x = 126.3 \qquad \sum x^2 = 1605.77$$

$$\bar{x} = \frac{\sum x}{n} = \frac{126.3}{10} = 12.63$$

$$s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}} = \sqrt{\frac{1605.77 - 1595.169}{9}} = \sqrt{\frac{10.601}{9}}$$

$$= 1.0853$$

$$\frac{s}{\sqrt{n}} = \frac{1.0853}{\sqrt{10}} = 0.3432$$

Now $$t_{cal} = \left| \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} \right| \sim t_{(n-1)}\ d.f$$

$$= t_{cal} = \frac{12.63 - 12}{0.3432} = 1.836$$

Table value

$t_{(0.05,9)}=2.262$ (two tailed test)

Inference

$t_{cal}<t_{tab}$

We accept the null hypothesis H_0.

We conclude that the new variety of green gram will give an average yield of 12 q/ha.

Note

F-test is used to test the equality of two means

$$F = \frac{S_1^2}{S_2^2} \sim F_{(n_1 - 1, n_2 - 1)} \, d.f \text{ if } S_1^2 > S_2^2$$

where S_1^2 is the variance of the first sample whose size is n_1.

S_2^2 is the variance of the second sample whose size is n_2.

Otherwise

$$F = \frac{S_2^2}{S_1^2} \sim F_{(n_2 - 1, n_1 - 1)} \, d.f \text{ if } S_2^2 > S_1^2$$

Inference

$F_{cal} < F_{tab}$

We accept the null hypothesis H_0; the variances are equal.

Test for equality of two means (Independent samples)

Example 2

A group of 5 patients treated with medicine. A is of weight 42,39,38,60 &41 kgs. Second group of 7 patients from the same hospital treated with medicine B is of weight 38, 42, 56, 64, 68, 69 & 62 kgs. Find whether there is any difference between medicines?

Solution

Ho:., $\mu_1 = \mu_2$ (i.e.) there is no significant difference between the medicines A and B as regards on increase in weight.

H1 $\mu_1 \neq \mu_2$ (i.e.) there is a significant difference between the medicines A and B Level of significance = 5%

Before we go to test the means first we have to test their variability using F-test.

F-test

Ho:., $\sigma_1^2 = \sigma_2^2$

H1:., $\sigma_1^2 \neq \sigma_2^2$

$$S_1^2 = \frac{\sum x_1^2 - \frac{(\sum x_1)^2}{n1}}{n1 - 1} = 82.5$$

$$S_2^2 = \frac{\sum x_2^2 - \frac{(\sum x_2)^2}{n2}}{n2 - 1} = 154.33$$

$$\therefore F = \frac{S_2^2}{S_1^2} \sim F_{(n_2 - 1, n_1 - 1)} \, d.f \text{ if } S_2^2 > S_1^2$$

$$F_{cal} = \frac{154.33}{32.5} = 1.8707$$

$F_{tab}(6,4)$ d.f = 6.16

Means, $F_{cal} < F_{tab}$

We accept the null hypothesis H_0: the variances are equal

Test statistics

$$t = \frac{|(\bar{x}_1 - \bar{x}_2)|}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \sim t_{(n1+n2-2)}d.f$$

Where

$$S^2 = \frac{\left[\sum x_1^2 - \frac{(\sum x_1)^2}{n1}\right] + \left[\sum x_2^2 - \frac{(\sum x_2)^2}{n2}\right]}{n_1 + n_2 - 2} = \frac{330 + 926}{10} = 125.6$$

$$t = \frac{|44 - 57|}{\sqrt{125.6\left(\frac{1}{7} + \frac{1}{75}\right)}} = 1.98$$

Table value

$T_{tab[(5+7-2)=10]}$d.f at 5% is 2.228

Inference:

$t_{cal} < t_{tab}$

We accept the null hypothesis H_0

We conclude that the medicines A and B do not differ significantly.

Example 3

The summary of the results of an yield trial on onion with two methods of propagation is given below. Determine whether the methods differ with regard to onion yield. The onion yield is given in Kg/plot.

Method I	**Method II**
n1=12	n2=12
$\bar{x}_1 = 25.25$	$\bar{x}_2 = 28.83$
SS1=186.25	SS2=737.6667
$S_1^2 = 16.9318$	$S_2^2 = 67.0606$

Solution

Ho:., $\mu_1=\mu_2$ (i.e) the two propagation method do not differ with regard to onion yield.

H_1 $\mu_1 \neq \mu_2$ (i.e) the two propagation methods differ with regard to onion yield.

Level of significance = 5%

Before we go to test the means first we have to test their variability using F-test.

F-test

Ho:., $\sigma_1^2=\sigma_2^2$

H1:., $\sigma_1^2\neq\sigma_2^2$

$$S_1^2=\frac{\sum x_1^2-\frac{(\sum x_1)^2}{n1}}{n1-1}=16.9318$$

$$S_2^2=\frac{\sum x_2^2-\frac{(\sum x_2)^2}{n2}}{n2-1}=67.0606$$

$$\therefore F=\frac{S_2^2}{S_1^2}\sim F_{(n_2-1,n_1-1)}\,d.f \text{ if } S_2^2>S_1^2$$

$$F_{cal}=\frac{67.0606}{16.9318}=3.961$$

$F_{tab}(11,11)$ d.f=2.82

$\Rightarrow F_{cal}>F_{tab}$

We reject the null hypothesis H_0: the variances are unequal.

Here the variances are unequal with equal sample size then the test statistic is

$$t=\frac{\left|(\bar{x}_1-\bar{x}_2)\right|}{S\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}\sim t_{\left(\frac{n1+n2}{2}-1\right)}\,d.f$$

Where

$$S^2=\frac{\left[\sum x_1^2-\frac{(\sum x_1)^2}{n1}\right]+\left[\sum x_2^2-\frac{(\sum x_2)^2}{n2}\right]}{n_1+n_2-2}$$

$$S^2=\frac{SS1+SS2}{n_1+n_2-2}=\frac{186.25+737.6667}{12+12-2}=41.9962$$

$$t=\frac{25.25-28.83}{\sqrt{41.9962\left(\frac{1}{12}+\frac{1}{12}\right)}}=\frac{3.58}{\sqrt{6.9994}}=1.353$$

t_{cal}=1.353

table value

$$t_{\left(\frac{n1+n2}{2}-1\right)}=t_{\left(\frac{12+12}{2}-1\right)}=t_{11}\,d.f \text{ at 5\% los}=2.201$$

Inference:

$t_{cal}<t_{tab}$

We accept the null hypothesis H_0

We conclude that the two propagation methods do not differ with the regard to onion yield.

Equality of two means (Dependent samples)

Paired t test

Example 4

In certain food experiment to compare two types of baby foods A and B, the following results of increase in weight (lbs) we observed in 8 children as follows:

Food A(x)	49	53	51	52	47	50	52	53
Food B(y)	52	55	52	53	50	54	54	53

Examine the significance of increase in weight of children due to food B.

Solution

H_0 : $\mu_1 = \mu_2$, there is no significant difference between the two foods.

H_1 : $\mu_1 \neq \mu_2$, there is significant difference between the two foods.

Level of significance = 5%

Test statistic:

$$t = \frac{|\bar{d}|}{S/\sqrt{n}} \sim t(n-1)d.f$$

x	y	d=x-y	d^2
49	52	-3	9
53	55	-2	4
51	52	-1	1
51	52	-1	1
47	50	-3	16
50	54	-4	16
52	54	-2	4
53	53	0	0
Total		**-16**	**44**

$$\bar{d} = \frac{\sum di}{n} = \frac{-16}{8} = -2,$$

$$S = \sqrt{\frac{\sum di^2 - \frac{(\sum di)^2}{n}}{n-1}} = 1.3093$$

$$t_{cal} = \frac{|-2|}{1.3093/\sqrt{8}} = 4.32$$

Table value:

$T_{(8-1)}$ d.f at 5% is = 2.365

Inference:

$t_{cal} > t_{cal}$

We reject the null hypothesis H_0 and accept the alternate hypothesis H_1: there is significant difference between the two foods A and B.

Homework:

1. 10 samples of leaves of the plant are chosen at random from a large population and their weight in grams are found to be as follows

63	63	64	65	66	69	69	70	70	71

From this data mean wt. in universe is 65 g. Can we assume this mean weight?

2. A health status survey in a few villages revealed that the normal serum protein value of children in that locality is 7.0 g/100ml. A group of 16 children, who received high protein food for a period of 6 months had serum protein values shown below. Can we consider that the mean serum protein level of these who were fed on high protein diet is different from that of the general population.

Children	1	2	3	4	5	6	7	8	9	10
Protein level g %	7.1	7.70	8.2	7.56	7.05	7.08	7.21	7.25	7.36	6.59
Children	11	12	13	14	15	16				
Protein level g %	6.85	7.9	7.27	6.56	7.93	8.5				

3. The following data related to the rate of diffusion of CO_2 through two series of differentporosity, find out whether the diffusion rate same for both sides.

Diffusion through finesoil (x_1)	20	31	31	23	28	23	26	27	26	17	17	25
Diffusion through coarse soil (x_2)	19	30	32	28	15	26	35	18	25	27	35	34

4. A new variety of cotton was evolved by a breed. In order to compare its yielding ability with that of a ruling variety, an experiment was conducted in Completely Randomised Design. The yield (kg/plot) was observed. The summary of the results are given below. Test whether the new variety of cotton gives higher yield than the ruling variety.

New Variety	$n_1 = 9$	=28.2	S_1^2=5.4430
Ruling Variety	$n_2 = 11$	=25.9	S_2^2=1.2822

5. The iron contents of fruits before and after applying farm yard manure were observed as follows:

Fruit No:	1	2	3	4	5	6	7	8	9	10
Before Applying	7.7	8.5	7.2	6.3	8.1	5.2	6.5	9.4	8.3	7.5
After Applying	8.1	8.9	7.0	6.1	8.2	8.0	5.8	8.9	8.7	8.0

Is there any significant differences between the mean iron contents and in the fruit before and after FYM?

Practical 8

Chi-square test- test for association and goodness of fit

χ^2 – test for goodness of fit

Example 1

The number of yeast cells counted in a haemocytometer is compared to the theoretical value is given below. Does the experimental result support the theory?

No. of Yeast cells in the square	Obseved Frequency	Expected Frequency
0	103	106
1	143	141
2	98	93
3	42	41
4	8	14
5	6	5

Solution

H_0: the experimental results support the theory

H_1: the experimental results does not support the theory.

Level of significance=5%

Test Statistic:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \sim \chi^2_{(n-1)\,df}$$

O_i	E_i	$O_i - E_i$	$(O_i - E_i)^2$	$(O_i - E_i)^2/E_i$
103	106	-3	9	0.0849
143	141	2	4	0.0284
98	93	5	25	0.2688
42	41	1	1	0.0244
8	14	-6	36	2.5714
6	5	1	1	0.2000
400	400			**3.1779**

χ^2= 3.1779

Table value:

$\chi^2_{(6-1=5)}$d.f at 5% significance= 11.070

Inference

$\chi^2_{cal} < \chi^2_{tab}$

We accept the null hypothesis: there is a good correspondence between theory and experiment.

χ^2 test for independence of attributes

Example 2

The severity of a disease and blood group were studied in a research projest. The findings sre given in the following table, know mn as the m x n contingency table. Can this severity of the condition and blood group are associated. Severity of a disease classified by blood group in 1500 patients:

Condition	Blood Groups				Total
	O	A	B	AB	
Severe	51	40	10	9	110
Moderate	105	103	25	17	250
Mild	384	527	125	104	1140
Total	540	670	160	130	1500

Solution:

H0: The two attributes severity of the condition and blood groups are not associated.

H1: The two attributes severity of the condition and blood groups are associated.

Calculation of Expected frequencies

Condition	Blood Groups				Total
	O	A	B	AB	
Severe	39.6	49.1	11.7	9.5	110
Moderate	90.0	111.7	26.7	21.7	250
Mild	410.4	509.2	121.6	98.8	1140
Total	540	670	160	130	1500

Test statistics

$$\chi^2 = \sum_{i=j}^{m} \sum_{j=1}^{n} \frac{\left(o_{ij} - E_{ij}\right)}{E_{ij}} \sim \chi^2(m-1)(n-1) \text{ df}$$

Here, m= 3 and n= 4

Calculations:

O_i	E_i	O_i-E_i	$(O_i-E_i)^2$	$(O_i-E_i)^2/E_i$
51	39.6	11.4	129.96	3.2818
40	49.1	-9.1	82.81	1.6866
10	11.7	-1.7	2.89	0.2470
9	9.5	-0.5	0.25	0.0263
105	90.0	15	225.00	2.5000
103	111.7	-8.7	75.69	0.6776
25	26.7	-1.7	2.89	0.1082
17	21.7	-4.7	22.09	1.0180
384	410.4	-26.4	696.96	1.6982
527	509.2	17.8	316.84	0.6222
125	121.6	3.4	11.56	0.0951
104	98.8	5.2	27.04	0.2737
				12.2347

$\chi^2 = 12.2347$

Table value:

$\chi^2_{(3-1)(4-1)} = \chi^2_{(6)}$ at 5% = 12.59

Inference

$\chi^2_{cal} = \chi^2_{tab}$

We accept the null hypothesis (i.e.) the two attributes severity of the condition and blood group are independent.

2 x 2 contingency table

Example 3

In order to determine the possible effect of a chemical treatment on the rate of germination of cotton seeds a pot culture experiment was conducted. The results are given below

Chemical treatment and germination of cotton seeds

	Germinated	Not germinated	Total
Chemically Treated	118	22	140
Untreated	120	40	160
Total	238	62	300

Does the chemical treatrment improve the germination rate of cotton seeds at 1 % level?

Solution:

H_0:The chemical treatment does not improve the germination rate of cotton seeds.

H_1: The chemical treatment improves the germination rate of cotton seeds.

L.O.S = 1 %

Test statistic

$$\chi^2 = \frac{N(ad-bc)^2}{(a+b)(c+d)(a+c)(b+d)} \sim \chi^2 \text{ (2-1) (2-1) df} \quad = \chi^2 \text{ (1) df}$$

$$\chi^2 = \frac{300(118\times 40 - 22\times 120)^2}{140\times 160\times 62\times 238} = 3.927$$

Table value:

χ^2 (1) df at 1 % L.O.S = 6.635

Inference

$\chi^2_{cal} < \chi^2_{tab}$

We accept the null hypothesis. (i.e)The chemical treatmentwill not improve the germination rate of cotton seeds significantly.

Yates correction for continuity

Example 4

In an experiment on the effect of a growth regulator on fruit setting in muskmelon the following results were obtained. Test whether the fruit setting in muskmelon and the application of growth regulator are independent at 1% level.

	Fruit set	Fruit not set	Total
Treated	16	9	25
Control	4	21	25
Total	20	30	50

Solution:

H0:Fruit setting in muskmelon does not depend on the application of growth regulator.

H1: Fruit setting in muskmelon depend on the application of growth regulator.

L.O.S = 1 %

Tet statistic

$$\chi^2 = \frac{N\left(|ad-bc| - \frac{N}{2}\right)^2}{(a+b)(c+d)(a+c)(b+d)} \sim \chi^2 \text{ (1) df}$$

$$\chi^2 = \frac{50\left[|16\times 21 - 9\times 4| - \frac{50}{2}\right]^2}{25\times 25\times 20\times 30} = 10.08$$

Table value:

χ^2 (1) df at 1 % L.O.S = 6.635

Inference

$\chi^2_{cal} > \chi^2_{tab}$

We reject the null hypothesis. (i.e) Fruit setting in muskmelon is influenced by the growth regulator.

Homework

1. The theory predicts the proportion of beans in the 4 groups A, B, C, D should be 9:3:3:1. In an experiment among 1600 beans, the number in the four groups were 882, 313, 287 and 118. Does the experimental result support the theory.
2. A study was conducted, among 100 professors from 3 different divisions for the preference on beverages of 3 categories test if there is any relationship between the field of teaching and preference of beverage.

Field of teaching				
Beverage	Business	Social Sciences	Agri	Total
Tea	20	10	10	40
Coffee	10	10	15	35
Cold drinks	10	8	7	25
Total	40	28	32	100

3. A random sample of 600 students from Delhi University are selected and asked their opinion ab out autonomous Status of Colleges. The results were given below. Test the hypothesis at 5% level that opinions are independent of class groupings.

