SUGAR CANE SOILS, MANURING AND IRRIGATION IN CERTAIN PROVINCES OF INDIA.*

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INTRODUCTION

IN this section a summary of information obtained on sugar cane soils, irrigation and manuring as a result of visits to certain sugar cane areas and experimental centres in India is furnished. The conditions and problems of sugar cane cultivation are so extremely varied in the different Provinces that it is well nigh impossible, in a few pages, to deal with the subject adequately. As, however, but few of the planting practices and experimental findings in India will be applicable to local conditions without test, a detailed presentation of the facts would be of little practical interest and value. Attention would therefore be directed mainly to the general aspects of the subject under review. A brief discussion of the possibilities of sugar cane cultivation in Ceylon, so far as it relates to the particular aspects of study referred to, will be included. References will also be made to *gur* (jaggery) and *khandsari* (unrefined) sugar manufacture, and to the experimental technique relating to field trials with, and the analytical examination of, sugar cane.

The sugar cane centres, factories, and research stations visited in the course of the tour were :—

The Coimbatore Sugarcane Research Station,
Hebbal and Irwin Canal Farms, Mysore,
Hadapsar Effluent Farm, Deccan, Bombay,
Padegaon Sugar Cane Research Station, Deccan,
The Sansar Sugar Factory, Kalamb, Deccan, Bombay,
The Agricultural College, Lyallpur, Punjab,
The Imperial Institute of Sugar Technology, Cawnpore, U. P.,

*Extract from a report made in January 1941 by the author on a tour in India to study the problem of alkali soils. An extract from the same report was reproduced in *The Tropical Agriculturist*, October, 1941.

The Shahjahanpur Sugar Cane Research Station, U.P.,
The Pusa Agricultural Research Institute, Bihar,
The Sugar Cane Research Sub-station, Patna, Bihar,
The Plassey Sugar Factory and Farm, Ramnagar, Bengal.

SUGAR CANE CULTIVATION IN INDIA—GENERAL

The total area under sugar cane in India during the 1940–41 season exceeded 4·5 million acres. Of this extent, about 55 per cent. or over 2·5 million acres were cultivated in the United Provinces alone. The Punjab and Bihar followed with over 500,000 acres each. The other cane-growing Provinces in order of production were Bengal, Madras and Bombay with a total acreage of 650,000 acres.

The rainfall of sugar-growing areas in India varies from 20 inches and less to over 80 inches. The greater part of the crop is irrigated by canal or tube well irrigation. In the U. P. 40 per cent of the crop (over 500,000 acres) is, however, unirrigated; in north Bihar, with an annual rainfall of about 40 inches, the crop is grown with no irrigation whatsoever. In the Bombay and Madras Presidencies and Mysore cane is grown entirely under irrigation which is freely given, while in the Punjab, Bengal and the U. P. the quantity of irrigation water supplied per acre is relatively small. The duty varies from 2 to 3 acre ft. per acre per crop, as in the U. P., to over 12 acre ft. per acre as in the Bombay Presidency.

The soils of the sugar cane areas of India are mainly alluvial silts and loams, *e.g.*, those of the U. P., Punjab, North Bihar, and parts of Bengal and Madras Presidency; but residual soils such as the red loams of Mysore, Bengal and Madras Presidency and the black and grey brown clay loams of the Deccan, Bombay, S. Bihar, and other parts of India are also utilized for the crop with success. On some of the latter soils, however, the problem of soil drainage requires careful attention, as sugar cane is a crop which is very susceptible to waterlogging. The soils are generally well supplied with calcium and potash, but are deficient in nitrogen and organic matter, and to a lesser degree, in phosphoric acid.

Manuring of the cane crop is, therefore, universal in India. In addition to farmyard manure, green manure, compost, and organic cakes, artificial fertilizers are used in large quantities. Nitrogen is the chief fertilizing constituent required by the crop, and the amounts of this constituent applied vary from 40 to 400 lb. per acre. In tropical India *i.e.*, Mysore, Madras, Bombay, where thick and relatively long-aged varieties are grown and irrigation is heavy, much larger quantities of nitrogen are applied than in the sub-temperate Provinces, *e.g.*, Punjab. Phosphoric acid and potash are not generally

applied, as the responses to these fertilizing constituents are small. In certain parts of the Bombay Presidency, Mysore, Bihar and Bengal, however, phosphoric acid has proved beneficial and is given at the rate of 40–50 lb. per acre as superphosphate or nicifos.

Sugar cane is generally grown in rotation with other crops in India, paddy being the most popular of these. Wheat, kurakkan, cambu, sorghum, tobacco, cotton, jute, legumes, *e.g.*, gram, and sunnhemp, and other green manures are among the other crops included in the rotation. Plantains and betel are occasionally used for the purpose in the Madras Presidency.

