https://doi.org/10.29321/MAJ.10.A04973

problem as to whether he is a loser if he sells his produce in a particular market at a particular rate per unit.

By increasing the dose of manure or other treatments given at a heavy cost one ryot is able to increase his acre yield very considerably. Whether it is economical to do so is a question yet remaining unsolved. Calculating the cost of production per unit of the produce as above, will immediately warn the producer to remain within economic limits.

Therefore I suggest that calculations of the cost of production must not end with cost of production and yield per acre, but must proceed further and should be resolved into the cost of production per trade unit of any produce if the producer must know his own economic position at any stage. It is, I believe, the want of such a clear idea of the economic position that does not induce the average wet land farmer to go in for any crop other than paddy and adopt other improvements suggested by the Agricultural Department as rapidly as he should.

AGRICULTURAL METEOROLOGICAL PROBLEMS.

BY S. AUDINARAYANAN, M. A.

Agricultural meteorology deals with the influences of weather on vegetation, particularly on animal life, vegetable food and textile supplies of the nations of the world. That agriculture depends both on the climate and the periodical variations of weather is a well known fact. But the relations are very complicated and there is difficulty in separating the effects of the several factors. So much so, the progress made in applying the data in meteorology to the purposes of agriculture is not as much as might have been expected. The greatest obstacle to the progress is the great inaccuracy in the data expressing acreage and yield. The meteorologist engaged in the study of weather and crop relations is constantly confronted with the internal evidence of gross inaccuracies and lack of homogenity in acreage and yield values.

A definite advance seems to have been made by the establishment of the Agricultural Meteorological Section under the Indian Meteorological Department. Their programme of work on the Research side includes the investigation of best methods and standardisation of those methods for the measurements of radiation, evaporation, soil temperature, and soil humidity so that these data may ultimately be systematically maintained in addition to those of air temperature, air humidity, rainfall, wind, sunshine etc. The Statistical Officer under the Imperial Council of Agricultural Research is travelling from province to province and is taking every effort to improve the defects in the collection of acreage and yield statistics. But the records at the several Agricultural Farms should be very accurate to be capable of yielding very good results.

At Lyallpur the cotton crop is being subjected to systematic experimentation and results of a far-reaching nature are anticipated. There the results of early and late waterings are being investigated. Also work is being carried out on the causes of the partial failures of the Punjab-American cottons. A very detailed study of the reactions of the plant to various environmental factors is being made which includes an examination of the moisture content of the soil correlated with the speed with which water passes up the stem of the plant, age of the leaves on different portions of the plant relative to their size, the carbohydrates in the various tissues of the plant body and the size and weight of bolls as affected by condition of growth. Such investigations must be started at the several Agricultural Farms and the Agricultural Department must make themselves responsible for meteorological studies relating to the influence of weather conditions on the growing crop.

Temperature, rainfall and sunshine are some of the very important factors that control climate. A broad climatic belt gives the nature of plants growing and there is also a narrow belt in which certain plants will grow. There is what is called optimum combinations of temperature, moisture and sunshine in which plants make their best growth and under which largest of yields will be obtained. Food is available to the roots of the plants only in a soluble form and it is carried up the plant and converted into vegetable tissue under the influence of solar energy which is expressed in heat units or calories. Different plants require unlike proportions of moisture, heat and sunshine. Many plants have a certain period during growth when there must be a well-defined combination of certain weather factors to produce large crop-yields. To determine these critical periods laboratory experiments must be performed side by side with field observations and the several factors must be correlated mathematically from past records. Anticipation of a type of weather known to be injurious or beneficial is of paramount advantage. This line of research requires attention.

High and low temperatures affect crops in various ways. But the principal ones are prevention of germination, checking of growth, killing all or part of the vegetative parts, injuring the blossoms or damaging the maturing parts. Also there are certain definite temperatures below which a plant will make no growth. This zero of vital temperature point is 43°F or 6°C. Kincer in U.S A. has suggested that the zero of the spring-seeded crops should be the mean daily temperature about the average date of the beginning of planting. Such temperatures have been determined for the following cases.

Spring Wheat	37° to 40°
Oats	43°.
Potatoes	45°.
Corn	55°.
Cotton	60° to 62°

Rainfall. The problem of dealing with the entire range of rainfall from the lowest to the highest limit between which any cultivation of crop is carried on, is not a very difficult one. Though emperical grouping of factors will solve the problem, yet more advanced mathematical methods could be used for calculating and fitting regression curves which is expected to be of wider applicability and more fertile of results.