Class grouping	Favour of	Against	
Commerce	120	80	200
Science	130	70	200
Arts	70	30	100
Total	400	200	600

4. In a survey of preference of new coverage 100 persons are collected and taste preference of average was surveyed according to sex of the person. We conclude that the taste preference and sex of the person are associated.

	Male	Female	
Favour	35	25	60
Against	25	15	40
Total	60	40	100

Practical 9

Calculation of Karl Pearson's correlation coefficient

Pearson's Correlation coefficient

Example 1

Compute Pearson's coefficient of correlation between advertisement cost and sales as per the data given below.

Advertisement Cost in 1000's	39	65	62	90	82	75	25	98	36	78
Sales in lakhs	47	53	58	86	62	68	60	91	51	84

Solution:

H_0: The correlation coefficient r is not significant

H_1: The correlation coefficient r is significant.

Level of significance 5%.

From the data, n = 10;

$\Sigma x = 650$, $\Sigma y = 660$, $\Sigma xy = 45604$, $\Sigma x^2 = 47648$, $\Sigma y^2 = 45784$

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\sum x^2 - \frac{(\sum x)^2}{n}}\sqrt{\sum y^2 - \frac{(\sum y)^2}{n}}}$$

$$= \frac{45604 - \frac{(650)(660)}{10}}{\sqrt{47648 - \frac{(650)^2}{10}}\sqrt{45784 - \frac{(660)^2}{10}}}$$

$$= \frac{45604 - 42900}{(73.47)(47.1)} = 0.7804$$

Correlation coefficient is positively correlated.

Test statistic

$$t = \frac{|r|}{\sqrt{\frac{1-r^2}{n-2}}} \sim (n\text{-}2) \text{ d.f}$$

$$t = \frac{0.7804}{\sqrt{\frac{1-(0.7804)^2}{10-2}}} = 3.530$$

t_{tab}= 2.306

Inference:

$t_{cal} > t_{tab}$, we reject null hypothesis.

The correlation coefficient r is significant. There is a relation between advertisement company and the sales.

Homework

1. Calculate the simple correlation coefficient between wing length & tail length of the following 12 birds of a particular species. Also test its significant.

Wing length (cm)x	1	2	3	4	5	6	7	8	9	10	11	12
	10.4	10.8	11.1	10.2	10.3	10.2	10.7	10.5	10.8	11.2	10.6	11.4
Tail length (cm)y	7.4	7.6	7.9	7.2	7.4	7.1	7.4	7.2	7.8	7.7	7.8	8.3

2. The date refer to the yield of grain in g/plant (y) and the number of productive tillers (x) and 15 paddy plants

Y	37	20	42	36	20	30	26	21	43	44	22	31	26	37	26
X	15	12	17	14	12	13	12	9	24	20	14	18	13	15	7

Find the correlation.

3. The following data relates to the yield in grams (y) and the matured pods (x) of 10 groundnut plants. Work out the correlation coefficient and test its significance.

X:	14	34	20	16	11	11	20	17	22	17
Y:	16	40	21	18	14	13	20	35	17	27

4. Find the persons coefficient of correlation between price and demand from the following data.

Price	11	13	15	17	18	19	20
Demand	30	29	24	24	21	18	15

Practical 10

Fitting of simple linear regression of y on x

Testing the significance of regression coefficient

Example 1

Form a paddy field, 36 plants were selected at random. The length of panicles(x) and the number of grains per panicle (y) of the selected plants were recorded. The results are given below. Fit a regression line y on x. Also test the significance (or) regression coefficient.

The length of panicles in cm (x) and the number of grains per panicle (y) of paddy plants**.**

S.No.	Y	X	S.No.	Y	X	S.No.	Y	X
1	95	22.4	13	143	24.5	25	112	22.9
2	109	23.3	14	127	23.6	26	131	23.9
3	133	24.1	15	92	21.1	27	147	24.8
4	132	24.3	16	88	21.4	28	90	21.2
5	136	23.5	17	99	23.4	29	110	22.2
6	116	22.3	18	129	23.4	30	106	22.7
7	126	23.9	19	91	21.6	31	127	23.0
8	124	24.0	20	103	21.4	32	145	24.0
9	137	24.9	21	114	23.3	33	85	20.6
10	90	20.0	22	124	24.4	34	94	21.0
11	107	19.8	23	143	24.4	35	142	24.0
12	108	22.0	24	108	22.5	36	111	23.1

Solution:

Null hypothesis H_0: regression coefficient is not significant.

Alternate hypothesis H_1: regression coefficient is significant.

$\Sigma y = 4174$; $\Sigma y^2 = 496258$; $\bar{y} = \Sigma y/n = 115.94$

$\Sigma x = 822.9$; $\Sigma x^2 = 18876.83$; $\ddot{x} = \Sigma x/n = 22.86$

$\Sigma xy = 96183.4$

$$SS(Y) = \sum y^2 - \frac{(\sum y)^2}{n} = 496258 - \frac{(4174)^2}{36} = 12305.8889$$

$$SS(X) = \sum x^2 - \frac{(\sum x)^2}{n} = 18876.83 - \frac{(822.9)^2}{36} = 66.7075$$

The regression line y on x is $\bar{y} = a_1 + b_1 \bar{x}$

$$b_1 = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}} = \frac{96183.4 - \frac{(822.9)(4174)}{36}}{66.7075} = 11.5837$$

$\bar{y} = a_1 + b_1 \bar{x}$

115.94 = a + (11.5837)(22.86)

A=115.94-264.8034

A=-148.8633

The fitted regression line is y =-148.8633+11.5837x

$$SS(b) = \frac{\left(\sum xy - \frac{\sum x \sum y}{n}\right)^2}{\sum x^2 - \frac{(\sum x)^2}{n}} = \frac{(722.7167)^2}{66.7075} = 8950.8841$$

ANOVA Table:

Sources of Variation	d.f	SS	MSS	F-value
Replication	1	8950.8841	8950.8841	90.7093
Error	36-2=34	3355.0048	98.6766	
Total	35	12305.8889		

For t-test

$$t = \frac{b}{SE(b)} \sim t_{(n-2)} d.f$$

$$SE(b) = \sqrt{\frac{Se^2}{SS(X)}} = \sqrt{\frac{98.6776}{66.7075}} = 1.2162$$

$$t = \frac{11.5837}{1.2162} = 9.5245$$

Table Value:

$t_{(n-2)}$ d.f=t_{34} d.f at 5% level=2.032

$t_{cal} > t_{tab}$. we reject H_o.

Hence t is significant.

Homework:

1. The following data are using length of 13 sparrows of various ages.

Age (days) (x)	3	4	5	6	8	9	10	11	12	14	15	16	17
Wing length(cm)(y)	1.4	1.5	2.2	2.4	3.1	3.2	3.2	3.9	4.1	4.7	4.5	5.2	5.0

Fit the regression line of y on x. Also test the significance of the regression coefficient.

2. Obtain the regression line of the form y = a + bx between the average number of tilters (x) and the yield in kgs (y) of turmeric crop from the following data

Average number of tillers(x)	3.5	3.2	3.5	3.8	3.6	3.74	2.8	4.2	4.0	4.5
Yield in (Kgs) (y)	2.0	1.8	1.9	2.1	2.0	2.3	1.7	2.5	2.6	3.0

3. Find out the regression equations y on x between the number of root fiber (x) and yields in kg(y) of ginger crop from the following data. Also test the significance of regression coefficient.

Number of root fibre (x)	6	5	3	7	4	9	10	11	15	8
Yield in kgs(y)	1.0	0.8	0.5	1.1	0.6	1.2	1.5	1.6	1.9	0.9

4. Find out the regression equation of y on x and test the significance of regression coefficient.

X	2.1	2.7	3.5	4.6	4.9	5.7	6.0	7.4	8.3	4.8
Y	11.2	12.8	16.4	17.8	19.5	21.1	22.8	26.3	31.0	21.1

Practical 11

Formation of ANOVA table for Completely Randomized Design (CRD) with equal replication and comparison of means using critical difference values

Completely Randomized Design (CRD)

Example 1

The following table gives the yield in kgs per plot of five varieties of wheat after being applied to each of four plots in a completely randomized design.

Varieties	Yield in kgs				Totals	Treatment means
A	8	8	6	10	32 (T1)	8 (T1)
B	10	12	13	9	44 (T2)	11 (T2)
C	18	17	13	16	64 (T3)	16 (T3)
D	12	10	15	11	48 (T4)	12 (T4)
E	8	11	9	8	36 (T5)	9 (T5)
Grand Total					224	

Solution:

Correction factor (C.F) = (Grand total)^2/(r x t); where r is the number of replications per treatment and t is the numbers of treatments.

= $224^2/(4 \times 5) = 2508.8$

Total Sum of Square (TSS) = ΣY_{ij}^2-C.F

= $8^2+8^2+\ldots.+9^2+8^2-2508.8 = 207.2$

Treatment Sum of square = $[(T_1^2+T_2^2+T_3^2+T_4^2+T_5^2)/r]$-CF

= $[(32^2+44^2+64^2+48^2+36^2)/4]-2508.8 = 155.2$

Error Sum of Square = Total sum of square-Treatment sum of square=207.2-155.2= 52.0

ANOVA table:

Source of variation	**D.F.**	**S.S.**	**MS (variance)**	**F (variance ratio)**	**F at 5%**
Between varieties	4	155.2	38.80	11.80*	3.06
Within varieties (error)	15	52.0	3.47		
Total	**19**	**207.2**			

*Significant at 5% level of significances

Here, F test indicates that there are significant difference between the variety means since the observed value of the variance ratio is significant at 5% level of significance. Now we wish to know as to which variety is the best and also which varieties show the significant difference among themselves. This can be done with the help of critical difference (c.d.)

Now, standard error of the difference between two treatment means is

S.E.d = $\sqrt{\frac{2XEMS}{r}}$, Where EMS is the error mean square and r is no. of replications.

=1.32

Critical difference (CD)= SEd x t at 5% for error df
= 1.32 x 2.131 = 2.81

Homework:

1. The following table gives the yields of five varieties of paddy with four replications each by using completely randomized Design.

Varieties	Yield in kg.			
A	8	8	6	10
B	10	12	13	9
C	18	17	13	16
D	12	10	15	11
E	8	11	9	8

Analyze the data to draw your conclusions.

2. Below are given the plan and yield in kg per plot of a completely randomized design for testing the effect of five different fertilizers A, B, C, D & E.

D	E	B	E	D
20	17	21	16	15
A	C	A	D	B
8	17	9	13	17
B	D	E	C	A
12	19	18	18	15
C	A	C	A	E
16	8	18	10	15
E	B	D	B	C
13	16	23	14	19

Analyze the data and state your conclusions.

Practical 12

Formation of ANOVA table for Randomised blocks design (RBD) and comparison of means using critical difference values

Randomised blocks design (RBD)

Example 1

The yields of six nitrogen treatments on a crop in kgs along with the plan of the experiment are given below. The number of blocks is five and the nitrogen treatments have been represented by A, B, C, D, E and F.

Block I	Block II	Block III	Block IV	Block V
D 17 C 12	B 12 C 15	E 23 A 30	A 28 F 64	F 75 C 14
F 70 B 6	E 26 A 26	C 16 D 20	B 9 D 23	D 20 B 7
A 20 E 28	D 10 F 62	F 56 B 10	E 33 C 14	E 30 A 23

It is required to analyse the data.

Solution

The first step in the analysis of data is to tabulate yield figures according to block and treatments in the follow manner.

Varieties	Blocks					Treatment totals	Treatment means
	I	II	III	IV	V		
A	20	26	30	28	23	1277 (T_1)	25.4
B	9	12	10	9	7	47 (T_2)	9.4
C	12	15	16	14	14	71 (T_3)	14.2
D	17	10	20	23	20	90 (T_4)	18.0
E	28	26	23	35	30	142 (T_5)	28.4
F	70	62	56	64	75	327 (T_6)	65.4
Totals	**156 (B1)**	**151 (B2)**	**155 (B3)**	**173 (B4)**	**169 (B5)**	**804 (GT)**	

Sum of Squares for different sources

CF= $GT^2/(b \times t)$; where GT is Grand total, b-blocks and t- no. of treatments

$=804^2/(5 \times 6) = 21547.2$

Total SS= SS of all observations – CF

=10466.8

SS due to blocks=$[(B_1^2+ B_2^2+ B_3^2+ B_4^2+ B_5^2)/t]$-CF = 61.4

SS due to treatments= $=[(T_1^2+ T_2^2+ T_3^2+ T_4^2+ T_5^2)/r]$-CF = 10167.2

SS due to error= Total SS-SS due to block-SS due to treatments = 418.2

ANOVA TABLE:

Source of variation	D.F	S.S	M.S	Variance ratio 'F'	F 15%
Blocks	4	61.4	15.35		
Treatments	5	10167.2	2033.44	97.24*	2.71
Error	20	418.2	20.19		
Total	29	10646.8			

* Significant at 5% level of significance

It is clear from the table that this observed value of 'F' is significant at 5% level of significance which proves that there are significant differences between the treatment means. Now, we have to test the significance of the difference between the individual treatments, and this will be done with the help of CD as usual.

Critical differences:

SEd = 2.89

CD= SEdx $t_{5\%}$= 6.03

Homework

1) The yield of rice (in kg) with five fertilizers tested in four blocks using RBD is given the following layout. Analysis the data & interpret your conclusion.

Block 1	Block 2	Block 3	Block 4
B 10	C 13	A 19	D 20
C 16	A 21	D 24	E 36
A 20	D 21	E 32	B 9
D 23	E 31	B 10	C 13
E 33	B 11	C 14	A 24

2) An experiment was conducted in RBD to study to comparative performance of yield of six varieties of oranges (kg/plot) are given below. Analyse the data and give your conclusion.

Treatments	**Blocks**				
	B1	**B2**	**B3**	**B4**	**B5**
V1	5.5	5.9	6.3	6.5	6.7
V2	7.4	7.7	7.9	7.5	8.1
V3	4.6	5.1	5.3	4.9	4.7
V4	5.0	5.8	5.6	6.1	5.3
V5	6.7	6.2	6.9	6.8	6.0
V6	8.2	7.9	7.5	7.2	6.9

Practical 13

Formation of ANOVA table for Latin square design (LSD) and comparison of means using CD values

Latin Square Design

Example 1

Below are given the plan and yield in kg/plot of a 5x5 Latin square experiment on the wheat crop carried out for testing the effects of five, manorial treatments A, B, C, D, and E. 'A' denotes control.

B	15	A	8	E	17	D	20	C	17		R1	=	77
A	9	D	21	C	19	E	16	B	13		R2	=	78
C	18	B	12	D	23	A	8	E	17		R3	=	78
E	18	C	16	A	10	B	15	D	23		R4	=	82
D	22	E	15	B	13	C	18	A	10		R5	=	78

C1 = 82, C2 = 72, C3 = 82, C4 = 77, C5 =80 ; GT = 393

Analyze the data and state your conclusions.

Solution

CF= $GT^2/(r \times c)$ =6177.96

Total SS= $15^2+8^2+\ldots.+10^2$-CF = 483.04

SS due to rows= $(77^2+78^2+\ldots+78^2)/t$ -CF = 3.04

SS due to columns= $(82^2+72^2+\ldots+80^2)/t$ -CF = 14.24

SS due to treatments:

Treatment A T_1	Treatment B T_2	Treatment C (T_3)	Treatment D (T_4)	Treatment E (T_5)
8	15	17	20	17
9	13	19	21	16
8	12	18	23	17
10	15	16	23	18
10	13	18	22	15
Total 45	68	88	109	83

SS due to treatment= $(45^2+68^2+\ldots+83^2)/r$ – CF = 454.64

SS due to error= TSS-SSR-SSC-SST = 11.12

ANOVA table:

Source of variation	**Df**	**SS**	**MS**	**Variance ratio F**	**F value at 5% level & 1% level**
Rows	4	3.04	0.76	123.34**	3.26 5.41
Columns	4	14.24	3.56		
Treatments	4	454.24	113.66		
Error	12	11.12	0.92		
Total	24	483.04			

** Highly significant

The observed highly significant value of the variance ratio indicates that there are significant differences between the treatment means.

