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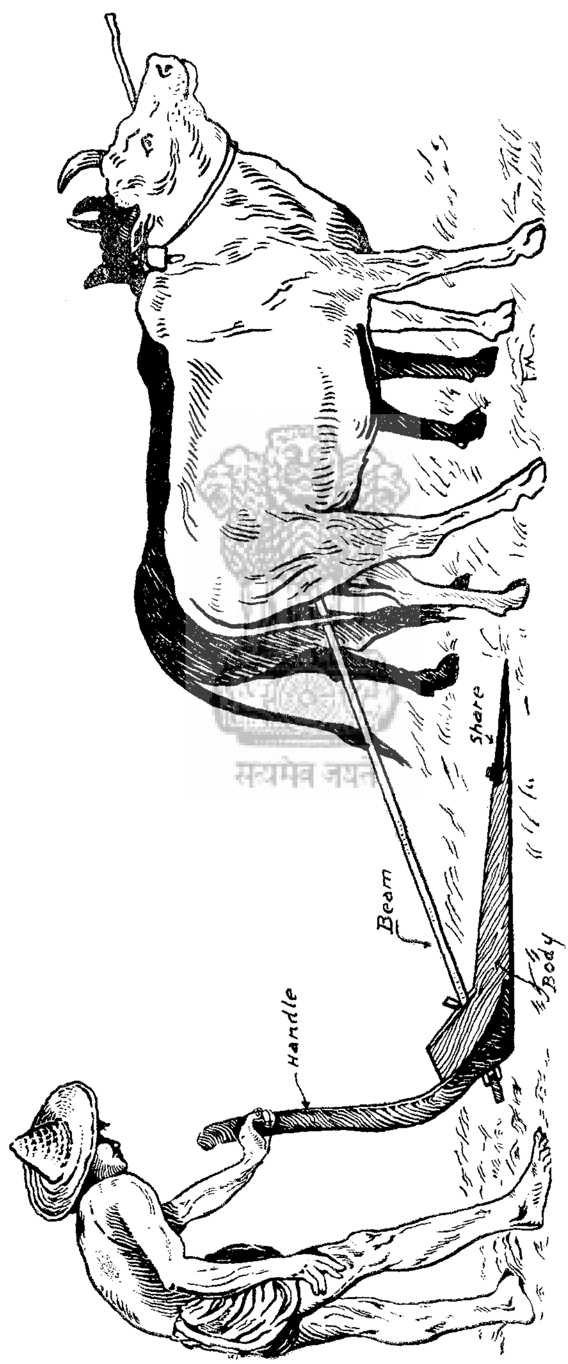

Hal or Har or Langal

PRINCIPLES

OF

AGRICULTURE FOR BENGAL.

BY

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CALCUTTA:

THE BENGAL SECRETARIAT BOOK DEPOT.

1911.

[*Price—Indian, Rs. 3; English, 4s. 6d.*]

ublished at the BENGAL SECRETARIAT BOOK DEPÔT,
Writers' Buildings, Calcutta.

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PREFACE

THIS book has been written at the instance of the Directors of Public Instruction and Agriculture, Bengal. with a view to ameliorate the teaching of elementary agriculture in Zilla and Collegiate Schools in Bengal. There existed hitherto no simple text-book in this Province for the use of such pupils. Those in existence were intended for more advanced students. This book is meant primarily to teach the scientific principles underlying a rational system of agriculture, and throughout an effort has been made to present the truths of science in connection with agriculture in simple language. All difficult words are explained in a glossary at the end of the book. It is not intended to be learnt by heart, and if the teacher intelligently expounds the text and the pupils read the chapters carefully, they ought to be able to easily remember the resumés and to answer all the questions at the end of each chapter.

Up to now, teaching of agriculture included work in school gardens; but where this is impossible, the school should possess a chest containing wide stoppered bottles for holding samples of soil-forming rocks, such as quartz, felspar, mica, etc. (page 22), loam, clay, sand, marl soils, example manures (see text), and seeds of all the crops described in the book.

Before teaching the chapter on germination, the pupils should germinate a few beans on a piece of damp flannel, and they should describe what they see after the teacher has explained germination

The teaching of this book is intended to be a two years' course, and the first four chapters should be thoroughly understood before going on to the other chapters, which are of a more practical nature.

This book has been read and criticised by Mr. P. B. Mukerjee Inspector of Schools, Presidency Division, Bengal, and he finds that it answers the purpose for which it is intended.

CALCUTTA, F. SMITH.

The 28th March 1911.

PRINCIPLES OF AGRICULTURE FOR BENGAL.

SYLLABUS OF CHAPTERS.

CHAPTER I.—Introductory Remarks. (*A*) What is Agriculture? (*B*) Factors in Agriculture—Soil, plant atmosphere, sunshine. Resumé Questions.

N.B.—The teacher should demonstrate with examples and by actual experiments (in wide mouthed glass bottles, &c.).

CHAPTER II.—(A) Plant Life—

(*i*) General description of a plant. Kind of plants—Annual, biennial, perennial. Parts of a plant—Root, stem, leaf, flower, fruit. Germination ; essentials of germination.

(*ii*) The functions of the parts of a plant—(1) seed, (2) root, (3) stem, (4) leaf, (5) flower, (6) fruit.

(*iii*) Composition of plants—(1) water, (2) dry matter—(*a*) combustible, (*b*) incombustible or ash, (3) essential ingredients, (4) non-essential ingredients.

N.B.—The teacher should illustrate with examples.

CHAPTER III.—Plant food—

(*i*) (1) Soil, (2) air and rain, (3) water and sunshine.

(*ii*) How plants feed and develop.

(*iii*) Most important elements of plant-food.

(*iv*) Nitrification.

CHAPTER IV.—Soils—

Part I—(*i*) General description of soil and sub-soil.

(*ii*) Formation of soils—

(1) Weathering of the earth's crust.

(2) Action of changes of temperature.

(3) Action of vegetation.

(4) Action of water.

(5) Action of frost.

(6) Action of animal and insect life.

Part II—(*A*) Composition of soils.

(*B*) Classification of soils—

(1) Indigenous and transported soils.
(2) Classification according to—

(*a*) Composition.
(*b*) Texture.
(*c*) Moisture.
(*d*) Temperature.
(*e*) Fertility.
(*f*) Crops grown.

(*C*) Brief and simple account of the soils of Bengal.

N.B.—The above to be taught as far as possible by ocular demonstration in the fields, specific example under each head being shown to the students.

CHAPTER V.—Preparation and improvement of soils—

Part I—Tillage—(*a*) its objects, (*b*) its effect on the physical character of the soil moisture evaporation capillary action, (*c*) implements of tillage—

(1) Plough.
(2) Harrow.
(3) Roller.
(4) Spade.
(5) Hoe.
Eastern and western implements contrasted.

Part II—Irrigation—

(*a*) Canals. Use of lever in lifting water. Method of working.

(*b*) Wells and tanks.

Part III—Drainage. Only surface drainage necessary in Bengal.

Part IV—Manures and manuring—

(*a*) Classification of general and special manures; natural and artificial manures.

(*b*) Composition and values.

(*c*) Great importance of conserving farm-yard manure in India—pitting with urine and protecting from sun.

(*d*) Applications.

(*e*) Green-manuring.

(*f*) Lime and liming.

N.B.—The teacher must demonstrate in the field.

CHAPTER VI.—The growing of crops—

(*i*) What crops to grow?

(*ii*) Plant selection for seed and change of seed; the paramount importance thereof.

(*iii*) Seed and its sowing (*a*) by hand, (*b*) by drill.

(*iv*) Rotation—(*a*) advantages; (*b*) reasons for; (*c*) rules for; (*d*) examples of.

(*v*) Fallowing—*Bare and green.*

(*vi*) Weeds, fungus and insect-pests and their preventions.

(*vii*) Harvesting, threshing, winnowing and storing.

N.B.—The teacher must give practical illustrations.

CHAPTER VII.—Particular crops—

(*i*) Paddy—(*a*) aus, aman, boro; (*b*) preparation of land, (*c*) seed, and selection thereof; (*d*)—

(1) Sowing time.

(2) Quantity of seed to sow.

(3) Manures.

(4) After-cultivation.

(5) Harvesting.

(6) Yields.

(*ii*) Jute—yields.

(*iii*) Sugarcane—yields.

(*iv*) Wheat, barley, oats—yields.

(*v*) Pulses and leguminous crops—yields.

(*vi*) Maize—yields.

(*vii*) Millets—yields.

(*viii*) Oilseeds—yields

(*ix*) Fodder crops—yields.

(*x*) Vegetable culture, increasing importance of in India, potatoes, carrots, turnips, cabbages.

(*xi*) Most useful fruit trees.

N.B.—Examples to be grown by the students.

CHAPTER VIII.—Live-stock—

Farm cattle—

(*a*) Selection of farm cattle for plough work.

(*b*) Housing.

(*c*) Feeding.

(*d*) Working.

CHAPTER IX.—Model School Gardens in Bengal.

CHAPTER I.

INTRODUCTORY REMARKS

[To be read in class. All new words must be explained by the teacher.]

What is Agriculture ?—Agriculture, from the Latin words *ager*, a field, and *cultura*, culture, is the term applied to the oldest form of productive activity of mankind. Its *rudiments* were the act of gathering wild fruits and berries and wild roots for food, and the heaping together of dry leaves and *moss* to make a sleeping place as practised by *prehistoric* man some thousands of years ago. From these *crude* elements, which are still the only form of agriculture of certain tribes of Central Africa and Polynesia, it has developed itself into a wonderful art which, if intelligently applied, is able to transform impenetrable forests into productive meadows by *tillage*, and deadly *swamps* into pleasant gardens by means of *drainage;* and with *irrigation* the agriculturist entices vegetation where before there were only sandy wastes and stones. Moreover, by good manuring an intelligent cultivator is able to get ten *maunds* paddy more per acre from his field.

The primary object of agriculture is the production of food from the soil, either for man's consumption or for cattle consumption. It cannot be called a pure science, because the laws regulating all the *phenomena* of cultivation have not been formulated, but it is very closely allied to natural sciences like chemistry, botany, meteorology, zoology and geology. In fact, the intelligent agriculturist is only able to deal with all the problems of cultivation by keeping in touch with the abovenamed sciences.

To call agriculture merely an *industry* does not give a just idea of its vast sphere of possibilities.

In its present state of advancement *agriculture may best be said to be the art of applying science to the production of food from the land.* Eventually it may become a science with fixed laws like physics, geology, etc , but it is yet far away from that state.

Men who take up agriculture as a profession, or simply go on tilling the field or fields left to them by their fathers, are called, as the case may be, *agriculturists, cultivators, farmers*, peasants or husbandmen. *Agriculturist* is rather a new term and it implies that the man tills his land in a more scientific manner. A farmer is a man who manages a farm in view of raising crops either for the market or for his own consumption and that of his cattle. *Peasant* is an old term whose real meaning was "*man of the land*" or of the country and became synonymous with cultivator or farmer (raiyat), as the tillage of the field was then the general occupation in contradistinction to mercenary soldiering.

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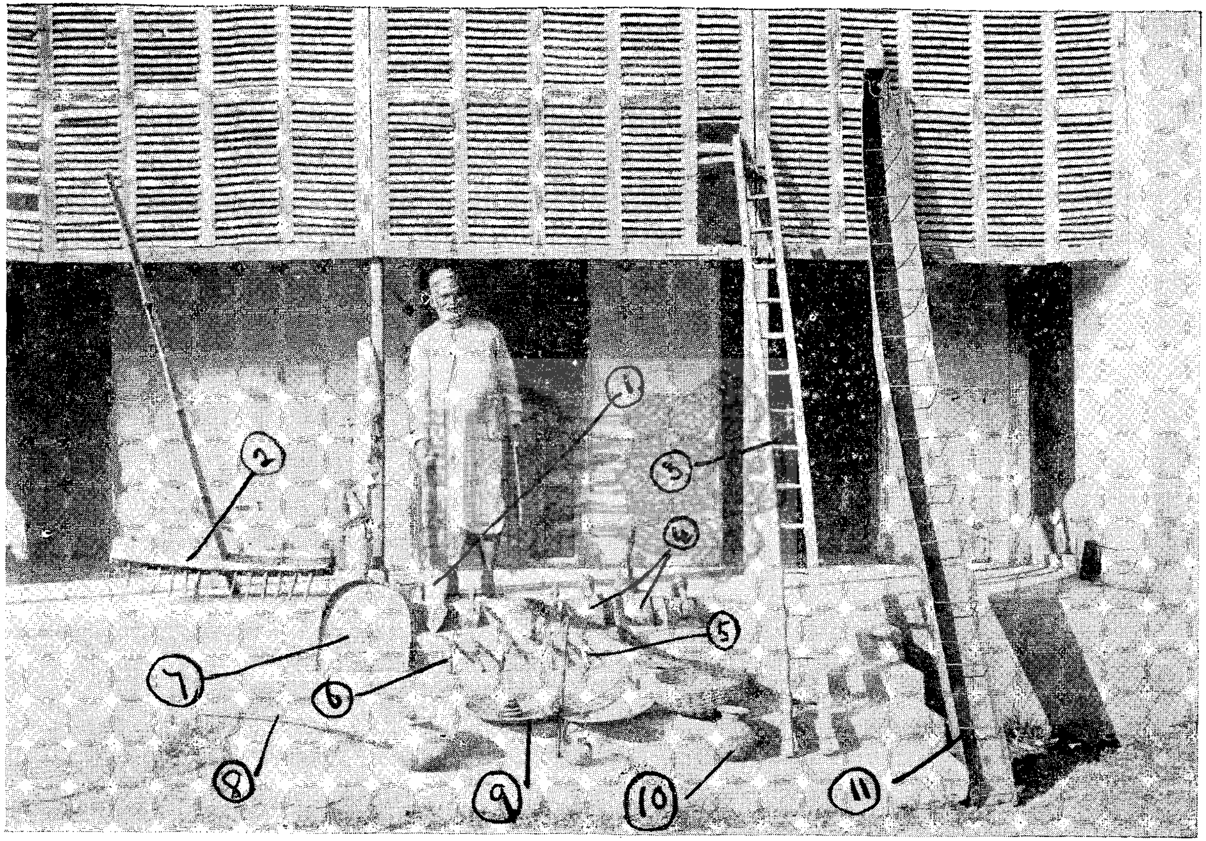

Agricultural Impliments—Burdwan.

1. Burdwan Plough.
2. Bhida or Rake.
3. Hangar or Ladder.
4. Kodali.
5. Khurpi.
6. Sickle.
7. Winnowing basket.
8. Crowbar.
9. Scales.
10. Serai or Earthen pot.
11. Dōn.

The *cultivator* is the man who takes up agriculture as a profession, but devotes his cares to the raising of one or more special crops. *A crop* is the sum total of a certain species of plant grown on a given area.

Again, according to the special plants that the agriculturist raises from the land, he may be called *horticulturist* or *gardener* if his special branch is the growing of vegetables, flowers and fruits to the exclusion of fodder crops or cattle food. If he devotes his time and abilities to the controlling, cleaning, thinning of forests and to the growing of trees for timber, his form of agriculture is called *forestry* and becomes "*animal husbandry*," when he only looks upon agriculture as the factor by means of which he can get fodder for fattening and breeding purposes.

Finally, ideal agriculture is that which will provide the farmer with all what he wants, viz., food from plants giving breadstuffs (cereals), milk, eggs, meat and wool from the stock living on his farm and money from the selling off of surplus products which will enable him to buy other necessities of life and a few luxuries. As recorded by history, agriculture held a place of honour in all the ancient nations; in fact, it was considered to be the most honourable profession.

In the *Manu Samhita*, one of the ancient Hindu *shastras* (Sir William Jones, it is said, took the *Vedas* as having been composed 1,580 years before the Christian era, and according to him the *Manu Samhita* was composed 300 years after the *Vedas*), it has been laid down that the Vaishyas should attend to agriculture. The Creator made over the cattle to the Vaishyas, who should not therefore consider the keeping and tending of animals to be derogatory. The Vaishyas should know how to sow seeds so that a good harvest may be obtained; they should also have a knowledge of the fertility of soils, and of weights and measures. It is also their duty to be competent judges of wages of servants (cowherds, ploughmen) and to be familiar with the languages of various races of men for the purpose of commerce.

The priests of ancient Egypt, Assyria, Mesopotamia, Greece and Rome had certain days in each season fully consecrated to the various deities presiding over the destinies of agriculture. History teaches us that nations grew in importance, not when engaged in warfare and destruction, but when peace allowed the cultivator to plough his fields The oldest emblem which represents agriculture is the *plough*, and the plough may well be said to have cut open the first furrow in the field of our modern civilisation. It is a good sign of the times that learned pandits in some parts of Bengal have of late insisted upon the importance of agriculture and given it as their opinion that the pursuit of agriculture is not inconsistent with high caste.

Again, according to the nature of the country and its climate, the agriculture of various latitudes is different, varying from the fields of rye that the inhabitants of northern countries raise with difficulty from the half frozen soil to the sumptuous vegetation of tropical regions like Bengal or the valley of the Amazon, and to the fir-covered slopes of Canada, or the flooded rice fields of the Ganges valley, with its antediluvian looking buffaloes ploughing the submerged areas. Thanks to the diversity of climates, soils, etc., what one agricultural area produces of surplus is sent to other parts, which in their turn produce and send away their surplus production, thereby giving rise to commerce and transportation.

Factors in Agriculture? Now if we are satisfied with the definition of agriculture as "the art of producing food," its factors are now to be defined, classified and studied. These factors are soil, plant, atmosphere, sunshine.

What is the soil? The soil is for the agriculturists that solid portion of the globe which is capable of affording an habitat for plants. A plant is a living organism which is able to transform dead or inorganic matter into organic matter.

The Atmosphere is the gaseous part of the globe which encircles it and is the general store of oxygen and nitrogen without which no living organism can exist. It is also the place where all meteorological phenomena which affect plant life take place; *viz.*, the formation of clouds, rain, hail, etc

Sunshine is the outward agency which produces the congenial temperature for plant life.

We have placed these three factors in a given order; the soil before the plant as inorganic matter was pre-existant to organic matter. Sunshine is taken last, although it is of paramount importance as a life-giver. In Lower Bengal, like in every other tropical country, vegetation is so exuberant, with its everlasting green foliage, that it takes a first place in the mind of the observer.

Our first chapter is therefore devoted to plants. Soil as being the dwelling place of plants comes second.

Trees and general vegetation were only able to grow after plant life of a lower order like lichens, mosses and ferns had accumulated enough organic matter.

INTRODUCTORY.

Resumé I.

Agriculture is the most important form of activity of man; its aim is the production of food from the soil.

It was held in honour by all ancient nations. Men devoting their time to agricultural pursuits are called agriculturists, cultivators, farmers, peasants. According to the special branch they choose, they are horticulturists or gardeners, foresters or cattle breeders. A *plant* is the unit of a crop. A *crop* is the sum total of a certain species of plant grown on a given area.

Questions.

What is the etymology of the word agriculture? What were its rudiments? Is it a new or an old occupation?

Can it be said to be a science? Can it be said to be an art? Can it to be said to be an industry?

What is it the most important form of activity of mankind?

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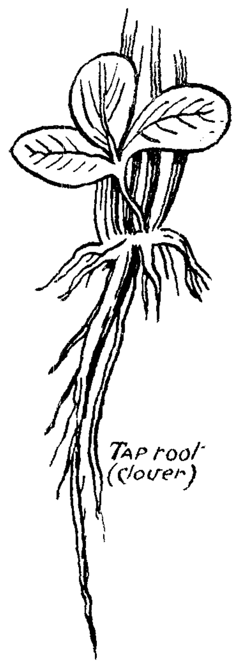
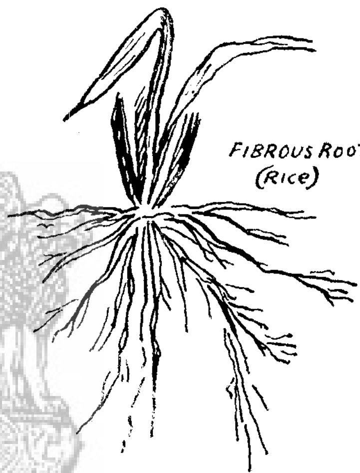
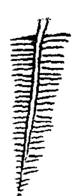
ROOTS.



Tap Root (Clover).



Fibrous Root (Rice).



Root Hairs Magnified.

To what sciences is it closely allied.
What is an agriculturist ?
What is a cultivator ?
What is a farmer ?
What is a peasant (raiyat) ?
What is horticulture ?
What is forestry ?
What is animal husbandry ?
What is ideal agriculture ?

Differences of climate, soils, and conditions giving different crops ; agriculture gives rise to what other activities ? What factors do we consider in agriculture ? Define these factors.

CHAPTER II.—PLANT LIFE.

PART I.—General descirption of a plant.

We said that agriculture was very closely allied to natural sciences. In this chapter on *plants* we freely borrow from botany and chemistry whatever is necessary to acquaint us with "What is a plant?" For the botanist a plant is a living organism which, broadly speaking, starts its life as a seed, develops roots, stem, leaves, flowers and fruit, and then dies. For the chemist it is a wonderful living laboratory which is capable of transforming inert or inorganic solid and liquid matter and gases into organic substances which are assimilated by man and beast and sustain their lives.

For the agriculturist a plant *is the unit of a crop, whether* it be cereal, fodder, vegetable or tree.

Leaving alone the study of classes, families and species into which the botanist classifies the 50,000 odd species of plants which exist, for the purpose of our study we will divide plants into three great groups—

1. Annual. 2. Biennial. 3. Perennial.

An *annual* is a plant which lives one year (cold countries) or one season. It flowers, produces seed and dies. Annuals produce more seed than any other plants.

Example.—Paddy, wheat, oats, mustard, poppy, &c.

A poppy produces 25 flowers and each flower produces 125 seeds.

A *biennial* is one which lives two years or two seasons (Bengal); the first year it manufactures and stores up food, usually in the form of starch in its roots or in its thickened stem. In the second year or season it flowers and produces seeds.

Example.—Turnips, cabbages, mangels, etc.

A *perennial* is one which lives three or more years. It seldom produces seed the first year, only a little the second year, and in the third year and afterwards the greatest quantity of seed. A perennial produces comparatively little seed.

Example.—Cocoanut tree, mango tree, litchi tree, etc.

These classes of plants multiply themselves—

1st—Annuals and biennials by seed only.

2nd—Perennial in two ways :—first by seed, and second by rootstock.

3. *Part of the plant.*—Whether annual, biennial or perennial, all plants (leaving out the algaes, mushrooms, litchens, mosses and ferns) consist of a root, a stem, buds, leaves and flowers.

1st.—The *root* is that part of the plant which fixes the plant to a definite spot and is generally hidden in the soil. It has neither

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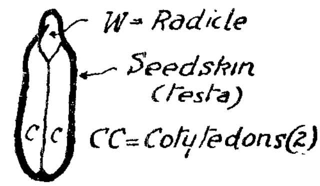
A



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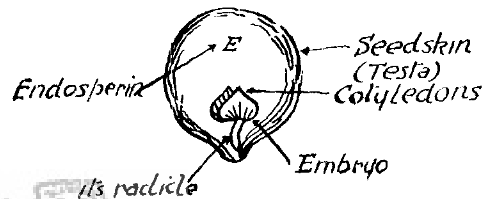
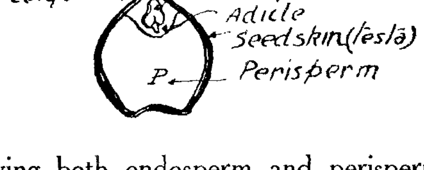


Almond (no endosperm cotyledons fill up the Seed).

Nux Vomica.

C



Piper having both endosperm and perisperm.

leaves nor reproductive *organs*. It is termed a *tap root*, when it runs straight down in the soil in a line with the stem in a downward direction. The tap root is said to be *conical*, in the case of carrot, *napiform*, in the case of turnip, and *tuberous*, in the case of the dahlia, orchids, etc. It is termed a *fibrous root* when it is very delicate and divided into many hair-like threads, like all grasses (*dhub*), rice, barley, wheat, etc.

The stem—Is that part of the plant, generally above ground, which serves to carry the leaves up towards the light and moreover is the support of the subsequent flowers and fruits.

The bud—Is that growth which appears on the stem or its dependencies (branches) and will develop into a leaf or a shoot or a flower.

The leaf—Is that well known part of the plant which carried by branches or the stem spreads its flattened structure in the air.

The flower—Is that part of the plant provided with organs which are necessary for the reproduction of the species.

The fruit—Is that part of the plant which contains the seed ready to reproduce the species.

A plant is cultivated.

For roots—

Examples.—Carrots, turnips; stems, sugarcane, potatoes, etc.; leaves, spinage, tobacco; fruits, plums, mangoes, kelas; seeds, common rice, wheat, etc.

Resumé II.

The most important factors in agriculture are—soil, plant, atmosphere, sunshine.

Soil—Is the solid portion of the globe in which plants live.

Plant is living organism which is able to transform inorganic matter into organic matter.

Atmosphere—Is the gaseous part of the globe composed chiefly of oxygen and nitrogen.

Sunshine—Is the agency which provides the necessary energy for plant life. A plant is a living organism which starts as a seed, develops stems, roots, leaves, flowers, fruits, and dies; it is capable of transforming inert matter into living matter; it forms the chief supply of food for man and beast.

An annual is a plant which lives one year.

A biennial is a plant which lives two years.

A perennial is a plant which lives many years.

The parts of a plant are root, stem, bud, leaves and flowers.

The *root* fixes he plant in the soil. Tap root runs straight in the soil. A fibrous root is made up of fibres or hair like threads.

Examples.—Conical, carrot; napiform, turnips, tuberous, orchids.

The stem—Carries the branches, leaves and flowers towards the light.

The bud—Appears on the stem or branches and becomes either a leaf, a flower or a shoot.

The leaf—Is that part of the plant which forms the foliage.

The flower—Carries the organs of reproduction. The fruit contains the seeds for reproduction of the plant.

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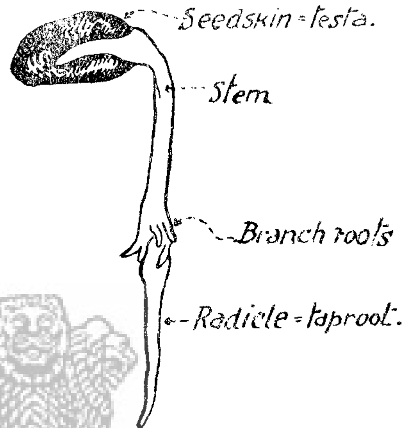
B

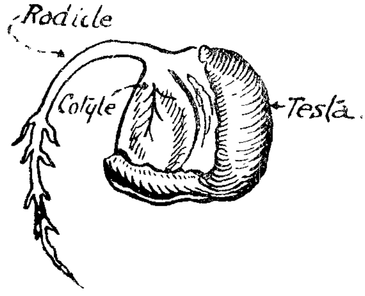


A

Bean.

A. Bean germinating.

B. Radicle completely out.



Germinating Seed of Wall-flower.

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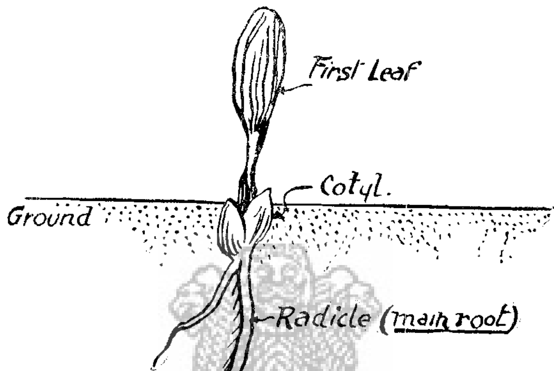
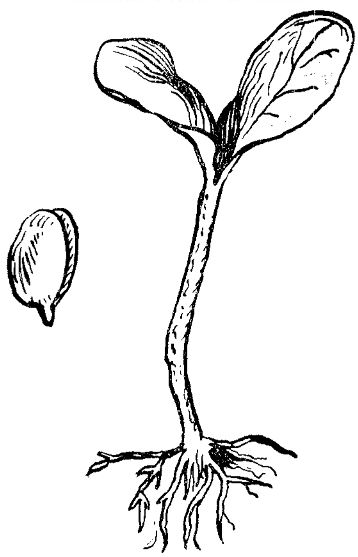
More Advanced Germination.





Plants are cultivated for—

Examples.—Leaves, spinage tobacco; roots, carrots; stems, sugar-cane, potatoes; fruits, mangoes; seeds, rice.

Question.—What are the four most important factors in agriculture? What is soil? What is plant? What is the atmosphere? What is sunshine? What is a plant? For the botanist? For chemist?

Which are the three groups into which plants are divided agriculturally? What is an annual, a biennial, and a perennial? How do they reproduce themselves? What are the parts of a plant? What is the root? What kinds of roots are there? What is the stem, the bud, the leaf, the flower, and the fruit? Plants are cultivated for what?

Germination.—(A few days before the lesson, place a few grains of beans or maize in water, let them germinate and show the students.) Plants usually start life as a seed. Every seed contains the rudiments (embryo) of a plant which can be recognised in the seed by the help of a microscope, one or two rudimentary leaves (cotyledons) folded up, a minute speck which develops into a stem and another white speck which will become the root; the remaining portion (when the cotyledons do not fill up the whole place) is filled up with concentrated food, designed to help the baby plant until it can prepare its own food from the soil, moisture and air. The whole baby plant or embryo and its food is enveloped in a protective seed-skin, the *testa*. When the seed is filled up with two cotyledons these two cotyledons contain the food which is generally in the form of starch or oil when on the contrary the embryo and its cotyledons are small; what surrounds them in the seed is called endosperm and constitutes the feeding bottle for the baby plant.

5. When conditions surrounding the seed are favourable, the baby plant, which may have been dormant for a long period, starts its growth: it germinates.

Essentials of Germination.—Three factors are essential for germination—

1st.—A suitable temperature.
2nd.—A proper degree of moisture.
3rd.—Air.