Soil. Physical circumstances and properties of the soil are of much importance to agriculture. Schubler has tried to find the effect of the colour of the soil on the absorption of radiated heat and the influence of moisture in the soil. A wet soil takes a longer time to warm or cool than a dry one. In permeable soils, rain carries down with it the temperature of the air and the surface layers. The relative importance of the temperature of the air and the soil upon plant growth presents difficulties. The power of the soil to retain water is important in its effect on the temperature of the soil and supply of water to the plant. Necessity of water increases with the nature of the sub-soil, the closeness of the stand of plants, size of leaves, dryness of air, velocity of wind and temperature.

Complete hydrodynamic solution of the movement of sub-soil water has not so far been obtained, but on the assumption that the velocity is proportional to the first differential of the relative saturation of the sub-soil and that the ratio of the surface of all particles per unit volume to the saturation quantity of moisture is constant, an integrable equation results for a linear change of particle surface with depth.

Sunshine. No plant life is perfected and reaches its maturity except through the influence of short wave solar energy. Dark rays of heat can replace sunlight in the growth of vegetation but sunlight can partially replace heat. Sunlight-hour-degree is the measure and is the product of the mean daily heat required to grow and mature and the possible number of hours of sunshine from planting to harvesting.

An enquiry into the relationship between meteorology and a crop or crops in any given district only shows what variations of weather are most desirable in that locality. For, in England the correlation between winter rainfall and subsequent spring crops was found by Hooker to be negative, whereas S. M. Jacob found the same correlation for the Punjab as positive. These opposite conclusions do not prove that correlation is useless but that care is necessary in scrutinising the results. It can rarely establish the standard that the crop really prefers.

The results obtained by Jacob, Wallen and others are a sufficient warrant that the method of correlation is an exceedingly powerful

weapon in the hands of a crop fore-caster. It is abundantly clear that the weather plays a part invisible to the eye in the internal structure of the plant that can be measured by such statistics. These numerical records must be worked up and the results taken into serious consideration and used in conjunction with the facts such as are learned by actual observation in the fields, for fore-telling the future harvest. Far more investigation is yet required into the behaviour of different crops under different conditions of weather. Though the problems are well defined yet the progress recorded has been singularly small.

In India, there is a vast store-house of valuable statistics awaiting expert knowledge and intelligent shifting. The method of correlation is by no means the only way of attack but its vitality is shown by the remarkable series of co-efficients obtained by Hooker in 1922. J. W. Smith has found the weather index of factors injurious to plant growth and finds a correlation between that index and the yield. R. A. Fisher has another method but has put his finger in a weak spot in the method of correlation. As you correlate yield with finer and finer time intervals of rainfall, the co-efficient tends to zero. Applications of statistical methods has been well recognised and what is to be considered is how far the Indian Statistics are going to throw light on the connection of weather conditions and yield.

The main sources of yield data in India are (1) the record of crop experiments by the Government revenue staff during settlement operations and routine of district administrations which gives only a discontinuous series which would not repay closer examination. (2) the record of failed crops noted by village revenue agency which if cautiously handled would give some useful result. (3) agricultural department experimental station records which are the most reliable. and lastly, and (4) the season reports of the Directors of Agriculture.

Jacob is of opinion that though fairly favourable as the conditions in India are for the study agricultural meteorology, yet for the solutions of the problems of agronomic meteorology-which concerns with the direct effect of rainfall, temperature, sunshine and winds in inducing the cultivator to bring varying amounts of unirrigated lands under the plough or of restricting or increasing the use of artificial sources of irrigation—the data provided in North India are unsurpassed in the whole world for the space and time they cover, their accuracy and continuity. The statistician who does not become the slave either of his satistical material or of his mathematical methods can obtain a clue to the variations of crop areas with variations of climate and weather. Though not well served in the side of yield statistics he will have an opportunity of helping to solve some of the world problems of agricultural meteorology.

