Modern Techniques of Farm Management

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Editors

Anil Kumar
Poonam Kashyap
Chandra Bhanu
Sanjeev Kumar
A.S. Panwar

ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut - 250 110 (U.P.), India

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ISBN: 978-81-928993-2-9

Editors:
Dr. Anil Kumar, *Principal Scientist*
Dr. Poonam Kashyap, *Scientist*
Dr. Chandra Bhanu, *Scientist*
Dr. Sanjeev Kumar, *Scientist*
Dr. A.S. Panwar, *Director*

Assistance:
Dr. O.K.Tomar, *Technical Officer*
Dr. Vinod Kumar, *Technical Officer*
Sh Teshu Kumar, *SRF*
Sh. Brijbir, *Stenographer*

Published by:
Director
ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut - 250 110 (U.P.), India
Ph. No.: 0121-288 8711
Fax No.: 0121-288 8546
E-mail: directoriifsr@yahoo.com
Website: www.iifsr.ernet.in

Printed at:
Yugantar Prakashan Pvt. Ltd.
WH-23, Mayapuri Industrial Area Phase-I, New Delhi-64
Ph.: 011-28115949, 28116018, 9811349619, 9953134595
E-mail: yugpress01@gmail.com, yugpress@rediffmail.com

Dr. S. Bhaskar
Assistant Director General
(Agronomy, Agro-forestry and Climate Change)
Division of Natural Resource Management
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan-II, New Delhi

FOREWORD

Farm Management is the science of optimising the right combination of crop and livestock enterprises in tune with the farm resources in order to maximize profit per unit area. Such resources include land, labour, capital and management including specialised knowledge, time and risk management skills, etc. Farm management is best examined and understood under the whole farm situation through study of human, technical and economic elements. An efficient farm management helps in decision-making process where available but limited production resources are allocated to selected production alternatives so as to operate the farm business in such a way to attain some set objectives.

In fact, farm management and farming systems are inter-related concepts with the former operating in institutional settings while the latter concerned with on-farm situations. The Indian Institute of Farming Systems Research (IIFSR) Modipuram has an important mandate of capacity building and human resource development. Going by this proposition and keeping in view the vast experience of IIFSR in organising capacity building programmes, this Institute is ideally suited for organising the training programme on farm management.

It is a matter of great pleasure that IIFSR is publishing a book entitled 'Modern Techniques of Farm Management' which would be very much helpful to the participant trainees in upgrading their knowledge and skills in the area of farm planning and implementation. I congratulate the Director and his entire team of scientists for bringing out this book which will be a valuable document for the farm managers in improving the production efficiency of the farm with optimisation of natural and human resources, and minimisation of risk factor through strategic decision making. I wish the team of IIFSR a great success in their endeavour towards capacity building and human resource development in the area of farm management.

(**S. Bhaskar)**

PREFACE

Farm management is a collective term for various management strategies and methods that are employed to keep a farm productive and profitable. In many respects, effective farm management is similar to the management processes that are employed with any type of business. There are decisions that must be made on a daily basis, as well as operational guidelines that must be observed by everyone involved with the operation. The issues of farm management have assumed greater importance during the recent times in view of the need to reduce the production cost, maximize the output and make agriculture more competitive. For effective management of an agricultural farm, the farm manger is ought to have managerial skills needed for farm planning, implementation and risk management associated with the farm production and profitability.

Training is an important tool for skill upgradation in order to make a person proficient in doing the specified job. It is an integral constituent of capacity building programme and has often been used as one of the essential method in technology transfer. The research information and technologies generated by the research institutions are being transferred down the line to the end users through a system of developmental machineries established in the country. The Indian Institute of Farming Systems Research (IIFSR), Modipuram has been a key institution having repository of the farm management technologies through years of systematic research. Training and published literatures are significant tools which have always been instrumental in upgrading the knowledge of end users.

The book entitled, 'Modern Techniques of Farm Management' has been brought out to serve the needs of farm managers who are working under institutional settings. There has been a growing need for such type of book dealing with conceptual and practical aspects of farm management. It was felt necessary to ensure a comprehensive content in the present book in order to meet the requirements of the readers. The present book has been designed to fill the gap existing between the already available literature and the latest development in the field. This book encompasses chapters from resource persons having expertise in different disciplines pertaining to farm management. We have tried to pool the essence of available knowledge and findings of research in this book in a systematic manner.

We are deeply indebted to Dr. A. K. Vyas, ADG (HRM), ICAR, New Delhi for his guidance and continuous support to organize a refresher course on Farm Management. We also express our gratitude to Dr S. Bhaskar, ADG (Agronomy, Agro-Forestry and Climate Change), ICAR, New Delhi for his moral support in bringing out this publication. We also convey our appreciation to all the resource persons who contributed their chapters for this book. Every information adds to our knowledge and acquisition of knowledge leads to wisdom. We hope that this book will contribute to the wisdom of farm managers and students of agriculture discipline.

Editors

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Chapter 1

Principles of Effective Goal Setting for Farm Production

A.S. Panwar

Goal Setting is the process of establishing desired results that guide and direct behavior. Goal setting involves the development of an action plan designed to motivate and guide a person or group toward a goal. Goals are a contract between employee and manager. They provide the framework for accountability and promote conversations between the manager and employee to monitor progress throughout the year.

On a basic level, there are two types of goals, *learning goals* and *performance goals*; each possesses different traits associated with the selected goal. *Learning goals* involve tasks where skills and knowledge can be acquired, whereas *performance goals* involve easy-to-accomplish tasks that will make one appear successful. A person with a learning goal orientation wants to develop competence by mastering challenging situations. In contrast, the person with a performance goal orientation wants to demonstrate and validate competence by seeking favourable judgments. Considerable research has indicated that a learning goal orientation has a positive impact on work-related behaviors and performance (VandeWalle, 2001).

APPROACHES TOWARD GOAL SETTING

Studies by Edwin A. Locke and his colleagues have shown that more specific and ambitious goals lead to more performance improvement than easy or general goals. As long as the person accepts the goal, has the ability to attain it, and does not have conflicting goals, there is a positive linear relationship between goal difficulty and task performance. An effective and consistent approach to goal setting includes three facets:

1. Goals should be SMART: SMART is an acronym that stands for specific, measurable, attainable, relevant, and timely. Specific goals help us to focus our efforts and clearly define what we are going to do (Table 1).

2. Goals should be manageable in number: Five or six meaningful goals are sufficient to challenge employees and keep them engaged in their contribution to the overall purpose. Adding more goals is likely to have a negative impact on productivity and derail progress toward achieving any of them.

Table 1: Characteristics of goal

S	Specific	The goal clearly defines the outcomes to be delivered, with any necessary interpretation agreed upon by the employee and manager in advance.
M	Measurable	The achievement of the goal can be objectively assessed according to a predetermined and applicable measurement.
A	Attainable	The employee has the resources, time, and access to people, data, etc., to allow him or her to achieve the goal.
R	Relevant	The goal addresses work and results that clearly align with the goals of the team, the department or division, and the organization as a whole.
T	Timely	The goal clearly specifies a delivery date or schedule.

3. Goals should address both institutional interests and personal development: Well-written, regularly monitored goals provide the framework for accountability and the basis for productive performance conversations between managers and employees.

PRINCIPLES OF GOAL SETTING

Under the right conditions, goal setting can be a powerful technique for motivating workers in relation to field or farm production. The following are some principles to be considered when attempting to use goal-setting to enhance motivation and performance:

Goals Need to be Specific

Farm workers perform at higher levels when asked to meet a specific high-performance goal. Asking organization members to improve, to work harder, or to do your best is not helpful, because that kind of goal does not give them a focused target. Specific goals (often quantified) let organization members know what to reach for and allow them to measure their own progress. Farm goals also need to be specific based on the mandate of the farm attached to the research or production organization. Research indicates that specific goals help bring about other desirable organizational goals, such as reducing absenteeism, tardiness, and turnover (Locke and Latham, 2002).

Goals Must be Difficult but Attainable

A goal that is too easily attained will not bring about the desired increments in performance. The key point is that a goal must be difficult as well as specific for it to raise performance. However, there is a limit to this effect. Although organization

members will work hard to reach challenging goals, they will only do so when the goals are within their capability. As goals become too difficult, performance suffers because the workers reject the goals as unreasonable and unattainable. A major factor in attainability of a goal is self-efficacy (Bandura, 1997). This is an internal belief regarding one's job-related capabilities and competencies. If farm workers have high self-efficacies, it is required to set higher personal goals under the belief that they are attainable. The first key to successful goal setting is to build and reinforce employees' self-efficacy within the available resources.

Goals Must be Accepted

Goals need acceptance to achieve the desired performance level. Simply assigning goals to workers may not result in their commitment to those goals, especially if the goals are difficult to accomplish. A powerful method of obtaining acceptance is to allow workers to participate in the goal-setting process. Participation helps the workers to understand the goals which tends to enhance goal commitment.

Feedback Must be Provided on Goal Attainment

Feedback helps the workers to attain their performance goals with needed refinement. Feedback helps in two important ways. First, it helps the workers determine how well they are doing. Performance feedback tends to encourage better performance. Second, feedback also helps people to determine the nature of the adjustments to their performance that are required to improve (Lunenburg, 2011).

Deadlines Improve the Effectiveness of Goals

For most employees, goals are more effective when they include a deadline for completion. Deadlines serve as a time-control mechanism and increase the motivational impact of goals. Being aware that a deadline is approaching, the employees will invest more effort into completing the task. In contrast, if sufficient time remains for attaining the goal, the employee is likely to slow down his or her pace to fill the available time. However, when deadlines are too tight, particularly with complex tasks, the quality of work may suffer. Timeline set to a goal helps to achieve it more effectively.

Group Goal-Setting is as Important as Individual Goal-Setting

Now-a-days, many organization members work in groups, teams, or committees. Having employees work as teams with a specific team goal, rather than as individuals with only individual goals, increases productivity. Furthermore, the combination of compatible group goals and individual goals is more effective than either individual or group goals alone. A related consideration is that when a team member perceives that other team members share his or her personal goals, the individual will be more

satisfied and productive. A recent study of project teams indicated that a perceived fit between individual and group performance goals resulted in greater individual satisfaction and contribution to the team (Kristof-Brown and Stevens, 2001).

DELIVERING PERFORMANCE FEEDBACK

Organizations use a variety of methods designed to collect data about employee performance and to deliver that feedback to the individual. The most effective feedback focuses not on what went wrong in the past, but on what can go right in the future. Forward-looking input is typically interpreted as encouragement and a boost forward. It emphasizes solutions rather than problems. Furthermore, the person accepting such feedback receives good ideas for completing the task, making the change, and delivering the result.

On the other hand, negative feedback often tends to produce defensiveness on the part of the farm worker and discomfort on the part of the manager. Even constructively delivered feedback is often seen as negative because it necessarily involves a discussion of mistakes, shortfalls, and problems. In theory, constructive feedback is supposed to "focus on the performance, not the person". However, in practice, almost all feedback is taken personally, no matter how it is delivered. Forward-looking input does not involve a personal critique because it is discussing something that has not yet happened.

CONCLUSION

Goal setting is critically important to individual farm workers and their managers. It is a human nature to feel both satisfied and self-confident when we make progress toward and meet our objectives. Strategies for managers include offering forward-looking input, eliminating defensiveness and promoting collaboration. Goals also promote more useful interaction between managers and their team workers, so that they can better align plans, monitor milestones, and make course corrections when needed.

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Chapter 2

Economic Principles of Farm Management

Brijendra Singh

The outpouring of new technological information is making the farm problems increasingly challenging and providing alterative opportunities for maximizing profits. Hence, the application of economic principles to farming is essential for the successful management of the farm business. Some of the economic principles that help in rational farm management decisions are:

- **Law of variable proportions or law of diminishing returns:** It solves the problems of how much to produce. It guides in determination of optimum input to use and optimum output to produce. It explains one of the basic production relationship viz. factor- product relationship.
- **Cost Principle:** It explains how losses can be minimized during the periods of price adversity.
- **Principle of factor substitution**: It solves the problem of how to produce? It guides in determination of least cost combinations of resources and explains factor – factor relationship.
- **Principle of equi–marginal returns:** It guides in the allocation of resources under conditions of scarcity.
- **Principle of product substitution**: It solves the problem of what to produce? It guides in determination of optimum combination of enterprises (Products) and explains product- product relationship. .
- **Principle of comparative advantage:** It explains regional specialization in the production of commodities.
- **Time comparison principle:** It guides in making investment decisions.

1. LAW OF VARIABLE PROPORTIONS

This law is also known as **'law of diminishing returns'** or **'principle of added costs and added returns'**. This law is a basic natural law affecting many phases of management of a farm business. The factor production relationship or the amount of resources that should be used (Optimum input) and consequently the

amount of product that should be produced (Optimum output) is directly related to the operation of law of diminishing returns.

This law derives its name from the fact that as successive units of variable resources are used in combination with a collective of fixed resources, the resulting addition to the total product will become successively smaller. Mathematically it can be expressed as:

$$Y = f(X_1/X_2, X_3, X_4, \ldots\ldots X_n)$$

Where,

Y = Output

$f(X_1 \ldots . Xn)$ = Function of different inputs

Most profitable level of production:

(a) Optimum input to use

An important use of information derived from a production function is to determine how much of the variable input to use. Given a goal of maximizing profit, the farmer or farm manager must select from all possible input levels the one which will result in the greatest profit. To determine the optimum input to use we apply two marginal concepts viz, marginal value product and marginal factor cost.

(i) Marginal value product (MVP) is the additional income received from using an additional unit of input.

$$\textbf{MVP} = \frac{\Delta \text{ total value product}}{\Delta \text{ input level}} = \frac{\Delta Y.\ Py}{\Delta X}$$

Where,

Y = Output

Py = Price per unit of output

X = Input

(ii) Marginal Input Cost (MIC) or Marginal Factor Cost (MFC) is defined as the additional cost associated with the use of an additional unit of input.

$$\text{Marginal Factor cost} = \frac{\Delta \text{ total input cost}}{\Delta \text{ input level}} = \frac{\Delta X.\ Px}{\Delta X} = Px^*$$

Where,

X= Input quantity

Px = Price per unit of input

*This conclusion holds provided the input price does not change with the quantity of input purchased.

Decision Rules:

1. If MVP is greater than MIC, additional profit can be made by using more input.
2. If MVP is less than MIC, more profit can be made by using less input.
3. Profit maximizing or optimum input level is at the point where MVP = MIC.

Example of determination of optimum input use:

Input price: Rs. 12 per unit, Output price: Rs. 2.00 per unit

Input X	TPP (Y)	MPP (ΔY)	TVP (Rs.)	MVP (Rs.)	MIC(Rs.)
0	0	-	-	-	-
1	12	12	24	24	12
2	30	18	60	36	12
3	44	14	88	28	12
4	54	10	108	20	12
5	62	8	124	16	12
6	68	6	136	**12**	**12**
7	72	4	144	8	12
8	74	2	148	4	12
9	72	-2	144	-4	12
10	68	-4	136	-8	12

TPP= Total Physical Product, MPP= Marginal Physical Product
TVP= Total Value Product

The above table exhibits that the profit maximizing input level i.e., optimum input use is therefore, at the point where MVP= MIC. These relationships exist at 6 units of input level use.

(b) Optimum Output

The determination of optimum output to produce is the problem before farm manager and to answer this question requires the introduction of two new marginal concepts.

(**i) Marginal Revenue (MR):** It is defined as the additional income from selling of additional unit of output.

$$\text{Marginal Revenue} = \frac{\text{Change in total revenue}}{\text{Change in total physical product}}$$

$$MR = \frac{\Delta Y.\ Py}{\Delta Y} = Py$$

Where,

Y = Output

Py = Price per unit of output

(ii) Marginal cost (MC): It is defined as the additional cost incurred from producing an additional unit of output.

$$\text{Marginal Cost} = \frac{\text{Change in total cost}}{\text{Change in total physical product}}$$

$$MC = \frac{\Delta X.\ Px}{\Delta Y} = Px$$

Where ,

X = Quantity of input

Px = Price per unit of input

Y = Output

Decision rules:

1. If Marginal Revenue is greater than marginal cost, more profit can be made by producing more output.
2. If Marginal Revenue is less than marginal cost, more profit can be made by producing less output.

3. The profit maximizing output level is at the point where MR= MC

Example of determination of optimum output to produce:

(Input price Rs. 12.00 per unit, Output price Rs.2.00 per unit)

Input (X)	TPP (Y)	MPP	TR (Rs.)	MR (Rs.)	MC (Rs.)
0	0	-	-	-	-
1	12	12	24	2	1.00
2	30	18	60	2	0.67
3	44	14	88	2	0.86
4	54	10	108	2	1.20
5	62	8	124	2	1.50
6	68	6	136	2	2.00
7	72	4	144	2	3.00
8	74	2	148	2	6.00
9	72	-2	144	2	-6.00
10	68	-4	136	2	-3.00

At the output level of 68 units of output, MR = MC. This is the optimum output to be produced.

2. COST PRINCIPLE OR MINIMUM LOSS PRINCIPLE

This principle guides the producers in minimization of losses. Costs are divided into fixed and variable costs. Variable costs are important in determining whether to produce or not. Fixed costs are important in making decisions on different practices and different amounts of production.

In short run, the gross returns or total revenue must cover the total variable costs (TVC). In other words, selling price must cover the average variable costs (AVC) to continue the production. In long run, gross returns or total revenue must cover the total cost (TC). Alternatively, stated that the selling price must cover cost of production (ATC).

In the short run MR=MC point may be at a level of output which may involve loss instead of profit. The situation of operating the farms, when the price of product

(MR) is less than average total cost (ATC) but greater than average variable cost (AVC), is common in agriculture. This explains why the farmers keep farming even when they run into losses.

Decision Rules:

(i) Short Run:

1. If expected selling price is greater than minimum average total cost (ATC), profit is expected and is maximized by producing where MR= MC.
2. If expected selling price is less than minimum average total cost (ATC) but greater than minimum average variable cost (AVC), a loss is expected but the loss is less than total fixed cost (TFC) and is minimized by producing where MR= MC.
3. If expected selling price is less than minimum average variable cost (AVC), a loss is expected but can be minimized by not producing anything. The loss will be equal to TFC.

(ii) Long Run:

1. Production should continue in the long run when the expected selling price is greater than minimum average total cost (ATC).
2. Expected selling price, which is less than minimum average total cost (ATC), results in continuous losses. In this case, the fixed assets should be sold and money may be invested in more profitable alternatives.

Illustration of the operation of cost principle:

This example depicts that in case of decline of selling price, the loss is Rs. 178. Now the question is whether the farmer should continue the production or not at the selling price of Rs. 350. If the farmer does not raise the enterprise A, the loss would be Rs. 707.00 in the form of fixed cost. If the farmer raised the enterprises A , the gross income of Rs. 3150.00 exceeds the variable costs (Rs. 2621.00) by Rs. 529.00 By this amount the loss of Rs. 707.00 on account of fixed costs get reduced i.e., (Rs. 707-529= Rs. 178). The loss would be reduced to Rs. 178.00 by raising the enterprise A.

Cost / Returns in cultivation of an enterprise A.	Rs./ha
Total variable costs	2621.00
Total fixed costs	707.00
Total costs	3328.00
Yield (quintals)	09.00
Average variable cost	291.22
Average total cost	369.77
Selling price	430.00
Gross returns	3870.00
Net returns	542.00
Suppose the price decline to	350.00
Gross returns	3150.00
Net returns	-178.00

3. PRINCIPLE OF FACTOR SUBSTITUTION

This economic principle explains one of the basic production relationship viz, factor-factor relationship. It guides in the determination of least cost combination of resources. It helps in making a management decision of 'how to produce'.

Substitution of one input for another input occurs frequently in agricultural production. Thus the problem is to find the least cost combination of resources, as this will maximize profit from producing a given amount of output.

The principle of factor substitution says that go on adding a resource so long as the cost of the resource being added is less than the saving in cost from the resource being replaced. Thus, input X_1 is being increased and input X_2 is being replaced, increase the use of X_1 so long as

Decrease in cost (Added/Replaced) > Increase in cost (Replaced/Added)

$$\text{The replaced input} > \frac{\text{Quantity saved of price per unit of added input}}{\text{Quantity increased of price per unit of replaced input}}$$

The added input

i.e. MRS > PR

Where,

MRS = Marginal Rate of Substitution

PR = Price Ratio

Profit or Decision rules:

1. If MRS is greater than price ratio (PR), cost can be reduced by using more added resources i.e.

$$\frac{\Delta X_2}{\Delta X_1} > \frac{Px_1}{Px_2}$$ then, increase the use of X_1

Or

$$\frac{\Delta X_1}{\Delta X_2} > \frac{Px_2}{Px_1}$$ then, increase the use of X_2

2. If MRS is less than price ratio (PR), cost can be reduced by using more replaced resource, i.e.

$$\frac{\Delta X_2}{\Delta X_1} < \frac{Px_1}{Px_2}$$ then, increase the use of X_2

Or

$$\frac{\Delta X_1}{\Delta X_2} < \frac{Px_2}{Px_1}$$ then, increase the use of X_1

3. Least cost combination of resources is at the point where MRS= PR, i.e.

$$\frac{\Delta X_2}{\Delta X_1} = \frac{Px_1}{Px_2}$$

Or

$$\frac{\Delta X_1}{\Delta X_2} = \frac{Px_2}{Px_1}$$

Example of selecting a least cost feed or ration:

Price of grain: Rs 4.40 per kg, Price of hay: Rs. 3.00 per kg.

Grain in kg (X_1)	Hay in kg (X_2)	ΔX_1	ΔX_2	MRS	Price Ratio
825	1350	-	-	-	-
900	1130	75	220	2.93	1.47
975	935	75	195	2.60	1.47
1050	770	75	165	2.20	1.47
1125	630	75	140	1.87	1.47
1200	520	75	110	**1.47**	**1.47**
1275	440	75	80	1.07	1.47

The least cost combination of grain and hay is a combination of 1200 kg of grain and 520 kg of hay, as the substitution ratio equates price ratio.

4. LAW OF EQUI-MARGINAL RETURNS

This law states that a limited input should be allocated among alternative uses in such a way that the marginal value products of the last unit are equal in all its uses. The equi-marginal principle provides guidelines for the rational allocation of scarce resources. The principle says that returns from the limited resources will be maximum if each unit of the resource should be used where it brings greatest marginal returns.

Example: A farmer has Rs. 3000/- and wants to grow sugarcane, wheat and cotton. What amount of money be spent on each enterprise to get maximum profits.

Amount (Rs.)	**Marginal Value Products from**		
	Sugarcane (Rs.)	Wheat (Rs.)	Cotton (Rs.)
500	880 (1)	750 (2)	650(6)
1000	700 (3)	650(5)	560
1500	650 (4)	580	550
2000	640	540	510
2500	630	520	505
3000	605	510	500

Thus, each successive rupees of 500 is allocated to the crop which has highest marginal value product remaining after previous allocation. The final allocation is Rs. 1500 on sugarcane, Rs. 1000 on wheat and Rs. 500 on cotton.

5. PRINCIPLE OF PRODUCT SUBSTITUTIONS

This principle explains the product-product relationship and helps in deciding the optimum combination of products. This economic principle also guides in making a decision of what to produce. This principle says that we should go on increasing the output of a product so long as decrease in returns from the product being replaced is less than the increase in the returns from the product being added.

Decrease in returns (Added/Replaced) < Increase in return (Replaced/Added)

i.e.

$$\frac{\text{Quantity of output reduced of replace product}}{\text{Quantity of output increased of added product}} < \frac{\text{Price per unit of added product}}{\text{Price per unit of replaced product}}$$

i.e., MRPS < PR (Price ratio)

Profit rules or decision rules:

1. If MRPS < PR, profit can be increased by producing more of added product.

$$MRPS_{Y1,Y2} = \frac{\Delta Y_2}{\Delta Y_1} < \frac{Py_1}{Py_2} \quad \text{then increase } Y_1$$

$$MRPS_{Y2,Y1} = \frac{\Delta Y_1}{\Delta Y_2} < \frac{Py_2}{Py_1} \quad \text{then increase } Y_2$$

2. If MRPS > PR, profit can be increased by producing more of replaced product.

$$MRPS_{Y1,Y2} = \frac{\Delta Y_2}{\Delta Y_1} > \frac{Py_1}{Py_2} \quad \text{then increase } Y_2$$

$$MRPS_{Y2,Y1} = \frac{\Delta Y_1}{\Delta Y_2} > \frac{Py_2}{Py_1} \quad \text{then increase } Y_1$$

3. Optimum combination of products is when MRPS=PR.

$$\frac{\Delta Y_2}{\Delta Y_1} > \frac{Py_1}{Py_2}$$

or

$$\frac{\Delta Y_1}{\Delta Y_2} > \frac{Py_2}{Py_1}$$

Example of an optimum combination of enterprises:

(P_{y1} = Rs. 280 per quintal; Py_2 = Rs. 400 per quintal)

Yield (Quintals)		ΔY_1	ΔY_2	$MRPS_{Y1Y2}$	PR
Y_1	Y_2				
0	60	-	-	-	-
20	56	20	4	0.20	0.70
40	50	20	6	0.30	0.70
60	41	20	9	0.45	0.70
80	30	20	11	0.55	0.70
100	16	20	14	**0.70**	**0.70**
120	0	20	16	0.80	0.70

Decision – This table depicts that the sixth combination which produces 100 quintals of Y_1 and 16 quintals of Y_2 is the optimum or profit maximizing combination.

6. PRINCIPLE OF COMPARATIVE ADVANTAGE

The crops and livestock production can be raised over a broad geographical area but the yields, production costs and profit may be different in each area. It is relative yields, costs and profits which are important for application of this principle. Individual or regions will tend to specialize in the production of those commodities for which their resources give them a relative or comparative advantage.

Example of comparative advantage

Crop account per hectare	Region A		Region B	
	Wheat	Bajra	Wheat	Bajra
Total revenue (Rs.)	5000	2250	2250	2200
Total cost (Rs.)	4250	2000	2100	2000
Net Returns (Rs.)	750	250	150	200
Return per rupees	1.18	1.12	1.07	1.10

Region A has great absolute advantage in growing both Wheat and Bajra than region B. Farmers of region A to make the greatest profit should increase acreage under Wheat as relative advantage. However, the farmers of Region B have relative advantage in growing Bajra.

7. TIME COMPARISON PRINCIPLE

Many farm decisions involve time. For example, a farmer has to decide between a cereal crop which would be harvested after about four months or an orchard which would start giving returns after four/ five years. Further, a farmer has to decide whether to purchase new farm machinery with 10 years of life or a second hand one which may have only five years of life. Several other decisions involving time and initial capital investment could be judiciously taken by compounding or discounting.

(i) Future value of a present sum

The procedure for determining the future value of a present sum is called compounding.The formula is:

$$FV = P(1+i)^n$$

Where,

FV= Future value

P= Present sum

i = Interest rate

n = Number of years

Example: Assume that you have invested Rs.100 in a saving account which earns 8 percent interest compounded annually and would like to know the future value of this investment after 3 years.

$$FV = P(1+i)^n$$

$$=100(1+0.08)^3$$

$$=100(1.2597)$$

$$=125.97$$

The future value of Rs.100 after 3 years will be 125.97.

(ii) Discounting

The discounting is done because sum to be received in the future is worth somewhat less now because of the time difference assuming positive interest rate.

$$PV = \frac{P}{(1+i)^n}$$

Where,

PV= present value

P= future sum

i= rate of interest

n = number of years

Example: Find out the present value of Rs.1000 to be received after 5 years. The rate of interest to be considered is 8 percent.

$$PV = \frac{P}{(1+i)^n}$$

$$= \frac{1000}{(1+0.08)^5}$$

$$= 681$$

The present value of Rs.1000 is Rs.681/-only.

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Chapter 3

Whole Farm Planning and Budgeting

H.L. Singh

Planning plays an important role in controlling future events. Is consist of a formal and informal blue print for achieving certain pre-defined objectives, such as profit maximization or cost minimization and satisfying at the farm level, by organizing the scarce resources which have alternative uses. The process of planning is based on fundamental assumptions that objectives can be better realized through systematic plans prepared well ahead of time than through management by crisis. As with any economic unit, planning at the farm levels helps achieving bigger economic objectives than what can possibly be achieved without planning. Moreover, with advancement in knowledge and technology it is becoming even more important to be able to anticipate difficulties and mistakes well ahead of time so as to avoid future events which may otherwise be more stressful and unsuccessful. In practical all farmers plan but to a varying degree. Generally, the larger and better organized the farm business, the higher is the degree of planning and vice versa. Few of the related definitions are as

FARM

A **farm** is an area of land that is used mainly producing crops and for rearing other related enterprises. The name is used for specialized units such as arable farms, vegetable farms, fruit farms, dairy, pig and poultry farms, and land used for the production of natural fibers, bio fuel and other commodities etc.

PLAN

A **plan** is typically any diagram or list of steps with timing and resources, used to achieve an objective. It is commonly understood as a temporal set of proposed actions through which one expects to achieve a goal.

PLANNING

Planning is the process of thinking about an organizing the activities required to achieve a desired goal. It involves the creation and maintenance of a plan, such as psychological aspects that require conceptual skills. There are even a couple of tests to measure someone's capability of planning well. As such, planning is a fundamental property of intelligent behavior.

Farm planning is a process to allocate the scare resources of the farm to organize the farm production in such a way as to increase the resource use efficiency and the income of the farmer.

Farm planning is process of deciding in the present what to do in the future about the best combination of crops and livestock to be raised through rational use of resources.

Farm planning is mainly a process of choice making or choosing from among competitive alternatives. It is concerned with various adjustments the farmer makes in the existing organizations with the purpose of making the most profitable use of scarce resources.

Thus it may be concluded that farm planning is the process of observation, appraisal and analysis of weighing the merits of new and old ideas and then deciding which ideas to use in the period ahead."

OBJECTIVES OF FARM PLANNING

The ultimate objective of farm planning is the improvement in the standard of living of the farmers and immediate goal is to maximize the net incomes of the farmer through improved resource use planning. When the objective is maximization of net income, it involves commonly called "the planning horizon" the length of the planning period on the basis of the farmers situation has to be, therefore, decided. The main objective is to maximize the annual net income sustained over a long period of time.

IMPORTANCE OF FARM PLAN

A sound farm plan helps the farmer to achieve the pre-determined objectives in an effective and systematic manner. Some of the important reasons for making farm plans are given as under.

1. It enables the farmer to achieve his objectives in relations to his farm and family in a more organized manner. The process of farm planning may also encourage him to develop and gather new ideas about farm practices with a view to achieve the stated objectives.
2. Farm planning enables a careful examination of the existing resources and their best allocation for achieving higher resource use efficiency, farm income and farm family welfare. Thus it helps maximizing efficiency and family satisfaction and minimizing the wastes.

3. A good farm plan serves as a basis for a judicious combining of the existing and new alternative enterprises. It is a continuous process wherein relatively more profitable new enterprises keep on replacing the old and less profitable one over time.
4. Supply needs of various inputs can be identified reasonably ahead of time and adequate arrangements made for their procurement.
5. The expected income cane be estimated well ahead of time. It helps the farmer to initiate steps for procuring the required credit. Also investment opportunities can be planned depending upon the surplus of expected incomes at some future point of time.
6. A good farm plan helps to prevent many of the stresses and strains in the business of farming through orderly planning.
7. A properly thought of farm plan may provide cash incomes at points of time when they may be most needed at the farm.
8. Above all, a farm plan acts as useful money saving device. It is always cheaper to commit mistakes on a paper than in the business.

COMPONENTS OF FARM PLANNING PROCEDURE

Any systematic farm planning procedure necessarily has the following five components.

1. Statement of the objective function
2. Inventory of scarce resource and constraints
3. Alternative choice / enterprises available to achieve the given objectives
4. Relationship of inputs to outputs i.e. the input-output coefficients
5. The actual methods and techniques of organizing the scarce resources and enterprises, with the given input-output coefficients, i.e. the planning technique.

Steps of farm planning: To have a best farm plan, some steps are needed to follow while farm planning is prepared. They are:

1) Preparing the farm map: The general layout of the farm, number and shape, irrigation channels can be shown in the farm map.

2) Recording the history of the farm: It is very important to obtain the information pertaining to utilization of resources and their efficiency. What was the crop rotations followed previously, etc on the basis of this information planning in

respect of crops to be grown, crop rotations to be followed; requirement of credit along with their sources etc can be possible.

3) **Planning Bullock and Human Labour Requirement:** Next a calendar of farm operations should be prepared and bullock and human labour requirements determined for different months. A labour schedule should be developed as to guide a farmer to appraise the amount of labour need in relation to the availability.

4) **Planning the Land Use and Soil Conservation practices:** When a full picture of the resources and their appraisal is obtained, the next step in farm planning is to adopt such practices which would lead to the best use of land. While planning the cropping scheme, due importance should be given for soil conservation. Therefore purposively crops and crop rotations need to be introducing a plan which will enhance soil conservation.

5) **Planning of Livestock Programme:** Livestock and crop production is having supplementary relationship. The size of live stock depends upon size of farm, cropping intensity, availability of irrigation etc. If irrigation water is ample naturally cultivator can grow fodder crops throughout year and he can maintain milch animals more.

6) **Planning the Marketing of Produce:** Only production is not sufficient to maximize the returns, good price for the produce is also important. Therefore, study of market conditions, prices etc. are essential to decide the time of selling. Similarly the agency through which marketing is to be done must be identified in view of getting maximum shares in consumer's price.

CHARACTERISTICS (ATTRIBUTES) OF A GOOD FARM PLAN

The main objective of farm plan is to obtain maximum returns; therefore following attributes are required to be incorporated into the farm plan

1. The most important characteristics of a good plan is that it should be written. All the minor details about the organization and operations of farm business should be clearly specified.
2. It should be forward looking.
3. Good farm plan provides a cropping scheme that includes a most profitable crop as well as some legumes to maintain fertility of soil.
4. It offers balanced combination of crops and live-stock enterprise leading to profit maximization.
5. The plan must be able to fulfill the farm and family requirement of the farmer.
6. The farm plan provides a regular employment and income to farm family and bullock labour, through the development of sounds crop rotations.

7. It is flexible enough to take advantage of any new technology or source of power.
8. The plan when it is practically implemented should be resulted into least cost. (i.e. minimum cost).

FARM BUDGETING

Budgeting is a method of analyzing plans for the use of agricultural resources at the command of the decision maker. Farm plan is a programme of the total farm activity of a farmer drawn up in advance. Farm plan serves as the basis of farm budgeting. Therefore, farm plan can be prepared without a budget but budgeting is not possible without farm plan. Budgeting can be defined as under:

The physical aspects of farm planning when expressed in monetary terms is called *budgeting*.

The expression of farm plan in monetary terms by estimation of receipts, expenses and net income is called *budgeting*.

Farm budgeting is a process of estimating costs, returns and net profit of a farm or a particular enterprise.

Budget is a statement of estimated income and expenditure.

We will be concerned with both planning and budgeting as the budget helps us to evaluate alternative plans and select the one that is most profitable. Therefore, farm planning and budgeting go side by sides.

TYPES OF FARM BUDGETING

The types (methods) of budgeting are discussed in details here as under:

a) Partial budgeting: During the period of normal operation of the farm business, small and often marginal changes are required to be made in the existing farm plan to account for the changes affecting a few aspects of the farm organization. Partial budgeting is considered to be appropriate to analyze marginal changes of this nature; hence it is a rough method of analysis. The analysis consists of accounting for additional costs and returns and then comparing them with the reduced costs and receipts due to the proposed minor changes in the farm plan. For example, hiring a tractor instead of using hired oxen, using an improved method of hybrid maize cultivation over the local method, etc. Thus, the change considered for partial budgeting may be very small or as big as a complete enterprise.

All the changes that can be appropriately analyzed with the help of a partial budget can be grouped into three categories.

i. **Factor substitutions**: often involves a change in the production techniques e.g. hiring a combine harvester instead of harvesting wheat manually.

ii. **Product substitution:** substitution between any two products, like wheat for gram can also be analyzed with the help of partial budgeting. Price and technological change often necessitate substitutions of this type.

iii. **Addition or introduction of enterprises without substitution:** In this case the introduction of entirely new enterprises may be considered in the existing farm plan. Such enterprises may generally be complementary and supplementary like poultry and piggery.

A partial budgeting is aimed at answering the questions relating to financial losses and gains due to the proposed minor changes in the farm organization. In this case four questions need to be answered.

i. What are the extra financial gains?

ii. What are the savings on account of costs?

iii. What are the losses in revenue?

iv. What are the additional costs?

b) Complete Budgeting

Complete or total budgeting is used as an aid to organize the entire farm business. It is generally used by beginners or by those farmers who want to completely overhaul their existing farming organization and operation. Therefore, complete budgeting can be specifically defined as "An estimation of the probable income and expenditure is made for the farm as a single unit of course, a complete budget is required when a farm plan is prepared for new farm or when drastic changes are suggested in the plan of the existing pattern on an established farm". Complete budgeting can be prepared for short run (annual budget) and for long run.

It is essentially a process of diagnosis and recommendation which can be split up into the following steps.

i. Listing existing farm resources and identifying objectives.

ii. Selection of enterprises

iii. Preparation of budgets for the tentatively selected enterprises

iv. Develop a suitable crop plan

v. Develop a livestock plan.

vi. Budgeting of human and other labour requirements

vii. Budgeting the machinery requirement

viii. Estimation of input requirement

ix. Planning for financing the proposed plan.

x. Estimation of returns from the plan.

ENTERPRISE BUDGETING

It is a pre-requisite for the preparation of a complete farm budget or for the application of farm planning techniques like linear programming, programme planning and gross margin planning. Also, partial or marginal adjustments in the existing farm plan often require the preparation of enterprise budgets of activities with respect to which changes may be contemplated.

An enterprise budget lists down all the expected requirements of inputs and corresponding expected output, both in physical as well as value terms, for a unit of a particular activity on the farm. Such budgets are mostly prepared for the production activities on the farm and necessarily indicate the return over variable costs per unit of the activities. Under such budgeting only variable cost, over which farmers has control is accounted so far. Enterprise budget may be positive or normative depending upon the type of data they make use of .

i. **Positive enterprise budget:** This type of budget is based on the existing level of technology as it makes use of the actual input and output data on the farm.

ii. **Normative enterprise budget:** The input output data used for preparing normative enterprise budgets relate to the recommended level of technology. These budgets therefore, account for the "package of practices" in the area of region. Extension agencies like universities, government departments, demonstration units etc prepare normative enterprise budgets.

CASH FLOW BUDGETS

After a complete budget is ready, it is often helpful on a farm to have some estimates of receipts and expenses for the rest of the year. This requirement is fulfilled by cash-flow budgets which include details about the proposed receipts, capital sales, operating capital and family expenditure and the amount to be borrowed and repayed by the farm. Generally these details are presented according to point

of time. Therefore, farmers has a picture of when and how much to spend on what. Similarly, the inflows of expected income give an idea of when and how much to expect from what.

BUDGETING TECHNIQUE

Alternate or optimum Farm Plan

Alternate or optimum farm plan implies optimum utilization of available resources in order to obtain maximum possible returns. In other words it is improved version of existing plan. For preparation of the alternate farm plan different techniques have been evolved. Important techniques are: (1) production function technique, (2) linear programming, and (3) budgeting. Here, the budgeting technique has been discussed. It involves three stages viz.

1. Appraisal of available resources.
2. Estimation of farm and family requirements
3. Estimation of costs, returns and profits of different activities.
4. Developing a plan.

Appraisal of the farm resources

Appraisal of the farm resources both quantitative and qualitative is very important. The farm resources viz., land labour, capital and management ability is basis for any farm plan. The resources are always scarce, it is therefore important to know the constraints of land, labour, capital and management. For example whether land is irrigated or unirrigated, having good soils or poor soils and what is its size. Similarly, the labour availability needs to be judged and month wise how much labour force will be available along with its ability are required to be determined. Capital is another factor which is very scarce and hence availability of capital along with its source must be known before developing the alternative farm plan.

Estimation of farm and family requirements

The agricultural produce is required for domestic consumption in the form of food grains and seeds. Similarly provision of fodder and feed for livestock is also very important. Therefore, estimation of these requirements should be done before the preparation of plan so that necessary provision of crops can be done in the alternate plan.

Estimation of costs, returns and profits of different crops

This is very important step as alternate farm plan includes mainly the profitable enterprises. Therefore, estimation of costs and returns of each and every crop or

enterprise is required to be done. For this purpose the input output data can be obtained from the following sources:

i) Experience of the farmer himself or from the neighboring farmers.

ii) Experimental farms.

iii) Field trials conducted by agricultural universities.

iv) Extension agencies conducting demonstrations on farmer's fields.

Developing a plan

While developing a plan, first of all consider those crops or enterprises which you want to meet the consumption needs of the family and farm animals. Decide the area that is to be put under each of these crops. Pick up one crop and allocate the quantity of limited resources required by it from the quantity available. Repeat this process for all these crops. Remaining limited resources are now available for allocation among other crops.

Then take up the crop which promises the highest net income per hectare over direct expends (cost 'A') and decide the maximum possible area which can be put under the crop considering the availability of the limiting resources. Allocate the required resources to the crop and substract the same from the total available resources. Then take up the next profitable crop and repeat the same process. The above process should continue till all the available resources are completely a finished. Thus, the above procedure will give the optimum farm plan consistent with the resources.

ADVANTAGES OF FARM BUDGETING

i. It evaluates the old plan and guides the farmers to adopt a new farm plan with advantage.

ii. It makes the farmer conscious of the waste (leakage) in the farm business.

iii. It gives comparative study of receipts, expenses and net earnings on different farms in the same locality and in different localities for formulating national agricultural policies.

iv. It guides and encourages the most efficient and economical use of resources.

v. It serves as valuable basis for improvements in farm management practices.

LIMITATION OF FARM BUDGETING

The budgeting technique has been often severely criticized. Some of the important criticism are:

i. By summing linearity, budgeting ignores the effect of diminishing returns.

ii. The severest problem of budgeting lies in estimating yields and prices. Because of no considerations of risk and uncertainty elements in estimation in the yields and prices, budgeting technique has limited utility as planning techniques.

iii. Budgeting can be criticized as a subjective technique of planning. It is based mostly on hit and trial and the calculations do not proceed systematically as in some other techniques.

iv. It is very difficult to incorporate several enterprises and constraints in the planning exercise when budgeting is used.

v. Budgeting may often be an inefficient technique of planning. Because of subjectivity, some may stop at a plan with lower profits than what could be obtained by some other more experienced planner.

