Vol. XV, Part V

September 1920

THE AGRICULTURAL JOURNAL OF INDIA

EDITED BY

The Agricultural Adviser to the Government of India

PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

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SOME COMMON INDIAN BIRDS.

No. 5. THE GOLDEN-BACKED WOODPECKER (*BRACHYPTERNUS AURANTIUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist;

AND

C. M. INGLIS, F.Z.S., M.B.O.U.

Many of the roads on the Pusa Estate being well bordered by trees, it is a common experience to hear the quickly-repeated tapping sound of a woodpecker as it digs away with its beak at a branch in which it has perceived the presence of some wood-boring insect. If the noise is traced to its source, it will usually be found to originate from a medium-sized bird coloured in black and golden-yellow and with a bright crimson crest, which may be seen clinging to the bark with its powerful claws, supported by its short stiff tail, and hammering away with its short, stout, chisel-like bill. This bird is the Golden-backed Woodpecker (*Brachypternus aurantius*), which is common throughout India and Ceylon, from Sind and the Punjab to Eastern Bengal, ascending the hills to about three or four thousand feet, but not apparently known from Upper Assam or Burma or in the Duars. It is generally seen singly or in pairs and often one may be seen following the other from tree to tree. In Ceylon it is accompanied by the Red-backed Woodpecker (*B. erythronotus*), which, as its name implies, is distinguished by having its back crimson, whereas in *B. aurantius* the back is golden-yellow or orange. Where both species occur together, it is probable that they hybridize occasionally. As regards other species of woodpeckers with which this one may be confused, the Common Golden-backed Three-toed Woodpecker (*Tiga javanensis*) is extremely like this bird and only markedly differs in wanting the hallux (inner hind toe). Tickell's Golden-backed Woodpecker (*Chrysocolaptes gutticristatus*) has also a very similar coloration but on account of its very much larger size is less likely to be mistaken for *B. aurantius* than is *Tiga javanensis*.

The Golden-backed Woodpecker is an extremely handsome bird, which Dewar briefly describes as having a bright crimson crest, top of head black, sides of head white with a number of black lines and streaks, upper back golden-yellow, lower back and tail black, wings black and golden-yellow with some white spots. The female differs from the male in having the top of the head black with small white triangular spots; it is shown peeping around the tree in our Plate. Unfortunately, like the Indian Roller, its voice is not in harmony with its plumage, its call, which is often uttered on the wing, being a loud harsh scream. Like the Roller also, it is rather a noisy bird.

Like all woodpeckers, it is an extremely skilful climber, seldom or never perching crosswise on a branch but clinging, always with the tail downward, to the stems and branches of trees, which it usually ascends and descends diagonally. The flight is undulating. It is seldom seen on the ground but occasionally descends to feed on ants which seem to form an appreciable proportion of its normal food, this consisting almost entirely of insects, largely ants varied with numerous small beetles, caterpillars and bugs, to which buds and fruits may occasionally be added. The late C. W. Mason examined the stomachs of sixteen birds throughout the year at Pusa and found 3,921 insects of which the great majority were ants, and it is notable that only one of these sixteen birds was found to contain longicorn beetle larvæ, although observation renders it certain that this bird does feed to some extent on wood-boring insects, which its long, worm-like, extensile tongue, armed with a many-barbed horny tip, is so admirably fitted to extract from their burrows after these have been laid open by the vigorous blows of the strong chisel-like beak. In Eastern Bengal it is stated to feed on the larvæ and pupæ of *Hoplocerambyx spinicornis*, a longicorn borer pest of *sal* (*Shorea robusta*), and in Madras it is stated to be very partial to toddy-palms, which may be due to the fact that these trees are infested by *Oryctes rhinoceros* and *Rhynchophorus ferrugineus*. At Pusa many of the dead *sissu* branches, at which one sees this woodpecker tapping away, are infested with a tree-living termite (*Coptotermes heimi*) and, although Mr. Mason's stomach-records do not support this, it is probable that this termite may provide a certain proportion of its food. As is the case with so many of our common Indian birds, it is wonderful how little we really know about its daily life. However, from the little we do know, we are justified in counting the Golden-backed Woodpecker, with all its kindred, amongst the farmer's friends.

