

PRACTICAL MANUAL

Introduction to Agronomy and Horticulture

(Course No. HNR 116) Credits: 2(1+1)

[For B. Sc. (Hons.) Forestry 1st Semester Students]



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College of Horticulture & Forestry
Rani Lakshmi Bai Central Agricultural University
Jhansi, Uttar Pradesh

Syllabus: HNR 116 Credits: 2(1+1)

Identification of field crop and tillage implements. Preparation of seed beds, identification of fertilizers and manures – mixing chemical fertilizers – calculating fertilizer requirements. Identification of green manure plants. Identification of important weeds of the region with particular reference to forest plantations. Preparation of weed herbarium. Calculations of spray volume and herbicide concentrations. Methods of application of herbicides. Identification of horticultural crops-garden tools and implements. planning and layout of orchard and plantations. Digging and filling of pits for fruit and plantation crops-planting systems, training and pruning of orchard trees-preparation and application of regulators, layout of different irrigation systems, identification and management of nutritional disorder in fruits-bearing habits and maturity standards, harvesting, grading, packaging and storage.

Name of Student

Roll No.

Batch

Session

Semester

Course Name :

Course No. :

Credit

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Date:

Course Teacher

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5	Preparation and application of growth regulators			
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Exercise- 1

Objective: Identification of horticultural crops-garden tools and implements.

(Tropical, Sub tropical & Temperate fruits)

S. No	Common name	Botanical name	Family
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(Tropical, Sub tropical & Temperate vegetables)

S. No	Common name	Botanical name	Family
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(Ornamental plants)

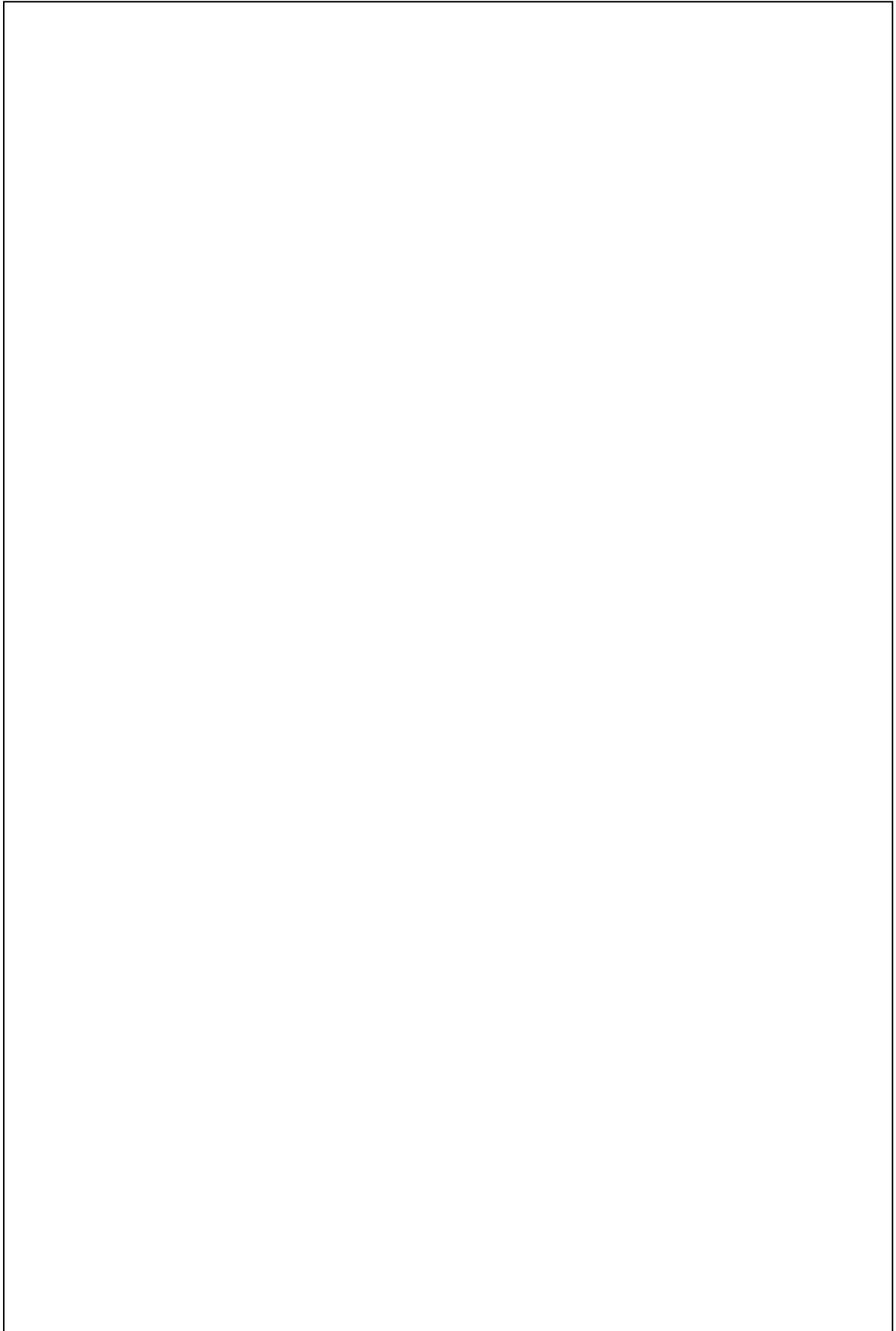
S. No.	Common name	Botanical name	Family
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Garden Tools, Implements, and Plant Protection items

S. No	Tools	Use
1.	Secateur	
2.	Budding cum Grafting Knife	
3.	Pruning Saw	
4.	Bill Hook	
5.	Lopper	
6.	Hedge Shear	
7.	Axe	
8.	Lawn Mower	
9.	Crow-bar	

10.	Shovel	
11.	Flat Spade (Khurpi)	
12.	Hand Hoe	
13.	Spade	
14.	Pickaxie	
15.	Hand weeder	
16.	Hand Cultivator	
17.	Garden Rake or Hand Rake	
18.	Garden fork	
19.	Watering can or Rose Can	
20.	Hand sprayer	
21.	Sprayer	
22.	Ladder	
23.	Grass Sword	
24.	Measureing Tape	
25.	Brush cutter	



Exercise No. 3

Objective: Prepare Layout of Different Planting Systems of Orchard

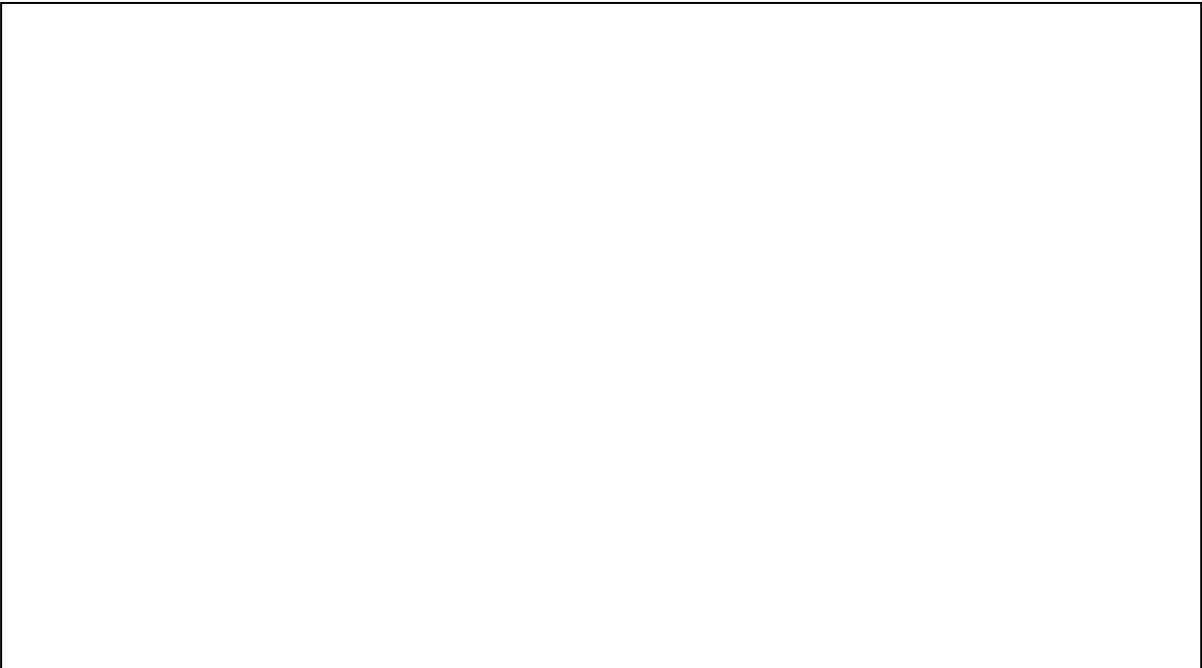
Materials Required:
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Planting system: Vertical row planting pattern