Changes occur within the seed during germination. The seed absorbs moisture and oxygen; it swells; heat is developed and carbonic acid gas or $C. O_2$. is given off and the soiled ingredients of the seed gradually become soluble; in fact, the baby plant digests them. The starch and fat yield sugar; the albuminoids (cereals) are converted into peptones and amides by the agency of ferments (enzymes) contained in the seed. With this the radicle and plumule are nourished, and the swelling going on causes the seed-skin to crack and split when the radicle or "little root" appears; after which the plumule or "little feather" comes forth. From the radicle roots are formed, and from the plumule stems and leaves are produced in due course of time. When all the conditions are satisfactory the roots, etc., soon begin their particular activities: the root starts absorbing food from the soil, the stem and leaf develop and in their turn discharge their special functions.

P.S.—It is important to see that the seed is not buried too deep when sowing because—

1st.—It will not get air, therefore no oxygen, and will not germinate.

2nd.—Because all the food inside the seed may become exhausted before leaves and roots are developed.

Resumé III.

Plants usually start life as a seed. Every seed contains an embryo, one or two cotyledons. Out of the embryo a root and a stem will be formed in course of time. The cotyledons contain the food for the embryo ; sometimes the cotyledons are large and fill up the whole seed, sometimes they are small and the food is contained within the seed, but not in the cotyledons ; it is then called endosperm.

Three conditions are essential for germination : a suitable temperature, air and a proper degree of moisture. When the seed germinates, it absorbs moisture and oxygen, it swells, and when the food contained in the seed is rendered soluble, the embryo absorbs it, grows, and when the seed-skin cracks the plumule (stem) and radicle (root) comes out ; when the food contained in the seed is all absorbed the young plant begins to absorb food from the soil.

Seed must not be buried too deep ; it will not get air enough, or the food in the seed will get exhausted before the plant has produced roots and leaves.

Questions.—What is contained in a seed ? What is the embryo ? What is a cotyledon ? How many ? What is the festa ? Where is the food stored ? When cotyledons are small ? Where is the food stored ? What is the endosperm. What occurs when a seed germinates ? Why does it swell ? What becomes soluble ? What are ferments what is given off ? When does the seed-skin crack ? What appears when the seed skin cracks ? What is the radicle ? What is the plumule ? Why must not seed be buried too deep ? Describe the whole process of germination.

PART II.—THE FUNCTIONS OF THE PARTS OF A PLANT.

Seed, root, stem, leaf, flower, fruit.

With the appearance of the radicle and plumule or root and stem the function of the seed is accomplished, the species of the plant is reproduced; therefore the function of the seed is to ensure the conservation of the species.

After germination, the development of the plant follows a regular course. The radicle grows into a root which is the chief feeder of the plant until the leaves appear.

Functions of the root.—

1st.—It is the support of the plant and keeps it firmly fixed in the soil.

2nd.—It nourishes the plant by taking up food from the soil in a liquid state and ensures an adequate supply of water, sufficient to maintain the turgidity of the plant in spite of continual loss of water by transpiration.

3rd.—Roots take up soluble salts and generally speaking all those salts which are in solution in the soil water. Moreover, the roots have a marvellous property. The minute roots, called root hairs, are capable of attacking and dissolving some of the ingredients of the soil by means of an acid sap which they contain, and they have an apparent selective power in choosing what each kind of crop requires most; some absorbing more potassium salts than sodium salts, etc. Some plants requiring more mineral salts than others have a stronger acid sap in their roots to ensure their greater solvent power. Besides providing the plant with water and salts the root has the important function of providing the necessary nitrogen for the organism. The most common form in which nitrogen is found in the soil is in the form of organic matter. Before plants can make use of the nitrogen of this organic matter it must be converted into amides, ammonium salts, nitrous acid salts and finally into nitric acid salts. These various changes are brought about by bacteria and a special bacteria is required for each change. Finally, nitrates are formed and these are soluble and the form in which nitrogen is assimilated by plants. The leguminosæ (plants which produce pods) like peas, dâls, beans, etc., obtain their nitrogen indirectly from the air contained in the soil by means of bacteria contained in little warts or nodules on their roots. These little warts contain germs or bacteria which absorb the free nitrogen of the air and convert it into available (readily assimilable) plant food. A few other plants can make use of the free nitrogen of the air, but these are exceptional. The leguminosæ on the other hand have this power well developed.

Functions of the stem.—The primary function of the stem is to form a rigid framework to support leaves and flowers. The rigidity, size and form of the stem vary very much, from the short thickened stem of the tuber (potatoes) to the hard and woody trunk of a tree.

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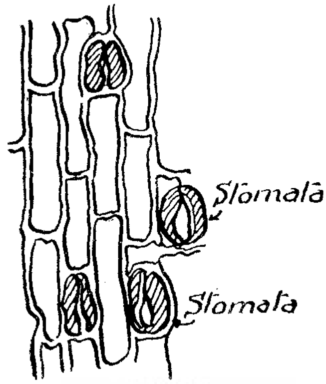
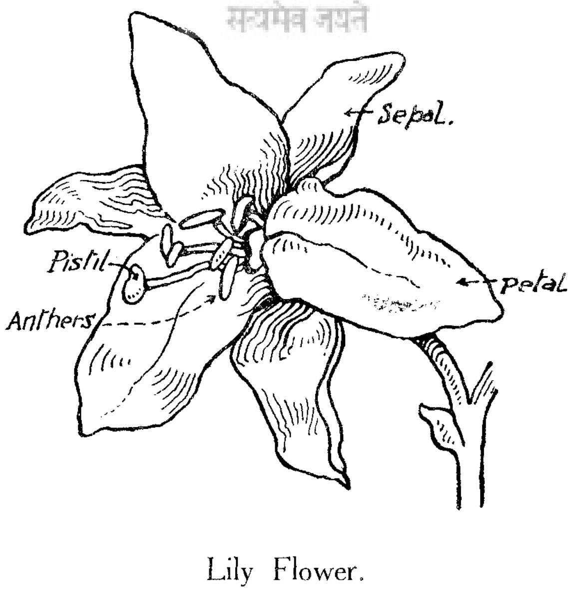


Breathing openings, stomata in leaves.
Much magnified.



Lily Flower.

In grasses, bamboos and sugarcane the stem which presents a jointed appearance at the nodes is called a *haulm*. The stem also acts as a channel or conglomeration of channels which convey the food from the roots into the leaves and from the leaves back to the growing parts or buds. In the stem most of the non-essential or inorganic salts of the prant are stored up, giving the stem its rigidity.

1st.—Function of the leaves. Carbon assimilation.—We said that the plant receives its food partly from the soil and partly from the atmosphere. From the soil through the roots, water, salts and nitrogen are taken up. The other constituents of the plant, carbon and oxygen are taken from the atmosphere through the leaves. The leaf under the influence of the sun absorbs carbonic acid gas from the air. This gas enters into the leaf with the air through small apertures called *stomata*, and from there is taken up by certain cells of the leaf (those cells containing chlorophyll or green matter of the leaves), is dissolved by the sap which permeates the whole plant, and then this dissolved carbonic acid is decomposed, oxygen being given off through the stomata while the carbon is retained. This carbon together with hydrogen and some oxygen forms formic aldehyde which is converted by the plant into sugars and starches. This extremely important process is accomplished in all green parts of the plant but mostly in the leaves. It does not occur in darkness neither at a very low temperature, and experiment with coloured glass-houses has brought to light the fact that the orange-red rays of the sun are the most active agents in the chemical action of the chlorophyll in plants. Here we may draw the attention of the student to the fact that plants in absorbing from the air this poisonous gas (carbonic acid gas) that man and animals alike expel from their lungs at each exhalation of air (respiration) purify the atmosphere and by giving off oxygen gas ensure the non-exhaustion of this most important element (oxygen).

2nd.—Respiration.—All living plants respire, *i.e.*, take in oxygen and give off carbonic acid gas like animals. This action is continuous (night and day): during the day carbon-assimilation is greater than respiration, and so this action is not noted; but during the night carbon-assimilation ceases and then respiration can be noted. This is the reason why plants are dangerous at night time in sleeping rooms.

3rd.—The leaf—Forms from the sap, organic matter like sugar or starch, which the plant takes from the leaves and stores up in its roots, stems, buds or seeds.

4th.—Transpiration.—A plant gets rid of its surplus moisture or gives off water (to prevent its dessication by the sun) through the stomatas of the leaf.

P.S.—Plants (fungi) which have no green leaves do not make use of the carbonic acid gas of the air.

Functions of the flower.—The flower or that part of the plant containing the organs of reproduction is most important for the conservation of the species. It is also that part on which most improvements or differentiations can be tried and realised in what is called cross-breeding and cross-fertilisation. The organs of paramount importance in the perfect flower are the *pistil* and the *stamen*. The *pistil* is the female part of the flower and consists of the *ovary* which

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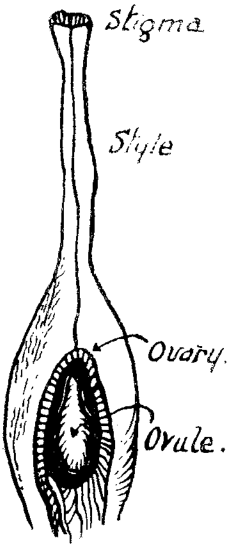
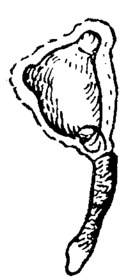
FLOWER





Single grain of pollen germinating (highly magnified).

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contains the *ovules* (little eggs) which may develop into seeds if fertilised by the male element of the plant, and the *stigma* which catches the *pollen* or male element which falls from the anthers of the *stamen* when the *ovules* are ready to be fertilised.

The *stamens* are the male part of the flower and each of them consists of the filament and the anther which contain the pollen. The filament is really the stem of the stamen and is generally of such a length as will put the anther in the most favourable position to shed *pollen* on to the stigma of the *pistil.*

The *pollen* is that powdery substance, generally yellow, which is contained in the anther of the *stamen.* It fertilises the *ovules* in the ovary.

A grain of pollen falls on the stigma and is retained there by the gum exuded by the stigma or held fast by a hair-like growth The outer skin of the *pollen* sends downward in the very substance of the stigma a thread-like growth which first reaches the ovary and then the ovules into which the whole substance of the *pollen* disappears. The *ovule* is then said to be fertilised.

A perfect flower contains both male and female organs. Some flowers contain only the male organs (staminate), others contain only the female organs (pistillate). The *pollen* of the male organ in such cases is carried to the female of the same species by wind or insects.

Some flowers have a pistil developed in such a way that the *pollen* can only come in contact with the *pistil* if it is carried there by an outward agency such as insects in search of honey deposited round the ovary. The pollen falls on the antennae or on the wings of insects and from there on to the stigma which the insect has to brush past before reaching the honey glands. Non-fragrant flowers are fertilised by wind. Fragrant flowers and flowers with rich glands, *e.g.*, (red clover, peas, beans, etc.), are fertilised through insects. The fruit is the result of the fertilisation of the ovule occasioning the development of the ovary. In some cases the walls of the ovary (or its parts called *carpels*) become fleshy and succulent, (mango, pear, plum) or dry and hard, (poppy). In other cases the whole of the floral stem becomes fleshy and succulent (strawberry, etc).

Fruits are either dehiscent (opening of themselves like the pods of leguminosæ) or indehiscent, in which case they are succulent and enticing to man or animal to eat the fruit, and in so doing to set the seed free. In all cases seeds are contained in a non-digestive outer skin, the testa, which prevents the seed from being dissolved by the acids in the stomachs of birds or animals.

Resumé IV.

The function of the seed is to ensure the conservation of the species. After germination the radicle grows into a root, the plumule into a stem.

Functions of the roots.—It is the support of the plant. It takes up food from the soil—water, soluble salts, nitrogen. Roots have an apparent selective power for different salts and take up different quantities according to the special plant. Nitrogen is absolved when in the

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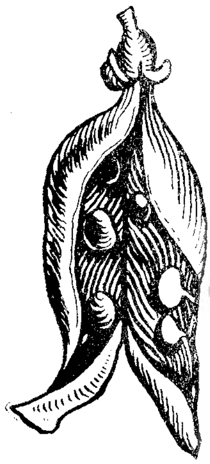
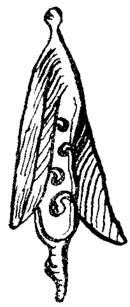
DEHISCENT FRUITS.

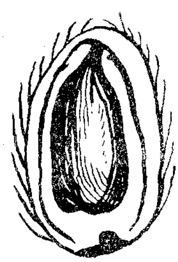
(Opening of themselves. Pea Seliqua).



The Pod
(of the pea).



INDEHISCENT FRUIT.



Almond (Badam)
(Drupe).

form of nitrates which are soluble. Leguminosæ obtain their nitrogen from the air by means of bacteria in their root nodules.

The stem supports the leaves and flowers; the stem of grain-bearing crops is called a haulm, the leaves absorb carbon from the carbonic acid gas of the air; leaves perspire and respire; air enters the leaves through the stomatos. In the leaves are formed sugars and starches. The flower contains the pistil and the stamen. The stamen is the male part and contains pollen (anthers) when falls on the stigma of the pistil, reaches the ovary and fertilises the ovules contained in the ovary. Perfect flowers contain pistil and stamen Staminate contain only the stamen Pistillate contain only the pistil. Some flowers are fertilised by wind or by insects. Fruit is a developed ovary. It is dehiscent or indehiscent.

Questions.—What is the function of the seed? What is the function of the root. Under what form (soluble or insoluble) can salts be absorbed by roots? Under what form can nitrogen be absorbed? What peculiarity present the roots of leguminosæ? What are the functions of the stem of the leaves? What is taken from the air? Through what openings does air enter the leaf? What cells absorb carbonic acid gas? Does the plant respire? Does the plant perspire? What beneficial action have plants on the surrounding atmosphere? What are the functions of the flower? What is the stamen? What is the pistil? What are the stamens, the anther and the pollen? What is the stigma? What is the ovary and the ovule? How does pollination occur? What becomes of the ovary? What is a dehiscent fruit or indehiscent?

PART III.—Composition of plants.

Water—dry matter—combustible—incombustible or ash.
Essential ingredients—non-essential ingredients.

Chemistry teaches us that a grown-up plant is composed of—

1st.—Water, and
2nd.—Dry matter.

Dry matter may be—

1st.—Organic matter or combustible,
2nd.—Inorganic matter or incombustible.

To determine how much water there is in a given plant, weigh it; then dry it; weigh it again and compare weights. The loss of weight represents the amount of water.

Weigh this dried plant, then burn it and weigh the ashes. The difference represents the amount of combustible matter. The ashes left are incombustible. The combustible dry matter of a plant is made up of—

1. Carbon.	3. Hydrogen.	5. Sulphur.
2. Oxygen.	4. Nitrogen.	6. Phosphorus.

The incombustible part of the plant (or the ashes) is made up of—

1. Potassium	Essential.	5. Sodium	Non-essential.
2. Magnesium		6. Silicon	
3. Calcium		7. Chlorine	
4. Iron		8. Manganese	

The plant takes up its carbon from the (CO_2) and carbonic gas contained in the air (function of leaves); its oxygen and hydrogen the form of water from the soil; nitrogen from the ammonia and nitrates of the soil (function of roots) and from the air (through warts on roots of luguminosæ); from the soil plants obtain all their ash or mineral matter. We have seen that the soluble food, taken up by the roots, contains all the ash constituents of the plant. The soluble food contains salts of calcium, potassium, etc., and are concentrated in the upper parts of the plant, the leaves evaporating the surplus water by transpiration. The essential ash constituents (potassium, magnesium, calcium and iron) are employed in the building up of new tissues and are stored up in the seed. The non-essential ash constituents are slowly deposited in the cells of older tissues where they form permanent incrustations. The deposition of silica round the stem and external parts of wheat, barley and rice are good examples of this getting rid of non-essential salts in a useful manner. Old tissues or the fibres of the stem are thereby made more rigid and impermeable and thus protect the plant from injury.

Resumé V.

A grown-up plant is composed of water and dry matter. Dry matter is organic matter or combustible and inorganic matter or incombustible; the combustible matter is made up of carbon-oxygen, hydrogen, nitrogen, sulphur, phosphorus.

The incombustible is made of potassium, magnesium, calcium, iron, which are essential, and sodium, cilicum, chlorine and manganese, which are non-essential.

Carbon is taken up by leaves. Hydrogen, nitrogen by the roots oxygen by the roots, besides all essential and non-essential element.

Questions.—What is a plant composed of? What is dry matter? What is combustible? What is incombustible? What are the elements of combustible matter? What are the elements of incombustible matter?

What part of the plant takes up carbon? What part of the plant takes up the other ingredients.

CHAPTER III.–PLANT FOOD.

Plant food.—Soil, air, water. How plants feed and develop.

Most important elements of plant food—

(1) *Soil.*—We have said that the plant is fixed to a certain spot by its roots, therefore the plant is not able to look about for its food like man or animal, neither can it shelter itself against inclement weather. It is a most dependent structure, and consequently a continual source of worry for the agriculturist. A plant must have water or it dies—sunshine, or it rapidly decays and does not bear fruit—enough food and appropriate food in the soil, or its growth will be untowardly affected. In the wild state, plants present more sturdiness, and as a rule are hardier than plants brought up under cultivation. The fact of growing on vast areas only one kind of plant (like wheat, rice, barley or sugarcane) tends to weaken the plant and makes it more liable to disease. It attracts more destructive insects that thrive very rapidly having an abundant supply of food. Therefore let us study what plants when used for crops most need and what it is in our power to give them. Briefly, the soil supplies all plant food except carbon; it contains all the essential mineral ingredients referred to in the preceding chapter, and it must not only contain them, but those elements must be available, that is to say, they must be in a soluble state. The soil must contain enough organic matter to provide for the plant an abundant supply of nitrogen.

I. (1 *Air and Rain.*—Air is composed chiefly of nitrogen and oxygen. In 100 volumes there are—

Oxygen	...	21
Nitrogen	...	77
		100 volumes.

But there is also a little carbonic acid gas, *i.e.*, about 3 to 4 volumes in 10,000 volumes of air. Ammonia, about 1 lb. in 26,000,000 cubic yards of air was found in one place, while 1 lb in 44,000,000 cubic yards was found in another place. It varies Air contains also a little nitrous and nitric acid, vapous and tracer of argon and ozone.

Rain.—Rain when falling brings down plant food with it and enriches the soil. At Rothamstead 28 inches of rainfall bring down from the air about—.

(*a*) 4·3 lbs. of nitrogen per acre, viz :—

2·5 lbs. as ammonia,
·8 lb. as nitrous and nitric acids,
1·0 lb. as organic nitrogen,
4·3 lbs.

(*b*) 24 lbs. of common salt or sodium chloride, and
(*c*) sulphur gases equal to about 17 lbs. of sulphur dioxide per acre.

No definite figures for Bengal are forthcoming at present ; and as in Lower Bengal the average rainfall is about 50—70 inches, most of which falls from 15th June to 15th September, even if more plant food is brought down by the rain than is the case in England, any advantage will be lost by the flooding, the plant food being carried off into the streams and rivers. During this period from June to September there is more electricity (lightning) about that in England, and the natural inference is that more nitrous and nitric acids will be formed in Bengal.

However, without any definite figures to work upon, it would be premature to make any statement in regard to the amount of plant food brought down by the rain in this Province. Figures for total nitrogen brought down by the rain in 1888 and 1889 in Madras (43—62 inches per annum) show that less was brought down than in England.

(3) *Water and Sunshine.*—Water is very essential to the taking up of plant food, as all plant food must be in solution before it can be made use of by plants.

If water is not forthcoming, the earth or soil dries up. The salts that were held in solution in water deposit themselves round the roots which are no more able to absorb them, and through evaporation the cells of the tissues soon lose their turgidity when the plant withers and dies. If sunshine is wanting for any lengthy period, the leaves lose their power of absorbing carbonic acid, the plant becomes yellow, and if the normal conditions are not rapidly restored, the plant dies. Tillage helps to keep the soil in a fit condition for plant life so far as moisture is concerned As to the conditions of congenial temperature and the regulating of sunshine these factors are beyond the power of man.

II. *How plants feed and develop.*—Plants feed and develop according to the amount of readily assimilable plant food contained in the soil and of the amount of air it receives and absorbs. The young plant is invariably rich in nitrogen and ash constituents, but as the plant matures the carbon compounds (starch or sugars) increase. A cereal crop when in full bloom contains all the nitrogen and potash it requires, but it continues to take up phosphoric acid for a little longer. As long as the plaint remains in a green state, it takes up carbon and silicon. During the time plants are forming seed they exhaust the root, stem and leaf of albuminoids starch, phosphoric acid and potash; therefore it is very important for farmers and gardeners to harvest many of their crops before they are fully ripe.

Ash.—In seeds, ash seldom varies much, but the leaves, stems and succulent parts of plants vary in composition according to the kind of soil. Of the ash constituents, the most important are phosphoric acid, potassium, calcium. These are found where cell growth is most active, viz., in the buds seed and in the cambium or the layer between the wood and the bark.

III. *Most important elements of plant food.*—The most important elements of plant food are—

(1) Nitrogeon,
(2) Phosphoric acid,
(3) Potash and
(4) Lime.

Nitrogen and phosphoric acid because they are essential to the formation of protoplasm which is living matter; potash is necessary for the formation of starches and sugars in the plant; lime is the base necessary for the nitrification of organic nitrogenous matter. To supply any or all of these ingredients is a costly process, and this subject is treated later in this book.

IV. *Nitrification.*—Organic nitrogenous matter in the raw state is of no use as plant food. Before plants can use or assimilate it, it has to be broken into small particles or decomposed by means of little germs or bacteria which live in the soil.

Conditions which favour nitrification—

1st.—Suitable temperature, about 90° Fah.
2nd.—Moisture.
3rd.—Darkness.
4th.—Organic matter.
5th.—Air.
6th.—A base like lime.

Nitrogen in humus or organic matter has to be converted into amides, then into ammonia, next into nitrous acid, and finally into nitric acid before it can be assimilated by plants.

Resumé VI.

A plant is a most dependent structure. It must have enough food, sunshine, and a suitable temperature, or it dies. Plants are weaker in the state of cultivation than wild. The soil supplies all the food with the exception of carbon. Air is composed of 21 parts of oxygen and 79 parts of nitrogen, and a little carbonic acid gas, a little ammonia and argon. Rain brings down to the soil nitrogen about 3-4 lbs. per acre per annum. Water must always be present to dissolve plant food. Plants feed and develop according to the amount of food readily assimilable, contained in the soil. The most important ash constituent are phosphoric acid, potassium and calcium, therefore they must be present in the soil.

The most important elements of plant food are nitrogen, phosphoric acid and potash and lime. Nitrification is the process of transforming raw organic matter into assimilable nitrates and is brought about by bacteria living in the soil. Conditions favourable to nitrification are suitable temperature, about 90° Fah., moisture, darkness, organic matter, air, and a base like lime.

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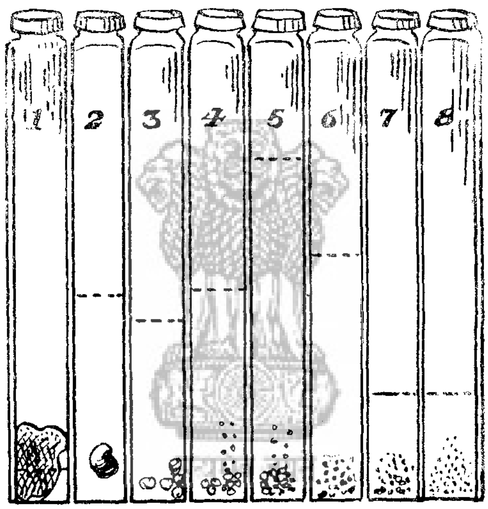
SOILS.



To show the granular character of Soil in good tilth after cultivation. The granules were sooted by a series of 8 different sieves the relative amount of each size of granules is represented by a dotted line. The largest size of granule (1) constitutes the smallest part of this Soil and (5) the largest.

Questions.—What does the soil afford to plants ? What is essential to the development of plants ? What supplies the soil to the plant ? What supplies the carbon to the plant ? What is the composition of air ? What is contained in the air besides oxygen and nitrogen ? How much nitrogen is brought on the soil by rain per acre per annum (approximately) ? Why must water be present in the soil ? How does the plant feed ? What are the elements contained in the ash of plant ? What are the most important elements of plant food ? What is nitrification ? What are the factors present in the process of nitrification ?

CHAPTER IV.—SOILS.

(*i*) General description of soil and subsoil.
(*ii*) Formation of soils—(1) weathering of the earth's crust, (2) action of changes of temperature, (3) of vegetation, (4) of water, (5) of frost, (6) of animals, insects and bacteria.
(*iii*) Composition of soils—organic matter, inorganic matter, how derived.
(*iv*) Classification of soils (1) indigenous and transported soils, (2) classification according to (*a*) composition, (*b*) texture, (*c*) moisture, (*d*) temperature, (*e*) fertility, (*f*) barrenness, (*g*) shrinkage, (*h*) crops grown.
(*v*) Brief and simple account of the soils of Bengal.

PART I.—GENERAL DESCRIPTION OF SOIL AND SUBSOIL.

The soil is the upper stratum of earthy matter formed by the disintegration of rocks with a certain proportion of animal and vegetable matter intermixed and modified by the action of worms and the oxidising influence of the air ; it is that portion of the ground which we till and in which plants grow. Soil is from three inches to several feet thick and of a darker colour than the sub-soil. The sub-soil is that part of the ground which is underneath the soil. It differs generally in colour from the soil and is more compact and firmer and contains far less organic matter. The part of soil derived from mineral matter is known as the inorganic portion and that from animal and vegetable matter as organic. In burning a quantity of soil the organic part only is consumed and the inorganic left behind. It does not always happen that a soil is formed from the débris of the underlying rock. Often the material has been brought from a distance and mixed together by geological agencies. There are thus soils made from transported materials and soils made from materials direct at hand. But in both cases generally the soil proper (consisting of organic matter and inorganic matter) as it appears in any place has always been formed on the spot. Nearly all transported materials owe their origin to the occurrence of boulder, clay or glacial drift, and alluvium. We may say that the sub-soil is rotting rock and the soil is rotten rock.

We have usually five layers on the earth's crust —

1st—Grass or vegetation.	*3rd*—Soil.
2nd—Vegetable mould.	*4th*—Sub-soil.

5th—Rock.

In many places in Lower Bengal we must go to a depth of over 1,000 feet before we can get at the rock.

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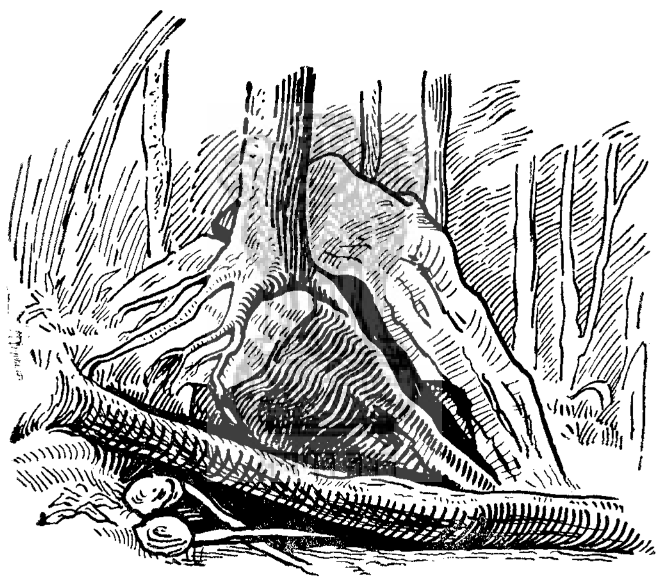

ACTION OF VEGETATION ON ROCKS.

The way in which Trees aid in soil formation. The larger cracks allow the entrance of rock-weathering agencies—(roots, air, water).

II. *Formation of soil.*—Soil is formed from rocks by several agencies. There are six such important agencies—

1st—Air.	*3rd*—Heat.	*5th* - Plants.
2nd—Water.	*4th*—Frost.	*6th*—Animals.

(*N.B.*—The above to be taught as far as possible by ocular demonstration in the fields, specific examples under each head being shown to the students.)

(1) *Weathering of the earth's crust.*—The combined action of air, water, changes of temperature and frost is called weathering. Weathering is the chief agency by which the ridges (mountains and valleys), which have been formed by the gradual cooling of the earth's crust, are levelled.

(2) *Changes of temperature.*—The hills and rocks are worn by alteration of temperature; by the heat of the sun they expand, and in the subsequent cool of the evening they contract and crack, often falling to pieces.

(3) *Frost.*—Frost is the most powerful agent we have. For the same mass ice occupies a larger space or volume than water. Therefore when water becomes frozen in the cracks of rocks, it forces the rocks as under. Air acts in two ways—

1st.—Chemically. *2nd.*—Mechanically.

1st.—Chemically on the minerals composing rocks by either giving off or takiug up oxygen. This is called deoxidation and oxidation, and where these processes take place, the rock falls to pieces. Best example of oxidation—rusting of iron.

2nd.—By means of its carbonic acid gas, this acts as an acid and partly dissolves rocks.

Mechanically by means of wind carrying away large particles.

(4) Water acts in two ways.—

1st.—Chemically, by dissolving many of the rocks over which it passes. As common table salt is soluble in water, so are many rock ingredients.

2nd.—Mechanically, by wearing rocks over which it runs and by washing away loose particles. Thus by weathering, rocks are gradually worn away and their loose particles are deposited at lower levels or in the valleys, and when gathered on the hill slopes form soils. These weathering agencies act also on rocks *in situ*, but the process is slower, as the particles when not carried away remain on the spot and protect the underlying rocks. In a word, all rocks and stones tend to grow smaller and soon lose their angular projections: mountains tend to become rounded in the long process of time and their débris can be looked for at the base of precipices and mountain peaks and at the bottom of rivers, whereas the smaller particles of rocks, which have been carried some hundreds of miles away from the original rocks, form the deltas of rivers. For example, the plain of Bengal is formed by particles carried from the western Himalayas some 1,000—2,000 miles away and brought down by the Ganges.

(5) *Action of vegetation on rocks.*—Plants act in several ways—

1st.—By their roots growing in the cracks and crevices of rocks and gradually forcing the rock asunder as the roots grow larger.

2nd.—The roots of all plants contain acids and these dissolve little particles of rock.

3rd.—The roots of plants are nearly always surrounded by moisture, and this causes the rock to slowly dissolve; also when plants decay they give off carbonic acid gas, which is one of our strongest dissolving acids in the soil.