Ratooning of sugar cane is fairly common in certain Provinces, but is generally discouraged, and precluded in a few areas, *e.g.*, Mysore, by controlling the irrigation water issue. Where ratooning is practised, one ratoon crop is generally taken, but occasionally the crop is ratooned for as long as 5 years.

Methods of cultivation vary widely in the different Provinces and even within a Province, being dependent to some degree on the type of cane cultivated. The Java method of cultivation in trenches is adopted in parts of Bengal, and the Madras Presidencies, the trenches being about one foot in depth. In the Bombay Presidency, Mysore, and other areas planting in furrows followed by earthing up later is generally the practice. Sowing on the flat with or without earthing later is adopted in the Punjab, Bihar, parts of the U. P., &c. Earthing up is essential on the richer soils to prevent lodging. Where this is impracticable, binding the tops of canes and leaves is practised. The spacing between rows varies from 1 to 4 ft. and is determined by the type of cane grown, method of cultivation, fertility of the soil, &c.

Average yields of well-cultivated crop in India vary from about 25 tons of cane per acre in the U. P. and Bihar to over 50 tons in parts of the Bombay and Madras Presidencies. Yields are determined by the variety, soil and cultural conditions, and the frequency and amount of irrigation water. In the U. P., Punjab and other parts of sub-tropical India early maturing varieties are generally cultivated owing to the danger of damage to the crop by frost.

Sugar cane is utilized in India for the manufacture of *gur* (jaggery), *khandsari* (unrefined) sugar, and refined sugar. The greatest development of the cane sugar industry in all its aspects is in the U. P.

SOILS

In the following paragraphs the soils of the areas visited are dealt with separately.

Coimbatore.—In Coimbatore sugar cane is grown on red and brown calcareous loams formed from the decomposition of igneous rocks and gneisses. " Kankar " or massive limestone underlies the soil at varying depths. Gypsum is often present in the soil profile. Provided the drainage is good, both the red and brown soils are very suitable for the crop.

Mysore.—In Mysore the soils on which sugar cane is grown are mainly the red, yellow and grey loams of 2 to 3 ft. depth, derived from igneous rocks and gneisses. These constitute about 50 per cent. of the 50,000 acres of irrigable land under the Irwin Canal. They are very deficient in nitrogen, the amount varying from 0·02 to 0·04 per cent. in the majority of the soils, and in organic matter, and are poor in phosphoric acid and bases. Their pH values generally vary from 6·5 to 7·5. About 40 per cent. of the irrigable area under the Irwin Canal is too gravelly or stony for the profitable cultivation of cane and 10 per cent. of the land becomes too moist for cane when water flows in the irrigation channels. A small area of cane is also grown on the black clay loams.

Bombay Presidency.—The soils of the cane-growing areas of the Bombay Presidency are mainly derived from igneous rocks, gneisses and schists. They are generally of heavy texture and vary from a few inches to as much as six feet in depth. They are underlain by decomposing rock material known as *murum.* In colour they show a wide variation from grey to brown and black. Eight soil types have been recognized in the Deccan area. These soils are rich in lime, potash and phosphoric acid, but are deficient in nitrogen and organic matter. Some of them have a tendency to water-logging, and need to be carefully drained if the formation of alkali salts is to be avoided. All these soils require intensive cultivation and manuring with nitrogenous fertilizers and bulky organic manures.

Punjab and Bihar.—The sugar cane soils of the Punjab and North Bihar are deep, alluvial silt loams rich in calcium carbonate, the content of which frequently exceeds 10 per cent. They overlie a sand or clay sub-soil. Their chief requirements are nitrogen and organic matter, but they are well supplied with mineral plant foods. They are generally slightly alkaline in reaction. They drain well normally. The soils of South Bihar vary, but comprise largely the black heavy loams derived from the weathering of basic igneous rocks and schists.

United Provinces.—The soils of the main cane-growing tracts of the U. P. are the alluvial loams of the Gangetic plains. These soils do not vary much in chemical composition but are of wide textural range. They are rich in lime and potash, occasionally deficient in phosphoric acid and invariably in nitrogen and organic matter.

Bengal.—Sugar cane is cultivated mainly in W. Bengal. The soils on which the crop is grown are of two main types : (i.) the alluvial soils of the Gangetic plain varying in texture from light to heavy loams, (ii.) the red lateritic soils derived from igneous and metamorphic rocks. The greater part of the crop is cultivated on the former types of soil. These are generally rich in plant food constituents. The red lateritic loams are acid in reaction and respond to liming. They are deficient in phosphoric acid and, to some degree, in nitrogen.