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Chapter 4

Crop Planning and Management

Raghvendra B. Yadav and Sanjeev Kumar

A plan is a temporal set of intended actions to achieve a goal. Planning is a basic management function involving formulation of one or more detailed plans to achieve optimum balance of needs or demands with the available resources. The planning process (1) identifies the goals or objectives to be achieved, (2) formulates strategies to achieve them, (3) arranges or creates the means required, and (4) implements, directs, and monitors all steps in their proper sequence.

Crop planning refers to strategies for growing different crops on a farm throughout the year in order to meet the requirements through optimization of available resources. A good crop plan should include information on what is needed to produce the desired output of different crops. Appropriate decision making is very crucial for management of the farm. For this purpose a set of activities have to be carried out before making the crop plan decisions. These activities may include farm layout, farm operations planning, cropping scheme and crop layout. All these activities have to be carried out in a synchronized and systematic manner so that the desired production could be achieved with available resources without compromising the long term productivity of the farm.

PRINCIPLES OF FARM PLANNING

1. Whole farm planning is a process to analyze the farming operation.
2. Each production system must be planned and combined with the other systems.
3. Both the physical infrastructure and the economical and management inputs must be planned.
4. Accurate information need to be obtained to ensure proper planning.

Integrated farm planning is one of the components that will contribute to the success of the farming business. There must be proper planning of the production system, marketing, quality of products and financial planning.

STEPS INVOLVED IN WHOLE FARM OR INTEGRATED FARM PLANNING

1. Setting of goals
2. Making an inventory and assessment of existing farm resources
3. Developing and implementing an action plan
4. Monitoring on-farm processes towards the goal

Step 1: Setting of Goals

Whole farm planning begins with the development of a long-term goal or vision for the farming business. The farm manager needs to determine the following:

- The vision or aim for the future of the farm.
- The long term goals e.g. improvement of soil fertility, etc. and short term goals e.g. the planning of tillage methods, diversification of crops or enterprises and improving the marketing of products.
- The amount of output and income expected from the farm.

Step 2: Inventory and assessment

- These goals should be able to properly plan an inventory of resources which include natural resources, human resources and financial resources.
- Natural resources can be determined by using a farm map, soil maps, soil testing, availability of water and vegetation. It can be obtained through the study of maps and other documents.
- Human resources including manpower availability, their skill levels and training of the different farm workers.
- The financial assets or resources.

Step 3: Action Plan

The planning that was done in the previous steps needs to be put in action. The management alternatives need to be identified and evaluated and then be used to develop an action plan. The action plan must fit in with the goals set in the first step and must make use of all existing positive resources as it can influence future planning.

Step 4: Monitoring and Evaluation

- Management alternatives must be evaluated separately to determine which plan suites the farming business best.

- As the whole farm plan is implemented, there is a need to evaluate the different options and plans through constant monitoring to determine if it is working in the desired direction. It might be necessary to make minor adjustments to the plan as time goes on.

FARM OPERATIONS PLANNING

I. Inventory of Physical Resources

a. Land, soil, water, microclimate

b. Infrastructure: Buildings, Irrigation, Fencing, etc.

c. Access roads

d. Equipments and implements

e. Inputs: seeds, fertilizer, pesticides, medications, etc.

f. Resource needs and gaps:

   i. What you have & what you need?

   ii. Working life of what you have/are acquiring, plan for replacement, etc.

II. Human Resources

a. Who does what and when?

   i. Owners, employees, labourers involved in farm

   ii. For each person:

      - Skill set
      - Preferred tasks
      - Availability for labor
      - Backup person for task

b. Who is responsible for making sure each task gets done?

c. Timing of peak labor needs

d. Additional labor needed

e. Decision-making procedures for deployment of manpower

CROP PLANNING

Crop planning considers what, when, where and which plants to grow in relation to their requirements for space, sunshine, water, maturation, season of planting and

tolerance for each other. It involves a cropping pattern in which different categories of cereals, pulses, oilseeds, vegetables etc. are raised, followed by a system of crop rotation to keep the cycle going and to provide a suitable, healthy environment for plants to grow. Crop plans must include varieties of crops. The following points need to be considered while making a crop plan:

a) Type of soil: The crops must be planned according to its soil type. Rice, wheat, sugarcane, cotton and jute all grow well in alluvial soils as these soils are rich in some nutrients. Similarly black soils are suited for cotton crop.

b) Type of climate - In the summers where temperature is high tropical crops like-gaur, bajara can be grown while in winter temperate crops like mustard, wheat etc. can be cultivated (Table 1).

c) Type of rainfall - In the dry regions where the rainfall is scanty and/uncertain, more dependence on rainfed crops like coarse cereals can be planned. In assured irrigation rice crop may be cultivated.

d) Type of topography: Crops like rice can be grown in lowland areas, Tea for gentle slopes and on plain other crops like wheat maize etc.

e) Soil pH: While selecting crops due care should be given to soil pH for e.g. Rice, carrot, garlic may be grown on acidic soils while wheat maize etc may be grown on saline soils.

Apart from above the area of farm must be divided based on the according to preference. The area of experiments must be divided according to the experiment needs for e.g. Rice should be in lowland area. Again the water requirement of the crop also need to be considered and crops with high water requirements need to be sown near to irrigation sources.

CROPPING SCHEME

It is the plan according to which crops are grown on individual plots of a farm with an object of getting maximum return without impairing the fertility of soil.

Criteria for Cropping Scheme

1. What crop is to be cultivated in a farm?
2. What amount of area is allotted for a particular crop?
3. What should be the relative claim for acreage of the competitive crop?
4. Selection of crops as per the facilities available for power, irrigation, inputs, labour transport etc.

Table 1: Crop Calendar

Vegetables	Crop Schedule Green Line means the crop is sown and harvested between the mentioned period.
	Jan · Feb. · March · April · May · June · July · August · Sept. · Oct. · Nov. · Dec.
Rice	
Wheat	
Maize	
Green Gram	
Black Gram	
Pigeon Pea	
Chick pea	
Mustard	
Sugarcane	
Potato	
Brinjal	
Tomato	
Cabbage	
Berseem	

5. Utilization of inputs and other resources available at the farm without wastage.
6. Preparation of budget for each crop.

Characteristics of a Good Cropping Scheme

1. *Area under Individual plots:* The areas of individual plot for each crop should be approximately same year after year unless there is a major policy shift.
2. *Number of Plots*: The number of plots should be equal to the duration or multiple of it. When the total duration of rotation in cropping scheme is 4, then the number of plots may be 4 or multiple of it *i.e.* 8, 12, 16 and so on.
3. *Resource use efficiency*: Cropping Scheme is related to the profitable use of productive resources and management.
4. *Crop rotation:* The rotation should be practiced to break the insect pest development cycle.
5. *Soil Fertility*: The cropping scheme must be planned in a manner so that it helps in maintaining soil fertility and other physic-chemical properties. Inclusion of one leguminous crop in rotation may be preferred for the maintenance of soil fertility and other physico-chemical properties.

Example of cropping Scheme:

Plot No.	*Kharif* crop	Area (ha)	*Rabi* crop	Area (ha)	*Zaid* crop	Area (ha)
1.	Maize	2	Potato	2	Sesamum	2
2.	Cucurbits	2	Wheat	2	Fallow	-
3.	Groundnut	2	Wheat	2	Moong	2
4.	Brinjal	2	Cabbage	2	Chilli	2
5.	Basmati Rice	2	Pea	2	Cucumber	2
6.	Radish	2	Cauliflower	2	Watermelon	2
7.	Jowar+Cowpea	2	Oat/Berseem	2	Cucurbits	2
8.	Okra	2	Pea	2	Cucumber	2
9.	Okra	2	Carrot	2	Fallow	-
Total		**18**		**18**		**14**

Cropping scheme for a farm of 20 ha with sandy loam soil situated near a city and having all facilities for intensive cropping.

Net Cultivable area= 20 ha (10 % area under building & layout).

Cropping Scheme:

Total cropped area = 18+ 18 +14 = 50 ha

Cropping intensity % = Total cropped area / Net cultivable area x 100

= (50 / 18) x 100 = 277.78 %.

FARM LAYOUT

Farm layout refers to the compiling of physical structures such as homesteads, outbuildings, waterways, contours, camps, water supply roads and the layout of orchards, vineyards or lands. However, the area where the farm is situated, the topography, the availability of natural resources, the farming practices, the different enterprises, availability of capital and preference of the owner will also affect the farm layout.

The main considerations in making a farm layout are to ensure easy availability of inputs to different enterprises and smooth facilitation of disposal of farm produce. For this purpose following points need to be taken into consideration in order to achieve good results:

Irrigation facility

There should be provision of assured irrigation facility on the farm in order to avoid any situation of drought or heat stress to the standing crop. Care should be taken that high water requiring crops should be grown near the irrigation source. Provision should also be made for underground flow of water to avoid seepage and evaporation losses of irrigation water.

Compost heaps

Application of farm yard manure/compost constitutes an essential part of maintaining soil fertility and ensuring good crop growth. The compost pits/ heaps should be prepared near the livestock unit with assurance of water supply so as to maintain proper moisture in the compost.

Livestock shed

A livestock shed should be constructed by the side of the main road preferably at a distance of about 100 meters. Buildings should be placed so that direct sunlight can reach the platforms, gutters and mangers in the livestock shed. The shed must

be at a higher elevation than the surrounding ground to offer a good slope for rainfall and drainage for the wastes.

Livestock feed store

At the farm a feed store should be closely placed to the livestock shed so that feed may be easily transported from feed store to livestock shed. It helps in reduction of the labour cost in transportation. It also must be far from any chance of fire.

Rainwater harvesting structures

It is an important component of the farm if it is located in the rainfed area. This structure is constructed to collect and store direct rainwater as well as run-off water for use in subsequent seasons. The rainwater structure should be constructed at a low lying location where water from all the areas flow down.

Implements shed/workshop

The implement shed is used for keeping the farm implements and machinery at one place. This type of shed should be constructed near the cropped area for easy transportation and handling. If the number of implements and machinery is more, it is desirable to have a workshop on the farm for their repair and maintenance at the farm itself.

Fish pond

To establish a fish pond care should be taken that it should be well dugged. For constructing fish pond, very sloppy land must be avoided, land with one percent slope be preferred. The pond should be in full sun and not surrounded by trees as this invites predators, such as fish-eating birds. The soil should not allow water to seep away.

Input store

The input store is used for storing various types of inputs like seed, fertilizers, pesticides, etc. required for growing crops in the farm. These inputs need to be stored with utmost care as many of these are either hygroscopic in nature or degenerate under high atmospheric humidity conditions. Hence, provision should be made for controlling temperature and humidity in such stores.

Crop harvest store

All the crop produce harvested from farm are kept in crop harvest store. It must be a little elevated place where water stagnation does not occur in its vicinity. It should also have provision for control of temperature, relative humidity and should be located near the crop field.

Generator facility

Generator facility is required in the farm for carrying out essential operations in the absence of electric supply. These operations like irrigation, use of power operated machines and other facilities required in the farm stores are almost essentially to be performed with a set timeline. The generator unit should be located conveniently at a place in the farm so that it can be accessed from the point where its electricity is required.

CONCLUSION

Whole farm planning assesses the physical aspects of the farm with regards to soil, vegetation and topography. This physical stocktaking of the farm is then the basis of farm design and layout. This may include soil conservation structures, water supply, irrigation and the improvement of natural vegetation or the eradication of alien plants. The whole farm planning enables the manager to consider the natural resources and take all the internal and external factors into account for decision making on type of production systems, type of products produced and marketing of the products. The focus of integrated farm planning is to consider the entire production of possible agricultural products and to plan the farm infrastructure in such a way that it complements the production process while ensuring the sustainable use of the natural resources. The farm manager also needs to develop risk management strategies as a means of increasing the farm viability.

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Chapter 5

Theory and Practice of Orchard Management

Poonam Kashyap

The orchard management refers to broad range of practices designed to maximize production of high quality fruit and increase grower profitability. A good management should aim at knowing the basic needs considering all the resources and providing them all basic inputs in optimum level in order to get more returns with maximum efficiency. The good orchard management practices should be planned from the establishment phase of the orchard. The selection of an orchard management practice depends on factors like climate, location of orchard, topography, tree spacing, planting system/ orchard design etc. However, it should be combined with pruning, nutrient and water management, provision for pollination, fruit thinning, disease and pest management in order to obtain desirable tree growth and vigour with the aim to promote precocity with high productivity.

ESTABLISHMENT OF AN ORCHARD

Establishment of an orchard is a long term investment and deserves a very critical planning. The selection of proper location and site, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production.

a. Location and site

The location should be having adequate water supply round the year. The site must have proper drainage and no water stagnation during rainy season. Irrigation water should be of good quality. Whether the climatic conditions are suitable for the fruits to be grown and whether the site is free from the limiting factors such as cyclones, frost, hailstorms and strong hot winds should also be taken into consideration.

b. Laying out of orchards

Any method of layout should aim at providing maximum number of trees per hectare, adequate space for proper development of the trees and ensuring convenience in orchard cultural practices. The system of layout can be grouped under two broad categories viz. (a) vertical row planting pattern and (b) alternate row planting pattern. In the former planting pattern (e.g. square system, rectangular system), the trees set in a row is exactly perpendicular to those trees set in their

adjacent rows. In the latter planting pattern (i.e. Hexagonal, Quincunx and Triangular), the trees in the adjacent rows are not exactly vertical instead the trees in the even rows are midway between those in the odd rows.

The various layout systems used are the following:

1. ***Square system:*** In this system, trees are planted on each comer of a square whatever may be the planting distance. This is the most commonly followed system and is very easy to layout. The central place between four trees may be advantageously used to raise short lived filler trees. This system permits inter cropping and cultivation in two directions.

2. ***Rectangular system:*** In this system, trees are planted on each corner of a rectangle. As the distance between any two rows is more than the distance between any two trees in a row, there is no equal distribution of space per tree. The wider alley spaces available between rows of trees permit easy intercultural operations and even the use of mechanical operations.

3. ***Hexagonal System:*** *In* this method, the trees are planted in each comer of an equilateral triangle. This way six trees form a hexagon with the seventh tree in the centre. Therefore this system is also called as 'septule' as a seventh tree is accommodated in the centre of hexagon. This system provides equal spacing but it is difficult to layout. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 x the distance between any two trees. As the perpendicular distance between any two row is less than unity, this system accommodates 15 per cent more trees than the square system. The limitations of this system are that it is difficult to layout and the cultivation is not so easily done as in the square system.

4. ***Diagonal or quincunx system:*** This is the square method but with one more plant in the centre of the square. This will accommodate double the number of plants, but does not provide equal spacing. The central (filler) tree chosen may be a short lived one. This system can be followed when the distance between the permanent trees is more than 10 metres. As there will be competition between permanent and filler trees, the filler trees should be removed after a few years when main trees come to bearing.

5. ***Triangular system:*** The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows. However, the vertical distance, between immediate two trees in the adjacent rows, is equal to the product of 1.118 x distance between two trees in a row. When

compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system.

6. ***Contour system:*** It is generally followed on the hills where the trees are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours. The width of the contour terrace varies according to the nature of the slope. The planting distance under the contour system may not be uniform.

HIGH DENSITY PLANTING SYSTEM

Planting of fruit trees rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is referred as 'High density planting' or HDP. This is achieved by :

(a) Use of size controlling root stocks: In apple, dwarfing root stocks and intermediate stocks like MM 106, MM 109, and MM 111 are used to control the size of the plant. In pears, Quince A, Adam and Quince-C are commonly used as dwarfing root stocks.

(b) Use of spur type scions: In temperate fruit crops like apple, the cultivars can be classified into a spur type or non-spur type. The spur types which have restricted annual growth are alone suitable for high density planting.

(c) Training and pruning methods to induce dwarfness: Under Indian conditions, apple trees trained under spindle bush, dwarf pyramid, cordon systems are found to contain the growth of the trees appreciably for HDP systems.

(d) Mechanical device and use of chemicals to control size: Growth regulators such as daminozide, ethephon, chlormaquat and paclobutrazal are extensively used to reduce shoot growth by 30 to 0 per cent. This results in increased flowering in the subsequent years and may be useful in encouraging earlier commercial fruit production in young trees. Besides chemical manipulation, mechanical devices employing the use of spreaders and tying down the branches to make them grow from near horizontal to an angle of 45° from the main stem are also some of the standard practices to control tree size.

ORCHARD SOIL MANAGEMENT

Orchard floor management refers to the management of the orchard soil in such a manner that the fruit trees give higher yield of quality fruits in successive years for sustainable economic returns. Methods of soil management practices are described as follows:

1. Clean culture

This type of cultivation is extensively followed in India. This involves regular ploughing and removal of weeds. The clean culture has many disadvantages *viz*., depletion of humus rapidly due to frequent cultivation, injury to the feeding roots, the trees may be short lived or stunted in growth, more aeration leading to the depletion of nitrogen, creation of hard pan in the soil, more soil erosion.

2. Clean culture with cover crops

This type of soil management involves raising of a cover crop or green manure after removing the weeds. If clean cultivation is attempted during the rains, considerable erosion is almost sure to occur. It is advisable to plant a green manure crop between the trees early in the rains and ploughing it into the soil towards the end of monsoon season. In India, green manure crops like Sunhemp, Cowpea, Dhaincha, Lupins etc. are more commonly used. Legume cover cropping in grape, mango, guava and other fruit crops is becoming a common practice in the management of orchards. Cowpea and French beans grow well under guava and sapota tree. In some places to prevent soil erosion, certain permanent cover crops like *Calapogonium muconoides, Centrosema pubescens and Peuraria phaseoloides* are raised in the alley spaces.

3. Mulching

This is one of the important soil management practices adopted in certain countries including India. Crop residues like straw, cotton stalks, leaves, saw dust, pine needles, coir dust and other materials like polythene films or certain special kinds of paper are spread in the tree basins and in inter-spaces between trees. Main objective of mulching is to conserve soil moisture and to control the weed growth.

4. Sod

In this method, permanent cover of grass is raised in the orchard and no tillage is given. This may be useful in sloppy lands for preventing soil erosion. But they compete for soil moisture and available nitrogen. The drawbacks of this system are the need for increased manuring and water application. They are harmful to shallow

rooted trees. Hence sod may be useful with deep rooted trees because soil moisture will be very low on the top layers.

5. Intercropping

In case of other long duration horticultural crops like tapioca, turmeric, ginger and banana some area between adjacent plants will be remaining unoccupied by the main crop for few months. The practice of growing any economic crop in alley spaces of the fruit trees in the first few years or in the unoccupied spaces of the long duration crop in the early periods is referred as intercropping. They also act as a cover crop and the land benefits by the cultivation, irrigation, manuring given to the intercrops. Vegetables are the best intercrops when compared to millets. The intercrops grown should be kept well away from the main fruit trees and irrigated independently. The intercropping should be stopped when trees occupy the entire orchard space. Thereafter, green manuring or cover cropping should only be practiced.

6. Chemical weed control

In this method, weeds are controlled by chemicals, referred as weedicides or herbicides. This practice is based on the principle of selectivity, killing only one kind of plants. Pre-emergence herbicides like diuron, atrazine, fluchloralin etc. are applied to the soil prior to emergence of weed seedlings by broadcasting, band application, soil incorporation or spray on soil surface. Post-emergence herbicides such as glyphosate, paraquat etc. are applied with the addition of surfactant after the emergence of weeds.

CROP REGULATION IN FRUITS

Crop regulation is the basis for the regular and quality crop. A range of methods are used to increase production with enhanced fruit quality by crop regulation. It can be achieved through manual thinning, chemical thinning, selective harvesting, training, summer and winter pruning, prevention of pre - harvest fruit drop, etc.

Uses of Plant Growth Regulators (PGRs)

1. Delay bloom:

Autumn application of GA3 and Ethrel cause delaying of bloom in spring in stone fruit, which can be a useful practice to increase fruit-set in frost affected areas. Blooming of Red Beaut plum can be delayed by several days with fall application of GA3 and Ethrel to help in better synchronization of flowering period with cultivar Santa Rosa, inter-planted for cross pollination. Concentration of plant growth regulators and time of application depend upon fruit crop and environment.

2. Thinning:

In blossom thinning, chemicals are applied at bloom, whereas in fruit-lets thinning, chemicals are sprayed a few days after petal fall i.e. after fruit set. In apple application of NAA at 10 ppm, 7-15 days after petal fall during the heavy cropping year (On-Year) causes satisfactory thinning and increases return bloom. In mango, fruit drop is exceptionally high as only approximately 0.1% of the perfect flowers develop fruits to maturity. Post setting drop of Alphonso mangoes can be controlled by foliar application of 25 ppm of NAA or 2,4-D. In Neelum 2,4-D at 30 ppm proved effective control of fruit drop without having any adverse effect on fruit size.

3. Pruning:

Opening up of the centre of the trees by topping off or thinning of branches have been reported to decrease biennial bearing in Mulgoa, Neelum and Bangalora cultivars. This improves light penetration into the interior of tree canopy. However, these practices have been unsuccessful in those cultivars which have inherent problem to bear irregularly.

4. Fruit set:

In citrus, fruit yield is often limited due to poor fruit set. Experiments with the use of PGRs have given some encouraging but, inconsistent results. Fruit set in Washington Navel Orange can be increased with the foliar application of 2,4-D at 8 ppm. In India, a foliar application of 2, 4-D or 2,4,5-T has been reported to be beneficial in improving fruit set and quality in mandarin.

5. Fruit drop:

Excessive fruit dropping in citrus is a major problem in India. If lack of soil moisture is the cause, use of organic mulching material like leaves or black polythene mulch can reduce the extent of fruit drop. Auxin, particularly 2,4-D at varying concentrations is very effective in controlling pre-mature/pre-harvest fruit drop in citrus. Sprays of 2,4-D at 8 ppm at 1.2 cm diameter stage in Valencia orange, and at 15 ppm in Pineapple and 2,4,5-T at 30 ppm in Jaffa and Mosambi are useful when applied in October. 2,4- D have also been found to be useful in reducing fruit drop in sweet lime and Darjeeling mandarin.

6. Fruit thinning:

Application of NAA at 350 ppm or Ethrel at 200 ppm in Kinnow mandarin during the ‘On Year’, 40 days after full bloom effectively controls fruit drop and reduce the tendency of alternative bearing.

7. Alternate bearing:

Alternate bearing has been one of the major problems. Most of the south Indian varieties are regular- bearer, whereas north Indian ones alternate-bearer. Paclobutrazol is a promising chemical for flower induction in mango. Soil drenching with Paclobutrazol (5 g and 10g/tree) results in minimum outbreak of September to October vegetative flushes. It gives early and profuse flowering and more annual yield without affecting fruit size and quality.

8) Mango malformation:

It is one of the most important disorders, causing huge losses. It is a major problem in Punjab, Delhi and Uttar Pradesh. However, it has also been noticed in Gujarat, Maharashtra, Bihar, West Bengal and Orrisa. Of the two types of mango malformation, vegetative malformation is more common in nursery seedlings and young plants. Floral malformation affects trees at the bearing stage. In vegetative malformation or bunchy top, compact leaves are formed in a bunch at the apex of shoot or in the leaf axil and growth of shootlet is arrested. Floral malformation directly affects the productivity. The incidence of disorder varies from variety to variety. De-blossoming alone or coupled with a spray of 200 ppm NAA lowers the number of malformed panicles significantly.

DISEASE MANAGEMENT IN ORCHARD

1. MANGO

(a) Powdery Mildew (*Oidium mangiferae*): Powdery mildew is one of the most serious diseases of mango affecting almost all the varieties. The characteristic symptom of the disease is the white superficial powdery fungal growth on leaves, stalks of panicles, flowers and young fruits. The affected flowers and fruits drop pre-maturely reducing the crop load considerably or might even prevent the fruit set. Rains or mists accompanied by cooler nights during flowering are congenial for the disease spread.

Control: Sprays of following three fungicides at 15 days interval are recommended for effective control of the disease:

i. Wettable sulphur 0.2 per cent (2 g Sulfex / lit. water).

ii. Tridemorph 0.1 per cent (1 ml Calixin / lit. water).

iii. Dinocap 0.1 per cent (1 ml / g Karathane / lit. water).

(b) Anthracnose (*Colletotrichum* spp): The anthracnose disease is of widespread occurrence. The disease causes serious losses to young shoots, flowers and

fruits under favourable climatic conditions of high humidity, frequent rains and a temperature of 24-32^0 C. It also affects fruits during storage. The disease produces leaf spot, blossom blight, withertip, twig blight and fruit rot symptoms. Tender shoots and foliage are easily affected which ultimately cause 'die back' of young branches. Older twigs may also be infected through wounds which in severe cases may be fatal.

Control: Trees may be sprayed twice with Bavistin (0.1%) at 15 days interval during flowering to control blossom infection. Spraying of copper fungicides (0.3%) is recommended for the control of foliar infection.

(c) Die back (*Botryodiplodia theobromae Pat.*): Die back is one of the serious diseases of mango noticed at any time of the year but it is most conspicuous during Oct.-Nov. The disease is characterized by drying of twigs and branches followed by complete defoliation, which gives the tree an appearance of scorching by fire.

Control: (i) Prune the diseased twigs and spray with copper oxychloride (0.3%) on infected trees. Pruning should be done in such a way that the twigs are removed 2-3 inches below the affected portion. (ii) In small plants, pruning of twigs is followed by pasting of copper oxychloride.

(d) Phoma blight (*Phoma glomerata*) : The symptoms of the disease are noticeable only on old leaves. Initially, the lesions are angular, minute, irregular, yellow to light brown, scattered over leaf lamina. As the lesions enlarge, their colour changes from brown to cinnamon and they become almost irregular. Fully developed spots are characterized by dark margins and dull grey necrotic centres. In case of severe infection such spots coalesce forming patches measuring 3.5-13 cm in size, resulting in complete withering and defoliation of infected leaves.

Control: The disease could be kept under control by spray of copper oxychloride (0.3%) or mancozeb (0.3%) just after its appearance and subsequent sprays at 20 day intervals.

(e) Bacterial canker (*Xanthomonas campestris pv. Mangiferae indicae*): Canker disease of mango, caused by a bacterium is prevalent in Andhra Pradesh, Maharashtra, Karnataka, Kerala, Tamil Nadu, U.P., Bihar, Delhi, Haryana, Madhya Pradesh and probably in several other mango growing areas. The disease causes fruit drop (10-70%), yield loss (10-85%) and storage rot (5-100%). Many commercial cultivars of mango including Langra, Dashehari, Amrapali, Mallika, and Totapuri are susceptible to this disease.

The disease is found on leaves, petioles, twigs, branches and fruits, initially producing water-soaked lesions and later turning into typical cankers. The disease first appears as minute water-soaked irregular lesions on any part of leaf or leaf lamina. The lesions are light yellow in colour but with age, enlarge and turn dark brown to black. In severe infections the leaves turn yellow and drop off. Cankerous lesions appear on petioles, twigs and young fruits. The water soaked lesions also develop on fruits which later turn dark brown to black.

Control : Three sprays of streptocycline (100 ppm) or Agrimycin-100 (100 ppm) after first visual symptom at 10-days intervals effectively control the disease. Monthly sprays of Bavistin (1000 ppm) or copper oxychloride (3000 ppm) were also found effective.

2. GUAVA

(a) Wilt: This is a serious disease occurring in northern and eastern India as well as other parts of the world. The exact cause of the disease is still not known but the pathogens, viz., *Fusarium oxysporum, Fusarium solani, Macrophomina phaseoli, Rhizoctonia bataticola and Caphalosporium* spp. may initiate the disease. It is characterised by yellowing of leaves followed by drying of leaves and twigs from the tip and complete wilting of trees within 10-15 days. The disease occurs more severely in alkaline soils.

Control: 1) Removal of infected trees should be done to prevent the spread of the disease. 2) Severe pruning and then drenching with 0.2 per cent either Benlate or Bavistin 4 times in a year and spraying twice with Metasystox and Zinc sulphate. 3) Soil treatment with 1.82 kg. lime or gypsum/tree 4) Application of 6 kg neem cake + 2kg. gypsum per plant. 5) Oil cakes like neem cake, mahua cake, kusum cake supplemented with urea @ 10 kg and 1 kg respectively also check the disease. 6) Maintenance of proper tree vigour by timely and adequately manuring, inter-culture and irrigation enable them to withstand infection. The pits may be treated with formalin and kept covered for about 3 days and then transplanting should be done after two weeks. 7) use of bio- control agents like T*richoderma* spp. and *Streptomyces chibaensis* for the control of wilt.

(b) Anthracnose (*Gloesporium psidii*): The affected plants begin to die back from the top of the branch while, shoots, leaves and fruits are readily affected. The growing tips gradually turn dark brown and the black necrotic areas extend backwards causing dieback.

Control: The disease can be controlled by spraying the trees with phytolon 2 g per litre of water.

(c) Fruit canker (*Pestalotia psidii):* This is characterised by small to medium raised dark brown cankerous spots on fruit surfaces. The fruits infected in the early stages fail to develop properly. Young infested fruits get cracked.

Control: The disease can be controlled effectively by spraying of Dithane Z-78 or Difoltan 0.2 percent at monthly intervals during June to October.

(d) Cercospora leaf spot (*Cercospora sawadal):* Water soaked patches under the leaf are the characteristic symptoms of this disease. The infection can be minimised by spraying of 0.3 percent copper oxychloride.

3. APPLE

(a) Scab (*Venturia inaequalis*): It is one of the most important diseases of apples. Cool, wet weather is necessary for apple scab infections. Scab is characterized by olive green lesions on leaves. Early season infections frequently occur on the lower leaf surface, but lesions can be found on the upper surface as well. Extensive infections can cause early defoliation and may reduce the next year's crop yield. Small, dark lesions occur on the fruit, often on the sepals or near the calyx end. Apple scab infections do not rot the fruit but may cause cracking as the fruit enlarge.

Control: Where scab is a problem, fungicides need to be applied from green tip through petal fall or first cover. Additional applications may be needed in cool, wet seasons. Fungicide applications can be made on either a protectant or post-infection schedule. The spray schedule to be followed for the control is as follows:

(b) Bitter Rot (*Colletotrichum* spp.): It is the most important summer rot disease of apples. In some seasons it has caused losses approaching 100% in just a few days. Fruit infections can occur soon after bloom and appear as small grey to brown flecks, which may not enlarge until later in the summer. The most damaging fruit infections occur more than a month after petal fall. Small, sunken, brown lesions form, sometimes surrounded by a red halo. The halo is especially visible on green or yellow fruit.

Control: To effectively control black rot, remove all dead wood from the tree and ground, including current season pruning. This wood needs to be burned, removed to a landfill, or chopped and composted. Chopped wood should not be used as mulch in the orchard until it has been thoroughly composted.

(c) Powdery Mildew *(Podosphaera leucotricha*): It is one of the most important apple diseases worldwide. Losses occur from the reduced grade of infected fruit and from stunting of leaves and defoliation. Infected terminals and leaves

Tree Stage	Name of Chemical	Quantity of Chemical for 200 lit. of water
Green tip	Captan or Dodine or Ziram	600g 200g 600 ml
Pink bud	Mancozeb or Difenoconazole	600g 30 ml
Petal Fall/ Pea Stage	Carbendazim or Thiophanate Methyl or Hexaconazole	100 g 100 g 100 ml
Fruit development (20 days after 4th spray)	Dodine or Propineb or Zineb	150g 600g 600g
Pre-Harvest (20-25 days before harvest)	Captan or Ziram	600g 600 ml

are stunted, distorted, and covered with a silver grey mat of mycelium. Severe infections can result in premature defoliation and fall blooming. Fruit infections are characterized by a net-like russet.

Control: Use plant varieties of apple with resistance to powdery mildew. Cultivars such as Jonathan, Idared, Rome, and Gala are susceptible whereas Red and Golden Delicious are more resistant. Remove infected shoots early in the spring. Spraying the affected plants with Wettable suphur can control the disease significantly.

INSECT-PEST MANGEMENT IN ORCHARD

1. MANGO

(a) Mango stem borer (*Batocera rufomaculata*):

Symptoms of damage: Grub tunnels in the sapwood on the trunk or branches. Grub bore into the sap wood and make irregular tunnels. Drying of terminal shoot in early stage. Fross comes out from several points along with oozing of sap out of the holes.

Management:

1. Removal and destruction of dead and severely affected branches of the tree.
2. Removal of alternate host, silk cotton and other hosts.
3. Use of tolerant mango varieties viz., Neelam, Humayudin.

4. Application of Swab Coal tar + Kerosene @ 1:2 or Carbaryl 50 WP 20 g / l can be done after scraping the loose bark to prevent oviposition by adult beetles.
5. Padding with monocrotophos 36 WSC 10 ml in 2.5 cm /tree soaked in absorbent cotton gives effective control.
6. Application of copper oxychloride paste on the trunk of the tree.

(b) Shoot borer (*Clumetia transversa*):

Symptoms of damage: Terminal shoots show tunnel from top to down wards. Stunting of seedlings with terminal bunchy appearance.

Management:

1. Field sanitation
2. Collect and destroy the infested plant parts.
3. Summer ploughing is done to expose the pupae.
4. Spraying of carbaryl 50WP 0.1%.

(c) Mango hoppers (*Idioscopus niveoparsus, I. clypealis, Amirtodus atkinsoni*):

Symptoms of damage: Nymphs and adults suck the sap of inflorescence. Presence of honey dew secretion on lower leaves and development of shooty mould. Clicking sound - movement of jassids amidst leaves. Hoppers provide shelter in the cracks and crevices of the barks on the tree.

Management:

1. Avoid close planting as the incidence very severe in overcrowded orchards.
2. Orchards must be kept clean by ploughing and removal of weeds.
3. Wettable sulphur @ 2 g/lit may be sprayed after spraying carbaryl to avoid mite resurgence.
4. Application of neem oil @ 5 ml/lit of water should be done.

(d) Fruit fly (*Bactrocera dorsalis*):

Symptoms of damage: Maggot bore into semi-ripen fruits with decayed spots and dropping of fruits. Oozing of fluid from the affected areas. Brownish rotten patches on fruits.

Management:

1. Collection of fallen infested fruits and disposal by dumping in a pit.
2. Summer ploughing to expose the pupa.
3. Application of Methyl Eugenol sex lure traps to attract the adult flies.
4. Bait spray - combining any one of the insecticides and molasses or jaggery 10 g/l
   a) Fenthion 100EC 1ml/l,
   b) Malathion 50EC 2 ml/l,
   c) Dimethoate 30 EC 1 ml/l,
   d) Carbaryl 50 WP 4 g/l. two rounds at 2 weeks interval before ripening of fruits.

Biological control: Field release of natural enemies *Opius compensates* and *Spalangia philippines*

2. GUAVA

(a) Fruit fly (*Dacus dorsalis* hendel):

Symptoms of damage: The eggs are inserted under the rind of the fruits. The adult flies emerge out in the month of April and starts laying eggs. The mature maggot comes out of the fruit and drop on the ground to form pupa.

Management:

1. The fallen and infested fruits should be collected and buried deep into the soil.
2. Ploughing around trees to expose pupa to be destroyed by heat and predators.
3. The adult flies may be trapped and killed by poison baiting or bait spray (20 ml malathion + 200 g molasses in 20 liters of water)
4. The hedges around the guava trees may be sprayed with endosulfan (0.1%), carbaryl (0.1%) or Quinalphos (0.05%).

3. APPLE

(a) European Red Mite (*Panonychus ulmi*):

Symptoms of damage: European red mites feed on leaves. Severe mite injury produces browning and loss of color in the leaves commonly referred to as bronzing. Extensive foliage injury may reduce the quality and quantity of fruit.

Management:

1. Predators like *Ambelacious fallacies*, *Zetzellia mali*, Chrysoperla spp., *Stethorus punctum*, renders good control.
2. Spray of IPOL orchard spray oil (2 %) with Lindane (0.05 %) at half inch green stage of apple.

(b) Woolly Apple Aphid (*Eriosoma lanigerum*):

Symptoms of damage: Both the adult and nymph cause damage by sucking of sap. Nodules like structures or galls are formed on aerial and underground parts of plant. Hypertrophy of the affected tissues of plant.

Management:

1. Removal and destruction of infested nursery plants.
2. Parasitoid Aphelinus mali provides significant control.
3. Preadators like *Coccinella septempunctata, Chilomenus bijugus, Ballia ancharis, Syrphus confractors* are effective in checking pest population.
4. Carbofuran, aldicarb and phorate granules 1 g ai/nursery plant.

TRAINING AND PRUNING OF FRUIT TREES

Young trees are pruned to train them to become structurally sound, to make them easy to care for and to ensure the production of high quality fruit.

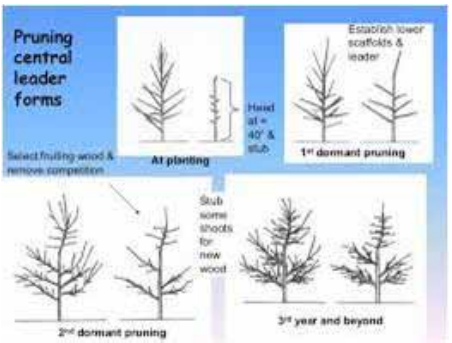
Objectives of pruning

- Control size for easier care in maintaining and picking fruit
- Increase strength – develop strong limb structure
- Distribute sunlight evenly throughout tree
- Regulate fruit bearing – removes excess fruitwood
- Renew fruitwood – to continue strong buds and flowers
- Remove undesirable wood- dead, broken, and crossing branches.

The optimum time of the year to prune fruit trees is the dormant season viz., December and January.

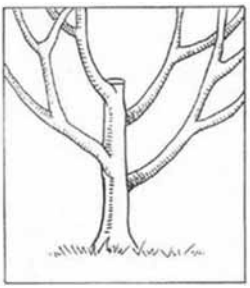
Training/Pruning Systems

1. Central Leader System



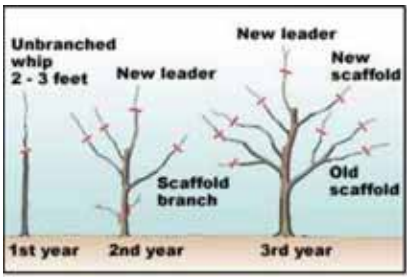
The central leader training system, the commonly used system for training apple, pear, cherry, plum and pecan trees, removes all strong upright shoots, leaving only the strongest branch to grow through the centre of the canopy. Three or four evenly spaced branches are chosen for scaffold whorls in the following years, with the first whorl about 2 to 3 feet above ground and about 18 to 24 inches of vertical space between branch whorls along the trunk. Spreaders placed between the trunk and branches spread the branch angles to a desirable range of about 60 degrees. A pyramidal shape ensures even sunlight to upper and lower branches. The central leader can be headed back to maintain the desired height at maturity.

2. Modified Central Leader System



Also called the multileader system, the modified central leader system is much like the central leader, but multiple vertical branches are trained instead of a single, main leader. The system works best with three to five leaders so the tree is well balanced. Rather than removing the competing vertical branches in the first two years after planting, the desired number of leaders are left on the tree and each is trained in the same way as with a central leader system. Spreaders are almost always required in order to open up the space between individual leaders. Apple, pear, plum and pecan trees are among the most common fruits trained to this system.

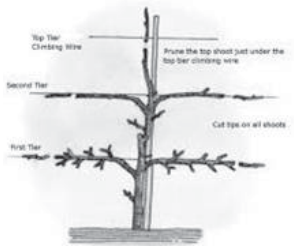
3. Open Centre System



Peaches, nectarines and plum trees are commonly trained to an open centre system, which maximizes spacing between branches and encourages short, wide trees that allow easier access to the fruit. Whips are headed

back to about 30 inches above the soil surface at planting to encourage branches just below the cut. The central leader is removed, leaving three to five evenly spaced scaffold branches growing from the trunk in a vase shape. The open centre reduces the need for pruning to thin branches because sunlight reaches the centre of the tree more easily.

4. Espalier

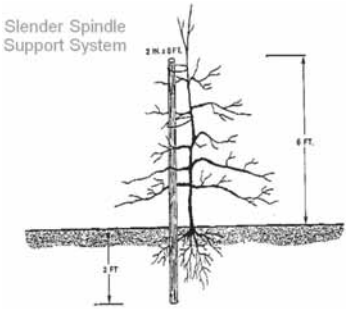


Espalier training systems work well for training apples and pears in small garden spaces. Espaliers require a wire trellis system with about 18 inches of vertical space between each row of wire and a vertical stake for each tree with about 12 to 20 feet of space between trees. The central leader is cut back to force branching; the center bud is trained vertically to the post and the two side buds are tied to the horizontal wires with soft twine. The leader is cut back when the tree reaches the top wire. Frequent pruning is needed to control branches sprouting from the horizontal branches and limit the number of fruiting spurs.

5. Tatura trellis

The Tatura trellis is a close-planting system for tree fruits, in which trees are trained to form a V shaped canopy. A trellis structure is needed to train the trees in forming the V, and to provide some support for the tree when carrying the crop. Each row of trees requires a trellis. The trellis consists of two end frames, intermediate frames, wires, and anchors. The capital outlay for materials and labour for the trellis structure may be as high as 30 per cent of the total establishment costs of the planting. Also, a failure of the trellis may lead to significant crop loss. Therefore, design and erection of the trellis must be carefully considered. Generally there are 2 basic shapes of canopies – Y shaped trees which have a vertical trunk and two opposing arms of the tree trained to either side of the trellis, and V shaped trees, where the whole tree is leaned to one side of the trellis while the next tree in the row is leaned to the other side.

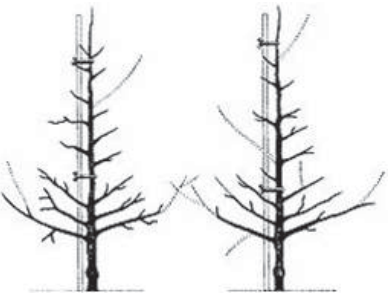
6. Spindle Bush



The system is best suited to densities up to 2,000 trees. At planting a number of laterals are selected to form part of the permanent scaffolds in the bottom third of the tree. Competing laterals that develop at the end of the unpruned central leader have to be removed in a very early stage. As the leader grows more scaffolds are selected and spaced equally.

Leader dominance is important and if it is lost will result in a reduced tree canopy, whereas if it becomes too strong lateral growth and development will be reduced. These systems can be free standing, however mostly utilise some form of support (either 2 to 3 wire trellis or individual supports). As tree densities get higher and row spacings get more restricted, variations on the spindle system such as the vertical axis, slender spindle and super spindle are favoured.