(*b*) *Animals, Insects and Bacteria.*—Animals act indirectly by making burrows, which allow the water and air to reach the rock and subsoil. Moles, ants, rats and field mice are active agents in this respect. Worms bring up to the surface 10 tons of earth per acre per annum. Whiteants do an enormous amount of this kind of work (in this respect) in Bengal. These insects thereby help oxidation, which is essential for the conversion of rocks into soil. Both plants and animals provide by decaying the humns or organic matter of soils.

Bacteria, ærobic (those that thrive best in a plentiful supply of oxygen or air) and anærobic (those that thrive without air), of which there are billions on and in the earth's crust, help very much by oxidation and deoxidation in the formation of soils.

Resumé.—Soil is the upper stratum of the earth and is formed of particles of rock mixed up with decayed vegetables and animals. It is where plants grow and is from 3 inches to several feet thick. The subsoil is under the soil. Soil is composed of inorganic matter and organic matter. Soil is either formed from the underlying rocks or brought from a distance. The five layers are grass, vegetable mould, soil, subsoil, rock.

The combined actions of air, water, heat, frost, is called weathering; frost makes the rocks crack asunder ; air, water, act mechanically and chemically. Vegetation dissolves particles of rock and in decaying add humus; animals act by burrowing, bacteria in transforming organic matter into plant food.

Questions.—What is the soil? What is the sub-soil? What is darker—soil or sub-soil? What are the five layers of the earth's crust? What are the agents active in soil formation? How does air act? How does water act? Heat? frost? What is the action of plants in soil formation? of animals? of bacteria? What kinds of bacteria do you know? What is ærobic? anærobic.?

PART IIA.—Composition of soils

III. Soils are composed of organic and inorganic matter. The organic matter is made up of the same chemical elements that are found in the organic matter of plants. It is derived from plant and animals decaying and decayed. The inorganic matter is also composed of the same chemical elements as the inorganic matter of plants with the addition of alumina. These elements are derived from the original rocks of the earth's crust.

The following table gives the relative proportion of the most abundant rock-forming minerals (of the crust of the earth) from which soils were originally derived:—

Felspar	...	...	48 per cent.
Quartz	...	...	34 do.
Mica	...	...	8 do.
Talc	...	...	5 do.
Carbonates of lime and magnesia			1 do.
Amphibole—			
Pyroxene	...	...	
Diallage	...	...	
Peridot (Olivine)	...	...	1 do.
Clay	...	...	1 do.
Other salts	...	...	1 do.

Felspar is an anhydrous aluminic silicate with potash, soda and lime (forms clay by weathering).

Quartz is composed of silica (forms sand by weathering).

Mica splits into thin shining plates, elastic and transparent.

Talc is a silicate of magnesia and is greasy to the touch. Clay is silicate of alumina.

Besides these mineral compounds the soil contains nitrogen in various forms, also phosphoric acid, potash, and lime ; and these four ingredients are the most important ingredients for the maintenance of plant-life in soil

Nitrogen—Is found in the soil in very small quantities, ·1 to ·2 per cent.

1st—*Nitrogen* is found in the soil as nitrates : nitrates of soda, lime and potash.

2nd—Ammonium salts: sulphate of ammonia.

3rd—Organic nitrogen, found in decaying matter.

Nitrogen is lost from the soil in two ways—

1st—By crops about 8 to 9 pounds per annum (Rothamstead).

2nd—By rain washing it away, about 10 pounds per acre per annum (Rothamstead).

Nitrogen is supplied to the soil—

1st—By rainfall about 4½ pounds per acre per annum (Rothamstead).

2nd—Residue of plants.

3rd—Absorbed nitrogen by aqueous deposit like dew.

4th—By manures.

5th—By the growth of leguminosæ. (Fixation of nitrogen by bacteria in their nodules.)

Phosphoric acid is found in very small quantities in most soils—1 to 3 per cent. We find it in three forms—

Phosphate of lime. This is soluble.

Phosphate of iron
Phosphate of alumina } These are insoluble.

Potash is also found in small quantities—from 1 per cent. to 2 per cent.

Silica is found in large quantites in most soils and is of great use, as it affects the texture of the soil keeping it open and porous; 50 to 93 per cent. of insoluble silicates and sand are found in most soils.

Alumina is found chiefly as silicate of alumina.

It affects the texture by making soils more compact; 3 to 10 per cent are found in soils.

Lime.—The quantity varies from 1 to 90 per cent. in the form of carbonate of lime-kankar.

N.B.—The organic part of the soil is derived from—

1st—Plants.

2nd—Animals.

1 to 2 per cent. of organic matter is found in Indian soils.

Resumé.—The organic matter of the soil is composed of the same elements that are found in plants. The inorganic matter is made up of the same elements that have been found in the ash of plants *plus* alumina, felspar forms clay by weathering—quartz forms sand—urica salt are found in lesser quantities. Nitrogen is found in the nitrates of soda, lime and potash of the soil or as sulphate of ammonia. Nitrogen is lost to the soil by being absorbed by plants and by rain washing it away. *Nitrogen* is supplied by rain (little) by decaying of roots and plants (chief supply) by manures and by growing leguminosæ.

Questions.—What is the soil composed of? What elements are found in the organic matter of the soil? What are the most abundant rocks forming minerals?

What is felspar? What is quartz? What is clay? What is talc like? Mica? How is nitrogen lost from the soil? What are the sources of supply of nitrogen in the soil? Why are leguminosæ active agents in the supply of nitrogen?

B.—Classification of soils.

B. Soils are classified according to—

(*a*) Composition.
(*b*) According to the texture.
(*c*) According to the quantity of moisture the soil contains
(*d*) According to the temperature.
(*e*) According to fertility.
(*f*) According to barrenness.
(*g*) According to shrinkage.
(*h*) According to the crops.

(1) *Indigenous and transported soils*—

According to their origin, soils are said to be indigenous and transported.

Soils are indigenous when formed out of underlying rocks and transported when formed by disintegration and brought down by rivers, glaciers, etc.

Transported soils are again subdivided into diluvial and alluvial.

Diluvial or drift soil consists of soil proper mixed up with stones and boulders. Alluvial soil consists of fragments of minerals arranged according to their size and specific gravity.

(2) *Classification of soils*—

According to composition.—As soils are formed from rocks, the composition of soil varies with the rock from which it is derived. Composition is the most important because we classify soils according to the predominant ingredient they contain.

A soil is—

1. Silicious where silica or sand predominate, and clay, lime and organic matter are present in small quantities.
2. Argillaceous where the percentange of clay or silicate of alumina is high.
3. Calcareous where the percentage of chalk or limestone is high.
4. Humus, where the percentage of vegetable matter or organic matter is high.

P.S.—*See* Composition of soils (pages 22 and 23).

Loam (normal) is made up of one part sand and one part clay.

Loam (sandy) is made up of two parts sand and one part clay.

Marl (normal) is made up of one part clay and one part lime.

Marl (sandy) is made up of one part clay, one part sand and one part lime.

Marl (clay) is made up of two parts clay and one part lime.

Light vegetable soil is made up of one part sand and one part humus. Garden vegetable soil is made up of one part sand, one part clay and one part humus.

(*b*) *Texture.*—Soils which are easy to work are called light soils; those difficult to work are called heavy soils.

Ex.—Sandy soil is light.
Clay soil is heavy.

This distinction is according to workability and not according to weight. The (work) texture indicates the physical state of the soil. The common adjectives used to describe the different textures are hard, mellow, compact, open, porous, lumpy, cloddy, fine, in good tilth, etc.

A finely divided, mellow, friable soil (two loams for example) is more productive than a hard and lumpy one of the same composition because it is more able to retain moisture and more air, and air promotes nitrification, hastens the decay of vegetable matter and brings about the quick desintegration of the mineral elements contained in it. Good texture is from the point of view of the farmer an essential condition, because it also affords a greater feeding surface for roots.

Ex.—The surface of a cubic inch is 6 square inches. Divide that cubic inch into smaller cubes and the surface is increased. Good texture is obtained in two ways—

1st—By modifying the size of the particles (tillage).
2nd—By adding extraneous materials.

Lumpy soils become mellow when the particles are made smaller. Very loose soils become retentive of water if they are compacted and if organic matter is added. Cowdung, castor-cake and green manures cement or bind together the particles of light sandy soils, while they loosen the texture of stiff clay soils. Lime also loosens the texture of stiff clay soils.

(*c*) *Moisture.*—Soils which contain a great quantity of water are called wet soils.

Ex.—Undrained clays.

Soils which do not contain much water are called dry soils.

Ex.—Sandy soil.

However much plant food a soil contains, it is of no avail if the right amount of water is not present—neither too much (undrained clays) nor too little. The amount of water used by some of the common crops varies considerably. Potatoes require more than gram for example, but the failure of crops is more frequently due to lack of moisture than to any other cause.

Dry soils are called warm soils; wet soils are called cold. Some soils can absorb far more heat from the sun's rays than others. This depends to a very great extent on the colour of the soil. Dark soils absorb most, while light coloured soils absorb least.

(*e*) *Fertility.*—Soils are spoken of as being fertile or rich, unfertile or barren.

The fertility of soils is of two kinds—natural and acquired. By natural fertility we mean that which belongs to the land itself and cannot be reduced below a certain point. A land is said to have acquired fertility when by manuring and tillage the farmer has improved it and made it fertile though it is not naturally fertile.

Fertility depends upon certain conditions—

1st.—Sufficient depth.
2nd.—Sufficient moisture.

3rd.—Plenty of available plant food.
4th.—Suitable texture.
5th.—A good subsoil.
6th.—Freedom from poisonous or injurious substances.

Indications of a fertile soil—

1st.—Natural variety or variety of natural plants growing on the land. Some plants only grow on rich fertile soil. *Ex.*—Sugarcane.

2nd.—The size and luxuriance of those plants and especially trees and common weeds. A strong luxuriant plant denotes a good soil.

3rd.—The kind and character of the soil. When dark and brown and glossy it is rich soil; when white quartz stones are found in the furrow, they indicate a poor soil.

4th.—A good subsoil. A deep fine subsoil is better than rocks.

(*f*) Sterility or barrenness in soils is caused by—

1st.—The want of one ingredient of plant food.
2nd.—The presence of one ingredient in too large a quantity.
3rd.—The presence of some poisonous or injurious poison, such as—

(*a*) an excess of organic acids;
(*b*) sulphate of iron;
(*c*) oxide of iron;
(*d*) common salt.

4th.—Want of drainage, the soil being water-logged.
5th.—When there is only a very shallow layer of soil resting on rocky subsoil, we have not sufficient depth or food to nourish plants with.

(*g*) *Shrinkage.*—Soils which contain clay shrink most. Sand hardly shrinks at all. Soils which shrink to any great extent often injure the plants growing on them by—

1st.—Rupturing or tearing off the little fine rootlets wherever crack occurs.

2nd.—When the soil becomes compressed, it strangles the plant by excluding the air.

(*h*) *According to the crops grown.*—Some soils only grow paddy, others grow jute, sugarcane, vegetables, etc. Accordingly they are known as paddy, jute, cane soils, etc.

Soils rich in humus are good for growing vegetables, potatoes, cabbages, cauliflowers, sugarcane, and as a rule for market gardening purposes.

2nd.—*Loams* are good for wheat, barley, sugarcane, *juar*, cotton with *arhar*.

3rd.—*Sandy loam* (barley, mustard, *rabi* crops),
4th.—*Clay loam.*—Paddy, gram, etc.

C—SHORT DESCRIPTION OF THE SOILS OF BENGAL.

1st.—Their composition.—They are nearly all poor in organic matter. Reference to the rough geological map given herewith will show that Bengal may be said to consist of three different geological types of soils marked—1st, brown (alluvial soils), 2nd, green (basaltic) or black cotton soil, and 3rd, red (archæan) gneiss Schists (rocks). The vast alluvial plains of the Ganges and the Hooghly are composed of clay and sand and stretch across Bengal from west to east. The second or black cotton soil is a basaltic formation and occupies only a small area in Chota Nagpur. The red tract which is the hard rocky type stretches west of the black cotton soil towards the Central Provinces. Besides these there are the Gondwana areas (which lie to a small extent in Orissa and to the west of the basaltic formation of Chota Nagpur), and the laterite area which runs through Orissa up the east coast and through Midnapore, Bankura, Burdwan, Birbhum to the flanks of the Raj Mahal Hills.

The three main types, of course, are again subdivided into a larger number of secondary types known by local names and differing in each district. Again in each district soils of different fertility are grouped into classes of which every cultivator can give very accurate and minute descriptions. The two great general divisions are the one crop or *ek-fasl* soils and the two crop soils or *do-fasl* soils.

According to the situation there are—

1st class soils (*awal*).—Homestead lands.
2nd class soils (*doem*).—Best paddy lands.
3rd class soils (*soem*).—Poor paddy lands.
4th class soils (*chaharam*).—Seldom cultivated.

Usar lands are waste lands, and of these there are plenty in Bengal.

Reclamation of soils can be resorted to in many districts.

Resume.

Indigenous soils are formed on the spot. Transported soils when brought down by rivers, glaciers, etc. Diluvial soils are mixed up with boulders. Alluvial soils are made up of fragments arranged according to their size.

Silicious soil contains mostly sand.

Argillaceous soil contains mostly silicate of alumina.

Calcareous contain chalk.

Humus contains mostly vegetable matter.

Loams.—Sand and clay. Marl—clay and lime. The texture of the soil influences the growth of plants.

Soils are either dry sand or wet clays.

Sand retains less water. Soils are fertile or barren.

Fertile soils have sufficient depth, sufficient moisture, plenty of available plant food, a good texture, a good subsoil, does not shrink too much, is free from poisonous substances. A soil is barren when it

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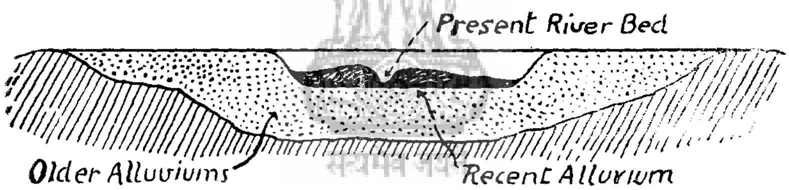

Diagram (theoretic) section of the river Ganges showing alluvial deposits.

contains an excess of organic acids or poisonous substances. The soils of Bengal consists of three geological types of soils—

I. Alluvial soil.
II. Basaltic (black cotton soil).
III. Archæn rocks.—Laterite soils.

Questions.—How are soils classified? What are indigenous soils? transported? alluvial? diluvial? What is a silicious soil? What is an argillaceous soil? What is a loam? A sandy loam? What is a marl? What adjectives are used to express the different textures of soils? Why is good filth desirable? How do you transform a lumpy soil into a mellow soil? What do you call wet soils? dry soils? Is a piece of undrained clay wet or dry? What are the necessary conditions to fertility? Why is a soil barren? What are the indications of a fertile soil? What is shrinkage? How many geological types of soils do you find in Bengal. Where is laterite found. How do cultivators classify the soils?

CHAPTER V.

PART I—Preparation and improvement of soils.

(I) *Tillage*—(*a*) *Its objects.*—We have seen in the preceding chapter that good texture of the soil is important for the growth and development of plants. We have said that a finely divided, mellow, friable soil is more productive than a lumpy hard one. We have added that a soil which is compact and difficult to work is much improved when the particles are made smaller, and that by such division they become mellow; and the means by which this is brought about is called tillage. Tillage is the operation of stirring, breaking up, and pulverising land by means of ploughs, harrows or weeders. Sub-tillage refers to the operation which stirs up the sub-soil. Inter-tillage designates the work accomplished while a crop is on the field. Tilth indicates condition or degree of fineness obtained by tillage. Good tilth means that the soil has been loosened and divided properly. Good tilth is the most important factor to a successful crop. Faulty tillage is at the bottom of many failures of crops. The primary object of tillage is to break up, to mellow and to make the soil so fine that the seeds may be well covered, but not too deeply and so that roots may find their way freely in the soil. The second object is to increase the supply of available plant food. Thirdly, it helps to keep control of the supply of moisture in the soil, and fourthly it helps to kill the weeds. As to the time of tillage or kind of tillage needed, one should be governed by the season, the character of the soil, and the needs of the plant. As in Bengal there are, generally speaking, three crop seasons; the tillage will be governed by the arrival of the rains for the early season crop (*bhādvi*) and the amount of moisture in the soil for the late rainy season (*aghani*) and again for the *rabi* or cold season crop.

(*b*) *Effects on physical character of the soil.*—First by dividing the soil into smaller portions, a much larger soil surface is exposed for the growing roots to use. Second, it gives the right compactness for the crop to be grown in it. Some soils being naturally loose want to be compact more than can by done by laddering. A large proportion of soil, however, are apt to be too compact when they need a tillage, which will lighten them and make them loose and friable. A farmer should closely study the peculiarities of his field, the special season, and the crop he wants to grow, and should then apply the mode of tillage best suited to the three named factors.

The most evident reasons as to how tillage increases the amount of available plant food are the following:—

First.—Tillage changes the arrangement of the particles of the soil and brings new particles into contact with the root or with particles which may have a reciprocal chemical action on each other; for example, interchange of acids or bases. Again tillage brings underlying particles into contact with the air which oxidises them; it alters also the relation

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The upper sample is loose garden loam (rich in humus). The lower is hard pulverised clay deficient in humus. Both were given the same quantity of water and allowed to dry. The loam remains loose and crumbly, the clay puddles and cracks and would either stifle sound plants or tear their roots.

of water to soil and the relation of air to soil. But the most beneficial effect remains in the fact of the soil getting ærated, and thereby allowing the organic matter to be more thoroughly rotted. Tillage also affects the life of the millions of bacteria of the soil, especially giving a fresh supply of nitrogen to those which can absorb it readily from the air. The nitric acid forming bacteria thrive in soils which are well ærated, therefore the neglect of tillage may mean the loss of nitrogenous plant food, the most valuable soil constituent; while a tillage intelligently conducted in ærating the soil helps decomposition and brings the nitrogen of the air well within the grasp of the nitrogen fixing bacteria.

Effect on moisture.—We have seen that however much plant food there may be in a given soil, if it is not in the form of solution, it is of no avail to plants. Therefore a certain quantity of water is always necessary. Let us devote a few lines to the study of the manner in which water is held in the soil –

1st.—By capillarity.
2nd.—By hygroscopic water.

Capillarity is a form of the general attraction of matter for matter. It is a force which compels a liquid to ascend or descend through very small channels called capillary tubes which are in the soil represented by the interstices between very small particles of soil. Capillary water is the source of direct supply of water for plants. Hygroscopic water is the moisture surrounding each particle of soil. It is only driven off at a temperature of 202° Fah It is of service to plants in periods of drought until capillary water is again available. Besides capillary and hygroscopic water we have to reckon with the quantity or level of free water in the soil. Free water is that water which is moving towards its level of equilibrium. Its depth may vary and its supply is the rainfall. Sometimes it comes to the surface and oozes out as springs. When the subsoil is clay, water may remain in it; if rainfall is abundant, the soil above the layer of clay becomes water-logged. The surplus rain-water is either eliminated by surface drainage or in the hot weather by evaporation. The capacity of the soil to hold water depends upon its composition (clay or sand or loam) and upon the kind of tillage it has received.

In Bengal the question of retention of enough water in the soil is of paramount importance. Free water or rain-water is stored up in tanks and wells for the dry season, while the raiyat ensures an efficient supply of capillary water by thorough but shallow tillage, being anxious not to disturb the subsoil especially on sandy tracts which would allow the water to percolate and be lost. The humus of the soil is a very efficient water-collector and water-holder; therefore manuring with green crops with cowdung and organic manures such as castor-cake is an excellent practice. Tillage enables the soil to hold moisture by two means—by increasing the depth of the soil in which the plant sends out roots (therefore when the surface soil becomes dry, the roots are still supplied by the water of lower layers), and by increasing the capillary power of the soil; as more particles have been separated there are more interstices for the water to run up. To

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Showing great difference in texture of soils. The finer soil offers many times more surface to the action of air and of water ; it will also hold more moisture.

conserve the soil moisture, evaporation should be prevented by establishing by thorough tillage a surface mulch of soil. The capillary action is thereby broken near the surface. This mulch acts very much like a board of wood on the soil, becoming dry on top and when removed showing moisture underneath.

(*c*) *Implements of tillage.*— (1) Plough (*har*, *langal*, *hal*); (2) Rake (harrow) (*bida*); (3) Ladder (roller) (moe) (*henga*); (4) Spade (*kodali*); (5) Khurpi (hoe). *See* plate 3 (Nos. 1, 2, 3, 4 and 5) on page 33.

The *har* or *hal* which is the plough of India can certainly boast of being the oldest and of having remained the most primitive implement for opening a furrow. The plough consists of three parts—the beam (*haris*) (Bihar)—Bengal, body (*har*) and the handle or stilt (*parihath*) (Bihar)—(Bengal). The beam goes through the body of the plough and is fastened by means of a peg. The body tapers off into the sole at one end in which the share is fixed. At the other end the handle is fixed. There are notches in the beam to allow the share to be raised or lowered at the point where the yoke is put on; where notches are not present, a little appendage consisting of a kind of hook is fixed to the yoke and the beam is hooked in, but is still free. Wedges help to fix the beam and handle to the body. A pair of small bullocks can easily pull this plough across a field of light soil. The plough has no mould-board which is the proud feature of modern improved ploughs. The furrow slice is neither lifted nor turned by the Indian plough, which simply cuts ridges straight ahead. When the whole field has been ploughed in one direction it is at once ploughed in the cross-direction and again diagonally. In this way the apparent faultiness of the Indian plough is corrected. Heavier ploughs suited to Europe and America might do more harm than good in so far as they would disturb too much of the subsoil and thereby set up loss of capillary water by altering the subjacent arrangement of soil particles. The illiterate Indian raiyat has found this out by experience, and unless some plough is devised which will not interfere with the good retention of moisture, it will be prudent not to condemn too soon the old-fashioned *har* of India. The ordinary English plough, of which there is an indefinite variety, consists, broadly speaking, of—

(1) The body.
(2) The beam.
(3) Sole.
(4) The mould-board.
(5) The share.
(6) The coulter.
(7) Beam wheels.
(8) Bridle.
(9) Stilts or handles.

First, the body is generally made of steel; its cutting edges should be kept very sharp, as otherwise the draught on the animals will be increased and the efficiency of the implement will be lowered. The beam is of different lengths and forms and is either made of wood, iron or steel. Wooden beamed ploughs are lighter and cheaper. The curve of the beam is more or less accentuated according to the draught desired. Some beams are fixed, others are adjustable. To control the depth of ploughing a bridle which enables the ploughman to raise or lower the hitch is found at the end of the beam.

The mould-board which does not exist in the Indian plough is that part of the plough (resembling the section of a spiral) continuous to the share which is so arranged that the furrow slice cut by the share is lifted and turned more or less over according to the boldness of the mould-board. Some ploughs have a mould-board with its rear portion ending more curved than the front portion. In this case the furrow slice is not only lifted and turned over but pulverised. This is the most perfect kind of plough. There are many kinds of coulters, some like a knife, others like a disc. As coulters increase the draught the ploughman should make sure he knows how to use them. When the soil is covered with the remains of a preceding corn or rice crop (stubble), a disc coulter does good service as it cuts up into bits stalks that the plough would otherwise drag along. The beam wheel is not essential. It only steadies the plough. As we have said there exist many kinds of ploughs. For different classes of soils there are different ploughs. The Indian plough does such fine work that the harrow as known in England is dispensed with altogether. The subsoil plough is an implement which is drawn in the furrow opened by all ordinary plough to stir the subsoil. Its use must be restricted.

The rake (*bida*) is the surviving rudimental harrow of England It consists of a beam in which are inserted 8 to 16 iron spikes or teeth (*kanta*). It is very effectual, as it is drawn not only across the field one way, but as in the case of the plough in every direction three or four times until a fine mulch is obtained. English harrows are either provided with spikes or cutting discs or spring teeth. As may be seen from the above, the principles underlying the basis of tillage are respected in both Indian and English implements. The only difference is brought about by local conditions and specially by the difference of the cost of labour. India can afford to plough and cross-plough a field four to ten times, as labour is cheap, whereas England must have something that will do the work in the shortest time possible so as to save labour. The ladder (*henga*), which takes the place of the English roller and is used for the same purpose to consolidate the soil and to prevent excessive evaporation, is also as useful as the English implement. It is, moreover, simple and cheap. The *kodali* (spade) is the replica or rather the model of the ordinary spade, while the *khurpi* is the equivalent of the hoe. Many attempts have been made to introduce into India implements which are in use in western countries, but three things have been constantly overlooked, and it is no wonder that those attempts have failed. In Bengal, so far as implements are concerned, the question is governed by three factors,—first, the size of the agricultural holding which is generally from two acres to eight acres; second, the amount of capital the cultivator has for disposal during the year which is nothing to Rs. 3; and, third, the comparative cheapness of labour. This means that implements must be cheap yet efficient, and where will you get greater cheapness with excellent efficiency at the price (insured by repeated ploughing,

Eastern and western implements contrasted.

cross-ploughing, harrowing, cross-harrowing and laddering) than in the local plough, *bida* and ladder, with the still further advantage that these latter are perfectly understood in every Indian village and can be repaired at a moment's notice? These two last factors—simplicity and cheapness—must never be lost sight of by implement-makers who wish to cater for the huge agricultural community of Bengal, or who wish to improve the present implements.

For larger and well-to-do cultivators there are the Meston plough (Cawnpore) for light land and the Hindustan plough for heavy land. The single-wheeled plant junior hand hoe for interculture of maize and juar saves the employment of ten coolies for weeding. The chaff-cutter, maize-huller, cotton gins and bullock-gears are all good implements, but all of them are governed by the factor of cheap supply of labour, and where hand-power can be got at the cheaper rate there is nothing to equal it, for even on his lowest scale man is man and possesses a certain amount of brain power which is wanting in animals or machinery that must be guided by man. At present, then, with the present scale of wages for agricultural labour in this province and the present arrangement in vogue for repairing implements throughout all the districts, we cannot recommend to the ordinary raiyat any other implements than are in use among the raiyats in this province already, viz., plough, yoke, *bida*, ladder, *kodali* and *khurpi*.

Resumé.—Tillage is the operation of stirring, breaking up and pulverising land by means of ploughs, harrows or weeders. Sub-tillage refers to the operation which stirs the sub-soil. Inter-tillage is the work done when a crop is on the field. Good tilth means that the soil has been loosened, divided properly, thoroughly ærated and that each particle of soil has been changed from one place to the other. Good tilth allows the roots to make full use of the elements of the soil, air to thoroughly rot the organic matter, air and water to come freely in contact with the root hairs. Tillage affects advantageously the texture of the soil. Capillary water is the water which can ascend and descend through the interstices between the particles of soil. Hygroscopic water is the moisture belonging to each particle of soil and is hard to drive off. In Bengal sub-tillage destroys the continuous supply of capillary water and it is therefore not always advisable. Plough is the implement to make a furrow, that is, which penetrates the soil, turns it over and changes the arrangement of particles of soil. The Indian plough consists of the body, the share, the handle, the beam. A modern plough has a mould-board. The rake (*bida*) or harrow is drawn across a field to smooth and break the clods of earth. The ladder smooths and compacts the soil previously ploughed or raked; the hoe and spade and *kodali* are used for interculture.

Questions.—What is meant by tillage, sub-tillage, inter-tillage? What is good tilth? What is the object of tillage? Second object? Third object? When is it time to till a field? What is the effect of tillage on the particles of soil? When soils are too heavy, what effect has tillage? When too light? How is the amount of available plant food increased by tillage? What is the effect of tillage on soil moisture? What is capillary water? What is hygroscopic water? What is the source of water in the soil? How does a raiyat insure sufficient

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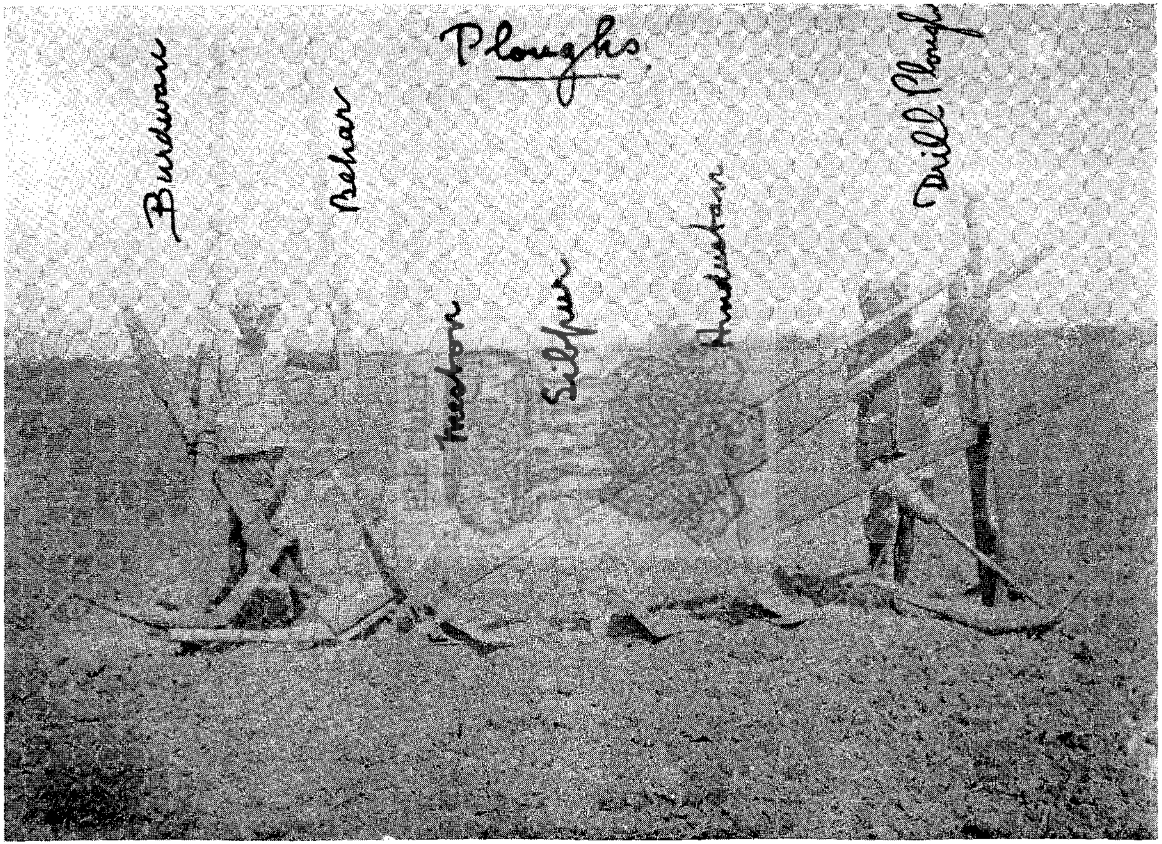

Ploughs in Bengal.
Burdwan—Behar—Meston—Sibpur—Hindustan. Drill Plough.

water in the soil by tillage? What is a plough? How many parts do you distinguish in a plough? What is the beam? How is it fixed to the body? Describe a western plough? Describe the mould-board? What is a *bida*? What is a *henga*? A ladder? A hoe? Spade? *Kodali*? Why are implements in use in Bengal good enough? Where is labour cheaper—in Bengal or in America?