The several methods of agricultural meteorological research are (1) Laboratory studies with plants, animals under completely

controlled conditions, of the effect of different kinds of temperature, humidity, light etc. in conjunction with different soils and different kinds of nutrition. (2) Pot culture studies in which factors other than the weather are controlled and statistical methods are used to ascertain, the effect of the different weather factors. (3) Field studies in which measurements of crop growth and yield and of the intensity of attack of diseases and pests on the one hand and meteorological factors on the other are carried out side by side. Analogous studies on animals are carried out by observations of the healthy fecundity etc. of herds and flocks in conjunction with meteorological records, and (4) Statistical studies in which records of crop yields and weather over a long series of year are correlated.

Insect pests and plant diseases. Value of forecasts of seasonal appearance of insect pests and plant diseases and their mass outbreaks, and research on the relation between meteorological factors and insect activities and plant diseases, are problems that have immediate bearing on the subject.

Investigations should be carried out on the following lines. (1) Application of climograph method to studies in distribution, seasonal cycle of development and periodic fluctuation in the number of insects. (2) Effect of atmospheric motion on the distribution of insects. (3) The insect fauna of upper atmosphere. (4) Influence of the colouration of insects on their thermal economy. (5) Effects of atmospheric pressure on insect activities and development. (6) Part played by light in the development of insects. (7) Determination of the distribution of the fungus spores by the winds in close co-operation with the metorologist, by the plant pathologist, and (8) Relation of weather to healthy crop growth and yield.

For each important crop plant, during the whole period of its growth and maturation, the following meteorological data should be recorded. (1) Air temperature (*a*) above the crop, (*b*) at the level of the top of the crop, (*c*) at midcrop height, (*d*) at the base, (*e*) in the soil, recorded every two or three hours or by a continuous recorder. (2) Moisture content of the land (*a*) at base near the crop, (*b*) under the crop, the usual precipitation records measured twice daily and nightly. (3) Relative humidity of the air (*a*) above the crop, (*b*) at the level of the top of the crop, (*c*) at each quarter of its height, (*d*) at the base. (4) Cloud records and sunlight intensity. (5) Relative penetration of precipitation into a crop at each degree of density and the length of time moisture remains on the foliage. (6) The relative amounts of dew deposited on crops of different heights for each stage of temperature, moisture and humidity as well as of crop density. (7) Relative penetration of wind of varying degrees of force into the crop and its relation to crop humidity, temperature and spore dispersal. (8) The humidity and temperature of the higher air strata.

and (9) More information about air currents and spore dispersal. The methods of collection of these data should be left to the meteorologist himself. The analysis of these data is a problem involving deep analytical and higher mathematical treatment.

UTILISATION OF DAIRY WASTES.*

T. LAKSHMAN RAO, B.A., D.I.C.,

Assistant Agricultural Chemist, Coimbatore.

The subject of this paper relates to the utilisation of the waste products of the dairy and is based mainly on certain experiments conducted in 1918 with the object of investigating the possibility of manufacturing locally, food and other products which could replace similar products which used to be then and still to a large extent are imported from outside, but which war conditions had rendered very difficult to obtain.

When milk coming into the dairy could be all disposed of as milk there will be of course no waste, but where the demand for fresh milk is limited and production is considerably in excess of such demand the milk will have to be converted into cream or butter or cheese and these processes would always leave a certain amount of waste in the form of skim milk or whey. If, however, by some means these waste products could be converted into something of marketable value not only such waste could be prevented but the mother industry could be made more profitable.

Skim milk contains about 3% of the protein, casein, held in colloidal suspension. The latter is easily separated by precipitation with acids. On a large scale the separation is best effected by the addition of sulphuric acid. In the experiments referred to above, the precipitation was effected by mixing one and a half parts by volume of strong sulphuric acid with seven parts of water and adding the mixture to 1,000 parts of milk. The precipitated casein was washed, pressed to free it of superfluous water and dried in a draught oven at a moderate temperature and finally powdered as fine as possible.

A purer product can be obtained by dissolving the moist casein in the least possible quantity of ammonia and reprecipitating with acid. This process is repeated three or four times. The curd is washed several times with alcohol, extracted with ether in a soxhlet apparatus and finally dried.

Casein has been found to lend itself to an enormous number of uses in industry. The uses to which it is put is increasing year by year. There are probably very few industries in which casein does

* Paper contributed towards a symposium on 'Utilisation of Wastes' and read at a Combined Conference of the Association of Economic Biologists, Coimbatore, The Indian Chemical Society and the Society of Biochemists, Bangalore.