S.E. of the difference between the treatment means (SED) = $((2*0.92)/5)^{1/2}$= 0.61

CD= SEd*t 5% at df = 0.61*2.179=1.33

Treatment means will be calculated from the original table on treatment totals.

Treatments	A	B	C	D	E	CD 5%
Mean yield in kg / plot	9.0	13.6	17.6	21.8	16.6	1.33

Conclusion represented symbolically

The treatments have been compared by setting them in the descending order oftheir yields.

Treatments	D	C	E	D	A	CD 5%
Mean yield in kg / plot	21.8	17.6	16.6	13.6	9.0	1.33

The treatment 'D' is the best of all. The treatments 'C' and 'E' do not differ significantly each other.

The yield obtained by applying every one of the manurial treatment is significantly higher that obtained without applying any manure.

Homework

1. An oil company tested four different blends of gasoline for fuel efficiency according to a Latin square design in order to control for the variability of four different drivers and four different models of cars. Fuel efficiency was measured inmiles per gallon (mpg) after driving cars over a standard course.

Fuel Efficiencies (mpg) For 4 Blends of Gasoline

(Latin Square Design: Blends Indicated by Letters A-D)

	Car Model			
Driver	**I**	**II**	**III**	**IV**
1	**D** 15.5	**B** 33.9	**C** 13.2	**A** 29.1
2	**B** 16.3	**C** 26.6	**A** 19.4	**D** 22.8
3	**C** 10.8	**A** 31.1	**D** 17.1	**B** 30.3
4	**A** 14.7	**D** 34.0	**B** 19.7	**C** 21.6

Analyse the data and draw yor conclusion.

2. The numbers of wireworms counted in the plots of Latin square following soil fumigations (L,M,N,O,P) in the previous year were

	Columns				
Rows	P(4)	O(2)	N(5)	L(1)	M(3)
	M(5)	L(1)	O(6)	N(5)	P(3)
	O(4)	M(8)	L(1)	P(5)	N(4)
	N(12)	P(7)	M(7)	O(10)	L(5)
	L(5)	N(4)	P(3)	M(6)	O(9)

Analyse the data and draw your conclusions.

PRACTICAL MANUAL

Livestock and Poultry Management

B. Sc. 3rd Semester

(309)

INDEX

EXERCISE-1

Study of Body Parts and Points of Cattle, Sheep, Goatand Their Significance

Objectives:

A person working with animals should have proper knowledge of thedifferent parts of the animal body for the following reasons:

1. To judge the utility of animal. Degree of development of certain parts of the animal body has relationship with the usefulness of the animal e.g. size of the udder and milk production in lactating animals, development of legs and ability to work in working bullocks etc.
2. The knowledge of external anatomy or body parts is essential for classification/recognition/registration of breed of animal.
3. For giving exact information and communication at the time of sickness, injury, theft, sale and purchase of animal etc.
4. To know about the sex as well as the general health/sickness of the animal.
5. The student must be acquainted with different terminologies of animal body parts.

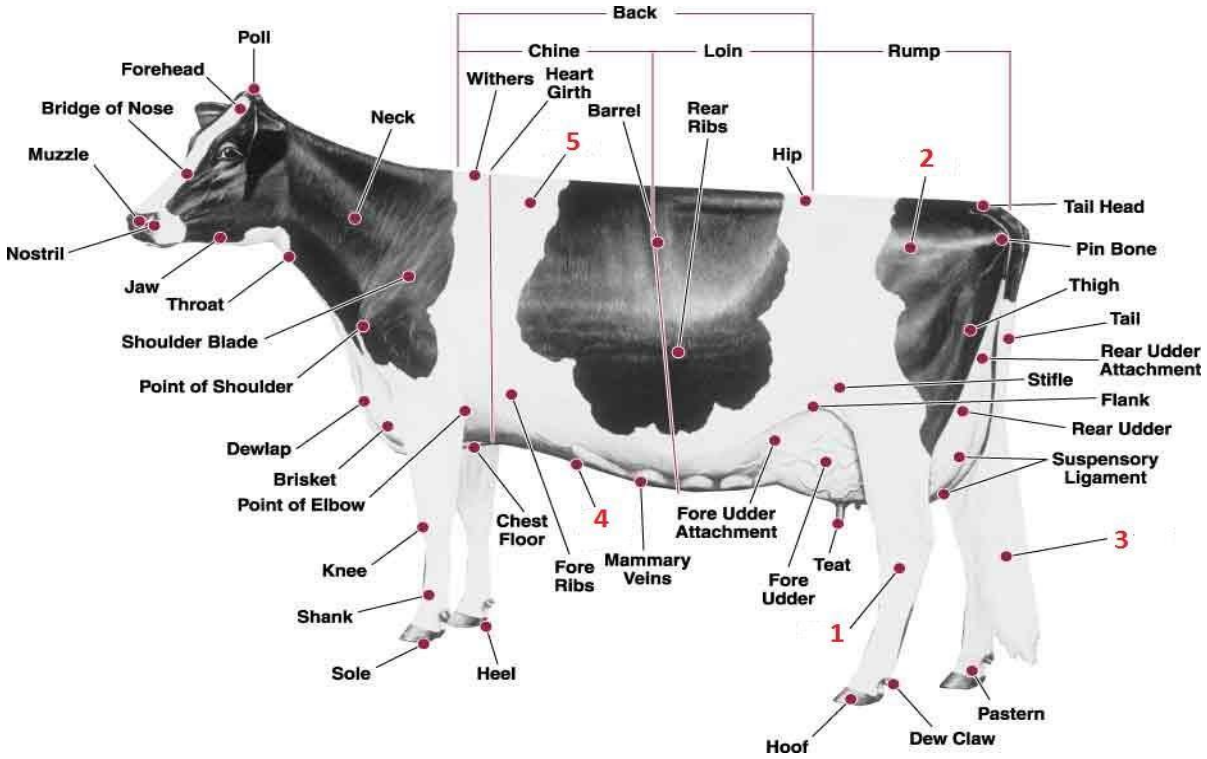
   For the convenience and ease of understanding the body parts, the cattle/animal's body is arbitrarily divided into five regions, viz.

(A) Head
(B) Neck
(C) Body or Barrel
(D) Fore limbs or Fore quarters and
(E) Hind limbs or Hind quarters.

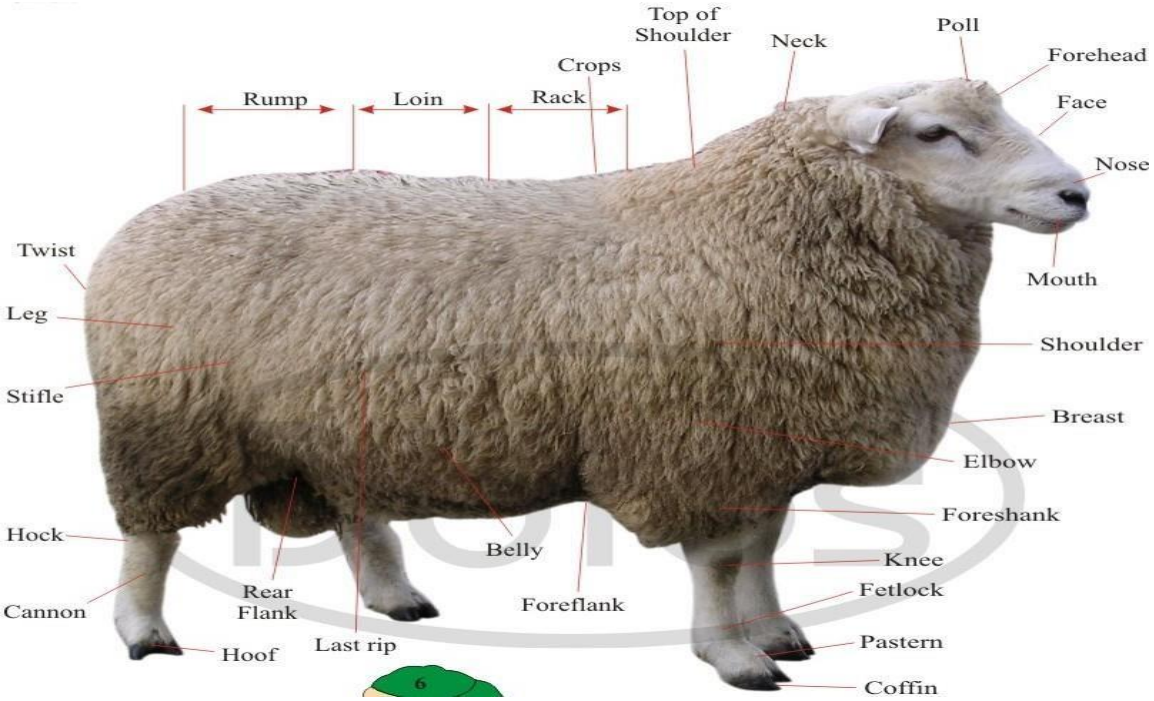
(A) Head :

1.	Mouth	:	Lips, tongue, teeth, jaw and dental pad, organ of prehension.
2.	Horn	:	Generally black in young age and yellowish black in old age. In some breeds they are pinkish yellow. The rings are present on horn. (A) Tip of the horn (B) Base of the horn.
3.	Head crest	:	The portion between the bases of horns.
4.	Fore head	:	The portion situated below the head crest and above the level of two eyes.

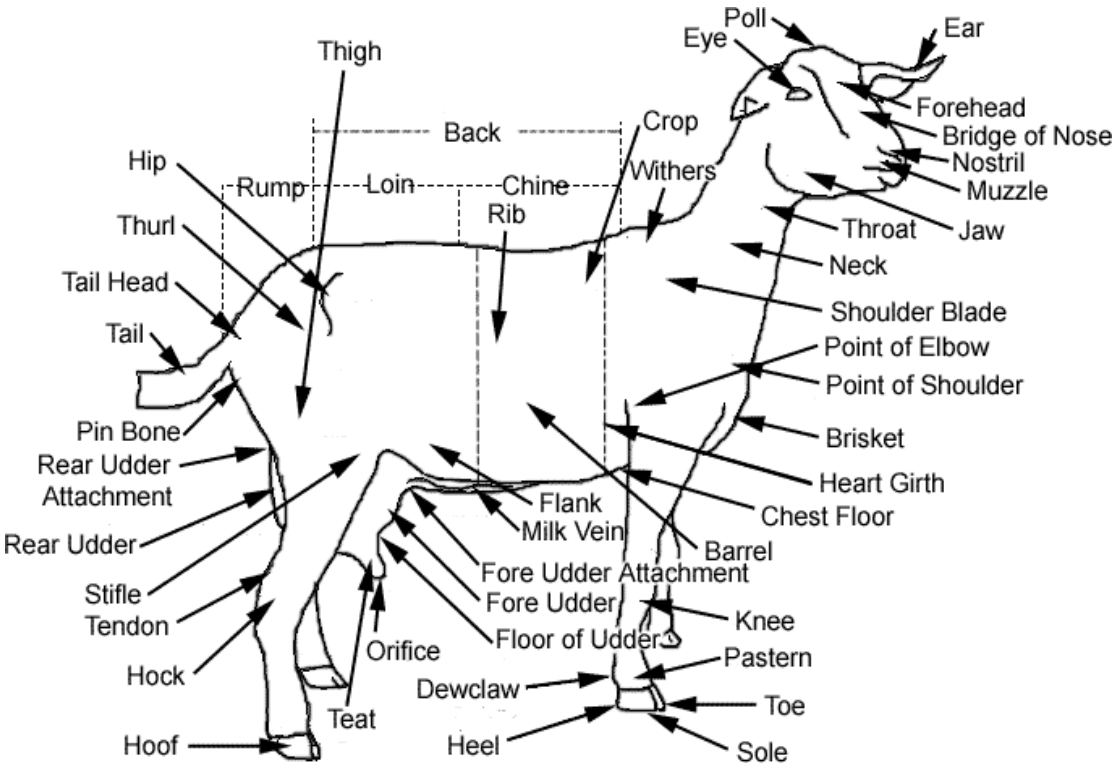
5.	Face	:	It is the portion below the level of two eyes up to the muzzle.
6.	Poll	:	It is the bulging portion situated at the middle top centre of the fore-head.
7.	Cheeks	:	Lateral portion of the face below the eyes on both the side.
8.	Chin	:	Portion below the lower lip. It is fleshy and pink in colour.
9.	Muzzle	:	The projecting part of the head including the mouth, nose and jaws.
10.	Muffle	:	Fleshy bare part of the upper lip and nose. Generally it is black. In some breeds it may be pinkish or spotted. It is wet with droplets of water in healthy animals. It has specified line and marking into muzzle print.
11.	Nose	:	It has two nostrils.
12.	Eye	:	Eye brows, eye lids, eye lashes and eye ball.
13.	Ear	:	Tip of the ear, fringe of the ear and base of the ear. They are erect to pendulous in shape.