PART II.—IRRIGATION.

Soils are improved by tillage, drainage and manuring. We have seen in preceding chapters that thorough tillage is a factor of paramount importance in ensuring a good crop. Irrigation is the art of watering the land by artificial means to enable crops to be grown or to increase production. Irrigation may be a matter of first necessity in some cases, while in others it is a matter of choice. In a country like Bengal, where the rainfall is not distributed over the greater part of the year as is the case in temperate zones, but where the rainfall is extremely heavy during three months (60 inches), irrigation is not a matter of choice, but one of necessity. In many parts of Bengal where there is no irrigation the land is dry and parched for several months and no crop can be raised thereon. The benefit of irrigation is not limited to providing the necessary moisture for plants, but it helps to a certain extent to control the temperature. As in cold countries meadows may be protected from frost by timely irrigation with sun-warmed water, so again in Bengal it tends to lower excessive heat by greater evaporation. Irrigation is also to a certain extent a labour-saving process, as in the time of rice-transplanting the muddy condition of the fields is of first importance to the cultivator; it also protects young rice seedlings from birds and insects. Irrigation, especially with the muddy water of the Ganges, is an important source of fertility, as the silt deposited on the land contains plant food.

The three following points have to be considered in irrigation:—

(1) The quality and amount of the water supply.
(2) How to bring that water to a given area.
(3) How to prepare the land for receiving the water.

The quantity needed for each crop and the time of application to ensure the best results depend entirely upon the class of soils and the object in view. Porous and sandy soils are best suited for irrigation; clay soils are less suited and require to be well drained. Some waters are suitable, while others are unsuitable for irrigation.

Suitable waters.- 1st. Muddy river water.
2nd. Hard spring water.
3rd. Sewage and liquid manure.

Unsuitable waters.—1st. Those which contain an excess of iron or sodium salts.

2nd. Water from peaty land or forest land containing excess of organic acids or tannin

3rd. Water from paper, dye or chemical works,

(1) *Advantages of Irrigation.*—It supplies the plants with sufficient moisture as most plants require water (from 5 to 9 per cent. of their composition).

(2) It helps to dissolve plant food and to distribute it evenly throughout the soil.

(3) It can be carried on at any period of the year.

(4) It is a cheap and ready means of making use of liquid manures and sewage which contain potash, phosphoric acid and ammonia. The soil is capable of absorbing and retaining these ingredients which cannot be extracted from the liquid by any known means that would pay to do so.

(5) Acids and poisonous substances hurtful to plants are washed out of the land into the drainage channels—

(*a*) *Canals.*—Bengal has already a splendid net-work of canals connecting the Ganges with other rivers, and wherever those canals have been erected the cultivator is independent of rain water and by using the canal water can save his crops in time of drought.

(*b*) *Wells and Tanks.*—In other areas where no canals have been constructed, irrigation is carried on by means of wells (deep or shallow) and tanks. The water of tanks, ditches or pools (*i e.*, watering from small depths) is lifted to the field by means of swing baskets, dons (iron and wooden) or by a very simple and ingenious contrivance called Baldeo Balti. This comprises two dons, one of which is emptying water, while the other is filling. From wells the water is lifted by means of motes or buckets by bullocks, hand or by levers. When the advantages of irrigation are thoroughly understood and when the net-work of irrigation canals has reached remote districts, the cultivator will be to a certain extent freed from the anxieties caused by drought or by his shallow tanks and wells drying up or being unable to supply the water for the necessary 12 to 16 irrigations required by sugarcane or certain garden crops. The necessity of keeping tanks in villages in a healthy and clear condition is not sufficiently understood, and deep wells should also be kept in repair for times of protracted drought. If each Bengali child be taught the importance of irrigation and the upkeep of tanks, 50 years will be sufficient to cover Bengal with such a system of canals that would leave well behindhand such countries as old Mesopotamia and modern Egypt which were and are famous for their art of irrigation. The establishment of canals, the amount of water they carry and the levelling of areas to be irrigated belong to the domain of the Engineer, but the building of wells, tanks or ditches can be carried out by any raiyat who wants to be sure of his water-supply. For crops other than rice, after supplying water, care should be taken to prevent water-logging and the surface drains should be well attended to.

Use of the Lever in Lifting Water.—The don and small bucket are lifted by means of a lever called *jank* (Orissa), *latha* (Bihar), which lifts the water with the minimum expenditure of energy on the part of the worker.

The lever (a bamboo) is balanced on a pole (fulcrum) fixed firmly in the soil. At one side of the fulcrum is the counterpoise which is a clod of earth and a stone. This is made to equal in weight the don or bucket (filled with water) which is attached to the lever at the other side of the fulcrum. When the don (bucket) is filled, all the worker has to do is to jerk the don (bucket) upwards and the water is lifted.

System of working.—In most countries the difficulty in irrigation is the difference of levels occasioned by the hilly nature of the land. In Bengal the chief difficulty to overcome is, that in nearly all cases water has to be lifted small heights from a low level to a higher level. Therefore irrigation is always a costly operation, especially when labour has to be hired. The system of working, most in vogue, is as follows :—

Each cultivator raises round his field an *aril* or bundh of about a foot in height. By practical experience he shapes his area so as to have each field (plot) nearly level.

Then the water is brought in at the highest point and the whole area is irrigated by force of gravity. An opening is made in each *aril* to let the water run into the next plot.

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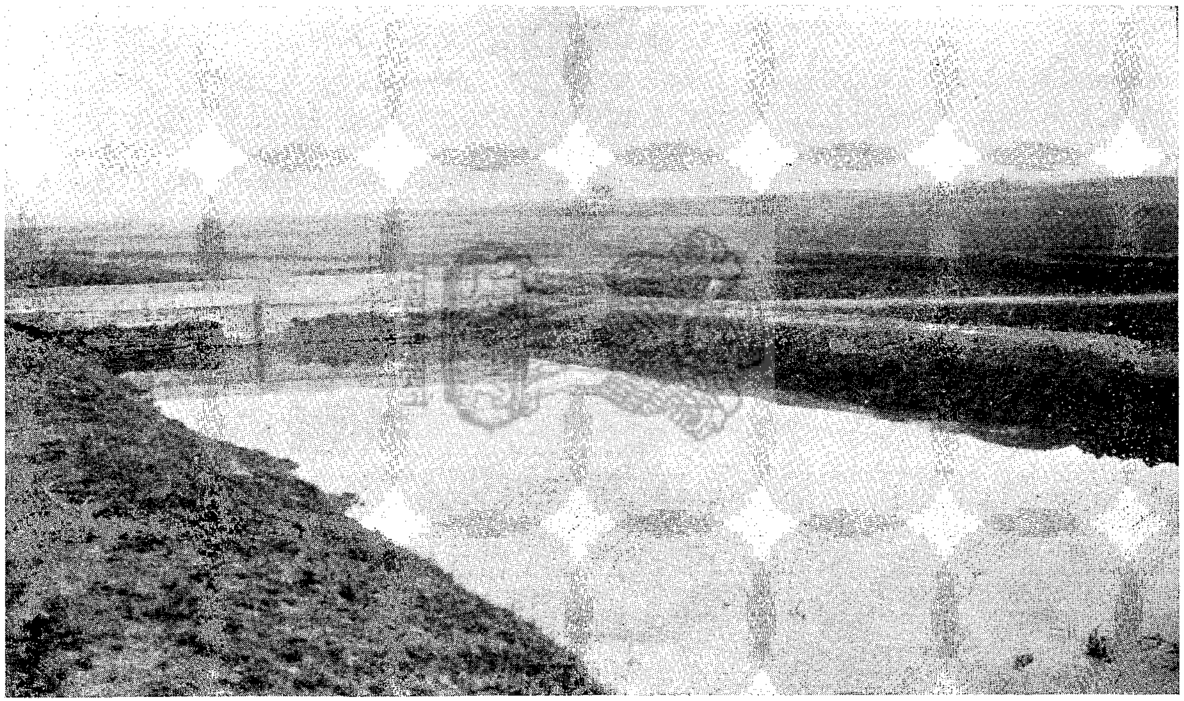

Irrigation by Canal.

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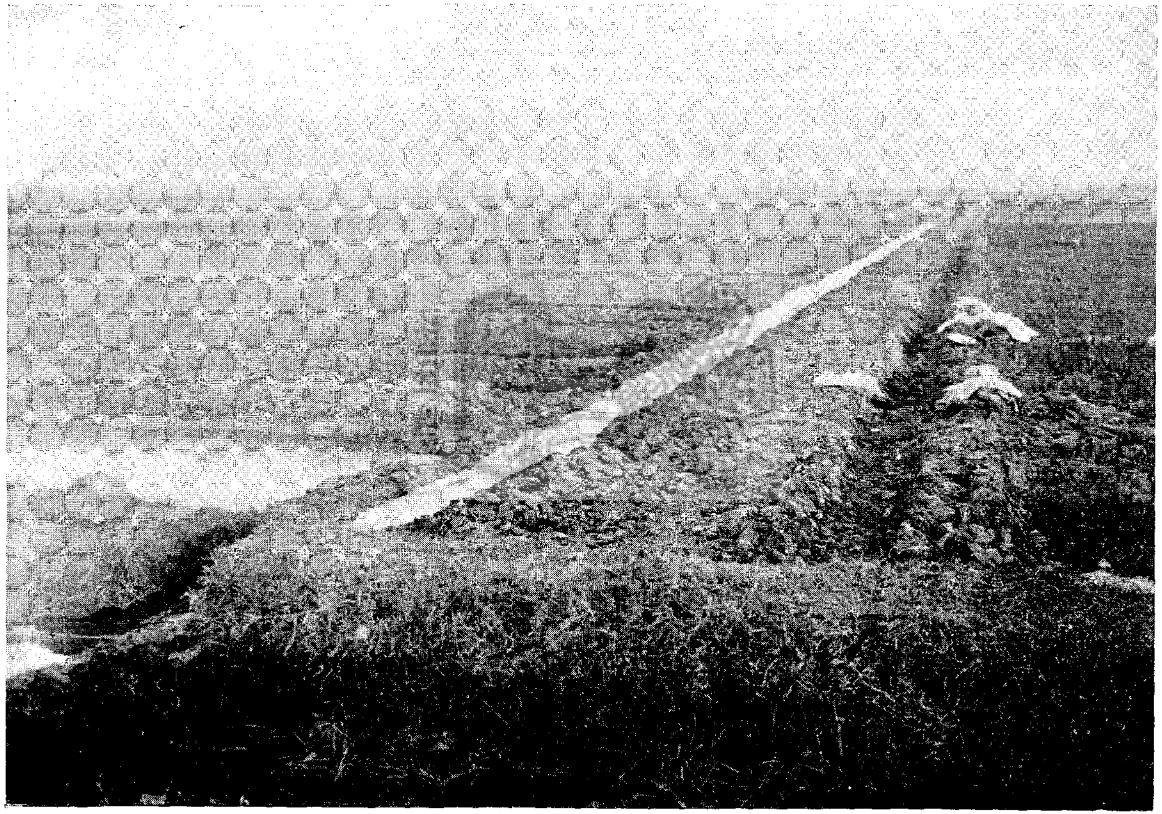

Irrigation by flow.

PART III.—Drainage.

If all lands must be abundantly supplied with water to be productive, the surplus which would become stagnant water must be removed either by natural or artificial means.

Natural drainage is of three types—General (see Geology), surface and subterranean. Nullahs, creeks, small streams and rivers constitute t e o en drains or general channels of natural drainage. Into these the water finds its way partly by direct surface flow and partly by lateral drainage. If the land is not level water percolates through the soil to reach open drains at a lower level. When open ditches must be maintained to drain off surface water only, it is best to make them broad enough and to keep the sides well grassed over.

In Bengal the necessity for under-drainage or pipe drainage does not exist. Well-kept surface drains are all that are required to ensure a quick flow of water in times of heavy rainfall (monsoon).

Owing to the flat (level) character of the country in this province and the scarcity of rocks on the surface, drainage by porous stratas of rock is not very important.

Resumé.—Irrigation is the art of watering the land by artificial means. In Bengal irrigation is absolutely necessary for most crops. Irrigation helps the cultivator at ploughing time and protects rice seedlings against birds and insects. There are suitable waters like muddy river-water or sewage and liquid manures, and unsuitable water like those which contain iron or sodium or organic acids or chemicals. A plant requires 5 to 9 per cent. of water to grow. Irrigation is done by means of rivers, channels, tanks, wells and pools. The fields must be levelled before constructing channels or drains. The water in Bengal has to be generally lifted on the field: it is done either by lever, dons or spoons, or by buckets or pumps; the simplest is the *latha*.

Taking away the water from the land is called drainage. In Bengal only surface drainage is necessary.

Questions.—What is meant by irrigation? How much water does a plant require (average)?

Does irrigation help to till the land?

What factors have to be considered in irrigation?

Which water is suitable? Which kinds of water are unsuitable? Describe the water lift (*latha*)? How does the cultivator prepare the land to receive water?

What is drainage? Is under-drainage necessary in Bengal? Why not?

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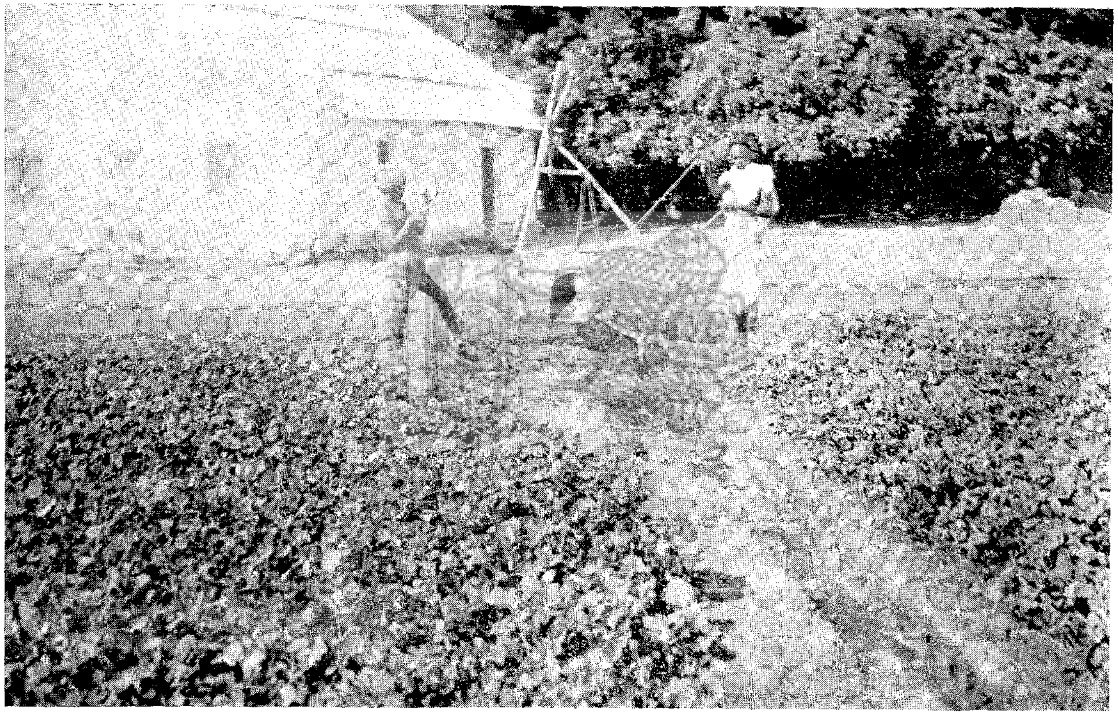

Swing Basket raising water.

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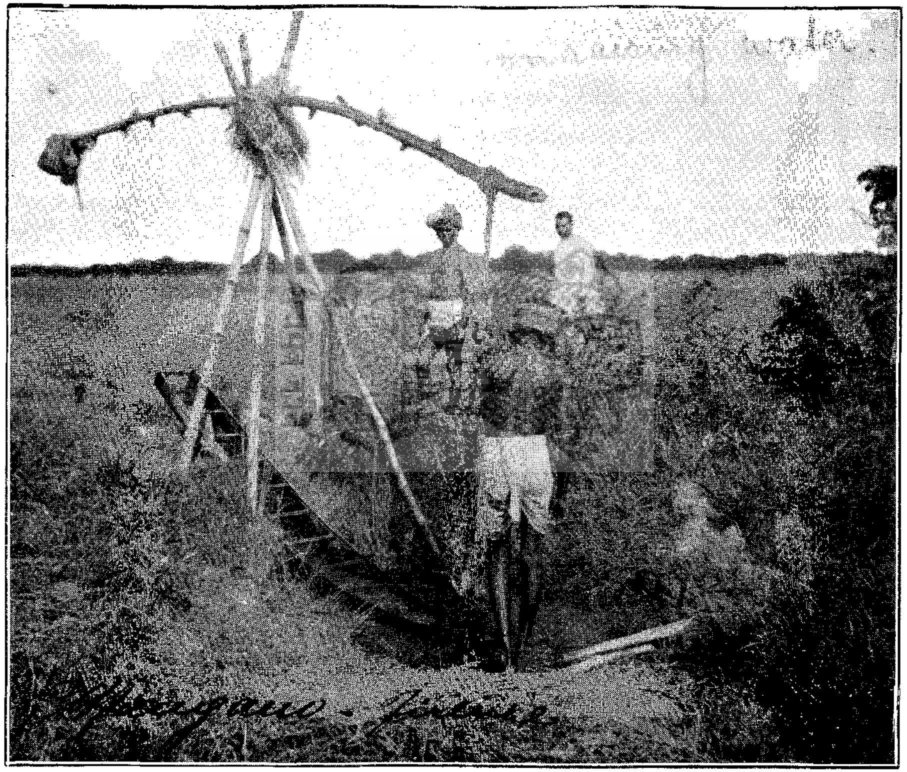

Dōn raising water.

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Irrigation by flow.

PART IV.—MANURES AND MANURING

Most of the soils of Bengal are extremely poor in plant food, and specially is this the case in organic matter, which is the chief source of the most important element of plant food, viz., nitrogen. If all human and animal excreta were returned to the land and carefully spread and incorporated with the soil the question of manuring would not be so important, but unfortunately there is a popular aversion in Bengal to human excreta as manure, and many of the poorer classes go even one step further and further impoverish the store of the total plant food in the province by burning their cowdung. This destroys the organic matter and sends off the nitrogen into the air from whence at present it is a costly process to reobtain the element in a useful manurial form. Further bones and seeds are exported, and this further lessens the total amount of plant food in the province. In this province we are not far wrong when we state that we are bordering on the state of their irreducible minimum so far as plant food is concerned, or in other words, we have got to that point when the amount of the plant food taken up by a crop each year is equal to the amount of plant food that has been produced by the decomposition taking place in soils during the year, *i.e.*, the decomposition resulting in the production of available plant food from insoluble plant food.

The most important elements of plant food are—(1) nitrogen, (2) phosphoric acid, (3) potash and (4) lime.

There are other elements, but they are generally present in the soil in sufficient quantities for the requirements of plants. Nitrogen is the most important because it is the most costly to supply per unit. It is also the element that is finally produced by the decomposition of organic matter and nitrification. Now the amount of organic matter governs the amount of bacteriological activity in the soil, and the greater the bacteriological action the greater will be the supply of available plant food in the soil, for these millions of germs that require a store of organic matter for their maximum development are the chief agents in converting insoluble (rock and sub-soil particles) plant food (of which there is always a supply in the soil) into an availables form suitable for plants to assimilate.

This problem of manures and manuring is further complicated by (1) the variation in the composition of soil, and by (2) the individual requirements of each crop.

(1 Soils vary in composition so much not only in different tracts but even in single villages, and the soil of one bigha will very often be found to be quite different in several places. For example in Bihar (Saran) north of the Ganges we have a light friable marl, while south of the Ganges at Bankipore we have a heavy clay. Near Calcutta we have a heavy clay, while in the north-west of Burdwan we get light sandy soils, but in every district that I have mentioned, we find all kinds of soil varying from clay to sand. All these soils agree generally in being poor in organic matter. Saran soils are rich in lime and poor

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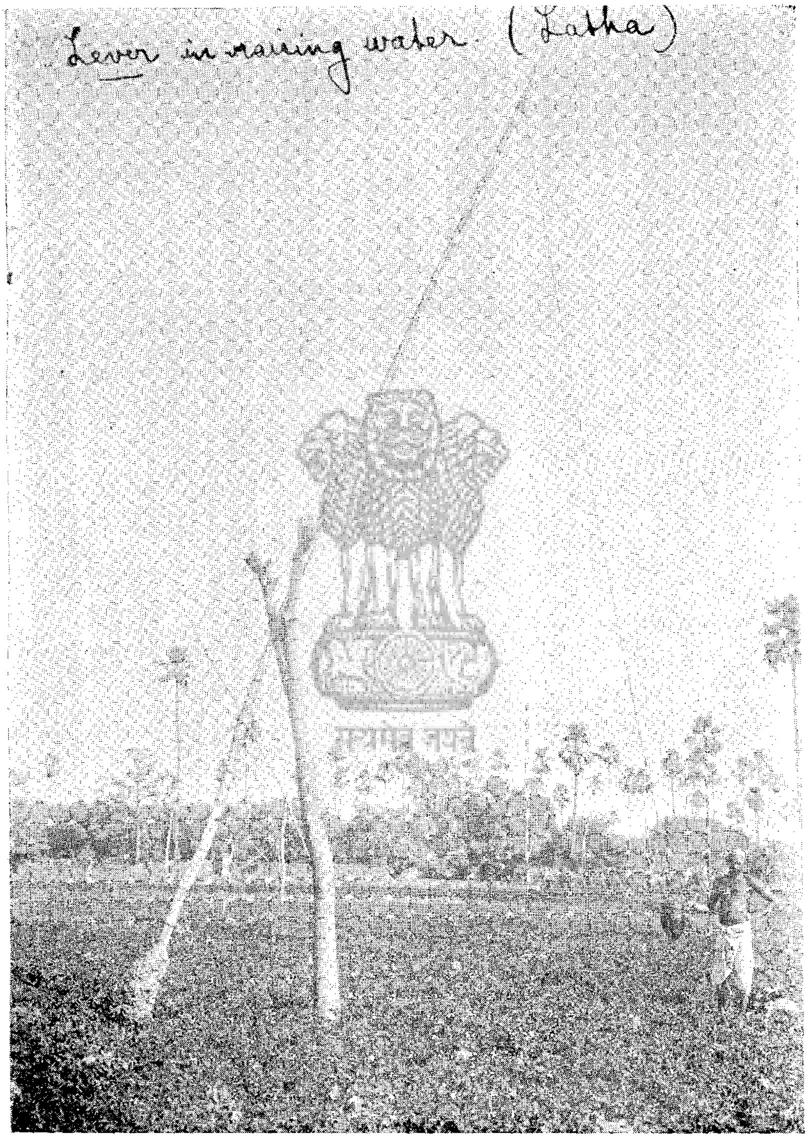

Lever in raising water. (Latha)

in phosphoric acid. Burdwan soils are poor in phosphoric acid and lime and contain some potash. Orissa soils are poor in all four ingredients—nitrogen, phosphoric acid, potash and lime. So it will be found all over the province that even in one village some land will be found to contain sufficient phosphoric acid, while in neighbouring fields probably phosphoric acid will be wanting.

(2) One crop has preference for one kind of plant food, while another crop requires a larger supply of another element to attain its maximum growth. For example leguminous crops (*dals*) require plenty of lime and potash to attain their maximum growth, while cereals (paddy, wheat and barley) require a good supply of nitrogen and phosphoric acid to attain their maximum.

This shows the advantage, the importance and the necessity of a rotation of crops.

The law of minimum is very important in the manuring of crops. This law is, "the minimum amount of one ingredient of plant food in a soil governs the total crop obtained" For instance, if to produce a crop of 30 maunds of paddy 40 lbs. of available nitrogen, 30 lbs. of available phosphoric acid, 30 lbs. of available lime and 35 lbs. of available potash are necessary, then if only 20 lbs. of nitrogen are present, although the phosphoric acid, potash and lime are present, in sufficient quantities, only a crop equal to the 20 lbs. of nitrogen can be obtained. In other words only a crop of 15 maunds of paddy can be produced. The remedy in a case like this would be to apply the other 20 lbs of nitrogen. Similarly if potash, lime or phosphoric acid were wanting, these would have to be applied to get the larger crop.

These remarks will enable any one to understand that with a given crop one standard manurial application will not have the same effect in every part of the province. For instance, if at Burdwan, where the soil is poor in nitrogen, phosphoric acid and lime, an application of 3 maunds of bone-meal and 30 seers of saltpetre has a wonderful effect on the outturn of the paddy crop, it will not necessarily follow that the same effect will be obtained elsewhere in the province. On the contrary, it is more than likely that one mile away from where the experiments are carried out, this application will have no effect whatsoever. How could it, if this precise area is rich in phosphoric acid and lime? The problem of "what manures shall I apply?" is one for the individual farmer or raiyat to solve, and when one considers the millions of poor raiyats that are in this province alone, one will easily understand the danger of recommending a manurial application suitable for the whole province. The expert is nonplussed when he gets 50 letters from 50 different places in the province stating "they have read with pleasure the report on the manuring of paddy with bone-meal and saltpetre, and will he send them sufficient for 1-5 acres with definite instructions how to act?" Probably 50 per cent. of these do not require to apply bone-meal at all. Accordingly the expert scientist is quite puzzled when he is asked to do something for the province as regards manuring when he finds the most intelligent cultivators have such a vague idea of the problem in question. To recommend a manurial application that would cost money to a poor cultivator and that application to have no effect on the crop can only end in bringing discredit on the Agricultural Department and a feeling of distrust that would not be eradicated for a generation.

The above explains how with all the best intentions in the world we can lead people astray. Many of our cultivators in Bengal know full well the value of manure and are not afraid to use it and we must take special care to guide them in the right way. Crores of rupees are being spent annually on manures in other countries, and I do not see why Bengal should not spend a little more than she is doing.

Now in Bengal there is one factor that is common to every district, viz.—"Poverty of soil in organic matter, and that is something definite that we can act upon."

A—Classification.—Manures can be divided into two kinds,—1st., General; 2nd, Special.

1st.—*General or natural.*—A general manure is one that supplies all the most important ingredients of plant life, viz.—nitrogeon, phosphoric acid, potash and lime, and the ingredients are generally present in an insoluble state. General manures are rich in organic matter.

2nd.—*Special or artificial.*—A special manure or an artificial manure is one that supplies only one or two of the ingredients of plant life, and the ingredients are generally present in a soluble state. Special manures are divided into (1) nitrogenous, (2) phosphatic (3) potassic and (4) calcareous.

b—Composition and values—

Examples of manures—

General.

(1) Farm yard manure.	(5) Sheep folding.
(2) Oilcakes.	(6) Sewage.
(3) Sea-weed.	(7) Liquid manure.
(4) Green manuring.	(8) Night-soil.

Special.

Nitrogenous.	Phosphatic.	Potassic.	Calcareous.
(1) Nitrate of soda (saltpetre of chili).	(1) Bones.	(1) Sulphate of potash.	(1) Bones.
(2) Nitrate of potash (saltpetre of India).	(2) Basic slag.	(2) Muriate of potash.	(2) Superphosphate of lime.
(3) Sulphate of ammonia.	(3) Guano.	(3) Kainite.	(3) Kankar.
(4) Guano.	(4) Superphosphate of lime.	(4) Saltpetre (Indian). Nitrate of potash.	(4) Lime.
(5) Soot.	(5) Mineral phosphate.	(5) Wood ashes.	
(6) Organic form— (a) Dried blood. (b) Horns and hoofs.			

Farm-yard manure.—Farm-yard manure is composed of the solid and liquid excreta of farm animals mixed with litter.

It varies in composition on account of five conditions—

(1) The condition of the animal.
(2) The kind of animal.
(3) The kind, quantity, quality of food with which the animal is supplied.
(4) The kind, quantity and quality of litter used.
(5) The after-management of the manures.

(1) Animals which are giving milk or which are pregnant produce much poorer manure than those which are dry or barren because those in milk or in pregnancy have to sustain themselves and form their young as well from the food, whereas barren or dry animals have only themselves to sustain. Young animals produce much poorer manure than matured animals because they have to form muscles and bone and procure the ingredients which form these from their food, viz., nitrogen and phosphate of lime, whereas adult animals have no bone to form and very little muscle.

(2) Horse manure is richer and contains less water than cow manure, but is far more liable to heat or fermentation. Pig manure is very rich but cold, soft and plastic. Cowdung is the most important form of farm-yard manure in Bengal.

(3) Some foods are very rich in nitrogeon and phosphate of lime, such as cakes, *dals*; other foods are very poor in these ingredients, viz., Indian meal, potatoes, turnips, mangel.

The quality of the food with which an animal is fed affects the quality of the manure produced. The richer the food the richer the manure and *vice versâ*.

Accordingly bullocks fed on mustard cake produce richer manure than those fed on straw only.

(4) The value of the litter depends upon—

(*a*) the manurial ingredients it contains, and
(*b*) the amount of liquid it can absorb and retain.

Ordinary straw contains plant food and can absorb liquids. Soil also is a very good absorbent and contains plant food. In Bengal most of the cattle byres have floors of earth. If two or three inches of this be scraped off every 6 months and mixed with the manure, it would be a good practice. This removed earth could be replaced with loose earth. On pucka floors where no litter is used the floor should be swilled every morning and the urine and swillings should be collected in a cess-pool near the byre from whence it can be lifted and spread over the manure in the pit.