Square System:

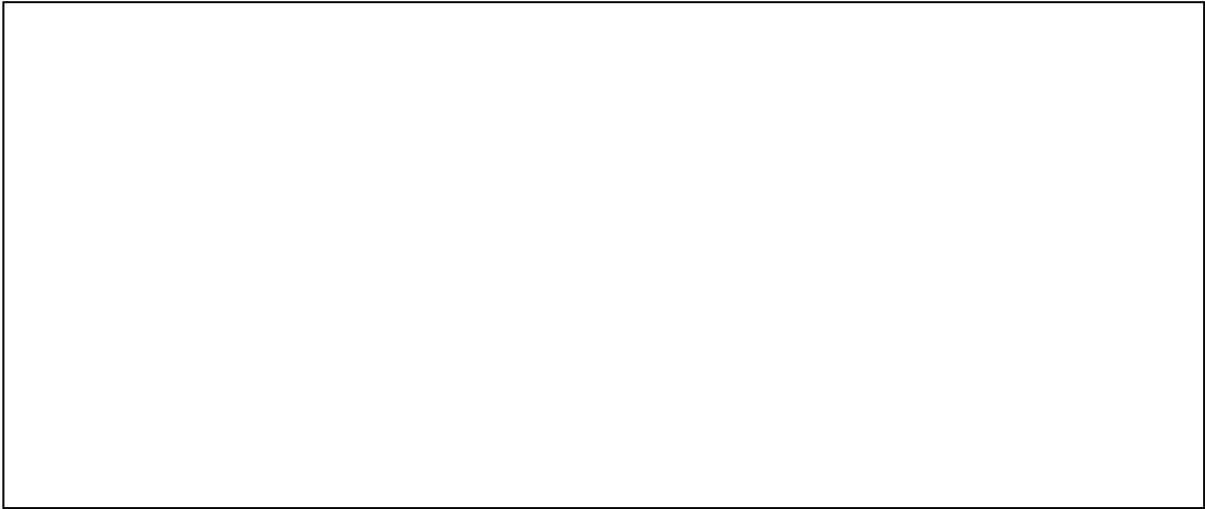


Rectangular system:

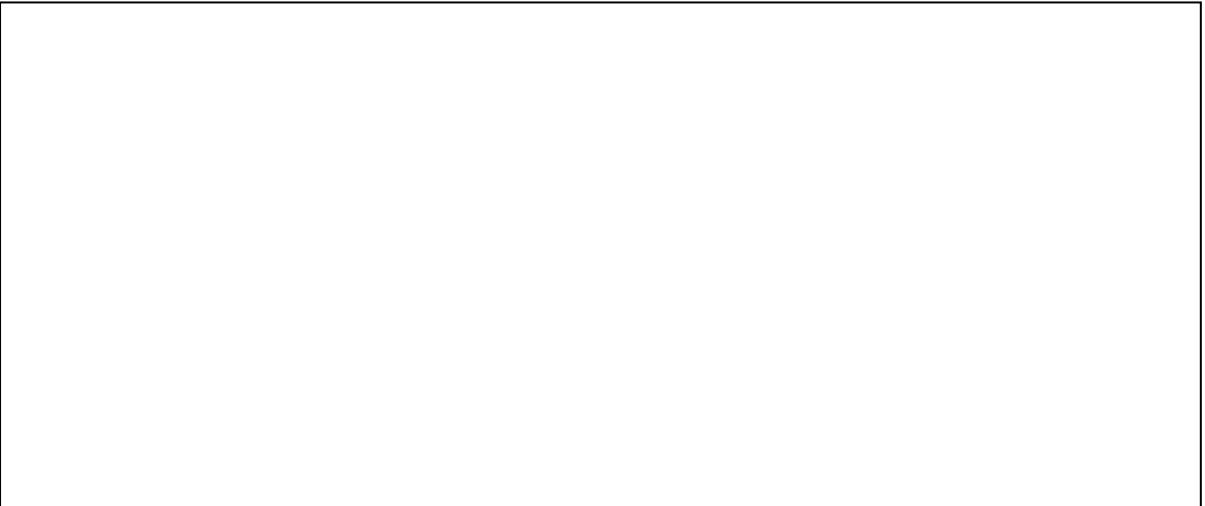


Alternate row planting pattern

Diagonal or Quincunx system:



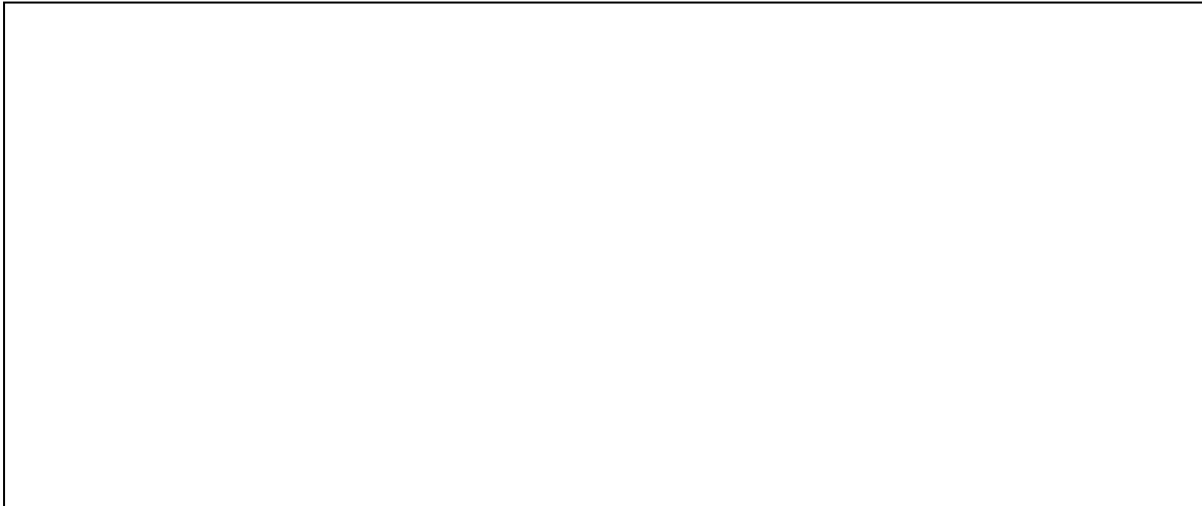
Hexagonal system:



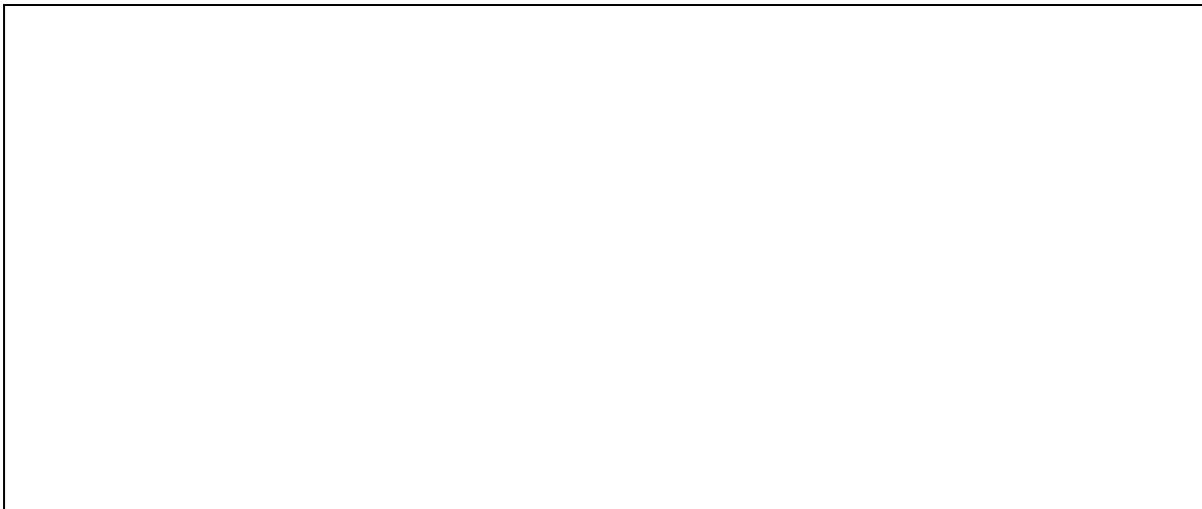
Triangular system:



Double Row System:



Contour system



Calculation of number of trees required per unit area

Quincunx system

$$\text{No of plants/ha} = \frac{\text{Total Area}}{(\text{Row to row distance}) \times (\text{Plant to plant distance})}$$