7. Vertical Axis



A vertical central leader (axis) is developed with relatively 'weak' fruiting branches arising around the leader. Tree density is between 1,000 to 2,500 trees/ha at a spacing of 4-5 m x 1-2 m and height can reach up to 3 metres. Maintaining apical dominance is important in the vertical axis system, particularly during early stages of development to ensure weak fruiting branches and therefore, no heading of the leader occurs. Branches are systematically renewed to prevent them from becoming permanent scaffolds. Support of 2 to 3 wire trellis is required. Similar to the spindle system, vertical axis systems are planted ideally using well feathered nursery trees.

8. Palmette

The palmette and its variations are generally limited to wide intra-row spacings (>2.0 to 2.5 m) with a tall tree which makes it best suited to planting densities of 700 to 1,500 trees/ha. There are a number of kinds of palmette training all with a central leader with scaffolds in the plane of the row only. Tiers of scaffolds are chosen in each season and tied to wires to reduce vigour and promote spurring. These systems have been popular because the bending of branches on trellises controls growth and provides a balance of fruiting and vegetative growth.

CONCLUSION

Orchard management practices are important for ensuring higher yield and quality of fruits through integrated management of soil, irrigation, tree canopy and nutrition. These inputs are dependent on each other as water and nutrients cannot be separated from the soil that supports the root system which, in turn, dictates the performance of the canopy and eventually the yield. Use of suitable cultural practices of orchard floor/ soil management promotes beneficial insects. It creates a conducive micro-environment which controls the disease and insect-pest problems and hence, reduces the susceptibility to damage and loss. Proper layout of orchard along with suitable training and pruning helps in attaining the required balance of vegetative to

reproductive growth. Improved light and water management is developed through training systems. Pruning promotes hormonal and growth regulators distributions, thus giving a proper framework to the tree. The mechanization of orchard operations is facilitated by newly developed tree management systems which improves the light penetration in the trees and hence, promotes proper colour and quality development in fruits.

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Chapter 6

Principles and Procedures for Plant Protection

Chandra Bhanu

Crops are affected by a number of pests which include weeds, insect-pests, disease causing pathogens (fungi, chromists, bacteria and mollicutes, viruses and viroides, parasitic algae, protozoa etc.), nematodes, rodents, birds, snails, parasitic plants etc.As per a conservative estimate, weeds, insects and diseases together cause 31-43% average annual losses in crop yield worldwide. The crop losses in developing countries are higher than developed countries.In India, the estimated crop losses due to various pests range between 10-30 percent. Among different pests, weeds cause 33%, insect pests 26%, diseases 26%, rodents and others cause 15% losses in crop yield.

Use of appropriate plant protection strategies is a key to the success of any agricultural farm. On an agricultural farm, crops are mainly affected by weeds, diseases, insect-pests, bird's damage, rodents, wild bores, blue bulls etc. In storage, different types of beetles, weevils, lepidopterons attack the grains/seeds which are to be managed efficiently to save the stored produce. Farm managers should have a clear cut strategy to manage crop pests on their own farm. Correct identification of weeds, pests and diseases of crops are first essential step in plant protection which facilitates in choosing the correct steps for their management.The descriptions of individual category of pests aregiven in the following section for their easy identification and formulating strategy for their management.

CATEGORY OF CROP PESTS ON FARM

1. WEEDS

Weeds are unwanted plants growing themselves without being sown. These are number one enemy of crops. They compete with crops for space, light, water and nutrient and cause quantitative and qualitative losses to crops. From management point of view, weeds can be categorized in two ways:

a. On the basis of growing site:

i. ***Weeds of cropped area***: For management of this category of weeds, selective herbicides recommended for a particular crop are used in integration with other weed control measures at a particular crop stage.

ii. ***Weeds of non-cropped area***: For management of this category of weeds, non-selective herbicides which kill all or most of the weed species in wastelands, roadsides, barren lands etc. are used. Paraquat, glyphosate, gluphosinate (for almost all kind of weeds) and 2,4-D (for most of broad leaved weeds) are example of herbicides used under these situations.

b. On the basis of major weed category (Fig.1):

i. ***Grassy weeds or narrow leaved weeds*** (Graminae or Poaceae family weeds which are monocots): For managing these types of weeds in broad leaved crops like pulses, most of oilseeds, vegetables etc., herbicide quizalofop-ethyl (Targa super) offers selective advantages and can be used to control most of the grassy weeds.

Grassy weeds

Echinochloa glaberescens

Cynodon dactylon

Dactyloctenium aegyptium

Broad leaved weeds

Commelina benghalensis

Phylanthus niruri

Medicago denticulata

Sedges

Cyperus rotundus *Fimbristylis miliacea* *Scirpus* sp.

Fig. 1. Major weed categories

ii. ***Broad leaved weeds*** (weeds of other families which are generally dicots): For managing these types of weeds in crops of grass family (wheat, rice, maize, sugarcane, sorghum, pearl millet etc.), 2,4-D offers selective advantage. There are reports of phytotoxicity of 2,4-D in some varieties of wheat, hence care should be taken during the use of this herbicide in sensitive crop varieties. Also, some of the weeds species like *Medicago denticulata*, *Phyllanthus niruri*, *Physalis minima* etc. are showing resistance 2,4-D at some localities in North India hence, species composition of crop weeds must be checked before selecting this herbicide.

iii. ***Sedges*** (weeds of Cyperaceae Family): This category includes some of the difficult to control weeds like *Cyperus rotundus* (*Motha*) which form underground tubers. Many species of *Cyperus* are major weed problem in rice and many other *kharif* crops. There are not much herbicidal options for controlling these weeds in crops. The herbicide 2,4-D applied in rice and other crops suppresses sedges to some extent. Imazethapyr applied in soybean and green/black gram also controls sedges. The herbicide Bispyribac Sodium applied in rice as post emergence also controls sedges to a great extent. Halosulfuron Methyl is a new molecule introduced in India for the control of *Cyperus rotundus* and other weeds in sugarcane which is otherwise very difficult to control.

2. INSECT-PESTS AND DISEASES

Diagnosis or identification is the process of gathering information about a plant problem and determining the cause. Once the cause has been determined, it is then possible to recommend a solution or remedy. Identification of insect-pests is quite easier based on the presence of various life stages (egg, larva, nymph, pupa, adult

etc.) and nature of damage caused by different life stages of that particular insect. However, identification of plant diseases is comparatively difficult and for a farm manager, it is essential to identify the symptoms produced on crop by a particular disease. On the basis of symptoms, the major categories of plant diseases (Fig. 2) are described in brief as below:

i. **Rusts**: Rust diseases are very easy to identify. In this disease, different coloured pustules (yellow, orange, red, brown, black etc.) are produced on leaf, stem or other parts of plants which are mostly dusty, but may be compact in some cases.

ii. **Powdery mildews:** Superficial growth of fungus on host surface giving a dusty or powdery appearance. Generally white powdery growth is seen on most of the crops.

iii. **Downy mildews:** The superficial growth is a tangled cottony or downy growth of fungus sporangia. These diseases are called by lower fungi group.

iv. **Smuts:** Smut means sooty or charcoal like powder. Infected plant parts show a black or purplish black dusty mass. Symptoms usually appear on floral organs. However, leaves, stem or root may also show symptoms depending upon the host and type of smut. Bunt of wheat also comes under smut diseases.

v. **White blister (rusts):** The white blister like pustules break open the epidermis and expose a white powdery mass of spores. Systemic infection causes malformation of stem, leaves and floral organs. Generally cruciferous crops are affected by the white blister. This is also a disease caused by lower fungi group.

vi. **Necrosis:** Death of cells, tissues or organs due to parasitic infection. **Leaf spot** (confined dead area on leaf), **blight** (extensive dead area on leaf or foliage), **stripe** (dead leaf area along the vein), **cankers** (dead area roughened, harder and raised), **rot** (extensive death of tissues making it soft and putrefied) are included under this category.

vii. **Scab:** Roughened or crust like lesion on diseased organ.

viii. **Damping off**: Topple down of newly emerged/emerging succulent plants due to infection and death of basal stem portion. This is often seen during nursery stage.

ix. **Anthracnose:** Ulcer like lesions on twigs, stem, pods, fruits caused by specific group of fungi.

x. **Die-back**: Death of twigs and branches from the tip backward.

xi. **Wilts**: The leaves and foliar portion of plant loose turgidity, become flaccid and droop. In advance stage, the infected plant completely dies.

xii. Mosaic: Different colour pattern on leaves seen in case of virus infected mosaic diseases with yellow and green patches on leaves.

3. PRINCIPLES OF PEST MANAGEMENT

The under-lying principle in any pest control programme is that the crop must be protected,while interfering as little as possible with factors which affect the long-term maintenance of theproduction system. A farm manager or farmer must have the idea about possible crop pests occurrence in his locality and should formulate a clear cut strategy to prevent/control them at every stage of crop, right from crop planning to harvesting and storage. The cheapest and most reliable way to deal with pest and weed problemsis to anticipate and avoid them, if possible.When pesticides are needed, choose materials andapplication methods that are cheaper and effective without adversely affecting other organisms or thenatural environment. The basic principles of pest and disease management are given as below:

I. A strong and healthy plant will have less insect-pest and disease problems. Insufficient nutrition makes a plant more vulnerable.

II. Some crop varieties are more susceptible to disease than others that are more resistant.

III. Damage done by pests and diseases can never be completely avoided. Aiming for complete control, especially with chemicals can:

- ❋ Also damage natural enemies of the pest or disease
- ❋ Cost more money than you get from extra yield
- ❋ Pollute the environment
- ❋ Damage human health
- ❋ Create resistance of the pest or disease against the chemical used

Hence, we should try:

❋ **Preventive measures**

- ❖ **Follow proper crop rotation** to break pest, weed or disease cycle. Mixed cropping can reduce the amount of losses caused to main crop. Avoid planting of susceptible crop in sick plots.
- ❖ **Deep ploughing and land configuration** (planting of ginger, pigeon pea on bunds avoids many diseases)
- ❖ **Proper tillage of field to enhance predation of pest stages**

- **Use stale seed bed for weed control**
- **Use resistant varieties** of crops
- **Seed/planting materials treatment:** Try to treat the seeds with fungicides, insecticides or bioagents to avoid the initial attack of insectsand soil/seed borne pathogens. This is the best and cheapest method of pest control in many cases e.g. loose smut of wheat.
- **Use of physical barrier** (wrapping polythene barriers at base of tree avoids mealy bug attack on mango)
- **Frequent scouting and diagnostic survey of field for early detection of pests particularly during prone stages of crops**
- **Proper crop spacing and sanitation prevents fast spread of diseases:** Transplanting of rice (particularly basmati type) at wider row to row and plant to plant spacing and keeping 2-3 rows unplanted at every 3 meters avoids the attack of many diseases.
- **Balance crop nutrition**: Application of potash and micronutrients like Zn, Fe and others keep plants healthy and more resistant to insect-pests and diseases.
- **Proper water management of crop**
- **In rice and sugarcane, release of parasitoides like *Trichogramma* spp. controls many lepidopteron borers.**

- **Chemical control:** If chemical control is necessary, start with cheaper and less destructive pesticides and lesser use of broad spectrum, highly hazardous pesticides. During chemical control of pests keep following points in mind:

  - **Use pesticides in rotation**: Do not use a single pesticide frequently and regularly on the same crop/field to avoid the buildup of resistant races/ biotypes of weeds, insect-pests or pathogens.
  - **Use recommended pesticides** as per the attack of weed, insect-pests or disease type. During chemical weed control in crops, use selective herbicides according to weed flora (narrow leaved, broad leaved or mixed) in the field. For weed control in non-cropped area or for killing perennial weeds, use non-selective broad spectrum herbicides like Glyphosate (systemic) or Paraquat (contact) herbicides according to infestation of weed flora.
  - **Use proper dose of pesticides and desired quantity of solution** according to size of farm. For controlling insect-pests and diseases, 800-1000L water solution and for controlling weeds, 500-600L of water solution is required for spraying one hectare of field.

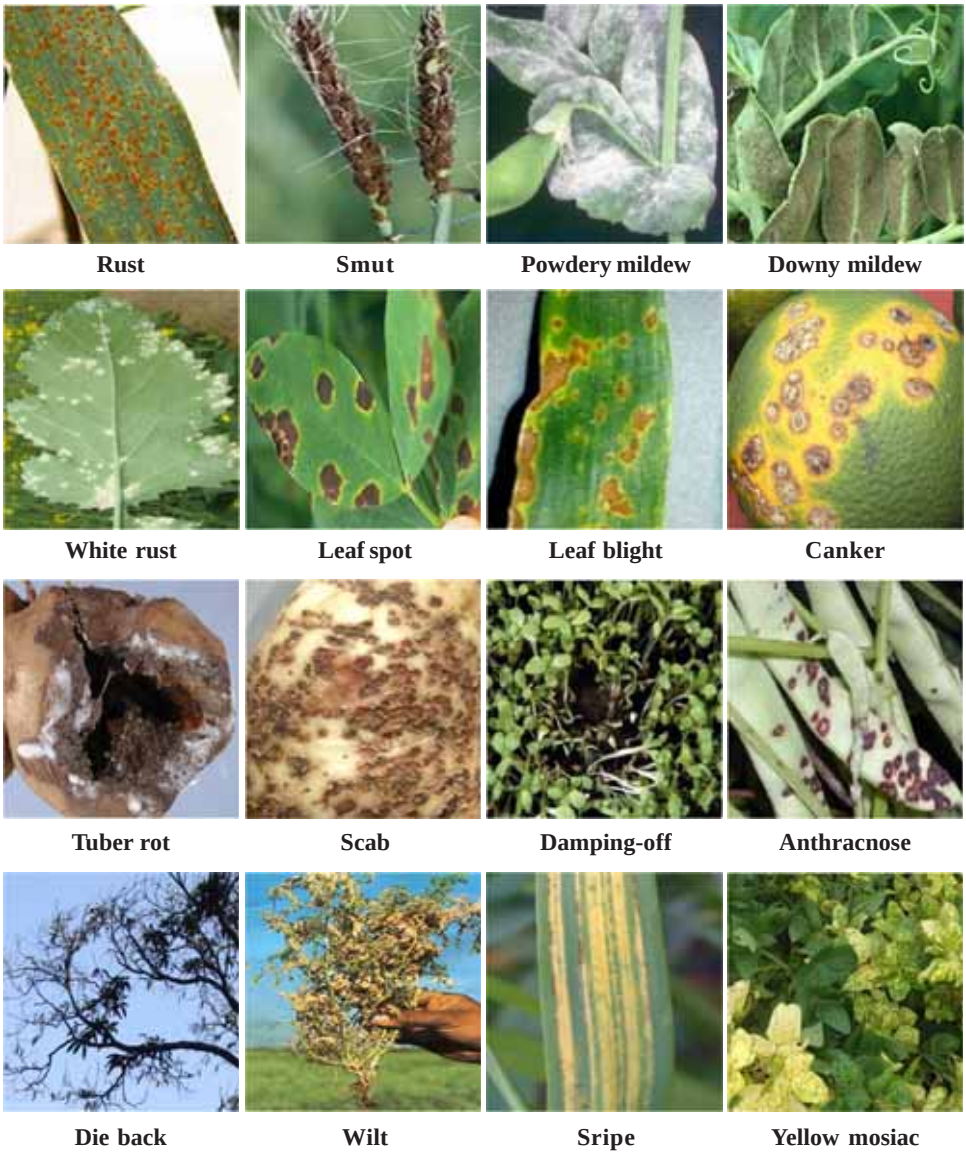

Fig. 2. Symptoms of common type of diseases

- **Use of proper nozzle type:** For controlling insect-pests and diseases, use solid cone or hollow cone nozzles. For spraying herbicides, use flat fan or cut nozzles for proper control.
- Use 2,4-D application with extreme care to avoid herbicide drift in remote fields.

- Apply pesticides during day time when pollinators are least present in the field (late afternoon time).
- During rainy days, spray pesticides at least before three hours of rainfall
- Never use spurious pesticides which will increase only production cost without sufficient level of pest control.
- For chemical control of fungal diseases use fungicides as per following categories of fungal pathogens:

  I. Diseases caused by lower fungi: For diseases like damping-off of vegetables, white rust of crucifers, late blight of potato and tomato, downy mildews, other *Pythium* and *Phytophthora* diseases, use Metalaxyl, Fosetyle-AL or Cymoxanil based fungicides for soil drenching, seed treatment or spraying.

  II. Diseases caused by higher fungi: For diseases caused by higher fungi like rusts, smuts, many leaf spots and blights use recommended fungicides for the particular disease. Mancozeb, carbendazim, wattable sulphur, copper oxychloride are some of the examples used for managing these diseases.

- Use proper air tight containers and apply fumigants for controlling stored grain pests.
- Use proper safety measures during pesticide application to avoid operational hazards.

INSECT-PEST AND DISEASE MANAGEMENT IN IMPORTANT CROPS

The important insect-pests and diseases of some major field crops and their management are given in Table 1 as below:

Table 1. Management of important insect-pests and diseases in crops

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
1. Wheat	A. Diseases			
	1. Rusts	*Puccinia graminis tritici* (Black stem rust), *P. recondita* (Brown rust), *P. striiformis* (yellow rust)	Rusty appearance on leaves and other plant parts.	Grow resistant varieties, alternate 250EC @1ml/L and Mancozeb 75WP@2g/L water.

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
	2. Leaf Blight	*Bipolari ssorokiniana* and *Alternaria triticina*	Small oval and discoloured lesions appear on leaves and later become irregular and large in size and brown to grey in colour.	Spray of Mancozeb 75WP@2g/L water
	3. Loose Smut	*Ustilago segetum*	Every heads of affected plant are converted into a loose, black mass of spores and no grains are formed.	Seed treatment with Carboxin (Vitavax) @1g/kg seed before sowing.
	4. Karnal bunt	*Tilletia indica*	Only few grains of ear are bunted due to local infection.	Spray of propiconazole 250 EC @ 1ml/L at flowering stage
	5. Powdery mildew	*Blumeria graminis tritici*	White powdery flocculent growth of fungus later turns grey or reddish brown as cleistothecia develops.	Alternate spray of propiconazole 250 EC @ 1ml/L or Mancozeb 75WP @2g/L water or wattable sulphur @ 0.25%.
	6. Cyst nematode	*Heterodera avenae*	Infected plants are dwarfed and pale in colour like nutritional deficiency. Such symptoms are found in patches and these patches enlarge year by year if not managed properly.	Follow crop rotation, apply granular nematicides e.g. carbofuran (furadan) @ 30kg/ha in soil.
	B. Insect pests			
	1. Aphids	*Macrosiphum* sp.	Numerous small greenish black wingless aphids are present below leaf surface or in spaces of spikelets	Spray dimethoate 30EC @1ml/L water.
	2. Army worm	*Mythimna separata*	Larvae feed on basal portion of stem leaving upper portion fallen on ground. They generally feed during night and hide in soil during day time.	Spray DDVP (Nuvan) @ 1ml/L water

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
2. Rice	**A. Diseases**			
	1. Blast	*Magnaporthe grisea*	Spindle shaped spots with brown margin and straw centre which may coalesce to make larger blasted areas on leaves. Necrotic areas on neck region cause neck blast.	Seed treatment with carboxin+thirum @3g/kg seed. Spray carbendazim+ mancozeb @1.5g/L or tricyclazole (beam) @0.6ml/L water. Apply potash and micronutrients in rice crop.
	2. Sheath blight	*Rhizoctonia solani*	Lesions develop on sheaths of lower leaves near the water line when plants are in the late tillering or early internode elongation stage. These lesions expand and its center become bleached with an irregular tan-to-brown border and extends to upper plant parts, including leaf blades, causing extensive, tan, irregularly shaped lesions with brown borders.	Balance crop nutrition. Avoid excessive application of nitrogen. Spray carbendazim+ mancozeb @1.5g/L or propiconazole 250EC @1ml/L water.
	3. Khaira disease	Zinc deficiency	Symptoms appear at 2-4 weeks age. Brown spots appear on the older leaves. These spots enlarge and coalesce making the leaf brown. Tillering and growth are reduced and plant remains stunted.	Apply zinc sulphate @20kg/ha before transplanting. Spray zinc sulphate @75g + urea@100g/15L tank. Repeat spray if necessary.
	4. Bakanae or foot rot disease	*Fusarium moniliforme*	Pale yellow elongated seedlings in nursery. Infected seedling after transplanting may die during hot weather. Elongation and death of infected culms also continue at advanced stage of crop.	Seed treatment with carbendazim @1g/kg or Carboxin+Thiram @3g/kg seed before sowing. Spray of carbendazim @1/L water at basal portion of hill in standing crop.

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
	B. Insect pests			
	1. Yellow Stem borer	*Scirpophaga incertulus*	Caterpillars bore into stem causes dead hearts and white heads.	Apply granular insecticide e.g. carbofuran (furadan) @ 30kg/ha in soil. Release *Trichogramma* parasitoid @50000-100000/ ha, 4-5 times at fortnightly intervals starting from the tillering stage.
	2. Brown plant hopper	*Nilaparwata lugens*	Nymphs and adult suck the plant sap mainly near basal portion of hills. Heavy infestation results into yellowing and withering of leaves and 'hopper burn' (death of plants in pockets).	Maintain good aeration in the field by spaced planting. Spray imidacloprid 17.8SL@1ml/5L water.
	3. Gall midge	*Orsiolia oryzae*	Maggots enter into growing point of tillers and reach the bud where they lacerate and feed till pupation. This stimulates the tillers to grow into a tubular gall or 'silver shoot' resembling onion leaf.	Spray dimethoate 30EC@1ml/L water.
	4. Gundhi bug	*Leptocorisa varicornis*	Both nymphs and adults suck the cell sap from developing grains which results into unfilled chaffy grains.	Dusting of methyl parathion powder @20kg/ha
3. Chick pea	**A. Diseases**			
	1. Wilt	*Fusarium oxysporum* f. sp. *ciceris*	Branches and leaves of affected plants droop down and finally die at advance stage of disease. Brown discolouration may be seen after tearing the tap root.	Grow resistant varieties. Seed treatment (5g/kg seed) and soil application (2.5kg/ ha) of *Trichoderma* formulations.

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
	2. Ascochyta blight	*Ascochyta rabiei*	Circular spots with concentric rings on leaves, pods, stem. Under wet and humid weather disease spread very fast and destroy whole crop within few days.	Grow resistant varieties. Spray chlorothalonil @800 ml/ha at fortnightly interval.
	B. Insects pests			
	1. Pod borer	*Helicoverpa armigera*	Larva feeds on leaves and developing pods keeping some portion inside and some outside the pods.	Biological control with NPV (250LE/ ha) or Bt (0.5kg/ha with UV protectant). Spray insecticides like quinalphos @2 ml/L. Use bird perching in the field.
	2. Cut worm	*Agrotis ipsilon*	Caterpillars cut the main stem or branches.	Dusting of methyl parathion powder @20kg/ha
4. Pigeon pea	**A. Diseases**			
	1. Wilt	*Fusarium udum*	Branches and leaves of affected plants droop down and finally die at advance stage of disease. Brown discol-ouration may be seen after tearing the tap root.	Grow resistant varieties. Seed treatment (5g/kg seed) and soil application (2.5kg/ ha) of *Trichoderma* formulations.
	2. Stem blight	*Phytophthora drechsleri*	Blighting of branches and main stem resulting in death of whole plant.	Spray metalaxyl+ mancozeb (3g/L) at fortnightly interval
	B. Insect pests			
	1. Pod fly	*Melanogromyza obtusa*	Maggots bore and feed into pods causing empty pods at maturity	Spray endosulfan @2ml/L
5. Moong bean/ Urd bean	**A. Diseases**			
	1. Yellow mosaic	*Gemini virus* transmitted by	Bright yellow to green colour pattern on leaves	Grown resistant varieties of Urd like

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
		white fly *Bemisia tabaci*		Pant Urd 31 and moong like Meha and Samrat. Seed treatment with Imidacloprid 17.8SL @5ml/kg seed followed by spray of dimethoate 30EC @1ml/L water at 25 and 45DAS. Rouge out infected plants till 45 DAS.
6. Mustard	**A. Diseases**			
	1. White rust	*Albugo candida*	White colour blisters mainly on lower side of leaves	Spray metalaxyl+ mancozeb (3g/L) at fortnightly interval
	2. Alternaria blight	*Alternaria* spp.	Dark colour small to large spots in concentric rings on leaves and pods	Spray mancozeb @ 0.25% at fortnightly interval
	B. Insect pests			
	1. Aphids	*Lypaphis erysimae*	Numerous wingless nymph and adults infest growing branches and suck the sap. This stops the growth of flowering branches.	Spray dimethoate 30EC @1ml/L water.
7. Sugar-cane	**A. Diseases**			
	1. Red rot	*Colletotrichum falcatum*	Loss of colour and drooping of 3rd or 4th leaf from top are earliest symptoms. As disease advances, entire top withers. The cane shrivels, rind shrinks and become longitudinally wrinkled. Red patched with ash coloured patches seen on mid rib of leaves.	Grow resistant varieties. Avoid seed setts from infected crop. Treat the seed setts with 0.5% Bavistin+ 0.1% Thiram before sowing.
	2. Pokah bong	*Fusarium moniliforme*	Leaf chlorosis, leaf twisting, knife-cut of leaf and top rotting on leaves.	Treat the seed setts with 0.5% Bavistin+ 0.1% Thiram before sowing. Two sprays of carbendazim

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
				(0.1%) in May and June.
	B. Insect pests			
	1. Early shoot borer	*Chilotraea infuscatellus*	Larvae bore into main shoot and produce dead hearts which can	Spray chlorpyriphos 20EC @2ml/L or chlorantranillipore be pulled out easily. 380ml/ha in 800L water or apply granular insecticides like Carbofuran @ 40 kg/ha. Release of *Trichogramma* parasitoid @50000-100000 parasitized eggs /ha in the month of March-April.
	2. Top borer	*Tryporyza nivella*	Larvae bore into top portion of shoot which results into drying of central whorl and dead hearts.	Spray chlorantranillipore (Coragen) 380ml/ha in 800L water during May-June or apply granular insecticides like Carbofuran @40kg/ha or chlorantranillipore (Ferterra) @20kg/ha in late June to early July. Four to five releases of *Trichogramma* parasitoid @50000-100000 parasitized eggs /ha in the month of March-April and July to September. These recommendations are also effective against other borers of sugarcane.
	3. White grub	*Holotrichia serrata*	Grubs feed on roots below the soil making plant weak. Death of	Apply fungal bioagent *Beauveria bassiana* @2.5kg/ha

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
			whole clump in case of severe infestation.	with well rotten FYM during land preparation. Follow crop rotation and apply summer ploughing.
8. Potato	**A. Diseases**			
	1. Late blight	*Phytophthora infestans*	Small watery brown patches develop on tip or margin of leaves and extend inwards. Under suitable conditions, disease spread very fast and can destroy whole crop within few days.	Spray metalaxyl+ mancozeb (3g/L), or cymoxanil+ mancozeb (3g/L) or mancozeb (2.5g/L) under favourable weather for disease.
	2. Early blight	*Alternaria solani*	Brown coloured spots on leaves with characteristic concentric rings.	Follow crop rotation. Apply recommended doses of fertilizers and micronutrients. Spray mancozeb (@0.2%) or zineb (@0.2%) at fortnightly interval.
	B. Insect pests			
	1. Aphids	*Myzus persicae* and others (also transmits potato viruses like potato leaf roll virus, potato virus X, A, S and Y causing different type of mosaic)	Nymph and adult suck the cell sap and results into stunted plant growth. Also transmits many virus diseases and thus become serious hindrance in seed potato crop.	Planting of main season crop when temperature become down. Spray dimethoate 30EC @1ml/L water.
	2. Cut worm	*Agrotis ipsilon*	Caterpillars cut branches or whole stem from the base.	Dusting of methyl parathion dust around affected area in the field. Drenching of soil around affected area with chlorpyriphos (2ml/L).

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
	3. White grub	*Holotrichia* spp.	Grubs feed on roots and tubers making tunnels in tubers.	Apply fungal bioagent *Beauveria bassiana* @2.5kg/ha with well rotten FYM during land preparation. Follow crop rotation and apply summer ploughing. In endemic area apply phorate 10G @25kg/ha in soil.
9. Brinjal	**A. Diseases**			
	1. Phomopsis blight	*Phomopsis vexans*	Numerous light brown coloured spots mainly on lower leaves. Infection on branches causes partial or complete wilting of plant. Fruit rotting initially starts with soft and spongy but later converts into dry rot.	Use healthy disease free seeds. Treat seeds with carbendazim @2g/kg seed. Spray carbendazim @ 0.1% at fortnightly interval.
	2. Sclerotinia rot	*Sclerotinitia sclerotiorum*	Rotting of main stem and branches with characteristic whitish growth of fungus. This causes partial or complete wilting of plant. Big size sclerotia can be seen after tearing of infected stem at later stages.	Spray carbendazim+ mancozeb @2.5/L water.
	B. Insects pests			
	1. Shoot and fruit borer	*Lucinodes arbonalis* Serious pest of brinjal	Larvae bore into young twigs and fruits making fruits unfit for consumption.	Avoid rationing. Follow crop rotation. Spray neem oil 2ml/L or DDVP (Nuvan) 1ml/L. Release of *Trichogramma* parasitoid @50000-100000 parasitized eggs/ha.

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
10. Okra	**A. Diseases**			
	1. *Yellow vein mosaic virus* (YVMV) and *enation leaf curl virus* (ELCV)	Both viruses are transmitted by white fly *Bemisia tabaci*	Yellowing of veins, stunting of plant and yellow coloured fruits in case of YVMV and severe cup shaped curling of leaves in case of ELCV	Control vector whitefly by alternate spraying of neem oil 2ml/L or dimethoate 30EC 1ml/L at fortnightly interval.
	B. Insect pests			
	1. Leaf hopper or Green Jassids	*Amrasca devastans*	Nymph and adult suck the cell sap. Severe infestation results into hopper burn which looks like blighting of crop.	Before flowering, spray acephate 75SP (1ml/L) or imidacloprid 17.8SL 1ml/4L water.
	2. Shoot and fruit borer	*Earias vittella*	Larvae bore into young twigs and fruits making fruits unfit for consumption. Infested fruits become rolled.	Collect and destroy affected fruits. Spray neem oil 2ml/L or indoxacarb 14.5SC 0.75ml/L. Release of *Trichogramma* parasitoid @50000-100000 parasitized eggs /ha.
11. Tomato	**A. Diseases**			
	1. Late blight	*Phytophthora infestans*	Small watery brown patches develop on tip or margin of leaves and extend inwards. Under suitable conditions, disease spread very fast and can destroy whole crop within few days. Fruit infection also occurs and causes rotting of fruits.	Spray metalaxyl+ mancozeb (3g/L), or cymoxanil+ mancozeb (3g/L) or mancozeb (2.5g/L) under favourable weather for disease.
	2. Tomato *Yellow Leaf Curl Virus*	Transmitted by white fly *Bemisia tabaci*	Yellowing and curling of leaves with leathery leaf pattern. Stunting in growth and no flowering and fruiting if infection occurs at early stage of crop growth.	Control vector whitefly by alternate spraying of neem oil 2ml/L or dimethoate 30EC 1ml/L at fortnightly interval particularly at initial growth stages.

Crop	Insect-pest/Disease	Causal organism/ Scientific name	Key symptoms/ marks of identification	Management
	B. Insects pests			
	1. Fruit borer	*Helicoverpa armigera*	Larvae bore into fruits making them unfit for consumption. Infested fruits later become rotted due to secondary infection.	Spray neem oil 0.1%. Release of *Trichogramma* parasitoid @250000-500000 parasitized eggs /ha. Spraying of quinalphos 2ml/L. Avoid spraying at fruit harvesting stage.
12. Cole crops (Cauliflower and cabbage)	**A. Diseases**			
	1. Leaf spot	*Alternaria brassicae*	Brown coloured spots with characteristic concentric rings.	Spray mancozeb, 0.25% or chlorothallonil, 0.25%.
	2. Sclerotinia rot	*Sclerotinia sclerotiorum*	Water soaked rotting of curd, petiole, stalk and stump region. Charact-eristic white growth of fungus mycelium can be seen on rotting organs.	Spray mancozeb 0.25% or carbendazim 0.1%. at flowering stage.
	B. Insect pests			
	1. Tobacco caterpillar	*Spodoptera litura*	Larvae feed on leaves and also on curd or head reducing its market quality.	Use light traps for collecting and killing adults. Spraying of quinalphos 2ml/L or DDVP 1ml/L. Avoid spraying at harvesting stage.
	2. Diamond black moth	*Plutella xylostella*	Larvae feed on the leaves and causes shot hole like appear-ance in the leaves.	Spraying of quinalphos 2ml/L or DDVP 1ml/L.

CONCLUSION

Pests and diseases are natural entities and regularly attack our crops and sometimes cause economic losses in yield and quality. The aim of a farmer or farm manager should be to manage the economic losses caused by a pest or pathogen and not the total control of all kind of crop enemies. It is also important to maintain the population of natural enemies of pests and pathogens through maintaining biodiversity at farm. Always follow the rule "prevention is better than cure". It is absolutely vital for the growers to maintaina "hands-on" management approach in production. Weeds may be shaded out by the developing crop, and pests anddiseases may be present, but reduced to such a low level that the manager could decide totolerate the problem without taking active measures for control. However, awareness and sufficient knowledge backup is neededbefore the action decision is taken. Routine visits or scouting to the field must be made frequently for quick detection and management.

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Chapter 7

Gender Sensitive Farm Tools

Nisha Verma

India is mainly an agrarian country and farming is one of the main occupations accounting for 33 per cent of the GDP (Gross Domestic Product). Around 78 per cent of the economically productive women in the country are engaged in various activities related to agriculture and allied enterprises as compared to 63 per cent of men. About 6.5 per cent of the power used in crop production and related activities in the country is contributed by about 241 million workers, of which about 42 per cent (i.e. 101 million) are female workers. By 2020, the ratio of agricultural workers to the total workers is expected to decline to 40 per cent from the current 52 per cent, though the total number would remain the same. From these about 50 per cent would be women against 42 per cent at present (Gite, 2012).

Farm women perform hard physical work in planting crops with care and maintenance, harvesting and processing, marketing and bartering of product simultaneously (Samants, 1995). Manual operations *viz*. weeding, sowing, transplanting require a huge labour force (35 percent) in crop farming. Amongst them weeding accounts for about 25 per cent of the total labour requirement (Nag and Datt, 1979). Women in animal husbandry and livestock sector constitute 69 percent of the labour force (Economic Survey 2002-03).

Current farming practices used by women farmers has considerable degree of ergonomic/ health impact on their body causing them immense pain and hardship. Some of these agricultural practices are found to have profound health risks on women. Manual operations involve enormous drudgery, as women workers, who perform most of the operation in India, have to work in awkward postures i.e. bending and squatting in sweltering weather. Drudgery is generally conceived as physical and mental strain, agony, fatigue, monotony and hardship experienced by human being, while all these result in decline in performance of men and women alike. Use of traditional tools for long hours with in appropriate working postures in field leads to drudgery (Singh 2014).

Since women workers play a major role in the country's agriculture and due to that, attention needs to be given to their capabilities and limitations during design and operation of various farm equipments, so as to get higher productivity, enhanced comfort and ensure better safety (Yadav *et al.*, 2010). A continuous work in

awkward posture and without proper rest-pause adversely affects workers' mental and physical well-being. Table 1 presents the drudgery level of farm women while using traditional methods/age old technologies in the farming systems of Western plain zone of Uttar Pradesh.

Table 1 : Drudgery level of farm women with prevailing technologies in the farming systems of Western plain zone of Uttar Pradesh

Farm operations	Technique used	Drudgery level	Reasons
Sowing	Placing the seeds in soil with the help of thumb and hand hoe	Slightly heavy	· Pain in lower back due to long hours of work in bending posture. · Pain/swelling in wrist and thumb.
Paddy transplanting	Manual transplanting in puddled field	Heavy	· Pain in lower back due to long hours of work in bending posture in deep puddled soil. · Discomfort/swelling in legs in moving forward and backward in wet field. · Discomfort/swelling in thumb and wrist due to transplanting of seedlings in wet field.
Vegetable / flower transplanting	Transplanting through digging the soil using hand hoe	Slightly heavy	· Muscular pain in different body parts due to squatting posture. · Muscular stress and pain in wrist muscles due to digging of soil through hoe and placing the seedling for long hours. · Lower working capacity due to poor grip, cuts, wounds and skin irritation.
Weeding	By using hand hoe	Moderately heavy	· Muscular pain and tiredness due to working in awkward (squatting) posture along with monotonous and repetitive position for long hours. · Decrease in working capacity due to poor grip, cuts, wounds and skin irritation.
	Manual weeding	Heavy	· Severe cuts, wounds and skin irritation. · Muscular pain and tiredness due to working in awkward (squatting) posture along with monotonous and repetitive position for long hours.

Farm operations	Technique used	Drudgery level	Reasons
Detopping	Traditional sickle	Moderately heavy	· Lower working capacity due to poor grip, cuts, wounds and skin irritation. · Tiredness, energy expenditure and shoulder pain due to cutting force.
Detrashing	Removal of trash through hand	Heavy	· Severe cuts, wounds and skin irritation.
	Traditional sickle	Moderately heavy	· Lower working capacity due to poor grip, cuts, wounds and skin irritation. · Tiredness, energy expenditure and shoulder pain due to cutting force.
Stripping of groundnut	Beating through logwood	Heavy	· Tiredness, heavy energy expenditure and shoulder pain due to beating force. · Lower working capacity due to poor grip cuts, wounds and skin irritation.
	Removal of pods from plant through hand	Heavy	· Muscular stress and pain in fingers due to monotonous and repetitive movements of fingers for long hours. · Very poor working capacity.
Dehusking of maize	Through hand	Heavy	· Muscular stress and pain in shoulder finger, wrist and palm muscles, tiredness due to pull force using wrist during maize dehusking. · Lower working capacity.
Shelling of maize	Beating through logwood	Heavy	· Tiredness, heavy energy expenditure and shoulder pain due to beating force. · Lower working capacity due to poor grip cuts, wounds and skin irritation.
	Grain removal by fingers	Heavy	· Immense pain in fingers due to continuous muscular stress during repetitive actions of fingers for long hours. · Very low working capacity.

Farm operations	Technique used	Drudgery level	Reasons
Carrying load (fodder/ grains/ vegetables)	Over the head	Heavy	· Carrying head load causing muscular stress on shoulders and neck and strain on eyes as well. · Severe pain in different body parts · Extreme energy expenditure and tiredness.
Harvesting of field crops/ sugar cane/ fodder crops	By using traditional sickle	Heavy	· Muscular pain in lower back due to bending or squatting posture. · Injuries while harvesting through traditional sickle.
	By using serrated sickle	Moderately heavy	· Muscular pain in lower back due to bending or squatting posture. · Decrease in working capacity due to poor grip, cuts, wounds and skin irritation.
Harvesting of roots/tubers and other crops (potato, groundnut, onion, garlic, radish etc.)	By using hoe or spade	Heavy	· Immense pain in shoulder, palms and lower back due to digging of crops from deep into the soil through pulling force. · Decrease in working capacity due to poor grip, cuts, wounds and skin irritation.
Threshing of paddy and other field crops	Beating through hands		· Pain in shoulders due to beating force. · Cough and respiratory tract allergies due to inhalation of dust and dirt particles.

Drudgery can be reduced by providing gender-friendly farm tools and equipments which increase the productivity of workers with safety and comfort. Time scheduling is also needed for achieving such task. The designing of gender sensitive tools should include the gender-perspective such as wearing, long hair, *purda* system, anthropometry, muscular strength, aerobic capacity, etc. So one way of reduction of drudgery can be through quantifying the particular field operation. For example, if work is being performed by a farm women with traditional tools in bending/ squatting posture, it can be reduced by providing women friendly farm equipment (equipment assessed/developed considering gender-perspective).

Men have generally done better in the use of agricultural engineering technologies, while women are left behind. It is generally felt that, the available agricultural technologies are not women friendly as they are not designed taking into consideration the women's ergonomic measurements. There exists a communication gap between

design engineers and farm planners and also the lack of women's access to articulate their felt needs (Shirahatti *et al*., 2010). With this backdrop, Govt. of India has encouraged the scientists to work for women in agriculture by establishing national research centres for women and promoting pro-women programmes in different facets of agriculture and allied enterprises. There are some studies carried out in different research centres to reduce the drudgery of farm women and to overcome the labour deficits during peak season. The improved gender sensitive tools that are suitable for women farmers of Western Uttar Pradesh are given below:

A. TOOLS FOR LAND PREPARATION

1) **Multipurpose tool**: This tool can be used as hoe, rake and spade. This tool is used for breaking up of compact ground, clod breaking and weeding from one side. It is used as rake for crop/weed residue collection from one side and removal from other side. From the third side levelling of soil can be done. Its long handle is useful for maintaining the straight body alignment to the centre of gravity, thereby avoiding musculoskeletal disorders due to working in wrong postures. It is having hardened and tempered steel blades. It is light in weight and minimizes energy expenditure and increases working capacity.

2) **Hoe:** This tool is used for hoeing, clod breaking and soil aeration and levelling of soil. This tool can be effectively used in hard soil from one side. From the other side it can be used for collecting the weeds and crop residues. It has 760 mm long tubular steel handle with comfortable plastic grip that is helpful in keeping the body straight and requires less expenditure of energy.

B. TOOLS FOR SOWING AND TRANSPLANTING

1) **Dibbler:** It is suitable for planting seeds of different crops e.g. maize, pigeon pea, wheat etc. Dibbler contains fertilizer application attachment along with the seed box in order to enhance the fertilizer use efficiency and to provide the crop a better stand. With the use of this tool yield can be increased up to

20 per cent. The tool is helpful in maintaining straight body posture and in relieving the from the muscular stress and pain.

2) **Four row paddy transplanter:** It is used for transplanting the paddy crops in four rows at a time. It is light weighted (25 kg) and covers an area of 245 m^2/ hour. The overall dimension of the transplanter is 820 mm x 1970mm x 900mm. It consists of frame, floats, seedling tray, operating handle, fingers (pickers/ tray), drive unit and depth control mechanism. It saves about 61 per cent cardiac cost of workers per unit area and helps in avoiding bending posture. Line sowing helps in promoting the use of mechanical weeders, thereby reducing drudgery during weeding operation. The productivity of workers is increased by more than six times as compared to the traditional method.