MANURING

The practices followed in regard to the manuring of cane at the centres or in the areas indicated are as follows :—

Coimbatore Farm.—At the Coimbatore Farm on the red and brown loams, in addition to a basal application of farmyard or green manure, sugar cane is manured with nitrogenous fertilizers at the rate of 100 lb. nitrogen per acre, half being in the form of organic cake and half as sulphate of ammonia. In other parts of the Madras Presidency, *e.g.*, at the Gudiyattam Sugar Cane Research Station, the normal manure application per acre is ; 10 tons farmyard manure at the time of preparation of the land, 2 cwt. superphosphate and 75 lb. nitrogen (in the proportion of two of sulphate of ammonia to one of groundnut cake) at planting, and an equal quantity of nitrogen at the time of earthing up. The varieties of cane cultivated are the Coimbatore strains.

Mysore.—In Mysore sugar cane is heavily manured, particularly with nitrogenous fertilizers, the quantity of nitrogen applied being as much as 400 lb. per acre. Of this amount, 60 lb. is applied in the form of green manure *e.g.*, sunnhemp, before planting, 100 lb. as compost or farmyard manure at planting and when earthing up, and 240 lb. as sulphate of ammonia, in equal amounts at planting, 6 and 12 weeks later, and subsequent to earthing up. In addition, 1½-2 cwts. concentrated superphosphate and, occasionally, 1 cwt. of sulphate of potash are applied in the furrows at the time of planting. After earthing up, the Java " cone " method of applying fertilizers is employed on Departmental Farms. Holes are made in the ridges 2–3 inches apart with the cone and the requisite quantity of fertilizer mixture applied to each hole with a standard measure. Yields of crop obtained are from 35–50 tons/acre, the variety commonly cultivated being H. M 320, a 12–13 month cane. This variety does not deteriorate in quality for 2 to 3 months after maturity.

Bombay Presidency.—At the Hadapsar Experimental Effluent Farm, nitrogen is applied to sugar cane as sewage at the rate of 225 lb. per acre. The effluent contains 2·8–3 p.p. 100,000

of total nitrogen of which 1·2 parts are as free and saline ammonia and the remainder as albuminoid nitrogen. In addition, the leguminous crop *dhaincha* (*Sesbania aculeata*) is cultivated for green manuring, the green material thus obtained being about 10 tons per acre. Experience has shown that it is very essential to stir the soil treated with the effluent frequently, if it is to be kept in good condition. 1,000 acres of cane are irrigated with effluent in the area, the irrigation rate being Rs. 72 per acre for a 15-month crop. Yields of cane on the farm average 42 tons per acre, the variety chiefly cultivated being Co 419.

At the Padegaon Sugar Cane Research Station on the heavy black, brown and grey loams, the following are the recommendations at present in regard to the manuring of the crop :—

(1) Green manure or compost to be applied at the rate of 10 tons per acre ; if the latter, half is to be ploughed in and half applied in the furrows.

(2) Top dressings of nitrogen at the rate of 300 lb. per acre for plant cane in the proportion of one of sulphate of ammonia to two of organic cake, *e.g.*, groundnut cake, are to be given as follows :—

At planting : 30 lb. nitrogen as sulphate of ammonia,
Two months later : 30 lb. as sulphate of ammonia and 75 lb. as cake,
Four months from planting : 40 lb. as sulphate of ammonia,
At earthing : 125 lb. nitrogen as cake.

Yields of crop obtained vary from 45 to 50 tons per acre. Some of the varieties now normally cultivated are Co 419, Co 360, and POJ 2878.

Punjab.—Early-maturing varieties only are cultivated in the Punjab. Manuring is chiefly with nitrogenous fertilizers at the rate of 100 lb. of nitrogen per acre as castor cake. This is given in two applications : the first after planting and the second before the rains about 4 months later. In addition, farmyard manure at the rate of 5 tons per acre is given as a basal dressing. Potash and phosphoric acid are not effective in increasing yields. Yields of crop on Departmental Farms vary from 30 to 35 tons per acre, but the average on cultivators' fields is about 25 tons per acre. Some of the varieties cultivated are Co 285, Co 312 and Co 313.