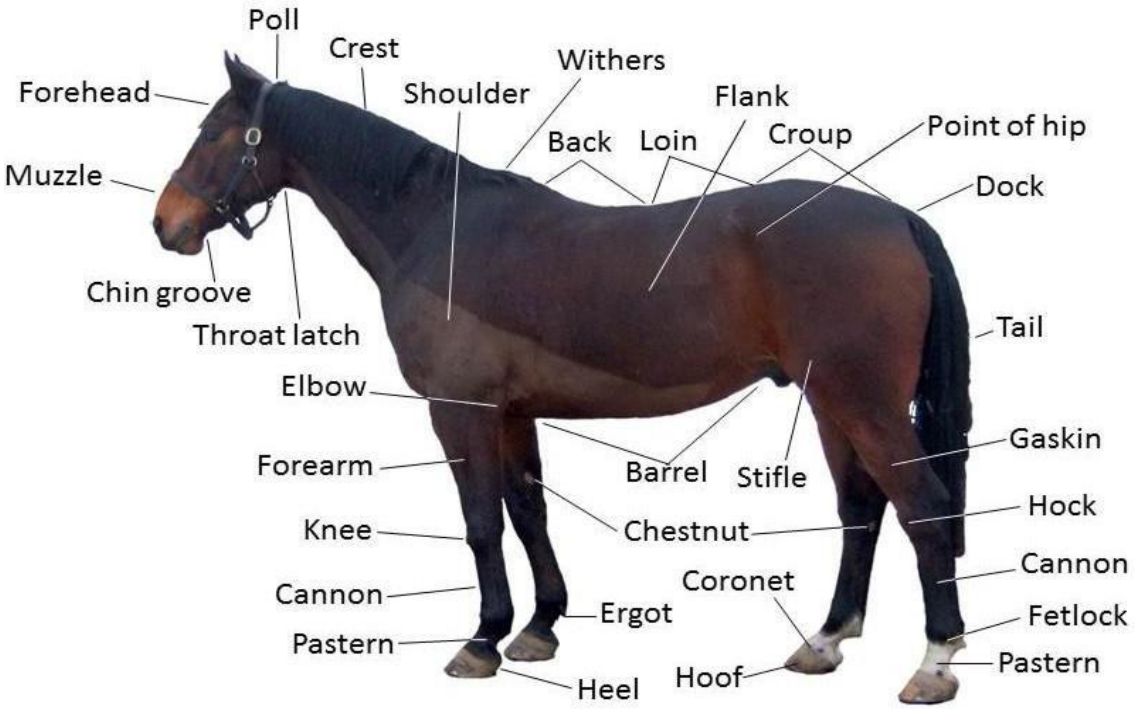
External Body Parts of Cattle



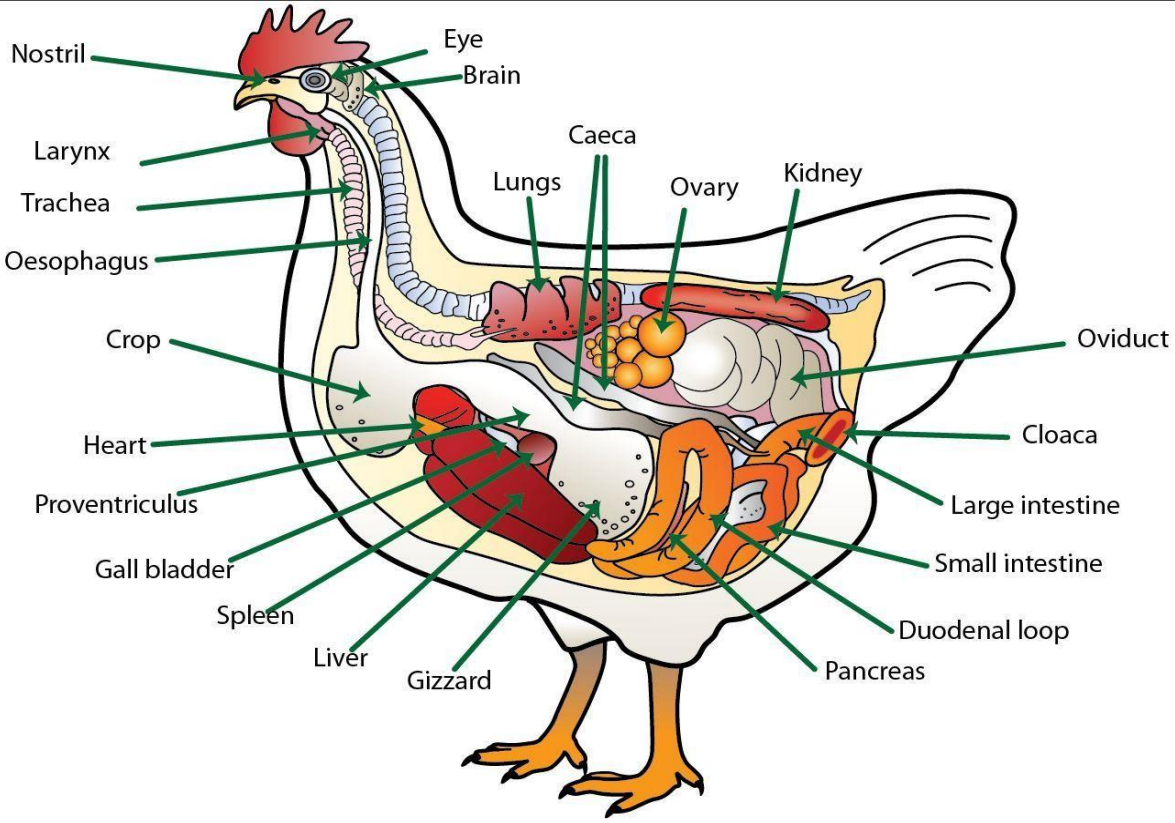
External Body Parts of Sheep



External Body Parts of Goat



External Body Parts of Horse



Body Parts of Chicken/Poultry

The External Body Parts of a Cow:

(B) Neck :

1.	Neck crest	:	It is the upper portion of the neck between head crest and hump/points of withers. It is the portion where yoke is placed in bullocks.
2.	Dewlap	:	A hanging loose, wavy fold of skin between chin and brisket. It is more developed in tropical breeds of cattle and helps in heat dissipation. European cattle possess less developed dewlap.
3.	Brisket	:	A fleshy bulging mass between and in front of the fore limbs.
4.	Jugular groove	:	A groove running down the neck above the wind pipe.

(C) Body or Barrel :

1.	Hump	:	The bulging fleshy mass between neck crest and back.
2.	Point of withers	:	Point just behind the hump located between the two shoulder blades.
3.	Back	:	Portion between point of withers and the last ribs.
4.	Loins	:	The triangle formed by joining the head of last ribs to the two hook bone.
5.	Sacrum	:	Portion from middle point of two hook bone and ending near the croup or root of tail.
6.	Rump	:	Sloppy/encircling portion on either side of the croup between the hook bone and pin bone.
7.	Hook-bone	:	It is the prominent bone on either side of the root of tail (tuber ischii).
8.	Pin bone	:	It is also the prominent bone on either side of the root of tail (tuber ischii).
9.	Tail	:	A distinct flexible appendage extending from the rear end of the animal's body.
10.	Switch	:	Bunch/tuft of hair at the end of the tail.
11.	Chest	:	Portion between two fore limbs just behind the point of elbow.
12.	Heart girth	:	The circular measurement around chest.
13.	Ribs	:	Thirteen pairs.
14.	Hollow of the	:	The depression of the abdominal cavity between

	flank		last rib and hook-bone which is triangular in shape.
15.	Flap of the flank	:	Thick skin hanging between hind limb and abdomen.
16.	Navel	:	Point on the lower side of the belly, left by dropping off the navel cord through which embryo receives nutrition and oxygen from the mother and gives off the waste products.
17.	Udder	:	Structure containing mammary glands of cows. It has four quarters each having one separate teat. Degree of development of udder generally shows the capacity for production of milk. The teats are well placed at equal distance, shows even development of udder.
18.	Milk vein	:	Situated on either side of abdomen between udder and milk well. It is zigzag and carried impure blood from the udder to the heart.
19.	Milk well	:	It is point on either side of the chest where the milk vein enters into the body cavity.
20.	Milk mirror	:	The bare yellowish portion extending from below the vulva up to the udder.
21.	Anus	:	Posterior opening of the alimentary canal.
22.	Vulva	:	External female uro-genital organ reflect that female is in heat or not.
23.	Supernumerary teats	:	Extra teats which are non-functional. They may be removed.

(D) Fore Quarters :

1.	Shoulders	:	Portion between the points of withers and point of shoulder.
2.	Point of shoulder	:	It is a prominent joint of shoulder situated between point of withers and the elbow joint.
3.	Arm	:	Portion between point of shoulder and point of elbow.
4.	Fore arm	:	Portion between elbow joint and knee joint.
5.	Knee joint	:	Joint between fore arm and shank.
6.	Cannon	:	The portion between knee joint and fetlock joint.
7.	Fetlock	:	Joint between the shank and pastern.

8.	Pastern	:	Round portion between the fetlock joint and coronet.
9.	Coronet	:	Hairy streak just above the hoof.
10.	Hoof	:	It has two digits, black in colour in case of cow and buffaloes. The space between the two digits is known as interdigital space.
11.	Dewclaw	:	Rudimentary hoof, two in number on each leg.

(E) Hind Quarters/Limbs :

1.	Point of hip or hook bone	:	The external angle of ileum occurs as a boney prominent on either side of loin.
2.	Hip joint	:	The prominence formed over the hip joint by the greater trochanter of the femur.
3.	Stifle	:	The joint between femur, patella and tibia. Situated between hip joint and hock joint at the flap of flank.
4.	Thigh	:	The region between the hook bone and pin bone on upper side and hock joint on lower side. 1) Upper thigh – Portion up to stifle. ii) Lower thigh – Portion from stifle to hock joint.
5.	Hock joint	:	The complex joint formed between lower thigh and cannon. It is made due to union of tibia and fibula, bones of hock and metatarsal.
6.	Hock point	:	The upper most extremity of the hock joint.
7.	Tendo-Achilles	:	The large tendon attached to point of hock. The milk man's or achilles tendon rope is tied on the tendon of the cows to prevent kicking or hamstring while milking. Parts below the hock joint are similar to those found in fore quarters.

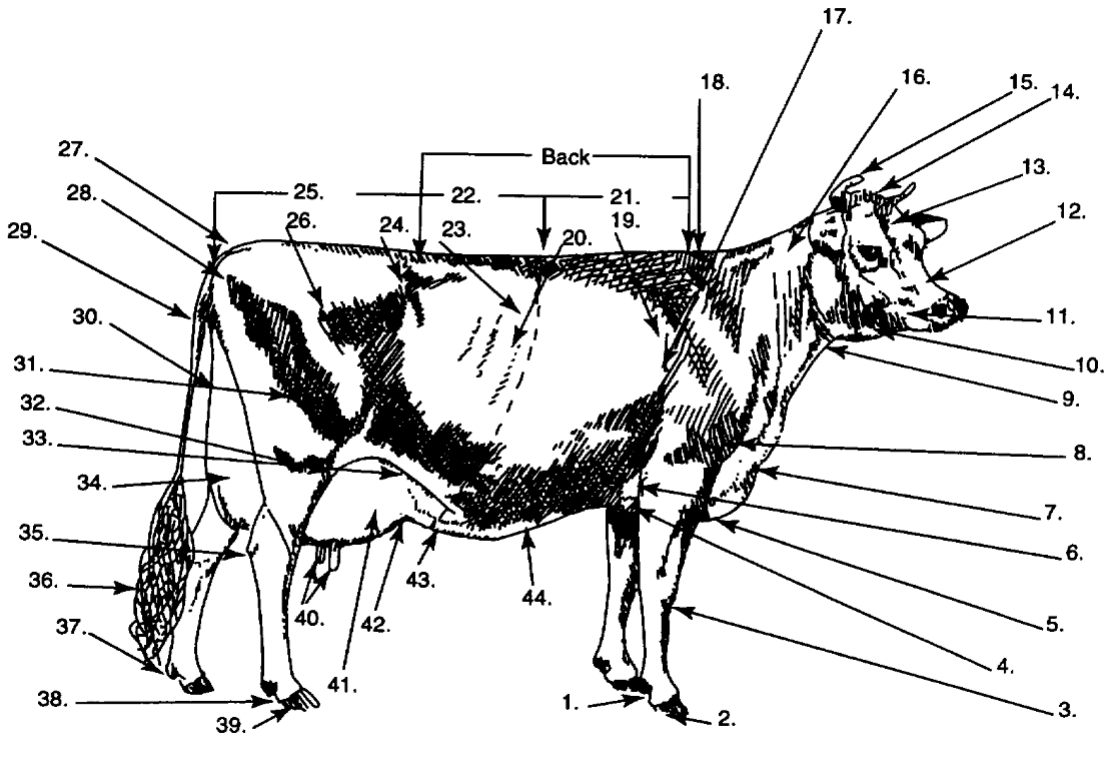
Points of Bull/Bullock :

1.	Scrotum	:	It is pouch in which testicles are situated.
2.	Testicles	:	Two in number, found inside the scrotum and produce sperms.
3.	Penis	:	Male uro-genital organ of copulation.
4.	Sheath	:	Outer covering of the penis.

Questions:

1. Draw the figure of cow and goat and point out the different body parts.
2. Write the importance of muffle, neck crest, hollow of the flank and udder animal.
3. Enlist the joints of fore and rear quarters of animal.
4. Differentiate the male and female animals from their body parts.
5. Identify and enlist the different body parts (Point 1 to 44) of the below given cattle.

Identify the Body Parts of a Dairy Cow



1. **Heel**
2. **Sole**
3. **Knee**
4. **Chest floor**
5. **Brisket**
6. **Point of elbow**
7. **Dewlap**
8. **Point of shoulder**
9. **Throat**
10. **Jaw**
11. **Muzzle**
12. **Bridge of nose**

EXERCISE-2

Measuring and Weighing of Farm Animals

Introduction:

The weight of farm animals can be work out without weighing machine. For which we have to measure the heart girth (circular measurementaround the chest taken from the point of withers and passing just near thepoint of elbow) and body length (from point of shoulder to the pin bone in bovine or point of buttock in horse) of animals. The height, length and weight of animals are essential for identification.

Objectives:

- To compare the growth rate of animals of various breeds or geneticgroups.
- To compare the relative growth of body parts and as a result to estimatethe utility of animal.
- To calculate the feed requirement and dose of medicines.
- It helps in classification of breeds.

Methods of Weighing:

The adult animals usually weighed every fortnightly, before offeringany water, feed etc. early in the morning by following ways:

(a) Weighing Bridge:

The animal is allowed to stand on the platform of the weighing bridgeand it expresses the body weight in kilogram. Usually used for large animals.

(Weighing Bridges for Large Animals)

(b) Spring Balance:

The small animals like newborn calf, kids etc. may be weighed with thehelp of spring balance.

(Different Types of Spring Balance)

(c) Platform Balance:

Small ruminants and pigs can be weighed by using the platformbalance.

(Platform Balance)

(d) Table Balance:

It can be used for recording the weight of poultry, rabbits, guinea pigsetc.

(Table Balance)

(B) Indirect Method: By Using Formula

(a) Cattle and Buffaloes:

(i) Shaffer's Formula:

It is commonly used for cattle and buffaloes and weight is expressedin pounds (2.2 lbs = 1.0 kg).

Body weight (W) = L X G^2/300

Where, W = Weight of animal in pounds
L = Length of animal in inches
G = Heart girth in inches

(ii) Minnesota Formula:

The body weight of an animal is expressed in kilogram.

Body weight (W) = L X G^2/600

Where, L = Length of body in inchesG = Heart girth in inches

(iii) Aggrawal's Formula for Indian Cattle:

Body weight (Seers) = L X G/ Y

Where, G = Heart girth in inches
L = Body length (inches)
Y = 9.0, if girth is less than 65 (inches) Y = 8.0, if girth is more than 80 (inches)

(One seer = 0.93 kg)

(iv) Mullick's Formula for Buffaloes:

Body weight (lbs.) = 25.156 (Y) – 360.232

Where Y = Heart girth in inches

(v) Bhandari and Others Formula:

(i) For Lactating Buffaloes:

Body weight (lbs) = - 2387.60 + 27.12 (G) + 24.55 (L)

(ii) For Dry Pregnant Buffaloes:

Body weight (lbs) = - 1934.45 + 20.52 (G) + 25.90 (L)

Precautions while taking the body weight:

(i) The animals of average body size should be selected.

(ii) The animals should be stand on leveled floor having equal weight onall four legs.

(iii) When the animal is passing urine/dung, measurements

should not betaken.

(iv) The animal should be in a normal posture without unduly stretching orcontracting any part of the body.

Questions:

1) Why body weight of individual animal should be recorded?

2) What precautions should be taken for measuring the body length and heart girth of an animal?

3) Mention the advantages and disadvantages of direct and indirect method of body weight measurement?

4) A cow body length is 80 inches and heart girth is also 70 inches, calculate the body weight of cow by using Shaffer's formula, Aggrawal's formula and Minnesota formula respectively in their respective units of measurements.

5) A cow body length is 90 inches and heart girth is 65 inches, calculate the body weight of cow by using Shaffer's formula, Aggrawal's formula and Minnesota formula respectively in their respective units of measurements?

6) Mention the different balances used for taking body weight of an animal by direct method?

EXERCISE-3

Use of Common Restraints Used in Different Animals

Objectives:

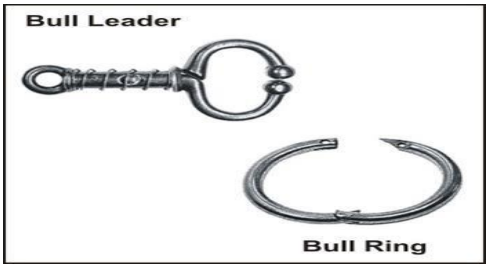
While taking work from farm animals or while milking, treatment, castration, applying identification mark, it becomes necessary that some of their activities or undue movement can be prevented. This process is called restraining and the contrivances/devices used for these purposes are called restraints. Some of the common restraints are as follows.

Muzzle **:** Muzzles are used to prevent cattle; horses etc. eating their beddings, calves suckling their mother or bullocks eating grasses while inter culturing. There are two kinds of muzzle

1. Wire muzzle or Coir muzzle
2. Leather box muzzle.

Bull-nose ring **:** They are used for restraining powerful bulls. They are generally made in the semi-circular pieces joined together. They are made from non-rusting metals like steel, aluminum or brass. A hole is first punched with the help of bull nose punch in the nasal septum and then bull nose ring is fixed.

Bull leader



: It is a long stick with sliding hook at one end and used to control the bull from close distance when applied on the bull nose ring.

Side stick : A specially prepared stick of desired length with ropes on either end or a simple strong-stick may be used for this purpose. It is tied at one end with the halter and the other end is held in a position by means of ropes. Side sticks are used to prevent animals licking medicines applied on the limbs and suckling their milk by her.

Mouth gags : Gags are devices for keeping the jaws of animals apart for examination of mouth. Drinking pattern mouth gag is most suitable for cattle, other mouth gag (i.e. Vernell's mouth gag, Butler's mouth gag, wooden mouth gag etc.) are also used for introducing the cattle probing.

Milk man's rope : It is applied by passing a thin rope around the joint of hind legs together and finally making a quick release knot of the free ends towards milker for milking.

Nose-peg : It is made from wood having one end button shaped and other long end pointed with a round groove at central bar and used for restraining camels.