If Row to Row distance and Plant to Plant distance is 10m, then

$$\text{No of plants/ha} = \frac{10,000}{10 \times 10}$$

$$\text{No of plants/ha} = 100$$

$$\begin{aligned} \text{Additional plants planted in centre of square} &= (\text{No. of rows length wish} - 1) \times (\text{No. of rows width wish} - 1) \\ &= (10-1) \times (10-1) \\ &= 9 \times 9 \\ &= 81 \end{aligned}$$

$$\text{Therefore, total no. of plants} = 100 + 81 = 181$$

Hexagonal system

$$\text{No of plants / ha} = \frac{\text{Total Area}}{(\text{Row to row distance}) \times (\text{Plant to plant distance})}$$

Objective: Training and Pruning of Fruit Plants

Materials Required:

Procedures:
Central leader:

Open centre:

Modified leader system:

Methods of pruning: The different methods of pruning commonly followed in fruit plants are:

1. Thinning out:.....

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2. Heading back:

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3. Disbudding or rubbing off:

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4. Pinching and topping:

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5. Ringing and Girdling:

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6. Notching:

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7. Nicking:

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8. De-suckering:

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9. Root Pruning:

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10. Ringing:

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11. Smudging:

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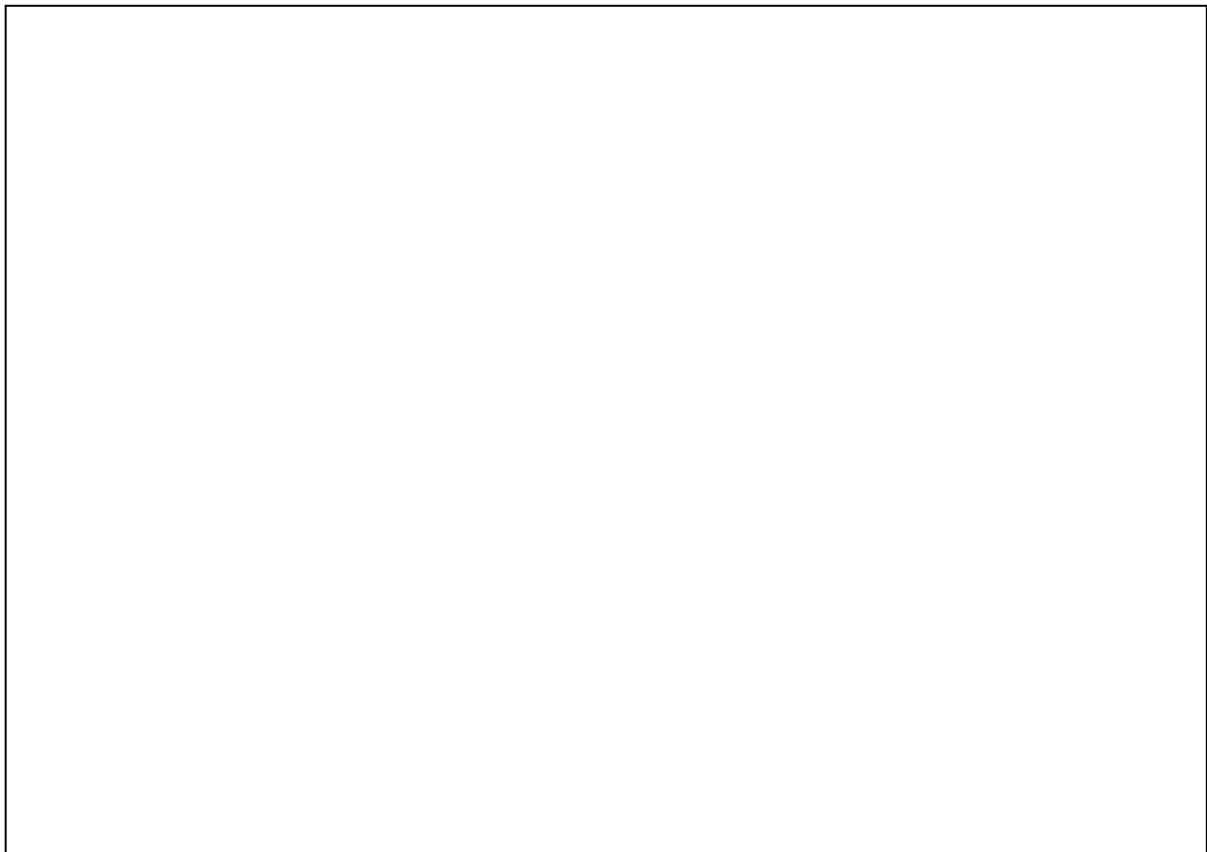
12. Bending:

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13. Disbudding:

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Assignment: Practice the procedures and draw sketches.



Objective: Preparation and Application of Growth Regulators

Materials Required:.....
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Preparation of growth regulators

Dust form:
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Lanolin paste:.....

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Solution form:

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Solvents for dissolving plant growth regulators

Name of growth regulator	Solvent
Indole Acetic Acid (IAA), Indole Butyric Acid (IBA), 4 CPA, NAA	Ethyl alcohol, Methanol, Potassium hydroxide, Sodium hydroxide
2, 4-D and 2, 4,5-T	Water
Gibberellic Acid (GA3), 6-Benzyl Adenine, Benzyl Amino purine, Kinetin 2 ip	Ethanol or Methanol, 0.1 N HCL

Procedure:.....

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Example: Before preparation, the following aspects should be known-active ingredients or strength of pure chemical that is mentioned in the label of the pack, the amount of chemical required for the

desired strength and volume are calculated by the following formula.

$$V_1S_1 = V_2S_2$$

Where V_1 = chemical required.

S_1 = strength of chemicals/hormone.

V_2 = water or powder required.

S_2 = concentration or strength of chemical/ hormone required.

[1% = 10,000 ppm]

Solved Problem:

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Assignment: Practice the job and record the calculation

Objective: Layout of Different Irrigation Systems

Surface irrigation.

Flooding System:

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Basin system:

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Border:

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Furrow irrigation:

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Sub-surface irrigation:

Sprinkler/Overhead/Aerial irrigation:

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Drip irrigation:

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Pitcher system irrigation:

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Funnel system:
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Problem: Practice the job on the field and draw neat sketch



Exercise No. 7

Objective: Identification and Management of Nutritional Disorders in Fruit Crops
Nutrient Disorders in Fruits

S. No.	Nutrition	Deficiency Symptoms	Control Measures
1.			
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10.			

Problem: Diagnose the disorder on the field and observation to be recorded crop-wise

S. No.	Crops	Symptoms on the plant	Remarks
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Objective: Maturity Standard of Fruits & Vegetables

Maturity Indices of some fruits and vegetables:

Banana:
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Mango:
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Papaya:
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Guava:
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Jackfruit:
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Pineapple:
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Sweet orange:
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Mandarin:
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Litchi:
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Pomegranate:
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Aonla:
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Apple:
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Grape:
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Tomato:
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Cucumber:
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Watermelon:
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French bean:
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Exercise No. 9

Objective: Storage Behaviour of Fruit and Vegetable Crops

Materials required:

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Practice the job and record.

Fruits/ Vegetables	Storage condition	Percentage weight loss after 7 days	Percentage of spoiled fruits after 7 days	Percentage change in TSS	Remarks
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				
	Room temperature				
	Refrigerator				

Exercise No. 14

Objective: Identification of manures.

Exp. 1: Identify different organic manures and record your observations. Write name of the manure and its characteristics.

Materials required: Paper sheet and pen to note down the instructions, samples of different organic manures, petri dishes.

Observations:

Sample number	Name of the manure	Specific identifying feature	Nutrient content (%)

Exp. 2: Write about different types of manures.