3) **Vegetable/ flower seedling transplanter:** Seedling Planter is made up of stainless steel. It has a handle, clutch, spring, connecting rod and mouth end. It is 3 feet in length and the diameter of the hole is 2 inches. It is very light weighted (1.9 kg). The saplings are loaded in the stainless steel (SS) chamber at the top and the clutch is released to make a hole on the soil to plant the seedling directly on the bed. It reduces labour cost, and weed growth. With the planter three labours are required to plant of 1 ha area while in traditional method minimum 30 labours would be needed to do the same work. It reduces muscular stress in the lower back and knees.

C. TOOLS FOR INTERCULTURAL OPERATIONS

1) **Cultivator:** This tool is ideal for breaking compact ground while weeding and cultivating in one action between the two rows of the crops. It has 90 cm long tubular steel handle with comfortable plastic grip which keeps straight body alignment and reduces muscular stress and energy expenditure.

D. TOOLS FOR PLANT PROTECTION

1) **Battery operated knapsack sprayer**: This sprayer is used to spray in all agricultural and horticultural crops and can be operated by dry lead-acid battery. It has heavy duty diaphragm pump capable of discharging 2.2 litres water per minute. The tank is light-weighted, ergonomically designed

and having 16 litres capacity with thick resilient shoulder pads which are very comfortable even with a full load.

E. TOOLS FOR CROP HARVESTING

1) **Improved sickle with plastic/wooden handle:** Improved sickles are very light weighted 217 g with wooden handle and 186 g with plastic handle. Both are having serrated blades made up of high carbon steel which follow the friction and sheer principle to cut the plant with less force. Handles of the improved sickles are specially designed to reduce stress on grip muscles while cutting fodder and field crops in order to avoid hand injuries.

2) **Brush cutter**: Brush cutter is the most durable, efficient and labour saving harvesting equipment which can be used for cutting various types of crops like paddy, wheat, sugarcane, etc. alongwith the cutting of dry grasses. The crop attachment makes the machine to cut and collect the crop at same time. This is very light weighted and efficient cutter (7-10 kg). Vibration dampening device reduces the operators fatigue and improves the working efficiency.

3) **Sugarcane detrasher:** This is used to remove dry leaves and green leaves for collection of fodder. Its cost of operation is less than Rs 900 per hectare. It is easy in handling and collection of leaves, and can be used in all the varieties of sugarcane. It helps in avoiding serious cuts and wounds of hands that occurs in traditional method of trash and top removal.

4) **Improved cane cutting knife:** It is used for cutting sugarcane, bushes and dead branches. Its blade is hardened and tampered and is made up of high carbon steel. Its blade size is 305 mm long and total length is 457 mm. It is having comfortable plastic grip which helps in increasing the working efficiency capacity and in reducing the muscular stress and pain.

5) **Light weighted spade:** Light weighted spade can be used for digging of roots/tubers and other crops e.g. potato, groundnut, radish, onion and garlic crops from the soil. The spade is very light weighted and it is having long handle which helps in keeping straight body alignment, thereby increasing the working efficiency.

F. TOOLS FOR THRESHING

1) **Multi-crop thresher:** This equipment has been used for threshing maize, wheat, paddy, sorghum, bajra, ragi etc crops. This thresher consists of three types of sieves which helps in threshing for different types of crops. It consumes 1.5 to 1.9 litre fuel per hour. Cleaning efficiency is 93 to 95 per cent. This thresher helps in avoiding muscular stress and heavy pain in diffe rent body parts occurrs in traditional threshing.

CONCLUSION

Women farmers are doing various farm operations viz. sowing, transplanting, hoeing, weeding, harvesting, threshing, winnowing, etc. either manually or by using traditional tools which involves lot of energy expenditure alongwith musculoskeletal problems. Possible interventions through introducing various gender sensitive improved farm tools related to the farm operations systems help in increasing the efficiency and productivity of farm women. Using gender sensitive tools by farm women helps in reducing drudgery, increase in working capacity and efficiency which result in better productivity and improvement in quality life of farm women.

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Chapter 8

Management of Livestock Farm

Mahesh Kumar

The term "livestock" has two merging words, "live" and "stock", signifying the fact that animals are property in addition to living beings. Broadly, livestock refers to any breed or population of domesticated animals kept by humans for a useful, commercial purpose of providing food, fibers, draught power fuel and manure to their owners. Livestock sectors are critical for the rural economy, especially the small and marginal farmers. They not only contribute to the income but act as best insurance against any natural calamity. Animal husbandry practices have varied widely across cultures and time periods. Originally, livestock were not confined by fences or enclosures, but management practices have largely shifted to intensive animal farming, sometimes referred to as "factory farming". These practices increased yield of the various commercial outputs, but have led to increased concerns about animal welfare and environmental impact.

CONTRIBUTION OF LIVESTOCK IN INDIAN ECONOMY

Livestock sector plays a major economic and cultural role in numerous rural communities. It is one of the most important agricultural subsectors worldwide which provide meat, milk, eggs, blood, hides, draught power, fuel and manure for soil nutrient replenishment. Also, being a source of cash income, livestock help the poor to escape poverty. Large numbers of poor farmers and herders depend on livestock for their livelihoods. Animal densities are strongly correlated with human densities and are highest in areas of intensified agriculture, especially in and around irrigation systems.

Importance of livestock in Indian economy can be judged from the fact that contribution of this sector to the GDP in the year 2012-13 was 4.11 per cent and 25.6 per cent of total value of output in total Agriculture, Fishing and Forestry Sector GDP.

PURPOSE OF LIVESTOCK REARING

Livestock are used by humans for a variety of purposes, many of which have an economic value. They provide food and non-food items to the people. Livestock products include:

1. **Food:** The livestock provides food items such as milk, meat and eggs for human consumption. India is number one milk producer in the world. It is producing about 137.7 m. tones of milk and 8.89 million tonnes of meat annually. The value of milk group and meat group at current prices was Rs 4,06,035 crores in the year 2013-14.

2. **Fibre and skins:** The livestock also contributes to the production of wool, hair, hides, and pelts. Leather is the most important product which has a very high export potential. India is producing about 47.9 million Kg of wool per annum.

3. **Draught power:** Despite increased availability of mechanical power, the Indian farmers especially in rural areas still depend upon animals for various agricultural operations. The bullocks are saving a lot of fuel which is a necessary input for using mechanical power like tractors, combine harvesters etc. Pack animals like camels, horses, donkeys, ponies, mules etc. are being extensively used to transport goods in different parts of the country in addition to bullocks. In situations like hilly terrains mules and ponies serve as the only alternative to transport goods. Similarly, the army has to depend upon these animals to transport various items in high altitude areas.

4. **Dung and other waste materials:** Dung and other animal wastes serve as very good farm yard manure and the value of it is worth several crores of rupees. In addition, it is also used as fuel (biogas, dung cakes).

5. **Storage:** Livestock are considered as "moving banks" because of their potentiality to dispose off during emergencies. They serve as capital and for landless agricultural labourers it is the only capital resource they possess. Livestock serve as an asset and in case of emergencies they serve as guarantee for availing loans from the local sources such as money lenders in the villages.

6. **Weed control:** Livestock are also used as biological control of brush, plants and weeds.

7. **Cultural:** Livestock offer security to the owners and also add to their self esteem especially when they are owning prized animals such as pedigreed bulls, horses and high yielding cows/ buffaloes etc.

8. **Sports / recreation:** People also use the animals like cocks, rams, bulls etc. for competition and sports. Despite ban on these animal competitions, the cock fights, ram fights and bull fights are quite common during festive seasons.

9. **Experimental Animals:** Livestock are also reared for conducting various experiments at many research institutes. The purpose of these experiments

may be to enhance animal productivity and also for conducting trials before use in human beings.

DISTRIBUTION OF LIVESTOCK POPULATION IN INDIA

Our country is blessed with rich biodiversity and we are proud to have wide domesticated animal diversity with many breeds within each species. As per 2012 livestock census by Department of Animal Husbandry, dairying and fisheries, Government of India, the total livestock population consisting of cattle, buffalo, sheep, goat, pig, horses and ponies, mules, donkeys, camels, mithun and yak in the country is 512.05 million. The total livestock population has decreased by about 3.33 per cent over the previous census. The total bovine population (cattle, buffalo, mithun and yak) is 299.9 million which shows a decline of 1.57 per cent over previous census (2007). In 19th Livestock Census, 37.28 per cent were cattle, 21.23 per cent buffaloes, 12.71 per cent sheep, 26.40 per cent goats and 2.01 per cent pigs. Mithun, Yaks, Horses, ponies, mules, donkeys and camels taken together contribute 0.37 per cent of the total livestock population.

FARM MANAGEMENT

Management of livestock farm is both an art and a science. It is a science influenced by years of research and is an art developed by centuries of practical experience. The organization of various activities and coordination among these activities involving all the key factors affecting animal production performance in the directions for improvement is the main task of a farm manager. The ultimate goal of an animal farm is to convert resources into products in the most viable and economical way.

The main motive of the manager of a commercial animal farm is profit maximization, but the managers of an animal farm of a research institute have extra responsibility as they have to keep the farm in such a way that it sets an example for farmers and other animal rearers. The guiding points in decision making are environmental aspects, welfare of animals, product quality and overall economics of the farm. The good farming practices of a livestock farm are described in the following sub headings:

Housing Management

Various buildings are constructed at a livestock farm which includes adult animal houses, milking barn, calving pen, calf pen, young stock/ heifer shed, dry animal shed, bull pen, isolation shed, quarantine shed and accessory buildings like general store room, milk room, feed store and hay or straw shed.

Appropriate housing that promotes excellent health and high welfare for different livestock species is an essential aspect of sustainable animal production. Animals too need shelter which can protect them from vagaries of seasons, parasites and other stray animals and which are conducive to good health and comfort. Livestock may be successfully housed in a wide variety of condition, ranging from close confinement to little restrictions except at milking time. The floor and manager requirement of dairy animal is given in table 1 below:

Table 1: Floor space requirement of animals

Types of animal	Floor space per animal (sq. ft.)		
	Covered area	Open area	Manger length per animal (Inches)
Cows	20-30	80-100	20-24
Buffaloes	25-35	80-100	24-30
Young stock	15-20	50-60	15-20
Pregnant animals	100-120	180-200	24-30
Bulls	120-140	200-250	24-30

There are two types of housing systems for animals:

a) Loose housing: In this type of housing animals are kept loose in an open paddock except at the time of milking and treatment. A shed is constructed along one side so that animals can be provided with shelter during very hot, cold or rainy day. Cost of construction of such system is cheaper and future expansion is possible. The animals have chance to move freely so that they will get sufficient exercise. If required 10-15 percent more animals can be accommodated, however, for shorter period.

In this system, common feeding and watering arrangement is possible. Clean milk production is also possible because the animals are milked in a separate milking barn. Some of the disadvantages of this system are that loose housing is not suitable for colder and heavy rainfall areas. It requires more floor space and there is competition for feed. Attention of individual animal is not possible. A separate milking barn is needed for milking of animals.

b) Conventional barn: These barns are completely covered with roofs and the side walls are provided with windows or ventilator located at suitable places to get more ventilation and lighting. In this system of housing, the animals are confined and secured at neck chain. The animals are fed as wells as milked in

the same barn. It is applicable for temperate and heavy rainfall region. The advantages of this system are that exposure to harsh environment is minimum and individual care can be given. Separate milking barn is not required. But this type of housing is very costlier and also future expansion is difficult. It is not suitable for hot and humid climatic conditions.

Cleaning and proper sanitation of animal housing is necessary to eliminate all micro-organism that are capable of causing disease in the animals and to avoid contamination of the milk for hygienic production. The floor should be clean and dry as far as possible to avoid injury from slip. Removal of dung, urine and liquid waste not only help in decreasing bad smell but it also restrict growth and multiplication of flies and other insects that spread deadly diseases to the animals eg. Babesiosis, Theileriosis etc. All of dung and used straw bedding should be disposed and animal house should be washed with liberal use of tap water. Feed and fodder left over in the manger should be removed daily. Periodical cleaning of water troughs eliminates the growth of algae, bacterial and viral contaminations and thus keeps the animal healthy.

Disinfection of animal sheds means making these free from disease producing bacteria and is mainly-carried out by sprinkling chemical agents such as bleaching powder, Iodine and lodophor, sodium carbonate, washing soda, Slaked Lime (Calcium hydroxide), Quick Lime (Calcium oxide) and phenol. Sunlight is the most potent and powerful sanitizer which destroys most of the disease producing organism, therefore door and windows should be kept open during day time.

Nutritional management

The animals need nutrition for maintenance of their body functions and also for production. The feed contains carbohydrates, protein, fat, mineral, vitamins and water. Feeding a balanced diet; avoiding over feeding and providing abundant supplies of cool and clean water will help to optimize feed and nutrient use on an animal farm. The amount of nutrients required by an animal depends on the species, sex, age, physiological stage and the production levels of the animals. Animals are fed with dry roughage, green fodder and concentrate based on their body weight as per requirements. Supplementation of diet with mineral mixture is also essential. It is necessary to feed animals as per feeding schedule. Negligence in feeding may aggravate the productive or reproductive problems.

Feeding after birth till maturity

The nutritional management starts right from birth of calf. A calf after birth should be fed colostrum within 2 hours and be sure to feed the calf enough of colostrum between 2 to 2.5 liters daily for the first 3-4 days following its birth.

Colostrum provides antibodies, which are absorbed intact in the first few days of the calf's life. Milk replacer is fed to calves from 10 days after birth. Most of the 3 months old calves, irrespective of birth weight have their rumen developed for microbial fermentation. It may not therefore be necessary to feed milk or milk replacers at this age because of high cost of feedings. Calf starters containing 22 per cent digestible crude protein (DCP) and 72 percent total digestible nutrients (TDN), may be fed from 3 months onwards. High quality calf starter is necessary along with adequate quantity of minerals and vitamins. The calves after weaning should be kept in separate stalls up to a minimum period of 3 months to eliminate the suckling instinct.

Feeding of pregnant cows

Feeding during gestation is based on body weight and growth of foetus. First and second time pregnant cows need special attention as they gain in body weight and fetal dry weight increase exponentially. In last three months of pregnancy foetus growth is higher, so allowances are given for foetus growth also. Good quality legume hay, concentrate mixture of grains, cakes and by-products in equal parts may be given in required quantities. A week before calving, bulky and laxative concentrate mixture should be fed.

Feeding after calving

The cow needs a small amount of feed during the first day of calving. Some hay or silage will be sufficient. From the next day a concentrate mixture0.5 kg per animal can be fed and full quantity should be resumed in a week. The degree of energy deficit during first few weeks after calving is closely correlated with the interval of first estrus, conception rate of first service, service per conception.

Feeding of lactating cows

Plenty of good quality hay is best for dairy cows. When good quality hay is not available, succulent fodder or silage can be fed. The quantity of concentrate feeding depends upon the quality of roughages fed or the pasture on which the animals are grazed. Generally beyond certain level of production, which is sustained by the roughage component itself, for every additional kg of milk, about 0.45 kg of concentrate mixture may be needed. The protein level in the mixture varies from 15 to 20 per cent depending upon the protein content in the roughage feed. The requirements of protein and energy can be met according to any systems of feeding as shown in the example given below in table 2:

Table 2: Requirements of cow weighing 400 kg (10 kg milk)

Requirements	Dry matter (DM) (kg)	Digestible Crude Protein (DCP) (kg)	Total Digestible Nutrient (TDN) (kg)	Metabolite Energy (ME) (Mcal)
Maintenance	6.0	0.25	3.0	10.8
Production (DCP 0.05 kg/kg milk TDN 0.37 kg/kg milk ME 1.38 Mcal/kg)	3.2	0.50	3.7	13.8
Total	9.2	0.75	6.7	24.6

Following points should always be kept in mind for feeding of animals:

- Use feed ingredients high in nutrient availability so that nutrients present in feedstuffs are readily available and utilized by the animal.
- Remove spill or waste feed as it is often wet, covered with saliva and will spoil and rot if left in manger.
- Monitor feed, forage and water quality to ensure the adequate consumption of un-contaminated feeds and water. Toxins in the feed or water may also influence animal production. For example, during a drought year, forage quality will often decline, and toxins such as nitrates may be taken up from the soil by plants and influence animal production. Likewise, some oil cakes may contain aflatoxin, a liver damaging compound secreted by molds infecting the feed. Feed additives and supplements like mineral mixture, hormones and antibiotics should be used as prescribed on the label, or under the care of a veterinarian. Examples of additives are products like monensin or bovatec, which affect fermentation in the bovine rumen and improve performance and feed efficiency. Hormones such as anabolic implants and steroids that improve production performance and growth rate and antibiotics, which when used properly in the diet, can result in improved feed efficiencies and health.

Reproduction Management

Future of any livestock farm depends on the progeny produced, thus management of reproduction is very important which involves following points:

- A female calf should be inseminated when she has acquired minimum body weight e.g. in case of crossbred cows if body weight is above 250 kg then it is fit for breeding.

- Heat detection of breedable female animals should be done regularly and with utmost care. If oestrus signs are observed in the morning, then inseminate the animal in the evening. If oestrus signs are observed in evening, then insemination should be carried out at next day morning.
- Generally Artificial insemination (A.I.) is practiced for large animals like cow and buffalo. Semen should be collected from disease free bulls or if procured from outside agency, the agency should be certified by Central Monitoring Unit (CMU) of Government of India.
- Frozen semen should always be stored in liquid nitrogen containers and semen straws should be taken from the container just before use.
- If natural service is done, e.g. in case of sheep and goat, then it should be ensured that the male are free from diseases.
- Insemination should be done as per breeding plan of the farm and proper AI / service records should be maintained.
- Once the animal has been declared pregnant, special care for feeding etc. must be ensured and expected date of calving should be noted.
- Reproductive rest of 45 – 90 days after calving should be given before AI.

Health Management

Good animal husbandry starts with proper health care and management. Livestock production is greatly affected by diseases. Proper knowledge of these diseases is a must to plan and organize effective animal health-care. So, every livestock manager should note the following precautions to maintain health of animals:

- Isolate sick animals from healthy animals such that transmission of infection does not occur and where necessary, cull diseased (if incurable) animals.
- Keep newly arrived animals separate from resident stock for an appropriate period to monitor them for diseases and infections. Avoid overcrowding in the house.
- Ensure that equipments and instruments used in animal husbandry are suitably cleaned and disinfected between each use.
- Dispose off dead animals at the earliest so that other animals cannot come into contact with carcasses.
- Get accurate and early disease diagnosis by qualified veterinarian.
- Avoid unnecessary medication.
- Eliminate ticks, lice, mites and control predatory animals.

- Consider droppings as potential source of diseases. Keep the animal house clean and dry.
- Keep the feed and water uncontaminated.
- Ensure periodic vaccination.
- Maintain record of incidence of diseases and treatment given.
- Ensure that people working with animals are properly experienced and trained for the tasks they perform and follow good hygienic practices .
- Ensure that facilities and equipments are properly designed and maintained to prevent physical injury.
- Ensure that animals are handled and transported appropriately.

Seasonal Management

The changes in climate are a regular phenomenon and it is very important to protect animals from extreme weather conditions.

Summer Season: Heat stress can severely impact both production and reproduction. Very high environmental temperature can result in heat stress. Common sign of heat stress are increased body temperature (> 102.6^{o} F), panting (>80 breaths/ minute), laziness, weary, sharp decrease in feed intake (10 to 15%) and milk production (10 to 20%), and adverse effect on reproductive performance of animals. To prevent heat stress, following steps should be considered:

- Animals should not be exposed to direct sun.
- Windows and ventilators should remain open.
- Use exhaust fans, mister, showers etc. so as to keep ambient temperature low.
- Abundant drinking water is needed due to greater consumption during hot weather.
- Ration formulation can be used to minimize heat production potential of the diet through the use of grains, fats, and high-quality forage.
- Adequate high-quality fiber must be used to maintain rumen function and cow health.
- Ration energy can be increased by using grains and other highly fermentable carbohydrates.
- Ration protein content and quality must be altered with heat stress. Excess degradable protein can have negative effects on intake and efficiency.

- Mineral content (especially potassium, sodium, magnesium) should be increased. Other elements and vitamins should be adjusted to offset reduced feed intake.

Winter season: Care for livestock in cold climates requires some attention to those basic needs like water, food and shelter so that animals can cope with the additional physical stress of winter. Providing adequate water, appropriate feed amounts and some shelter from wind, cold rains or wet snow will ensure that the animals handle winter conditions with no ill effects.

Water is the first essential nutrient and adequate water intake is just as critical in winter as it is in hot weather. To ensure adequate intake, water should be above 4^0C so some type of heating system is recommended. Animals should always receive proper feed adjusted for their production needs, but in winter, it is especially critical to have adequate amounts available and replaced on a regular schedule, since food is the "fuel" that keeps the metabolic fires going. For livestock that primarily eat forages, extra rations of grain are less effective than having a sufficient supply of good quality forages such as alfalfa or grass hay available at all times, since fiber digestion produces body heat for these types of livestock.

Proper bedding should be provided to the animals and make sure it is kept as clean and dry as possible. Any animal that is shivering needs additional warmth, but very hypothermic (cold) animals will often stop shivering and need immediate attention. Avoid large temperature changes (from very cold to very warm) as these conditions can cause pneumonia.

Rainy season: During this phase of the year environmental humidity is very high and chances of feed getting moldy are also very high. This reduces the quality of the feed and other forages resulting in poor intake by animals and high toxicity due to aflatoxins etc. Therefore store animal feeds in a dry place. Animals need dry bedding material for resting because wet, damp or soiled bedding contributes to health problems. Animals still need water during this period and chances of water contamination are more during this weather. Due to damp conditions, bacterial multiplication is high during such times and cows are likely to get teat diseases. Each time the cow leaves the milking parlour, ensure the teats are dipped in a teat dip and dried.

Product management

Milk is the main product from a dairy farm, produced basically as food for human consumption. A farm manager must therefore aim at maximizing on milk output and at the same time he must ensure that milk is produced in clean and hygienic conditions so that it is fit for human consumption. Milk is a very good media for bacterial and other micro-organisms development. As such, disease hazard

in public can easily be predisposed by infected milk during production, handling and marketing. Dirty milk also has will have short self-life. Some of the precautions to be observed during milking are as follows:

- Check for mastitis with a strip cup or any other method.
- Isolate sick animals and milk them last (Their milk should not be mixed with good milk).
- Wash udder, teats and flank of the animal with clean water preferably add a disinfectant. Wipe with a clean cloth.
- Always groom and cut the hair around the udder.
- Dispose fore-milk tie tails of troublesome animals when milking. Milker should be healthy and clean. Their finger nails should be trimmed. Cover their heads when milking as guard to falling hair. Avoid smoking during milking time.
- Milking area should be located away from bad smells and odours and It should be cleaned after every milking.
- Use seamless utensils preferably aluminum or stainless steel. Use cans, sufurias or metal buckets in milking.
- Scrub with a brush using hot water mixed with a detergent e.g. soap or detergent and rinse with cold water and place the utensils to dry on a rack upside down during the day.
- Utensils should be stored at night in a safe and clean place, which is well ventilated. Do not excite the animals.
- Regularize milking intervals.
- Squeeze the teat and do not pull. All milk should be got from the udder i.e. avoid incomplete milking. Use a teat dip after milking.
- Filter immediately after milking and use a white filter cloth.
- Disinfect, wash and dry the filter cloth after use.
- Store milk in cool and clean place.

Waste management

A lot of dung and urine are generated in an animal farm. The disposal of these is a tough challenge. Effective animal waste management demands that waste generated must be disposed off as infections, can spread through dung. It will also be used by various flies and insects as a place to lay their eggs. The most common environmental concern with animal wastes is adverse effects on the atmospheric

air with offensive odors and release of large quantities of methane which might contribute to the greenhouse effect.

Proper disposal and returning of nutrients back in the soil without pollution and spreading of diseases/pathogens is required for efficient utilization of wastes on large farms. There are many uses of animal dung. It can be used to fertilize soil for crops, can be dried and used for fires or may be mixed with clay to make building materials. Animal manure is rich in nitrogen, phosphorus and potassium. In addition to providing supplemental nutrients for crop growth, manure has several beneficial effects on soil properties. Utilization of these nutrients by proper technique is highly desirable for efficient utilization of the animal wastes. Some of the techniques used are:

- Composting and vermicomposting
- Biogas production (anaerobic fermentation).
- Use as fish feed in fish ponds.
- For growing algae (diluted slurry).

Water management

Water represents 60 to 70 per cent of the body weight and is essential for animals in maintaining their vital physiological functions. Animals are heavily dependent on water, the National Commission on Integrated Water Resources Development (1999) had suggested that the direct watering requirement of livestock is about 5 billion cubic meters a year based on a norm of 18-30 litres per caput per day. Therefore, when water requirement of livestock is poorly managed, it will pose a heavy tax on water resources and also contribute to the degradation and contamination of water bodies. Water-use in a livestock system is for three purposes:

I. Drinking water : Livestock need water as all living beings for mere survival.

II. Embedded water : Water is used for growing feeds and fodders for the livestock.

III. Service water : Water is necessary for various farm-operations *viz.* take cleaning etc.

The dairy waste management system should be designed to reuse waste water through irrigation thus to utilize flushed manure nutrients for growing fodder crops etc. If used water is properly channelized for irrigation and water amounts are small in relation to irrigation needs for crop production, then liberal use of water for cow washing, cow cooling, and manure flushing is not a problem. For some farms it might make sense to consider constructing storage structures for holding waste water until it is needed for irrigation.

Animal welfare

There must be reasonable expectation that research involving animals will contribute significantly to present and future knowledge, which may eventually lead to the protection and improvement of the health and welfare of either humans or animals. Any animal research project implies a potential violation ethical norms and values. However, experimentation on animals is covered by provisions of the Prevention of Cruelty to Animals Act, 1960 and Breeding of and Experiments on Animals (Control & Supervision) Rules of 1998, 2001 and 2006 framed under the Act. These are enforced by the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), a statutory body under the Prevention of Cruelty to Animals Act, 1960. Under these provisions, the concerned establishments are required to get themselves registered with CPCSEA, form Institutional Animals Ethics Committee (IAEC), get their Animal House Facilities inspected, and also get specific projects for research cleared by CPCSEA before commencing the research on animals.

Further, breeding and trade of animals for such experimentation are also regulated under these rules. no establishment shall perform any experiment on animals unless it is registered. In an amendment bought out in 2006 in the Rules for Breeding of and Experiments on Animals (Control & Supervision), powers to permit experiments on small animals were given to Institutional Animal Ethics Committee (IAEC) of the establishments. Only proposals for conducting experiments on large animals are required to be sent to CPCSEA for approval.

CONCLUSION

Livestock management is the practice of efficient, productive, and ethical care-taking of any agriculture related animal. It has a long chain of activities, involving the combination and co-ordination of human, physical and financial resources in a way of uplifting animal production performance. There are many different aspects that are involved in proper livestock management such as proper feed rations, correct dosages of medicine, intelligent breeding practices, adequate living conditions, etc. There are many practices that are used throughout livestock production such as heat detection, artificial insemination, rotational grazing, castration, weaning, supplementing rations, and administering medicine. For efficient livestock management, the utmost care must be taken on all these aspects for obtaining the desired output.

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Chapter 9

Breeding, Feeding and Health Care Management in Poultry

S. Malik

It is believed that the Indian Poultry Industry is 5,000 years old. Since last four decades it has witnessed remarkable growth from backyard to commercial poultry industry. India, with poultry population of 729.21 million (2012) and estimated more than 74,752 million eggs production (2013-2014), ranks among the top three countries in egg production. The total poultry meat production of the country is 1.917 million tonnes (2013-2014) and India ranks 5th in broiler production in the world. The per annum growth rate of poultry industry is 10-15 per cent in broiler and 5-7 per cent in layers. Broiler chicken industry has now occupied the second place in volume in the world just after pork. The chicken meat represents 25 per cent of total meat production from farm animals.

If we compare the performance of broiler production between 1953 and 2012, the market age reduced from 80 days to 40 days and feed efficiency improved from 3.52 to 1.70 kg feed per kg body weight. Meanwhile there is marked improvement in body weight from 1.52 to 2.25 kg. In case of egg production, there is vast improvement during this period. The per annum egg production of white leghorn recorded 340 eggs. Considering the availability, the per capita per annum availability of poultry meat and eggs were 190 g and 5 eggs, respectively in 1950-51, which has now increased to 1.56 kg. poultry meat and 61 eggs in 2013-2014, respectively.

But still we are far behind from the recommendation of Nutritional Advisory Committee of Indian Council of Medical Research (11.0 kg poultry meat and 180 eggs per capita per annum). Moreover, India's 75 per cent of egg produce is consumed by the 25 per cent population living in urban and semi-urban areas. The improvement in egg production and broiler performance was achieved by the continuous effort through applied research in breeding, nutrition and health sector.

POULTRY BREEDS AND VARIETIES

A. Egg Purpose

(i) Commercial: White leghorn breed and its different strains / varieties developed by public and private sector can be used for commercial egg production. The

age at sexual maturity of White leghorn is 140 days and on average its egg production is 320 eggs in a laying year.

(ii) Backyard System: The improved layer varieties have the potential of producing 160-200 eggs in a laying year at the organized farm conditions and 140-170 eggs in a laying year in free range conditions. The birds have on average 1.5-2.0 kg body weight in females and 2.5-3.5 kg. body weight in males. The major varieties developed for egg production by different Institutes/Organizations are: Gramapriya, Krishna J., CARI Gold, CARI Nirbheek, CARI Shyama, CARI Hitcari, Gramalaxmi and Kalinga Brown.

B. Meat Purpose

(i) Commercial: Broiler hybrids developed by private sector are available for commercial broiler production. These strains/varieties can achieve 2.25 kg body weight in 40 days with feed efficiency 1.7 kg feed per kg body weight. The import varieties under commercial production are Vencobb-100, Vencobb– 400 and Saguna broiler

(ii) Backyard System: The varieties developed for meat purpose have the potential to gain 1.40-1.60 kg. body weight in 8 weeks of age in semi intensive conditions but the dual purpose varieties may gain only 1.20-1.40 kg. body weight during the same period. The varieties developed for meat and dual purpose by different Institutes/Organization are: Vanaraja, Krishi- Bro, CARI Dhanaraja, CARI Devendra, Giriraja, Swarndhara, Nandanam – 1 & 2, Kuroiler, Satpuda Deshi.

STORAGE OF FERTILE EGGS

The temperature for holding fertile eggs before incubation varies between 10-21°C. At very low and very high temperature, the eggs do not hatch well.

HATCHING OF EGGS

Hatching is the production of chicks from fertile eggs. In chicken hatching period is 21 days. Hatching of fertile eggs can be done in two ways:

(i) Natural hatching: When the fertile eggs are placed under the broody hen, the bird provide heat from her body to the eggs. The eggs also get humidity (moisture) from nest as well as from the soil and oxygen from the air. Birds have natural instinct for rearranging (turning) of eggs to make certain that they are well covered and uniformly getting temperature. The native (desi) hens are excellent for this purpose. This method is suitable only for small scale chick production because one hen can hatch only 10-15 eggs at a time.

(ii) Artificial hatching: By this method, incubators are used for hatching of eggs. Incubators are more efficient and suitable for large scale chick production. In incubators system the total incubation and hatching period is divided into two parts. The first period is called incubation period, which is 18 days and second period is called incubation and hatching period, which is 3 days long. The requirements of temperature and humidity for both the periods are slightly different. For successful hatching four factors are very important, *viz*. Temperature, Humidity, Gaseous environment and turning of eggs.

INCUBATION

The temperature in incubation period is maintained in between 99.5 – 100.5ºF (37.5 to 38.0^{0}C). Very high or low temperatures reduce hatchability by increasing embryonic mortality, weak and deformed chicks. The relative humidity should be 60 per cent during incubation period. Dry and wet bulb thermometers are used to determine humidity. The reading of the wet bulb should be around 85.

The oxygen concentration should be 21 per cent, which is generally available in normal air. More or less oxygen concentration decreases hatchability. On average the CO_2 concentration should not go beyond 0.5 per cent. The oxygen and CO_2 concentrations are maintained by proper ventilation and exhaust system in the incubator and hatcher. Turning of the eggs should be done at least 4 times in a day. Turning of eggs is essential during incubation in order to improve hatchability.

HATCHING

The eggs are transferred to a separate machine called Hatcher during this period. The eggs with live embryos are only transferred to the hatcher. The temperature of the hatcher is maintained at 98^{0}F (37.0^{0}C) and relative humidity between 70- 80 per cent. The oxygen and CO_2 requirement is same as in the case of incubation period. The turning of eggs is not required during this stage.

For small scale chick production, machines are available in which incubation and hatching (21 days) can be performed in the same machine. Eggs are set in upper trays for incubation during first 18 days and shifted in lower trays during the last three days for hatching. However, hatchability is slightly lower in comparison to separate incubator and hatcher.

CANDLING OF INCUBATED EGGS

The eggs should be candled on 7th day to remove infertile eggs and on 18th day to remove dead germs. Candling is performed in dark room using Egg Candler fitted with electric bulb, and according to behaviour of light, the eggs can be classified into fertile and infertile eggs as follows:

Transparent eggs - Infertile eggs
Translucent eggs - Dead germ
Opaque eggs - Live embryo

The eggs with only live embryos should be transferred into the hatcher machine.

BROODING OF CHICKS

Brooding is the care and management of new born chicks for successful rearing without hen. During this initial phase of brooding, young chicks can not regulate their body temperature, so they require artificial heat to sustain body temperature. The young chicks needs shelter /brooder house upto 6 weeks of age to save from predators *viz.* crow, rats, snake, fox, stray dog and raccoon. Brooder house should be separate from other houses. There should be adequate ventilation in the brooder house to maintain the balance of oxygen and carbon dioxide. Adequate care should be taken to avoid direct and chilled wind of high speed.

Brooder house should be thoroughly cleaned and disinfected with a disinfectant solution (Kohrosolin/Phenyle) much before arrival of chicks. All the equipments, feeders, waterers and hovers should be thoroughly cleaned and kept in working order. Poultry diseases are highly contagious and therefore, movement of workers should be restricted in brooder house. There should be 2-3 inches thick layer of dry saw dust/rice husk or other locally available material in the brooder house. The moisture of the litter should be between 20-25 per cent as higher moisture may create ammonia problem which cause ill effect on chicks.

Optimum temperature of brooder house maintains good growth rate and reduce mortality in chicks. The starting temperature should be 35^0C during the first week and it should reduce 5^0C per week during the successive week till 21^0C. The heat source of 2 watts /chick is adequate upto 6 weeks of age. The season of brooding also define the requirement of heat. Monitoring of chicks' behaviour is also very essential. If the temperature is higher than required, the chicks will stay away from the source of heat; if it is lower the chicks come closer to the source of heat. Brooders should be warmed for up 24 hours before the chicks' arrival. The chick guard may be prepared by locally available material. The per chick brooder space is 45-65 cm^2.

Table 1: Floor, Feeder and Drinker space of different categories of chicken.

Particulars	***Chick***	***Grower***	***Adult***
Floor space	½ -1.0 ft^2	2.25 ft^2	3.25 ft^2
Feeder space (linear cm)	2.5-6.50	6.5-10.0	14 .0
Drinker space (linear cm)	0.50-1.50	1.50-2.50	2.50

NUTRITIONAL REQUIREMENTS OF POULTRY

(i) Average per day requirements of feed and water for the birds

The average per day requirements of feed and water of different age groups of birds are mentioned in the table 2. If birds will not provided water for two days, the birds start moulting and cease egg production. The quantities mentioned in table may be slightly varying according to season and breed / variety of birds.

Table 2: Average per day requirements of feed and water.

Age (Weeks)	*Amount of Water/ 100 birds (L)*	*Feed consumption/ bird (g)*
0-4	2.8-4.0	6-30
5-8	12-14	32-50
9-12	20-25	55-70
13-16	35-40	70-80
16 -20	45-50	80-100
20 and above	- do -	100-150

(ii) Feeding requirements of Poultry

The ISI requirements of chicken feeds of different categories of birds are presented in table 3. Feeding balanced feed is essential, because when feeds lacks essential protein type, minerals and vitamins, much more will be eaten, and much less will be produced.

ENERGY SOURCES

The energy sources are used in feed at the levels of about 50-70 percent. Moreover, they also add about 25-35per cent of total protein requirement of poultry. All the monocotyledon crops are the good source of energy. The major energy sources are Maize, Barley, Rice, Rice polish, deoiled rice polish, Oat, Wheat, Wheat Bran, Pearl millet, Sorghum, Sal seed, Broken/Damaged food grains, Tapioca meal, Hominy fees, dried poultry waste, molasses, Mango seed kernel and small millets.

Yellow maize is the major source of carotene (precursor of vitamin A) and xanthophylls, a pigment deposited in broilers and egg yolk. Due to fibre and manganese in oats, mixing of oats in the feeds reduces the incidence of cannibalism, feather picking and hock disorders. Wheat bran is excellent source of manganese, iron and a good source of riboflavin, pantothenic acid, choline, niacin and thiamine. Germ-free caged layer droppings can be used as feed ingredient for poultry. It is high in calcium and phosphorus and has about 10-12per cent of protein.

Table 3: ISI requirements of chicken feeds

Particulars	*Broiler Starter (0-5 weeks)*	*Broiler Finisher (6-9 weeks)*	*Layer chick starter (0-6 weeks)*	*Grower (7-20 weeks)*	*Layer (21-80 weeks)*
Energy (Kcl/Kg)	2900	3000	2700	2700	2800
Protein (%)	22.0	19.0	22.0	16.0	18.0
Crude Fibre (%)	6.0	6.0	7.0	8.0	8.0
Calcium (%)	1.0	1.0	1.0	1.0	2.75
Available phosphorus (%)	0.5	0.5	0.5	0.5	0.5

* Mineral mixture and vitamin mixture as per ISI.

Fats as Energy Source

Mutton fat, Beef tallow, lard and edible oils @ 3-8 per cent included in the ration are used as source of fat for poultry.

Protein Sources

The protein of the feed supplies amino acids to the body. The quality of the protein of particular ingredient is dependent on the composition of amino acids in the ingredient. So the amino acids are divided into two groups *viz.* essential amino acids and nonessential amino acids. The maximum protein synthesis occurs, when all the essential amino acids are present in the feed in proper proportions as required for growth and production. The excess of the amino acids goes waste as the amino acids are not stored in the body.

Vegetable Protein Sources

All the dicotyledonous crops (mainly pulses and oilseeds) are the good source of protein. Soybean cake, Ground nut cake, Mustard cake, Cotton seed cake, Maize gluten meal, Maize gluten feed, Cluster bean meal, Sesame meal, Sunflower meal, Ram til cake, Linseed meal and Penicillin mycelium waste are some of the sources of vegetable protein.

Animal Protein Sources

Fish meal, Meat meal, Meat cum bone meal, blood meal, liver residue meal, hatchery by product meal, feather meal and silk worm pupae meal are the sources of animal protein.

The animal protein sources contain higher levels of limiting amino acids (lysine and methionine) than vegetable protein sources. The animal protein sources are good source of calcium and phosphorus and supply vitamin B_{12} through natural sources. Fish meal is chief source of all the required amino acids and good source of riboflavin, pantothenic acid, choline, vitamin $B_{12,}$ calcium and phosphorus.

MINERAL SUPPLEMENTS

Oyster shell meal (38per cent Calcium), Bone meal, Ground limestone (Calcium) and Di-calcium phosphate are good sources of mineral supplements. Salts should be given only in required amount as, too much can become poison for poultry.

UPPER LIMIT (PER CENT) OF FEED INGREDIENTS USED IN POULTRY RATIONS

For formulating low cost ration, one should know how much maximum an ingredient can be mixed in the poultry ration. By this way costly feed ingredient may be avoided by using cheap locally available feed ingredients without hampering the production level.

Table 4: Upper limit of different feed ingredients

Ingredients	***Chicks-/ Growers/ layers***	***Ingredients***	***Chicks-/ Growers/ layers***
Energy Sources:		**Vegetable protein sources:**	
Maize	60	Groundnut cake/ Soybean meal	40
Wheat/ Pearl millet	50	Groundnut cake (Deoiled)/ Safflower cake/ Linseed meal/ Maize gluten meal/feed	20
Rice Polish	40	Mustard cake	10
Sorghum (White)/ Barley	20-40	Cotton seed meal	5
Tapioca meal	25	**Animal protein Sources:**	
Rice polish (Deoiled)	20	Fish meal	15
Oats	10-20	Liver residue meal	10
Wheat bran	10-15	Meat meal	5-10
Poultry manure meal	10	Silk worm pupae meal/ Meat cum bone meal	6

Ingredients	*Chicks-/ Growers/ layers*	*Ingredients*	*Chicks-/ Growers/ layers*
Molasses/Salseed meal (deoiled)	5-10	Blood meal/ Feather meal/ Poultry / hatchery by product meal	5
Fats as Energy Sources:			
Mutton fat, Beef tallow, lard and edible oils	3-8		

SUGGESTED RATIONS FOR LAYERS AND BROILERS

Some of the suggested rations for egg type and meat type chickens are given below.

Table 5: Suggested rations for Layers

Ingredients (kg/100 kg body weight)	**Starter (0-6 weeks)**		**Grower (7-20 weeks)**		**Layer (above 20 weeks)**	
	1	**2**	**1**	**2**	**1**	**2**
Maize	10.0	44.10	27.0	—	35.0	20.0
Broken Rice	38.0	—	—	41.0	—	25.0
Rice polish	—	18.0	40.0	40.0	30.0	30.0
Wheat bran	—	6.80	15.0	—	3.30	—
Rice bran (deoiled)	8.1	—	—	—	—	—
Groundnut cake	40.0	6.0	5.0	11.0	10.0	10.0
Maize gluten meal	—	6.0	5.0	—	10.0	—
Mustard cake	—	6.0	—	—	—	—
Fish meal/fish offal	2.50	12.0	6.0	6.0	4.0	5.0
Meat meal	—	—	—	—	—	6.0
Bone meal					1.60	2.0
Lime stone	—	—	0.60	1.0	5.0	1.0
Methionine	0.06	—	—	—	—	—
Choline chloride	0.06	—	—	—	—	—
Antibiotic & coccidiostat	0.10	—	—	—	—	—

Ingredients (kg/100 kg body weight)	Starter (0-6 weeks)		Grower (7-20 weeks)		Layer (above 20 weeks)	
	1	2	1	2	1	2
Salt	0.45	0.50	0.80	0.50	0.50	0.50
*Minerals Mixture.	0.68	0.56	0.50	0.40	0.50	0.40
*Vit. premix	0.05	0.04	0.10	0.10	0.10	0.10

* Mineral mixture and vitamin mixture as per ISI.