United Provinces.—The main fertilizing constituent required by cane on the alluvial soils of the U. P. is nitrogen. There is no response generally to applications of phosphoric acid and potash, but occasionally phosphoric acid gives beneficial

returns. The quantity of nitrogen applied varies from 100 to 150 lb. per acre, 60 lb. being in the form of green manure and the balance as organic cake and sulphate of ammonia. Where artificials are not normally used, farmyard manure at the rate of 10 tons per acre is applied at the time of preparation of the land. At the Shahjahanpur Sugar Cane Research Station molasses have been found to give increased crop yields, but owing to the disadvantages attendant on its usage, *e.g.*, difficulty of handling, its relatively high cost, it has not proved economic to utilize it for the purpose. At Padegaon, Bombay, Deccan, molasses alone have not proved effective in increasing yields, but mixed with *gurhal* ash, beneficial results have been obtained. The average yield of crop on the Shahjahanpur sugar cane station is 30 tons per acre, but the average for the province is only from 20 to 25 tons per acre. Yields can be increased to 50 tons per acre by heavy manuring, but the practice is not recommended. Varieties chiefly cultivated are Co 312 and Co 421.

Bihar.—On the alluvial soils of N. Bihar, where again short-aged varieties of sugar cane are grown, the quantity of nitrogen applied as top dressings to sugar cane is comparatively small, *viz.*, 40–60 lb. per acre. This is given in organic and inorganic form, and is additional to a basal application of green manure (sunnhemp) or farmyard manure which is reckoned to give about 60 lb. of nitrogen per acre. Phosphoric acid is invariably applied at the rate of 40–50 lb. per acre in the form of super-phosphate or nicifos. The fertilizer mixture is given in two dressings, half at planting and half at earthing. Sugar cane press mud is recommended for application to cane at the rate of 4 to 7 tons per acre, about 10 to 12 weeks before planting. Yields of crop in Bihar average about 20–25 tons per acre. No irrigation water is normally given in N. Bihar and this may partly account for the relatively low yields. The crop varieties popularly cultivated are Co 331, Co 313 and Co 299.

Bengal.—On well-cultivated sugar cane plantations on the alluvial silt and loam soils of Bengal, nitrogen is applied to the crop at the rate of 100–125 lb. per acre partly as a basal dressing of green manure or farmyard manure and partly as top dressings of castor, groundnut or mustard cake mixed with sulphate of ammonia or nicifos. The green manures cultivated are sunn-hemp, *dhaincha* (*Sesbania aculeata*) or cowpea. When cattle manure is used half is applied when the land is being ploughed and half in the furrows. Phosphoric acid is applied at the rate of 30–50 lb. per acre as bone meal or nicifos. The fertilizers are given in three dressings, two before and one at earthing up. Yields on these soils average 30–35 tons/acre for plant cane and 20–25 tons/acre for the ratoon crop. The varieties

cultivated are mainly Co 213, Co 313 and Co 421. On the red lateritic soils of N. Bengal liming at the rate of about 10 cwt. per acre has proved to be very effective.

IRRIGATION

In tropical India, *e.g.*, the Bombay and Madras Presidencies and Mysore, sugar cane is heavily irrigated, the duty being as high as 12 acre ft. per annum exclusive of rainfall. In parts of sub-tropical India where irrigation facilities are available, the crop is watered during the dry season but in restricted quantities. Thus in the U. P. the maximum number of irrigations per season each of 3 to 4 acre-inches per acre is six, the total duty being less than 2 acre ft. per acre. The irrigations are given during critical periods at intervals of a fortnight to a month. In the Punjab the number of irrigations varies from 16 to 20, and the interval between irrigations from 10 to 15 days. The total duty per season is 5 to 6 acre ft. per acre. In Bengal on one large plantation in Ramnagar, where the annual rainfall is 55–60 in. only one or two irrigations are given during the dry season. In other parts of sub-tropical India, *e.g.*, North Bihar, parts of U. P. and the Punjab, the crop is almost entirely cultivated without irrigation. This is due to the high water-retentive capacity of the soils, the absence of irrigation facilities and a comparatively higher and better distributed rainfall (42 to 55 inches per annum). The crops in these areas show, however, marked responses to as few as two or three irrigations during the hot weather.

In the tropical sugar cane districts of India, where the rainfall is generally low (about 20 inches per annum), irrigation is regularly practised, the interval being, on the average, once in 10 days, or more frequently at certain periods. At the Padegaon Sugar Cane Research Station in the Bombay Presidency, experiments carried out with varying duties of water showed that, exclusive of rainfall, 8 acre ft. per annum at field site was the optimum. Presuming a loss of 30 per cent. in transit, a duty of 120 in. of irrigation water at distributary head was required. The yield obtained with normal manuring and cultivation and the irrigation duty indicated was 45–50 tons per acre for a 14-month crop. The duty fixed by the Irrigation Department for sugar cane in the Deccan Canal areas is 124 inches per acre per annum.