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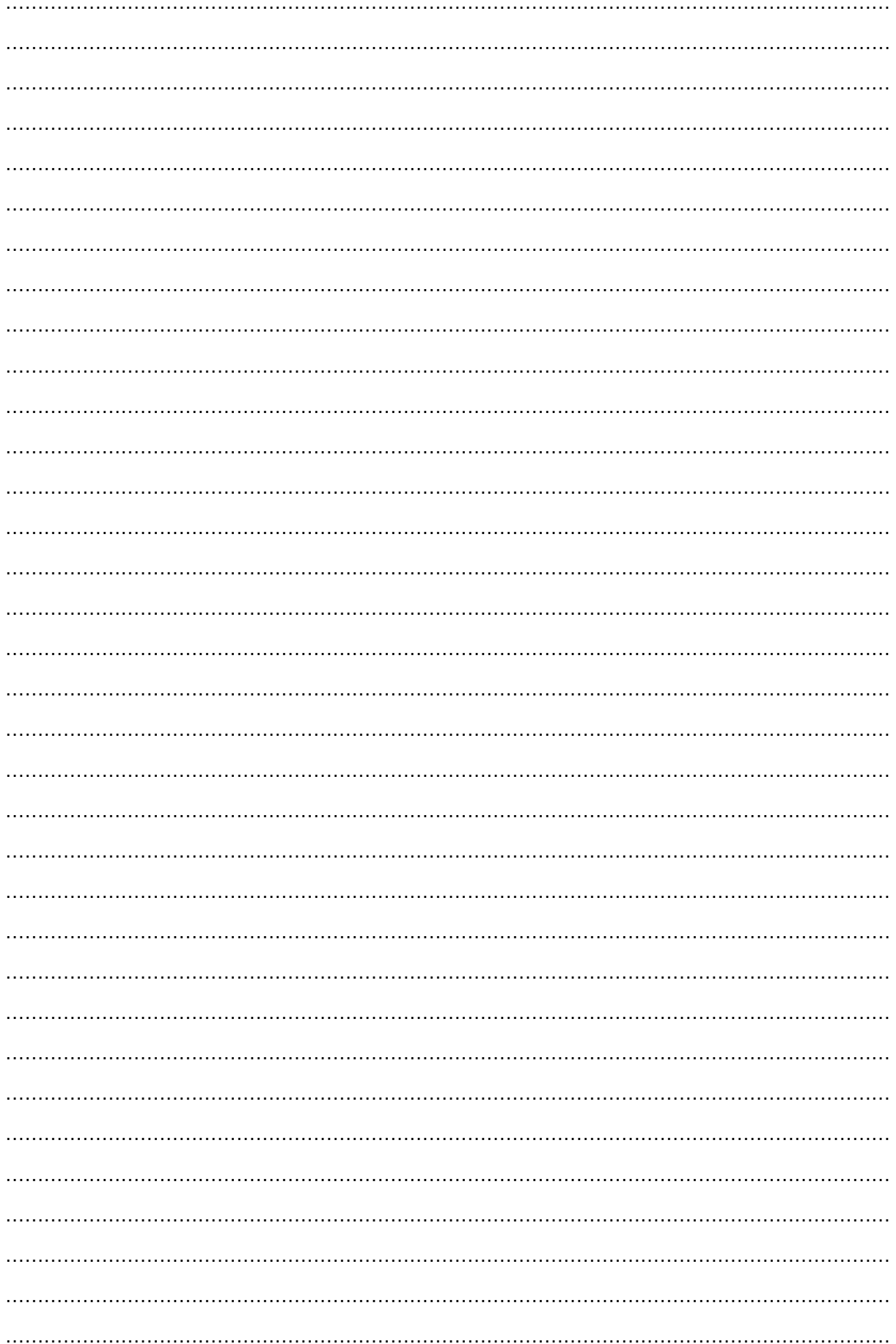
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Exercise No. 17

Objective: Numerical exercise on calculations of spray volume and herbicide concentrations.

How to calculate proper quantities of herbicides?

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Active Ingredient (a.i.):

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Acid equivalents (a.e.):

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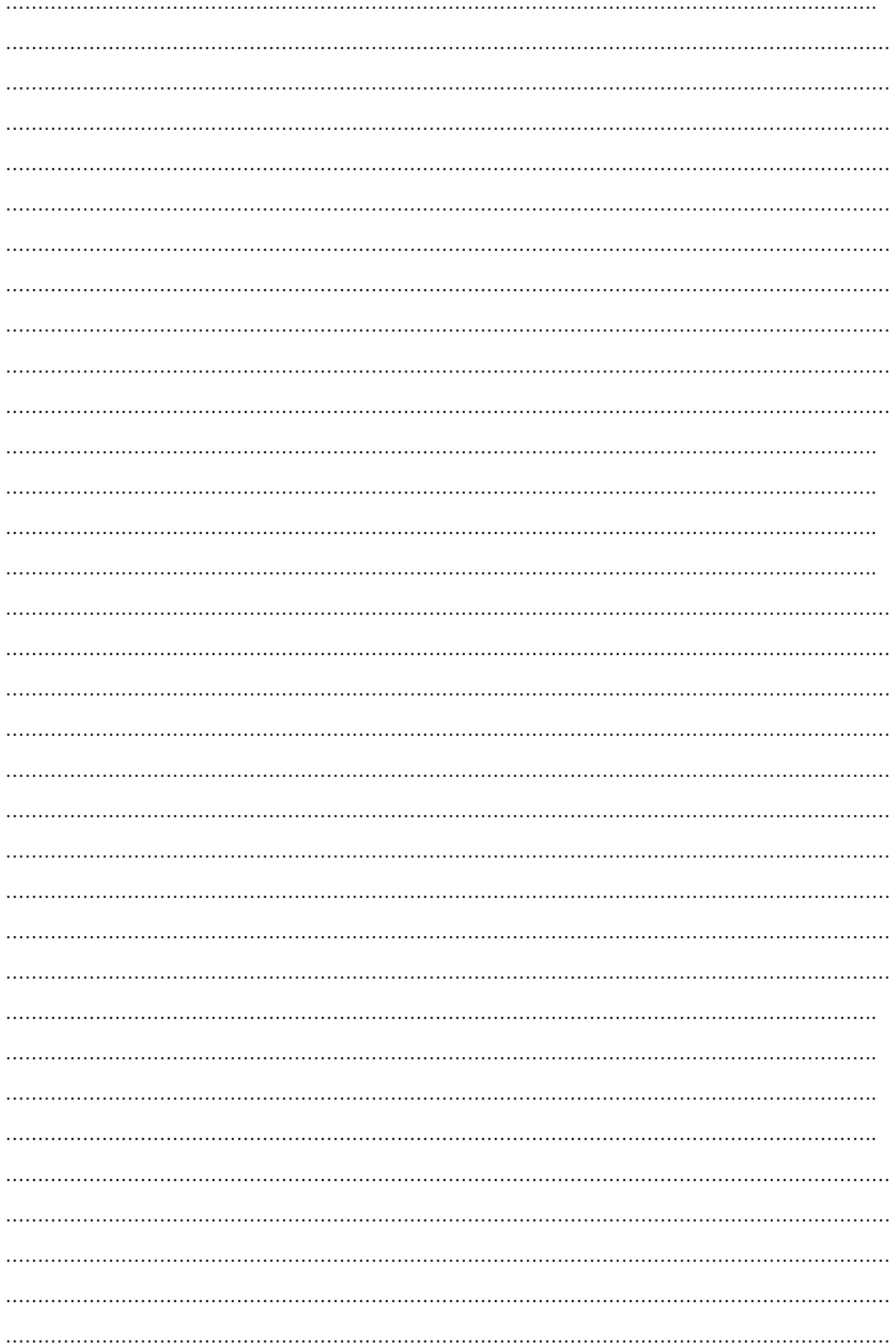
Problem 1: Calculate the amount of Atrazine (50 % WP) in kg/ha, if rate of application is 1.0 kg ai/ha.

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Problem 2: Suppose Na salt of 2.4-D contains 80% a.i. and if 1 ½ kg of a.i. per ha is to be sprayed. The quantity of Na salt required will be?

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Problem 3: If you buy a herbicide with 80% (0.80 a.i.) as diuron and want to apply one kg a.i. of Diuron