Travis or crush : These are made of hard seasoned wood or metal tubing to restrain the animals in standing position. Now a day's Travis for large animals are available in various designs for specific use.

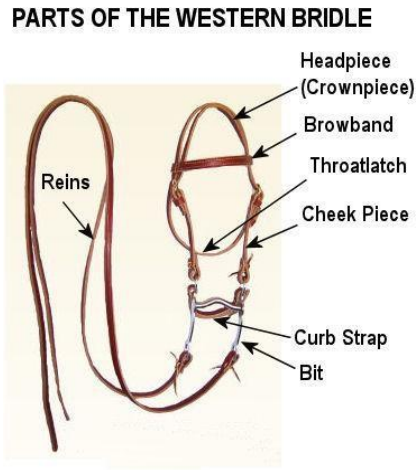
Halter : Halters are made up of leather, but for farm animal's simple rope can be used.

Nose string : A thin cotton rope is passed through the hole made in nasal septum and behind the base of horn. Then both end of the rope is tied.

Twitch : A twitch consists of a piece of stout wood about one meter long carrying a hole at one end. A loop of piece of rope is inserted through this hole. For applying a twitch, the horse should be haltered and held by an assistant. The rope is applied on the muzzle with left hand while holding the stick with right hand. After adequate grip on upper lip, twists up the loop by means of stick.

Cradle : Ten or twelve pieces of wood are arranged on two pieces of cord. Two short pieces of wood board longitudinally are kept on either side of long pieces. It is useful to prevent a horse getting his head to a fore or hind limb in cases of blistering or wounds. It allows very little vertical or lateral flexion of head.

Bridle : It is driving harness for a horse. It is made up of leather with iron-bit which acts as a mouth-piece. There are various types of bridles available for special purposes.



Questions:

1) Sketch the different restraints used in restraining animals.
2) Enlist the common restraints used for restraining of bulls.
3) Name the animals in which nose string and nose ring are used along withthe method of application for restraining.
4) Enlist the common restraints used for restraining of horse along withmethod of application.
5) Define restraints and restraining.
6) Justify: Restraining of bull is more difficult than cow.

EXERCISE-4

Systems of Identification of Livestock

If a herdsman has only few animals, recognizing each animal separately is possible for differentiating them according to their external appearance. But when the number is large, some systematic method of identification is necessary.

Objectives/Importance:

1. Identification of farm animals is essential for efficient routine management viz., breeding a cow in estrus, treatment of sick animal, recording milk production of animals etc.
2. It is necessary for registration as well as for insurance of livestock.
3. In case of loss or theft of animals, identification marks are useful.

Systems of Identification:

1. Name:

Name can be given to the animals after the place of purchase, owner, from physical appearance or on the names of rivers, gods etc. Generally this system of naming is used along with other systems of identification. This system is useful for small number of animals only while not applicable in large herd or flock.

2. Marking or Numbering:

Name alone is inadequate for large herd or flock for identification purposes. For this reason, system of giving identification marks or numbers should be followed.

(a) Tattooing:

This consists of piercing small letters and/or figures by steel points into the subcutaneous tissue by means of tattooing fork. The steel points carry small amount of tattooing ink into the subcutaneous tissues.

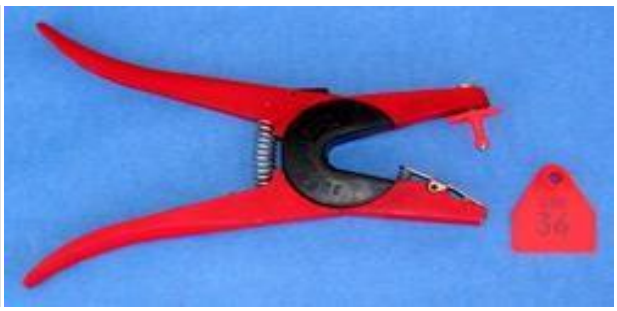
The part to be tattooed should be thoroughly scrubbed with methylated spirit to remove grease and debris. Tattooing ink is applied over the parts. The desired number or figure fixed to the tattooing ink is applied over the parts. The desired number or figure fixed to the tattooing fork is then firmly pierced. The ink is rubbed on the pierced mark of the part with the thumb. The inner surface of ear is most suitable site for tattooing. A portion of the ear free from hair and devoid of major blood vessels is chosen. Tattooing can be done underneath the root of tail, escutcheon or on inner surface of lips or on the

gums; if necessary. Tattooing number is used for new born calves, foals,lambs, kids etc.

(Tattooed Dog) **(Tattooing ink with tattooing fork)**

(b) Ear Tagging:

Tags are small metal or plastic plates like labels which can be readily inserted on the ears of young animals. Tags bear number of the animal and name of the farm. Tags are fixed to the ear with the help of tagging forceps. Tagging is mostly used for marking sheep and goats. Though pigs and young calves can be tagged, the marking site of the tag should be on the top of ear. Some antiseptic should be applied to the wound for healing.



(Ear Tags with Ear Tag Applicator)

(c) Ear Notching:

This method is mostly used to mark pigs at a commercial farm. It comprises of cutting 'V' or 'U' shaped notched at specified places along the borders of ears. Notches may be made by means of special ear notching or sharp scissors.

Coded series for ear notches are used for identification, for thisreason, one must decide suitable coding system for his farm.

(Ear Notching in Pigs)

(d) Branding:

It consists of searing a number on skin, hooves or horns. Branding is most suited for marking cattle, buffaloes, camels etc. Calves should be branded at the age of one year. Branding is done by means of metal numbers specially made for this purpose. It is usual practice to brand the animal on shoulder and thigh or horns or hooves. Branding preferably is done during thewinter season.

(i) Hot Branding:

The iron numbers fixed to wooden handle are heated in fire and are branded on the thigh or shoulder so that roots of hair will die. These numbers can be read throughout the life of an animal.

(ii) Cold Branding:

In this method the metal (brass) bumpers are dipped in a liquid popularly known as branding oil or branding ink. The liquid has some corrosive substance in its composition which acts as a burning agent. These numbers gone away after a year or two.

(Hot Branding Iron Rod) (Cold Branding Iron Rod)

(iii) Freeze Branding:

In this method the branding iron is frozen at -196^0 C or at -70^0 C by liquid nitrogen or carbon dioxide. Here the hair turns white.

(e) Number Plates:

Plates of various shapes and sizes bearing the name and address of the owner and number of the animals are placed around the neck of animal by means of neck strap or neck chain. Sometimes such plates are also fixed around the base of the horn. Such plates are largely used for dairy cattle and buffaloes.

(f) Wing and Leg Bands:

These are very light, adjustable aluminum colored numbering strips. These are mainly used for identification of birds. Wing bands are inserted through a slit made in the skin near the edge of wing. Leg bands are appliedon the legs with a slight free movement, if properly adjusted. There are practically little chances of their loss.

(Birds with Wing Tag)

(g) Toe Punching:

Small holes are pierced in the webs of the feet of chicks after hatching.

These marks are used for group identification in ducks.

(h) Colour Marking:

The colours are painted/spread on different body parts of animal. This is commonly used in sheep, goats, camels and donkey for group identification. This method is very simple and cheap.

(Colour Marking in Goat)

(i) Electronic Chip:

It is the electronic silicon chip that can be fitted at the shank region or at neck region by putting incision on skin and muscles at the part and remain for throughout the life. The electronic identity gives detail and record the information about the animal regarding different farm activities (milking, breeding).

Questions:

1) Enlist the methods of identification commonly used for each of the following: Cattle, Buffalo, Poultry, Duck, Sheep, Goat, Camel and Donkey.
2) State the procedure of tattooing and ear tagging in calf/foal.
3) What precautions will you take while branding an animal?
4) What precautions will you take after branding an animal?
5) Write the complete procedure of hot and freeze branding.
6) Write the complete procedure of ear notching in pigs.
7) What are the advantages of Colour marking method of identification?

EXERCISE-5

Methods of Determination of Age in Farm Animals

Importance/Objectives:

Ageing means to determine the approximate age of an animal, which hasfollowing importance.

1. Age is essential for assessing the productive value/life of animals. The performance of animal is best when it is young. Age directly shows relative productive value of an animal.

Average Useful/Productive Life Span of Different Species of Livestock:

Species	Cow/ Buffalo	CB Cow	Bullock	Horse	Sheep	Poultry
Productivelife (years)	4 to 15	2.5-15	3-14	3-15	1-6	1-2

2. Certificate: While issuing certificate for soundness or vaccination etc., age is to be mentioned in the certificate.

3. Medico-legal issues: In case of injury, fatal accidents. Illicit slaughter, disputes, theft, veterinarian has to give evidence, witness certificates etc. For these purposes age of animals has to be ascertained.

Methods of Determination of Age:

1) Outward appearance (cattle & buffaloes)
2) Counting rings on the horns (cattle)
3) Examine, type, number and degree of wear and tear of teeth.

1. Outward or General Appearance:

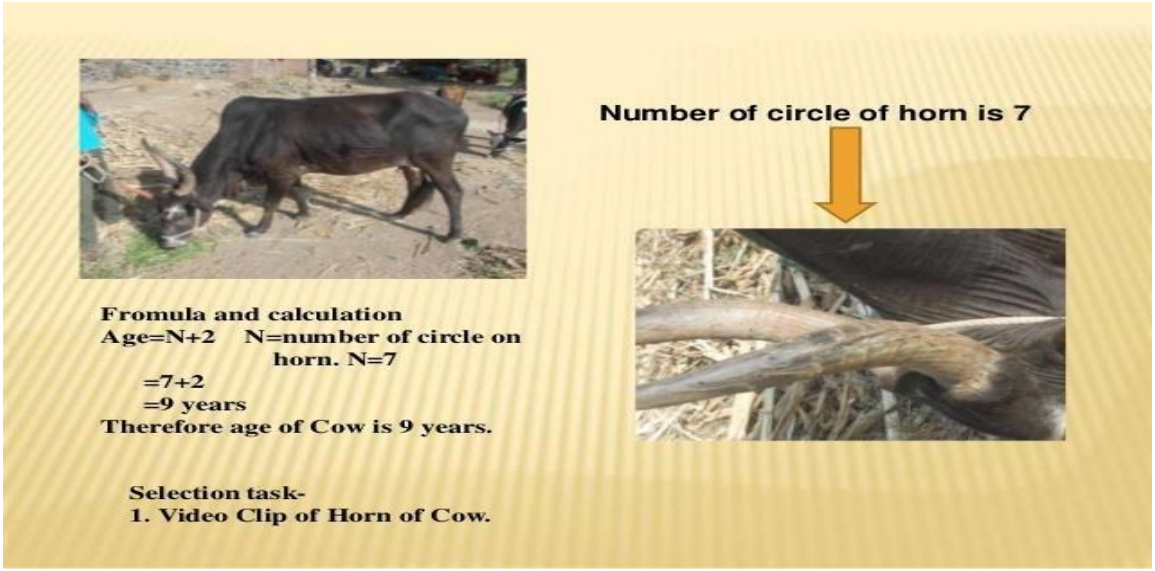
Size of animal, size and shape of horns, skin and hair coat, udder and teats and general alertness are indicative of its age. Immature animals areshort and small. The degree of their growth indicates the age. In young animals, skin is tight, shining smooth and glossy. As the age advance, the skin becomes loose and wrinkled, hair becomes dull and rough. Size and shape of udder and teats in female also indicates the age. Young animals have tight udder and relatively smaller teats. As age advance, udder becomes loose and pendulous and teats become longer. Young animals are active and alert. They respond immediately to any stimulus like any sharp sound etc. With advancement of age the animal looses activeness and alertness.

Limitations:

It requires a lot of practice and experience for fairly precise estimation of age. Well cured and well fed animals look younger than what they are and vice-versa.

2. Counting of Rings on Horns:

It is observed that cattle develop one ring at the base of their horns when they are about three years old and then one ring every year thereafter. Hence counting the number of rings on the horns and adding 2 to it, to know the approximate age of the animals.



Limitations:

(i) This method can only be used for the horned animals.

(ii) It was observed that if the animals are not well fed, more than one ringmay appear every year. It leads to incorrect estimation of age.

3. Determination of Age by Examination of Teeth:

Animals have two types of teeth.

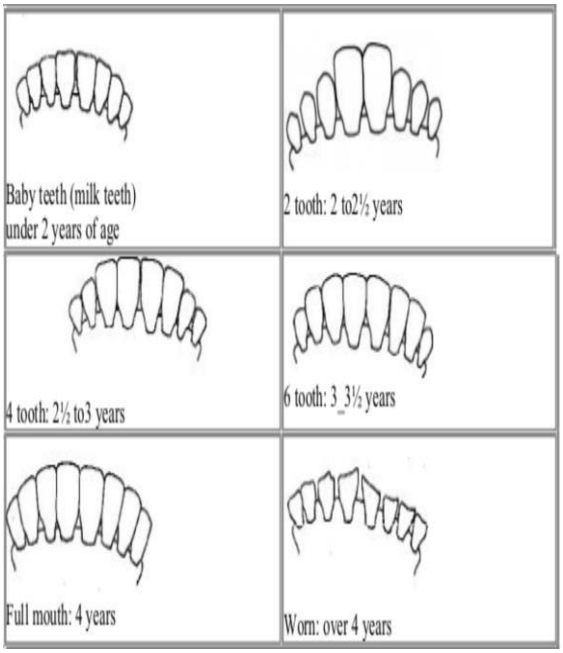
(a) Temporary

(b) Permanent teeth.

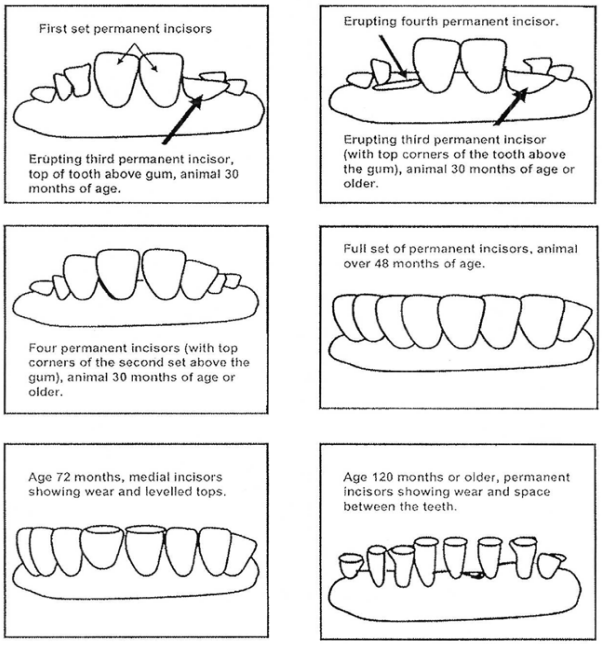
Incisors and premolars are temporary as well as permanent, while molars arepermanent teeth. Canine teeth are not present in ruminants.

Dental Formula of Ruminants
(Cattle, Buffalo, Sheep, Goats)

Temporary dentition
2 (I 0/4, C 0/0, PM 3/3) = 20
Permanent dentition
2 (I 0/4, C 0/0, PM 3/3, M 3/3) = 32



Cattle Teeth

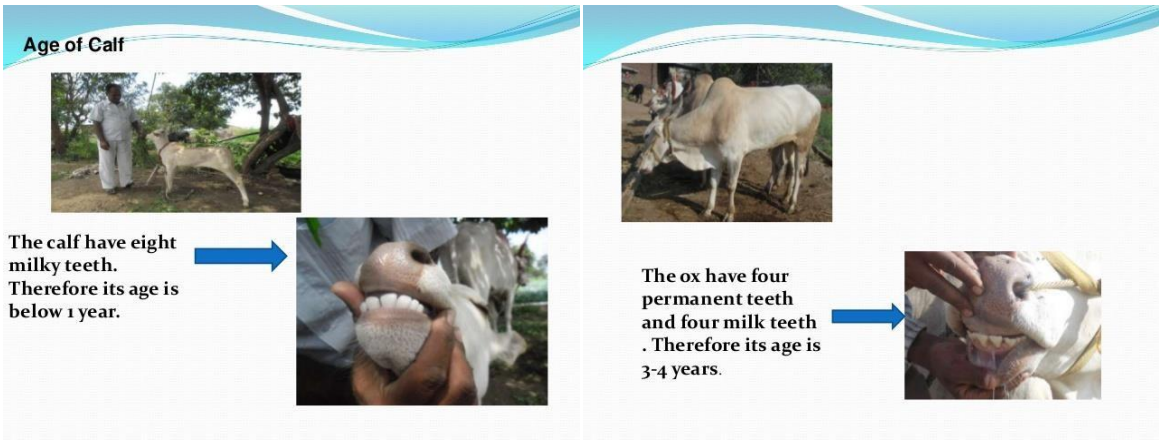


Dentition and Eruption Pattern

Time of Eruption of Temporary and Permanent Dentition in Cattle and Buffaloes:

Time of eruption	Incisors	Molars
Birth to one month	All 8 temp. present.	All 12 temp. (I, II, III pair).
At 6 months age	All 8 temps. present.	IV pair permanent erupts.
At 18 months age	All 8 temps. present. Slightly yellowish.	V pair permanent erupts.
At 24 months age	I pair permanent erupt.	VI pair permanent erupts. I and II temp replaced by permanent erupt.
At 36 months age	II pair permanent erupts.	III pair temp replaced by permanent.
At 48 months age	III pair permanent erupts.	All 24 permanent present.
At 60 months age	IV pair permanent erupts.	All 24 permanent present.