Where heavy irrigation is given, as in Mysore and Bombay, at the early stages of cultivation of the crop the irrigation water is let into the furrows in zig–zag fashion. After earthing, the water is circulated likewise between the rows. Where the crop is not earthed, the fields are divided into small plots by shallow drains which thus carry the water over the whole field.

THE POSSIBILITIES OF SUGAR CANE CULTIVATION IN CEYLON

As this question has been comprehensively dealt with in the report of the Committee appointed by the Hon'ble the Minister for Agriculture and Lands, of which the writer was a member, no further comment is required except to indicate that (1) there are comparatively large extents of soil in Ceylon suitable for the crop. These soils are similar to the Mysore and Bengal red loams, but are relatively richer in plant nutrients than the latter. They would, however, require systematic manuring, particularly with nitrogenous fertilizers, if good yields are to be secured over a period of years; (2) as the crop, if cultivated on any large scale, would need irrigation during the dry weather, owing to the low water-retentive capacity of our soils and tropical red soils generally, experiments would have to be conducted to determine the optimum water requirement on different soil types under varying manurial treatments.

ANALYTICAL AND FIELD EXPERIMENTAL TECHNIQUE

Methods of Analysis.—The methods adopted in India for the analysis of sugar cane and its products are those detailed in "A Handbook for Cane Sugar Manufacturers and their Chemists" by G. L. Spencer and "Methods of Chemical Control for Cane Sugar Factories and Gur Refineries" issued by the Sugar Technologists' Association of India.

Sugar Cane Sampling for Analysis.—At the centres visited, a sample of sugar cane for analysis consists of from 30 to 75 canes taken at random from 6 to 7 clumps. When samples are required from randomized experimental plots, the clumps are selected from the border rows. The canes are crushed in a bullock or electrically-driven crusher after the unmillable tops have been removed. The juices are strained and weighed. When new varieties are being tested out, each sample consisted of the canes from a single clump.

Analyses commence when canes are eight months old at Coimbatore, in Bihar and the U. P. and when ten months old in Mysore, and are continued up to the thirtieth month. Monthly and, at certain stages, fortnightly analyses are carried out.

Tests for Maturity.—At Pusa, the Q1/Q2 ratio (an extension of the top/bottom ratio of Visvanath and Kasinath) is used to determine the stage of maturity in cane, Q1 being the Brix of the third or fourth internode below and Q2 the Brix of the fourth internode above the central internode, as determined by the hand refractometer. Regression equations have been worked out for determining the Brix value of the juice of the whole cane without crushing the stalk.

Experimental Field Technique.—The plot dimensions for field experiments with sugar cane vary somewhat at different experimental centres, but the nett harvested plot area is generally 1/40th of an acre (1 *guntha*), the gross area being about 1/28th acre. The plot is at least three times as long as it is broad. The number of harvested rows is 5 or 6 when the rows are spaced 3 ft. apart, and the length of the rows varies from 60–72 ft. The Statistician of the Pusa Research Institute, however, recommends that the nett harvested plot should consist of 4 rows each 90 ft. long, 2 rows at either side and a length of 6 ft. at the ends of the rows being left as a border.

SUGAR AND JAGGERY (GUR) MANUFACTURE

Refined sugar was manufactured in 147 factories in India during 1940–1941, about 50 per cent. of which were in the U. P., and 25 per cent in Bihar. Research in sugar technology is carried out at the Imperial Institute of Sugar Technology, Cawnpore. Here a complete experimental factory unit to deal with a ton per hour of sugar cane has been erected to study the research problems connected with cane sugar manufacture and the utilization of the by-products of the industry. Courses in sugar technology are also conducted at the Institute. In the U. P. and Bihar, *khandsari* or unrefined sugar is extensively manufactured as a cottage industry in small mills distributed over the planted areas. The process of manufacture is briefly as follows :—The juice is boiled in a special furnace after neutralization with lime if necessary, and clarification with superphosphate solution and *bhindi* mucilage prepared by soaking overnight 1 part of crushed *bhindi* (ladies' fingers) plant in 10 parts of water and squeezing the soaked plant. The striking point of the "rab" or concentrated juice is ascertained by a simple instrument called the "rabometer". At the proper concentration the "rab" has a Brix value of 85–87. The "rab" is then poured into cooling pans, (a little sodium hydrosulphite being added at the same time to bleach the product) and allowed to crystallize for 7–10 days. The rab is then centrifuged in a power drawn centrifuge. Trials made in this laboratory with the clarificants mentioned have confirmed their value for the preparation of jaggery of good keeping quality from kitul (*Caryota urens*) toddy.