APPENDICES

List of different field crops

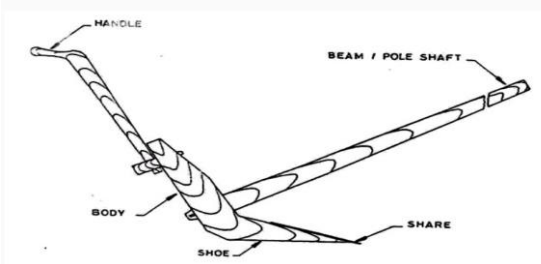
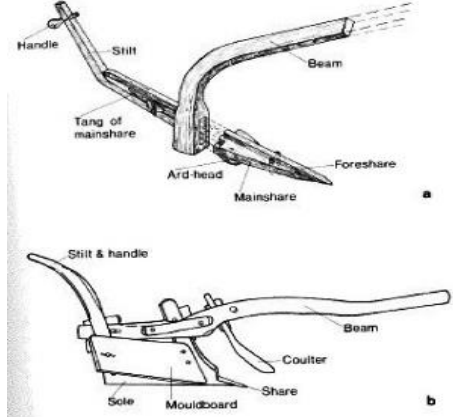
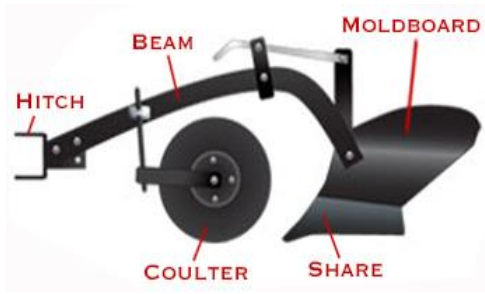
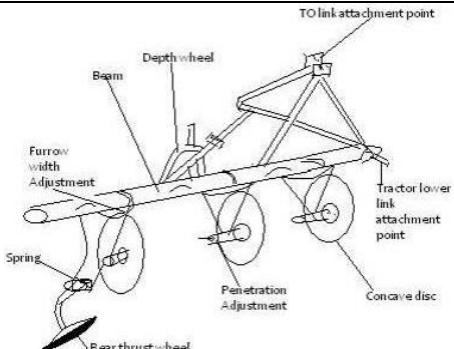
	Crop Name	Botanical Name	Family
I Cereals			
1	Paddy	<i>Oryza sativa</i> (L)	Gramineae/poaceae
2	Wheat	<i>Triticum aestivum</i>	Gramineae/poaceae
3	Maize	<i>Zea mays</i> (L)	Gramineae/poaceae
4	Sorghum/Great millet	<i>Sorghum bicolor</i> (L) moench	Gramineae/poaceae
5	Barley	<i>Hordeum vulgare</i>	Gramineae/poaceae
6	Bajra/Pearl millet	<i>Pennisetum glaucum</i>	Gramineae/poaceae
7	Finger millet	<i>Eleusine coracana</i> (L)	Gramineae/poaceae
8	Indian or Foxtail millet	<i>Setaria italic</i>	Gramineae/poaceae
9	Kodo millet	<i>Paspalum scrobiculatum</i>	Gramineae/poaceae
10	Little millet	<i>Panicum millare</i>	Gramineae/poaceae
11	Proso millet	<i>Panicum miliaceum</i>	Gramineae/poaceae
12	Barnyard millet	<i>Echinochloa frumentacea</i>	Gramineae/poaceae
II Pulses			
1	Pigeon pea/Arhar/Tur	<i>Cajanus cajan</i>	Leguminoseae/Fabaceae
2	Green gram	<i>Vigna radiate</i>	Leguminoseae/Fabaceae
3	Black gram	<i>Vigna mungo</i>	Leguminoseae/Fabaceae
4	Kidney bean (Moth bean)	<i>Phaseolus aconitifolius</i>	Leguminoseae/Fabaceae
5	Cowpea	<i>Vigna sinensis</i>	Leguminoseae/Fabaceae
6	Horse gram	<i>Macrosylemee uniflorum</i>	Leguminoseae/Fabaceae
7	Chickpea	<i>Cicer arietinum</i>	Leguminoseae/Fabaceae
8	Lentil	<i>Lens esculenta</i>	Leguminoseae/Fabaceae
III Oilseeds			
1	Groundnut	<i>Arachis hypogeal</i>	Leguminoseae/Fabaceae
2	Sesamum	<i>Sesamum indicum</i>	Pedaliaceae
3	Castor	<i>Ricinus communis</i>	Euphorbiaceae
4	Sunflower	<i>Helianthus annus</i>	Compositae
5	Soybean	<i>Glycine max</i>	Leguminoseae/Fabaceae
6	Rapeseed and mustard	<i>Brassica spp.</i>	Cruciferae
IV Forage crops			
1	Cowpea	<i>Vigna sinensis</i>	Leguminoseae
2	Stylo	<i>Stylosanthes lamata</i>	Leguminoseae
3	Siratro	<i>Phaseolus macroptinium</i>	Leguminoseae
4	Velvet bean	<i>Stizolobium deeringianum</i>	Leguminoseae
V Fibre crops			
1	Cotton	<i>Gossypium spp.</i>	Malvaceae
2	Jute	<i>Corchorus spp.</i>	Tiliaceae
3	Sunhemp	<i>Crotolaria juncea</i>	Fabaceae
VI Sugar crops			
1	Sugarcane	<i>Sachharum officianarum</i>	Graminae
2	Sugarbeet	<i>Beta vulgaris</i>	Chenopodiaceae
VII Miscellaneous crops			
1	Potato	<i>Solanum tuberosum</i>	Solanaceae
2	Tobacco	<i>Nicotiana spp.</i>	Solanaceae

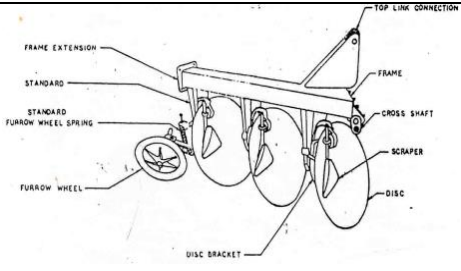
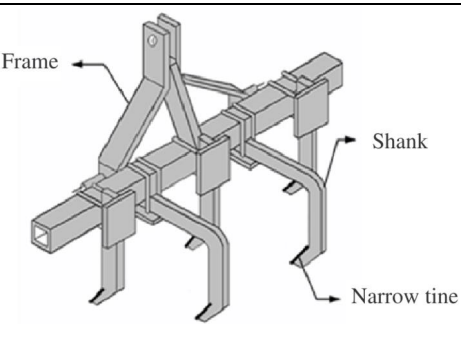
TILLAGE IMPLEMENTS

Any device used to carry on some work is called as implement. Implements are operated by animal power or by machinery. Implements are classified into primary, secondary and intercultural, depending on the purpose for which it is being used.

Primary Tillage Implements

Primary tillage is the deepest operations/performed during the period between two crops. The following are the implements used for primary tillage.

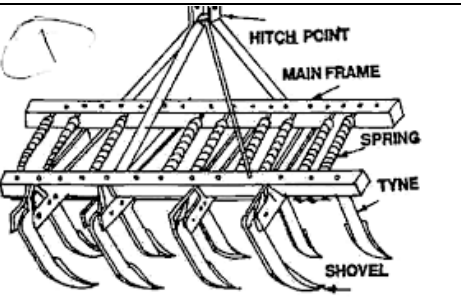
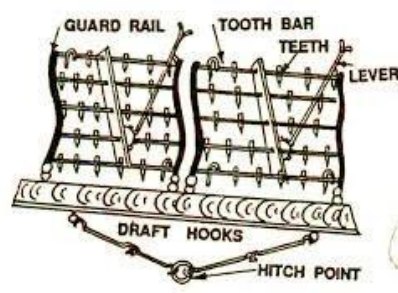
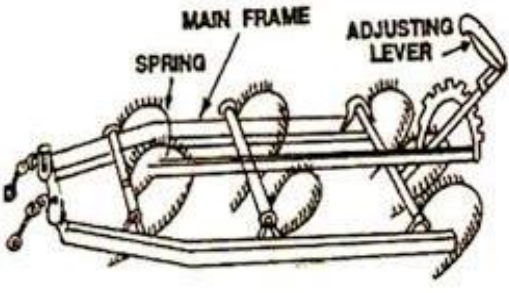
<p>1. Country/wooden/Desi plough - The indigenous plough consists of a wooden body to which a handle and a shaft pole are attached. The body is made of a bent piece of hard wood with two arms making an angle of about 135°. It is given a wedge shape with an isosceles triangular section. A small piece of flat iron (shares) serves as the piercing point of the plough and is fixed over the plough body with clamps. The shaft pole is secured with the yoke during working. The working of plough results in the opening of 'V' shaped furrow. The width of furrow depends on the size of the plough bottom.</p>	
<p>2. Improved iron plough - The bullock drawn improved iron plough is made of mild steel except the pole shaft and hence it has longer life. As and when the share wears off, it can be pushed forward. Pole shaft angle and height of the handle can be adjusted according to field requirements. The plough is provided with a mould board as optional attachment for soil inversion. This plough is suitable for dry ploughing in all types of soil with a pair of bullocks</p>	
<p>3. Mould board plough - It is a modern tillage implement used to plough deeply and pulverize the soil. It is more durable, easy to pull and can be adjusted properly. The main parts of the mould board plough are the frog or body, handle, beam, share, mould board, wheel and coultter. This type of plough leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverization. The animal drawn mould board plough is small, ploughs to a depth of 15 cm</p>	
<p>4. Disc plough - In the disc plough, the share, the mould board and coultter of the mould board plough are replaced by an inclined concave steel disc of 60-90 cm diameter, set at an angle to the direction of travel. Each disc revolves on an axle and the angle of the disc to the vertical position and to the furrow wall is adjustable. Lever arrangements are provided to lift the discs clear off the ground and for changing the angle of molding and adjusting the depth of penetration of the discs into the soil.</p>	