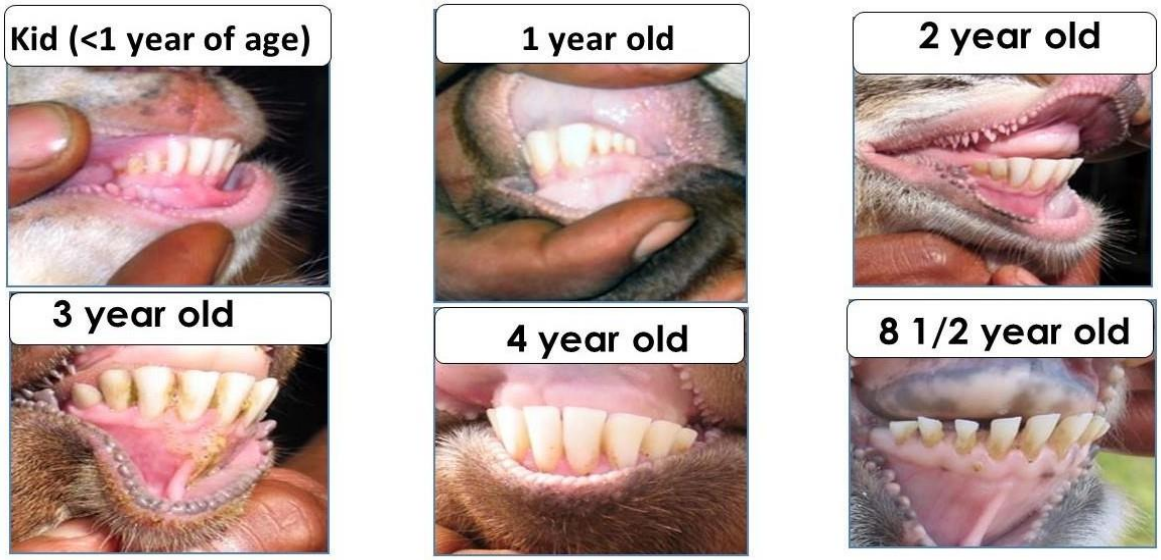
At five years of age, the animal is called **full mouth**. After five years the age of cattle is estimated by degree of wear of the teeth. At 10 years most of the crown is worn out and at 14-21 years only stamp of teeth remain.



Determination of Age by Observing the Pattern of Dentition

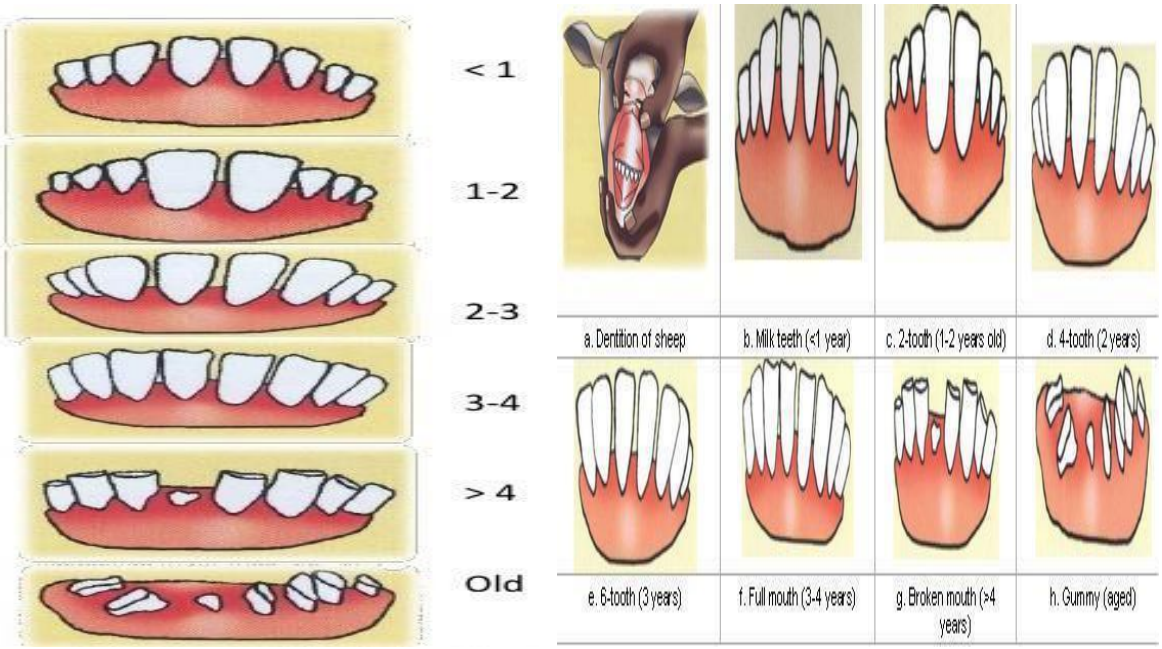
Time of Eruption of Temporary and Permanent Dentition in Sheep andGoats:

Time of eruption	Incisors	Molars
Birth – 1 month	All 8 temp. present.	All the 3 pair of premolar is present (I, II and III pairs).
3 months age	--	4th pair permanent erupts.
9 months age	--	5th pair permanent erupts.
15 months age	Central pair replaced by permanent.	--
24 months age	Medial pair replaced by permanent.	6th pair permanent erupts.
30 months age	Lateral pair (IIIrd pair) permanent erupts.	1st, 2nd, 3rd pair replaced by permanent.
36 months age	4th (corner) pair replaced by permanent.	--



Dentition Pattern and Age Determination in Goat

After 3 years the age can not be determined accurately but teeth become shorterand wider apart as the sheep or goat become older.



Mouthing Sheep and Goat for Age Determination

Broken Mouth: When a sheep loose one or more permanent teeth are called asbroken mouth.

Gummer: By about 18-20 years of age animals loses all the teeth are calledgummer.

Questions:

1) Write the age of full mouth cow and goat.
2) What is the difference between permanent teeth and temporary teeth?
3) Draw the dentition of permanent teeth in cows.
4) What is dental pad?
5) Write the dentition formula of calf and adult cattle.
6) Mention the different methods of ageing and explain.

EXERCISE- 6

Identification of Common Feeds and Fodders

Objectives:

To identify the feeds and fodders on the basis of chemical compositionand nutritional parameters

Introduction:

Livestock feeds are generally classified according to the amount of specific nutrients they furnish in the ration. An attempt is being made in this chapter to familiarize the students, to the important feed stuffs that are commonly used for feeding of ruminants and non ruminant animals. The various feeds and fodders can be divided into following

ROUGHAGES:

Roughages are bulky feeds having large amount (>18%) of crude fibre (less digestible material) and low total digestible nutrients (TDN <60%) content on DM basis.

Green/Succulent Roughages: Succulent feeds usually contains moisture from 60-90%, For the sake of convenience succulent feeds are again classified into 'pastures, cultivated fodder crops, tree leaves, silage and root crops.

a. Pastures: The word pastures refer to land on which different types of edible grasses and other plants grow or are grown for grazing livestock. Permanent pastures are those covered with perennial or self-seeding species of plants. Temporary pastures are those planted with quick growing crops like Sudan grasses and millet to provide supplemental grazing during lean season.

b. Cultivated Fodder Crops:

Leguminous: Leguminous fodder such as Cowpea, Berseem, Lucerne etc. belong to "Leguminosae" family and very palatable to the animals. Legumes contain 2-3% DCP and 12% TDN on fresh basis. If legumes are fed liberally to cattle and buffaloes then there is no need to incorporate the protein supplements in diet up to 6-7 litres of milk per day. Sudden changes in feeding from non- leguminous to leguminous and early morning feeding of leguminous fodder should be avoided to reduce the possibility of **bloat** due to accumulation ofgases in rumen.

Non leguminous: Contain lower percentage of nitrogen 0.5 to 1.0% DCP

and 11-15% TDN, these includes many cereal crops, cultivated grasses, indigenous grasses and introduced grasses e. g. Maize, Jowar, Bajra Oat etc.

c. Tree Leaves/Top feeds: Tree leaves are also fairly good source of nutrients and may serve as potential feed resource wherever feeds and fodders are in acuteshortage e.g. Babul, Luceana, Mulberry, and Banyan.

d. Root Crops: Root crops sometimes may be used as alternate feedstuffs during the natural calamity and scarcity period. They contain low crude fibre (5- 11 %). e.g. Tapioca, Turnips, Sugar beet, Carrot

e. Silage: Silage is an anaerobically fermented feed prepared from green fodder whenever the supply of green fodder is in plenty. It possesses all the charactersof green fodder and very high nutritive value.

Dry Roughages: Contains only 10-15% moisture. Dry roughages are dried plant materials, which are preserved for usage in summer and in adverse climatic conditions.

a) Hay: Leguminous crops harvested at pre-flowering or half blooming stage is air dried to reduce the moisture content < 15% and preserved in the form of hay. The moisture content of hay reduced to desirable level to check the enzymatic fermentation and fungal infestation during storage. Lucerne is best crop for hay making rather than berseem and cow-pea due to their hollow and thick stems, whereas under non-leguminous category oat is best crop for hay preparation. Due to high lignifications, different nature of fibre and less palatability of non leguminous fodder than the leguminous fodder, hay is generally not prepared from non leguminous fodder.

b) Straws/Stover: The crop residues left after harvesting the main product of crop (i.e. grains) are known as straws/stovers. Straws are deficient in protein, mineral, vitamins and energy. Due to its high crude fibre, low TDN and high degree of lignifications, strategic nutrients supplementation is pre requisite with straw feeding.

CONCENTRATES:

Generally contains less than 18% crude fibre and more than 60% TDN. These are less bulky and more digestible than roughages.

Energy rich concentrates: The crude protein is generally less than 20% in energy rich concentrates. These are also called as basal feeds.

a) Cereal Grains: Cereal grains are rich in soluble carbohydrates e.g. Maize, Barley, Rice, Oats etc.

b) Millets: eg. Ragi, Jowar and Bajra.

c) Mill by products: The by-products of milling cereal grains i.e. Bran (rice, wheat), flour, hulls, polishing and embryo of seeds are used as a part of concentrate mixture.

d) Molasses: By product of sugar factories used in feeds as binding agent forpelleting and as readily available source of soluble carbohydrates.

e) Roots and tubers: e.g. Roots - turnip, sugar been, carrot.Tubers - potato, sweet potato.

Proteins rich concentrates: The crude protein is more than 20% in protein richconcentrates.

a) Plant origin: Oil seed cakes, pulses, pulse chunni, pulse churi, Brewer's yeast and grains etc.

b) Animal origin: The by-products of slaughter houses i.e. meat, blood and bones are dried and made in to powders to be mixed in concentrate feeds. e.g. Meat meal, meat cum bone meal etc. The marine by-products are also used as animal protein source for feeding of livestock eg. Fish meal. Poultry-by-product meal can also be used for livestock feeding.

FEED SUPPLEMENTS:

Mineral Supplements:

Those supplements which are given to the animals for providing the major or minor minerals in desired quantity. Many mineral mixtures are marketed under the different trade names. Generally, salt, calcium carbonate, zinc sulphate and copper sulphate supplements improve production and reproduction.

Vitamin Supplements:

Various Vitamin supplements for poultry, pigs and cattle are marketed in India under different names. For poultry vitamin A, B and D synthetic vitamin supplements are marketed.

FEED ADDITIVES:

Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as pH shift, growth or metabolic modifier. These are the products used for the purpose of improving the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health, e.g. providing enhanced digestibility of the feed materials.

Hormones: Some of the hormones have growth promoting properties like estrogens, androgens, progestogens, thyroxine and pituitary growth

hormones. Synthetic estrogenic hormones like stillbestrol and hexestrol are being used in many countries as growth promoters. There are certain side effects in the animals fed on synthetic hormones, like restlessness, milk secretion from rudimentary teats, etc.

Probiotics: Many microbial feed additives for animals have been used which include bacterial and/or fungal cultures from both ruminal and non-ruminal sources. Most commonly used products are based on *Aspergillus oryzae, Saccharomyces cerevisiae, Lactobacillus spp.*

Antibiotics: Antibiotics are not classified under nutrients, but are considered as feed supplements. At the lower intake antibiotics are known to stimulate the growth of animals when added to their feed and drinking water. There are number of antibiotics which have been tested for the growth promotion effect like chlortetracycline, penicillin, oxytetracycline, bacitracin, streptomycin, terramycine, neomycin, erythromycin, flavomycin etc. In India penicillin, terramycine, tetracycline, flavomycin etc. are being used as a feed supplements in poultry, pigs and pre-ruminant calves.