All over India much attention has been given to improvements in *gur* (jaggery)-making outfits. A bulletin on this subject has been issued by the Sugar Committee of the Imperial Council of Agricultural Research, New Delhi.

In Mysore and the Madras Presidency much attention has been given to the manufacture of activated carbon from paddy husk with the primary object of utilizing it for decolourizing

cane juices and so obtaining a superior quality of jaggery (*gur*). The material is also useful in the oil-refining industry and in the preparation of gas masks. Two methods of manufacture have been adopted : (1) the carbonization process followed by alkali and acid treatments. This is described in leaflet No. 81 of the Department of Agriculture, Madras—" Manufacture of Active Carbon from Paddy Husk", (2) the zinc chloride-hydrochloric acid process. Recently at the Bilari Research and Testing Station, U. P., where research on *gur* and *khandsari* sugar manufacture is being carried out, a process has been worked out for the preparation of activated carbon from the same raw material using calcium chloride as the activating agent. At this station too, a complete unit, which includes a crusher (*Kolhu*), furnace (*bel*), crystallizer, hand centrifuge, and sugar drier, has been designed for the manufacture of sugar on a cottage industry scale. The cost in India of one such unit is reckoned at Rs. 750. Such a unit, even at double the cost, should prove very suitable if it is intended to establish a cane sugar cottage industry in Ceylon.

At Mandya Farm a new type of white jaggery is prepared which is very much like sugar. The juice, after liming and treatment with activated carbon obtained from paddy husk in the proportion of 1 lb. of the latter to 100 gallons of juice, is boiled in the usual way in a shallow pan (about 8 in. to 1 ft. deep) to a temperature of about 116°–118°C, *i.e.* about 2°C less than that for jaggery. The pan is removed from the fireplace, the contents allowed to cool slightly, and then stirred rapidly with a wooden stirrer till the jaggery begins to grain. A creamy-white product of good keeping quality is thus obtained.

UTILIZATION OF BY-PRODUCTS

Molasses in the chief by-product of the cane sugar industry. At the Mandya factory in Mysore and in a few others in U. P. and Bihar, a part of the molasses is utilized for the manufacture of power alcohol. The material is also used as a cattle food in various ways, as a manure, for soil reclamation purposes and as a surfacing for roads. At the Indian Institute of Science, Bangalore, attempts are being made to work out a process for the extraction of potash from molasses by treatment with tartaric acid obtained from green tamarind.

At the Sugar Technological Institute, Cawnpore, *begasse* (cane fibre), cane trash, and press mud have been successfully employed for the manufacure of compost by the hot fermentation process. The final product has a nitrogen content of about 1 per cent. In the *khandsari* sugar industry, *begasse* and cane trash are used as fuel.

MISCELLANEOUS

In this brief section will be set down the observations of the writer in regard to work of experimental or practical interest connected with local agricultural or chemical science, and not referred to elsewhere in this report. The original publications in respect of some of these subjects are available for reference, if necessary.

In addition to the centres already indicated, the following were visited :—

The Indian Institute of Science, Bangalore.
The Nutrition Research Laboratories, Coonoor.
The Dry Farming Station, Rohtak, Punjab.
The Ganeshkand Fruit Experiment and Cold Storage Research Station, Poona.
The Guntur Agricultural Station, Madras Presidency.

(1) *Paddy Rotations.*—In many parts of India paddy is not cultivated successively on the same land, but the practice of rotations on paddy land is by no means general. The cultivation between paddy crops of a leguminous crop for food, such as cowpea and grams, or for green manuring, *e.g.* sunnhemp, *dhaincha* (*Sesbania aculeata*) is fairly commonly practised. Sugar cane is perhaps the most popular crop for growing in rotation with paddy. In the Coimbatore District of Madras, paddy is rotated with sugar cane, plantain and betel or turmeric. In Mysore under the Irwin Canal Scheme, the normal rotation practised is sugar cane or cotton, green manure (a mixture of sunnhemp, horse gram and cowpeas), paddy, and kurakkan or cigarette tobacco (Harrison's Special). A rotational system of irrigation or block system of cultivation is adopted in the area, the blocks being of 50 acres maximum extent. In the Sind, U. P., and Bihar, grams, peas, rape seed and leguminous green manure and fodder crops, *e.g.*, berseem clover (*Trifolium alexandrinium*), *matar* (*Lathyrus sativus*) are among the crops cultivated occasionally after paddy. In Bihar and U. P. sugar cane is included in the rotation, in places. Berseem clover is popular in the Punjab between rice crops. At the Chinsura Paddy Farm in Bengal, when early varieties of rice are cultivated a *rabi* (winter) crop of gram or lentils is grown. Jute, sugar cane, potatoes and the green manure *dhaincha* are other crops grown in rotation with paddy in certain areas of the Province.