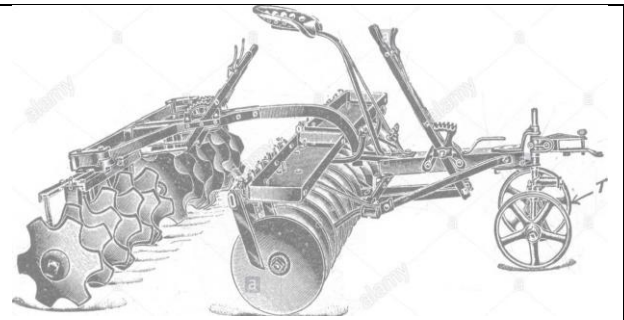
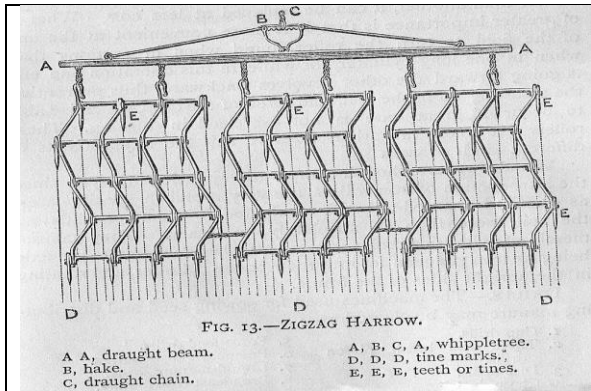
<p>5. Reversible disc plough - It is constructed in such a way that the disc can be reversed and the soil is thrown on one side. The land and furrow wheel adjust themselves properly when the plough is reversed. Reversible disc plough saves time taken up by ordinary disc plough. The furrow slice cut at each trip by the reversible disc plough is laid over the previous furrow thus resulting in a leveled field after ploughing.</p>	
<p>6. Chisel plough or subsoil plough - It is bullock drawn implement used to break hardpan that exists in the soil due to continuous same type of operation. It consists of a curved chisel "C" like tyne with 37 cm radius of curvature and 3 cm thickness. It is rigidly held in a frame, which is provided with a handle and a shaft pole. The operation of this plough is the same as that of an ordinary plough. It makes a simple vertical cut in the sub soil up to a depth of 45 cm and facilitates the downward movement of water and sub soil drainage.</p>	

Secondary Tillage Implements

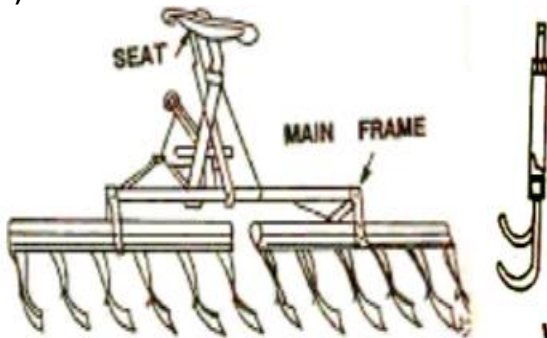
Secondary tillage is the shallow operation performed after the primary tillage. Secondary tillage implements are used for breaking clods and producing a loose, friable, smooth state. These implements are used with the following objectives.

- Breaking the furrow slice and working the soil to get the required tilth
- Destruction of weeds
- Stirring the soil and forming mulch
- Mixing the manures and fertilizers with soil
- Covering the seeds

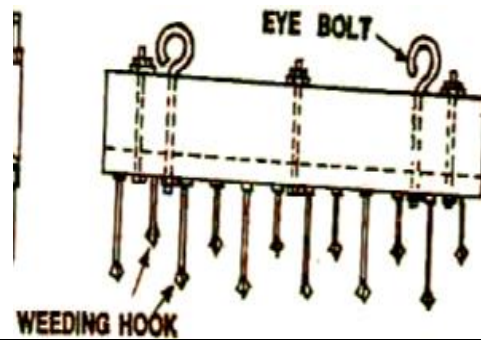
<p>1. Cultivators - These implements have number of tines for piercing the soil and breaking clods. Tines of 23–30 cm long are fixed to a heavy and sturdy, frame, mounted on wheels. These tines penetrate up to a depth of 20 cm in heavy models. Cultivators are used when the soil is ploughed deep with heavy mould board ploughs to break the big clods that are formed.</p>	
<p>Harrows - They are smaller implements with many tines like cultivators. Used for breaking smaller clods left unbroken by cultivators and for producing a powdery seedbed. Tines are set closer (5-8 cm) and are smaller in size. They penetrate up to about 10 cm depth. There are different types of harrows in use.</p>	
<p>a) Spike tooth harrow</p> 	<p>b) Spring tine harrow</p> 
<p>c) Chain harrow</p>	<p>d) Disc harrow</p>



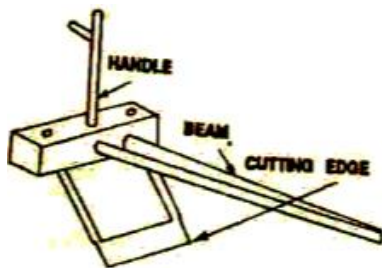
e) Acme harrow



f) Patela

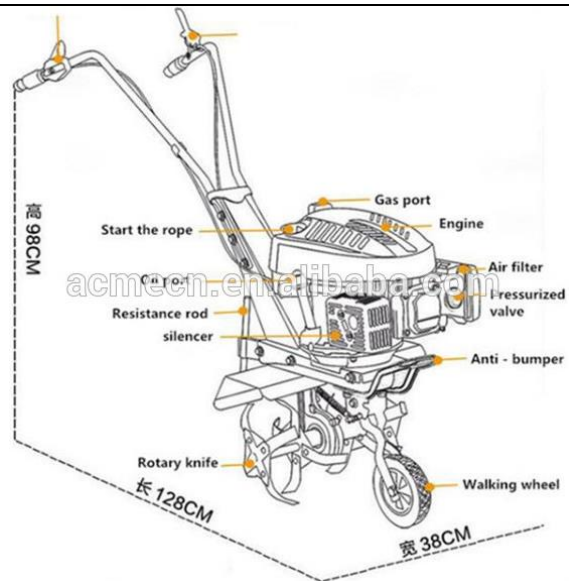




g) Blade Harrows



Inter Cultural Implements

i) Japanese rotary weeder: It consists of two small-toothed rollers or drums mounted on a frame provided with handle. Each roller consists of about 5-toothed blades. This implement, while working is pushed and pulled alternatively by the operator in between rows of rice crop. The float provided will guide the implements smoothly while working and prevent the implement sinking into the puddle. The weeder is used to bury the weeds into the mud so as to decompose them add organic matter to the soil, sufficient for working this implement.



<p>ii) Cono weeder: It is also similar to rotary weeder in which instead of two toothed rollers or drums two toothed cones are mounted on a frame provided with handle. This implement while working is pushed and pulled alternatively by the operation in between rows of rice crop. The float provided will guide the implement smoothly while working and prevent the implement from sinking</p>	
<p>iii) Long-handled weeders - Long handled weeders are used for weeding in row crops for removing shallow rooted weeds. Useful in dry land and garden land crops when the soil moisture content is 8–10 percent. They are manually operated.</p>	

Seed bed preparation for Kharif crops: The land is prepared well with disc plough or MB plough. Then sowing is done by adopting suitable method. After sowing, seed bed is prepared to facilitate easy irrigation in crops if required. Seed bed preparation for few crops is given as under:

(i) Raised nursery bed for rice

Materials required: Spade, hand hoe, rake, measuring tape, seed, water etc.

Measurements: 8.0 m x 1.25 m

Procedure

1. Earmark the area around four sides at rightangle.
2. Prepare a bund of 30 cm thickness in the middle of the row taking soil from both sides.
3. Prepare raised beds of 1.25 m x 8 m size, 20 cm above groundsurface.
4. Prepare a channel 30 cm wide on both sides to drain excess water.
5. Pulverize the soil inside bed with the help of spade or khurpi to a desirable depth.
6. Sow rice seeds in rows 10 cm apart and irrigate with 1-2 days interval during rainless period. Seedlings are ready to transplant within 25-30 days.
7. 50 such beds of 8 m x 1.25 m = 10 m² size are sufficient to transplant the seedlings in 1 ha field i.e. area of nursery required for 1 ha is 1/20 ha.

Precautions

1. Seed bed should be free from weeds, pebbles and clods.
2. Bed should be raised by 20 cm from soil surface to provide good drainage.

(ii) Seed bed preparation for maize

Materials required: Measuring tape, khurpi, spade, kassi, rake etc.

Measurement: 3.5 m length, 2.4 m width. Width of bed may be decided on the basis of row spacing.

Procedure:

1. Demarcate the area from all four sides keeping corners at 90° angle.
2. Bund the area with 30 cm thickness on the earmarked line taking soil from both the sides.
3. Soil inside bed should be mellow and friable.
4. Demarcate the rows at 60 cm keeping first and last row at 30 cm in width of the bed and make shallow furrows with the help of hand hoe.
5. Sow seeds in furrows at a depth of 4-5 cm keeping plant to plant distance of 25 cm.