(5) After management of manure—

loss is liable to occur in two ways by—

(1) Drainage.
(2) Volatisation.

Drainage.—When the dark-brown liquid which the manure contain is allowed to escape, it carries with it nearly all the nitrates and potash

To prevent this the manure should be kept in a hole or pit. It is best to make the pit watertight by means of a layer of clay at the bottom and sides or by cement.

Volatisations.—Volatisation is the giving off of nitrogen in the form of carbonate of ammonia; this is caused by the manure over-heating itself, and when the manure is covered with a white mould, this indicates that the manure has lost a good deal of its nitrogen.

(1) To prevent this keep the sun from shining on the manure by means of a shed on cover with a layer of earth.

(2) Keep the manure moist by pouring over the solid excreta, the liquid and washings of the byre.

(3) Keep the manure well consolidated so as to exclude air. This is done by the manure itself if no strawy litter is used.

(4) Apply an absorbent or ammonia fixer such as soil or sulphate of lime.

Great importance of conserving farm-yard manure in India pitting with urine and protecting from sun.—From the above it will be seen how important it is to conserve. Cowdung in India, to mix the urine with the solid excreta and to protect the whole from the sun.

It would be out of place in a book of principles to give the full percentage composition of all the different manures mentioned; so only the most important will be taken. These are cowdung, oilcakes, bones, super-phosphate, saltpetre, wood ashes, and poudrette. Full details of the others can easily be found in works of reference by those interested. The main point is to find out what percentage of nitrogen, phosphoric acid and potash is contained in a manure. The following table, from average samples of manures in Bengal, gives an idea of the percentage of the useful ingredients:—

	Nitrogen.	Phosphoric Acid.	Potash.	Organic matter.
Cowdung	0·45 to ·6 °/o	0·3 °/o	0·4 °/o	26 °/o
Castor cake	6·4 °/o	3·1 °/o	1·1 °/o	80 °/o
Nightsoil (poudrette) ...	·46 °/o	1·31 °/o	1·14 °/o	9·01 °/o
Saltpetre (Indian) ...	8 to 9 °/o	...	34 °/o	...
Sulphate of Ammonia ...	20 °/o	...	...	...
Bones	3 to 4 °/o	18·20 °/o	...	25 °/o
Superphosphate (Indian)	·45 °/o	16 °/o soluble. 2 °/o Insoluble.	...	14 °/o
Ashes	...	...	5·6 °/o	...
Rape cake	5·7 °/o	2·3 °/o	1·1 °/o	83 °/o

Cowdung—Has been explained on the preceding pages. The nitrogen is present in the form of organic nitrogen.

Oil-cakes—(Castor-cake, rape-cake, etc.) are the refuse from oilseeds after the oil has been extracted. The nitrogen is present in the form of organic nitrogen.

Bone-meal—Is finely ground bones. The nitrogen is in the form of organic nitrogen.

Superphosphate—Is bone-meal that has been acted upon by sulphuric acid which converts the insoluble phosphoric acid in bone-meal into a soluble state.

Saltpetre—Is potassium nitrate adulterated with other salts. It is prepared in Bihar. The nitrogen is present in the form of a nitrate and is immediately assimilable by plants.

Sulphate of Ammonia—Is a salt that is prepared from the ammoniacal product of gas works, coke ovens, bone distilleries, etc. The nitrogen is present in the form of an ammonium salt which must first be converted into a nitrate before a plant can take it up. This change takes place very rapidly in Bengal.

Ashes—Are the remains of vegetable matter after burning.

Poudrette—Is human excreta mixed with earth and dried.

A general manure contains its plant food in insoluble forms, and before plants can make use of these forms the manure must first be converted into a soluble form. This takes time and requires the requisite amount of air, moisture and heat before the changes can take place. These changes, however, take place very rapidly in Bengal, where the favourable conditions for them are at a maximum.

The very fact of the ingredients of plant food being in an insoluble state in a general manure is of extreme importance as will be seen from the next paragraph.

A special manure contains its ingredients generally in a soluble state, and this is where the danger comes in when recommending special manures. For example, the nitrogen in saltpetre and sulphate of ammonia and the potash in saltpetre are soluble in water. What would be the use of applying these manures in June, July, August and September in Bengal when the land goes under water? These are the most costly manures, and it would be simply waste of money to apply them in these months as they would be washed into the drainage channels. Similarly in the *rabi* season, irrigation is necessary and extreme personal care will be required to prevent the manure being washed away The phosphoric acid in bone-meal is in an insoluble condition and is not soluble in water, so there is not so much danger of loss with this manure as with the others. Superphosphate and wood ashes are not so soluble and are therefore less easily lost than as saltpetre is, but they are more soluble than bone-meal.

Accordingly extreme (personal) care is necessary in the use of artificial manures; and unless this can be ensured, we recommend them to be left alone.

There is an art in irrigation, and where manures are applied, the art requires to be highly developed in order to obtain the money value out of the manure. It is not enough to swill the crops and to flood the land in order that manures may produce their full effect. The art is to give sufficient water and no more.

When the land is covered with water, decomposition of manure is reduced to a minimum, as air, one of the essentials of decomposition, is excluded, so that there is less fear of loss by flooding and washing away from a general manure during the rains. Accordingly general manures such as cowdung, castor-cake and green manurings are more safe to deal with than one that can be washed into your neighbour's field, hence the reason why we recommend general manures. Also at the end of September, conditions for the decomposition of their insoluble portions into a soluble state are at a maximum in Bengal (when the water is below surface level) and the ingredients of plant food become much more quickly available than is possible with such manures in a more temperate climate.

Cowdung is so quickly decomposed that, so far as we can find out at present, there is no residue left for a second year's crops. Leguminous crops or *dals* have a special feature in that on their roots they have little warts or nodules in which there are bacteria that are able to make use of the free nitrogen of the atmosphere and convert it into available plant food for the use of the crop. This causes plant food to be stored up in the soil in the roots of the crop, and when the crop is harvested, the roots decompose and give up their store of plant food to the next crop. This is the reason why after a certain period of time leguminous crop should occupy the land so as to give the opportunity to the bacteria in the warts on the roots of the leguminous plants to return a little atmospheric nitrogen to the soil. Also when green-manuring is resorted to, a leguminous crop should be taken, as in addition to the store of organic matter that will be incorporated with the soil, an additional stock of atmospheric nitrogen will be obtained. Hence the reason why we recommend *dhaincha* which is a leguminous plant.

Applications.—After many years of experiment the following manurial applications have been found economical in Bengal, and we give them as a basis on which cultivators can work:—

Paddy —*a.* 50 maunds cowdung.
b. Green manuring with *dhaincha*.
Potato —*a.* 200 maunds cowdung.
b. 20 maunds castorcake
Jute —*a.* 100 maunds cowdung
b. 7 maunds castor-cake.
Surgarcane—200 maunds cowdung *plus* 8 maunds castor-cake.

It will be noticed that all the applications are general manures. When soluble manures such as saltpetre and sulphate of ammonia are applied, they should only be applied when the crop is ready to take them up. Hence the reason why we recommend them to be applied as a topdressing, and for 2 or 3 weeks after they are applied, special care must be taken in irrigating so that just sufficient water is given to keep the soil moist. Flooding the land at this time would be fatal. These two nitrogenous manures are beneficial to all cereals (paddy, wheat), sugarcane, etc., and to quick-growing crops such as jute, potatoes, vegetable, etc., but they are not recommended for leguminous crops.

Before applying phosphatic, potassic and calcareous manures care should be taken to find out that the soil is really poor in these ingredients and in need of such applications. This can be roughly done by chemical analysis, but the actual economical necessity can only be found out by a practical test in the field. A clay soil will roughly contain sufficient potash for ordinary plant requirements, while a sandy soil will be benefited from an application of potassic manure.

Similarly for phosphoric acid and lime, chemical analysis can aid in diagnosing if manurial application would help, but the only certain guide is by practical experience in the field. Roughly the presence of sufficient lime in a soil can be easily tested by taking samples of soil from different points in the field, mixing them together and pouring on the mixture a few drops of dilute hydrochloric acid. If bubbles are given off, there is lime in the soil; if no bubbles are given off there is none or very little.

This is your guide for lime and phosphatic manuring. If no trace of lime can be found, bones and superphosphate of lime will very probably give good results. They both supply lime and phosphoric acid

But although lime may be present in sufficient quantity, phosphoric acid may be wanting. This is the case in Saran, where the soils are rich in lime and poor in phosphates.

All these remarks only demonstrate the necessity of each cultivator testing his own land himself on a small area. When he is convinced that a certain manuring is beneficial, he can easily extend the area.

In conclusion it only remains to be said that general manures are safe to recommend and can safely be tried. They contain their plant food in an insoluble state which is converted into a soluble state. They supply nitrogen, phosphoric acid, potash and lime to the soil and have the great advantage that they will supply organic matter which is wanting in nearly all Bengal soils. It would seem therefore superfluous to add that cowdung should receive every possible care and that the urine which contains the soluble nitrogen and potash should be carefully mixed with the solid excreta and stored.

The above examples of manurial applications give an idea of the quantities that may be economically applied.

If nitrogenous manures are applied, one to two maunds per acre are quite sufficient, while with superphosphate and bones 2 to 3 maunds per acre should not be exceeded. Wood ashes do not contain a high percentage of potash, and 10 maunds per acre must be applied to give an appreciable amount. As this is a cheap article where available, it will not cause the manurial application to be too dear economically.

(*e*) *Green manuring*.—One redeeming feature in Bengal is that its flora is rich in leguminous plants, some of which are undoubtedly well suited to purposes of soil improvement by the faculty of their root nodules to absorb free nitrogen. Every one knows that *dals* (from the pulses) are the daily food of the population.

By growing leguminous crops for green manuring it is possible to maintain in the soil a good supply of vegetable matter and humus, thus securing the mellow, friable texture that is so desirable and at the same time furnishing a supply of nitrogen. In Bengal, where fermentation and nitrification go on so rapidly, green-manuring is exceedingly important, especially since the soil is exposed to the wasteful action of the heavy rains of the monsoon.

Lime and liming.—Lime besides being an essential ingredient of plant food is a stimulant. It stimulates nitrification and decomposition and hastens the formation of soluble plant food. Lime is abundant in Bengal in the form of nodules and is known to every raiyat in the form of *kankar*. Most soils are poor in lime, however, and it is providential that such is the case, for most of the soils are poor in organic matter. Now the quantity of organic matter in soils agrees with the quantity of lime generally present, so liming is not very pressing till the quantity of organic matter has been increased. If organic matter is present in soil in large quantities, an application of lime will give beneficial results. If lime is entirely absent in a soil small applications of bones or superphosphate will supply the necessary amount of lime necessary for plant food. If green manuring is resorted to extensively, liming will be necessary.

Lime—Is an essential ingredient and a stimulant ; soils deficient in lime are corrected by applications of bones or superphosphate.

Resumê.—Manuring is the operation which consists of giving to the soil extraneous substances containing plant food and specially the most important elements of plant food, viz., nitrogen, phosphoric acid, potash and lime. The Bengal cultivator ought not to burn his dung, as nitrogen escapes in the air. To manure a field two factors have to be considered,—1st, the composition of the soil, and 2nd the special requirements of the crop. There are general manures like farm-yard manure which supplies all these most important elements of plant food and special manures which supply one or several of the elements but not all. *Ex.*—Lime, bonemeal, etc. The value of farm yard manure depends upon the age of the cattle, how they are fed and how the dung and urine are conserved. Loss of nitrogen occurs by drainage and volatisation. Green-manuring consists in growing a leguminous crop and ploughing it in before sowing another crop.

Questions.—What is manuring ? What is the custom among Bengal raiyats with regard to dung ? Why must not dung be burnt ? What are the points to consider before manuring ? What kind of manure is always advantageous ? What are the elements of plant food that manure can give ? How do you divide manures ? What is a general manure ? What is a special ? Give an example of special manure. Give examples of general manures ? Give three special manures giving phosporic acid. Which are the factors to be considered farm-yard manure ? How is loss of nitrogen liable to occur ? What is as regards volatisation ? What is green-manuring ? What is liming ?

सत्यमेव जयते

CHAPTER VI.—THE GROWING OF CROPS

We are now convinced that tillage is one of the chief factors of fertility, that irrigation is a very essential point in this country and that by intelligent manuring our fields will yield more than what they will without manure. It now only remains for us to decide what crops to sow, how to choose the seed and how to treat the growing plant until it attains maturity.

I.—The kind of crop to be sown depends on local conditions regulated by the laws of supply and demand.

The chief crop in Bengal is paddy (rice); then come jute, sugar-cane, oats, wheat, barley, maize, juar according to the locality.

II.—Plant selection for seed and change of seed, the permanent importance thereof.

One of the chief defects in this respect noticeable in Bengal is the poor average quality of fruits, vegetables and staple crops. Most of the fruits are chiefly seeds, and this shows that no attempt has been made to develop good qualities.

P.S.—In some districts plantains and mangoes have been distinctly improved.

Vegetables are mostly poor and degenerated, and as for staple crops the average raiyat is satisfied with saving indiscriminately for the next season, the seeds of the weakest or poorest looking plants of his fields. An intelligent plant breeder or hybridiser has a splendid field of work in Bengal.

Every cultivator should bear in mind the following facts:—

1. Start a crop with good seed, and
2. Seed must be adapted to the local conditions existing where the crop is intended to be sown.

It is useless to sow Svalof square head (wheat) in Bengal and to expect a bumper crop as the difference of climate is too great.

Changing seed.—In the case of many staple and garden crops it is best every second or third year to plant seed produced in another locality so as to check the deteriorating influences that may exist in a given locality.

Everyone knows that in remote villages and districts continual intermarriages between individuals of the same village bring about degenerate offspring. As it is in the animal world, so it is in the vegetable world. In many cases our crops would benefit by using seed grown further to the north, and especially is this the case with potatoes, barley and oats. It must, however, be borne in mind that violent change is undesirable; 2° or 3° difference of latitude is quite sufficient in seletion of seed.

III.—The seed.

1. The seed must be genuine, that is, must give the variety whose name it carries.

2. It must be free from foreign material of any kind. It must not be mixed with dirt or with weed seeds; the injury which follows planting weeds with a crop is too evident to need explanation.

3. The seed should be plump; old seed shows a certain amount of shrivelling up, while lean seed contains less plant food for the young plant.

4. Good seed has a certain lustre and colour which is the best proof of the seed having been well kept and stored.

5. It must not be old although some seeds retain their germinating power for many years.

When tested it should give a good percentage of germination, that is, out of 100 seeds put on a damp piece of flannel damped with water every day and put on a plate of sand—count how many seeds sprout, *i.e.*, germinate. This gives the percentage of germination. Every seed is not perfect, so there will always be a certain number which will fail to germinate.

As we have already said, seed requires for germination a proper degree of moisture, sufficient air and a suitable temperature, and by proper tillage and requisite and timely irrigation, the soil is rendered fit to fulfil all these conditions.

Seed will not germinate in a water-logged soil; it rots. Seed will not germinate in a dry soil; it dries up. A soil which is mellow, and at seed time contains about one-half of the total amount of water it is capable of holding and which has been well ærated by thorough tillage, two or three ploughings and harrowings, is in a condition most favourable to the germination of seeds.

In the case of very light soils it will be found useful to compact the soil after sowing. This can be done with the roller or common ladder (*henga*).

Sowing—(*a*) *By hand*—Staple crops and many other crops are sown broadcast, that is, by the cultivator throwing handful of seed all over the field. This is the usual practice in Bengal.

(*b*) *By drill*—The other practice is called (see diagram) sowing by drill. The drill is an implement that has 1, 2, 4 or 8 coulters fed from a central box into which the sower feeds the seed from a bag slung over his shoulder. The coulters are made of bamboo. This system of sowing is not much known in Bengal amongst the ordinary cultivators, as their holdings are too small to derive much benefit from even distribution. The area to be sown, being small, the cultivator sowing himself and after-cultivation being done by hand labour, we have not been able to find any advantage of drill sowing over broadcast sowing. Hence at present there is no reason to change the present system of broadcast sowing. The field is prepared into a good tilth. Finally the plough is passed over the field making ridges into which seed is deposited in a given quantity.

IV.—Rotation.

Rotation is the order in which we grow our crops throughout a number of years on the same land.

(*a*) *Advantages of rotation*—

(1) It is economical of manure.

(2) It enables plants to make more equal use of the food contained in the soil.

This depends upon—

A. The depth to which the roots grow.

B. The length of time during which the plants grow.

C. The power of the roots to absorb plant food.

(3) The land is kept much cleaner and thereby the fertility is raised.

(4) It reduces cost of labour.

(5) Disease of crops is rendered less harmful and farm pests are not so troublesome.

(6) We have larger crops and better returns.

(*b*) *Reason of rotation*—

(1) All plants tend to exhaust the soil in different degrees.

(2) All plants do not absorb the same ingredients in the same proportion.

(3) Some crops tend to allow weeds to grow.

(4) Some plants enrich the soil in nitrogen.

(*c*) *Rules for rotation*—

(1) Crops of the same natural order should not follow one another too freely.

(2) Deep rooted crops should be followed by shallow rooted crops.

(3) A weedy crop should be followed by a clean crop.

(4) Leguminous crops should find a place in every rotation.

D. *Examples of Rotation for Bengal.*

A.	B.	C.	D.	E.
1st year paddy	1st year— Jute ... ... Summer paddy	1st year— Summer paddy ... Winter gram ...	1st year— Summer jute ... Winter potatoes.	1st year— Sugarcane.
2nd ,, paddy	2nd year— Jute ... ... Summer paddy	2nd year— Summer paddy ... Winter gram ...	2nd year— Summer aus paddy Winter potatoes ...	2nd year— Summer maize. Winter barley and gram.
3rd ,, paddy	3rd year— Jute ... ... Summer paddy	3rd year— Summer paddy ... Winter gram ...	3rd year— Summer jute ... Winter kalai.	3rd year— Rahar (arhar).
4th ,, paddy	4th year— Jute ... ... Summer paddy	4th year— Summer paddy ... Winter gram ...	4th year— Summer aus paddy Winter potatoes.	4th year— Aus paddy.
			5th year— Summer jute ... Winter kalai.	5th year— Sugarcane.
			P.S.—In this rotation only manure the potatoes.	*P.S.*—Only manure sugarcane. Juar can substitute maize in another rotation.

N.B.—From the above, rotations can be multiplied indefinitely.

V.—Fallowing.

Fallowing is a method of increasing the fertility of the soil. There are two kinds of fallows :—

Bare fallow and green crop.—Bare follow is to cultivate a soil and leave it to the action of the atmosphere for a whole season without growing a crop. In Bengal on most paddy lands fallowing is practised extensively, but unfortunately most cultivators do not plough their lands after harvesting, with the result that the effect of fallowing is lost. The surface of the land is left caked for five months, and the air cannot have its full effect on the soil. The effect of bare fallowing is to prepare the stock of plant food due to the natural fertility of the soil for the next year's crop. If the raiyat burns his cowdung, he should at least give his soil every chance of doing its best, and this only requires one or two ploughings after harvesting his paddy crop. Green crop fallow is to grow a green crop like potatoes or vegetables. These crops are very carefully cultivated and are manured, and the results of both these practices, which increase the fertility of the soil, are felt on the following crops.

Potatoes and vegetables are not yet fully appreciated and not grown sufficiently by the Bengal cultivator. In addition to the excellent food supply they produce, they increase the fertility of the soil.

VI.—Weeds.

A weed is a plant out of place. The ordinary raiyat in Bengal understands weeds and how to get rid of them very well. Weeds take the place of the plants and thereby lower the outturn. They also take up the food of plants and thereby lessen the plant food of the crop and correspondingly lower the outturn. Accordingly weeds must be removed carefully from every crop.

Fungus and insect-pests.—The effects of these pests are known but too well by the ordinary cultivators, but their cause is too often attributed to visitation of evil spirits. In each branch alone there are splendid opportunities for the work of a lifetime for many workers. This book is not a work for describing fungus and insect-pests in detail—their life history or their methods of remedy and prevention; special books on the subject must be consulted.

The intention of this book is to show how to produce a strong healthy crop which is the best prevention against fungus and insect-pests. One pennyworth of prevention is worth a pound of cure; and if cultivators will always bear this maxim in mind, they will be saved many terrible devastations. When the pest is there, remedies can be resorted to, but the cost in each case will be found almost always prohibitive.

With such huge areas under one crop as is the case in Bengal with paddy, it is not surprising that terrible devastations take place nearly every year. A pest requires its special host on which to thrive best; and with such a plentiful supply of food as the Bengal paddy crop, the paddy pest has everything favourable to cause its maximum development. It is thus easy to understand the terrible destruction that sometimes takes place. If at the time of any severe attack of insect or fungoid pests the crop is prevented from thriving by drought or flood, the attack is fatal, as the crop has not the power to withstand this additional burden. Hence the reason why a strong healthy crop must always be aimed at.

The chief prevention against devastation by pests is rotation. A district should always grow several crops, so that in the case of an attack on one crop the other may *survive*. Should a particularly severe attack occur on paddy, for example, and the pest is travelling across a large district, if the paddy suddenly gives place to sugarcane or jute, the pest would lose its host (food) plant and would not be able to thrive so well, with the result that the natural enemies of the pest would find the pest in weakened circumstances and would have more chance of destroying it. In this way the pest is prevented from devastating the whole district. Hence the necessity for different crops or for rotation of crops.

Other preventions that are worthy of note are—

1st.—Drain marshy spots or make of them useful storage areas for water.

2nd.—Plough up the paddy lands after harvesting the crop in order to bury the stubble and to allow the sun to have full effect on the soil. This disturbs and destroys the grubs or spores in the soil.

3rd.—Clean away weeds and grasses round fields to prevent pests finding a host plant.

4th.—Top dress crops with manures to push them on at critical times of their career.

5th.—Consolidate the land by laddering (*henga*) to make it difficult for insects to get in and out of the land.

6th.—Take great care of the manure pits and heaps which are favourite breeding places for insects.

VII.—Harvesting, threshing, winnowing and storing.

These processes are exceedingly simple and primitive, and so long as labour remains cheap enough and the weather at harvest time can be depended on for being fine and dry, they do not require to be superseded.

Harvesting.—Harvesting is a very simple process in Bengal and is done by means of the sickle. So long as labour is as cheap as it is, there is no necessity to bring in the improved implements of western countries, and they will therefore not be mentioned.

All the cereals (rice, wheat, barley, oats, millets and maize, etc.) and pulses (peas, gram, rahar, mung, khesari, etc.) which are cut when dead ripe, and jute, which is cut when plants are in full flower or fruit pods are forming, are harvested by means of the sickle.

Sugarcane (one year) is harvested by means of the *kodali*. For ratooned cane harvesting is done by means of the sickle. Potatoes, turmeric, ginger, are harvested by means of the *kodali*.

Cotton and maize cobs are harvested by hand picking.

Threshing.—Threshing is done by hand or by treading of bullocks.

Hand.—All cereals can be threshed by beating the grain against a log of wood. Other crops could be similarly thrashed, but it is difficult to get hold of the stalks, so they are generally trod out by the bullocks.

Bullock treading.—Cereals are also threshed by means of bullocks. A stake is fixed in the ground and the crop is arranged round this stake and the bullocks which are all tied together and to the stake are made to walk round the stake till the grain is threshed out. When the animals void their dung, the man in charge catches it in his hand, and if not sharp enough, he gathers it up immediately. When the bullocks urinate the liquid is immediately absorbed by the straw chaff and very little comes in contact with the grain.

From the above it will be seen that hand-threshing is a cleaner process than treading by bullocks.

Steam threshers are not of much importance so far as the ordinary raiyat is concerned at present, so they will receive no further consideration.

Winnowing.—At threshing time the larger part of the straw is removed and what is left is composed of grain, chaff, small bits of straw and dirt. The grain is finally separated from the chaff by winnowing. Winnowing simply consists of allowing the mixture of grain and chaff to fall 5-6 feet on a windy day when the grain falls, and in falling, the chaff, being lighter, is blown away from the grain. In this manner the grain can be perfectly cleaned. The experience the cultivators have of cleaning their grain with the help of nature is really wonderful.

In western countries threshing and winnowing are performed together by means of the steam thresher.

The thresher is not yet required by the small cultivator in Bengal.

Winnowing machines have been invented only for cleaning grain, but in Bengal we are not yet convinced of its necessity for the small cultivator. It would mean capital expenditure which the cultivator requires for other things first. When the cultivator understands co-operation and can lay aside suspicion of his neighbour, improved implements for harvesting, threshing and winnowing may come into vogue

Storing.—The methods of storing grain in vogue amongst the cultivators are also simple in the extreme, and yet, wonderful to relate, they keep the grain dry and sound.

Some (Sonthals) make ropes of straw and make these ropes of straw into balls, 1 yard in diameter, with paddy in the inside. These balls are stored in their houses. The grain is kept in perfect condition in these balls.

Other cultivators (in Lower Bengal) build houses (of these straw ropes, or of bamboos) on stilts to keep them above the water level in times of flood and the grain is kept in excellent condition. Other cultivators use earthen jars that remind one of the jars in the tale of Ali Baba and the forty thieves. The jars are filled with grain and then covered up with a lid and the lid is made water-tight and air-tight by means of cowdung plaster. If before closing the lid a piece of cotton were dipped in carbon bisulphide, a poisonous and highly inflammable liquid, and placed inside the jar, these jars would be perfect so far as the storing of grain is concerned.

Several kinds of bins for storing grain have been made and can be had by those who can afford to buy them.

Resumé.—The kind of crop depends on local conditions. The chief crop in Bengal is paddy (rice), then come jute, next, sugarcane, oats, wheat, barley, maize and juar. It is necessary to take the seed from the best plants in the field. Every cultivator should have as his watchword—Start a crop with good seed and seed must be adapted to local condition and change your seed every two or three years, taking a seed from a more northern district. The seed must be genuine, be free from weeds, young, plump, lustrous and must give a good percentage of germination. Seed is sown by hand or drill. Drill is an implement little known in Bengal. Rotation is necessary to ensure freedom from pests and fungus, good outturn and renovating of land. Fallowing is allowing the land to rest. The best preventive against attacks of pests and fungi is to have a healthy crop; therefore good tillage, soil well ærated, plenty of water should be carefully attended to.

Questions.—What is the chief crop in Bengal? Why is plant selection necessary? Why is it necessary to start a crop with good seed? Why is it a good practice to change seed every third year and take a more northern variety? What are the good points to observe in choosing one's seed? What is a drill? What is the use of rotation? Give a three years' rotation? A year's? What is fallowing? How to prevent attacks of pests? Or fungus? What is harvesting? And threshing? Winnowing? How do the raiyats store their rice?

CHAPTER VII.–PARTICULAR CROPS.

(1) PADDY, RICE, DHAN (*Oryza satva*).—NAT. ORDER GRAMINEÆ.

Paddy is found in a wild state in moist tropical countries. It is an annual plant and is extensively cultivated in all the warmer parts of the globe. The best varieties, as also the most prolific, require a damp warm atmosphere with a moderate degree of sunshine. Bengal is exactly suited for rice.

Rice is the staple article of food in Bengal. It is the corn of the Bengali as wheat is that of the Englishman, Frenchman and German, barley that of the Scandinavian, rye that of the Russian and maize that of the American.

(*a*) There are three different classes of rice or paddy in Bengal, viz.—

1st.—Aus paddy, high land rice or summer crop,
2nd.—Aman paddy, transplanted rice, or autumn crop, and
3rd.—Boro paddy, very low land rice, or winter crop.

Each class is controlled by the water supply. On land that becomes dry in September, aus paddy is taken. The crop is sown broadcast in May, or it may be transplanted in June and will be ready for harvesting early in September. Each district has its own special varieties which are generally coarse grained. There are also fine grained varieties, and from experience we can recommend those of the Central Provinces From the fine aus variety procured from that locality we have obtained an outturn per acre of 27 maunds of grain plus 85½ maunds of straw (at the Cuttack Agricultural Station). Aus paddy is not so important in Bengal as aman paddy. Where there is a plentiful supply of water on the land in October, aman paddy is taken. This is the most important crop of the Province Seed is generally sown in seedbed in early June, the crop is transplanted out in the fields in July, and the crop is harvested in December. Sometimes seed is sown broadcast in the fields, but transplanting is the best method and gives the best outturn per acre.

There are thousands of so-called varieties of this class of paddy, but most of the differences are due only to environment.

For the sake of simplicity, this class of paddy is best divided into three kinds—

(*a*) Fine	grained. Examples-	Dadkhani, Katharibhog, Badshabhog.
(*b*) Medium	,, ,,	Balam, Patna.
(*c*) Coarse	,, ,,	Maharajwa.

The finer grained are for the wealthier and higher classes, while the coarser are eaten by the poorer classes.

Many other distinctions could be made, such as colour and shape of grains, scented and unscented, drought resisting and flood resisting, but these factors are not so distinguishing as the fineness and the coarseness of the grain. If a drought resisting variety is desired, one should go for seed to a district where the rainfall is small and precarious.

Boro paddy is not so important as the other two classes. Lands that floods from June or July to November are put under boro paddy when the flood subsides in December. Seed is sown in seedbed in December, transplanted in January and the crop is ready for harvesting in two months. In North Behar boro paddy is taken in the beds of rivers and streams when the water subsides. Boro paddy is generally coarse grained.

From the above it will be seen that paddy can be grown all the year round, according to the supply of water.

(*b*) *Preparation of the land.*—Five or six ploughings and two or three ladderings give the necessary tilth for sowing broadcast. For transplanted paddy the land is ploughed two or three times in puddle (out of the six ploughings) and laddered twice until the field has the consistency of soft mud (porridge-like mass) when transplanting can take place. Boro paddy is treated like aman paddy.

(*c*) *Seed and selection thereof.*—Choose the variety that is required according to the local demand (or customer's taste) and see that seed true to type is obtained. See that the sample is clean, free from dirt and weed seeds, not weevil-eaten, plump and fresh. Old shrivelled sheeds germinate badly and produce weekly seedlings.

(*d*) *Sowing time.*—This depends on whether the paddy is aus, aman or boro. Aus is sown in May and transplanted in June. Aman paddy seed should be sown in seedbed in the first week of June. This date is very important, in order that the seedlings may be transplanted in the beginning of July. In Bengal all aman paddy should be transplanted by the 15th of July. Every day after the 15th of July acts against a maximum outturn being obtained and every day after the 15th of July increases the risk ensuing from drought or flood. We cannot impress this date too much on the people of Bengal. Boro paddy is sown and transplanted in November, December and January according to the supply of water and risk of frost (in North Behar).