(2) *The Harrowing of a Broadcast Paddy Crop.*—In many parts of India where paddy is sown broadcast for any reason whatsoever, the practice of harrowing or ploughing a growing crop of paddy when the crop is about 4–6 weeks old is common, as it has been found appreciably to increase crop yields. The practice is adopted in certain parts of Mysore, in the Punjab

Hills, in E. Bengal and Bihar. The implements used are a spiked harrow or a country plough without a mould board, these being generally drawn by bullocks.

(3) *Dry Farming.*—At the Dry Farming Research Station at Rohtak in the Punjab where the annual rainfall is about 15 inches, experiments are conducted to study the problems of dry farming in India. The crops grown in winter are barley, wheat and gram; in summer cambu, cotton, sunflower and green manure crops. The importance of keeping land fallow has been strongly indicated. Increased yields subsequent to fallowing are attributed to: (1) the moisture conserved, (2) the greater availability of the nitrogen and mineral nutrients of the soil as a result of the practice. Moisture conservation is also promoted by (1) the eradication of weeds, (2) artificial mulches of *bajra* (cambu) and cotton stalks and, to a lesser degree, by (3) the formation of a soil mulch. Deep cultivation (6 inches) was not more advantageous than shallow cultivation (4 inches) in conserving moisture. Yields of cambu from plots so treated were not significantly different. The value of the " Sohaga " or levelling beam for breaking clods, levelling plots and improving the tilth of seed beds has also been demonstrated.

At the Agricultural Station, Guntur, Madras Presidency, dry farming is practised with great success. The annual rainfall is only 35 inches, most of which falls during the S.-W. monsoon from June to September. Rain does, however, fall during the south-west monsoon months of October and November. The soils of the district are of two main types: (1) the heavy black clay loams of over 6 ft. depth and high water-retaining capacity. These drain freely. They are well supplied with potash and lime, but are poor in nitrogen and phosphoric acid; (2) the red light loams of poor water-retaining capacity and low nutrient status. The former type of soil predominates. The crops cultivated in the district are cigarette tobacco (Variety Harrison's Special), of which there were 110,000 acres in 1940, chillies, groundnut, cotton, dry grains, dhal and fodder crops. There are two main seasons for cultivation: (1) the wet or S.-W. monsoon season (*punasa*), (2) the N.-E. monsoon or partially dry season (*pyru*). In the former, groundnut, fodder and the minor food crops are cultivated, and in the latter, tobacco, cotton, chillies and millets. It will be noted that the more important crops are not cultivated during the heavy N.-E. rains, but immediately following them. The high water-retentive capacity of the black soils enables them to satisfy adequately the requirements of these crops for water during the subsequent cool, dry months (December to February) which

are ideal for the ripening and harvesting of the crops, and the preparation of the produce for storage or sale.

The system of rotation practised, which has been found best for the district, is as follows :—

1st year ..	1st season (June-September)	Groundnut and dhal in rows, cambu and Italian millet broadcast ; or fodder
	2nd season (October-March) (if favourable)	Maize and sorghum for food and fodder ; or fallow
2nd year ..	1st season ..	Fallow
	2nd season ..	Chillies
3rd year ..	1st season ..	Fallow
	2nd season ..	Sorghum
4th year ..	1st season ..	Fallow
	2nd season ..	Tobacco or cotton

Generally only one crop is taken each year. If the N.-E. monsoon is favourable, a second crop may be taken. Like elsewhere, it is the distribution of the rainfall rather than the quantity which matters. Inter-cultural operations are very essential for success. Good yields of crop are obtained in normal seasons. Thus yields of cigarette tobacco average 750 to 1,000 lb. per acre. No artificial fertilizers are generally applied, but cattle manure is widely used, even tobacco being given a dressing of $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. The leguminous fodder *Phaseolus trilobus* (*pillipesera*) grows excellently in the area and is sown either as a pure crop or mixed with sorghum.

(4) *Middle Class Land Colonization in Mysore.*—An interesting experiment in middle class land colonization has been inaugurated at Maddur Taluk, Mysore, on an area of red loamy soil under the Irwin Canal Scheme. 10 colonists (some of whom are graduates in agriculture) have been selected and each has been alloted 25 acres of land, 15 of which are irrigable. The land is ploughed by tractor and discharrowed before it is given over to the colonists. A deposit of Rs. 1,000 was paid by each colonist. The colonists are compelled to follow the advice and directions of the Agricultural Department officers in all matters connected with the scheme. In the first year cigarette tobacco was cultivated, and yielded, with manuring, 5,000–6,000 lb. of green leaf per acre ; 5–6 acres were cultivated by each colonist. The dry crops included in the cultivation programme are : kurakkan, sorghum, gingelly, castor, cowpeas, groundnut, *Dolichos lab-lab* and pasture or fodder grass. On the irrigable land, the crops proposed to be cultivated are tobacco, cotton, paddy, sugar cane, kurakkan and groundnut. Money is to be lent to the colonists at the rate of Rs. 1,000 per annum for the first two years and at Rs. 500 per annum for the next three or four years, and is to be recovered from the crop returns.