Observations

1. There will be 4 rows each at 60 cm in entire width of bed (2.4 m)
2. As per P x P spacing of 25 cm, there will be 14 plants in 3.5 m length of row.
3. Total number of plants in a bed of 3.5 m x 2.4 m size will be 56.
4. Keeping the above crop geometry (60 x 25 cm). One hectare planting requires 66,666 plants.
5. Keep seed rate of maize 20-25 kg/ha.

Precautions:

1. Seed bed should be free from weeds, pebbles and clods.
2. Seed bed should be thoroughly leveled.
3. Spacing of first and last row and last plant within row should be half of the normal.
4. Seed bed preparation for pearl millet

Materials required: Spade, measuring tape, khurpi, kassi, rake etc.

Measurement: 3.6 m length, 2.7 m width

Method:

1. Demarcate the measured area on all four sides at right angle to each other.
2. Bund the area taking half soil from both the sides of row.
3. Prepare shallow furrows at a row spacing of 45 cm along the width of bed.
4. Sow seeds 3-4 cm deep in furrows.
5. Maintain plant to plant spacing of 15 cm thinning extra plants two weeks after sowing.

Observations:

1. Keeping R x R spacing of 45 cm, there will be 6 rows in above bed.
2. Keeping 15 cm spacing between plants, there will be 24 plants in a single row.
3. Total no of plants/bed will be $24 \times 6 = 144$.
4. Using above crop geometry i.e. 45 cm x 15 cm, 1,48,000 plants/ha are required.
5. Seed rate of pearl millet is 4 kg/ha

Precautions:

1. Seed bed should be mellow and friable.
2. It should be free from debris.
3. Seed bed should be well leveled.

Identification of fertilizers

Fertilizers: Fertilizers are industrially manufactured chemicals containing plant nutrients. Nutrient content is higher in fertilizers than in organic manures. The nutrients are released almost immediately.

Name of the fertilizer	Properties				
	Physical properties			Chemical properties	
	Colour	Solubility	Structure	Reaction	Nutrient content
Urea	White	Highly soluble in water	Granular	Acidic	N=46%
Diammonium phosphate	Brownish	Highly soluble in water	Granular	Alkaline	N=18%, P ₂ O ₅ =46%
SSP	Greyish	Highly soluble in water	Dust	Neutral	P ₂ O ₅ =16-18%, S=10-14%, Ca=18-21%
TSP	Greyish or blackish	Easily soluble in water	Granular	Neutral	P ₂ O ₅ =48%, Ca=15%
MOP	Brick red	Easily soluble in water	Granular	Acidic	K ₂ O=60%
Gypsum	Whitish	Easily soluble in water	Dust	Acidic	S=18%, Ca=33%
Zinc sulphate	Whitish	Easily soluble in water	Granular	Acidic	Zn=36%, S+18%

Organics manure: Organic manures include plant and animal by-products such as oil cakes fish manures and dried blood from slaughter houses. Before their organic nitrogen used by the crops it is converted through bacterial action into readily usable ammonical N and nitrate N. These manures are therefore, relatively slow acting, but they supply available N for a longer period.

Classification**A. Bulky organic manures**

(i) FYM:

- (a) Cattle manure
- (b) Sheep manure
- (c) Poultry manure

(ii) Compost:

- (a) Village/rural compost from farm-wastes
- (b) Town/urban compost from town refuses

(iii) Sewage and sludge

B. Concentrated organic manures**1. Oil cakes**

(a) Edible oil cakes (i.e., used for cattle feeding)

- (i) Mustard cake,
- (ii) Groundnut cake,
- (iii) Sesame cake,
- (iv) Linseed cake

(b) Non edible oil cakes (i.e., used as manures)

(i) Castor cake,

(ii) Neem cake,

(iii) Sunflower cake,

(iv) Mahua cake,

(v) Karanja cake

2. **Slaughter house wastes** - (i) Blood meal, and (ii) Bone meal

3. **Fish meal**

4. **Guano** - Material obtained from the excreta and dead bodies of sea bird

C. Green manures

(a) Leguminous plant (example: Sunn hemp, Sesbania sp., mungbean, cowpea, guar, senji, berseem)

(b) Non-leguminous plant (example: Sorghum, pearl millet, maize, sunflower)

D. Green leaf manures

Green leaves of trees like neem, pungam, glyricidia, vadhanarayana etc.

Table Nutrient Content of the Organic Manures

Manure	N (%)	P ₂ O ₅ (%)	K ₂ O (%)
Bulky organic manures			
Cattle dung	0.40	0.20	0.20
Cattle urine	1.00	–	1.35
Sheep and goat manure	3.00	1.00	2.00
Poultry manure	3.03	2.63	1.40
Horse manure	2.00	1.50	1.50
Horse urine	1.35	–	1.25
Pig dung	0.60	0.50	0.40
Pig urine	1.10	0.10	0.45
Farm litter compost	0.50	0.15	0.50
Rural compost	1.22	1.08	1.47
Town compost	1.40	1.00	1.40
Water hyacinth compost	2.00	1.00	2.30
Vermicompost	3.00	1.00	1.50
Night soil	5.50	4.00	2.00
Sugarcane trash	2.73	1.81	1.31
Sewage sludge	1.5-3.5	0.75-4.00	0.3-0.6
Concentrated organic manures			
Castor cake	4.0-4.4	1.9	1.4
Groundnut cake	6.5-7.5	1.3	1.5
Cotton seed cake (decorticated)	6.9	3.1	1.6
Linseed cake	5.6	1.4	1.3
Coconut cake	3.4	1.9	1.9
Neem cake	5.2-5.6	1.1	1.5
Safflower cake (decorticated)	7.9	2.2	1.9

Nutrient Content of Green Manure Crops and Green Leaf Manures

Plant	Scientific Name	Nutrient content (%) on air dry basis		
		N	P ₂ O ₅	K ₂ O
Green manure				
Sunn hemp	<i>Crotalaria juncea</i>	2.30	0.50	1.30
Manila agathi	<i>Sesbania rostrata</i>	3.30	0.60	1.20
Daincha	<i>Sesbania aculeata</i>	3.20	0.60	1.20
Pillipesara	<i>Phaseolus trilobus</i>	2.80	0.50	1.15
Sesbania	<i>Sesbania speciosa</i>	2.71	0.53	2.21
Kolinji	<i>Tephrosia purpurea</i>	3.10	0.52	1.18
Green Leaf manure				

Glyricidia	<i>Glyricidia sepium</i>	2.76	0.28	4.60
Pongamia	<i>Pongamia glabra</i>	3.31	0.44	2.39
Neem	<i>Azadiracta indica</i>	2.83	0.28	0.35
Gulmohur	<i>Delonix regia</i>	2.76	0.46	0.50
Weeds				
Parthenium	<i>Parthenium hystorophorus</i>	2.68	0.68	1.45
Water hyacinth	<i>Eichhornia crassipes</i>	3.01	0.90	0.15
Sarannai	<i>Trianthema portulacastrum</i>	2.64	0.43	1.30
Aduthoda	<i>Aduthoda vesica</i>	1.32	0.38	0.15
Ipomea	<i>Ipomoea cornea</i>	2.01	0.33	0.40
Calotrophis	<i>Calotrophis gigantean</i>	2.06	0.54	0.31
Cassia	<i>Cassia fistula</i>	1.60	0.24	1.20

Techniques of weed preservation: Collection of weeds and their preservation is essential so that one can know about their growth, development, competition and management under field conditions.

Objectives:

- (i) To know about the common weeds,
- (ii) To learn about collection of weed specimen and preparation of weed album/herbarium.

Materials required: Herbarium sheets (Appendix), wooden block press, blotting papers or old newspapers, pencil or marker, glue/adhesive tape, thread etc.

Procedure: The scientific method of weed collection and preparation of herbarium consists of the following important steps:

1. Collection of weed sample

The weeds with height of about 15 to 20 cm are uprooted carefully along with roots. The specimen should contain all parts of the weed plant including root, stem, leaves, flowers and fruits. For good identification, no part of the plant should be excluded. If plants are too small or large, extra care may be taken in collecting a specimen. A large plant may be divided into 2 or more sections, each pressed separately. However, excess branches or leaves may be removed provided remaining leaves and branches truly represent the plant. If the plants are very small, more number of specimens of the sample plant should be collected.