1. Broken Rice, deoiled rice bran or broken rice can be mixed in place of maize as a principle source of energy upto 80 per cent.
2. Groundnut meal can be replaced with Til cake (100%), sunflower (100%) or mustard (50%).
3. Rice polish can be replaced with rubber seed cake, tapioca or mango kernel cake.
4. Rice bran (deoiled) can be replaced upto half with by - products from pineapple pulp, banana peel, tea garden waste, cabbage waste, jack bean, apple waste, orange pulp.

VACCINATION AND HEALTH MANAGEMENT

The vaccination of birds is very essential to save the birds from deadly viral diseases because there is no curative medicine for viral diseases. The vaccination schedule in poultry is mentioned in table7.

MEDICATION AND DEBEAKING SCHEDULE

Regular monitoring and deworming of birds for internal parasites is very important due to scavenging nature of birds, which exposes them to internal parasites. Debeaking of birds is not required in rural poultry production. The beak helps in foraging and scavenging of insect etc. in the backyard of the farmer. But in case of more birds (100-200 or more) with the farmers, the birds may start cannibalism or may start eating eggs also. Therefore, debeaking of birds in this case may be performed. Deworming is also essential for the flock to avoid any adverse affect on their growth and production performance.

DIRECTION FOR MINIMIZING LOSS FROM DISEASES

(i) Keeping fresh and clean drinking water in plenty in the backyard is most essential.

(ii) Chicks should be procured from reliable source and from disease free flock.

Table 6: Suggested rations for Broilers

Ingredients (kg/100 kg body weight)	Starter (0-5 weeks)		Finisher (6-20 weeks)	
	1	2	1	2
Maize	14.0	49.0	15.0	50.0
Broken Rice	30.0	—	40.0	—
Rice polish	10.0	—	—	20.38
Rice bran (deoiled)	—	8.21	—	—
Groundnut cake	14.0	20.0	10.0	13.0
Sunflower cake	14.0	20.0	12.0	—
Animal fat	3.0	—	—	—
Fish meal/fish offal	10.0	—	10.0	10.0
Blood meal	3.18	—	1.30	—
Silk worm pupae meal (deoiled0	—	—	—	5.0
Bone meal	1.0	—	0.60	1.0
Limestone	—	—	0.60	—
Methionine	0.06	0.06	—	—
Choline chloride	0.06	0.06	—	0.02
Antibiotic & Coccidiostat	0.10	0.10	—	—
Salt	0.50	0.45	0.40	0.50
*Minerals & Vit. Mixture.	0.10	2.12	0.10	0.10

* Mineral mixture and Vitamin mixture as per ISI.

Table 7: Vaccination schedule

Age (days)	Name of the Vaccine	Dose	Route of Administration
01	Marek's disease (HVT strain)	0.2 ml	Subcutaneous
4-7	New Castle disease (Ranikhet disease) - F_1 / Lasota strain	One drop	Intraoccular/Intranasal (Eye/nasal)
14 day	Infectious Bursal disease (Gumboro) - MB strain	One drop	Intraoccular/Intranasal (Eye/nasal)
35 day	New Castle disease (Ranikhet disease) – *R_2B strain	0.5 ml	Subcutaneous
42 day	Fowl Pox	0.2 ml	Wing web prick

*Repeat R_2B at every 6 months interval.

Table 8: The debeaking and medication schedule

Age	Programme
1- 4 days	Antibiotic course, Electrolytes and Vitamins solution
5-8 days	Probiotic course
9-15 days	Vitamins solution
16-22 days	Coccidiostate / Coximer
23-30 days	Calcium supplements (Ascal / Vetkal)
31-42 days	Liver tonics, first Debeaking
42-50 days	First deworming
13-16 weeks	Second Debeaking and second deworming
Growers and Adults	Vitamins solution and Calcium supplements

(iii) Watch the birds at the morning on daily basis. If the birds show any abnormal behaviour, e.g. not consuming feed and water or symptoms of any disease or mortality, the affected bird should be immediately isolated from the other birds. Prompt action should be taken to arrange treatment by Veterinary Surgeon. The suggested medicine should be given to all the birds of the flock.

(iv) If any disease spread in the farm, keep the movement of the birds restricted. Keep the shelter area clean and disinfected. Vaccinate the birds if the disease is viral.

(v) Birds should be vaccinated and de-wormed at regular intervals as per the direction of Veterinary Surgeon.

(vi) Different species of poultry like chickens, ducks, turkey, etc. should not be kept in the same premises, but should be raised separately to avoid transmission of diseases.

(vii) The litter should be kept dry and the houses should be ventilated.

CONCLUSION

Poultry still has good scope for development considering the gap in availability and demand of the poultry products. For the sustainable development of poultry the following steps are suggested. Firstly Breeding technologies should be used for the development of the quality poultry products, not only the improvement in quantity. Secondly, availability of poultry feed is major problem in some areas of the country so formulations of cheaper balance ration using locally available feed ingredients

should be developed on regional basis. Thirdly, development of thermostable vaccines for viral diseases in small doses particularly for Ranikhet disease is essential for avoiding the cold chain system, which is difficult to maintain in the country.

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Chapter 10

Fish Pond Management

Peyush Punia and A.K. Prusty

The fisheries sector has been playing a very important role in the Indian economy through employment generation, contribution to food and nutritional security, and earning valuable foreign exchange through export. Fisheries sector in India is undergoing a transformation and contributes to the livelihoods for large section of economically underprivileged population of the country. The emerging production technologies, higher economic growth, population explosion and sift in dietary pattern are driving rapid growth in production and demand for food of animal origin. As per the present reports the fisheries sector in India has recorded faster growth as compared to the crop and livestock sector. However, due to various reasons the spread of aquaculture has not been uniform in the country, it has spread extensively in the eastern part of the country. Efforts should be made to spread it across the country wherever the suitable endowments exist.

Though fish culture in ponds is known to be practiced in India, particularly in the Eastern region, productions achieved by traditional methods are low except in some cases where the fish farmer is fortunate enough to have supplies of treated sewage for his ponds which helps in achieving larger fish yields. The average production from freshwater fish ponds in India is estimated to be around 600 kg/ha/yr. The fish production in experimental ponds has reached upto 10-15 t/ha/yr, while on an average it is around 2 t /ha/yr in Fish Farmers Development Agencies (FFDA) ponds. Though the modern technologies of fish culture are available in the country, still the traditional methods of aquaculture are being followed in different parts of the country.

PRINCIPLES OF MIXED FARMING COMPOSITE FISH CULTURE

Mixed farming of fishes is aimed at fuller utilization of pond productivity so that high fish yields are resulted. Technology of mixed fish farming or multi-species culture are the use of fast growing non-predatory food fishes which effectively utilize food both the natural kind as well as supplementary fish food; use of non-compatible species of fish so as to avoid serious competition between the different verities; stocking optimum number of each kind of fish so that the different ecological niches are adequately populated and exploited and contribute to the fullest strata-wise fish production the increase of productive potential of the pond by stimulating natural fish food production through fertilization and use of supplementary feeds to

provide adequate food for the large number of fish stocked to realize high yields. Periodical harvesting is to be followed and then restocking the replenished stock with same species and number harvested. The objective is not just attaining a large fish crops but optimum production of marketable fish from ponds.

HOW TO START FISH CULTURE?

As we need land for the crops, the same way we need pond for fish culture. In villages there are natural ponds of different types and sizes.

Selection of Natural Ponds

Fish ponds of 0.2 - 5.0 hectare ponds are suitable for carp culture but 0.4 ha pond is ideal. Black / gray clayed soil is suitable for fish culture. The pond should be free from flooding. The pond should be full of water throughout the year. There should be nearby canal or water pump to replenish the loss of water due to seepage and evaporation.

Repairing of Natural Ponds

Usually the natural ponds have drawbacks like eroded bunds, uneven bunds, uneven bottom, non-existence of water inlets and outlets etc. To make the pond bottom even there is need to remove the soil from raised portion of pond bottom and deposit it in the low lying areas so that pond bottom is smooth. Dugged out soil can be used to raise the height of the pond bund. Water inlet and outlet are to be provided. Both inlet and outlet should be enclosed with small meshed nets to avoid the escape of cultured fishes from pond and entrance of wild fishes from outside the ponds.

Construction of New Ponds

The success in carp culture and high production of table-size fish through carp culture depend largely on the designing and construction of pond. The basic principle involved in designing and construction of carp culture ponds are of very specialized nature and vary from region to region depending upon several factors like topography, soil type, water supply, etc.

Site selection

The site should have continuous water supply, electrical supply, roads, and cheap availability of labour. An ideal site should be away from flood influence and at the same time should not be far away from water resources. The selection of a suitable site for construction of ponds for carp culture mainly depends upon the soil type, the topography and water supply.

The soil of a fish must retain water for which it should have enough clay to make the pond water tight. The types of soil best suited for the pond are in general impervious. These are clays, silty clays, clay loam etc. Porous (sandy or gravelly) and peaty soils must be avoided as these will neither retain water nor permit compaction.

The topography or surface features of the area proposed for construction of ponds for carp culture should generally be flat or gently sloping towards the outlet. The site should be so selected that the earth available by excavation should, as far as practicable, balance with the earth required in filling or raising dykes (bunds).

A dependable source of water supply must be available near the site. There should be enough water to fill the pond and maintain water level, which should not fluctuate more than 60 cms. Equally important is the need for avoiding excess water. The common water sources for carp culture pond are rivers, streams, springs, canals and surface run off from rainfall. Any of these would be suitable provided control of supply is possible and water is not contaminated.

Soil characteristics for fish culture

The soil characteristics at the selected site should be as follows:

a) Colour - Black/gray
b) Soil pH - 6.5 to 7.5
c) Water holding capacity - 60%
d) Sand - 40%
e) Silt - 30%
f) Clay - 30%
h) Available Nitrogen - 30 to 50 mg/100 g
i) Available Phosphorous - 6 to 16 mg/100 g

Water quality parameters

The physico- chemical characteristics of the pond water should be as follows:

a) Water temperature - 25 to 32^0C
b) Turbidity - less than 20 ppm
c) Total alkalinity - 75 to 150 ppm
d) Total hardness - 40 to 150 ppm
e) Dissolved Oxygen - 5 to 8 ppm

f) Nitrate - 0.2 ppm
g) Phosphate - 0.5 ppm

Designing of pond

While designing fish ponds the first step should be to study the survey report and maps on the soil type, topography, water supply etc. The area of the pond should be larger so that fishes will have larger run for a healthy growth. The width of the pond should not normally exceed 40 m, so that relatively small net and limited number of men would be sufficient to catch the fish. The area of pond should be 0.2 to 5.0 hectares but ideal pond should be of 0.4 hectare. Very large ponds are difficult to manage particularly in controlling the overgrowth of weeds. It is better to have a rectangular pond.

The slopes of the ponds and bunds may generally be 1½ : 1 (1½ horizontal: 1 vertical) to 2½: 1 (2 ½ horizontal: 1 vertical). The bottom of pond should be generally slopping towards the outlet. For easy and complete draining of ponds, the pond bottom should fall above the ground water table.

The free board above the water level to top of bund should be 0.9 to 1.0 metes which will help in avoiding the flooding of pond. The width of pond bund on all sides should be around 3 to 4 meters. Pond should have controlled inlet and outlet, so that water can be filled in and drained out easily at will. The inlet and outlet should be covered with small meshed netting to avoid the entrance of wild fishes and escaped of cultured fishes.

Construction of pond

Once the designing is over it is necessary to prepare the detailed estimate of the items of work to be carried out as per the design. The probable cost of construction is to be estimated. As far as construction and supervision pond are concerned, the following may be taken into consideration for achieving good results:

***Construction time*:** The time to build a pond and to fill it with water is an important point for pond management. The most desirable time to finish a pond construction is late summer, so that the pond may be filled immediately by rain water during monsoon. If a pond is built during winter or early summer and is not filled with water immediately, weeds may grow and may cover pond bottom.

***Preparation of site*:** Before construction of pond is started, the site should be cleared by removing all trees, bushes etc. including their roots. No woody material should be left because the same will eventually rot and may later produce leakage.

Trees and bushes should be cut on the banks about 5 meters from the pond water line to facilitate proper sunshine over the water area and leaves of the trees may not fall in water.

***Actual construction*:** After the clearance of the area, it is necessary to mark the outline of the ponds and dykes. The excavation can be carried out either by manual labour or by using bulldozer. If a bulldozer is used, final shaping should be given by manual labour. The sides and bottom of the pond should be properly finished and rammed to proper level as per blueprint and design. The dykes of the pond should be strong enough to withstand weather action. For big ponds erosion of dykes is a problem for which grass turfing is suggested.

Drainage arrangement

Suitable drainage arrangement should be provided so that whenever necessary, the fish pond can be emptied and refilled. Installation of drain pipes with controlling valves is also a convenient method for drainage of ponds. The drain pipe should be installed at the lowest point of the pond so that the entire water can be let out. The size of the drain pipe depends on the size of pond and volume of water running in and out of the pond. Different types of pipes may be used of which, asbestos cement, concrete spun pipes, cast iron pipes, etc. are of more common types.

MANAGEMENT OF STOCKING POND

Stocking pond management envisages the exploitation of pond space and resources to the fullest advantage for the production of marketable fish per unit area of water.

Management of Stocking Pond

Stocking pond management comprises the following stages:

a) Pre-stocking management.

b) Post-stocking management.

Pre-stocking management

The pond management should be completed one month before the stocking of seed. Proper management practices of fish culture in the pond on scientific lines enhance the fish production. The practices to be followed are as follows: (a) control of noxious vegetation (b) removal of fish enemies and (c) fertilization, liming and raking.

Control of noxious vegetation

Excessive weed growth can exert adverse effects on the pond with regards to living space, sun light penetration, oxygen circulation, sheltering of fish enemies. These water plants also extracts the nutrients from the soil for their development which otherwise would have been used for the natural food production for fishes in water. The water plants also make the netting in the pond difficult. So it is essential to remove the water plants from the pond including their roots. If the roots are left out they will again grow and the hardened roots will accumulate the silt which will be hazardous for the ecology of the pond.

Usually there are following types of water plants which grow as weeds in fish ponds:

i) Bottom rooted- Plants which are rooted at the bottom of ponds and spreading within the bottom layer of water, e.g. *Vallisneria, OIttelia.*

ii) Submerged rooted- Plants which are rooted at the in the bottom soil or on the deeper margin of pond and ramifying in the volume of water, e.g. *Hydrilla, Potamogeton, Charra* etc.

iii) Marginal rooted-

- Plants which are rooted on the marginal region of the surface layer of water and ramify on thr surface of water and also on the adjoining land e.g. *Ipomoea, Jussiaea, Marsila.*
- Plants which are marginally rooted and ramifying within the marginal region of water volume, e.g. *Typha, Pharagmites, Cyperus* etc.

iv) Emergent & rooted- Rooted at the bottom but the leaves spreading on the surface of water, e.g. *Nymphaea, Nymphoides, Nelumbo.*

v) Floating vegetations

x) Surface floating:

- With roots, e.g., *Pista, Spirodela, Lemna, Azolla, Eichhornia.*
- Without roots, e.g. *Wolffia*

y) Submerged floating, e.g. *Ceratophyllum*

For removal of aquatic weeds, following methods of weed control can be used:

***Manual means*:** This method can be used against emergent and submerged weeds. Chains or roll of barbed wire dragged through the beds to entangle the weeds which can be skimmed out. Twisted straw rope can also be employed for this purpose.

***Mechanical means*:** The submerged weeds can be removed with the help of weed cutter which are easy to handle.

***Chemical means*:** When weed control is not possible by manual/mechanical method, it can be done controlled by applying chemicals @ 0.50 to 0.70 gallons/ liter of water.

i. 2,4-D and Dalapan for emergent weeds and grasses.

ii. Simazine, Diuron 3 and Ammonia for submerged weeds.

iii. Paraquat 1 against floating weeds.

Chemical methods should not be practiced in village ponds as the toxicity of chemical in water last long which can be harmful for the villagers who usually use this water.

***Biological means*:** Biologically weeds can be controlled by using fishes like grass carps @ 150 to 200 kg/ha in fish ponds which feed on vegetation. These fishes give production without damaging the natural pond system.

Removal of fish enemies

The perennial ponds also harbor unwanted animal, like crabs, frogs, turtle and some other predatory fishes. The presence of unwanted fishes may pose problem as they may compete for food, oxygen, space and prey on the newly stocked baby fishes. To remove them from the pond, following control methods are adopted:

- Complete draining or pumping out the water during the summer months. After removal of water the pond is allowed to dry up. After every crop also the pond should be dried until the pond will develop cracks and this will help in eradication of unwanted and harmful micro-organisms from bottom of the pond.
- When it is not possible to dry the pond, repeated operation of netting operation should be carried out for removal of weed fishes and unwanted animals.
- Application of Mahua oil cake @ 2,500 kg/ha/m of pond water has been found to be very effective in controlling fish enemies. The mahua oil cake is soaked in a tub with water. After getting completely soaked the mahua oil cake is mixed with water and sprayed in the ponds. Then with repeated netting this cake gets thoroughly mixed in water. Within 6 to 8 hours all the fishes get killed. The killed fishes are suitable for eating. The toxic effect of mahua oil cake will last for 15 to 20 days. After that this cake will serve as fertilizer to the pond and will help to develop the natural feed in the pond.

Fertilization, liming and racking

For increasing the natural fertility, stocking ponds require to be fertilized depending on the quality of the soil. A combination of both inorganic and organic fertilizers is recommended in pond possessing neither too clayey nor too sandy soil with medium organic contents. Stocking ponds should be initially fertilized two to three weeks in advance of introduction of fingerlings.

***Liming of Pond*:** The pond water should be slightly alkaline for the better growth of fish. Lime keeps the water in alkaline form and also helps to keep the fish enemies at bay. It also increases the calcium contents in the water which helps in the growth of fish. Normally liming in fish pond @ 250 kg/ha hastens mineralization of organic matter thus increasing pond productivity and helps in maintaining the sanitation of the pond. Direct application/ spreading of lime on the pond bottom and keeping the pond bottom dry at least two weeks would be very effective for increasing productivity and controlling parasites. It can also be spread over the water surface. In order to maintain slightly alkaline pH in the fish pond, the amount of lime required for different types of soil pH are mentioned in table 1.

Table 1: Lime application rate

pH level	*Soil medium*	*Lime application rate (Calcium carbonate kg/ha)*
4.0-4.5	Highly acidic	1,000
4.6-5.5	Medium acidic	700
5.6-6.5	Low acidic	500
6.6-7.0	Neutral	200

***Manuring of pond*:** Manure fresh raw cow dung initially @ 10,000 kg/ha and later 10,000-15,000 kg/ha in 7 to 11 installments or poultry droppings initially @ 5,000 kg/ha and later @ 1,000 kg/ha every quarter (organic manures) in combination with either ammonium sulphate + single super-phosphate + calcium ammonium nitrate in the ratio of 11:5:1 @ 1,400 to 1,800 kg/ha/yr in 4 to 10 installments or urea and triple super-phosphate @ 100 kg/ha each month (inorganic fertilizers) . About 15 to 20 days prior to transfer of fingerlings in the pond, both inorganic and organic fertilizers should spread on the pond surface. If mahua oil cake is used in the pond, the dose of manure should be reduced to half. It may be noted that if the colour of water turn green, the inorganic manuring should be stopped. When the colour of pond water turns deep brown, the organic manure should be stopped.

***Racking*:** Repeated racking of the pond bottom releases the obnoxious gases accumulated.

STOCKING OF PONDS

The major consideration in stocking should be the economics of fish production as stocking of ponds is done for getting maximum quality and quantity of fish under most economical conditions. Stocking depends on the size of the pond. A sound stocking programme could be evolved if the food requirement (i.e. quantity of food consumed in unit time) of different age or size group of fishes, and quantity of fish food within the pond are known. If, however, such information is not available, then stocking will be on empirical experience.

Healthy fingerlings of 120-150 mm size should be stocked. Carps seed to be stocked can be easily procured from nearby government or private hatcheries or from fish seed farms. Before the stocking of fingerlings in the pond it should be ensured that sufficient natural feed has developed in the pond. The fish should be stocked early in the morning or evening, when water is having minimum temperature. Before the seed is stocked the seed should be acclimatized to the pond temperature for 10-15 minutes in the fingerling containers only.

Selection of Fish Species

The fulfillment of the objective of fish culture to ensure maximum production per unit area and time calls in for fuller utilization of pond resources. Efficient fish species of complementary feeding habits are selected to ensure less inter-specific and intra-specific competition of growth. The selected species should withstand the climate of the region, be compatible, grow fast, be resistant to diseases, and be able to utilize the natural food, and artificial feed.

In mixed culture of Indian major carps alone – catla (*Catla catla*, zooplankton surface feeder), rohu (*Labeo rohita*, herbivorous column browser subsisting on plankton, periphytic organisms and decaying vegetable matter), and mrigal (*Cirrhinus mrigala*, an illiophage bottom feeder) are cultured.

Mixed culture of exotic carps along with Chinese silver carp (*Hypophthalmichthys molitrix*, a phytoplankton surface feeder), grass carp (*Ctenopharyngodon idella*, an aquatic vegetation column feeder) and common carp (*Cyprinus carpio* var. *communis*, an omnivore scavenging the bottom) are cultured. In composite culture of both the Indian and exotic carps all the above six species are brought together.

Species Combination

Manipulation of the species ratio is for minimizing the inter-specific and intra—specific competition for food available at various trophic levels and zones in a pond. Either single species or more than one species occupying different niches could be

utilized in a pond for exploiting the food available at various zones. Manipulation in the numbers of species could be done for ensuring attainments of market sizes by all species involved. The combination details are given below in table 2.

Table 2: Species, stocking ration and number to be followed in fish culture

Fish Species	*3-Species culture*		*3-Speces culture*		*4-Speces culture*		*6-Species culture*	
	Ratio	**Number**	**Ratio**	**Number**	**Ratio**	**Number**	**Ratio**	**Number**
Rohu	3.0	1,500	-		3.0	1,500	3.0	1,500
Catla	4.0	2,000	-		3.0	1,500	1.0	500
Mrigal	3.0	1,500	-		2.0	1,000	1.5	750
Silver carp	-		4.0	2,000	-		2.0	1,000
Grass Carp	-		3.0	1,500	-		1.0	500
Common carp	-		3.0	1,500	2.01,000		1.5	750

Stocking Density

For profitable fish culture, the stocking ponds should be stocked at a rate below the "carrying capacity" which could be raised. Stocking density varies depending on the type of fish culture selected. In India, with the improvement in management practices the stocking density of 5,000 fingerlings/ha are profitable.

POST- STOCKING OPERATION

The pond stocked, would have rich crop of zooplankton consequent on mahua oil cake poisoning which would be utilized by the fishes introduced. This potentiality for producing plankton could be increased manifold, the details of which have already been discussed under pre-stocking operations.

Supplementary Feed: The carps relish on available protein rich natural feed of phyto and zooplanktons developed in the fish pond. However, it may not meet the demand of the fish for better growth. This food shortage is obviated in ponds under intensive fish culture by resorting to artificial feeding, is termed 'supplementary food'. Artificial feed could be of either plant or animal origin. Supplementary food alone can effectively increase the caring capacity many times for natural level of production and in combination with fertilizers boosts production further up.

A mixture of rice/wheat bran and mustard/groundnut oil cake in the ratio of 1:1 @ 2 per cent body weight is recommended as artificial feed. The feed is made in balls and kept under water in gunny bags having small holes at the two corners. The first feed can be given in the morning after sun rise. No feed should be given after 4 PM. When the fish is young at that time the feed is to be broadcasted in the

powder form twice a day from one side of pond in the direction of wind flow. The quantity of the feed can be increased or decreased as per the natural feed present in the pond and water temperature. In cold months the feed intake of the fish is less.

HARVESTING

Morning hours are most suitable for fish harvesting because during morning hours the atmospheric temperature is low. The morning harvested fish are safer and takes more time to putrefy. Harvesting can be carried out profitably and effectively under low water level conditions. Fishes should be removed when they are in prime conditions and are in heavy demand. Periodical harvesting of marketable sized fishes in ponds under culture would help in providing space by reducing the pressure of density on the pond which also provides scope for left over smaller fishes to attain the marketable size.

Depending upon the availability of the fingerlings, replenishment of the removed number could be done so as to obtain sustained yield of fish. Netting is the effective means for harvesting in ponds. At the time of final harvesting it is better to remove whole of water. It has two advantages, one all the fishes are caught, secondly the emptied pond is dried and gets direct sunlight which makes the culture of pond healthier. By this method one can make the pond ready for further culture of fish in the same pond.

PROBLEMS OCCURRING IN FISH PONDS

Some of the problems encountered in fish culture ponds and their possible solutions are enumerated below:

Sl. No.	Problem	Solution
1.	Reduction in water level restricting space for growing fishes	Replenishment water with water
2.	Depletion of oxygen by algal blooms and organic pollution caused by decay and decomposition of unutilized feed	Feeding and manuring should be stopped till blooms disappear.
3.	Accumulation of metabolites	Replacement or replenishment of water
4.	Dissolved Oxygen depletion in pond	Use of fountain type or peddler type aerators
5.	Parasitic infection	Use of antibiotics, periodical check-up of healthiness of the fish and the hygienic conditions of the pond which could be improved by the application of lime.

FISH DISEASES

There is no probability of fish disease in the pond when one takes care of pond oxygen and proper scientific management is followed. But when the ecology of pond gets polluted, there is possibility of fish disease. When the fish disease is occurring the following precautions should be followed:

- Diseased fish should be kept in separate pond, and then treated.
- Medicines to heal up the fishes should be used.
- The fishes from diseased pond should not be shifted to other ponds where the healthy fishes are stocked.
- The fishes which die due to disease should be immediately removed and buried in the soil far away from culture farm.
- The fishes should not be kept in crowded condition or under stress.
- Before stocking of fishes in the culture pond, the diseased fishes should first be removed.
- The pond water should always be clean and suitable for fish culture.

CONCLUSION

By adopting the improved techniques of fish management and with continuous harvesting, it has been possible to raise marketable fish even under high stocking densities increasing the overall production manifold. Recent advances have shown that reconditioning and reuse of water permits very heavy stocking and with intensive feeding offers great scope for further increasing pond fish production.

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Chapter 11

Principles of Selection of Enterprises for Multi-Enterprise Farm

N. Ravisankar and A.S. Panwar

Multi-enterprise farms play significant role in maintaining the sustainable soil, livestock and human health. Enterprise means a systematic purposeful activity. The process of producing a particular farm commodity is called a farm enterprise. Small farms particularly in Asia including India usually are multi-enterprise farms and they produce more than one commodity. For example, if a farm produces, rice, vegetables, milk and egg. It has four enterprises. Multi-enterprise farm combines many purposeful farm activities to produce many commodities in time and space dimension using the principles of minimum or no competition and maximum complementarity. Multi-enterprise agriculture system helps to increase productivity and profitability through integrated use of water, nutrient, and energy in small farms. It has the potential to reduce cultivation cost by synergetic recycling of byproducts/ residues of various components within the system and ensure a regular source of income and employment. The multi-enterprise agriculture system adopted on a small piece of land also helps to improve the economic conditions of resource poor farmers and provide better opportunities for employment at farm level by producing 6 Fs (food, feed, fodder, fibre, fuel and fertilizer)

Integrated Farming System constitutes one or few major enterprises gradually aligning with few more complementary and supplementary enterprises, is constantly evolving, and after a stage, the farming system becomes self-contained ('closed system', where the required inputs are generated from within the system), economically remunerative and ecologically sustainable.

WHY MULTI-ENTERPRISE FARM?

Income through arable farming alone is insufficient for bulk of the marginal and small farmers. Activities such as dairy, poultry, fish culture, sericulture, biogas production, edible mushroom cultivation, agro-forestry, agri-horticulture *etc* assumes critical importance in supplementing farm income. It fits well with farm level infrastructure and ensures fuller utilization of byproducts. Enterprise diversification is one of the most commonly used risk management strategies by growers. A farm manager is often confronted with the problems as to what enterprises to select and

the level at which each enterprises should be taken up. How far he can go or should go in combining enterprises with another depends partly on the interrelationships between different enterprises and the inputs and output generated.

CONCEPT

The multi-enterprise farms uses two dimensions *viz.*, time and space for improving the number of commodities or activities in the farm. Time concept relates to increasing crop/other enterprise intensification in a situation where there is no constraints for inputs including irrigation. In other words increasing the cropping intensity in areas where the production potential *viz.*, land is underutilized even with full resources potential. It is a time bound programme for most of the field crops. It is considered for 365 days or 12 months. In case of long duration crop and perennial crop, the duration of each rotation will vary from 2-3 years depending upon the duration of constituent crop. The areas where, only one crop (100%), two crops (200%) and three crops (300%) are raised in a year leaving the land fallow for 2-8 months, the cropping intensity has to be increased to 200%, 300% and 400% respectively, well within the same one year. This will provide an opportunity to increase gross cultivable area in a year and will ultimately help to enhance the productivity per unit area per unit time.

In case of rainfed areas where there is no possibility of increasing the intensity of cropping with time, the 'space concept' can be applied. In space concept, crops are arranged in a tier system combining two or more crops with varying field durations as intercrops by suitably modifying the planting method. Building of crops/ other agricultural allied components in a vertical dimension (otherwise called multi-tier system), the land equivalent area can be increased. Thus by making use of these time and space concepts either in irrigated or rainfed areas within a specified time (a year) and unit area of land (a hectare), productivity is sought to be increased by repeated and or intensified cropping and other activities.

ENTERPRISE SELECTION FOR INTEGRATION

The integration should aim for complementary combination of farm enterprises adopting the principles of efficient recycling of farm and animal wastes, minimizing the nutrient losses, maximizing the nutrient self-sufficiency through efficient cropping system and crop rotation. **Integration of farm enterprise in multi-enterprise farm depends on several factors such as:**

1. Soil and climatic features of the selected area
2. Availability of the resources such as land, labor & capital

3. Present level of utilization of resources
4. Economics of proposed multi-enterprise model and credit facilities
5. Market facilities for produced commodities
6. Technological know-how on various enterprises
7. Household demand
8. Institutional infrastructure for integrating the enterprises
9. Managerial skill of farmer/farm manager
10. Social customs prevailing in the locality

The multi-enterprise farm should also fulfill the following principles of sustainable agriculture for its long term sustainability in terms of productivity and profitability:

- Environmental soundness.
- Maintenance of soil health.
- Self sufficiency for resources.
- Promotion of plants and animals diversity.
- Sustainable livelihood.

TYPES OF ENTERPRISES AND INTERACTION IN MULTI-ENTERPRISE FARM

There are five types of enterprise categories found in multi-enterprise farm which are given below:

- Independent enterprises,
- Joint enterprises,
- Supplementary enterprises,
- Complementary enterprises and
- Competitive enterprises.

The interaction among components can be classified into competitive, non-competitive and complementary.

Competitive Interaction: One species may have greater ability to use the limiting factor and will gain at the expense of the other and this is called as competitive

interaction or interference. When one or more growth factors are limiting, the species that is better equipped to use the limiting factor(s) will gain at the expense of the other.

Non-competitive: If the crops are grown in association and the growth of either of the concerned species is not affected, such type of interaction is called non-competitive interaction or interference. It occurs when the resources (growth factors) are present in adequate quantities as a result of which the growth of either of the concerned species is not affected.

Complementary: If one species is able to help the other it is known as complementary interaction. If the component species are able to use the growth factors in different ways (temporal or spatial) or if one species is able to help the other in supply of growth factor (like legumes supplying part of N fixed by symbiosis to non-legumes), it is complementary interaction or interference.

Complementary Enterprises

Livestock is the best complementary enterprise with crops, especially during the adverse years. Installation of bio-gas plant in crop-livestock system will make use of the wastes, at the same time provides the valuable manure and gas for cooking and lighting. In a wetland farm there are greater avenues for fishery, duck farming and buffalo rearing. Utilizing the rice straw, mushroom production can be started. Under irrigated conditions (garden lands), inclusion of sericulture, poultry and piggery along with arable crop production is an accepted practice. The poultry component in this system can make use of the grains produced in the farm as feed. Pigs are the unique components that can be reared with the wastes which are unfit for human consumption. In rainfed farming, sheep and goat rearing form an integral part of the landscape. Sericulture can be introduced in rainfed farming, provided the climatic conditions permit it. Agro-forestry (Silviculture and silvi-horticulture) are the other activities which can be included under dryland conditions. In the integrated system, selection of enterprise should be on the cardinal principle that there should be minimal competition and maximum complementary effect among the enterprises.

EVALUATION OF MULTI-ENTERPRISE FARM

Productivity (Productivity per unit area): The productivity of a component is estimated and compared with the crop component is expressed in terms of equivalent crop yield. Productivity in term of grain yield can be recorded and expressed as kg of grain equivalent yield (GEY), GEY= [Productivity of component/intercrop (kg) x

Cost of component/intercrop (Rs/kg)]/ Cost of main crop (Rs/kg)

Economic analysis: Parameters like cost of cultivation/production, gross and net return and per day return can be worked out and expressed as Rs/ha.

Employment generation: Labour required for various activities in crop production given as man days/ha/year (A man working for 8 hours in a day is considered as one man day; A woman working for the same period is treated as 2/3 man day and computed to man days).

PLANNING FOR MULTI-ENTERPRISE FARM

Careful evaluation of potential for each of the enterprises needs to be done by systematically comparing the resource needs for each enterprise to the resources available. Determining the resource requirements for each enterprise will probably require a good deal of homework. Physical, financial, management and marketing factors play a greater role and these questions needs to be put and answered by a manager for planning and starting a multi-enterprise farm.

Enterprise Compatibility Analysis

Before making any final decisions, one must consider the relationships among enterprises. For example, one may have enough labour to produce one enterprise as long as you don't also select another labour intensive enterprise. Obviously, the timing of the resource requirement can be as critical as the amount of the resource required. A monthly chart of resource needs for each enterprise may be helpful. There are several advantages to having several enterprises within one farm business. First of all, it reduces the risk. The chances of production failure and/or poor prices are lower when spread out over several commodities. Cash flow and profit will probably be less variable from year to year in a diversified operation.

Next, diversification done correctly will mean spreading fixed costs out over more commodities. It will also mean using resources more evenly throughout the year. Finally, crop rotation and crop mix done properly have been shown to be effective methods of pest control and increasing soil fertility. These production practices include such things as inter-cropping, cover crops and green manure crops. Enterprise selection for a farm should not be any simpler than a major decision for any business.

EXAMPLE OF MULTI-ENTERPRISE FARM

Coconut based Self Sustainable multi-enterprise farm (developed at ICAR-CIARI, Port Blair) :

Requirement of land

1.	Land allotted to pig shed, vermi-compost unit and common uses of storage godown	250 m^2
2.	Area under Coconut plantations Tapioca intercropping in coconut Colacasia intercropping in coconut	9288 m^2 4240 m^2 3000 m^2
3.	Area under lined pond (for irrigation and fish rearing along with poultry+ducks)	378 m^2
4.	Area under lined pond for tilapia + fish culture	84 m^2

A. Crop production

a) Crops and crop sequences to be followed and area allotted under different sequences

Crop sequence	**Area (Net) allotted (m^2)**
1. Coconut (Sole)	2048
2. Coconut + nutmeg , clove +Colacasia + Pineapple	3000
3. Coconut+ nutmeg, clove + Tapioca + Colacasia	4240
Total	**9288**

b) Average expected annual production and income from crop production

Farm produce	**Gross area**	**% of total**	**Expected annual production**	**Gross returns (Rs./year)**
Crop production (Net area = 9288 m^2)	-	92.8	-	-
i) Coconut (for pigs + house hold + sale)	9288 m^2	34.6	5250 nuts	42000
ii) Nutmeg	3620 m^2 (45 plants)	13.5	3801 nuts	11403
	3620 m^2 (101 plants)			
iii) Clove	3000 m^2 4240 m^2	13.5	25 kg	3750
iv) Pine apple	3000 m^2	11.2	19500 kg	97500
v) Tapioca (for pigs)		15.8	10600 kg	31800
vi) Colacasia (for pigs)		18.9	7240 kg	7240
Total A	26768 m^2	-	-	193693

B. Pig for meat purpose

Expected production from the pig unit (4 pigs (1 male + 3 female))

a) Meat

Four pigs with Av. Meat yield of 56 kg/pig @ 75 % of body weight (75 kg)= 224 kg

Total meat production per year = 224 kg

Total value of meat = 224 kg x Rs.150/kg = Rs.33600/-

b) Pig dung

Total production of Pig dung = 0.876 t

Total value of cow dung = 0.876 ton x Rs.1000/ton = Rs.876/-

c) Sale of piglets

14 piglets /year/pig for 4 pigs, 42 pigs sold @ Rs.800/ each = Rs.33600/-

Gross income from dairy:

Rs.33600 + Rs.800 + Rs.33600 = Rs.68000/-

C. Fish + poultry + duck

a) Area under pond: 378 m^2

b) Fish species **:** Catla, rohu, mirgal

c) Average production and expected income from the pond

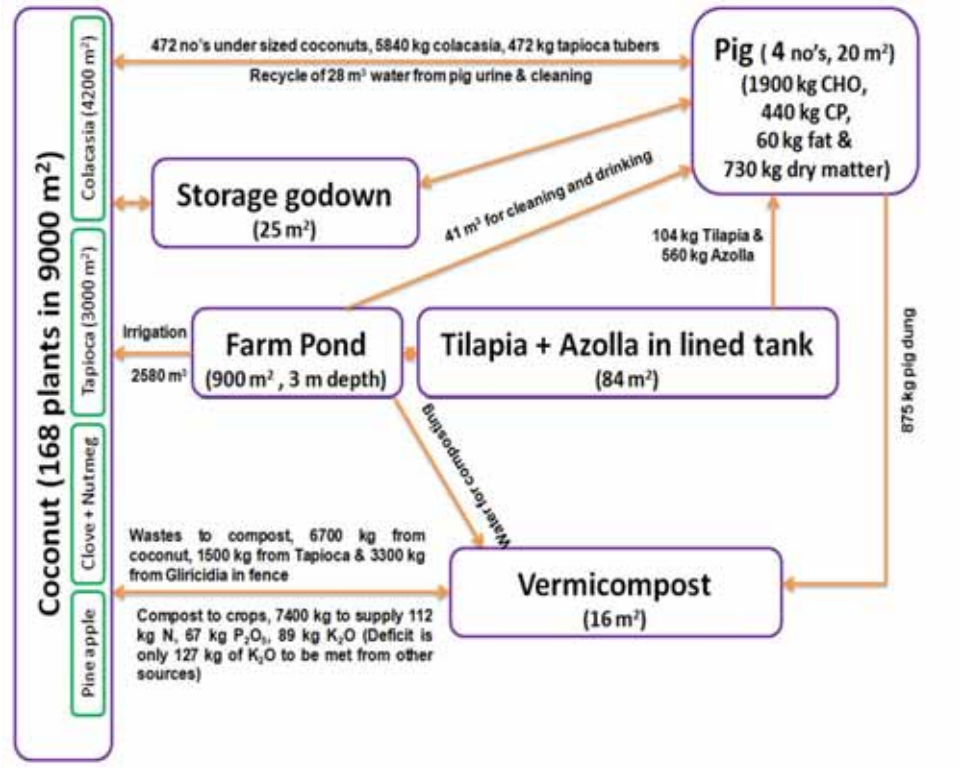
Fruits	Number / area	Productivity (kg/unit)	Production (kg)	Market whole sale price Rs. /kg	Total produce Value (Rs.)
i) Fish	378	2000/ha	756	50	37800
ii) Poultry	25	85/bird	2125	2	4250
iii) Ducks	20	20/bird	400	5	2000
Total A	**-**	**-**	**380**		**44050**

D. Azolla + Tilapia in pond

Azolla and Tilapia is a good protein source for Pigs. The total requirement of protein for 4 pigs can be met by using the azolla, tilapia, waste coconuts and colacasia. Around 50 kg of tilapia and azolla can be produced from the lined pond having the area of 84 m^2. The value of tilapia and azolla produced worth Rs 5000/-.

E. Vermicompost unit

The waste materials of plantations like coconut, nutmeg, gliricidia on the fence and pig wastes and urine can be converted as vermicompost. Around 7500 kg of vermicompost worth Rs 30000/= can be produced.



Flow of inputs and outputs in coconut based multi-enterprise farm

LIVELIHOOD SECURITY UNDER MULTI-ENTERPRISE FARM

The production potential of different farm components integrated into an IFS model and their impact on livelihood security of normal-size farm family of small and marginal category is summarized in table below.

Farm produce	Gross area, m^2/ Unit size	% of total	Expected annual production (kg)	Estimated requirements of a Family (7 members) (kg)	Value of household consumption (Rs.)	Surplus for sale (kg)	Gross value of surplus (Rs.)
A. Crop production							
Coconut (for pigs + house hold + sale)	9288 m^2	34.6	5250 nuts	500 nuts	4000	750 nuts	38000
ii) Nutmeg	3620 m^2 (45 plants)	13.5	3801 nuts	100 nuts	300	3701 nuts	11103
iii) Clove	3620 m^2 (101 plants)	13.5	25 kg	0.5 kg	75	24.5 kg	3675
iv) Pine apple	3000 m^2	11.2	19500 kg	250 kg	1250	19250 kg	96250
v) Tapioca (for pigs)	4240 m^2	15.8	10600 kg	10600 kg*	31800	Negligible	-
vi) Colacasia (for pigs)	3000 m	18.9	7240 kg	7240 kg*	72404	Negligible	-
Total A	26768 m^2	-	-		44665		149028
B. Pig unit Pigs	4 pigs	-	224	12	1800	212	31800
C. Fish + Poultry + duck							
Fish	378	-	756 kg	150 kg	7500	606 kg	30300
Poultry	25	-	2125 no's	1525 no's	3050	600 no's	1200
Duck	20	-	400 no's	200 no's	1000	200 no's	1000
D Azolla + Tilapia	84 m^2	-	50 kg	50 kg	5000	-	-
E. Composting							
Vermicompost	100 m^2	1.00	7500	7500	30000	-	-
G. Land for common uses such as; Animal sheds, stores and dwelling unit	150 m^2	1.50	-	-	-	-	-
Total							213328

Chapter 12

Optimization of Resource Use and Income Generation in Integrated Farming Systems

A.K. Prusty

In India, Agriculture and allied sector provides livelihood support to about two third of the population and still continues to be the main stay employing and feeding most of the rural masses. It is not only the main source of employment, income and food for over 70 percent of the population but also the main culture of the rural families. In the context of ever increasing human population, increase in demand for foodgrains and natural resources, shrinking land mass, conversion of cultivable land into non-agricultural purpose, change in ecological environment, less availability and high cost of labour etc. No single farm enterprise is likely to support the farmers for generation of adequate income and gainful employment year round (Mahapatra, 1994). A judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming. Farmers take decisions as to field, crop and livestock management given their access to knowledge and information, personal circumstances, and in the context of the broader socioeconomic, institutional and political environment. For achieving sustainability in agriculture and enhancing income in addition to management of resource for current as well as future use, optimization of resource-use is the need of the hour. Integrated farming systems as a powerful tool for management of natural resources is a viable option to achieve this goal.