(5) *The Utilization of Nelli (S) (Phyllanthus emblica) as a Source of Vitamin C.*—At the Coonoor Nutrition Research Laboratories *nelli* (S) fruit which is a very rich source of vitamin C, is dried in the sun, ground finely, mixed with talc in the proportion of 10 of the *nelli* flour to one of the latter, and made into tablets for supplying troops. Each tablet contains 5–8 mgm. of ascorbic acid. Work carried out by us at Peradeniya on local *nelli* showed that while the fresh fruit was a rich source of vitamin C, though not as rich as the Indian product, a very high proportion of the vitamin was lost during sun-drying. Further work is being undertaken on this subject.

(6) *Insects as Test Animals for Nutritional and Vitaminic Studies.*—At the Indian Institute of Science, Bangalore, interesting experiments have been conducted with the rice moth as a test animal for studies on the vitamin B contents of foods. Fed *en masse* on a diet devoid of vitamin B1, the moths showed poor growth, while those treated with a full diet followed the normal course of development. The experiments indicated that sorghum constitutes a complete and adequate diet and hence a good source of vitamin B1, to these insects. In view of these findings, the rapid development of the rice moth in unpolished rice, which is a good source of vitamin B1, can be well understood.

(7) *The Malting of Grains.*—Methods have been worked out by the Agricultural Chemist, Madras, and Dr. B. N. Sastri of the Indian Institute of Science for the preparation of malted grains and malt extracts. At Coimbatore, sorghum (*cholam*) is the chief grain to which attention has been directed. The process is described in leaflet No. 4 of the Madras Department of Agriculture, entitled "Malt from Cholam". Dr. Sastri has prepared a malt extract from kurakkan. This grain, he has found, is a complete food so far as proteins are concerned. Work on this subject has just been started in this laboratory.

(8) *The Ganeshkand Fruit and Cold Storage Experiment Station, Poona.*—This is the main horticultural station of the Bombay Presidency and is under the direction of Dr. G. Cheema, Horticulturist, who is also in charge of the cold storage research station. The fullest facilities are available at the station for the conduct of cold storage trials, while limited facilities also exist for work on the gas storage of fruit. A full-time chemist is attached to the station.

(9) *The Lyallpur Fruit Preservation Laboratory.*—At the Agricultural College, Lyallpur, Punjab, a fully-equipped laboratory exists for the investigation both on a laboratory and semi-commercial scale of problems relating to the canning and bottling of fruit, fruit juices, fruit preserves, &c., and the cold

storage of fruit. A whole-time reserach chemist is attached to the laboratory. The semi-commercial production of bottled citrus juices is undertaken in the institution.

(10) *The Crop Water Requirement Research Station, Lyallpur, Punjab.*—This station, situated a few miles from Lyallpur, is under the charge of the Professor of Agriculture, Lyallpur Agricultural College, who is assisted by a staff of five research officers. The station has a well laid out irrigation system permitting of the accurate measurement of the water supplied to a crop which is led into the fields through open concrete flumes. Trials are being carried out with the irrigation requirements, under varying cultural conditions, of sugar cane, wheat, cotton, and other crops.

(11) *Ranawara (S) (Cassia auriculata) Bark as a Source of Tannin.*—The bark of *Cassia auriculata* (*ranawara* S) finds wide application in producing a satisfactory half-tanned leather, owing to its high tannin content (about 13 per cent.). The material is obtained by coppicing the tree, drying the stems and removing the bark mechanically. It is reported that there is a good market for the bark in India. There would appear to be good scope for developing this industry in the dry sandy areas of Ceylon, *e.g.* Paranthan, and Puttalam districts, where the plant grows freely.

(12) *Useful Trees along Roadsides, &c.*—All over Mysore and Madras avenues of tamarind are common along the main roads. In certain parts of India avenues of mango trees have also been observed. Roads in our dry zones may advantageously be lined with such trees or others useful to man and beast. In Madras, *Sesbania grandiflora* (*Katuru murunga* S) is used as a hedge plant or as standards for betel vines. This is a practice worthy of emulation by local betel cultivators.