2. Pressing and drying of collected specimen

The weed specimens collected are kept soon on blotting paper by keeping the leaves, roots and flowers in proper position and covered by another blotting paper. Plants with long stem or leaves may be folded into V, N or W bends but should not be doubled back in such a way as to lie across itself. The paper is kept on a smooth surface and sufficient weight is kept on the upper blotting paper so that the weeds inside get pressed. All the moisture is absorbed by these two blotting papers from the weed sample over night. Next day the weight is removed and the weeds are transferred to another dry blotting paper, by changing the position of the sample exactly reverse and are covered with dry blotting paper. Again sufficient weight is kept to press the sample.

In this way the paper is changed 2 to 3 times by changing the position, of weed every time to absorb moisture from all parts of weed plant. When the specimen dry completely, it is ready for preservation.

3. Poisoning

The weed specimen once dried need chemical treatment to protect them from insect attack and other destructive organisms. Thus dipping of specimens in a insecticide solution is essential. The following solutions are used for the treatment.

- i. Mercuric chloride (25 g) + cresol (25 g) in one litre industrial alcohol.
- ii. Mercuric chloride (15 g) + phenol crystals (10 g) in one litre denatured alcohol.
- iii. 20% lauryl pentachloro phenate in methylated sprits.

The plants are re-dried as discussed earlier. These solutions are corrosive and proper care is needed to handle them.

4. Mounting on herbarium sheet.

After the specimens are dried and poisoned, they are mounted on herbarium sheets. Generally the size of the herbarium sheet is 42 cm x 29 cm (A sample herbarium sheet is given in Appendix section). The herbarium sheet should be of good quality and medium in weight. The specimens are placed in the centre of the sheet. Glue or narrow strips of adhesive tape (preferably transparent) are used to mount the specimens on the

herbarium sheet. Several herbarium glues are available in the market.

5. Preparation and fixing of identification label: It consists of following two steps:

A. Collection of information: The collector of weed specimen should record maximum useful information at the time of the collection. The data may be written either on the edge of same newspaper in which weed specimen will be brought from field to laboratory or a diary may be used citing some reference number for a particular weed specimen. The collector should record information in respect of the following parameters.

Location: Name of the village or town nearby the field and its distance and direction from the known town for exact location, the district may be mentioned.

Date: The date should be clearly mentioned with day, month and year. It should be written as March 15, 2018.

Habitat: Under this category, name of place with ecological conditions viz., field, pasture, roadside weeds, hillside, sand dune, nallah (eroded stream), light exposure (sun or shade), moisture conditions (dry, moist, wet, etc.) and denseness of community (bare ground, thin or dense population) should be pointed out.

Occurrence of weeds: A weed under consideration should be described in relativity of number of other species of weeds. For this purpose, an arbitrary scale of comparison using terms like rare, occasional, frequent, common and abundant may be followed.

Noting of essential characteristics Nature - Annual, biennial, perennial

1. Root - Tap, fibrous, adventitious, shallow, deep
2. Stem/branches - Woody, herbaceous, erect, spreading, trailing, prostrate Leaves - Simple, compound, narrow, broad
3. Flower - Shape, colour, fragrance

Features of special reference: Some plants in nature are known for their special characteristics in terms of fragrance, colour, leaf curling, stinging hairs, presence of thorns, double colour of leaves, milky juice of stem or leaves, habitat of growth, stickiness etc. The specific characteristics of plant along with right stage of growth and development of the plant should be mentioned.

Miscellaneous points of interest: A collector by his own wisdom or discussion with local people may collect valuable and rare information about a weed specimen.

This includes special use, preference shown by insect-pest, industry, special control measure, anything special about dissemination and propagation.

B. Format of identification label: The lower right hand corner of the herbarium sheet should bear the label containing the information as,

LABEL

Ref. No. ...

Location and Habitat:

Common name (English):

(Local):

Scientific name:

Description:

Collectors Address:

Date & Time:

Preservation: The individual labelled specimens are then arranged in weed albums when the collections are small and or herbarium cabinets for large collections and long-term preservation. Album is a book with blank pages for the insertion and preservation of weed collections. A weed herbarium (plural: herbaria) is a collection of preserved weeds mounted, labelled, and systematically arranged for use in scientific study. The term can also refer to the building or room where the specimens are housed, or to the scientific institute that not only stores but uses them for research.

Certain weeds plants are soft, bulky, or otherwise not amenable to drying and mounting on sheets. For these plants, other methods of preparation and storage may be used. For example, conifer cones and palm fronds may be stored in labelled boxes. Representative flowers, fruits, fleshy roots or stems may be pickled in formaldehyde to preserve their three-dimensional structure. Weed seeds are often air-dried and packaged in small paper/polythene envelopes or kept in small glass jars. No matter the method of preservation, detailed information on where and when the plant was collected, habitat, colour (since it may fade over time), and the name of the collector is usually included.

Calculating Proper Quantities of Herbicides: Herbicides are usually applied in the form of solution or granules. Solution formulations are applied using sprayers. Granules are generally mixed in sand and applied manually or

with the use of applicator. Correct dose of herbicide application is important for effective control of weeds. To calculate the herbicide dose, first account for the dosage (kg a.i./ha) of chemical required for the crop and active ingredient of herbicide to be used. The quantity of herbicide requirement may be computed by using the formula,

$$\text{Quantity of commercial formulation (kg or l/ha)} = \frac{\text{Dose (kg a. i./ha)}}{\text{Active ingredient(a. i.)}} \times 100$$

Commercially, the herbicides are available either in solid or liquid form. On the label of the containers you will find a.e.= Acid equivalent or a.i. active ingredient for liquids and g/lit solids

Active Ingredient (a.i.): It is that part of a chemical formulation which is directly responsible for herbicidal effect. Generally expressed as % by weight or by volume. Thus, the commercial herbicide production is made up of two parts i.e. the effective part and the inert part.

Acid equivalents (a.e.): Some herbicides like phenoxy acetic acid, picloram and chloramben etc. are active organic acid but many of these generally supplied in the form of their salts and esters. e.g. 2-4 D is available in the form of ester, sodium salt or amine salt. The theoretical yield of the acid in such herbicide formulation is called its acid equivalent. In case of Na salt of 2-4 D. The acid equivalent is 92.5%, which means 2-4 D is 92.5 % in sodium salt.

Different methods for herbicides application:

	Soil application		Foliar application
1.	Surface	i.	Blanket spray
2.	Sub surface	ii.	Directed spray
3.	Band	iii.	Protected spray
4.	Fumigation	iv.	Spot treatment
5.	Herbigation		

1. Soil application of herbicides:

(i) Surface application: Soil active herbicides are applied uniformly on the surface of the soil either by spraying or by broadcasting. The applied herbicides are either left undisturbed or incorporated in to the soil. Incorporation is done to prevent the volatilization and photo-decomposition of the herbicides. e.g. Fluchloralin – Left undisturbed under irrigated condition - Incorporated under rainfed condition

(ii) Subsurface application: It is the application of herbicides in a concentrated band, about 7-10 cm below the soil surface for controlling perennial weeds. For this, special type of nozzles introduced below the soil under the cover of a sweep hood. e.g. Carbamate herbicides to control *Cyperus rotundus*. Nitratin herbicides to control *Convolvulus arvensis*

(iii) Band application: Application to a restricted band along the crop rows leaving an untreated band in the inter-rows. Later inter-rows are cultivated to remove the weeds. Saving in cost is possible here. For example when a 30 cm wide band of a herbicide applied over a crop row that were spaced 90 cm apart, then two-third cost is saved.

(iv) Fumigation: Application of volatile chemicals in to confined spaces or in to the soil to produce gas that will destroy weed seeds is called fumigation. Herbicides used for fumigation are called as fumigants. These are good for killing perennial weeds and as well for eliminating weed seeds. e.g. Methyl bromide, Metham

(v) Herbigation: It is the application of herbicides with irrigation water both by surface and sprinkler systems. In India farmers apply fluchloralin for chillies and tomato, while in western countries application of EPTC with sprinkler irrigation water is very common in Lucerne.

2. Foliar application

(i) Blanket spray: It is the uniform application of herbicides to standing crops without considering the location of the crop. Only highly selective herbicides are used here e.g. Spraying 2,4-Ethyl Ester to rice three weeks after transplanting.

(ii) Directed spray: It is the application of herbicides on weeds in between rows of crops by directing the spray only on weeds avoiding the crop. This could be possible by use of protective shield or hood. For example, spraying of glyphosate in between rows of tapioca using hood to control *Cyperus rotundus*.

(iii) Protected spray: It is a method of applying non-selective herbicides on weeds by covering the crops which are wide spaced with polyethylene covers etc. This is expensive and laborious. However, farmers are using this technique for spraying glyphosate to control weeds in jasmine, cassava, banana.

(iv) Spot treatment: It is usually done on small areas having serious weed infestation to kill it and to prevent its spread. Rope wick applicator and Herbicide glove are useful here.