Traditionally, farmers depend on traditional methods, such as, instinct and experience, and comparisons with neighbors in order to make decisions about which commodities to produce and in what quantities. This does not guarantee optimal crop patterns (Alsheikh and Ahmed, 2002). The research in integrated farming systems (IFS) for the last few decades in India has revealed that the enterprise planning and implementation are usually done in isolation with component approach, and needs scientific and systematic approach. In this situation, optimization techniques are useful for resource allocation and designing IFS on scientific basis. Farming systems studies involving a number of enterprises and taking the physical, socio-economic and bio-physical environments into consideration are complicated, expensive and time-consuming. There exists a chain of interactions among the components within the farming systems, and it becomes difficult to deal with such inter-linking complex systems manually. This problem could be overcome by

construction and application of suitable whole farm models. Optimization techniques, such as linear programming and compromise programming, fuzzy linear programming, etc. are useful tools for efficient resource allocation under various constraints.

COMPUTERIZED OPTIMIZATION TECHNIQUES

Though farmers try to maximise their annual net farm return (gross margin) they also worry about the risk in farming. Farmers combine different activities by considering the risk-return trade-off among different farm enterprises. They try to choose the combination based on their past experience, asset position, entrepreneurship etc. Farmers often like to stabilise their farm income or minimise the income variability. However, it is difficult to take into consideration different activities and constraints in a complex scenario of multi-enterprise integrated farming systems manually for optimization of resources and risk minimization. Thus, computerization of optimization techniques is essential to make the results more relevant and useful. Optimization models optimize the use of farm resources, costs/ profits or determine the optimum requirements for specific farm income, and can analyze farm response to policy change in an effective way. Computer programs are widely available for standard Linear Programming (LP) and other more sophisticated types of mathematical programming e.g., Lindo Systems Inc. (1994). Computerization of optimization techniques the advantages of ease and quickness of computation as well as the avoidance of calculation errors with large number of possible activities and constraints.

MODELLING TECHNIQUE

Modelling techniques are classified into three major categories: dynamic simulation, mathematical programming (MP), and multi-agent models. This is a very simple categorisation, and many models actually use combinations of these techniques.

The first category is (dynamic) simulation models. These models make use of ordinary or partial differential equations or difference equations to calculate the behaviour of systems in space and time (Leffelaar 1999). This category represents a wide and large group of models that can simulate the behaviour of a system in time and space. Typically they represent decision-making through parameter settings or what-if rules in the model.

The second category is optimization models, which in their simple form are systems of equations aimed at characterizing farm-level activities in relation to farm production, investment, marketing, etc. These types of models are based on the specification of behavioural assumptions (e.g. profit maximization). Programming

models (e.g. linear or multiple goal linear programming models) can be used to solve the problem of optimal resource allocations subject to constraints. (Non-) Linear programming (LP) represents the farm as a (non) linear combination of so-called 'activities'. An activity is a coherent set of operations with corresponding inputs and outputs. An activity is characterised by a set of (technical) coefficients that quantify the relationships between activities and certain defined goals or objectives (Ten Berge et al. 2000). As inputs are limited resources, constraints (i.e. minimum and maximum values) to the activities are defined. This system of activities is optimised within the limits of the constraints for a user-specified goal, such as profit. Standard mathematical formulations of different types of optimization models can be found in (Hazell and Norton 1986).

The third category is multi-agent modelling techniques, i.e. modelling approaches in which families, farmers or household members are represented as an individual entity (agents) explicitly taking into account interactions between these entities. Often in terms of modelling technique, they make use of the same approaches as dynamic simulation models, but whereas those models typically focus on one household or an average representation of a population of households, agent based models represent multiple instances of individual households in their models, together with their interactions.

LINEAR PROGRAMMING

Linear programming is a technique used to solve planning problems mathematically using the Simplex algorithm. To apply this technique, the problem must be defined in terms of an objective function to be maximised (or minimised); a set of activities that may be undertaken; and a set of constraints that have to be satisfied relating resources available to resources required (Dent, Harrison and Woodford, 1986; Pannell (1997). The LP approach is the most common method of optimising whole-farm plans from which to examine the benefits of a new technology within the whole farm context (Hardaker, Huirne and Anderson, 1997). As a whole-farm model, linear programming can examine the different farm activities within the context of various physical, financial and labour constraints. A detailed knowledge of feasible or realistic technical ratios and biological relationships is required to properly specify these constraints. By optimising a specified objective function, the LP method can attempt to replicate how a farm manager decides to what extent a new technology is adopted on the farm. The objective function might be to maximise total farm gross margin or some other objective, subject to a lifestyle constraint such as an upper limit on the use of family labour.

Limitations of the LP methodology for the evaluation of new technologies at the farm-level include its relative complexity and the greater amount of information

required to properly model the underlying biological processes, compared to the previously described techniques. Other limitations relate to some of the basic assumptions of LP that inputs and outputs are divisible, the relationship between variables is linear the combined effect of inputs and outputs is additive and inputs and outputs are constrained to be positive (Pannell, 1997).

MULTI-OBJECTIVE PROGRAMMING

Traditional linear programming (LP) approach to the modeling of agricultural decisions rests on certain basic assumptions about the situation being modeled and the decision maker seeks to optimize a well-defined single objective. In reality this is not the case, as the decision maker is usually seeking an efficient compromise amongst several objectives, many of which can be in conflict, or trying to achieve satisfying levels of his goals. Multi-objective programming (MOP) or vector optimization technique tackles simultaneous optimization of several objectives subject to a set of constraints usually linear. Since an optimization solution cannot be defined for several objectives, MOP used in obtaining the set of feasible solution which are efficient (Pareto optimal) solutions rather than to locate the single optimum solution. The elements of this efficient set are feasible solution such that there are no other feasible solutions that can achieve the same or better performance for all the objectives and strictly better for at least one objective (Romero and Rehman, 1984).

RECENT DEVELOPMENTS

Major developments are taking place especially in the implementation of decision-making in the models. First, approaches are being developed to make the constraints and options within the optimization models more flexible, thereby giving the system the possibility to develop over time, depending on internal or external conditions. Different modelling techniques can deal with different aspects related to the consequences of global change for farm households: combining different techniques into a single modelling framework seems therefore, a logical choice and is actually taking place in many new farm-level modelling studies. A variety of quantitative and qualitative design approaches have been developed to support the analysis of current farming systems, and the design and evaluation of alternatives. One such model is Farm DESIGN model developed by Wageningen Univeristy, The Netherlands. Farm DESIGN can serve as an exploratory tool to generate alternative management options in search of improved farm performance. Several recent research efforts have demonstrated the usefulness of integrated simulation models to aid the (re)design of sustainable farming systems by means of exploratory studies that look for ways of balancing crop-livestock interactions to improve resource use

efficiencies at farm scale (Dogliotti *et al.*, 2005, Groot *et al.*, 2007, Rossing *et al.*, 2007 and Tittonell *et al.*, 2007). The inputs and outputs of Farm DESIGN are used in three ways in the exploratory procedure, namely:

a. **Decision variables:** The inputs that are adjusted in the exploration procedure, for example, crop areas, feed inputs, herd composition and other management parameters are included as decision variables

b. **Objectives** those are either minimized or maximized: Selected outputs such as productivity and profitability (economic result), erosion, organic matter and N, P and K balances (aspects of environmental sustainability) and labour input and seasonality (aspects of social sustainability).

c. **Constraints:** Limitations to combinations of inputs that are infeasible (e.g. summed area of crops should not exceed the total farm area, labour requirement should be lower than or equal to availability) and to outputs that are undesirable, for instance unacceptable nutrient losses, unbalanced feed rations (aspects of animal welfare) and violation of regulations (adhering to organic farming principles).

The model supports iterative cycles of learning and adaptation of the structure of a mixed farm. Learning cycles are typically divided into a number of phases (Kolb, 1983), and the model contains different windows and calculation procedures for these subsequent phases. In the Farm DESIGN model we largely follow the terminology of Giller *et al.* (2008), who proposed the Describe – Explain – Explore – Design cycle (DEED) for innovation in interactive processes with stakeholders. Here we introduce an extra step and define the steps in this cycle as follows:

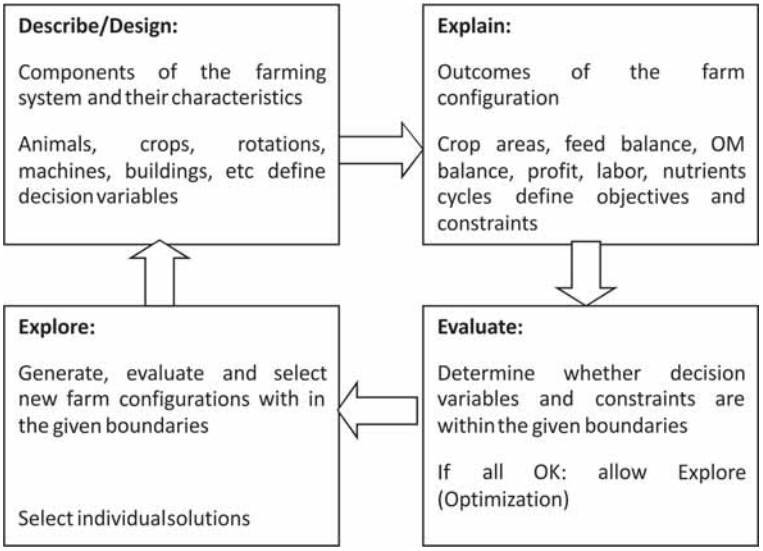
'**Describe**': make an overview of the components of the system, in Farm DESIGN a mixed farm.

'**Explain**': determine the results of the farming systems in terms of agronomic, environmental and economic indicators.

'**Evaluate**': establish whether the results obtained in the explain phase are in line with the objectives and constraints that are set for the farm.

'**Explore**': generate new options for farming system structure in a multi-objective optimization procedure.

'**Design**': A new configuration of the farm is selected from the set of solutions generated in the explore phase, after detailed examination of the consequences. This is the starting point for further fine-tuning and a new learning cycle.



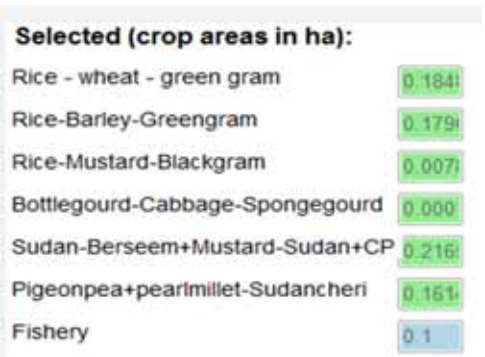
Economics of existing farm

Enterprise	Gross Return (Rs.)	Cost (Rs.)	Net Return (Rs.)
Crop	149282	58843	90439
Livestock	408800	161037	247763
Fishery	44895	9262	35633
Total	602977	229142	373835

ALTERNATIVE FARM OPTIONS AFTER OPTIMIZATION OF THE EXISTING FARM USING FARM DESIGN

Land Allocation (Optimized farm) within defined constraints such as fixed area for fish pond as well as objective of profit maximization:

- **IFs Model Area : 0.9 ha**
- **Crop (0.80 ha)**
- **Livestock : 5 Cows**
- **Fishery: 0.1 ha**



Economics of optimized farm

Enterprise	Gross Return (Rs.)	Cost (Rs.)	Net Return (Rs.)
Crop	149282	58843	90439
Livestock	408800	161037	247763
Fishery	44895	9262	35633
Total	753379	231643	521736

CONCLUSION

Mathematical Programming techniques seem to be the most powerful approach to represent farm level decision-making in enhancing resource use efficiency and increasing farmers income by judicious mix of different enterprises based on science based evidences: They are grounded in economic theory and are the only technique that can deal with the many options available to the model 'farmer' to make a decision. In combination with dynamic simulation models and agent based models, consequences of climate change for production and greenhouse gas emissions can be evaluated and fed back into the optimization program to affect decision-making, although this assumes that "real" decision-making objectives can be appropriately encoded in model objectives. The modeling that involves multiple objectives is useful in farming systems research and extension and will more accurately evaluate the extent of adoption of a new technology within a farm system by more closely matching the farmer's decision-making priorities.

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Chapter 13

Technologies of On-farm Storage and Phyto-Sanitation

Amit Nath

Grain production has been steadily increasing with advancement in production technology, but improper storage results in high losses. According to World Bank Report, post-harvest losses in India amount to 12 to 16 million metric tonnes of food grains each year, an amount that the World Bank stipulates could feed one-third of India's poor (Chaturvedi and Raj, 2015). The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010). In India about 263.2 million MT (in 2013-14) of food grains are produced annually (Chaturvedi and Raj, 2015) and out of which 60-70 per cent are stored by the farmers for their own consumption. The Indian farmers prefer to store their food grains in traditional ways using diverse types of storage structures made by locally accessible materials. While big farmers keep food grains in the storage facilities provided by government agencies like Food Corporation of India and also in the private cold storage and ware houses.

For scientific storage of agricultural produce cleaning, grading, shelling, decortications and drying to safe moisture levels i.e. 10-12 per cent in case of cereals, 8-10 per cent in case of pulses and 6-8 per cent in case of oilseeds are important. A number of useful equipments for such unit operations are available that need to be commercialized and extended to targeted beneficiaries. Scientific storage-room, warehouses storage bins, or even Cover and Plinth (CAP) storage capacity for growers are available enabling them to earn 25-50 per cent more net returns.

On farm storage is also required to reduce losses in highly perishable fresh horticultural produce. Low-cost, low-energy, environmental friendly cool chambers made from locally available materials and which utilize the principles of evaporative cooling have been therefore developed in response to this problem. These cool chambers are able to maintain temperatures at 10–15°C below ambient, as well as at a relative humidity of 90 per cent, depending on the season. Fruits and vegetables are stored in plastic crates within the chamber. The shelf life of the fruit and vegetables maintained in the cool chamber was reported to be increased from 3 days at room temperature to 90 days (Anon. 2006).

There are several factors which are responsible for losses of food grains such as environmental factors, type of storage structure used, length and purpose of storage, method of storing grains, etc. The environmental factors consist of

temperature, moisture content of grains, pH, humidity, etc. Other biological factors are insects - pests, microorganisms and rodents. During storage, significant qualitative and quantitative losses occur due to those biological factors. There are various newly developed storage structures, advance methods of storage, advances in insects and pests controls and various grain protecting practices are the latest technologists for on farm storage practices in India.

ADVANCES IN GRAIN STORAGE STRUCTURES

The percentage of overall food crop production retained at the farm-level and the period of storage is largely a function of farm-size and yield per acre, family-size, consumption pattern, marketing pattern, form of labour payment, credit availability and future crop expectations (Greeley, 1978). Indigenous storage structures are generally preferred by the farmers in India at home level. The traditional storage structures (Fig. 1) have several disadvantages and limitations. Hence, the some modifications have been done in the traditional grain storage structures to offer better safety to the stored grains. For small-scale storage of grains the PAU bin, Pusa bin, Coal-Tar drum bin and Domestic Hapur tekka are generally used.

Fig. 1. Traditional seed storage structures

The name PAU bin, itself suggest that the bin has been developed by the Punjab Agricultural University. The bin is made up of a galvanized metal iron structure. The bin has moderate capacity varying from 1.5 to 15 quintals. The Pusa bin is also called as LDPE (low density polyethylene) sandwiched bin. This means that the storage structure is made of mud or bricks with a polythene film embedded within the walls like a sandwich. The developed bin has minimal moisture migration during storage because of the good insulating properties of LDPE. The coal-tar drum bin (200 kg) was developed at Central Institute of Agricultural Engineering (CIAE), Bhopal. It is a low cost bin and can be easily available at domestic level. The domestic Hapur tekka or bin has capacity 200 to 1000 kg. It is cylindrical in shape, made of galvanized iron and /or aluminum sheet, has a small hole in the bottom through which grain can be removed.

In addition to small scale storage, there are structures for large scale storage of food grains. Several agencies are having storage facilities for farmer on rental basis like Food Corporation of India, Central Warehousing Corporation, State Warehousing Corporation, grain marketing co-operatives and several state government agencies. The large scale grain storage is also done in Cover and Plinth (CAP) and silos.

CAP storage involves the construction of brick pillars to a height of 142 from the ground, with grooves into which wooden crates are fixed for the stacking of bags of food grains. The stacks are covered with 250 micron LDPE sheets from the top and all four sides (Fig.2). Food grains such as wheet, maize, gram, paddy, and sorghum are generally stored in CAP storage for 6-12 month periods. It is the most economical storage structure and is being widely used by the FCI for bagged grains. The structure can be fabricated in less than 3 weeks. It is an economical way of storage on a large scale (India Agronet, 2009).

Fig. 2. Cover and Plinth (CAP) Storage Structure for paddy and wheat

The silos are either metal or concrete. Concrete silos are typically cheaper than metal silos. In silos the grains in bulk are unloaded on the conveyor belts and, through mechanical operations, are carried to the storage structure (Fig. 3 & 4). Galvanized silo storage systems have been a proven scientific system for storage of food grains in Europe and America. This system ensures zero wastage due to moisture, fungus and rodents etc. In India this system is adopted to some extent by private sector since 1990, but it is limited to the process industry rather than for storage of grain for longer period. The storage capacity of each of these silos is around 25,000 tonnes.

Fig. 3. Steel silos for maize storage with flat bottom

Fig. 4. Australia's on farm grain silos that can be found typically across the wheat belt

ADVANCED STORAGE METHODS

Grain Aeration

Aeration is widely used for preservation of stored grain. Aeration can be defined as the forced movement of ambient air of suitable quality through a grain bulk for improvement of grain storability. It is an acceptable practice to reduce the commodity temperature and is done by using mechanical aeration by means of fans. This system is suitable for low humid environment. On commercial scale, forced aeration plays important and effective role to preserve grains (Navarro and Noyes, 2002).

Refrigerated Storage

In this method, ambient air is cooled and then passed over the bulk grains via existing aeration system. Refrigerated aeration has been used for cooling dry grain in subtropical climates when ambient temperatures are too high. The initial investment for refrigerated storage system is comparatively higher, but together with the dehumidified air method, it could provide answers to the practicability of aeration for safe commercial storage in tropical climates (Navarro and Noyes, 2002).

Hermetic Storage

An airtight or sealed storage is termed as "hermetic storage" or "sacrificial sealed storage". The method enables insects and other aerobic organisms in the commodity or the commodity itself to generate the modified atmosphere by reducing oxygen (O_2) and increasing carbon dioxide (CO_2) concentrations through respiratory metabolism. Respiration activity of the living organisms creates an atmosphere containing about 1-2 per cent oxygen and about 20 per cent carbon dioxide (White and Jayas, 2003).

Insect control success due to the hermetic storage treatments is comparable to conventional fumigants (over 99.9% kill), and losses due to insect activity are minimal (0.15% loss in weight for a storage period of 15 months) (Navarro *et al.*, 1984; Varnava, 2002). Low O_2 and high CO_2 environment kills insect and mite pests, and prevents aerobic fungi from growing (Weinberg *et al.*, 2008). Elevated CO_2 and depleted O_2 levels will generally maintain stored grain quality for long period of time. Commodities including cereals, oilseed grains, pulses, cocoa and coffee can be stored safely for many months, maintaining high quality and limiting moulds and myco-toxins.

ADVANCES IN PEST MANAGEMENT SYSTEMS

Usually chemical fumigants, contact insecticides are used to control stored product pests. Increase awareness about health issues due to organic residues in food grains has enforced restrictions on use of chemical pesticides because of adverse effects of pesticide residues in grain and environment. This has resulted in imposition of strict limitations on pesticide registration by regulatory agencies. In addition, in many countries, insects in particular have been developing resistance to contact insecticides and to the conventionally used phosphine gas. Birational approach is being preferred over the conventional practice to tackle these issues.

The major pests of stored grains include beetles (*Callosobrunchus sp, Trogoderma granarium*, *Tribolium confusum*), weevils (*Acanthoscel idesobtectus*), moth (*Corcyra cephalonica*) and rodents. The preventive and curative are the two categories of treatments applied for controlling insect and pest infestation. The preventive treatment is that which is given before infestation in order to inhibit insect attack. The curative treatment involves use of fumigant aluminium phosphide to control infested stock or godown in airtight condition. For controlling rodents rat cages, poison baits and use of rat borrow fumigation is recommended (India Agronet, 2009).

A variety of traps developed with synthetic pheromones has been developed for use in monitoring programmes in food processing and storage facilities. The pheromone is incorporated into a plastic matrix from which it is slowly released during several weeks or months. Grain probe trap or pitfall-cone trap, are placed at or below the surface of grain masses and do not require the use of pheromones. These traps capture beetles that are simply walking through the holes of the probe shaft, drop through the void inside the probe and are directed by a funnel into a collection vial.

A recently developed technology for monitoring insects is a probe trap equipped with an electronic device to count insects that relay the counts to a computer (Shuman

et al., 1996). Probe traps installed in shelled and unshelled peanuts in a pilot plant experiment indicated no significant differences in the presence of *Tribolium castaneum* aggregation pheromone attractants in the probes. Phillips *et al.* (2000) found evidence suggesting that pheromones and food attractants should not be used in devices intended for monitoring insects in bulk-stored grain. A special device containing a heater and a ventilator named "speedbox" (Jakob *et al.*, 2006) that was developed especially for use at low temperatures and shorter treatment time, allowed optimizing the Phosphine fumigation by effective control of all developmental stages of major stored product insects at low temperatures and at decreased exposure time.

Some essential oils are highly selective to insects, probably because they bind to the insect-selective octopaminergic receptor, a non mammalian target (Kostyukovsky *et al.*, 2002). A screening of a large number of essential oils from aromatic plants was conducted to isolate effective oils for using as fumigants in grain bins for insect control.

Hygienic Practices

Hygiene of storage environment is major factor which contribute to growth of the insect and pests infestation. Sanitation in and around stored grain installations is the almost efficacious and profitable administration exercise to prevent insect infestations in stored grain. This is the most essential IPM practice for storing and protecting grain because a successful sanitation is 80 percent of an effective IPM program in stored grains. Before harvest and storage of new grain, cleaning equipments for handling grain like harvesters, vehicles, aeration fans, etc. is required. Taking off any grain or grain dust from inside the bins by cleaning empty bins and brushing down walls is essential. Getting rid of any spillage grain close to the external of the bin and storage installation is requisite. Cautiously examining storage bins and fastening or sealing of any gaps or openings which may be expected entry spots for rodents or insects is requisite.

Spinosad as a Natural Grain Protectant

Spinosad is a reduced-risk insecticide derived by fermentation from the soil actinomycete, *Saccharopolyspora spinosa* (Mertz and Yao, 1993). The spinosad is growing as a grain protectant, awaiting final acceptance by major grain importing and exporting countries (Nayak *et al.*, 2005). Spinosad effectively controls economically important beetle and moth pests associated with stored grain and is also effective against certain coccid species. On all other economically important species of beetles and moth pests associated with grain, spinosad is effective at 1 mg/kg in killing adults and/or preventing population growth (Getchell, 2006).

PHYTO-SANITATION

Increasing outbreaks of food borne illness alongside consumer concerns over interregional disease transmission have driven the development of more stringent laws and regulatory frameworks. Major importing countries are tightening their food safety legislation and demanding the adoption by exporting countries of agreed inspection, examination and certification procedures. New regulations with regard to quality control, such as the Hazard Analysis Critical Control Point (HACCP), have been adopted by all major importing countries (except Japan), and have been made compulsory for their food processing industries. In terms of impacts on developing countries, the regulations based on HACCP shift the burden of responsibility to exporting processor or trader, by making them fully responsible for the quality of the product in terms of food safety.

Safe food is one which has minimum pesticide residues, metals and other contaminants and is practically safe in the hands of consumer without any harmful effects. There have been many instances when commodities exported by India have been rejected by importing countries. Recent examples are concerns of EU regarding high pesticide residue levels in grapes during 2004-05 and rejection of sesamum exports by Russia due to poor quality. Thus, strict monitoring from production to transport, processing, handling, packing, etc. is absolutely necessary encompassing the entire food chain.

With the reduction of tariff barriers, there is a possible danger that alternative forms of protection will be utilized, including arbitrary technical barriers as well as sanitary and phytosanitary measures. The Uruguay Round Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical Barriers to Trade (TBT) adopted by WTO Members in 1995 have given a new direction to the international food trade. Among technical regulations and standards, sanitary and phytosanitary (SPS) regulations occupy a particularly relevant place in the regulators' agenda, because of their primary aim of protecting citizens from everyday food hazards. This has become a virtual minefield for trade policy-makers as national differences in risk perceptions and tolerance can be manipulated or exploited to protect domestic industry from international competition (Hooker and Caswell, 1999).

The SPS Agreement attempts to address the application of measures associated with the protection of human, animal and plant health in such a way that they are not a disguised restriction on international trade, so to prevent such measures from being used as unjustified trade barriers. There are several key principles including the sovereign right of a country to put protective measures in place, but these measures should not be more restrictive than necessary to achieve the appropriate

level of protection. The Agreement stresses that not only should SPS measures be scientifically based but also stresses the importance of risk assessment in determining the appropriate levels of SPS measures. Of crucial importance are transparency in the development and implementation of measures and the adoption of international standards.

Phytosanitary certificate means a certificate issued in the model format prescribed under the International Plant Protection Convention of the Food & Agricultural Organization and issued by an authorized officer at the country of origin of consignment or re-export (Anon. 2003). It certifies that the plants or plant products have been inspected according to appropriate procedures and are considered to be free from quarantine pests/diseases and practically free from the injurious pests/diseases and that they are considered to conform to the current phytosanitary regulations at the importing country.

The vegetables & fruits from India can be exported to the European Union countries based on the phytosanitary inspection at the pack houses approved jointly by National Plant Protection Organization (NPPO) /APEDA where adequate facilities for inspection, examination etc. are available and the produce is packed under the supervision of plant quarantine official (Anon. 2015). Phytosanitary status of the inspected consignments will be secured by proper storage in demarcated quarantine area at the pack house, transported by clean & disinfested vehicles. Also, loading of the consignment at exit point will be ensured in clean and disinfested cargo containers preventing cross contamination (Anon. 2015).

Irradiation as a phytosanitary treatment has gained increasing acceptance in recent years, and the application of irradiation to control arthropods in fresh commodities, stored products and ornamentals has grown. Irradiation is an accepted quarantine treatment to control fruit flies in ten fruits and four vegetables and the mango seed weevil in mangoes. Irradiation has several major advantages over other post harvest treatments. Whereas development of heat, cold and fumigation treatments involves generating data for each fruit pest combination, irradiation treatments are developed for a pest species irrespective of commodity.

CONCLUSION

India produces about 263.2 million MT of food grain annually, but the post production losses are also high. Major stock is stored at farmers' level (70%) and remaining at organizational level. The advancement in scientific design and development of low cost storage structures has been found effective as it has created interest and awareness among farmers and traders to preserve the food grains safety. The modified and improved structures provide safe and economical means of grain storage for long durations. Need of the hour is to strengthen traditional

means of storage with modern inputs and to provide cheaper storage structures such as low cost bins to farmers so as prevent enormous storage losses. With the chemical insecticides being phased out due to their residual effect on human health; the need for the hour is to maintain hygienic practice in the storage systems. Maintenance of CA or hermetic storage environment for the control of insect growth is also very effective and is possible for bulk storage system. Precision monitoring system of insect population and application of control dose of insecticides are few such measures for ensuring grain safety and security. Sanitary and phytosanitary measures and phytosanitary certificates are becoming very essential for export of any agricultural products and also processed food products from our country.

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Chapter 14

Contingency Planning in Crop Management under Abiotic Stress

Mohammad Shamim

A contingency plan is a plan devised for an outcome other than in the usual (expected) plan. Agriculture is highly susceptible to the extreme weather events and a prolonged undesirable weather have potential to cause severe damage to the crops standing in the field. Any significant deviation (either positive or negative) from the normal is called as weather extreme or climate variability. It is a dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. An extreme weather always causes damage to the agriculture, livestock, poultries, fisheries and other components of the farming systems.

The onset of monsoon in time with good distribution of rainfall are critical for achieving optimum crop yields by farmers, particularly during *Kharif* season along with other factors like inputs, labour and technology. Temperature plays a key role during Rabi season particularly in wheat production. Rainfall during the monsoon season not only determines the success of rainfed crops but also Influences water availability to irrigated agriculture. Any deviation from normal monsoon pattern affects crop production, fodder availability to livestock and causes huge losses to farmers. Whenever, significant negative departure occurred in the South-West monsoon, such as in the years 2002, 2009, 2012 and 2014, agricultural production during *Kharif* declined significantly (Rao *et. al.*, 2015).

EXTREME WEATHER

An extreme weather event refers to any dangerous meteorological phenomena with the potential to cause serious social disruption, or loss of human life. Extreme weather events are rare in nature and occur only 5 per cent or less of the time. Frequent extreme weather events are the results of the anthropogenic climate change and it is increasing day - by - day towards greater threats for agriculture as well as human life.

Nature of the extreme weather events are primarily defined by the latitude, altitude, topography, and current atmospheric conditions of the location. Actually the duration and the intensity of the extreme weather events are responsible to cause damage of the farming systems including agriculture, livestock, poultry, fisheries

and serious social disruption as well as human casualties. Year to year deviations in the weather and occurrence of climatic extremes results in cold wave, fog, hailstorm, thunderstorm, dust storms, heat wave, intense and excessive rain.

CONTINGENCY MEASURES AGAINST EXTREME WEATHER

Cold Wave

A cold wave is a meteorological phenomenon that is described by drastic fall in temperature within a short period of time over a large area requiring substantially increased protection to agriculture, livestock, poultry, fisheries and social activities. The precise criterion for a cold wave is determined by the rate at which the temperature falls, and the minimum to which it falls. A cold wave can cause death and injury to livestock. Exposure to cold mandates greater caloric intake for all animals. They often necessitate the purchase of foodstuffs at considerable cost to feed livestock. The belief that more deaths are caused by cold weather in comparison to hot weather is true as a result of the after effects of these temperatures (i.e. cold, flu, pneumonia, etc.) all contributing factors to hypothermia.

Besides the livestock, mustard, and horticultural crops like mango, papaya, banana, litchi, pomegranate etc. are worst affected by cold wave. Selection of cold tolerant fruit species /varieties, application of light irrigation, frequent smoking in the orchard and covering young fruit plants with thatches or plastic shelter are the suitable contingency measures to reduce the damage due to aberrant weather.

Fog

Immediately after the onset of western disturbance a lot of moisture is available in the atmosphere and the regional and synoptic scale conditions provide the trigger for the formation of dense fog. Increasing trend in the relative humidity and increased presence of aerosols of particulate matter are most likely causes of poor visibility. Fog is a meteorological phenomenon generally occuring during the winter season. The long foggy weather is alarming situation for the mango producer as flowering gets delayed. The increase in relative humidity during fog results in higher incidence of fungal diseases like late blight in vegetables.

Frost

Atmospheric condition that exists when the temperature of the earth's surface and earth bound objects falls below zero degree (freezing). Frost is mostly experienced in the month of January in northern India. Himachal Pradesh, Punjab, Haryana and Madhya Pradesh are frost prone areas. Suggested measures include preference of frost tolerant varieties, change in planting time to avoid sensitive

stages coinciding with frost periods, adopting shelter belts, shade trees, and use of mulches as ground cover to prevent loss of heat etc.

Thunderstorm, Hailstorm and Dust-storm

Thunderstorm, Hailstorm and Dust storm are not regular weather phenomena but these can be seen occasionally when winter season transforms into spring in northern India. The thunderstorms and squally weather which are very hazardous in nature are responsible for the mechanical abrasions of the fruits and vegetables which deteriorate quality of the farm produce. Generally affected crops are wheat, apple, litchi and other fruit crops. Suggested measures include use of anti-hail guns and anti-hail nets, use of damaged fruits in preparation of processed foods, crop insurance etc.

Heat Stress

Extreme positive departures from the normal maximum temperature result in heat wave during the summer season. India meteorological Department (IMD) has defined heat wave under two categories. The first category includes places where the normal maximum temperature is more than 40°C. In such regions, if the day temperature exceeds by 3 to 4 °C above the normal, it is said to be affected by a heat wave. Similarly, when the day temperature is 5°C or more than the normal, severe heat condition persists.

The second category considers the regions where the normal maximum temperature is 40 °C or less. In these areas, if the day temperature is 5-6°C above the normal, then the place is said to be affected by a moderate heat wave. A severe heat wave condition exists when the day temperature exceeds the normal maximum temperature over the place by 6°C.

A prolonged severe heat stress condition may results into serious problems of water supply, aggravate moisture stress in the soil and adversely affect agriculture. The effect of the heat wave on the crop depends on crop growth stages. Sometimes, intense heat wave followed by late onset of monsoon creates worst and miserable situation because of scarcity of the water for delay in sowing operations. Generally heat stress lasts for 4 to 5 days, but it may go upto 15 days in exceptional cases when onset of monsoon is too late.

Generally, the affected crops due to heat stress are wheat, mustard, rapeseed, linseed and vegetables. Occurrence of heat stress at late reproductive phase or grain filling stage adversely affects wheat production in the country. Re sowing of nursery and providing light and frequent irrigation during nursery stage of basmati rice, mulching in sugarcane crop and making the silage of sorghum fodder at harvest

stage are the suggested contingency measure against heat stress. Shortage of the drinking water for the cattle has negative influence on milk yield. Poultry component of the farming system is very sensitive to both cold as well as heat wave condition and an intensive care is required to safeguard them against the extreme weather conditions.

Drought

Drought is a meteorological phenomenon recurrent in nature resulting from deficit in soil moisture and or water both in rainfed and irrigated areas. There may be various scenarios of the drought in rainfed situation *viz.,* early season drought (delay in onset of monsoon) delays the sowing of the crops and affects the germination and crop establishment phase, mid-season drought (normal onset of monsoon followed by prolonged dry spell during vegetative and reproductive phenophases of the crops) and terminal drought (prolonged dry spell during maturation stages of the crops). Alternate choice of crop/cropping systems, selection of appropriate cultivars, and changes in agronomic management practices are the suitable contingency plans for above abiotic stresses under rainfed situation.

Ensured availability of quality fodder **d**uring sub-optimal monsoon/drought situation becomes a challenge for sustaining the life of the livestocks as availability of green fodder and natural grasses is drastically reduced. Even the supply of crop residue, normally used as maintenance ration, is reduced whereas demand is increased due to lesser supply of green fodder. To ameliorate the situation and to save the animals, utilization of fodder from perennial trees with judicious use of mineral mixture, stored silage and hays etc. are advisable under drought situation.

Unusual Rains (untimely and unseasonal)

Due to climate change, frequency of untimely rainfall with very high intensity has increased which often leads to waterlogging in the field. Heavy rainfall coupled with high speed winds at any growth stage of annual and perennial crops results in serious crop losses, outbreak of pests and diseases and sometimes total crop failure. Besides crops, livestock and poultry sector also suffers due to short supply of quality feed and fodder under heavy rains. Re-sowing of crops (late sown cultivars), providing surface drainage, and application of growth promoters/nutrient sprays to promote quick flowering/ fruiting, plant protection measures against pest/ disease outbreaks with need based prophylactic/curative interventions are required in contingency planning. Post-harvest measures include shifting of produce to safer place for drying, maintaining the quality of grain/fodder and protection against storage pest/ disease damage.

CONCLUSION

An extreme weather always causes damage to the crop, livestock, poultry fishery and other components of the farming systems. Providing forecast about occurrence of these extreme weather events with higher accuracy for block or district level at least 3-5 days ahead may certainly reduce the damage to agriculture. Adoption of suitable contingency measures for specific farm enterprises help in putting check on potential losses due to extreme weather conditions.

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Chapter 15

Economics of Farm Productivity and Profitability

Harbir Singh

Agriculture sector in the country is facing lot of challenges concerning sustainable food production and nutritional security, loss of biodiversity, natural resource degradation and plateauing of productivity growth mainly in green revolution areas. Further, the issues concerning climate change has necessitated a re-look at the development strategy being followed to overcome the challenges. It is widely accepted that the problems of agriculture sector is highly location-specific and those can be addressed better if the problems are viewed from system's perspective through an integrated approach to manage farm resources. Producing more food with limited land and water resources requires continuous raising of productivity. But productivity can not be substantially improved unless one has access to better technologies (seeds, irrigation, fertilizers, farming practices, etc) and better incentive structures (prices and markets).

The adoption of new and improved technologies involve investment which may initially raise the cost of farming. In fact, cost of farming in relation to productivity holds the key to how profitable the farming is or can be. Hence, we need a closer look at different cost concepts and how it is measured. This paper discusses and list out few important concepts, indicators and methods which are useful in measuring farm productivity and profitability in a typical farm operating environment.

FARM MANAGEMENT GOALS

Setting clear goals is one of the key element for good farm management. Goals give a focus for making farm decisions under limited resource conditions. Some important goals may be food security, profit maximization and risk minimization. These and other goals influence planning and decision-making on the farm. A profitable farming requires that the farm produce is produced in an efficient manner and is sold the market on remunerative prices. Farm profitability can be increased by enhancing the scale of production in an efficient manner.

SOME KEY CONCEPTS

It is useful to understand key words and definitions for understanding and analyzing various aspects of a typical farm.

***Factors of production*:** The main factors of production are natural resources (land, water) labour and capital.

***Farm enterprises*:** Farm enterprises can be divided into three types: competitive, supplementary and complementary.

***Cost of production*:** Value of inputs needed to produce crops or livestock. Variable costs apply to a specific enterprise. Fixed costs generally apply to the farm as a whole.

***Opportunity Cost*:** Opportunity cost is defined as the cost of any activity measured in terms of the best alternative activity which is forgone. Let's say you have Rs.10,000 and your choice is to either buy shares of a company or leave the money in a bank account that earns only 5 per cent per year. If the company stock returns 10 per cent, you have benefited from your decision because the alternative would have been less profitable. However, if company stocks returns 2 per cent when you could have had 5 per cent from the bank, then your opportunity cost is (5 per cent - 2 per cent = 3 per cent).

***Shadow Price*:** For an enterprise, a shadow price is the maximum price that management is willing to pay for an extra unit of a given limited resource. If a production line is already operating at its maximum 40-hour limit, the shadow price would be the maximum price the manager would be willing to pay for operating it for an additional hour, based on the benefits he would get from this change.

***Value of production*:** Money received from the sales of produce, added to the value of that consumed or stored.

***Gross profits*:** What an enterprise adds to total farm profits (Gross margin=Value of production – Variable costs).

***Farm profit*:** Money left over after variable and fixed costs are paid.

***Productivity*:** It is the measure of output produced per unit. It is a physical rather than a financial indicator, and usually measured as a relative concept (across farms or over the time)

***Partial productivity*:** A subset of total output measured in relation to a subset of inputs is called a partial productivity measure.

***Technological progress*:** Technical progress is a condition when all farms, in aggregate, move towards a higher production frontier.

***Technical efficiency*:** It measures how efficient one farm is in comparison to the best farm around (local frontier). It is an indicator of maximum output produced with the best combination of resources.

***Economic efficiency*:** It measures the financial returns on resources used and looks at the cost of using resources to produce a given level of output. Low profitability is often traced to poor efficiency in one or more areas of the farm business.

***Profitability*:** It is a measure of the financial performance of farm. It indicates total receipts less total costs. While absolute profitability is a measure of whole farm performance, relative profitability is useful for comparisons between farms with different scales.

***Depreciation*:** It is the reduction in value of an asset over a period of time. A necessary condition for calculating depreciation on an asset is that the asset must be owned, not rented, and it should have a useful life of more than one year that can be projected. Most often used methods for estimating depreciation are:

Straight line method:

Depreciation = (Cost of acquisition– Salvage value) / Life of asset

Diminishing balance method:

Depreciation= (Original cost –accumulated depreciation occurred in prior years) x Rate of depreciation

***Costs*:** The term 'cost' generally refers to the outlay of funds used for productive services. For the sake of simplicity, costs incurred in farm operations may be categorised into two groups:

Paid-out Costs

- Hired labour (human, animal and machinery)
- Maintenance expenses on owned animals and machinery
- Expenses on material inputs such as seed (home grown and purchased), fertilizer, manure (owned and purchased), pesticides and irrigation
- Depreciation on implements and farm buildings (such as cattle sheds, machine sheds, storage sheds)
- Land revenue
- Rent paid for leased-in land.

Imputed Costs

- Value of family labour
- Managerial input of family
- Rent of owned land
- Interest on owned fixed capital

The details of cost concepts and the items of costs included under each concept are given below:

Cost A1 = All actual expenses in cash and kind incurred in production

i. Value of hired human labour
ii. Value of hired bullock labour
iii. Value of owned bullock labour
iv. Value of owned machinery labour
v. Hired machinery charges
vi. Value of seed (both farm produced and purchased)
vii. Value of pesticides
viii. Value of manures (owned and purchased)
ix. Value of fertilizers
x. Depreciation on implements and farm buildings
xi. Irrigation charges
xii. Land revenue, cesses and other taxes
xiii. Interest on working capital
xiv. Miscellaneous expenses

Cost A2 = Cost A1 + rent for leased-in land

Cost B1 = Cost A1 + interest on value of owned capital assets (excluding land)

Cost B2 = Cost B1+ rental value of owned land (net of land revenue) and rent paid for leased-in land

Cost C1 = Cost B1 + imputed value of family labour

Cost C2 = Cost B2 + imputed value of family labour

Cost C2* = C2 adjusted to take into account valuation of human labour a market rate or statutory minimum wage rate whichever is higher

Cost C3 = Cost C2* + 10% of Cost C2* on account of managerial function performed by farmer

It may be noted that costs progressively escalate in an alphabetical order, that is to say that $C_i > B_i > A_i$, where i = 1 or 2. Further, costs with suffix 1 (A1, B1 and C1) exclude components of land rent/rental value while costs with suffix 2 (A2, B2 and C2) include that and therefore, A2 > A1, B2>B1 and C2 > C1. It is interesting to note that this type of classification of costs is useful to distinguish actual expenses incurred by the owner operators and tenant farmers from imputed costs, such as interest on owned fixed capital, value of family labour, rental value of owned land incurred by the farmers. This classification enables to work out range of costs associated with farm enterprise, returns to factors of production and profitability at farm level.