(2) *Quantity of seed.*—In broadcasting, the quantity of seed is regulated by the fineness of the grain. About 30 seers of a fine grained paddy and about 40 seers of a coarse grained paddy are sufficient seed per acre. In transplanting, 15 seers of seed, either coarse or fine grained paddy, sown on $\frac{1}{15}$th of an acre, will give sufficient seedlings to transplant 1 acre of land.

In transplanting it has been found that planting 1 seedling every 8 to 10 inches apart gives a better outturn than 2, 4 or 8 seedlings.

(3) *Manures.*—All our experiments on the manuring of paddy agree that—

(*a*) 50 maunds of cowdung, or
(*b*) 6 maunds of castorcake per acre, or
(*c*) green manuring with dhaincha—

are economical manures to apply. They may be employed by everybody and they should be learnt by heart by every child. There are many other manures, but the kinds and quantities should be tried carefully first before employing large quantities on large areas

Cowdung or castorcake should be applied before ploughing in puddle. Dhaincha seed (6 seers per acre) should be sown in April or May according to rainfall and ploughed under (green manured) at the time of puddling the land for transplanting.

(4) *After-cultivation.*—After-cultivation with aman paddy consists simply of weeding once (generally) by means of the *khurpi*.

With aus paddy one or two weedings are given. Sometimes the crop is partially ploughed. This loosens the soil and gives the paddy plant a better chance of spreading its roots and of tillering. Weeding is also thereby facilitated.

(5) *Harvesting.*—The crop is harvested when the straw turns yellow or becomes dead ripe.

(6) *Yields.*—Good yields or outturns of paddy per acre as obtained at the Cuttack and Burdwan Agricultural stations are :—

	Grain	Straw.
Aus paddy	... 25 to 27 maunds	... 60 to 70 maunds.
Aman paddy	... 40 to 50 maunds	... 55 to 70 maunds.

We have no definite figures to give for boro paddy.

JUTE (PĀT).—NAT. ORDER TILIACEÆ.

Jute is an annual plant that is cultivated for its fibre. It requires about the same soil and climate as rice, but it cannot stand water-logging. There are two species of jute, viz.—

Corchorus capsularis and
Corchorus Oltorius.

Corchorus capsularis has rounded capsules (fruits). *Corchorus Olitorius* has long pods (fruits). Of these two species, many so-called varieties are grown. *Corchorus capsularis* appears to be generally green stemmed, while *Corchorus olitorius* is either red-stemmed or green-stemmed. This appears to be the case throughout Bengal. A green-stemmed capsularis or a red-stemmed olitorius should be chosen as giving the best results. Jute requires plenty of moisture to grow well, but it cannot stand water-logging. It grows well on all soils, either high-lying or low-lying, provided the requisite water is obtained.

(*b*) *Preparation of the land.*—The requisite tilth for sowing is obtained by 7-8 ploughings and three ladderings. Manure is applied just before sowing the seed.

(*c*) *Seed and selection thereof.*—Good clean shiny seed of the variety required should be selected for sowing. Strong healthy plants should be selected in the field for the production of the seed supply for the following year. Before sowing, the seed should be subjected to a germinating test and 90 per cent. germination should be obtained.

(*d*) (1) *Sowing time.*—The best time for sowing jute seed is immediately after the first showers of April and May, so that the plants may be strong enough to withstand the heavy rains of June and July.

(2) *Quantity of seed.*—Four and-a-half seers of seed per acre when the seed germinates 90 per cent. is sufficient seed rate.

(3) *Manures.*—The following manurial applications have proved economical in Bengal, and they should be noted :—

(1) Sixty eight and-a-half maunds of cowdung, or
(2) Seven maunds of castorcake.

(4) *After-cultivation.*—The after-cultivation consists of three bidarings, one thinning, two weedings and one or two waterings (if necessary) according to the degree of moisture of the soil; the crop is then ready to be cut in the middle of August and the process of retting commences.

(5) *Harvesting.*—Plants are generally cut with a sickle, but in very low-lying lands simply uprooted. In either case the plants are tied in bundles and left on the field for two days.

Steeping or retting.—The fibre is found on the outer layer of the stem and is mixed with gum and vegetable matter which must be removed and the process of removing these is called retting.

The bundles of jute are placed in a ditch (pit) of gently running water and kept under water by means of bamboos or stones. Some people plant bamboos against the stream to prevent the bundles being washed away. Bacteria which live upon the gum contained in the bark rapidly free the pure fibre and in 10 to 20 days after (steeping) immersion in water the process is finished. The bundles now are taken out of the water and the fibre is extracted by beating the stems with a stick and stripping off the fibre from the pith which is left behind. This process is called stripping. The fibre is then cleaned by washing in clean water. This cleaned fibre is then wrung out and placed on bamboos in the sun to dry. When dry, the fibre is made into bales and is ready for the market. The fibre is then cleaned by washing in clean water.

(6) *Yields.*—Good outturns per acre are 20 to 25 maunds of fibre (Burdwan and Cuttack Agricultural stations).

SUGARCANE (UKH).—NAT. ORD. GRAMINEÆ.

III.—Saccharum officinarum.

Gramineæ.

The sugarcane is a perennial robust grass with a stem reaching even 16 to 32 feet in height. The stem is a cylinder, solid jointed, and ending in a slender hollow top which bears the flowers which are very like that of any other grass. The roots are fibrous and wide spreading, either keeping near the surface of the soil or going deep down. In loose soil they strike straight down to a great depth. The larger fibres fix the plant, while the smaller ones which are very numerous are the feeding roots Hence it will be understood at once that in order to obtain a good crop the soil should be prepared with extra care in order to give the roots the best possible chance. The sugar is contained in the stem. When young the stem is carefully protected by a sheath (of rather coarse leaves) which is a protective device. The sugarcane has so many enemies, not only insects always on the look-out for sweet things, but even carnivorous animals have a weakness for the sweet juice, and jackals, wild pigs, and monkeys have to be guarded against. The joints are called nodes and the smooth portions between them are called internodes. Leaves which look like blades grow laterally and are alternate. The green cells of the plant prepare under the influence of the sun most of the sugar which when ready is stored in the stem.

(*a*) There are many varieties of cane in Bengal—some are thick stemmed, others are thin stemmed ; some are drought resisters, others can put up with lots of water; some are soft skinned, while others are hard ; some are very long stemmed, while others are short.

We shall not attempt a classification of canes in this little book, but content ourselves with the statement that the Khari cane is an excellent variety. It withstands drought and water-logging very well, sustains attacks of animals, insects and fungus pests excellently, is very prolific and a good yielder and produces a good quality of gur.

The Shamshara variety of the Burdwan district is also an excellent variety, but pigs and jackals must be carefully fenced out as they do much damage, and a plentiful supply of water is necessary throughout the early growing season.

(*b*) *Preparation of land.*—The land must be ploughed, cross-ploughed, and laddered till a fine tilth is obtained. This is obtained by 8—10 ploughings and 4—5 ladderings.

If the sets are planted on the plough furrow, this is all the preparation the land gets. If the ridge and furrow system of planting is adopted, the land is drawn up into furrows 2½″ wide separated by ridges 2½″ wide. These furrows are laid according to the level of the land, so that irrigation is easy. If the Poona bed system of planting is adopted, the land is laid out in beds 10′ square with irrigating channels round each bed—then the bed is laid out in ridges 2½″ wide separated by furrows 2½″ wide. If the Mauritius pit system of planting is adopted when the necessary tilth is obtained the land is

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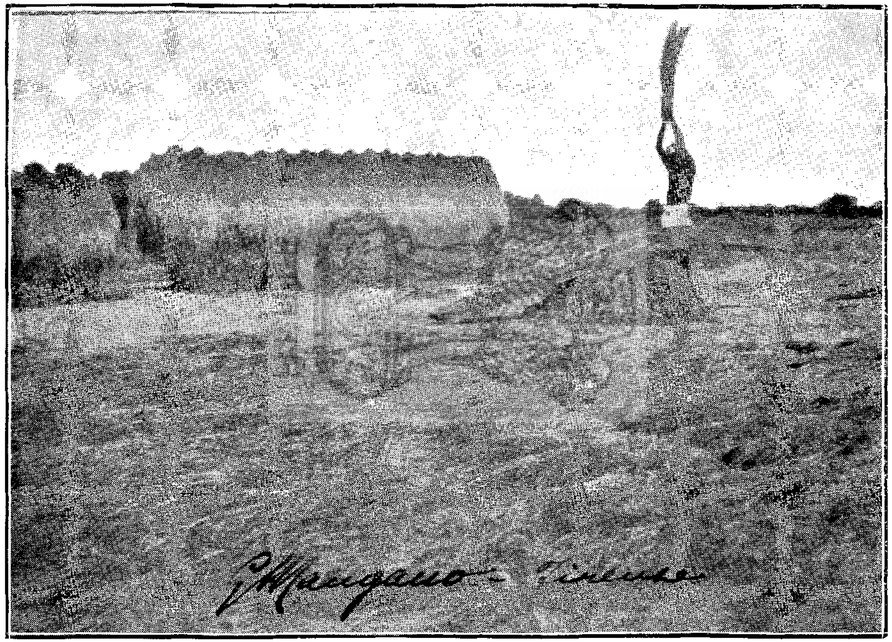

Threshing by hand.

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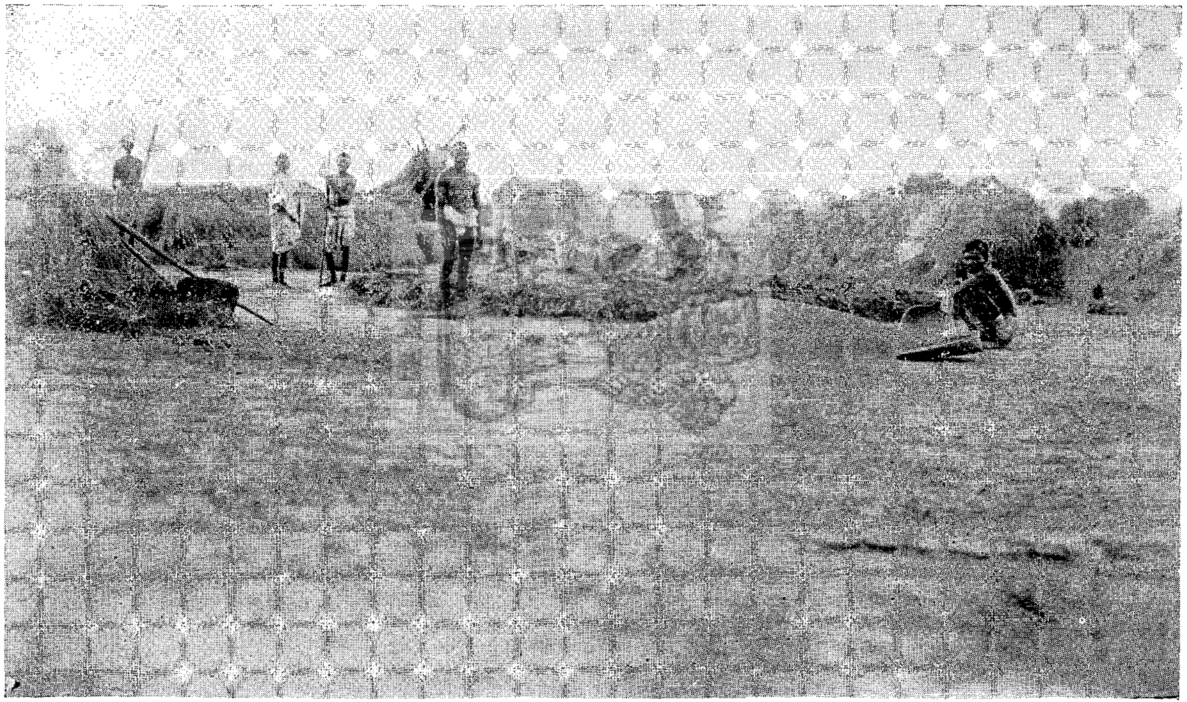

Threshing by Bullocks.

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set out with pits (1′ deep and 1′ in diameter) three feet apart each way.

(c) *Seed and selection thereof.*—Choose the variety that is wanted and see that strong healthy sets are obtained. Each set should have at least 2 internodes or 3 nodes and must contain buds. The seed is best selected at harvest time. Take the strongest and healthiest canes when preparing for the crushing mill and cut off the tops for planting purposes. These tops are of very little value for crushing and are excellent for seed.

(1) *Sowing time.*—The best time for sowing cane is when the cane is being harvested. Harvest the cane, and carry the canes to the crushing mills after, which the extra men can best be employed in planting the next year's cane crop.

Accordingly December, January, February and March are the months for planting cane. The earlier the cane is planted the better, in order that the cane may be well established before the hot weather sets in.

(2) *Quantity of seed to sow.*—The quantity of seed required per acre depends upon the method of planting. Planting on the plough furrow requires an enormous number of sets in comparison with the ridge and furrow system of planting. If whole canes are employed for planting, more sets will be required than if only parts of the stem (sets) are used If the land is badly infested by whiteants, whole canes should be planted. This gives food for the whiteants while the young shoots are taking root, after which flooding the land keeps the whiteants in check.

The number of sets for planting in the plough furrow on an acre of land can easily be worked out, but we leave this to the student, as this mode of planting is a wasteful practice. Each line (furrow) is 9″ apart and sets are planted 1′ apart in the line ($66' \times 132' = \frac{1}{5}$th acre). In the ridge and furrow system of planting if two rows are planted in each furrow, that gives us two rows in every 5 feet or one in every $2\frac{1}{2}''$ feet. In short, planting on the plough furrow requires three times more seed than that of the ridge and furrow system. In the ridge and furrow system with two rows of canes in each furrow $2\frac{1}{2}''$ wide, 17,160 sets are required per acre.

(3) *Manures.*—All our experimental results on manures in Bengal (Agricultural Stations) agree that 200 maunds of cowdung plus 8 maunds of castorcake per acre is the most ecomomical application for sugarcane.

The cowdung and half the castor-cake is applied in the furrows before planting the sets, while the remaining half of the castor-cake is applied round the plants before levelling the ridges in June.

(4) *After-cultivation.*—The after-cultivation of the sugarcane crop consists of—

7 Hoeings with *kodali*, March to June,
3 Weedings, April, May and June,
1 Levelling with *kodali* in June, and
10 Irrigations (1 in December, 1 in March, 2 in April, 3 in May, 1 in June and 2 in November).

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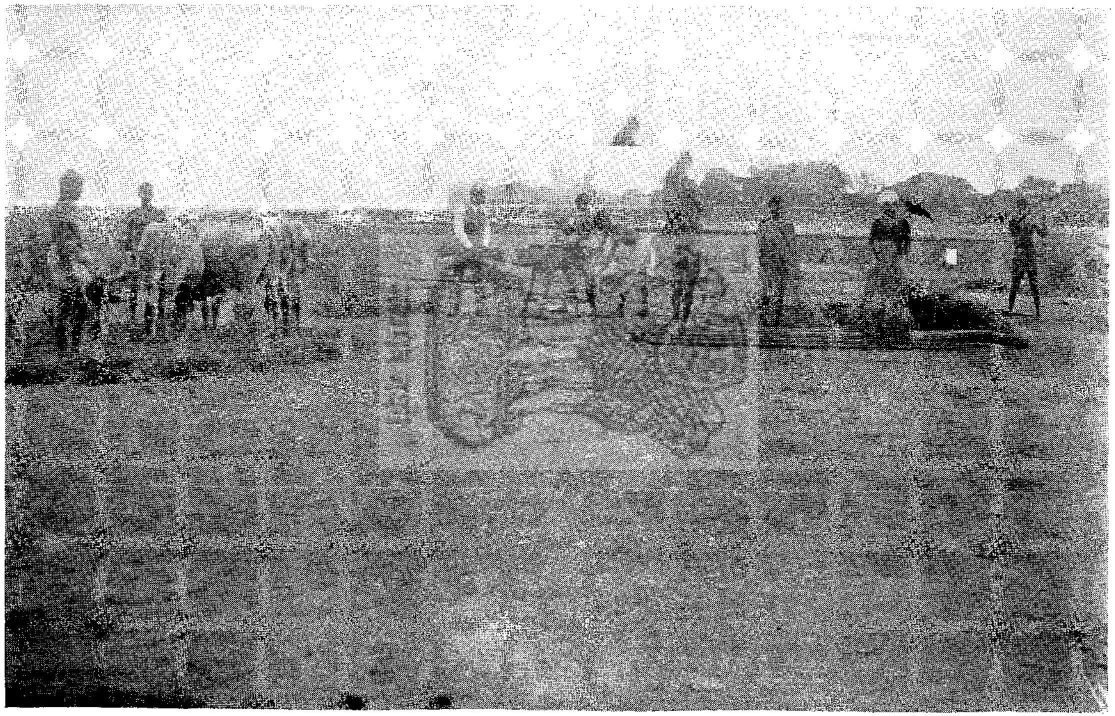

Threshing by hand, bullocks and power machine.
Winnowing by hand.

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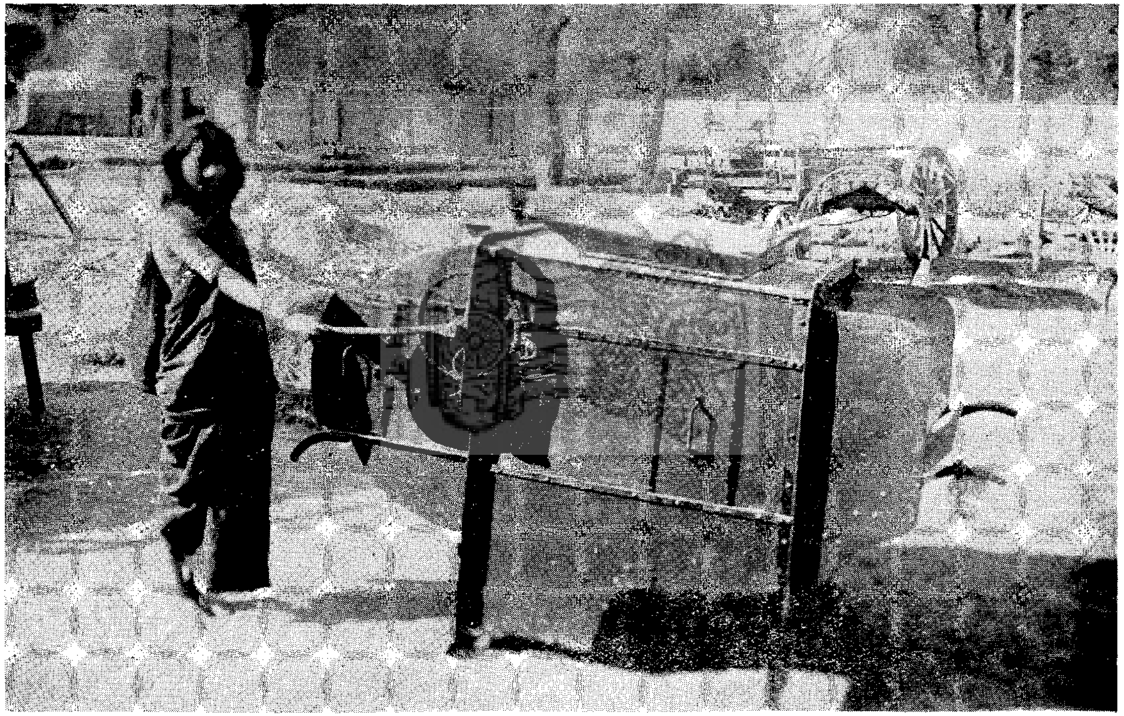

Winnowing Machine.

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(3).

(Rice) Paddy packed in straw ropes.

(5) *Harvesting*.—The sugarcane should be harvested when the highest percentage of sucrose is present in the stem. This depends on the time of planting and the climate. In Bengal, the cane begins to get ready for harvesting about December. Cane is ready for harvesting when the leaves shrivel up and the cane snaps straight across instead of bending when it is bent down. One year's cane is harvested by means of the *kodali*. The crop is uprooted and the canes are separated from the rootstock by means of the sickle. Ratooned canes are cut by means of the sickle.

A crop is said to be ratooned when it is cut down the first year with the sickle and the cane is allowed to grow a second year. Canes can be ratooned two, three, four, and more years. Canes are cut and carried to the crushing mill. Near the crushing mill three roller crushing mills should be employed (Mylne's Beheea Three-Roller Cane-Crushing Mill is an excellent machine), the evaporating pan is erected and the fuel for this evaporating pan is obtained from the dried leaves of the sugarcane and the remains of the cane when the juice has been pressed out. Each day this refuse is spread out to dry for the fuel of the following day. The ashes from the fuel can be most usefully employed as manure.

The canes are crushed in the mill, the juice is caught generally in clean tins. The juice should be strained (through clean cloth) into these tins, *i.e.*, before the juice is placed in the evaporating pans where the juice is boiled (evaporated) down till the right consistency is obtained, *i.e.*, when the *gur* of Bengal is produced. This *gur* is scraped out of the evaporating pans into basket moulds lined with cloth. During the evaporating process the addition of a little lime helps to cause the deposition of impurities which are sieved off before *gur* is made. This helps to give a clear sample of *gur*.

(6) *Yields*.—Good outturns as obtained at the Bengal Agricultural Stations are 50 to 70 maunds of *gur* per acre. Ratooned canes will give $\frac{1}{2}$ to $\frac{2}{3}$ the outturn of ordinary cane. Larger outturns have been obtained, but the net profit was less than from the above.

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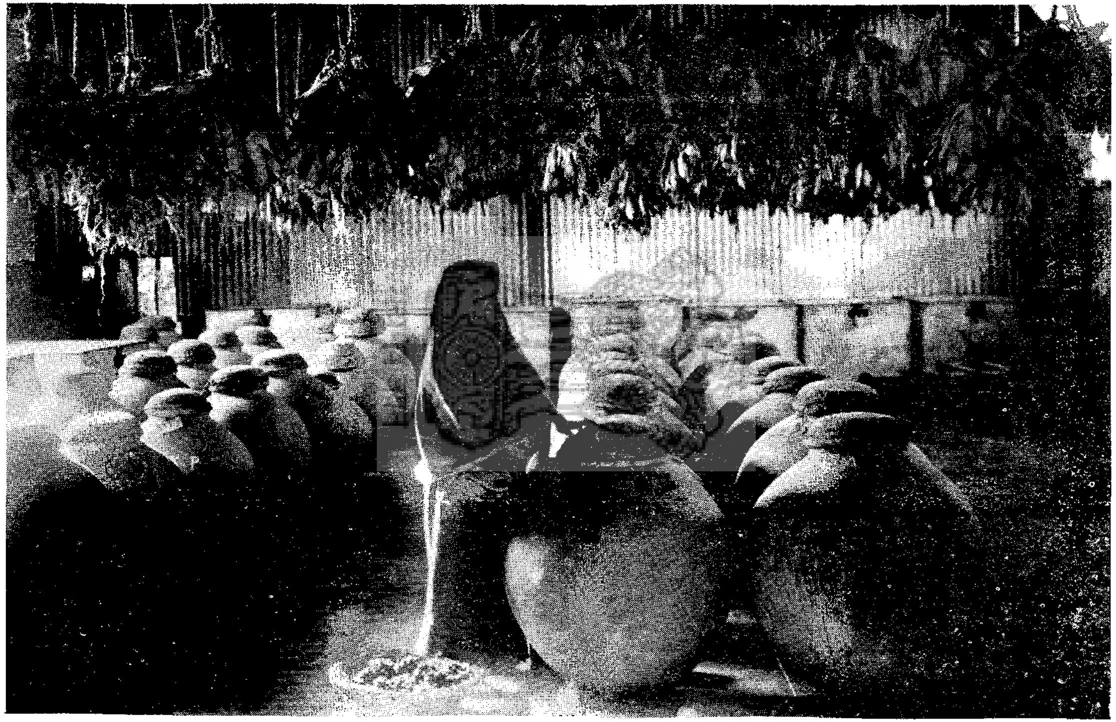

Grain stored in Jars and Bins.

IV.—Wheat, Barley, Oats.—Nat. Order Gramineæ.

All three are gramineous and *rabi* crops, *i.e.*, sown in October and November and harvested in February and March and are grown chiefly in the North-Western part of the Province.

Wheat.—(Gehun) Triticum vulgare. (গোধুম)
Barley.—(Jau) Hordeum vulgare. (যব)
Oats.—(Jai) Avena sativa. (জই)

Wheat.—There are several species and many varieties of wheat, but it will suffice here to mention the Muzaffarnagar white, Buxar white and red deshi (United Provinces) varieties. They are all good varieties. The Muzaffarnagar is more subject to rust than the red deshi variety under moist conditions. However, the Muzaffarnagar wheat is a favourite with the export trade.

Barley.—There are four known species and many varieties, but we shall only mention here that the seed that has given the best results in Bengal so far comes from the North-West of India (from outside the Province of Bengal.)

Oats.—There are six known species and numerous varieties, but the seeds that can be recommended for Bengal come from Shahabad and Hissar and are known as Dumraon and Hissar oats. This crop is particularly suitable for churs (flooded lands).

(*b*) *Preparation of the land.*—The preparation of the land is the same for all three crops and the necessary tilth for sowing can be obtained by five ploughings and five ladderings.

(*c*) *Seed and selection thereof.*—Choose the variety that is desired and see that a clean plump sample of seed, free from foreign and weevil-eaten grain, is obtained, and make sure that the percentage of germination is satisfactory (95 per cent.). At harvest time mark the strongest and healthiest plants and place them at one side to give the requisite seed supply for the following year.

(*d*) 1. *Sowing time.*—The time to sow these crops is in October and November according to the supply of moisture in the soil.

2. *Quantity of seed to sow or seed rate*—

(*a*) Wheat—50 to 60 seers per acre.
(*b*) Barley—60 to 70 seers per acre.
(*c*) Oats—70 to 80 seers per acre.

3. *Manures.*—These crops are generally not manured as the manure is applied to the other crops in the rotation. If manures are applied they are spread before sowing the seed. The average outturn per acre of these crops is very small in India in comparison with England and the crops well respond to manuring. The following may be applied with economy:—

(*a*) 80 maunds cowdung, or
(*b*) 80 maunds poudrette (night-soil).

Applications of 1 maund of saltpetre have given excellent results in India.

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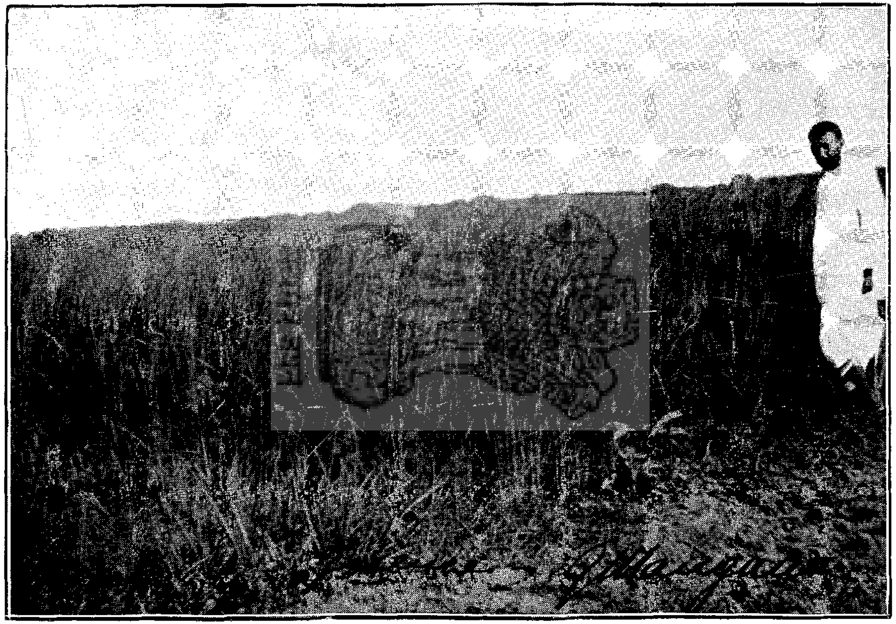

Paddy.

4. *After-cultivation.*—After-cultivation consists of 1 or 2 weedings with the khurpi and 1—3 irrigations according to the locality. In some districts irrigation is not necessary. If rain falls and the soil surface becomes caked run the bhida across the land two or three times to get the necessary mulch to retain the soil moisture.

5. *Harvesting*—

(*a*) Harvest wheat when dead ripe.

(*b*) Harvest barley when ripe (yellow). Don't let the crop stay too long on the field, or the heads drop off.

(*c*) Harvest oats when the tops turn yellow to prevent the grain falling on the field.

6. *Yield.*—Good outturns per acre—

Grain.		Straw
(*a*) Wheat ...	10 to 14 mds.	20 to 30 mds.
(*b*) Barley ...	12 to 16 ,,	16 to 20 ,,
(*c*) Oats ...	14 to 20 ,,	30 to 40 ,,

See Reports on the Bengal Agricultural Stations.

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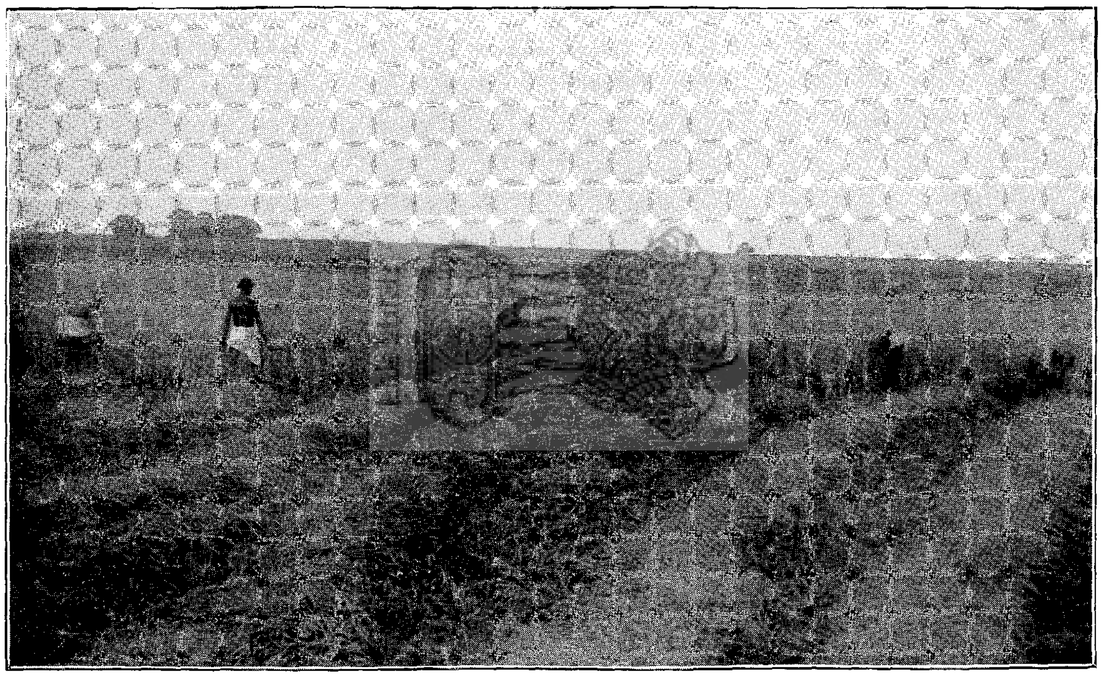

Paddy Harvesting.