Table: Various feeds and fodders for livestock

A.	**GRASSES**	
	Sewan	*Lasirus sindicus*
	Bhurat	*Cenchrus biflorus*
	Dhaman	*Cenchrus setigerus*
	Anjan	*Cenchrus ciliaris*
	Elephant grass	*Pennisetum purpureum*
	Dub	*Cynodon dactylon*
	Para grass	*Brachiaria mutica*
	Guinea grass	*Panicum maximum*
	Napier grass	*Pennisetum purpureum*
B.	**TOP FEEDS**	
	Mango	*Mangifera indica*
	Beri (pala)	*Zizyphus nummularia*
	Neem	*Azadirachta indica*
	Subabool	*Leucaena leucocephala*
	Sares	*Albizia lebbek*
	Khejri (loong)	*Prosopis cineraria*
C.	**SHRUBS**	
	Ker	*Caparis aphylla*
	Kheemp	*Leptadenia pyrotechnica*

D.	**CULTIVATED FODDER**	
	Legumes	
	Lucerne	*Medicago sativa*
	Berseem	*Trifolium alexandrinum*
	Cowpea	*Vigna sinensis*
	Sun hemp	*Crotalaria juncea*
	Non Legumes	
	Oat	*Avena sativa*
	Jowar	*Sorghum vulgare*
	Bajra	*Pennisetum typhoides*
	Maize	*Zea mays*
	Barley	*Hordeum vulgare*
E.	**CROP RESIDUES**	
	Wheat bhusa (Tudi)	*Triticum aestivum*
	Paddy straw	*Oryza sativa*
	Bajra straw (Kadbi)	*Pennisetum typhoides*
	Groundnut straw	*Arachis hypogaea*
	Guar straw (phalgati)	*Cyamopsis tetragonoloba*
	Moong straw	*Phaseolus aureus*
	Soyabean straw	*Glycine max*
	Sugarcane bagasse	*Saccharum officinarum*
	Sugar beet pulp	*Beta vulgaris subsp. vulgaris*
F.	**CONCENTRATED FEEDS**	
	Wheat bran	*Triticum aestivum*
	De oiled rice bran	*Oryza sativa*
	Guar churi/guar korma	*Cyamopsis tetragonoloba*
	Moth churi	*Phaseolus aconitifolius*
	Groundnut cake	*Arachis hypogaea*
	Cotton seed cake	*Gossipium hirsutum*
	Mustard cake	*Brassica campestris*
	Soybean meal	*Glycine max*

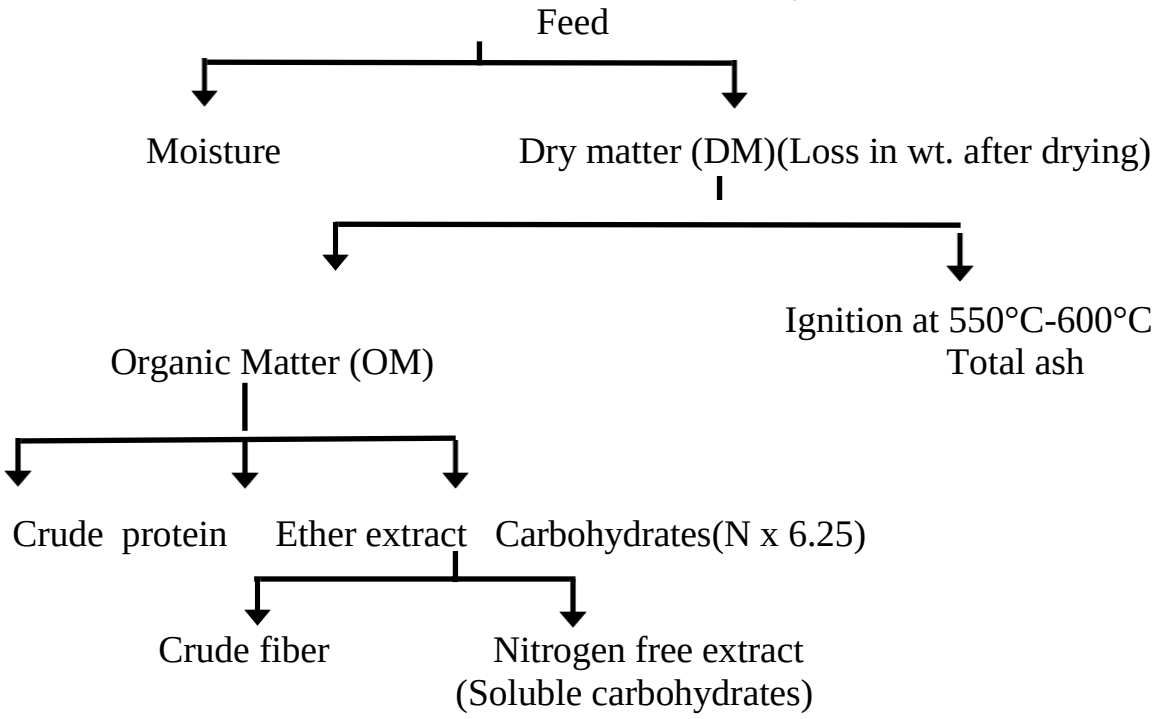
Feed EvaluationObjectives:

To evaluate the different feeds resources for their proximate principlesby using Weende's system of analysis

Introduction:

Proximate analysis is a scheme for approximating the nutritive value of a feed or any organic/biological material without actively using the feed in a feeding trial. This system of analysis was developed at Weende Research Station in Germany in 1865 by Wilhelm Hennberg (1825-1892) and Fredrich Stohmann (1832-1897), hence, it is also called Weende system of analysis. It forms the basis for description of feed composition tables, purchasing feed, ration formulation and is the starting point for more detailed analysis for specific nutrients. It partitioned the biological materials into moisture, crude protein, ether extract or crude fat, crude fibre, nitrogen free extract and total ash. These are called proximate principles. One important reason for development of the proximate analysis scheme was to allow comparison of feeds on a specific basis. It is often stated that one can not compare apples with oranges, but one can compare the protein as a percentage of dry weight in apples and oranges, and in doing so, make some realistic judgments about the nutritional value of each fruit. By the same token, proximate analysis allows one to make legitimate comparisons of feeds on the basis of specific nutrients, allowing one to judge how much better one feed is than another in terms of specific nutrients.

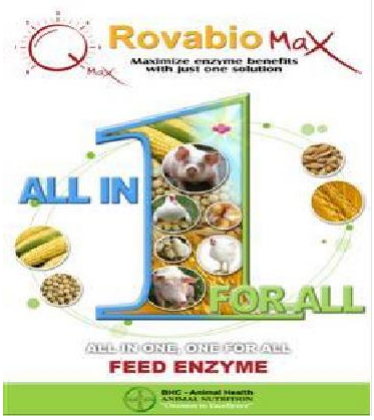
The scheme of Weende Proximate Analysis is as under

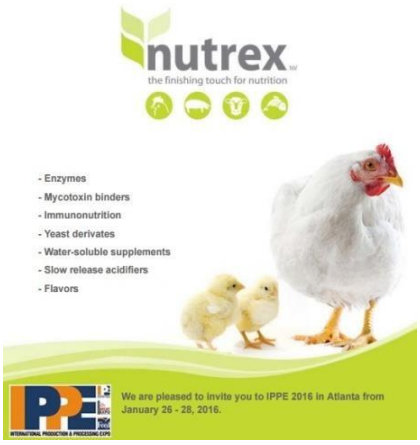


Fractions of Food/Feed according to Weende's System

Sl. No.	Fraction	Components
1.	Moisture	Water and volatile acids and bases, if present
2.	Ash	Essential elements (i) Major: Ca, P, Mg, Na, K, S, Cl (ii) Trace: Fe, Cu, Co, I, Zn, Mn, Mo, Se, F, V, Cr, Sn, As, Si, Ni Non essential elements: Al, B, Pb, Ti, Silica
3.	Crude protein	Proteins, amino acids, amines, nitrates, nitrogenous glycosides, glycoproteins, B-vitamins, and nucleic acids
4.	Ether extract	Fats, oils, organic acids, pigments, sterols, waxes and vitamin A, D, E and K
5.	Crude fibre	Cellulose, hemicellulose and lignin
6.	Nitrogen free extract	Cellulose, hemicellulose, lignin, sugars, fructans, starch, organic acids, pectins, tannins, resins, pigments and water soluble vitamins

Examples of some feeds, feed supplements and feed additives:





OIL-CAKES

Jatropha oil cakes

Pongamia oil cakes

Cottonseed oil cakes

soybean meal

rape seed meal

cotton seed meal

Questions:

Give the classification of feeds in chart form with suitable example.

What are the role of feed supplements and feed additives in maintaininganimal health and production?

Write in detail about energy rich and protein rich concentrates.

Write the importance of Hormones, Probiotics and Antibiotics in animalproduction system.

What are the different fractions of food/feed according to Weende's system?

Concentrate feeding is more important than roughage feeding for milchanimals, justify.

Give the classification of feedstuffs in chart form with suitable examples.

Define roughage and concentrate. Write the difference between the two.

EXERCISE- 7

Study of Daily Routine Farm Operations and FarmRecords

Daily Operations Schedule

The various operations should be carried out in an orderly manner as per wellprepared schedule.

Schedule of Day-to-Day Operations on Dairy Farms (100 cows)

Approximate time (hours)	Sl. No.	Farm operations
03.00 - 03.30	1.	Cleaning/brushing of milch animals
03.30 - 05.00	1.	Feeding half of the daily concentrate ration just beforemilking.
	2.	Milking cows.
05.00 - 05.30	1.	Delivery of raw milk (in cans) to the milk pick-up van ofdairy plants and receiving previous day's empty cans.
	2.	Washing and disinfection of milking barns.
05.30 - 08.00	1.	Cleaning of milk cow sheds.
	2.	Feeding of dry/green fodder to milch stock.
	3.	Cleaning farm premises.
	4.	Isolation of sick animals.
	5.	Isolation of "in-heat" cows for artificial insemination

Note: Use milkers at the rate of one for every 12-14 cows, for all the aboveoperations. Milkers go off duty by 8.00 a.m. and farm labour come on duty.

Approximate time (hours)	Sl. No.	Farm operations
08.00 - 12.00	1.	Cleaning calf, maternity, dry-stock, bullock and bull sheds.
	2.	Feeding half of the daily concentrate ration to calves, pregnant cows and bulls.
	3.	Exercising and grooming of bulls.
	4.	Treating sick animals.
	5.	Breeding cows that are "in-heat".
	6.	Harvesting, chaffing and feeding of green fodder to all thestock. Mangers in all sheds should be filled with green fodder.

Note: Animals should be taken for grazing (if practiced) between 09.00 a.m. and 02.00 p.m. in winter, and between 06.00 a.m. and 10.00 a.m. and again between 05 .00 p.m. and 07.00 p.m. in summer.

Approximate time (hours)	S. No.	Farm operations
12.00 - 01.00	1.	Lunch-cum-rest period for labourers.
01.00 - 03.00	2.	Miscellaneous jobs for dairy farm stock identification; periodical vaccination; preparation of concentrate mixture; repair of farm fences, fittings and repair of equipments; rope and halter making; weekly scrubbing and white- washing of drinking water tanks; manure disposal/ conservation; hay and silage making; periodical spraying of animal houses with suitable pesticides; periodical deworming of stock; clipping hair from sides and hind- quarters of cows; grooming; toe trimming; dehorning of calves; attending to sale and purchase of livestock and their transportation; fitting and training of cows for show.
Note: *1.* The dairy manager should plan the jobs well in advance in such a way that they are evenly distributed over the week. Some jobs may require longer time and the labour have to work extra time on such occasions. *2.* Milkers come on duty by 2.30 hours and remain up to 5.30pm hours whereas general farm labours go off duty by 5.00 hours.		
02.30 - 03.00	l.	Washing, brushing of milch cows by milkers.
Approximate time (hours)	**SL.No.**	**Farm operations**
03.00 - 04.30	l.	Feeding the other half of daily concentrate ration to milkcows just before milking.
	2.	Milking.
	3.	Cleaning calf, maternity, dry-stock and bull sheds andfeeding the other half of concentrate ration to calves, pregnant cows and bulls.
04.30 - 05.00	1.	Delivery of milk (in cans) to milk pick-up vans of milkplants and collection of mornings empty cans.
	2.	Washing and disinfection of milking barns.
	3.	Feeding dry and green fodder to calves, dry-stock andbulls.
05.00-06.30	1.	Cleaning of milch cow shed.
	2.	Feeding green / dry fodder to milch stock.
	3.	Cleaning farm premises.

Dairy business cannot be carried out without maintaining the necessary set ofaccurate records.

Records are essential for the following purpose.

Importance of Records:

1. Records are the mirrors of a farm. They are necessary from genetic improvement of dairy cattle. Records are necessary to know the milk production efficiency of the dairy animals and based on this information. We can retain or cull the cows or their off springs. Hence without a set of records properly, accurately and reliably maintained, improvement of livestock by breeding is not possible.

2. Records give us the information about the financial status of the dairy farm. Whether it is making profit or incurring loss or is just maintained. They alsogive the information about the extent of profit or losses.

3. Profit can be increased by reducing the wasteful and undue expenditure. To know such items, it is necessary to have detail record on each item of expenditure viz. feeds, labours, interest, depreciation of farm building and farm equipments, animals and miscellaneous items like medicine, vaccination breeding charge etc. The sales of milk, sale of culled animals, sale of manures, sale of empty gunny bags etc are also recorded.

Classification of Records:

Records required to be maintained on the dairy far can be classified into fourmajor group or categories.

1. Register Pertaining to Financial and Account Matter.
2. Register Pertaining to Accounting Of Animals.
3. Register Pertaining to Milk Production.
4. Register Pertaining to Reproduction

1. Registers Pertaining of financial and Account Matter

It includes registers such as cash book, ledger book, Milk coupes, bill book, receipt book, demand & collection register, dead stock register, concentrate and forage register etc. These register are more pertaining to administration and account side rather than the technical side and hence not discussed in detail over here.

2. Register Pertaining to Accounting of Animals

These include registers such as cattle yard report/daily dairy roll call register, herd register, birth & death register. This group of register is concerned with increase or decrease in the herd strength. The increase in herd

strength may be by birth, purchase of animal and farm transfer. The decrease in herd strength could be due to death, sale and farm transfer of animal.

a. Cattle Yard Report

This is a primary record, maintained daily and is also called daily diary. It is a key register on the livestock farm. Entries in all other register are made from this register. This register gives herd strength and detail of all changes in the strength. It also records details of sickness & treatment, vaccination, deworming, estrus, breeding/service to the heifers and cows, pregnancy diagnosis, feeding etc. Any other item thought to be important is also noted in this register such as extreme change in climate, rainfall, cloudy or windy weather, cyclone etc.

Cattle Yard Report				
Date	Herd Strength and Events of Animals	Treatment/Vaccination	Events of Feeds and feeding	Remark/Weather

b. Roll Call Register

This is an annual register maintained month wise. It is changed every year on 1st April. It gives the number of animals in each class or the herd. Change in the number of animals in any class is noted and detail of change is given. The number of animals in each class on the last day of the month is recorded and carried over to the first date of next month, after actual counting the herd strength.

Roll Call Register Month……									
Date	Cows	Heifers	Bulls	Bullocks	Male Calves		Female Calves		Others
					≤1yr	≥1yr	≤1yr	≥1yr	

c. Herd Register

This is also an annual register. It is changed every year on 1st April. In this register all the individual animals in different classes of the herd are listed according to their date of birth. The animal as on 31st March is listed class wise on 1st April of the next year according to their birth date. The details of each animals, viz. name and number, date of birth, parents etc. are given. Any new addition of animals in each class after 1st April is

demarcated by a line. The details of removal of animals from the herd during the year should begiven in the respective columns.

d. Birth Register

This is an annual register, which give information about the number of births on the farm, sex of calves born (male and female). Birth weight of the calves, name of sires & dams, Date of last service of dam, gestation period, number of heifers becoming cows, their age at the first calving etc. Average of the above characters for the year is made at the end of the year.

Birth Register Place……Year……..											
Sr. No. of Birth	Name & No of Dam	Name & No of Sire	Date of Fertile service	Date of calving	Male Calves		Female Calves		Gestation Period of Dam	Age of first calving (Days)	Remark
					Name & tattoo No.	Birth wt (kg)	Name & tattoo No.	Birth wt (kg)			

e. Death Register

Like birth register, it is also an annual register. It gives information about total death during the year and their cause. The frequency of a particular disease can be seen from this register. The responsible person must sign the register, as it is concerned with final write off of the animal.

Sr. No.	Name & No. of animal	Breed Group	Sex	Class	Date of Birth / Death	Post mortem done or not	Post mortem report and reasons of death

3. Register Pertaining to milk Production

These include 4 register viz. daily milk production register, Monthly Milk Production register, Lifetime milk production register (monthly progress register) and history sheet.

a. Daily Milk Production Register

This is written daily both morning and evening or sometime thrice a day. Cows are listed in this register according to their breed group and date of calving. The daily total milk production is divided by the number of milking units (Both morning & evening milking unit) gives "wet average". If the milk production is divided by total number of cows, then it gives

"herd average ". By watching carefully the fluctuation in the wet average as well as correcting the reason efficiency of the milk animals is maintained by taking care to breed the animals within 2-4 months postpartum. This is included in the column of date oflast service. The total milk production of each cow for a month is transferredinto the monthly milk yield register.

b. Monthly Milk Production Register

It is an annual Register cows in the milk on 1st April are entered in this register according to their date of calving up to 31st March is entered at the top of the register from April the entries are made till the cow dries -off or till the total milk production of incomplete lactations completed. If not, the total milk production of incomplete lactation is carried over a new register next year. Lactation day are also shown at the bottom. This register gives information like name and number of cows, which have completed their lactation, their lactation milk yield, length of LP, length of previous dry period etc. If the cow has calved again, this information is then entered into the history sheet of concerned cow completing the lactation.

c. Life Time Production Register (Monthly Progress Register)

This register gives the information about the milk yield of the individual cow from first calving till death or sale. That is the performance of entire productive life of each cow is available from this register. Annual milk production each year and also the progressive annual average (PAA) are calculated from this information. The PAA figure indicates the upward and downward trend in the productive efficiency of the cow. This figure can be used in taking decision for culling or retaining the animal.

d. History Sheet

This register gives overall milk productive capacity of the cow. One page is allotted to each heifer on calving. At that time all details of their parentage/pedigree, breeding, description of phenotype, birth date, date of calving, age of first calving etc. are entered on the upper part of the page. Relevant information about service, date of calving, calf born, sex of calf etc. are entered in the lower part in respective columns. On completion of lactation, lactation milk yield , milk yield of first 300days, lactation period, dry period, gestation period etc are entered and the average are calculated. The averagedaily milk production from first to latest calving is a good indicator of the increase or decrease in overall efficiency of the animal to produce milk and to reproduce, from the lactation to lactation.