Other related and equally important term is cost of production. Sometimes we may find that few researchers, particularly biological scientists use the cost of production and cost of cultivation interchangeably, which is not correct. The cost of production is estimated by multiplying the ratio of value of main product to cost of cultivation and the ratio of value of main and by-product to derived yield. The criteria for imputing different cost items are given in the Table 1.

Table 1: Cost imputation criteria for a typical farm enterprise

Sl. No.	Cost items	Criteria
1.	Family labour	On the basis of statutory wage rate or the actual market rate whichever is higher
2.	Owned animal labour	On the basis of cost of maintenance which includes cost of feeding, depreciation on animal and cattle shed, labour charges and other expenses.
3.	Owned machinery charges	On the basis of cost of maintenance of farm machinery which includes, fuel, electricity, lubricants, depreciation repairs and other maintenance expenses.
4.	Implements	Depreciation and charges on account of minor repairs
5.	Farm produced manure	Valued at the rates prevailing in the village
6.	Rent of owned land	Estimated on the basis of prevailing rents in the village for identical type of land or as reported by the sample farmers subject to the ceiling of fair rents given in the land legislation of the concerned state
7.	Interest on owned fixed capital	Interest on the present value of fixed assets charged at the rate of 10 per cent per annum.

APPORTIONING OF JOINT COSTS

There are cost items which are incurred for the farm as a whole, and not exclusively for a given crop or enterprise. Such joint costs are allocated to individual enterprises, among different categories of livestock and so on. For example, depreciation on farm buildings and implements, land rent, land revenue, cesses and taxes and interest on owned fixed capital are such costs which are allocated to each category of crops in proportion to their areas. The cost on livestock is allocated to each category of animals in proportion of its numbers to the total number of animals owned by the farmer.

The apportioning of joint cost incurred jointly on different crops grown in mixed cropping is done in proportion to the total value of output contributed by the individual crop in the mixed cropping. The apportionment of total cost of cultivation between the main product and by-product is done in proportion to their contribution to the total value of output. The most common criteria for evaluating farm assets are given in Table 2.

Table 2: Assigning values to farm assets

Sl. No.	Farm asset	Criteria
1.	Owned and self-cultivated land	Evaluated at rates prevailing in the village, taking into account the differences in type of soil, distance from the village, distance from the main road, source of irrigation available etc.
2.	Farm buildings (cattle sheds, storage sheds, etc)	Evaluated at rates prevailing in the village
3.	Implements and other farm machinery	Evaluated at market price
4.	Livestock	Evaluated at market price

INVESTMENT APPRAISAL CRITERIA

Primarily the benefit-cost analysis (BCA) has been used for evaluating an investment in a project by comparing the economic benefits with the economic costs of the activity. Benefit-cost analysis has several objectives. First, BCA can be used to evaluate the economic merit of a project. Second the results from a series of benefit-cost analyses can be used to compare competing projects. BCA can also be used to assess business decisions, to examine the worth of public investments, or to assess the wisdom of using natural resources or altering environmental conditions. Ultimately, benefit-cost analysis aims to examine potential actions with the objective of increasing social welfare.

Measures of Costs and Benefits

Several variations on the basic benefit-cost rule can be used to compare the benefits and costs of investments, projects, or farm decisions. These are given below:

Net Present Value (NPV)

The net present value (NPV) is the current value of all the net benefits from a project/ enterprise. Net benefits are simply the sum of benefits minus costs. The sum is discounted at the discount rate. Using this method, if the project has a NPV greater than zero then it appears to be a good candidate for implementation. The formula used to calculate the NPV is:

$$NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}$$

Where,

C_0 = initial investment

C_i = cash flow

r = discount rate

T = Time

Benefit-Cost Ratio (BCR)

The benefit-cost ratio (BCR) is calculated as the NPV of benefits divided by the NPV of costs. In other words, the total discounted benefits are divided by the total discounted costs. Projects with a benefit-cost ratio greater than 1 have greater benefits than costs; hence they have positive *net* benefits. The higher the BCR, the greater the benefits relative to the costs. Note that simple benefit-cost ratio is insensitive to the magnitude of net benefits and therefore, may favour projects with small costs and benefits over those with higher net benefits.

BCR = Total sum of discounted benefits (Bt) divided by total sum of discounted costs (Ct).

If the BCR exceeds one, then the project might be considered as profitable.

Internal Rate of Return (IRR)

The internal rate of return (IRR) is the maximum interest that could be paid for the project resources, leaving enough money to cover investment and operating costs, which would still allow the investor to break even. In other words, the IRR is

the discount rate for which the present value of total benefits equals the present value of total costs:

$$PV\ (Benefits)\ -\ PV(Costs)\ =\ 0.$$

In general, the IRR should be greater than the discount rate for a project to be accepted.

TIME AND DISCOUNTING

Discounting is a technique that converts all benefits and costs into their value in the present. Discounting is based on the premise that a rupee received today is worth more than a rupee received in the future. Another way of saying this is that a rupee received in the future is not worth as much as that same rupee received in the present. That is, the future value of the rupee is discounted. Discounting is the opposite of compounding. Not surprisingly, the rate at which a future value is discounted is closely related to the rate at which present values are compounded, namely the interest rate. As we know from compounding, if the interest rate is 5 per cent, then Rs.100 kept in bank today will be worth Rs. 105 a year from now. Whenever the benefits and costs used in a benefit-cost analysis occur in the future, it is important to discount these future values to account for their present value.

Example:

Suppose you are given the choice of two investments. The first pays you Rs.210 today, but nothing thereafter. The second investment pays Rs.100 today and Rs.115 next year (total Rs.215). Does the second investment look better? Maybe or may not be. It depends on the discount rate. If the discount rate is 5 per cent, the first investment looks like a better choice, even though the second investment pays out a greater sum.

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Chapter 16

Supervision of Farm Operations and Manpower

Anil Kumar

Supervision is the act of overseeing something or somebody. It includes advising, educating, monitoring, and supporting in relation to task output or task performance. Business Dictionary defines supervision as monitoring and regulating of processes, tasks or delegated responsibilities. According to Webster's Dictionary, supervision can be defined as "Social and educational process to provide guidance and leadership through cooperative action." It is directly concerned with giving guidance, evaluation and the development of professional growth of personnel. Depending on the context, supervision involves different proportions of:

- Educational input with the purpose to improving knowledge, skills, and attitudes of workers.
- Organizing input with the purpose of improving the effectiveness and/or efficiency of resources used and quality of results or output on a farm.
- Motivational input with the purpose of establishing a good spirit and morale that improve the drive and satisfaction of the workers.
- Monitoring and enforcement of compliance with law, rules, norms, ethics, and policies in farm operations.

PRINCIPLES OF SUPERVISION

Rogers and Olmstead (1950) gave the following principles of supervision:

1. Supervision is an essential part of the administration, integral but not identical to it.
2. Supervision is a cooperative activity. It takes place through the shared ideas, efforts and experiences of all the members of a team.
3. It seeks to improve the methods of administration and create a physical, social and psychological climate favorable to learning.
4. Planning is fundamental to supervision. It is orderly in procedure from the birth of idea to the execution of a series of activities.
5. Supervision is creative. It provides opportunity for developing originality and self-expression.

6. It is scientific in its approach to problem-solving.
7. Supervision substitutes leadership for authority. It is based on the democratic philosophy that expects individual differences and assumes that people are capable of acquiring growth.
8. It is primarily the art of building creative human relationships.
9. Successful supervision is measured in terms of quality and growth of those being supervised.
10. Supervision helps in fixing goals as a means for systematic evaluation of performance.

ROLE OF SUPERVISORS

A good supervision is judged from its results which depend upon the ability and the efforts of the supervisor. Supervisors are not merely inspectors, but their primary aim is to aid the workers to become self-directed. He should make the workers learn to isolate and analyse their problems and seek the best methods for solving them. This can only be possible if the supervisor has a thorough understanding of the workers problems and helps them in developing confidence in their ability to solve those problems. One of the important functions of the supervisor is to help interpret the goals to the workers so that they understand it better: what is being planned, why it has been planned and how it will be executed (Singh, 1987).

The supervisor is a status leader by virtue of his appointment to his position. As a leader of his group he has to play his proper role in the process of deliberate change. He should also take special responsibility for the security, growth and accomplishment of his subordinates. According to Adam and Dickey (1966), appropriate functions for status leader are: (i) improving the human relations within the group, (ii) furnishing expertness along certain lines, (iii) generating leadership among others, and (iv) coordinating the efforts of others.

Reining Jr. (1968) described the job of supervisor as (i) technical relating to the work to be done (ii) institutional relating to the policies and procedures according to which the work must be done, and (iii) personal relating to the handling of workers. Although supervisor has authority by virtue of his position, yet it should not be used as force but only a basis for cooperation. He has to lead and not push the group. He will be judged by the contribution he makes to release the potential ability and power of the people he leads. He is not to use authority only but also to accept responsibility. He is to encourage action through group conscience, building morale and stimulating growth.

SUPERVISORS AS CHANGE AGENTS

Supervisor is the person directly involved or charged with responsibilities relating to the study and improvement of the activities of others. It is his responsibility to motivate his employees for production. According to Indik, Georgopoulos and Seashore (1960), a level of performance tends to be positively associated with supervisors' supportive behaviour. The change in the organization will best be realized if the supervisory role incorporates the change-agent role. The change-agent is the catalyst who attempts to bring about the change, and in this case the principal change-agent is the supervisor.

While introducing changes, supervisor has to face hostile attitude of the workers. He will have to give deep and searching thought to several factors involved such as values, aspirations, concept of self, fears and ethics, etc. He has to adopt different strategies in different situations to overcome resistance from the subordinates. Some of the strategies of change suggested by Pfiffner and Presthus (1967) are as under:

1. **The strategy of pressure:** Sometimes, one has to use pressure or force, which may be done apologetically. This approach should be used only in exceptional cases. Irrational use of force must be avoided.
2. **The strategy of communication:** It is important to assess what is being communicate, the strategy of communication can facilitate change, but at the same time it can also hinder change.
3. **The strategy of social awareness**: Social factors play an important role in the process of change. The supervisors should understand social grouping of workers, their values and belief systems location of power centres, socio-metric pattern, etc. in addition to technical knowledge.
4. **The strategy of goal setting**: This involves job analysis, analysis of work flow, layout and scheduling so that there should not be unnecessary displacement and disruption of the work schedule.
5. **The strategy of fusion**: Generally, there is difference in the organizational goals and the personal goals. The acute differences result in conflict, which must be avoided through 'fusion', i.e., to bring the two sets of goals more closely together. The principal thought for the supervisor to keep in mind is that resistance to change arises to a considerable extent from disturbing deep-seated personal goals of workers.

TECHNIQUES OF SUPERVISION

The supervision in broadest sense is not mere inspection. It is to provide motivation to the staff for action and has to equip them with necessary knowledge, services and supplies for the action. This type of supervision cannot be provided through

inspection visits only, but needs careful planning. While planning for supervision, supervisor must know the purpose of supervision, the problem to be solved and the solutions of the problem. Supervisor also has to know that he is going to work with workers of different personalities and abilities. A good supervisor is also an effective teacher. Therefore, he must understand the learning process and its implication for supervision. Singh (1987) elaborated various techniques of supervision to provide the guidance and leadership which are given below:

1. **Supervisory visits:** This is the most common method being used by the supervisors. The supervisory visits are made to see the actual work being done by the workers. in the field and the problems being faced by them. These visits should not be ceremonial but the results of observational analysis should be utilized to build a sound plan for improving the work. In many instances workers are terrified by visits of the supervisors because most of these are conducted for inspection purposes. The visits will be pleasant if the behaviour of the supervisor results in improvement of relationship between workers, the supervisor and the work. A good supervisor does not only teach the workers but also learns from them.

2. **Individual contact approach:** This is the informal visit of the supervisor to the workers to talk individually or visit of the worker to the office of the supervisor to discuss his problems and progress. In these meetings the atmosphere should be kept informal as far as possible and talk should be between two colleagues and not between an officer and a subordinate. In a friendly atmosphere, the worker will be able to express his opinion freely and frankly. The supervisor should always be ready to discuss the problems of the worker.

3. **Group contact approach:** Group meetings are becoming more and more common during these days. These meetings are used to solve common problems and to take collective decisions. The success of the supervisor depends upon his ability to hold successful group contacts and group meetings. Generally, these meetings are considered as wastage of time and worker do not take much interest in such meetings. The favourable attitude towards group meetings can be created through making these meetings of real value to the participants. This can be done by skillfully building meetings around those purposes which the workers consider important.

The group contact should be a real discussion between all the participants. If it is a one sided affair, i.e. dominated by the supervisor it is not going to be a success. The supervisor should ensure wide participation of the group members in the discussion and see that the business is conducted in an efficient but relaxed atmosphere. These meetings will serve the purpose only if the supervisor is ready to accept the group decisions and make efforts to put these decisions into practice.

4. **Need-based approach:** Psychological research has established that behaviour of the person is influenced by causes and these causes are not simple but complex in nature. Most of these causes are based on the needs of the persons. Some important needs are need for security and need for achievement, need for recognition, etc. Since the supervisor has to deal with persons, if he does not know human psychology it will be difficult for him to inspire them for action. The needs of workers can be identified by various methods. A successful supervisor is the one who not only locates the problems but also makes efforts to find solutions to them.

5. **Collective approach:** Modern supervision is more of a problem solving process rather than checking of the subordinates. Problems can be solved in a better way through collective efforts. Workshops are the most common technique being employed to solve problems collectively. Workshop has the advantage of group discussion as well as learning by doing. Workshop can be organized when a group of persons can profit by a sharing ideas and working together on a basic problem of common interest.

MORALE BUILDING

Morale is both an index of a sound employment situation and a positive means of building an efficient organization. It reflects a socio-psychological situation, in which men and women voluntarily seek to develop and apply their full powers to the task upon which they are engaged, by reason of intellectual or moral satisfaction which they derive from their pride in the service. High morale is complex combinations of many factors that make people do what the organization expects them to do.

Morale can be built up if the members of the organization have a sense of belonging to the group. An adequate flow of information and opportunities for sharing in institutional thinking helps in morale building. Homogeneity, constructive competition, intellectual and emotional quality and commitment are some other requirements for the maintenance of positive morale. In administration, morale is not only visible in the results but also in the amount of satisfaction achieved through being on that job. Morale is tested by finding sentiments and attitudes of the workers.

One of the important jobs of supervisor is to raise the morale of the workers by acting as a stimulator, catalyst and motivator. Some of the approaches to build up morale suggested by Singh (1987) are mentioned below:

1. The supervisor should keep in mind that human dignity and sensitive appreciation of higher goals are not lacking in the persons he is supervising.

2. Creation of a social atmosphere or climate that will tend to make people relatively well-adjusted in their work, create team spirit, and minimize obsessive pre-occupation with personal troubles.
3. The supervisor should know that discipline means not only stopping an undesirable behaviour, but teaching a goal of desirable accomplishment.
4. Instead of originating action by command, the supervisor must find ways of stimulating the subordinates to take the initiative themselves.
5. The supervisor should try to know his subordinates. One of the best ways of influencing people or changing their attitudes and customs is to learn their feelings and sentiments.
6. Supervision calls for a set of supervisor-subordinate relationships through two-way communication, and problem solving through consultation.
7. The supervisor should act as a guide, friend, helper, leader and not an authoritarian controller. The dominant characteristics of supervision are help and support.
8. The dominant method of securing change should be through persuasion.

CONCLUSION

An effective supervision leads to greater employee motivation resulting in more effective coordination of work and better time management. An understanding of how work links to the overall goal by the employees leads to significant learning on the job and building up of morale. The uninhibited two-way communication helps in avoiding conflict/misunderstanding in the group, thereby reducing the stress levels of supervisor and employees significantly.

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Chapter 17

Soil Testing Procedures and Calculation of Fertilizer Doses

Vinod Kumar and O.K. Tomar

All green plants having chlorophyll pigment make food through the process of photosynthesis by using carbon dioxide from air, energy from sunlight, and water and nutrients from soil. Like other living organisms, plants also require nutrients to complete their life cycle. Some of these nutrients are classified as essential nutrients, whereas others are grouped into beneficial nutrients. These nutrients are taken by the plants from different sources like carbon, hydrogen and oxygen from air and water, and primary, secondary and micronutrients from the soil.

About 118 elements have been recognized but all are not essential and only 17 have been listed as essential. The essential elements are Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), Zinc (Zn), Iron (Fe), Molybdenum (Mo), Manganese (Mn), Copper (Cu), Boron (Bo), Chlorine (Cl) and Nickel (Ni). Apart from these essential nutrients, there are some beneficial elements like Sodium (Na), Silicon (Si), Vanadium (V) and Cobalt (Co). Arnon and Stout (1939) and Arnon (1954) have proposed the criteria for essentiality of an element as follows:

- The plant must be unable to complete its life cycle in absence of the mineral element
- The function of the element must not be replaceable by another mineral element
- The element must be directly involved in plant metabolism such as component of an essential plant constituent or required for a distinct metabolic step like enzyme activation.

Several studies have indicated the extent of nutrient deficiency in Indian soil as follows:

Nitrogen	-	89% (63% low and 26% medium)
Phosphorus	-	80% (42% low and 38% medium)
Potassium	-	50% (13% low and 37% medium)
Sulphur	-	41%

Boron	-	33%
Zinc	-	48%
Iron	-	12%
Molybdenum	-	13%
Manganese	-	5%
Copper	-	3%

The inherent capacity of the soil to supply essential nutrients to plants is known as "soil fertility". If the inherent capacity of the soil to supply nutrients is less and the demand of the plants is more, the nutrients need to be supplemented from external sources (organic/inorganic). In order to determine the deficiency of a particular nutrient in the soil vis-à-vis requirement of the plant, soil test is carried out for estimating the appropriate dose of nutrients to be supplied through external sources. Soil testing procedure involves a number of steps like soil sampling, chemical analysis and preparation of soil test results.

SOIL SAMPLING

Soil tests measure the relative nutrient status of soils and are used as a basis for profitable and environmentally responsible fertilizer application. The accuracy of a soil test result is influenced by the laboratory analysis but may be influenced even more by the quality of the soil sample. Sample collection is extremely important in the accuracy and repeatability of a soil test.

Time of Sampling

Soil samples to be analyzed for soil pH, EC, salt content, zinc (Zn) and phosphorus (P) can be taken nearly any time of year. Potassium (K) values from samples taken in frozen soil may test high compared to other times of the year. Sulphur (S) and chloride (Cl) are mobile in the soil, so sampling in the fall or spring is recommended. Soil sample should be taken after harvesting of the field without disturbing the field. Soil sample should be taken when field is at moisture level of field capacity.

Depth of Sampling

Soil sampling and analysis assumes normally from 0-6 inches in depth. This weight per unit volume (bulk density) assumes a medium soil texture with some compaction. In some cases soil samples upto 12 inches are also taken for analysis. Under conventional tillage and conservation tillage, sampling 0-6 inch depth is adequate. Soil pH tends to become acid at the surface, especially if N fertilizers are applied to the surface. Separating the 0-6 inch depth into a 0-2 inch depth would identify these trends.

For analysis of soil pH, P, K, Zn, copper (Cu) and manganese (Mn), sampling the 0-6 inch depth is adequate. In long-term no-till fields, soil pH, P, and K may become stratified. Most studies for P and K suggest that stratification is not important as long as the fertilizer P and K rates based on 0-6 inch value are followed. However, soil pH may be important in the surface 0-2 inch layer because of possible herbicide interaction with lower pH levels. The 0-6 inch depth is also important for soluble salt. To determine soil NO_3-N, S and Cl, samples are taken from at least the. 0-24 inch depth. The 0-24 inch sample should be broken into a 0-6 inch depth and a 6-24 inch depth so that the relative position of N in the soil can be determined. In some years, NO_3-N can be leached to lower depths so that large amounts are in the 6-24 inch layer but only a small amount may be left in the 0-6 inch layer.

DETERMINING WHOLE FIELD NUTRIENT VALUES

Collecting a selectively random sample composite is strategy for determining whole field nutrient values. Selectively random sampling means that the field is sampled only in areas which represent most of the field area. Unusual landscape features such as eroded areas, saline or sodic zones and old building lots are not sampled. Also, avoid sampling in dead furrows or back furrows, under old manure or hay piles, sugar beet, tare piles, animal droppings, next to ditches, sloughs and roads, known banded fertilizer locations, and small depressions. Collecting at least 20 soil cores from a field results in a large volume of soil collected. In some soils, such as fine sandy loams, the soil may break up easily in a bucket, enabling thorough mixing before a 2/3 pint subsample is obtained for analysis. However, many soils do not break up easily. It may be necessary to take the entire sample out of the field, dry and grind it to obtain a good mixture. The resulting sample, whatever the method of collection and preparation, must represent the 20 core locations to provide the most accurate and reproducible results.

1. Soil pH and plant nutrients

Soil pH is the negative logarithm of hydrogen ion (H^+) activity in an aqueous solution. Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases, thus becoming more acidic. From pH 7 to 0, the soil is increasingly more acidic, and from pH 7 to 14, the soil is increasingly more alkaline or basic.

Agronomists generally use soil pH as measured in a 2:1 water-to-soil mixture as an index of a soil's acidity or alkalinity. In a soil test report, pH is often reported with descriptive modifier as shown in Table 1.

Table 1: Soil pH and interpretation

5.0	5.5	6.0	6.5	7.5	8.0	8.5
Strongly	Medium	Slightly	Neutral	Neutral	Mildly	Moderately
Acidic	Acidic	Acidic	Best Range for Most Crops			Alkaline

Nitrogen

One of the key soil nutrients is nitrogen (N). Plants can take up N in the ammonium (NH_4^+) or nitrate (NO_3^-) form. At pH's near neutral (pH 7), the microbial conversion of NH_4^+ to nitrate (nitrification) is rapid, and crops generally take up nitrate. In acid soils (pH < 6), nitrification is slow, and plants with the ability to take up NH_4^+ may have an advantage. There are other factors such as soil moisture, temperature, texture and cation exchange capacity that can also affect volatilization.

Soil pH is also an important factor in the N nutrition of legumes. The survival and activity of Rhizobium, the bacteria responsible for N fixation in association with legumes, declines as soil acidity increases. This is the particular concern when attempting to grow alfalfa on soils with pH below 6.

Phosphorus

The form and availability of soil phosphorus (P) is also highly pH dependent. P in these Ca-P minerals will still contribute to crop P requirements. As plants remove P from the soil solution, the more soluble of the Ca-P minerals dissolve, and soluble P levels are replenished. Greenhouse and field research has shown that over 90 per cent of the fertilizer P tied up with Ca-P minerals will still be available to crops in subsequent years. The fate of added P in acidic soils is somewhat different as precipitation reactions occur with aluminum (Al) and iron (Fe). The tie-up of P in Al-P and Fe-P minerals under acidic conditions tends to be more permanent than in Ca-P and Mg-P minerals.

Potassium

The fixation of potassium (K) and entrapment at specific sites between clay layers tends to be lower under acid conditions. This situation is thought to be due to the presence of soluble aluminum that occupies the binding sites. Liming increases K availability, likely through the displacement of exchangeable K by Ca.

Sulfur

Sulfate ($S0_4^{2-}$) sulfur, the plant available form of S, is little affected by soil pH.

Micronutrients

The availability of the micronutrients manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and boron (B) tend to decrease as soil pH increases. Molybdenum (Mo) behaves counter to the trend described above.

2. BULK DENSITY MEASURE BY CORE METHOD

This is a field method for bulk density determination.

Principle: In this method a cylindrical metal sampler or core of known volume is driven into the ground to the desired depth and carefully removed to preserve a known volume of sample as it existed in situ. This core sample is dried at 105oC and weighed. Bulk density is the oven dried mass divided by volume of the sample. The core method is usually unsatisfactory if gravels are present in the soil.

Apparatus: A core sampler, Sharp knife, A tray, Moisture boxes and oven.

Procedure: Drive the sampler vertically into soil surface far enough to fill the sample but not to compress the soil in the confined space. Carefully remove the sampler and its contents. Trim the soil extending beyond the sampler with a sharp knife. The soil sample volume is the same as the volume of the sampler or the core. Transfer the wet soil to a tray and weight it. Take a portion of the sample in a moisture box, weigh and place it in an oven at 105^0C for about 24 hours and weigh it again.

Observation and Calculations:

Mass of wet bulk soil sample = M1 g.

Mass of the moisture box = M2 g.

Mass of moisture box + wet soil = M3 g.

Mass of moisture box + oven dry soil = M4 g.

Mass of wet soil = (M3 – M2) g.

Mass of oven dry soil = (M4 – M2) g.

3. MEASUREMENT OF ELECTRICAL CONDUCTIVITY (EC) IN SOIL

Purpose: Salted soils are classified on the basis of two criteria, one is on the basis of total soluble salt (TSS) content and another is exchangeable sodium percentage (ESP) or more recently sodium absorption ratio (SAR).

Principle: The electrical conductivity of water extract of soil gives a measure of soluble salt content of the soil. Pure water is very poor conductor of electric current, whereas water containing the dissolved salts in soil conducts current approximately in proportion to the amount of soluble salts present. Based on this fact, the measurement of electrical conductivity of an extract gives a satisfactory indication of the total concentration of ionized constituents. The conductivity of the soil is the specific conductivity at 25^0C of water extract obtained from a soil and water mixture of a definite ratio. It is measured on a conductivity meter and normally reported in dS/m or milimhos/cm and the value gives information on the total amount of the soluble salts present in soil, i.e. on the degree of salinity.

4. DETERMINATION OF ORGANIC CARBON IN SOIL

Purpose: Besides its value as a source of plant nutrients, organic matter has a favourable effect upon soil physical properties. The determination of organic carbon in soil serves indirectly as measure of available nitrogen.

1. Walkley and Black Method (1934):

Principle: Organic carbon is oxidized with potassium dichromate in the presence of concentrated sulphuric acid. Potassium dichromate produces nascent oxygen, which combines with the carbon of organic matter to produce CO_2. The excess volume of $K_2Cr_2O_7$ is titrated against the standard solution of ferrous ammonium sulphate in presence of H_3PO_4.

Reaction:

$2K_2Cr_2O_7 + 6H_2SO_4 + 3C = 2Cr_2(SO_4)3 + 8H_2O + 3CO_2$

Where,

Mol. wt. of $K_2Cr_2O_7$ = 294.212,

Eq. wt. of $K_2Cr_2O_7$ = 294.212/6 = 49.03

2 $K_2Cr_2O_7$ = 3C

49.03 g $K_2Cr_2O_7$ = 12C/4 = 3.0 g C

As 1000 cc (N) $K_2Cr_2O_7$ = 3.0 g C

1 cc (N) $K_2Cr_2O_7$ = 3 g C / 1000 = 0.003 g C

Apparatus:

1. Conical flask – 500 ml

2. Pipettes – 2 ml, 10 ml, & 20 ml capacity

3. Burette – 50 ml capacity
4. Volumetric measuring flask – 2 Nos. (1 Lit. capacity)
5. Reagent bottles.
6. Asbestos sheet

Reagents:

1. *1 N potassium dichromate*: Dissolve 49.04 AR grade potassium dichromate dry ($K_2Cr_2O_7$) in distilled water and make up the volume to one litre.
2. *Concentrated sulphuric acid (Sp. Gravity 1.84, 96%)*: If the soil contains chloride, then 1.25% silver sulphate may be added in H_2SO_4.
3. *Orthophosphoric acid (Sp. Gravity 1.75, 85%)*
4. *Sodium Fluoride (chemically pure)*
5. *0.5 N Ferrous ammonium sulphate*: Dissolve 196.0 gm of AR grade Ferrous ammonium sulphate in distilled water, add 20 ml of concentrated H_2SO_4 and make volume to one litre. The ferrous ammonium sulphate should be from a fresh lot and light green in colour.
6. *Ferroin indicator*

Procedure:

1. Weigh 1 gm. of 0.5 mm sieved soil into dry 500 ml conical flask. Add 10 ml of $K_2Cr_2O_7$ into the flask with pipette and swirl.
2. Add rapidly with a burette 20 ml conc. H_2SO_4 and swirl gently until soil and reagents are mixed then more vigorously for one minute.
3. Allow the reaction to proceed for 30 min on asbestos sheet to avoid burning of table due to release of intense heat due to reaction of sulphuric acid.
4. Add slowly 200 ml of distilled water, 10 ml of concentrated orthophosphoric acid and add about 0.2 gm NaF (one small teaspoon) and allow the sample to stand for 1.5 hrs. The titration end point is clear in a cooled solution.
5. Just before titration add 1 ml ferroin indicator into the conical flask. Titrate the excess $K_2Cr_2O_7$ with 0.5 N ferrous ammonium sulphate till the colour flashes from yellowish green to greenish and finally brownish red at the end point.
6. Simultaneously blank test is run without soil.

Calculations:

% Organic carbon = 10 (B – S)/B x N x 0.003 x100/wt of soil (g)

Observation Table:

Sl. No.	Lab. No.	Blank reading (B)	Burette reading (S)	Difference (B – S)%	Organic carbon %	Organic matter

Where,

B = ml of std. 0.5 N ferrous ammonium sulphate required for blank.

S = ml of std. 0.5 N ferrous ammonium sulphate required for soil sample.

N = Normality of std. ferrous ammonium sulphate (0.5N)

The correction factor 1.3 is multiplied as according to Walkley and Black method only estimated 77% carbon (av. Value).

The result can be converted to corrected total organic carbon by multiplying the factor 100/77 = 1.3. Soil organic matter contains (58%) of organic carbon, the percentage of organic carbon multiplied by 100/58 = 1.724 which gives the percentage of organic matter

i.e. Organic matter = Organic Carbon x 1.724

5. DETERMINATION OF AVAILABLE NITROGEN - (ALKALINE PERMANGNATE METHOD)

Purpose: Soil nitrogen occurs largely in the organic form (97-99%). The availability of N is associated with the activity of micro-organisms which develops the organic matter (NH_4-N and NO_3-N). The nitrification rate of a soil is measure of the rate of release of available nitrogen from the organic matter in the soil. A discrete fraction of the soil organic nitrogen is attacked by $KMnO_4$ and that this fraction was most readily susceptible to biological mineralization. This forms the basis for determination of available nitrogen by alkaline permanganate method (Subbiah and Asija, 1856).

Principle: The organic matter in the soil is oxidized by $KMnO_4$ in presence of NaOH. The ammonia released during oxidation is absorbed in boric acid to convert the ammonia to ammonium borate. The ammonium borate formed is titrated with standard H_2SO_4. From the volume of standard H_2SO_4 required for the reaction with ammonium borate, the N is calculated.

Apparatus:

1) Conical flask - 100 ml

2) Funnels, filtration stands

3) Volumetric flask - 100 ml

4) Beaker

5) One litre round bottom flask

6) Distillation unit (Kheldhal Digestion Unit)

Reagents:

1) *Potassium permanganate $KMnO_4$ (0.32%)*: Dissolve 3.2 g of potassium permanganate in 1 lit distilled water with the intermittent shaking till it is completely dissolved. Store in amber coloured bottle and in the dark

2) *Sodium hydroxide solution, 2.5% NaOH (92.5%)*: Dissolve 25 g of pure sodium hydroxide pellets in one lit. distilled water.

3) *Boric Acid H_3BO_3 (2%)*: Dissolve 20 g boric acid of AR grade in 800 ml distilled water by heating the content. Cool it and dilute to 1000 ml volume.

4) *Mixed indicator (Bromocresol green + Methyl red)*: Weigh out separately 99 mg of Bromocresol green and 66 mg of well powdered methyl red and dissolve them together in 100 ml ethyl alcohol.

5) *Working Boric Acid solution*: Add 20 ml of the mixed indicator to one litre of 2% boric acid solution and adjust the pH to 5.0 after shaking, or add 0.1N NaOH continuously until the solution assumes reddish purple tingeuine red colour.

6) *Standard sulphuric acid, H_2SO_4 (0.02N)*: Standardize the H_2SO_4 solution using standard NaOH. NaOH be standardized against 0.02N $H_2C_2O_4$ or 0.02N potassium pthalate.

7) *Liquid paraffin*

8) *Glass beads*

Procedure:

1) Transfer 20 g of sieved soil into 1lit. round bottom flask.

2) Add little distilled water with the help of jet in such a way that the particles of soil do not remain stuck to the sides of the flask.

3) Add 2 to 3 glass beads to present bumping and 1 ml of liquid paraffin to prevent frothing.

4) Add 100 ml of potassium permanganate and 100 ml of sodium hydroxide solution to the flask (both the solutions should be prepared fresh).

5) Distil and collect the distillate in a beaker containing 20 ml of boric acid working solution.

6) Collect approximately 150 ml of distillate.

7) Titrate the distillate with standard H_2SO_4 0.02N till the colour changes from green to red and record the burette reading.

8) Carry out blank without soil.

Observations:

1) Weight of soil sample taken = 20 g

2) Volume of standard H_2SO_4 required for = …..... S ml soil sample

3) Volume of standard H_2SO_4 required for = ……... B ml blank sample

4) Normality of H_2SO_4 = 0.02N

Calculations:

Available N kg ha^1 = (S – B) x 0.00028/20 x 10^6 x 2.24

N = Normality of H_2SO_4 (98g of H_2SO_4 =28g N

1 ml of 0.02N H_2SO_4 = 0.00028gN

Ratings:

Nitrogen Kg/ha	
1. Very low	< 140
2. Low	140 – 280
3. Medium	281 – 420
4. Moderately High	421 – 560
5. High	562 – 700
6. Very High	> 701

6. DETERMINATION OF AVAILABLE PHOPHOROUS IN SOIL - (OLSEN'S METHOD, 1954)

Purpose: Phosphorous is most critical essential element in influencing plant growth and production throughout the world. It is determined by modified Olsen's Method.

Principle: Under neutral to alkaline soil conditions, Olsen's P (0.5 M $NaHCO_3$ solution at pH 8.5) is the most widely used extractant for estimation of available

phosphorous in soil. The reagent is designated to control the ionic activity of calcium through the solubility product of $CaCO_3$ in case of neutral and calcareous soil. In this process the most effective form of 'P' is extracted from the phosphates of Fe, Al and Ca present in different type of soils. The extracted phosphorous is measured calorimetrically.

Apparatus:

1) Conical flask – 150 ml.

2) Funnel

3) Pipettes

4) Volumetric flask – 25 ml.

5) Reagent bottles

6) Spectrophotometer

Reagents:

1) *0.5M $NaHCO_3$*: Dissolve 42.0 gm of P-free sodium bicarbonate in about 500 ml of hot distilled water and dilute to 1 litre. Adjust the pH to 8.5 using dilute NaOH or dilute HCL. Prepare fresh solution before use.

2) *Activated Charcoal*: Wash pure activated charcoal or commercially available Darco G-60 with acid to make P-free, even if having traces of P.

3) *Ammonium molybdate [$(NH_4)6\ Mo_7O_2.4H_2O$]*: Dissolve 12.0 gm of ammonium molybdate in 250 ml of distilled water to get solution 'A'. Prepare solution 'B' by dissolving 0.2908 gm of potassium antimony tartarate $K_2[Sb_2(C_4H_4O_6)_2].3H_2$ in 100 ml of distilled water. Prepare one litre of 5N H_2SO_4 (14 ml of concentrated H_2SO_4 diluted to 1 lit.) and add solutions "A" and "B" to it. Mix thoroughly and make the volume to 2 lit. with distilled water. Store in amber coloured bottle in dark and cool compartment (Reagent C).

4) *Ascorbic Acid Solution*: Dissolve 1.056 gm of ascorbic acid in 200 ml of molybdate tartarate solution (reagent C) and mix well. This ascorbic acid (reagent D) should be prepared as required because it does not keep more than 24 hrs.

5) *P-nitrophenol indicator*: Dissolve 0.5 gm of p-nitrophenol in 100 ml of distilled water to get approximately 5N H_2SO_4.

6) *Standard P Solution (Stock Solution)*: Analytical grade (AR) KH_2PO_4 is dried in an oven at 60°C for one hour and after cooling in desicator, weigh 0.4393 gm and dissolve in about 500 ml distilled water (shake the content until the salt dissolves.) Add 25 ml of approximately 7N H_2SO_4 and make the volume

to 1 lit. Add 5 drops of toluene to diminish microbial activity. This gives 100 ppm stock solution of P (100 mg/ml).

7) *P solution (5 ppm)*: Pipette out 5 ml of stock solution of P and make up the volume to 1 lit with distilled water. This solution contains 5 mg P/ml (i.e. 5 ppm solution).

8) *Hydrochloric Acid (0.02 N)*: Dilute 1.8 ml of concentrated HCl to 1 lit.

9) *Standardization of sodium hydroxide (NaOH)*: Pipette out 10 ml of 0.02 potassium hydrogen pthalate in a 250 ml conical flask. Add 3 drops of phenolphthalein indicator. The end point is appearance of pale permanent pink colour.

Procedure:

1) Weight 2.5 g of soil sample in 150 ml plastic conical flask, add pinch (0.3 g) of phosphate free activated charcoal AR grade. Add 50 ml of Olsen reagent and shake for 20 minutes exactly on platform type shaker at 180 rpm.

2) Filter the contents immediately through Whatman No.42 filter paper. Transfer 5 ml of aliquot into 25 ml volumetric flask.

3) Pipette out 5 ml of filtrate into 25 ml volumetric flask. Add 4 ml of the freshly prepared ascorbic acid and ammonium molybdate solution. Shake well and keep it for 30 minutes then make the volume.

4) Prepare the standard curve using 0, 1, 2, 3, 4 and 5 ml of 5 ppm standard P solution into 25 ml volumetric flask and develop the colour using the same procedure as above. The corresponding P concentration will be 0, 0.2, 0.4, 0.6, 0.8 and 1 ppm.

5) Measure the absorbance and colour intensity at 882 nm after half an hour by spectrophotometer

6) Run a blank method sample with the extracting solution.

Observation Table:

Sl. No.	Lab No.	Reading on spectrophotometer	P (ppm)	P (kg/ha)

Calculation:

$$P\ (ppm) = \frac{GR \times 50 \times 5}{\text{Correct Ht. of Soil}}$$

Where,

GR – Concentration of P in microgram analyzed sample. (read from std. curve)

P (kg/ha) = P (ppm) x 2.24

Rating:

Phosphorous (kg/ha)

1) Very low	< 7
2) Low	7 – 13
3) Medium	13 – 22
4) Moderately high	22 – 28
5) High	28 – 35
6) Very high	> 35

7. DETERMINATION OF POTASSIUM ON FLAME PHOTOMETER

Purpose: Next to nitrogen and phosphorous, potassium is the most critical essential element in influencing plant growth and production throughout the world. Potassium plays essential role in plants. It is an activator for dozens of enzymes responsible for plant process. Potassium is essential for photosynthesis, for protein synthesis, for starch formation and for translocation of sugars.

Principle: When a solution of the metallic salt is atomized into a non luminous flame, electrical K atoms get excited and emit light when come to ground state. The light emitted is filtered through a glass filter which allows light to definite wavelength of that element, 766.5 nm for K, to pass. The light falls on photocell emitting electrons generating an electric current. This current is measured on the galvanometer and is proportional to the concentration of metal element present in solution atomized.

Reaction:

$$Soil\text{-}K + NH_4OAC = Soil\text{-}NH_4 + K^{++} Acetate^{-}$$

Apparatus:

1) 100 ml conical flask

2) Funnels, filtration stands

3) 100 ml volumetric flasks

4) Flame photometer

5) 50 ml volumetric flasks

Reagents:

1. *Neutral normal ammonium acetate solution*: Take 58 ml of glacial acetic acid in 500 ml volumetric flask. Also take 71 ml of concentrated ammonium hydroxide solution in another 500 ml volumetric flask. Dilute both the solutions with distilled water upto the 2/3 volume and mix both in 1 lit. flask then adjust pH to 7.0 and finally make up the volume to 1 lit. For bringing pH of solution to 7, add dilute acetic acid or ammonium hydroxide.
2. *Standard potassium stock solution (1000 mg/litre)*: Dissolve 1.908 g chemically pure KCl in distilled water, make up the volume to 1 L. This solution contains 1000mg / liter of K. It serves as standard stock solution. Also prepare secondary stock solution of 100 ppm K from thi primary stock solution by taking 10 ml and making 100 ml volume.
3. *Working solution*: Pipette 0, 0.5, 1, 2, 4, 6, 8 and 10 ml of 100 mg K/ ml solution in 100 ml volume flask separately and make up the volume with NH_4OAC solution. This gives 0, 0.5, 1, 2, 4, 6, 8 and 10 mg respectively.

Precautions while handling flame photometer:

1. All the necessary safety precautions meeting the appropriate specifications for use of LPG burner should be strictly followed.
2. Never view the flame from the top of the chimney. It should be viewed from the round viewing indicator provided on the front side.
3. Ensure air is flowing through the burner before LPG is allowed in to the burner and lighting it.
4. Always start the air compressor first and then the LPG gas to avoid inadequate air and gas accumulation.
5. While switching off, turn off the LPG gas supply first. After the flame goes off, switch off the compressor.
6. Inadequate air and more fuel would result in accumulation of fuel gas, which will cause flame to appear above the chimney and burn the chamber.
7. Ensure that all the end clamps are tight and that there is no leakage. The leakage can be checked using soap solution at the nozzle end.

Procedure:

1. Add 25 ml of NH_4OAC extracting solution to a conical flask containing 5 g air dry soil sample.
2. Shake on a reciprocating shaker at 200 to 220 oscillations per minute for 5 min and filter.
3. Determine potassium as indicated in preparation of standard curve, dilute if necessary.

Calculation:

Available K (kg/ha) = C x 25/5 x 2.24 = C x 11.2

Where, C = concentration (mgL^{-1}) of K in the sample filtrate on X-axis, against the reading.

Potassium (K) – kg/ha,

1. Very low	> 120
2. Low	121 – 180
3. Moderate	181 – 240
4. Moderately high	241 – 300
5. High	301 – 360
6. Very high	Above 360

8. RECLAMATION OF PROBLEM SOILS (By Schooover Method 1952)

1. DETERMINATION OF GYPSUM REQUIREMENT OF ALKALI SOIL

Principle: Gypsum requirement of alkali soils can be determined by treating the soil with known amount of excess saturated gypsum solution, and then estimating the unreacted or unutilized amount by versenate titration method as suggested by Schoonover (1952). Though, Ca can be estimated by other methods also but the versenate titration is more suitable.