V.—Pulses.—Gram and other leguminous crops.—Nat. Ord. Leguminosæ.

1. (*a*) Gram (Bunt) (Chola) *Cicer arietinum.*
   (*b*) Pea (Matar) *Pisum sativum.*
   (*c*) Lentils (Masur) (Musuri) *Ervum Lin.*

2. (*a*) Mung. (*Phaseolus radiotus.*) (Sona mung *var.* aurea) (Kala mung *var.* grandes).
   (*b*) Urid. Mas kalai. *Phaseol Mungo.*
   (*c*) Horse gram (*Kulthi*) *Dolichos biflorus.*
   (*d*) Khesari, *Lathyrus sativus.*
   (*e*) Groundnut. (China badam) *Arachis hypogeæ.*

3. Pigeon pea. (Arhar) *Cajanus indicus.*

The pulses are divided into three classes according to their season of growth, viz., (1st) *Rabi* crops, *Ex.* Gram, peas and lentils. (2nd) *Kharif* crops, *Ex.* Mung, urid, horsegram and khesari, and (3rd) a two-season crop arhar, which is generally sown in June and harvested in March and April. The first class consists of valuable crops. They require rich soils and careful cultivation. Gram and lentils prefer heavy (clay) soils while peas prefer light (sandy loams) soils. These crops are generally grown in mixtures of other crops. *Ex.* Wheat and gram; barley and gram; barley and peas; barley, peas and linseed; wheat, gram, lentils, linseed and mustard.

The second class are generally grown on poor sandy soils that would give poor returns from other crops. Occasionally they are taken as a second crop after paddy.

Gram and lentils are also sometimes grown as a second crop after paddy.

Arhar occupies the land from June to April, *i.e.*, two seasons. It grows on light sandy soils and is a splendid drought resisting plant.

Groundnut may also be classed as an oilseed. Seed is sown in June and the crop is harvested in November and December. There is no reason why the second class should not be grown as *rabi* crops, but the class of soil and local conditions generally keep the classes as sub-divided above.

(*b*) *Preparation of land.*—The necessary tilth for sowing is obtained by three to five ploughings and two to three ladderings.

(*c*) *Seed and selection thereof.*—The same remarks as made on the previously mentioned crops hold good for these crops.

(*d*) 1. *Sowing time*—

Gram, lentils, peas.—October and November.

Mung, urid, horse-gram, khesari, groundnut.—June, July, August and September according to local conditions, or even in October.

(Pigeon pea) arhar is sown in June.

2. Quantity of seed or seed rate per acre.—

Gram ...	1	md.	Broadcast.
Lentils ...	20 to 30	seers	Ditto.
Peas ...	1½	md.	Ditto.
Mung ...	5—6	seers	Ditto.
Urid ...	5—6	„	Ditto.
Horse gram ...	10	„	Ditto.
Khesari ...	5—6	„	Ditto.
Groundnut ...	20	„	per acre when sown in line 1½′ apart.
Arhar ...	5	„	is sufficient per acre when sown in lines 3′ apart

3. Manures are generally not applied to these crops, but to the other crops in the rotation. Potassic manures *Ex.* wood ashes will benefit these crops.

4. *After-cultivation.*—No after-cultivation is generally necessary. One weeding may be given in the case of gram, peas and lentils. One or two weedings for groundnut and arhar will keep down the weeds till the crop is fully established, after which no treatment is necessary.

5. *Harvesting.*—Crops are harvested when ripe, collected together and threshed by treading or beating of sticks. Crops should not be allowed to stand too long in the field when ripe for fear of the pods opening.

6. *Yields per acre*—

	Mds.
Gram	12
Peas	12
Lentils	10
Mung	10
Urid	10
Horse-gram	10
Khesari	10
Groundnut	20
Arhar	15

VI.—MAIZE (BHUTTA) (MAKAI) ZEA MAYS.—NAT. ORD. GRAMINEÆ.

There are many kinds of maize, but the one that has given the best results in Bengal on the plains is the Jaunpur variety. In the Darjeeling hills the Jaunpur variety does badly and is not to be compared with the best hill varieties; one of which that we can recommend is the seed from Kalimpong.

(*b*) *Preparation of the land*.—To obtain the requisite fine seed bed requires five to seven ploughings and three to four ladderings.

(*c*) *Seed and selection thereof*.—At harvest time choose the best cobs from the crop—see that they are uniform in size and colour, tie the cobs together and hang them over a string in a dry place till next sowing time, when the seed can be taken from the cobs and is ready for sowing.

(*d*) (1) *Sowing time*—May and June according to moisture conditions. The plants require to be well established before heavy rains fall.

2. *Quantity of seeds*.—Seed rate per acre—

Twelve seers of seed are sufficient to dibble an acre of maize in lines 2′—3′ apart and to dibble two or three seeds in holes 1 apart in the rows.

3. *Manures*.—Manures depend on the rotation Maize after sugarcane is not manured, but maize requires a rich soil. If the preceding crop in the rotation is not manured, then maize should be manured. A hundred maunds of cowdung per acre applied before sowing seed is an excellent manurial application to produce early cobs for selling in the market.

4. *After-cultivation*.—Careful after-cultivation is necessary, first to keep down weeds till the young maize plants have established themselves and to heap up soil on the plant roots from which it is being continually washed, and finally before the plants get too high to prevent interculture a last kodalying should be given, after which no further treatment is necessary till the crop is harvested.

When the young plants are 1′ high, the extra plants in the rows should be thinned out, leaving only one plant at each spot in the lines. The *kodali* is a splendid implement for interculture between the rows. After kodalying the land on large areas the *Planet* Junior hand hoe is an excellent implement for keeping down weeds and dispenses with the use of 8—10 khurpis.

5. *Harvesting*.—The cobs can be harvested when the tops of the plants wither and when the grain in the cobs have got beyond the milk stage.

6. *Yield*.—A good outturn per acre is 20 to 30 maunds, and the richer the soil and the heavier the manuring the heavier, will be the outturn.

VII.—Millet.—Nat. Ord. Gramineæ.

In backward districts and districts of poor rainfall and poor soil in Bengal millets are still grown for food, but their cultivation is generally overshadowed by the extended cultivation of paddy.

The most common kinds grown are—

(a) Great millet (Juar) *Andropogon Sorghum* (*Sorghum vulgare*).
(b) Common millet (Cheena) *Panicum miliaceum*.
(c) Millet (Marua) *Eleusine coracana.*
(d) Millet (Kodo) *Paspalum scrobiculatum.*
(e) Spiked millet (Bajra) *Pennisetum typhoideum.*
(f) Shama (*Panucum frementaccum*).

As we desire to see millets disappear from Bengal as food-crops, no further remarks will be made on these crops.

VIII.—Oilseeds. Nat. Ord. Cruciferæ.

In Bengal the most important are—

(*a*) Indian mustard (rai) *Brassica juncea.*
(*b*) Indian colza (Sarson) *Brassica campestris* (*var. dichotoma*).
(*c*) Indian rape (Tori) *Brassica uhapus.*

Nat. Ord—

(*d*) Linseed (Tissi) *Linum usitatissimum.* Nat. Ord. Lineaceæ.
(*e*) Castor (Reri) *Ricinus communis.* Nat. Ord. Euphorbiaceæ.

Nat. Ord. Leguminosæ—

(*f*) Groundnut (China badam) *Arachis hypogœa* (treated under pulses).

The first three are mixed together in the ordinary cultivator's mind and called tori, sarisa and rai, and as a matter of fact there is very little difference between them. Raipur and Jabalpur varieties of mustard (rai) are recommended in Bengal. These three with linseed are *rabi* crops. Castor is a two-season crop (May to February), while groundnut is a summer crop (see pulses).

(*b*) *Preparation of the land.*—For all these crops the necessary tilth can be obtained by by 4—5 ploughings and 2—3 ladderings.

(*c*) *Seed and selection thereof.*—For mustard colza, rape (rai, sarson and tori) and linseed make sure that the seed has a good lustre. Dull looking seed is not to be recommended. Make sure that the seed is clean and not weevil eaten and germinates well (90—95 per cent.). At harvest time strong healthy plants should be marked with red cotton and kept at one side for the seed of the next year.

For castor seed choose the best plants. Collect the capsules which are covered with prickles and allow them to soften and rot by keeping them in a heap under straw for some weeks. Then beat the capsules with wooden mallets when the seeds can be extracted.

(*d*) 1. *Sowing time.*—The first four crops are sown in October and November. Castor is sown in May.

2. *Quantity of seed.*—Five to 6 seers of mustard, rape and colza are sufficient per acre.

Linseed is generally sown in mixture with other crops. One or two seers per acre are generally sown in mixture with other crops.

For castor three seers of seed are sufficient for dibbling two seeds every 5-6 feet apart on an acre of land.

(3) Manures are generally not applied to these crops, except castor which requires plenty of plant food to give a good crop. Castor, however, is generally grown on *dearaha* (flooded) lands when no manuring is given Otherwise cowdung (100 maunds) per acre should be applied.

(4) *After-cultivation.*—For the first four crops one weeding and one or two irrigations are generally sufficient, while for castor the land is weeded and then kodalied till the plants are 2 feet high, after which little treatment is required.

(5) *Harvesting*.—The first four crops are harvested in February and March as soon as they are ripe to prevent capsules opening and the seed falling on the ground. Castor is harvested when the capsules begin to dry. The capsules are picked off the trees while the stalks are cut down and used for fuel.

(6) *Yields*.—Good outturns are—

Mustard, colza and rape	...	8—10 mds. per acre.
Linseed ...	...	6— 8 " "
Castor ...	...	8—11 " "

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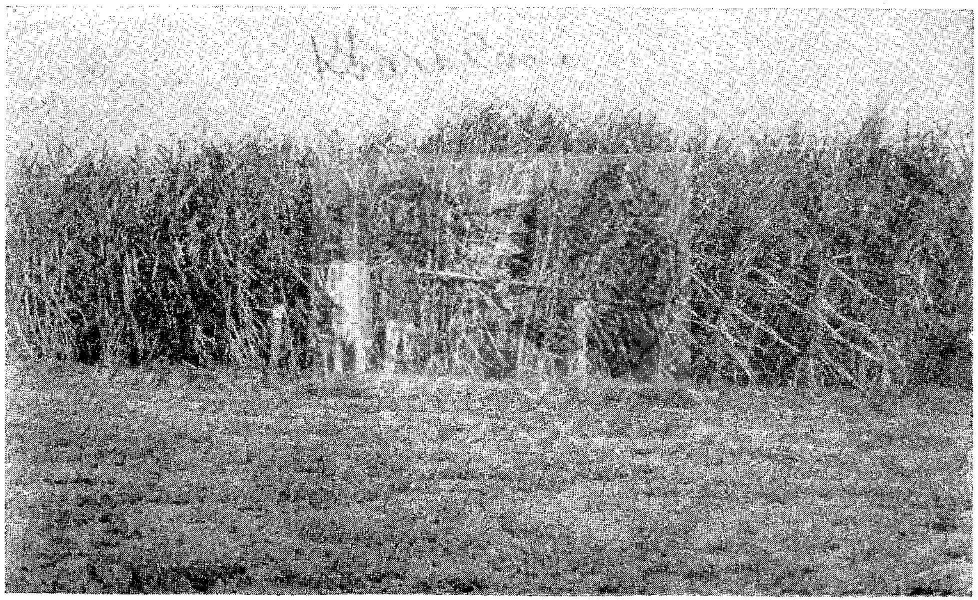

Khari Cane at Dumraon.

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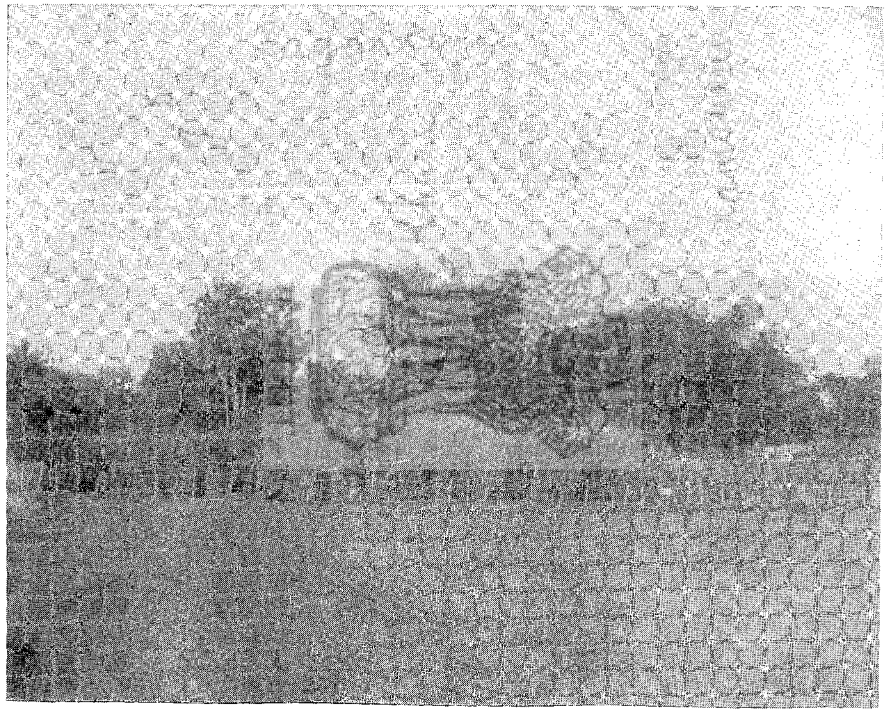

Sugarcane.

Mungo. Khari. Shamshara.

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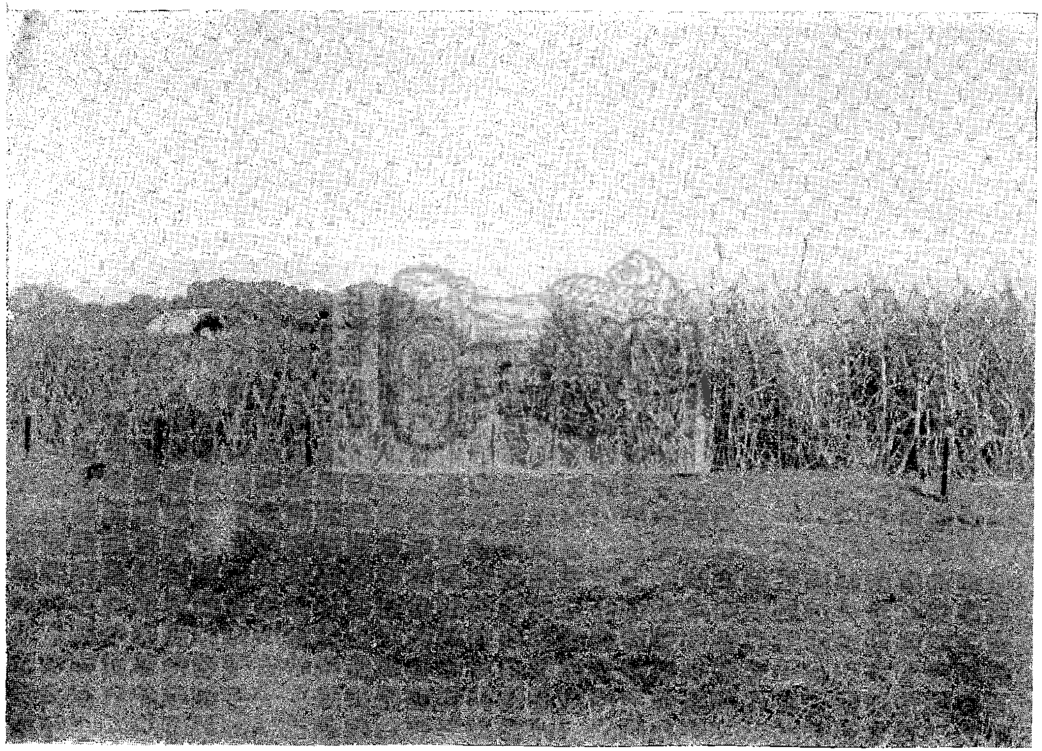

Khari Cane—showing the effect of Manures.

IX.—FODDER CROPS.

In Bengal, where most of the land is put under cultivation and there is very little grazing land, fodder crops are most important. In other words it becomes a question of producing large quantities of fodder off small areas. Temporary and permanent pastures and meadows as understood in England are non-existent in Bengal. However, they are not necessary so long as Bengal has juar: 17 to 20 tons (about 500 maunds) of green juar can be grown per acre, and this makes up for a lot of pasturage. *Dhub* grass is an excellent fodder, but cannot compare with juar so far as outturn is concerned, so it may be neglected

Maize may be grown for fodder, in which case more seed per acre would have to be sown than in the case of maize for seed purposes. As maize is a first class food-grain, it is a mistake to use it as a fodder. Hence juar (*Sorghum vulgare*), the great millet, is *par excellence* the best fodder in Bengal.

Where paddy is grown very little extra fodder is required to be grown as the paddy straw suffices for the cattle.

Wheat straw, barley straw and oat straw are excellent fodder and are all used as such. Where these crops are grown, little juar needs to be sown. Maize stalks after the cobs have been harvested are also used for fodder. All the pulse straws are excellent fodders and are also used as such juar. When the ordinary crops of the holding do not supply sufficient fodder, a little plot is put under juar.

Great millet (*juar*) *Sorghum vulgare*. Nat. ord. *Gramineæ*.

The seed that has given the best results so far in Bengal is that brought from the Saran district of Bengal.

(*b*) *Preparation of the land.*—Obtain a good deep seed bed. This requires 5—7 ploughings and 3—5 ladderings.

(*c*) *Seed and selection thereof.*—Choose the best plants in the field and save the seed from these plants for the following year.

(*d*) 1. *Sowing time.*—June.

2. *Quantity of seed per acre.*—20 seers for broadcast sowing.

3. *Manures.*—The other crops in the rotation are generally manured. The richer the soil the better will be the outturn, so apply 100 maunds cowdung per acre if it is available.

4. *After-cultivation.*—Juar seedlings are very small and delicate and hand weeding is necessary. Till the plants are 3 inches high, the weeds must be kept down. One weeding generally suffices. When 4 to 6 inches high the plants are strong and hoeing may be done. Then thin out the plants to 9 inches apart.

After this probably one hoeing with the *khurpi* will suffice.

5. *Harvesting.*—Cut when the plants are in flower. Plants may be cut as soon as the heads are well formed. The best time for cutting for feeding green is when the heads are half ripe For *silos* there is some doubt as to the best time for cutting, but the common practice in America (U.S.A.) is when the seed is in the milk stage.

6. *Yields per acre of fodder.*—A good outturn is 16—20 tons of green fodder per acre.

X.—Vegetable Cultivation

In a country like Bengal, where vegetarianism is the rule, it is surprising that more vegetables are not grown. The various *sags* and common country vegetables are very well known and appreciated; but potatoes, carrots, turnips, parsnips, cabbages and cauliflowers are not so well distributed as they deserve to be. Potatoes, carrots, parsnips and turnips have been mistaken for forms of flesh in the past and have wrongly been misinterpreted as being foreign, and have been therefore looked upon with disfavour, but these mistaken ideas are gradually being removed. When the people are better educated and understand that many crops in every country are really foreign to that country, these vegetables will be found to be no more foreign or fleshy than *dâls*; and each cultivator will have his patch of vegetables. It is not right that the cultivator should live on rice alone, and as his material welfare improves, he will require a little variation in his food supply. Potatoes, carrots, turnips, parsnips, cabbages and cauliflowers are of all the farm crops the highest yielders per acre and are very wholesome to eat. In the solution of the problem of how to produce sufficient food for the increasing population of Bengal these crops will form a very important factor. Especially will these crops be beneficial where huge masses of people are crowded together and where people take to sedentary habits. Vegetable cultivation is most carefully carried out in certain districts of Bengal, and in the Patna district, for example, the market gardeners compare well with their brethren of other countries.

It is not within the scope of this little book to take up every vegetable in detail, but a few will be taken as examples.

This Province only requires a sufficient supply of water and manure to grow vegetables very well. Naturally those grown in the hills have a better flavour than those grown on the plains on account of the slower development of the former. Potatoes, carrots, turnips, cabbages are all *rabi* crops. Gourds, pumpkins, palwals and cucumbers are all *kharif* crops and will not be further mentioned in this book.

Potatoes (*alu*) *Solanum tuberosum*. Nat. Ord. *Solanaceæ*.

To the same natural order belong tomatoes and brinjals. These two latter carry their fruits above ground, while the tuber (swollen stems) of the potato are carried below the surface. The treatment of all three is the same.

Carrots (*gajar*) *Daucus carota*—Nat. order *Umbelloferæ*. Parsnips belong to the same natural order and both receive the same treatment.

Turnips (*shalgam*) *Brassica campestris*, var Rapa. Nat. order *Cruciferæ*. Swedes belong to the same natural order and are nearly allied to turnips.

Cabbages (*kobi*) *Brassica oleraces*. Cauliflower is nearly allied to the cabbage and both belong to the natural order of *cruciferæ*.

B. Preparation of the land—The land requires to be carefully cultivated till a deep fine tilth is obtained. This requires 8—10 ploughings and 6—8 harrowings. When the necessary tilth is obtained the land is laid out in beds and ridges and furrows by means of the kodali according to the system of irrigation and the lie of the land. A most useful form of laying out the land is to run the channel down the highest piece of land and run the ridges and furrows about 10 feet long at right angles to these irrigation channels. The furrows hence become also irrigation channels. When the system of laying out the land has been decided upon (and this depends on local conditions) the land is laid out in ridges and furrows. First of all make the irrigation channels. Then in the case of potatoes the manure is spread in the furrow, the sets are planted thereon and the furrows are then closed. In other words the furrows become the ridges and *vice versâ*.

In the case of carrots, turnips and cabbages the furrows are opened, cowdung is spread therein, and then the furrows are closed. The transplants (seedlings) are then dibbled in the ridges.

C. *Seed and selection thereof.*—Seed must be true to its variety and it must be saved from large and well developed plants that must be quite ripe before being gathered. Seed must also be fresh, free from weed seeds and should not be injured.

For the plains of Bengal potato sets are best taken fresh each year from the new crop coming in from the Nainital Hills, Darjeeling Hills or the Sylhet Hills in September, and these can always be had in the Calcutta market at a moderate rate.

For the others change of seed is beneficial, but change every year is not necessary as these seeds are very small and can be stored without any difficulty.

D. (1) *Sowing time.*—Potatoes can be sown in October and November.

The others can be sown in every month from August to April. At first they must be carefully sown in boxes and prepared for transplanting out in the field.

(2) *Quantity of seed per acre.*—Potatoes ten to twenty maunds per acre according to the size of the sets. Large sets should always be cut, but in cutting make sure that there is at least one bud in each half and lime the cut surfaces of the sets. For carrots, turnips and cabbages one pound of seed will give sufficient seedling for one acre of land.

(3) *Manures.*—These crops must be well manured.

Two hundred maunds of cowdung or twenty maunds of castor-cake per acre are economical manurial applications. Cabbages and turnips respond wonderfully to saltpetre and a top dressing of one maund of saltpetre per acre placed by handfuls round the base of each plant acts on the plant very quickly.

(4) *After-cultivation.*—Careful after-cultivation is necessary; weeds must be kept down and caking of the land prevented until the crops are finally established.

The small seeded plants could be sown in the field and then carefully weeded and thinned out, but on small areas t is best to transplant when the plants begin to meet across the rows ; there is no need for further after-cultivation.

(5) *Harvesting.*—The crops are ready for harvesting in three to four months after planting. When the leaves shrivel the crops may be harvested.

(6) *Yields per acre.*—The outturns depend entirely on the manuring and cultivation, other things being equal.

Potatoes.—200	maunds per acre is a good outturn.	
Carrots.—200—300	ditto	ditto.
Turnips.—300—400	ditto	ditto.
Cabbages.—500—600	ditto	ditto

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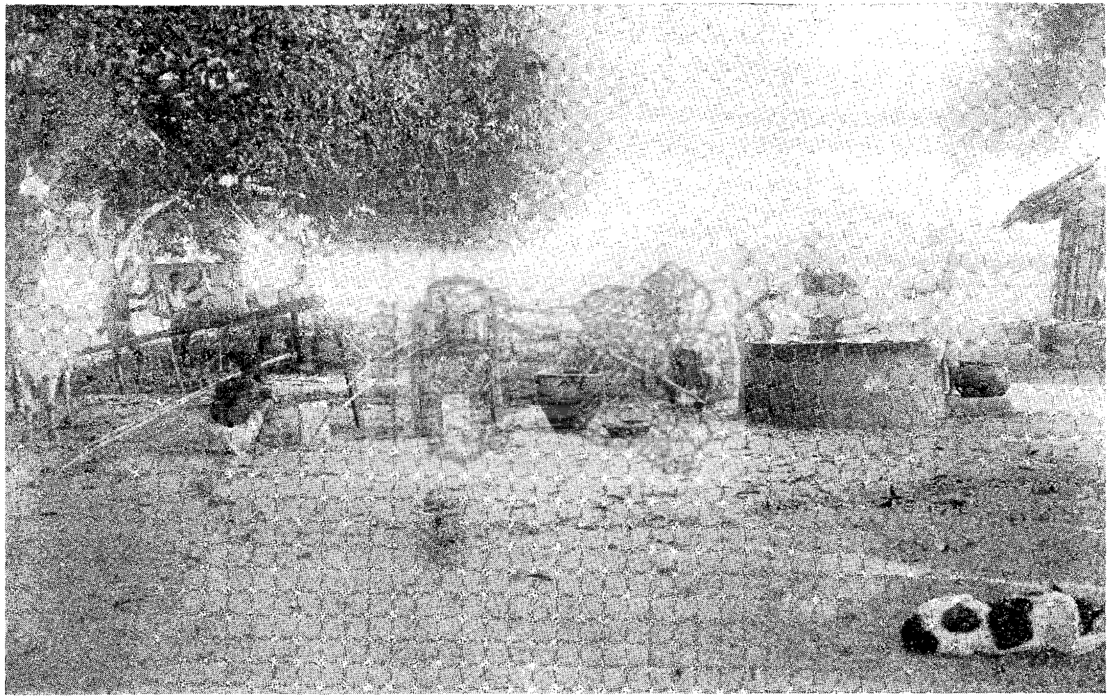

Sugar Manufacture

Beheea Mill. Howrah Mill Cooling Pot. Boiling Pan.

XI.—Most useful fruit trees in Bengal.

Banana (Kela), *Musa sapientium.*
Mango (Am), *Mangifera indica.*
Jack (Kanthal), *Artocarpus integrifolia.*
Cocoanut (Narial), *Cocos nucifera.*
Papaya (Papita), *Carica papaya.*
Guava (Amrud), *Psidium guava* or *Pyriferum.*
Pineapple (Ananas), *Ananas sativa. Bromelia Ananas.*
Orange (Narangi), *Citrus Aurantium.*
Lemon (Nimbu), *Citrus medica.*
Pomelo (Mahtabi Nimbu), *Citrus decumana.*
Custard apple (Sharipa), *Anona squamosa.*
Litchi (Lichi), *Nephelium Litchi.*
Sweet Melon (Kharbuja), *Cucumis melo.*
Mash Melon (Phunti), *Cucumis melo* var. *Cucumis momordica.*
Water Melon (Tarbuja), *Citrullus vulgaris.*
Peach (Shooftalu), *Prunas persica.*
Tamarind (Amli), *Tamarindus indica.*
Pomegranate (Anar), *Punica Granatum.*
Bael (Bel), *Aegle Marmelos.*

N.B.—The botanical names are for reference only.

The above list shows how rich Bengal is in fruit trees and what a large subject in itself is fruit culture. Such an important subject requires a book to itself, and information regarding the requisite preparation of the land for orchards, the selection of the seed and plants therefor, with the necessary directions as to planting time, manuring and after-treatment of the land, trees and fruits must be sought for in such a work.

Kelas, papitas, pineapples and melons are quick developing plants and give fruits in one to two years.

Cocoanuts grow very quickly and in six to seven years a very tall tree bearing fruits is produced.

The remainder are slow developing trees, and the production quickly of fruits with improved qualities of size, colour and flavour is obtained by budding and grafting.

Budding and grafting can easily be learned from the good mangoe growers of Malda and Bihar (Hajipur) by those who are interested and the art only requires a little practice.

The principles underlying the operation are that a tree which has fruit, bearing the necessary characters of size, shape, colour and flavour, is chosen.

Buds or branches from such a tree have the power of bearing similar fruits. They are taken and grafted on a strong growing (healthy) stock.

In budding and grafting these buds and branches respectively on the stocks the point is to see that the cambium layer of the larger of the bud or branch is brought into contact with the cambium layer of the stock.

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After that bind the parts together to help conjunction and lessen the risk of attack from fungoid diseases by covering the junction with a good layer of mud and cowdung.

Résume—Rice is the chief crop in Bengal. *Aus paddy* or early rice is ready to be harvested in September. *Aman paddy* or late rice is generally harvested in December. *Boro paddy* is cultivated in very low-lying lands on which water remains even in December; harvested January or February. Paddy wants plenty of water. Harvesting is done with a sickle, threshing by bullocks and winnowing by being shaken against the wind.