4. Register Pertaining to Reproduction

It includes cattle yard report, service book, service ledger and history sheet.

a. Cattle yard Report

Some details are already given under group 1 register. This gives information like cows & heifer coming in heat, date of heat, date of service, (natural or artificial) name & number of sire/ bull used etc. These entries should be made promptly. Otherwise calves with unknown sire will be born. These entries of the service are transferred into service book later on. Findingof rectal palpation of repeat breeders, pregnancy diagnosis etc from this register are transferred to service ledger.

b. Service Book

This is maintained monthly. Service to heifers and cows are written in this register from cattle yard report. This is useful in making the list of cows/heifers due for pregnancy diagnosis. Similarly, list of advanced pregnant animals and the list of animals expected to calve in current month are made from this register.

Service book Month…….Year……				
Date	Name and No of Cows/ Buffalo	Name and No of bull /Buffalo bull	Natural services of AI	Remarks

c. Service Ledger

This register gives the information of near past history and currentstate of reproduction of each breedable female in the herd. The list of examination of repeat breeder and anoestrus animals can be prepared from this register.

Sr. No.	Service ledger (Classified/individual service register)							
	Name & No of Heifer/ Cow	Date of Calving	Service Records(Dates ofAI/PD)					
			1st	2nd	3rd	4th	5th	Remark

d. History Sheet

Some information about this register is given in group1. It gives information about overall reproductive efficiency of each cow e.g. age at first calving, Length of dry period, calving interval for all lactation etc. of individual cow.

Questions:

What are the importance of maintaining dairy farm records?

How you will maintain milk production records at your farm?

Mention theimportance of different milk production register in detail.

Make the roll call register and birth register.

Define: Wet Average and Herd Average.

Define: Service Book and Service Ledger.

Mention the importance of History Sheet.

EXERCISE- 8

Clean Milk Production and Milking Methods

Measures/Tips for Clean Milk Production:

It is desirable to milk the animals in a clean milking byre. Milking should be done in clean sterilized utensils by healthy milkers, dressed in clean cloths. Udders and teats of these animals should be washed with warm potassium permanganate solution and dried with a clean piece of cloth. Strip cups should be routinely used to detect mastitis in early stage.

Precautions at milking time:

After the letdown of milk by action of hormone oxytocin released, the milking operation should be swift, yet comfortable to the cows. At the time of milking the surrounding should be clean, quiet and peaceful. Barking of dogs, shouting, beating the animals, presence of peculiarly dressed strangers, visitors in large number should be avoided, since these results in release of fright hormone adrenalin and withholding of milk/ reduction in milk production.

Clean Milk: milk drawn from the udder of healthy animals, which is collected in clean, dry milking pail and free from extraneous matter like dirt, dust, flies, hay, manure etc. Clean milk has a normal flavour with low bacterial count and issafe for human consumption.

Preparations for clean/high quality milk production:

Milk is easily contaminated with dirt, bacteria and odours. Milk should be clean and should have good flavour. The ***measures of clean/quality milk production*** include;

1. **Healthy cow**: Diseased free cows are milked first. Cows should be tested for Mastitis, T.B., J.D. and Brucellosis, and positive reactors are handled accordingly.
2. **Clean cow**: Always groom and wash cow's flanks, udder and belly before milking.
3. **Clean barn**: Milking barn should be at higher level and away from the manure pit. It should provide good ventilation and functional drains. Adopt effective fly control measures. There should not be any stagnation of water.
4. **Clean milker**: Careless milker cannot produce clean milk. Milking should be done quickly and thoroughly. Milker should be healthy and should wear clean cloths.

5. **Utensils**: Use small/narrow mouthed milking pails for clean milk with lower bacterial content. Pails should be thoroughly washed with washing soda and hot water. All utensils should be seamless.
6. **Handling of milk**: Filtered milk should be removed from the milk room immediately after it is drawn, as it readily absorbs the odours of the barn.
7. **Strip cups**: Use strip cups to detect mastitis. Do not mix milk from cows with mastitis.
8. **Cooling the milk**: Store the milk at 4°C temp, at which multiplication of bacteria will be slow. Store the milk in refrigeration tank.
9. **Flavour in milk**: Milk may contain some feed flavour, silage odour. This can be avoided by feeding of silage 2 to 3 hrs before milking.
10. **Transport, processing & distribution of milk**: Use of clean materials and careful handling of milk maintains its quality.

Milk removal:

Milk removal involves both the passive withdrawal of milk from the cistern and major ducts, and the active ejection of milk from alveoli caused by contraction of the myo-epithelial cells/ basket cells.

Milking is an art and science. Milking is the most important and regularsingle job to be performed on the dairy farm. The physiology of the discharge ofmilk is a delicate process and requires close co-operation of the man and the cow. The milking hours should be regular and not encroached upon by other jobs.

Methods of milking:

Cow is milked either by hands or by machine twice daily. Hand milking consists of an upward movement followed by a downward pull of the teat accompanied by pressure on the teat cistern.

The **methods of hand milking** include (1) Full hand milking, (2) Stroking method, and (3) Striking method. A good milker is a skilled workman, who is faster, efficient, gentle and clean.

The **machine milking:** It is milking 2 to 4 cows at a time, hence it is time saving. It solves the problem of non-availability of skilled milkers & strikes.

Modern milking machines are working on alternating negative and atmospheric pressures, for which a double-chambered teat cup assembly is required. Negative pressure and atmospheric pressure are allowed alternativelyto enter the chamber between the rubber inflation and the metal

shell of the teat cup assembly. When atmospheric pressure enters the chamber, the rubber inflation collapses around the teat. This assists blood & lymph to flow out of theteat.

The amount of time the inflation is expanded compared with the time it is collapsed is termed the pulsation ratio. Ratios from 1:1 to 2.5:1 are most popular. The usual pulsation rate is 48 to 60 pulsations per minute. The amount of vacuum (negative pressure) recommended is within the range of 340 to 350 mm Hg.

Too long teat cups, excessive vacuum, incomplete milking of quarters, improper teat cups etc. may cause teat erosion and damage to the udder.

Managed milking: It is the fast milking or 3 minutes milking. It does not mean that the milker must be faster, but it does mean that cows can be milked in less time and with less handwork.

Managed Milking Programme includes:

1) ***Preparation for milking***: Keep clean & dust free milking barn. Assembleonly the clean equipments.
2) ***Assembling the cows***: Time should be given to the cows to get settled andquiet. Avoid excitement of the cows.
3) ***Feeding***: The cow is a creature of habit and will adjust herself to any ofthe feeding routines followed during milking.
4) ***Equipments***: The equipments should be prepared and assembled beforemilking time.
5) ***Regularity in milking time***: Observe routine timings of milking.
6) ***Operator***: The milker should be ready only for the milking, should not have other jobs to look after during milking. Milking should not be interrupted. He should maintain cleanliness.
7) ***Preparation of cow***: Proper stimulus before milking is important for higher and clean milk production. Stimulus is induced in 45 seconds andit remains effective for only about 7 minutes. Therefore, milking should be completed within 3 to 5 minutes.

Questions:

Define clean milk? What is the difference between clean milk and normalmilk?

What are the steps you will take at your dairy farm for clean milk production?

Write in detail about various milking methods.

Define managed milking.

EXERCISE- 9

Planning and Layout of Housing for Different Types ofLivestock

Housing of Dairy Cattle

Objectives

1. To protect the animals from extreme/harsh climatic conditions.
2. To protect them from the predators.
3. To increase the efficiency in the herd management in terms of feeding,cleaning, watering, health control, handling etc.
4. To increase the efficiency of labour utilization in carrying out the farmwork.

Points to be considered while deciding the location of dairy farm/buildings The points- which should be considered before the erection of dairy buildings are as follows:

1. Topography and drainage: A dairy building should be at a higher elevation than the surrounding ground to offer a good slope for rainfall and drainage for the wastes of the dairy to avoid stagnation within. A levelled area requires less site preparation and thus lesser cost of building.Low lands and depressions and proximity to places of bad odour shouldbe avoided.
2. **Soil type:** Fertile soil should be spared for cultivation. Foundation soil as far as possible should not be too dehydrated or desiccated. Such a soil is susceptible to considerable swelling during rainy season and exhibit numerous cracks and fissures.
3. **Exposure to the sun and protection from wind:** A dairy building shouldbe located to a maximum exposure to the sun in the north and minimum exposure to the sun in the south and protection from prevailing strong wind currents whether hot or cold. Buildings should be placed so that direct sunlight can reach the platforms, gutters and mangers in the cattle shed. As far as possible, the long axis of the dairy barns should be set in the north-south direction to have the maximum benefit of the sun.
4. **Accessibility:** Easy accessibility to the buildings i& always desirable. Situation of a cattle shed by the side of the main road preferably at a distance of about 100 meters should be aimed at.

5. **Durability arid attractiveness:** It is always attractive when the buildings open up to a scenic view and add to the grandeur of the scenery. Along with this, durability of the structure is obviously an important criteria in building a dairy.
6. **Water supply:** Abundant supply of fresh, clean and soft water should be available at a cheap rate.
7. **Surroundings:** Areas infested with wild animals and dacoits should be avoided. Narrow gates, high manager curbs, and loose hinges, protruding nails, smooth finished floor in the areas where the cows move and other such hazards should be eliminated.
8. **Labour:** Honest, economic and regular supply of labour is available.
9. **Marketing:** Dairy buildings should only be in those areas from where the owner can sell his products profitably and regularly. He should be in a position to satisfy the needs of the farm within no time and at a reasonableprice.
10. **Electricity:** Electricity is the most important sanitary method of lighting a dairy. Since a modern dairy always handles electric equipments which are also economical, it is desirable to have an adequate supply of electricity.
11. **Facilities, labour, food:** Cattle yards should be so constructed and situated in relation to feed storages, hay stacks, silo and manure pits as to effect the most efficient utilization of labour. Sufficient space per cow and well arranged feeding mangers and resting areas contribute not only to greater milk yield of cows and make the work of the operator easier but also minimizes feed expenses. The relative position of the feed stores should be quite, adjacent to the cattle barn. Noteworthy features of feed stores are given below:

- Feed storages should be located at hand near the centre of the cow barn.
- Milk-house should be located almost at the centre of the barn.
- Centre cross-alley should be well designed with reference to feed storage, the stall area and the milk house of Housing:

Types of Housing: Two systems

1. Conventional Housing or Stanchion Barn

In this system, the animals are tied throughout the day and night in a completely enclosed structure or barn. Feeding, watering, milking, treatment etc is carried out at the same place. These barns are completely covered with roofs and the sidewalls are closed with windows or ventilator

located at suitable places to get more ventilation and lighting. This system is followed in countries having cold climate such as European countries. Facilities for heating or cooling the internal air are also provided in the barn through heaters or coolers and used according to the season. Management is also mostly through automation.

Advantages of Conventional Housing System

1. The animals and men caring for animals are less exposed to harsh environment.
2. The animals can be kept clean.
3. Diseases are better controlled.
4. Individual care can be given.
5. Separate milking barn is not required.

Disadvantages of Conventional Housing System

1. Cost of construction is more.
2. Future expansion is difficult.
3. Not suitable for hot and humid climatic conditions.

Cow sheds:

Cow sheds can be arranged in a single row if the numbers of cows are. Small say less than 10 or in a double row if the herd is a large one. Ordinarily, not more than 80 to 100 cows should be placed in one building. In double row housing, the stable should be so arranged that the cows face out (tail to tail system) or face in (head to head system) as preferred.

Figure: Cattle shedAdvantages of Tail to tail system:

1. Under the average conditions, 125 to 150 man hours of labour are required per cow per year. In cleaning and milking the cows, the wide middle alley is of great advantage.
2. Lesser danger of spread of diseases from animal to animal.
3. Cows can always get more fresh air from outside.

4. The head gowala can inspect a greater number of milkmen while milking. This is possible because milkmen will be milking on both sides of the head gowala.
5. Any sort of minor disease or any change in the hind quarters of the animals can be detected quickly and even automatically.

Advantages of face to face system:

1. Cows make a better showing for visitors when heads are together.
2. The cows feel easier to get into their stalls.
3. Sun rays shine in the gutter where they are needed most.
4. Feeding of cows is easier; both rows can be fed without back tracking.
5. It is better for narrow barns.

2. Loose Housing System

Here the animals are kept loose all the while, except a temporary tying at the time of milking and treatment. Facilities of suitable manger under the shed and water-trough in paddock under the tree-shade are provided to the animalsfor free access to feed, water and rest. This system is widely practiced in hot tropical countries including India due to its many advantages over conventional system.

Advantages of Loose Housing System

1. Animals move freely and are most comfortable to get feed, water, sunlight, exercise etc at their will.
2. The construction cost is less because of its simplicity in design.
3. Expansion of buildings/sheds is easy, if required in future.
4. The sheds have flexible utility. A cow shed can be utilized for heifers andvice-a-versa.
5. It is labour saving – less labourers required for feeding, watering, cleaningetc.
6. Detection of heat, sickness and such problems is easy since the animalscan manifest them through their behaviour.

Limitations of Loose Housing System

1. Separate milking parlour is required to be constructed.
2. More labour is required in catching and handling of animals.
3. Chances of spread of contagious disease are more as the animals move freely and are in intimate contact to each other, and there is common feeding and watering.
4. It is difficult to disinfect the animal shed regularly and completely.
5. Powerful or bossy animals do not allow sufficient space for feeding, watering, rest etc to the mild or weak animals.

Floor Space Requirement per Animal as per BIS (Bureau of Indian Standard)

Sr. No.	Category of animals	Floor space required (sq.m.)		Maximum No. of animals/shed
		Under shed	***In paddock***	
1.	Cows	3.5	7.0	50
2.	Buffaloes	4.0	8.0	50
3.	Down calvers (Advanced pregnant cows/heifers)	12.0	12.0	Individual
4.	Breeding Bulls	12.0	120.0	Individual
5.	Young calves	1.0	2.0	30
6.	Older calves	2.0	4.0	30

Minimum height of shed at eaves should be 175 cm (6 feet) in the medium toheavy rainfall areas, and 220 cm (7.5 feet) in semi-arid areas**.**

Feeding and Watering Space Requirements

Sr. No.	Category of animals	Feeding space/animal (cm)	Watering space/animal (cm)	Width of manger/water-trough (cm)	Depth of manger/water-trough (cm)
1.	Adult	60-75	6.0-7.5	60	40
2**.**	C/B Calves	40-50	4.0-4.5	40	15

These requirements are to be provided under loose housing system when feedand water are available *ad libitum.*

Approximate Storage Space requirement per quintal (m^3)

1. Hay (loose): 1.60 2. Hay (baled): 0.70 3. Hay (Chopped): 0.60

4. Straw (loose): 3.00 5. Concentrates: 0.17 6. Silage: 0.50**Various Buildings or units required for a Dairy farm Dairy cow building must have following parts**

- Feeding passage
- Manger
- Standing space
- Gutter or drainage channel
- Milking passage

Main building units

- Milking barn or parlour
- Down calver shed / calving pen
- Calf pen
- Young stock or heifer shed
- Dry animal shed
- Bull shed
- Isolation shed
- Quarantine shed

Accessory buildings

- Store room
- Milk room
- Hay or straw shed

PRECAUTIONS:

It should never be taken for granted that the bull, howsoever mild and well-behaved, will not go vicious. While handling the bulls, i.e. tying, untying, leading, taking for a walk etc., one should always be cautious and at the same time confident.

The bulls have enormous physical strength. Hence very strong and thick ropes, chains, walls, fences etc., should be used for bull management. Halters, nose strings and nose rings should be changed before they get worn out and giveway. This will not provide any opportunity to the bulls to learn about their enormous strength and capability.

Questions:

What are the factors you will consider while deciding the location of dairy farm building?

Point out the difference (10 differences) between loose housing and conventional barn system For Gujarat which housing system is suitable and why?

Mention the advantages and disadvantages of loose housing and conventional barn system.