Instrument: Mechanical shaker.

Reagents:

1. Std Gypsum Solution $CaSO_4.2H_2O$
2. 0.01N $CaCl_2$ Solution

3. 0.01N EDTA Solution

4. Buffer Soution

5. EBT Solution

Procedure: Take 5 gram dry soil in 250 ml conical flask add 100 ml saturated gypsum solution than stopper the flask and shake for 5 minutes after that filter with Whatman No. 1 filter paper. Take 5 ml filterate in 100 or 150 ml porcelain dish add 1ml buffer solution and 2-3 drop of EBT solution, then titrate it against EDTA solution. Run a blank 5ml saturated Gypsum solution.

Observation:

Blank Reading =14.00

Sample Reading =10.3

Ca retained in Soil =2V (Gypsum) - 2V (filterate) = 7

Calculation:

Ca in aliquot (me/L) = 2v

Volume of EDTA Sol. Used = V

Ca retained in soil = Ca retained in Soil = 2V (Gypsum) - 2V (filterate) = A (me/100g)

G.R. = (t/ha) for 30cm soil depth = A x 3.852

G.R.(Agri Grade) = Gr x 100/% Purity

G.R. = 2 x 14 - 2 x 10.3 = 7.4

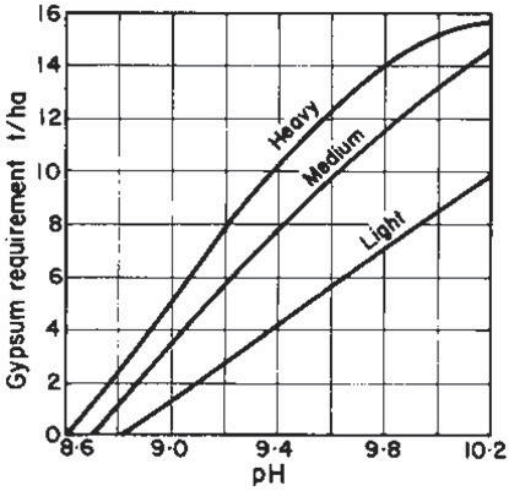
7.4 x 3.852 = 28.504

G.R. (Agri Grade) = 28.504 x 100/90

= 31.6t/ha

pH Based Gypsum Requirements

Relationship between pH of 1:2 soil-water suspension and the gypsum requirements of sodic soils of the Indo-Gangetic plains. Light, medium and heavy refer to soils with a clay content of approximately 10, 15 and 20 percent, respectively. A cation exchange capacity of 10 cmol (+)/kg soil is common for most medium textured soils



PREPARATION OF SOIL TEST RESULTS AND FERTILIZER RECOMMENDATION

Correct interpretation of soil analysis is an essential part of soil testing programme. The data obtained from soil analysis would be meaningless unless they are correlated with crop yield. On the basis of soil testing results, the recommended fertilizer does for the crops are modified for making fertilizer recommendations to the farmers.

Preparation of Soil Test Report

The format of soil test report should contain following four parts:

1. Information about the field.
2. Soil test values with corresponding classification in 6 tier system of each of the nutrients.
3. Nutrient dose for a particular crop.
4. Calculation of the fertilizer to apply essential nutrients.
5. Salinity and alkalinity problems and steps taken to overcome them.

Recommendation of Fertilizers

Step 1: Find out the range in which the given soil fits e.g. any one of the very high, high, moderately high, medium low and very low.

Step 2: Increase or decrease the recommended dose of the nutrient according to the category.

Classification Chart for Soil Test Data:

Category	Org. C (%)	Av. N (Kg/ha)	Av. P (kg/ha)	Av. K ((kg/ha)
Very Low	< 0.20	<140	< 7	<100
Low	0.21-0.40	141-280	7-14	101-150
Moderate	0.41-0.60	281-420	15-21	151-200
Moderately High	0-61-0-80	421-560	22-28	201-250
High	0.81-1.00	561-700	29-35	250-300
Very High	Above 1.00	>700	>35	>300

1. Very high : 50% less
2. High : 25% less
3. Moderate : Recommended
4. Moderately high : Recommended
5. Low : 25% more
6. Very low : 50% more

Step 3: Calculate the quantity of straight fertilizers based on above example.

Step 4: Calculate the gypsum or lime for problem soils.

Problem: Calculate fertilizer dose (kg ha-1) for sorghum as per six tiers system of fertility rating from given information. Recommended dose of fertilizer is 80: 40:40.

Soil Available N= 82

Soil Available P= 10

Soil Available K= 206

Solution:

As per six tier systems soil is very low in N content, low in P content and moderate in K,

According to six tier system one should apply 23% more P and recommended dose for K

Fertilizer doses will be

For N = 80 + (50 % of 80)

= 80 + 40 = 120 kg

For P = 40 + (25% of 40)

= 40 +10 =50 kg

Now fertilizer dose will be 120:50:40.

SUGGESTED READINGS

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Chapter 18

Handling and Use of Plant Protection Equipments and Pesticides

Chandra Bhanu

The environmental safety and sustainability are of prime concern today at national and international levels. We need a place to live with clean air, water, food and an environment which will not threaten our health and safety. Any chemical pesticide which is off-target is a pollutant and can be dangerous. Pesticide use and drift can affect air quality, pesticides in the food chain can threaten wildlife and soil may no longer be suitable for optimal crop production. Objectionable pesticides' residues are causing several health problems in humans i.e. cancers, birth defects, hormonal irregularities, respiratory problems, reproductive defects, suppression of immunity, neurological disorders, skin diseases etc. The benefits of pesticide use are meaningless if pollution occurs through indiscriminate use and/or carelessness. As pesticide applicators, it is important to plan our crop protection programme carefully by both controlling pest populations (increasing efficiency) and at the same time protecting the environment (assuring safety) and ourselves from the potential adverse effects of pesticide use.

PLANT PROTECTION EQUIPMENTS

Different types of plant protection equipments are sprayers, dusters and equipments used in aerial spraying of pesticides. These instruments are used according to the type of pesticides for pest control. One of the important steps in use of sprayers is to know the quantity of water required per unit area for spraying. Different types of sprayers and water required for spraying with them are described as below:

1. **High volume sprayers**: Requires 500 to 1000 L water solutions/ha for field crops and 1500 to 2000 L water solutions for orchard crops. Examples are knapsack sprayer (tank capacity 15-20 L), hand compression sprayer, rocker sprayer.
2. **Low volume sprayers**: Requires 50 to 100 L water solutions/ha. These are normally motorized knapsack sprayers.
3. **Ultra-low volume sprayers**: Requires 1-5 L water solutions/ha.

4. **Aerosols**: Requires less than 1L water solutions/ha. Generally used in enclosed spaces.

Type of Nozzle used for pesticide spraying

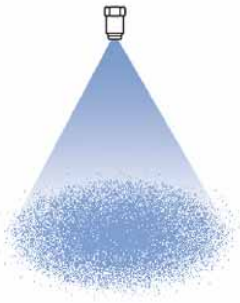
For herbicides: Use flat fan or cut nozzle

Cut nozzle

Flat fan nozzle

For fungicides and insecticides: Use hollow cone or solid cone nozzle

Hollow cone nozzle



Solid cone nozzle

PESTICIDES

A pesticide is "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. A pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Pests are living organisms that occur where they are not wanted or that cause

damage to crops or humans or other animals. Examples of pests include insects, mice and other animals, unwanted plants (weeds), fungi, microorganisms such as bacteria and viruses, and viroids.

Classification of Pesticides (based on type of pest controlled and general mode of action)

Type of pesticide	Pest controlled/general mode of action
Insecticides	To prevent, destroy, or to kill the flying and crawling insects
Herbicides	To prevent, inhibit the growth, or killing the undesirable plants/weeds
Rodenticides	To prevent, destroy, or to kill the mice, rats and other rodents
Fungicides	To prevent, destroy or inhibit the fungi that cause plant disease/ wood rot, etc.
Nematicides	To prevent, destroy, to kill or to repel the nematodes
Fumigants	To destroy insects/fungi present in a commodity
Antimicrobials	To prevent, destroy, or to kill the microorganisms such as bacteria, molds, fungi
Biopesticides	Natural materials such as animals, plants, bacteria, fungi, virus etc. that target a variety of pests

PUBLIC CONCERNS ABOUT CHEMICAL PESTICIDES

It is a common idea that chemical pesticides are toxic poison and initially it was believed that chemical pesticides were toxic only against the kind of pests to which they were applied. Majority of scientific and user community felt that humans and other animals were not affected by pesticides unless they were fed large amount of pesticides either intentionally or accidentally. Therefore, pesticides were applied indiscriminately for a long time on soil, field crops, fruits/vegetables crops, water bodies, and even directly on human and animals to control various parasites and diseases affecting them. Hundreds of pesticides were produced annually and many of the more toxic newer pesticides (particularly insecticides) came in common use which at very lower doses can kill many of the organisms which are integral part of agro-biodiversity. Some of these pesticides like DDT and BHC are of persistent in nature. Their residues have been accumulated in long chain of producers and consumers in the ecosystem and causing several threats to them including human beings.

PESTICIDES IN FOOD CHAIN

Food chain refers that how producers (plants), consumers (animals etc.) and decomposers are interdependent. Each animal has a place in the chain based on the

type of food consumed. Animals that consume plants are near the bottom of the chain. Animals which eat these plant-eaters are on the next level. Carnivorous animals are at the top of the chain. Application of pesticides over broad areas may eliminate certain needed food sources. Elimination of food sources can cause wildlife to relocate to other areas, substitute other food sources, or die. Wildlife moving to another area can create additional competition for food and space with resident species. A predatory animal lacking prey may shift to a valued game species or even domestic livestock. Fish and wildlife can be exposed to pesticides by eating animals poisoned by pesticides or plants containing pesticides. Also, this pesticide transfer could occur with birds feeding on insects, earthworms, etc. In this complex food chain each consumer level may face the pesticide toxicity to varying degree.

TOXICITY OF PESTICIDES TO MAMMALS (INCLUDING HUMANS)

1. **Acute Toxicity:** Toxicity that causes harm or death of test animal (rat or mice) from a single exposure. The assumption is that as mammals, both humans and rats share common physiological characteristics. Acute toxicity is generally expressed by LD_{50} (Lethal $Dose_{50}$) or LC_{50} (Lethal $Concentration)_{50}$.

Lethal $Dosage_{50}$ (LD_{50}) of pesticides

An LD_{50} is a standard measurement of acute toxicity that is stated in milligrams (mg) of pesticide per kilogram (kg) of body weight. An LD_{50} represents the individual dose (mg/kg body weight) of pesticide required to kill 50 percent of a population of test animals (e.g., rats, fish, mice, cockroaches). Because LD_{50} values are standard measurements, it is possible to compare relative toxicities among pesticides. The lower the LD_{50} dose, the more toxic the pesticide is. A pesticide with an LD_{50} value of 10 mg/kg is 10 times more toxic than a pesticide with an LD_{50} of 100 mg/kg.

The toxicity of a pesticide is related to the mode of entry of the chemical into an organism. **Oral LD_{50}** values are obtained when test subjects are fed pesticide-treated feed or water. **Dermal LD_{50}** values are obtained when the pesticide is applied to the skin of the animal. **Inhalation LD_{50} (**or **LC_{50}** =lethal concentration $_{50}$) values are obtained when the animal breathes the pesticide with a mask. Often the inhalation LD_{50} is lower (more toxic) than the oral LD_{50}, which is in turn lower (more toxic) than the dermal LD_{50}.

LD_{50} values are not always given on the pesticide label, rather, the relative toxicity of a pesticide product is reflected by one of three signal words: POISON/ DANGER, WARNING, or CAUTION. The purpose of signal words is to alert the user to the level of toxicity of the product. The signal word is generally assigned based on the pesticide's inhalation, oral or dermal toxicity, whichever is the most toxic. The levels of toxicity and their LD_{50} values of pesticides are presented in the Table-1.

Table 1: Hazard Indicator Categories of Pesticides

I **Extremely toxic**	**II** **Highly toxic**	**III** **Moderately toxic**	**IV** **Least toxic**
Signal words: POISON (in large boldfaced letters on the label and usually accompanied by skull and cross bones symbol)	POISON (in large bold facedletters)	DANGER (in large bold facedletters)	CAUTION (in large bold facedletters)
Acute (single) oral dosage lethal to human adults: Few drops to 1 teaspoon (Approx.)	1 teaspoon to 2 tablespoons (Approx.)	25 ml-500 ml (Approx.)	>500 ml (Approx.)
Colour of lower triangle			
			
Bright red	Bright yellow	Bright blue	Bright green

2. **Chronic Toxicity:** This refers to harmful effects of exposure over long periods of time. Long-term effects of pesticide exposure or of exposure to multiple pesticides are poorly understood. Laboratory tests with rats measure various factors over time such as whether the chemical is **carcinogenic** (causes cancer) or is **teratogenic** (causes birth defects) or **mutagenic** (causes mutations). In general, from least to most toxic common pesticides for humans are:

Fungicides → Herbicides → Rodenticides → Insecticides

Among the insecticides, from least to most toxic common insecticides are:

Microbial pesticides → Insect growth regulators → Botanicals pyrethrins → Organochlorines → Carbamates → Organophosphates

In general least to most toxic formulations of insecticides are:

Enclosed bait → Granules → Dust → Water solution → Water emulsion → Oil solution → Aerosol → Emulsifiable concentrate → Liquid concentrate

Pesticide type and persistence

If a chemical is "broad spectrum", that means it kills lots of different organisms within its category. In contrast, "narrow spectrum" chemicals affect a more narrow range of organisms. Some of the pesticides like organochlorine (DDT, BHC etc.) are highly persistent in nature. Their continuous use in agriculture and vector control programmes worldwide in the past resulted in their increased accumulation into environment and posed serious threat to life of many organisms including humans. Their residues are present in various components of the environment even today. Some of the pesticides have high level of immediate toxicity to many life forms but do not persist into environment and degrade quickly. Careful use of these pesticides may save many life forms from their toxic effects.

Good Agricultural Practices (GAPs) to reduce pesticide hazard

1. Every chemical pesticide is a poison/toxin and must be handled with same sense. Indiscriminate use of all these poisons must be avoided.
2. Do not transport pesticides along with foodstuffs
3. Store pesticides under strict control of responsible persons
4. Use pesticides only when it is needed. Use integrated pest/disease/weed management modules involving other non - chemical means of pest control. Alternative pest management options based on ecological principles i.e. cultural control, bio-intensified pest control, resistant varieties, etc. should be given more preference.
5. Promotion and use of pest/disease forecasting systems, precision farming and expert systems. Use only appropriate pesticide for well identified pest/pathogen/ weed and in desired doses. Adjust application timing to avoid the risk to non - target organisms.
6. Do not apply a single pesticide regularly to avoid the buildup of pesticide resistant biotypes of weeds/pest/pathogens.
7. Use proper application equipments with appropriate safety measures during application of pesticides to deliver to target site and to avoid drift to non target sites.
8. As far as possible, arial spraying of pesticides by helicopters/aero-planes should be avoided.
9. Transgenic crops such as herbicide resistant crops which promote regular and more consumption of pesticides should not be promoted. At the same time, transgenic crops which have in built resistance to pests and diseases should be promoted after desired safety testing.

10. As far as possible, drained water from pesticide applied agricultural farms should not be allowed to reach the important water bodies and ground water. Avoid the application of hazardous pesticides on water bodies.
11. Use safer pesticides like botanicals to control human/animal parasites.
12. Plant protection specialists must come out from their chemical pesticide dominated recommendations and should incorporate ecological means of pest suppression.

CONCLUSION

Chemical pesticides have been identified as indispensable part of crop production programme. However, pesticides can also harm public health and the environment. Any pesticide which is off-target is a pollutant and can be hazardous. The benefits of pesticide use are meaningless if pollution occurs through indiscriminate use and/or carelessness. The repeated and indiscriminate use of pesticides causes widespread contamination in the environment and poses several short and long term problems to humans and biodiversity. Hence sustainability of environment must be kept in mind during our crop production and vector control programmes and proper handling and use guidelines of pesticides must be followed by all the stakeholders.

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Chapter 19

Records Management in Crop Farm

Chet Ram

Record keeping is essentially required in farm management for smooth disposal of different works associated with the farm activities. There are three factors mainly responsible for farm management viz. land, labour and capital. Records of all these three components have to be kept for proper and efficient management of farm resources.

A. RECORDS RELATED TO LAND AND OTHER ASSETS

1. Land records

In land records, all the details of farm land are registered with regard to source of purchase of land, whether purchased or leased in, area of land, valuation of land and terms and conditions. This record consists of all the correspondence letters regarding purchase/ contract of land, a detailed map indicating plot numbers and their area. The land is categorized into different blocks and each block is named indicating plot wise area falling in that block. Further, the area occupied by roads, buildings, irrigation channels, pump house and the actual cultivated area are also need to be indicated in the land records.

2. Land allotment register

In this register, details of the farm land allotted to different scientists/ officers for conducting experiments are recorded. All the correspondence, letters, related to allotment are also kept in the concerned file. During the month of March, a cropping scheme for the whole year is prepared which consists of the details of *kharif*, *rabi* and *zaid* crops to be grown in the experimental as well as general cultivated area of the farm. In this record the details of recommendations of the farm management committee and approval of the competent authority are also retained.

3. Crop register

It is essential to keep plot-wise details of *kharif*, *rabi* and *zaid* crops to be grown in various plots of the farm. In the crop register, the area under different crops and date wise operations from sowing to harvesting alongwith the crop yield are recorded.

4. Produce hand over register

In this register the details of farm produce from each and every plot handed over by the concerned scientists/officers are kept up. In this case the date of hand over, name of officer handing over the produce, amount of produce handed overand signatures of handing over and receiving officers are recorded.

5. Day book or weighment book

In this book, the daily record of farm produce handed over to the farm section and daily disposal of farm produce are maintained. The entries in this register consist of date, name of produce, from where obtained, who handed over, amount in Kilograms (gross, tear, net weight), produce register, page number, remarks and signature are made.

6. Produce register

In this register the name and category of each and every farm produce is recorded on separate pages. The entries consist of serial number, date, quantity obtained, quantity harvested, quantity disposed, value, receipt number, date and signature.

7. Tree register

In this register the details of all the different groups of trees standing in the farm area.

8. Seed register

This register consists of details of seeds of different crops purchased for sowing is recorded. The entries consist of serial number, date, bill number, quantity purchased, value, quantity issued and balance quantity.

9. Fertilizer register

In this register the details of different fertilizers are recorded on separate pages with the entries consisting of serial number, date, purchased bill number, value, quantity purchased, quantity issued, balance quantity, signature of receiver, indent number, signature of store keeper and remarks.

10. POL register

POL is required for using farm machinery like power tiller, tractor, diesel engine, etc. The details of diesel, petrol, mobil oil, gear oil, coolant, grease, etc. are maintained in the register as is being done in the fertilizer register.

11. Agro-chemical register

This is a type of stock register in which details of agro-chemicals used for controlling diseases, insect-pests, weeds and for seed treatment are recorded as per the details mentioned in fertilizer register.

12. Stock register for miscellaneous items

In this case the details of small and sundry items are recorded.

13. Farm machinery register

In this case a stock register of different farm machinery like tractor, power tillers etc, which are permanent items, is maintained. The entries consist of serial number, date, particulars, quantity received, value, date of purchase, signature and remarks. An indent register is also maintained for issuing different farm machinery and implements to the indenter for carrying out farm operations.

14. Auction register

A number of farm produce and condemned items are generally auctioned for disposal purposes. The auction register consists of the name and address of bidders, their signatures with date, security money deposited and the final bid for auction.

15. Cash deposit register

The farm produce of perishable and semi- perishable nature are often sold by the farm section on daily basis. The proceeds obtained from sale of the farm produce has to be recorded in the cash deposit register. In this case the entries consists of serial number, name of produce, quantity sold, rate of selling price, amount received, cash memo number and date.

16. Cash book register

It consists of the details of cash memo book received and used for sale of farm produce.

B. RECORDS RELATED TO CAPITAL

Capital is required for carrying our different farm operations for the whole year. The money used for purchase of different items required for daily operations are recorded in following two types of registers:

1. Imprest register

A particular amount of imprest money is allotted to the farm section which is used for daily purchase or repair of items which are needed urgently. The bills of

purchased/ repaired items are then submitted to the drawing and disbursing officer for adjustment purpose. This register consists of entries as per the details mentioned below:

Sl. No.	Date	Particulars	Bill No.	Date	Value	Amount paid	Voucher submitted	Balance	Remarks	Signature

2. Advance register

When the urgently needed item is not purchased/ repaired from the imprest money, advance money is obtained, the details of which are mentioned in this register.

C. RECORDS RELATED TO LABOUR/CONTRACTUAL/ JOB CONTRACT

1. Muster roll register

This register consists of the details of labour used on daily basis. The entries in this register are 'P' for Present, 'A' for Absent, 'R' for rest and 'L' for leave for each labour. At the end of the month the total unit is added and then multiplied by the rate for calculating final payment. Signature and remarks columns are also there in this register.

2. Daily allotment register

Based on the availability of the labour, indenting scientists/ officers are allotted labours on need basis for conducting daily farm operations. However, at present the job contract is being given and records related to job contract are maintained.

3. Indent register for labour

In this register the records are maintained pertaining to indent given by different scientist/officers for labour requirement in the agricultural operations to be performed. Based on the indent, the labour contractor is issued slips of labour allotment to the indenting scientist/officers for performing agricultural operations on the succeeding date.

4. Work verification register

After the completion of a particular agricultural operation, the indenting scientist/ officer verifies the satisfactory work completion report which is recorded as per the format given below:

Sl. No.	Field no.	Work description	Date of indent	Work completion date	Unit area	No. of operation	Total unit	Work completion report	Signature of Scientist/ Officer

5. Bill entry register

On the basis of satisfactory work done by the labourers, the labour contractor raises bills for payment. These bills after verification are sent to the concerned section for payment. The details of bills verified for payment are kept in the bill entry register.

D. OTHER RECORDS

1. Repair register

The farm unit maintains a number of implements, machineries, tubewells, etc. which oftenneed periodic repair for proper maintenance. The repair register consists of details of the repair work performed for different implements, etc.

2. Daily tools allotment register

The labourers working on the farm are issued small hand operated tools like sickles, spades, etc. daily in the morning to perform the designated field operations. These tools are returned by the labourers to the farm office daily in the evening. The details of issuance and receipt of these tools are maintained in the daily tools allotment register.

3. Register of file records

This register is essentially a record of records. Since there are so many registers/ records maintained in the farm office, sometimes it becomes difficult to locate a particular register if proper indexing is not done. It is always necessary to keep a record of all the files concerned with different aspects of farm management. Some of the files which are generally maintained in the farm office are as follows:

1. Repair file
2. Farmer planning file
3. Contract file
4. Field allotment file
5. RTI file
6. Theft file
7. Imprest file

8. Contingency/ Advance file
9. Tender file
10. Electricity bill file
11. Farm produce price fixation file
12. Auction file
13. Sanction file of contractual bill
14. Audit file
15. Tractor insurance file
16. Circular file
17. Correspondence file
18. Tubewell file

Log Books:

1. Log book for tractor
2. Log book for power tiller
3. Log book for diesel engine
4. Log book for pump/ tubewell house

Chapter 20

Record Keeping in Dairy Farm

Ajayvir Singh Sirohi

Record keeping is a key operation on dairy farms. Only with realistic records can the farm manager judge his production, keep an account of the expenditure and income, and determine whether his operation is profitable. It also helps to provide adequate information for breeding and genetic improvement of the animals. Moreover, records form the basis on which we can make the planning for future requirements of the farm.

Broadly, records of dairy farms comprise two types, technical records which deal with performance of animals and business records which deal with purchase, disposal, accounts etc. The technical records are generally prepared first on the daily diary and then transferred to the respective permanent record / register.

ADVANTAGES OF RECORD MANAGEMENT

1. Records provide basis for evaluation of animals
2. These help in selection and culling of animals
3. These help in systematic breeding programme and progeny testing of bulls
4. These help in preparation of pedigree and history sheet of animal
5. These help in fixing price of animal for sale and purchase
6. These help in ascertaining the income and expenditure (economics) of animal farm
7. These help in determining the cost of milk production

TYPES OF FARM RECORDS

A. Cattle Section Records

1. Daily report diary
2. History and pedigree sheet
3. Livestock register
4. Milk record register
5. Calf feeding register

6. Cattle feed receipt register
7. Feed and fodder register
8. Breeding and calving register
9. Health register
10. Bull assignment register
11. Weight register

B. Farm Section Records

1. Labour sheet
2. Muster roll
3. Machinery and implement book
4. Tractor register
5. Field register
6. Fodder cultivation record

C. General Records

1. Ledger
2. Cash book
3. Purchase register
4. Bill payable book
5. Inventory register
6. Store stock book
7. Attendance and pay record

The records are maintained in the following forms:

1. Bound register
2. Loose leaf system
3. Envelope system
4. Computerized system

These records are maintained according to either calendar year or financial year.

STUDY OF RECORDS

The records are analysed for calculation of economic traits at farm. The performance of the farm can be judged by interpreting these traits.

1. Wet average = $\frac{\text{Total milk production}}{\text{Total number of milch animals}}$

2. Herd (dry) average = $\frac{\text{Total milk production}}{\text{Total number of milch + dry animals}}$

3. Average number of services per conception:

Average service per conception for a herd is a measure of fertility in animals which were reproductive successes and have become pregnant. Poor levels of fertility may be due to inaccurate oestrous detection. Improper techniques for artificial insemination may also lead to average services per conception greater than 2.0.

4. Conception rate:

Conception rate is a measure of a animal's fertility at service. It is calculated by dividing the number of pregnant animal by the total number of inseminations.

5. Average calving interval:

a) = Service period + gestation period

b) = Lactation period + dry period

The service period / days open period should not exceed 80-85 days if a calving interval of 12 months is to be achieved. It is the part of the calving interval that can be shortened by improved herd management. Calving interval has been extensively analysed and reported. It is probably the best index of a cattle herd's reproductive efficiency.

6. Reproductive efficiency = $\frac{\text{12 x Number of calves born x 100}}{\text{Age of cow (m)-age at first breeding (m) + 3}}$

FORMATS OF DIFFERENT TYPES OF SOME IMPORTANT RECORDS

Livestock Register

Sl. No.	Date of entry / Purchase	Purchased/ transferred from	Particular of animal	Brand number allotted	Sex	Dam No.	Sire No.	Date of disposal	Remarks

Young stock / birth register

Sl. No.	Date of birth	Calf No.	Sex	Birth weight	Colour	Sire No.	Dam No.	Date of disposal	Remarks

Mortality register

Sl. No.	Animal No.	Sex	Date of birth	Date of death	Cause of death	Post mortem report No.	Remarks

Permanent stock / inventory register

Sl. No.	Date	Particulars	Voucher / Invoice No.	Cost (Rs)	Receipt	Issued	Balance in stock	Remarks

Cash book register

Receipts						Payments					
Date	Name of particular	Folio	Discount	Cash	Bank	Date	Name of particular	Folio	Discount	Cash	Bank

Daily feeding register **Month_____, 20___**

Date	Number of animals	Concentrate (kg)			Green fodder			Dry fodder			Other feed		
		Received	Issued	Balance	Received	Issued	Balance	Received	Issued	Balance	Received	Issued	Balance

Daily milk production register

Sl. No.	Animal No.	Date of calving	1		2		3		31		Total milk in the month	Days in milk
			M	E	M	E	M	E	M	E		

Cattle breeding register

Cow No.	Date of calving	First service			Second service			Third service			PD Date and its result	Expected date of calving	Date of calving	Sex of calf	Weight of calf	Number of calf	Remarks
		Date of service	Time of service	Bull No.	Date of service	Time of service	Bull No.	Date of service	Time of service	Bull No.							

Cattle History and Pedigree Sheet

Identification of the animal	Date of birth or date of purchase and age of purchase	Sir No	Dem No 1 2 3 4 5	Paternal grar
			Dam's milk yield	1st L.Y
			Dam's lactation length	1st L.I
			Dam's days dry	

Growth

	1	2	3	4	5	6	7	8	9	10	11	12					
18	19	20	21	22	23	24	25	26	27	28	29	3					
36	37	38	39	40	41	42	43	44	45	46	47						
13	14	15	16	17	18	19	20	21									

REPRODUCTION AND PRODUCTION

SERVICE CALVING

S.No.	Bull No.	Date	Date	Sex of calf	Weight of dam at calving	Total	300 days	Lactation length	Date dried	Days dry	P y
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Immunization and health test record

Date	Immunization		Health Test		
	Against What disease	Remarks	For what disease	Results	Remarks

General In

Record all veterinary peculiaritie

Date

Annexure I

ROLE OF ESSENTIAL NUTRIENTS IN CROP DEVELOPMENT

There are seventeen plant food nutrients essential for proper crop growth and development. Each is equally important to the plant, yet each is required in vastly different amounts.

PRIMARY (MACRO) NUTRIENTS

Primary (macro) nutrients are nitrogen, phosphorus, and potassium. They are required in greatest quantity and most frequently by plants as fertilizer.

NITROGEN: Plants absorb nitrogen from the soil in three forms: nitrate (NO_3^-), Nitrite (NO_2^-) or Ammonium (NH_4^+).

Functions

- Necessary for formation of amino acids, the building blocks of protein
- Essential for plant cell division, vital for plant growth
- Directly involved in photosynthesis
- Necessary component of vitamins

Deficiency Symptoms

- Stunted growth due to reduced cell division and dormant lateral buds
- Chlorosis (yellowing of leaves)
- Suppressed or late flowering
- Increase in starch content but decrease in protein content
- Wrinkling of cereal grains
- Purple color appears in shoot axis

PHOSPHORUS: Soil contains phosphorus in organic and inorganic forms. Plant absorbs only inorganic forms of monovalent phosphate anions (H_2PO_4) and divalent phosphate anions $(H_2PO_4)^{2-}$. The organic forms will be available only after transformation into inorganic forms.

Functions

- Involved in photosynthesis, respiration, energy storage and transfer, cell division, and enlargement
- Promotes early root formation and growth

- Improves quality of fruits, vegetables, and grains
- Vital to seed formation
- Helps plants survive harsh winter conditions
- Increases water-use efficiency
- Hastens maturity

Deficiency Symptoms

- Purple or red pigmentation on leaves
- Premature fall of leaves and floral buds
- Delay in seed germination
- Older leaves affected first and become dark brown
- Stunted and slender stem in young plants

POTASSIUM: It is absorbed as potassium ion (K^+) and required in meristematic tissues, leaves and root tips. It accumulates in older leaves.

Functions

- Carbohydrate metabolism and the break down and translocation of starches
- Increases water-use efficiency
- Important in fruit formation
- Activates enzymes and controls their reaction rates
- Improves quality of seeds and fruit
- Improves winter hardiness
- Increases disease resistance

Deficiency Symptoms

- Mottled or marginal chlorosis followed by necrosis of leaf tips, margins and between veins
- Loss of apical dominance, leads to rosette or bushy habit
- Dieback of shoots i.e. progressive death from shoot tip towards base
- Increased tendency to lodging (bent to the ground) in corn

SECONDARY NUTRIENTS

The secondary nutrients are calcium, magnesium, and sulphur. For most crops, these three are needed in lesser amounts than the primary nutrients.

CALCIUM: Plant absorbs calcium from the soil in the form of Ca^{2+} ions.

Functions

- Utilized for continuous cell division and formation
- Involved in nitrogen metabolism
- Aids translocation of photosynthesis from leaves to fruiting organs
- Essential for nut development in peanuts
- Stimulates microbial activity

Deficiency Symptoms

- Stunted growth
- Chlorosis, downward hooking and deformation in young leaves
- Necrosis of young meristematic regions such as root tips or young leaves

MAGNESIUM: Like calcium, magnesium is also available in the soil in the form of exchangeable cation and absorbed by plant as Mg^{2+} ions.

Functions

- Key element of chlorophyll production
- Improves utilization and mobility of phosphorus
- Activator and component of many plant enzymes
- Influences earliness and uniformity of maturity

Deficiency Symptoms

- Chlorosis between the leaf veins
- Necrotic or purple spots on older leaves
- Premature leaf abscission
- Extensive development of chlorenchyma and scanty pith formation

SULPHUR: Plants obtain sulphur from soil as divalent sulphate anions (SO_4^{2+}). Atmospheric SO_2 and SO_3 are also absorbed directly.

Functions

- Integral part of amino acids
- Helps develop enzymes and vitamins
- Promotes nodule formation in legumes
- Aids in seed production
- Necessary in chlorophyll formation (though it isn't one of the constituents)

Deficiency Symptoms

The sulphur deficiency symptoms are similar to those of nitrogen deficiency because sulphur and nitrogen are constituents of proteins.

- Chlorosis of younger leaves
- Stunted growth
- Accumulation of anthocyanin
- Terminal bud growth inhibited
- Lateral buds develop prematurely

MICRONUTRIENTS

The micronutrients are boron, chlorine, copper, iron, manganese, molybdenum, nickle and zinc. These plant food elements are used in very small amounts, but they are just as important to plant development and profitable crop production as the major nutrients. These elements work "behind the scene" as activators of many plant functions.

BORON: Boron is absorbed by plant roots in its ionic form such as $B_4O_7^{2-}$, $H_2BO_3^-$, HBO_3^{2-}, BO_3^{3-}.

Functions

- Essential in germination of pollen grains and growth of pollen tubes
- Essential for seed and cell wall formation
- Promotes maturity
- Necessary for sugar translocation

Deficiency Symptoms

- As with other immobile elements, symptoms first appear on new leaves
- The well known internal cork of apple is caused by a deficiency of this element
- In citrus the peel is uneven in thickness
- Thick and shorter roots, flower abortion and sterility
- The branches and new growth are distorted, thick, and brittle; also the upper foliage exhibit a mottled chlorosis (i.e. scattered yellowing of leaves).

CHLORINE: Chlorine is absorbed as chloride ion Cl^-.

Functions

- Enhances maturity of small grains in some soils

- It plays important role in opening and closing of stomata.

Deficiency Symptoms

- Wilting due to a restricted and highly branched root system
- Leaf mottling and leaflet blade tip wilting with chlorosis

COPPER: Copper is absorbed by plants as the cupric ion Cu^{2+} and may be absorbed as a salt of an organic complex such as EDTA.

Functions

- Catalyzes several plant processes
- Major function in photosynthesis
- Major function in reproductive stages
- Indirect role in chlorophyll production
- Increases sugar content
- Intensifies color
- Improves flavor of fruits and vegetables

Deficiency Symptoms

- Cu deficient soils may have losses of 20 per cent or more in grain yield while not showing any typical visual symptoms of copper deficiency.
- Crop maturity can also be delayed by 7-14 days, resulting in greater foliar disease instances and a much greater risk of frost injury to the maturing grain.

IRON: Iron may be absorbed by the root of plants in ionic form. It is also absorbed by leaves when Iron sulphate and complex iron compounds are applied to the crop.

Functions

- Promotes formation of chlorophyll
- Acts as an oxygen carrier
- Reactions involving cell division and growth

Deficiency Symptoms

- Iron deficiency, also called iron chlorosis or lime chlorosis, starts with a yellowing of the leaves in between the dark green veins, giving the leaves a spidery look. Over the time, the leaves become whitish and start to die back, eventually resulting in stunting and dying back of the entire plant

MAGANESE: Manganese (Mn) is an important plant micronutrient and is required by plants in the second greatest quantity compared to iron. Like any other element, it can have a limiting factor on plant growth if it is deficient or toxic in plant tissue. It is similardeficiency to iron in many ways.

Functons

- Manganese is used in plants as a major contributor to various biological systems including photosynthesis, respiration, and nitrogen assimilation.
- Manganese is also involved in pollen germination, pollen tube growth, root cell elongation and resistance to root pathogens.

Deficiency Symptoms

- Manganese deficiency symptoms, which often look like those of iron deficiency, appear as interveinalchlorosis (yellow leaves with green veins) on the young leaves, and sometimes tan, sunken spots that appear in the chlorotic areas between the veins.
- Plant growth may also be reduced and stunted.
- Manganese deficiency can occur when the pH of the growing medium exceeds 6.5, because it is tied up and unavailable for uptake.
- Manganese toxicity symptoms begin with the burning of the tips and margins of older leaves or as reddish-brown spots across older leaves. Severe toxicity may result in spots becoming more numerous and larger, forming patches on the older leaves.

MOLYBDENUM: Molybdenum plays important role in the function of enzymes.

Functions

- Required to form the enzyme “nitrate reductase” which reduces nitrates to ammonium in plant
- Aids in the formation of legume nodules
- Needed to convert inorganic phosphates to organic forms in the plant

Deficiency Symptoms

- The main symptoms of molybdenum deficiency cereals are stunting and failure of leaves todevelop a healthy dark green colour.
- The leaves ofaffected plants show a pale green or yellowish greencolour between the veins and along the edges.
- Inadvanced stages, the leaf tissue at the margins of theleaves dies. The older leaves are more severely affected.

ZINC: Zinc is an essential micronutrient but is required in very small quantities.

Functions

- Aids plant growth hormones and enzyme system
- Essentially required for chlorophyll production and seed fromation
- Necessary for carbohydrate formation

Deficiency Symptoms

- Chlorosis - yellowing of leaves; often interveinal; in some species, young leaves are the most affected,but in others both old and new leaves are chlorotic
- Necrotic spots - death of leaf tissue on areas of chlorosis
- Bronzing of leaves - chlorotic areas may turn bronze coloured
- Rosetting of leaves – zinc deficient dicotyledons often have shortened internodes, so leaves are clustered on the stem
- Stunting of plants - small plants may occur as a result of reduced growth or because of reduced internode elongation;
- Dwarf leaves (‘little leaf’) - small leaves that often show chlorosis, necrotic spots or bronzing remain dwarf
- Malformed leaves - leaves are often narrower or have wavy margins.

NICKEL: In the past, nickel (Ni) was not considered an important element for plant growth, but research has concluded that it is an essential element for plant growth. The normal range for nickel in most plant tissue is between 0.05-5 ppm.

Functions

- Nickel is a component of some plant enzymes, most notably urease, which metabolizes urea nitrogen into useable ammonia within the plant. Without nickel, toxic levels of urea can accumulate within the tissue forming necrotic legions on the leaf tips. In this case, nickel deficiency causes urea toxicity.
- Nickel is also used as a catalyst in enzymes used to help legumes fix nitrogen.
- There is evidence that nickel helps with disease tolerance in plants, although it is still unclear how this happens.

Deficiency Symptoms

- Minor nickel deficiency displays no visual symptoms, but can reduce growth and yield of plants.
- Significant nickel deficiency will display visual symptoms typically in the old leaves of the plants as nickel is a mobile element.
- Deficiency symptoms in legumes are exhibited as whole leaf chlorosis along with necrotic leaf tips (caused by the accumulation of toxic levels of urea).

Annexure II

GUIDELINES FOR DISPOSAL OF FARM PRODUCE*

Farm produce of the Institute/Centres (under Indian Council of Agricultural Research) such as rice, wheat, milk products, potato, fruits etc. will be disposed as per following procedure:

(a) In Institutes carrying on educational activities and having hostel/co-operative messes/canteens attached with the Institutes, requirement of these shall be met before the produce is distributed to other members of the staff. Similarly, the requirement of Guest house/Scientists Home (like the visiting Scientist's Hostel at the Institute) shall also be given preference.

(b) If possible, the produce shall be sold to the staff according to their requirements. However, if the quantity available is not sufficient to meet full demand of all, the Director shall ensure that the produce is distributed equitably among the staff so that all categories of staff get reasonable share.

(c) The price of the commodity shall be decided by the Price Fixation Committee taking into consideration the prevailing rate as certified by the Civil Supplies Department. The price so fixed shall be reviewed quarterly in consultation with the Civil Supplies Department of the state concerned.

(d) If any surplus produce is left over after meeting the demand of the staff, the balance shall be disposed off through public auction.

(e) In respect of commodities under statutory rationing, the Director shall ensure that the rules of Civil Supplies Department are adhered to strictly.

**Source: ICAR Establishment & Administration Manual Chapter 34 (34.20.)*

Annexure III

LIST OF CONTRIBUTORS

Sl. No.	Details
1.	Dr. A.S. Panwar Director ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
2.	Dr. Brijendra Singh Professor and Head (Retd.) Department of Agricultural Economics and Management, S.V. Patel University of Agriculture & Technology, Modipuram, Meerut- 250110
3.	Dr. H.L. Singh Assistant Professor (Agril.Economics) S.V. Patel University of Agriculture & Technology, Modipuram, Meerut- 250110
4.	Dr. Raghvendra B. Yadav Professor, Department of Agronomy S.V. Patel University of Agriculture & Technology, Modipuram, Meerut- 250110
5.	Dr. Sanjeev Kumar Scientist (Agronomy) ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut - 250110 (UP)
6.	Dr. Poonam Kashyap Scientist (Fruit Science) ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut - 250110 (UP)
7.	Dr. Chandra Bhanu Scientist (Plant Pathology) ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut - 250110 (UP)
8.	Dr. Nisha Verma Scientist (Family Resource Management) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut- 250110 (UP)
9.	Dr. Mahesh Kumar Principal Scientist (Animal Physiology) Central Institute for Research on Cattle, Meerut - 250001(UP)
10.	Dr. S. Malik Principal Scientist (Poultry Science) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)

Sl. No.	Details
11.	Dr. Peyush Punia Principal Scientist (Fish Resource Management) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
12.	Dr. N. Ravisankar Principal Scientist (Agronomy) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
13.	Dr. A. K. Prusty Scientist (Aquaculture) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
14.	Dr. Amit Nath Principal Scientist (Food Technology) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
15.	Dr. Mohammad Shamim Scientist (Agro-Meteorology) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
16.	Dr. Harbir Singh Principal Scientist (Agricultural Economics) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
17.	Dr. Anil Kumar Principal Scientist (Agricultural Extension) ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
18.	Dr. Vinod Kumar Sr. Technical Officer ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
19.	Dr. O.K. Tomar Asstt. Chief Technical Officer ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
20.	Sh. Chet Ram Retd. Farm Manager ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut -250110 (UP)
21.	Dr. Ajayvir Singh Sirohi Senior Scientist (Livestock Production Management) Central Institute for Research on Cattle, Meerut - 250001(UP)