Jute is the next crop in importance, cultivated for its fibre. Sown immediately after the showers of April and May on well-prepared land; thinning when plants are a few inches high; must be irrigated if rains are delayed; harvested in August and September; retted in water, stripped of bark, etc., by hand, then dried and tied in bundles.

Sugarcane is a graminæ and remains in the field 10 to 11 months, requires extremely careful tillage, heavy manuring and several irrigations. Harvesting is done by means of a *kodali* and at once the canes must be crushed and the juice boiled before fermentation sets n. The *gur* so produced can be refined by several means.

Cereals—Wheat, Barley, Oats.—Cold weather crops, sowing time October and November. Rotation crop 2-3 weedings, irrigations when soil gets too dry. Harvest when yellow.

Pulses.—Gram, pea, lentils, mung, urid, etc., *kharif* like mung, etc., *rabi* ex gram; soil must be rich and must have been well manured for the preceding crop. Harvested when ripe, threshed by beating with sticks.

Maize.—Sowing time May and June on well, ploughed land. Dibbled in lines 2 or 3 feet apart. Requires a rich soil or else must be well manured. After tillage must be careful and strong.

Questions.—Describe rice cultivation. What is retting? What is steeping? How is sugarcane planted? What cereals are cultivated in Bengal? What leguminosæ are cultivated? Describe *maize* cultivation. Juar cultivation? What are oil-seeds? Why must vegetable cultivation be so careful?

CHAPTER VIII.-LIVE-STOCK

The live-stock of the farm in Bengal are chiefly cattle and goats. All farm work is mainly done by bullocks. In certain districts buffaloes are also used, but they cannot stand the heat like cattle and require plenty of water to keep them in good health. The cows of Bengal give very little milk (½ to 2 seers per day), while buffaloes give plenty of milk (6—12 seers), that is twice as rich in fat as cow's milk. Hence buffaloes are the most important milking animals of Bengal. Goats are kept by poorer people and their milk is used. Ponies, donkeys, sheep and poultry are found in every district. The ponies are generally very miserable animals, being underfed and badly treated. Donkeys are only of interest to the dhobies. Sheep are very poor animals carrying only hair instead of wool with very little flesh on their bones, while the poultry are very small in comparison with European breeds.

Accordingly cattle are the most important animals to the Bengal cultivator. He takes little notice of the female, but the males are carefully looked after, and at 2—2½ years old they are castrated. These castrated animals are the bullocks or the draught animals of India.

The size of the animals in Bengal varies according to the climatic conditions. In Lower Bengal, where the climate is moist and damp and there is little grazing, the bullocks are very small, while to the north-west part of the Province, where drier conditions prevail, splendid looking large animals are to be found.

Bullocks can be roughly divided into two classes—

(*a*) Plough animals, and
(*b*) Cart animals.

Cart animals can be used also for ploughing, but one pair on a farm is generally kept for cart work and plough animals are not used for cart work unless there are no cart bullocks.

(*A*) *Selection of bullocks for plough work.*—Choose healthy, sound compact animals with good bone and action, with not too much daylight under them and young. In other words (1) the animals must be healthy, *i.e.*, free from disease. (2) He must be sound, *i.e.*, must not be lame either in legs or joints, must have good teeth and mouth, in order that he may eat, and must have no malformation. (3) He must be compact, *i.e.*, well formed. The head must be connected by a short thick neck to a solid rectangular trunk (body) well set on four well proportioned legs. Misshappen heads on long necks attached to hollow backed trunks covered with bony protuberances are sights only too common in Bengal A good solid barrel of a trunk is the best sign of strength

(4) *Bone.*—The bone must be in proportion to the size of the animal. A well built animal with large bones is to be preferred to one with small bones.

(5) *Action.*—In walking and running the legs should not catch one on the other, either back against the front and *vice versâ* or back and front legs amongst themselves, and the general action of movement should be lively.

(6) Not too much daylight under them. This means the leg must not be too long For ploughing the longer the legs the greater the draught on the animals, hence get the body (within proportions) as near the ground as possible.

(7) *Age.*—Choose a young animal—one with 6 broad teeth and the other two showing appearances of coming up. More years of work can be got out of such an animal than from an older animal.

Accordingly in judging animals if ten points each be allotted for points (1), (4), (5), (6) and (7), twenty points for point (2) and thirty points for point (3), we have 100 points and students with a little practice can judge animals for themselves.

For cart bullocks the same points hold good except the length of the legs which must be long to allow of faster movement over the ground.

B. Housing.—Simple houses of bamboo or mud or corrugated iron are excellent for animals in Bengal. The main points to be observed are to keep the animals cool in summer and warm in winter. Under the shade of trees, corrugated iron sheds are as good as any other and are far more durable. They are also fairly cheap Allow 4′×8′ floor space for each animal and 8′ high and the animal has quite sufficient accommodation for Bengal where the animals are outside most of the day and where doors and walls are seldom required.

C. Feeding.—Bullocks are fed on the straws of paddy, wheat, oats, barley, pulses, maize, millets and juar. The straws are chopped up fine and called bhusa. The chaffs of the grains of the above crops are also used as fodder.

At times of hard work oilcake must also be supplied to the animals. At these times it it best to feed the whole, steeped in water as a sloppy mass.

Each animal requires a little salt each day to keep in good health. When green juar is fed it is also chopped up and 20 seers per bullock are allowed per day.

Two feeds are given per day, viz., at midday and in the evening. Whenever grazing can be found the animals should be allowed to graze.

Food ration per bullock per day.

8 to 10 seers bhusa (dry) ½ to 1 seer mustard cake 1 chittak salt	fed in two feeds.

D. Working.—In the working of animals one must be very careful. It is very unwise to work the animal too hard at one time. An animal can do a certain amount of work and no more. The wise cultivator gets to work early in the morning before the sun is hot. At 12 A.M., he takes them under the shade, feeds and waters them and gives them a rest until 3 P.M., when he can take them out again to work for another four hours.

At times of hard work, especially when ploughing in puddle, the bullocks must be well fed. At these times oilcake must be given to them, or they will soon break down. It is very unkind (cruel) to twist their tails or kick them or cunningly to poke their soft parts with a stick to make them work. The best incentive for them to work is a kind word and something in the stomach. With good care and treatment the bullock is a wonderful motive power. He is patient and plodding and worthy of every kind action of the Indian cultivator.

Resumé.—The bullock is the plough animal and farm motive power in Bengal. It should be well fed, kindly treated and protected from the sun during the great heat of the day.

Questions.—In the selection of a plough bullock what are the chief points to be considered? How would you house your animals? What daily food ration would you give to a bullock when working and not working?

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CHAPTER IX.—MODEL SCHOOL GARDENS IN BENGAL.

Agricultural teaching in schools in Bengal, although it has already attracted the sympathetic attention of all those interested in the welfare and development of the enormous rural population of this Province, has not so far been a marked success. This has been due principally to the want of necessary arrangements for teaching the practical part, and, secondly, to the want of an agricultural text-book. It was erroneously thought that the Government Agricultural Experimental Stations would serve also the purpose of school gardens.

We have been watching carefully the agricultural classes at Cuttack, Dumraon and Burdwan for the past five years, and are forced to the conclusion that experience shows that little good can result from the system of teaching at present in vogue.

By visiting agricultural stations occasionally, and then looking at plots where highly scientific experiments are carried out, boys cannot hope to grasp the simple principles that they must learn.

What they want is a plot of land in which they can follow the natural development of a plant from seed to maturity. At present their visit is a grand picnic for them, and a terrible time of anxiety for the Farm Superintendent so long as the boys stay on the farm, for each thinks he has a right to a stick of sugarcane, a handful of ground-nut, or a cob of maize after having come so far. The Farm Superintendent gravely shows them two plots and in a wise manner says :—"This plot was manured with saltpetre while that received superphosphate—do you note the difference ?" What is the use of such a statement to boys who do not understand how plants feed and what food they require ? Again, what is the use to boys who know nothing of soil physics to be told by the Superintendent "This plot has received so many ploughings and ladderings !"

What is required is that each boy should have a plot of land, a kodali, a well close by, and some seed, and let nature reveal itself to him. Then to the teacher's astonishment the boy will ask endless questions instead of being forced to learn.

To obtain this a school garden is necessary, and this should be within a reasonable distance of the school, say within 200 yards.

Size of garden.

The garden should be oblong in shape, should be walled in, well drained, and the size should be sufficient to allow a plot of land for each pupil, besides a central road, pathways, a border round the garden, and sufficient room for a tool house and a compost heap. A constant supply of water is essential.

Size of plots

Each plot should be 5′ × 20′, which will allow of five kinds of crops being grown each ason. By this means the boy will

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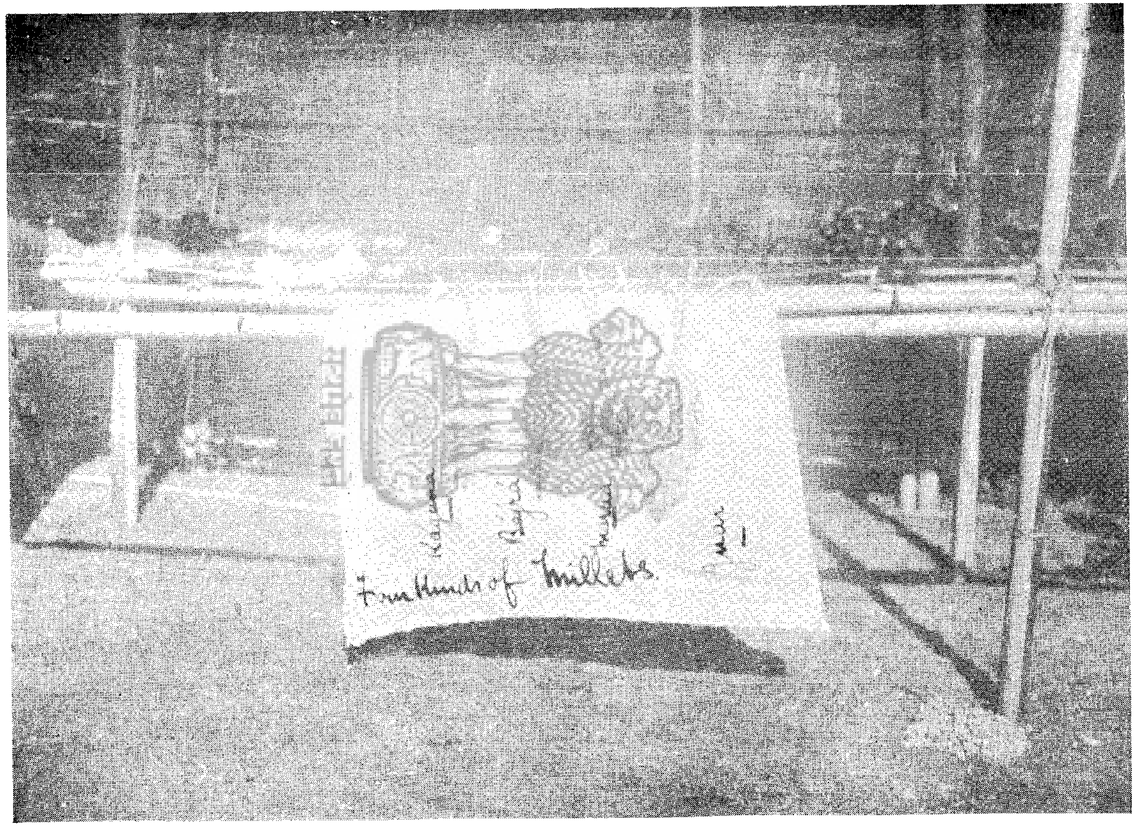


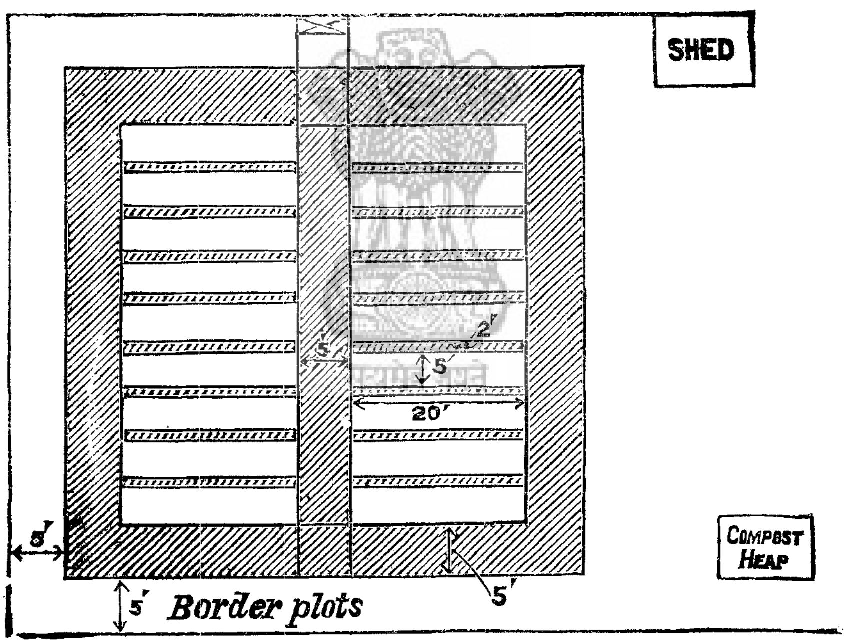
Bengal Millets.

become acquainted with about twenty different crops in his two years' course. The central pathway and the pathway that runs round the garden should be raised and 5′ wide, while pathways between the plots should be 2′ wide. Between the outside pathway and the wall, a border of 5′ should be left, while at one end the compost heap and the tool shed should be arranged.

The well or tank should be situated at the most suitable part of the garden.

The sketch below gives an idea of what is meant above.

The shed must be large enough to accommodate the necessary tools. Each boy will require a kodali, a khurpi, a basket and a reaping-hook, while sufficient watering-cans must be provided to allow of watering. In addition to this, the garden must possess lines of thick cord with pegs, a measuring tape and straight wooden rods 5′ long marked at each foot by a shallow cross-cut, to facilitate the marking out of plots and lines.



Plan of School Garden.

One or two seed boxes for vegetables will suffice for the whole garden, while one plot will give enough paddy seedlings for all requirements. These can be arranged near the shed and in the border plots respectively.

Rules and discipline.

Now that we have the garden, it is necessary to lay it out. The measuring should be done by the teacher, aided by half a dozen pupiil, when the wall, main pathways, compost heap, shed and water-supply should be erected and prepared by outside labour. After that every thing should be done by the boys under the supervision of the teacher.

Pupils should only be allowed to work in the garden while the teacher is present. They should not be allowed in the garden during class hours. In season they should go to the garden every day. When work is finished, they should form up in line, and before replacing their tools in the shed, the teacher should call the roll and make sure that every implement has been properly cleaned. The roll-call should be strictly kept and reasons for absence carefully noted. A note-book must be kept by every pupil showing when each piece of work in the garden was done, the method of procedure, the results obtained, and reasons, based on actual observations made in the garden on work done, should be given.

These notes should be corrected weekly by the teacher. Seed of each crop grown by each pupil should be carefully collected by him. He should dry and clean them and place them in a labelled bottle so that he may know each kind thoroughly.

What to teach.

All the necessary lessons to be taught to the pupils are given in my book "Principles of Agriculture for Bengal."

EXAMPLES.

1st—Digging the ground (this does away with ploughing, laddering and bidering as this work is done by the kodali).—Its physical and chemical actions on the soil. Chapter V, "Principles of Agriculture for Bengal.")

2nd—Manuring.—Read chapter on "Plant food" for first-year's students, and chapter on "Manures" for second-year's students.

3rd—Seeding.—Why seed must not be sown too shallow or too deep. Read chapter on "Germination." When seedlings show above ground, the teacher should pull out a few carefully and demonstrate the formation of plumule and radicle.

4th—How plants feed and grow.—Read chapter on "Functions of Root, Stem and Leaves." Teacher should demonstrate the advantages of good tilth (cultivation) on the formation of roots, and consequently stems and leaves. Border plots will supply the requisite examples.

5th—Production of seed.—Read chapter on "Pollination and Formation of Seed."

6th—Harvesting.—Crops should be harvested and samples of seed should be collected in small bottles, in order that the students may become acquainted with the different seeds. Germinating tests should be made later of each kind of seed, and the percentage of germination should be found out.

Crops to be grown in the garden.

The following crops should be grown in the garden :—

Kharif—

1. Jute.
2. Aus paddy.
3. Maize.
4. Juar.

Aghani—

1. Aman paddy.
2. Ground-nut.

Rabi—

1. Wheat.
2. Oats.
3. Barley.
4. Gram.
5. Peas.
6. Lentils.
7. Urid.
8. Linseed.
9. Mustard.
10. Potatoes.
11. Cabbages.
12. Cauliflowers.

Annual crops—

1. Sugarcane.
2. Turmeric.
3. Ginger.

EXAMPLE OF ONE PLOT.

Divided into five parts, *i.e.*, each crop will cover a space of 5′ × 4′.

First year.

Kharif—

1. Aus paddy.
2. Jute.
3. Maize.
4. Juar.

Aghani—

1. Aman paddy.

Rabi—

1. Mustard.
2. Wheat.
3. Linseed.
4. Gram.

Second year.

Kharif—

1. Sugarcane.
2. Aus paddy.
3. Jute.
4. Maize.
5. Aman paddy.

Rabi—

1. Sugarcane.
2. Linseed.
3. Wheat.
4. Peas.
5. Gram.

Full details as to how to treat these crops from the preparation of the land to the harvesting of the crop are given in the text-book "Principles of Agriculture," and the scientific principles underlying agriculture contained therein should be explained by the teacher both in the class-room and in the garden.

If each pupil takes up four or five different crops every summer and winter under the constant supervision of a qualified teacher, at the end of his second year he ought to have a good knowledge of all the crops of Bengal.

GLOSSARY.

Agency—Action, the business of an agent.

Absorbent—Anything which absorbs fluids.

Antennae—The horn-like filaments that project from the head in insects, crustacea and myriapods and are considered as organs of touch and hearing.

Albuminoid—Resembling the white substance of the egg.

Aperture—A little opening.

Areobic—Which want air to develop and live.

Anaerobic—Which do not want air to exist.

Aqueous—Like water.

Algues—An herbaceous growth living in water.

Byre—A cow-house.

Basis—The base or foundation of anything.

Botany—The science which treats of plants.

Cross-breeding—In fertilisation of plants this means to take the pollen of a different species to fertilize a given species.

Cross-fertilization—The action of fertilising a plant with pollen of a different plant.

Cambium—A mucilaginous viscid substance interspersed between the wood and bark of exogenous trees and particularly abundant in spring.

Crevice—A crack, an opening caused by the solid being broken.

Crude—Raw; in its natural state, unripe, immature, ill-arranged.

Cotyledons—A lobe forming part of a seed and containing nourishment for the young plant during germination.

Cloddy—Lumpy.

Capillarity—The state of being capillary, that is, of having little holes or tubes as fine as hairs.

Coulter—The appendage of a plough which is fixed in front of the share.

Counterpoise—To weigh against with equal weight.

Cess-pool—A cavity sunk in the ground to receive and retain the water or sewage from drains.

Disc—A flat circular surface.

Drought—Dryness, want of rain.

Efficient—Excellent, first rate.

Excreta—The refuse of men and animals.

Endosperm—Matter surrounding the embryo, forming its nutriment.

Enzyme—Certain ferments which promote digestion.

Embryo—The first rudiments of the plant within the ovule—something not developed.

Eradicate—To destory, to extirpate.

Fir—The name of several species of cone-bearing trees highly valued for their timber.

Fodder—Vegetable matter like grass or leaves given as food to animals.

Fern—A cryptogamic plant with reproductive organs on the back of their leaves.

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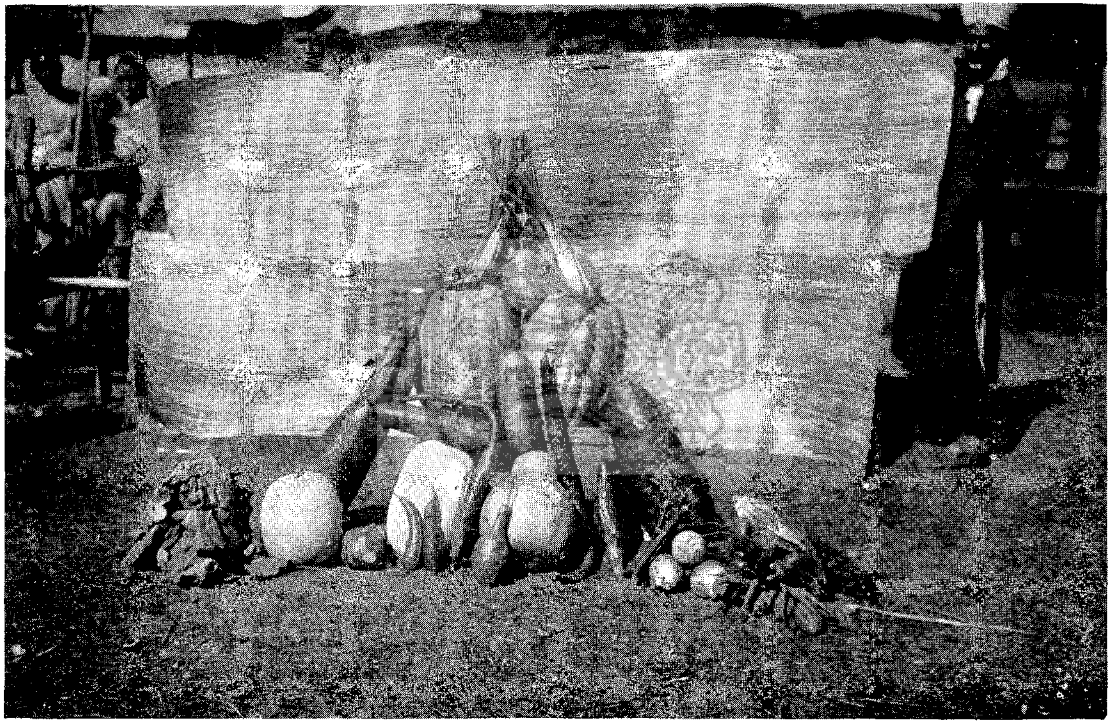

Vegetables.

Ferment—Any substance, as a fungus whose presence in another body produces the peculiar effervescence and decomposition called fermentation.

Fragrant—Giving off an agreeable perfume.

Frost—That temperature which causes freezing.

Geology—The science which treats of the rocky formations of the earth.

Genuine—Pure, real.

Hybridiser—A man who produces new genii of plants by cross-breeding.

Habitat—The natural abode of an animal or a plant.

Hygroscopic—Imbibing moisture from the atmosphere.

Incorporated—Added to, to mix with.

Ingredient—A substance; one of the substances forming a mixture.

Incrustation—The slow process in plants by which salts gradually fill up the cells.

Inclement—Not favourable, harsh.

Ice—The solid state of water brought about by low temperature.

Indiscriminately—Without thought or consideration (discrimination).

Illiterate—Not knowing how to read or write.

Jerk—To give a sudden pull or twitch.

Litter—What is prepared for domestic animals to sleep on, straw etc.

Lustre.—The brilliancy of something new, polished.

Latitude—The distance of a place north or south of the equator.

Lichen—A cryptogamic plant without stem and leaves which grows on the bark of trees and rocks.

Lumpy—In clods or big pieces.

Laver—A bar of metal, wood, etc, turning on a support called the fulcrum and contrived originally to raise heavy weights.

Moss—A natural order of small herbaceous plants which live in shady places.

Meteorology—The science which treats of the changes of the weather and occurrences in the atmosphere.

Mushroom—The common name of numerous cryptogamic plants of the natural order—fungi.

Mellow—Tender, soft.

Mulch—A covering of half-rotten straw, litter, or fine earth.

Notch—A hollow cut in anything.

Nodules—A small knot or swelling.

Peptone—The substance into which the nitrogenous elements of food are converted by the action of the gastric juice.

Permeate—To fill up every space in a given thing.

Protoplasm—A transparent substance apparently structureless, nearly identical with the white of an egg and constituting the basis of living matter in animal and plant structures.

Plump—Fat, round, not shrunken.

Percentage—A certain number in every hundred.

Porous—Like a sponge, with holes or cavities.

Parched—Scorched, too dry.

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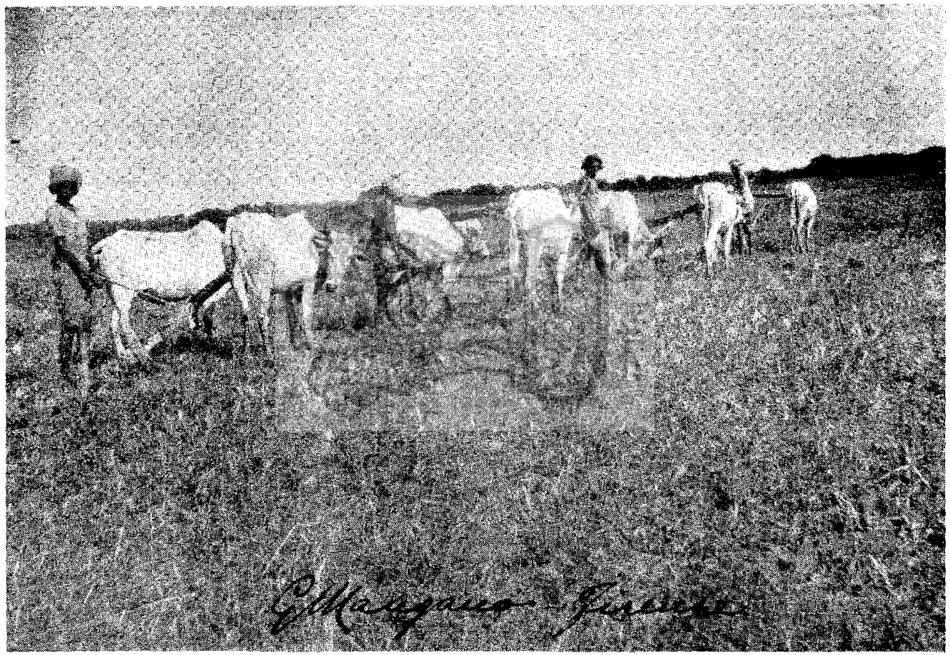

Bhagalpuri Breed for Lower Bengal.

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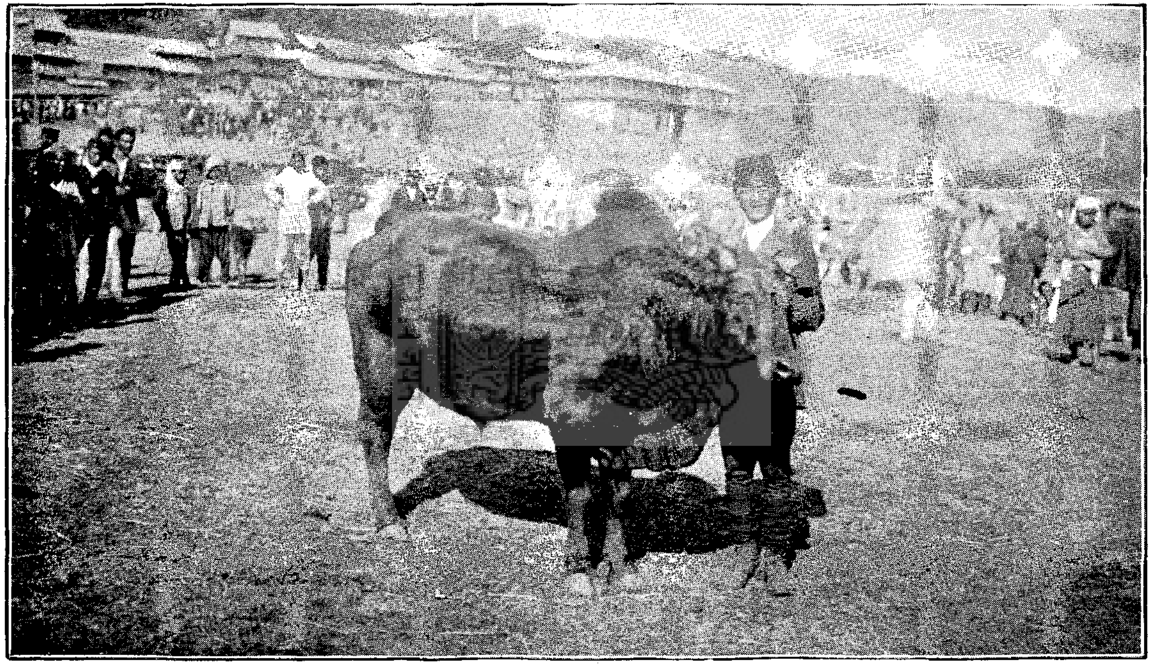

Siri Bull (Darjeeling Hills) Showing good points.
This animal is only for the hills.

Phenomenon—A remarkable or unusual happening. Something which appears.

Prehistoric—Prior to the time known by history, very ancient.

Polynesia—A numerous group of isles in the Pacific ocean.

Residue—What is left behind.

Redeeming—Making good, rescuing.

Rudiment—A thing in its rude or unformed state, a first principle.

Rye—A grain allied to barley growing in cold countries.

Science, pure—Treats of laws or general statements apart from particular instances. Ex. Mathematics.

Science, applied—Treats with the employment of laws and is exemplified in dealing with concrete phenomena.

Swamp—Wet spongy land, low ground filled with water.

Species—Each different kind or order of plants or animals.

Speck—A spot, a stain, a very small thing.

Starch—A substance occurring in grains in the cellular tissue of plants.

Shrinkage—A contraction into less compass, having become smaller.

Stubble—The stumps of paddy or other crops left in the ground after harvest.

Sewage—Refuse carried off by sewers.

Subterranean—Under the surface of the soil.

Soluble—Which can be melted, like sugar in water.

Sturdiness—Very healthy state of a plant.

Swilled—To wash.

Stimulant—Producing a transient increase of vital energy.

Shrivelling—Wrinkle. Drying up.

Tillage—The operation, practice or art of stirring the soil to cultivate it.

Turgidity—The state of being turgid, that is swelled out beyond its natural state.

Volatilisation—When a liquid becomes gaseous.

Watertight—Not allowing water to percolate.

Weevil—Insects with a snout of the beetle tribe.

Wedge—A piece of metal or wood, thick at one end andl soping to a thin edge at the other.

Yield—To give.

Zone—A division of the earth with respect to the temperature of different latitudes.

Zoology—The science which treats of animals.

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