Like other woodpeckers it nests in a hole in a tree, often in a mango tree in Northern India ; in Bihar nests have been found in mango, litchi, *sissu* and *siris* trees. In the Southern part of its range it breeds from February to June but in the Northern part it breeds from March to July, courtship being of a rather rough and ready fashion, punctuated by harsh screams. The glossy white (delicate salmon-pink when fresh and unblown) eggs, usually three in number, measuring about 28 millimetres long by 20 broad, are laid in a hole excavated in a tree by the parents or more frequently in a natural cavity to which merely an entrance has been made by the birds. Dewar states that "woodpeckers seem to excavate a new nest every year," but we are not aware how far this is the case. Woodpeckers, however, are very apt to desert any nest-hole that has been interfered with at all. We have many times found them to do this even when no chipping was done to enlarge the hole, the only interference being by means of a thin twig. Sometimes also they only partly excavate a hole and then leave it for another site. The nest-hole is about two and a half to three and a half inches in diameter and usually runs in horizontally for about three to six inches and then turns downwards. When the downward shaft is bored by the bird it is rarely more than eight or nine inches deep with a chamber of some five or six inches in diameter, but when the bird cuts into a natural cavity in the tree the egg may be found two or three feet below the entrance. No regular nest is formed, the eggs being laid on a few chips of wood. The young, when first hatched, are naked but assume the sexual coloration with the first feathers. If caught young, they may be trained to a diet of "*sattoo*" with some soft fruit and occasionally some insects.

In Bengal, Burma, Madras, Bombay and Assam this bird is protected by law throughout the whole year

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[*Note.* For the purpose of these papers I have used for this bird the specific name *aurantius* given in the *Fauna of India* volume. The correct name is, however, apparently *benghalensis* under which name it was first described by Linnæus in the tenth edition of the *Systema Naturæ* (1758; pp. 113-114), in which there is no mention of any species under the name *aurantius*. The *Fauna* volume quotes the twelfth edition (1766) as the authority for *aurantius* and *bengalensis*; I have not had access to this edition, but in the thirteenth edition, edited by Gmelin in 1788, this bird is referred to (Vol. I, pp. 433–434) under the name *bengalensis*, whilst *Picus aurantius* is recorded from the Cape of Good Hope (*l.c.*, p. 430). Not being an ornithologist and not having access to the necessary literature, I do not propose to do more than point out that *benghalensis*, Linn. (1758) is apparently the correct name for the Golden-backed Woodpecker.—T. B. F.]

THE EGYPTIAN COTTON PROBLEM.

A REPORT TO THE EGYPTIAN GOVERNMENT.

BY

H. MARTIN LEAKE, M.A., F.L.S.,

Director of Agriculture, United Provinces.

In November 1918, I received an invitation to visit Egypt to report on the steps to be taken by the Government of that country for the maintenance and improvement of the quality of Egyptian cotton and the increase of its yield. I visited the country on my way home in the spring of 1919 for the purpose of making preliminary enquiries and, on my return journey, spent some three months during the cotton season in the cotton-growing districts.

The results of my enquiry are embodied in the report here published. In many respects, economic, practical and scientific, the problems encountered in the growing of cotton in Egypt are fundamentally different from the problems presented in India. Nevertheless there are points of similarity and it is possible that the report may be of some small value to those interested in the Indian problem; I am indebted to the Egyptian Government for permission to publish it in this Journal.

I cannot let pass the opportunity which here presents itself of expressing my great indebtedness to all those persons with whom I came into contact in the course of my visit and enquiry, especially to Mr. J. Langley, Under Secretary of State for Agriculture, and to Mr. E. Shearer, who is known to many of the members of the Agricultural Service of this country as a former member, for their unfailing courtesy and ever ready assistance.

INTRODUCTION.

In letter No. 383—4-1-3, dated the 19th May, 1919, of the Ministry of Agriculture, I was asked to present a report embodying my "recommendations with a view to the maintenance and improvement of the quality of Egyptian cotton and the increase of its yield." The existing qualities are definite and possess a material extant physical basis. The question of their maintenance, thus, offers a definite concrete problem. The same is the case with the question of yield; and the improvement of the yield consists in the very definite and material fact of an addition to the return obtained from the acre or *feddan.** No such definiteness attaches to the third problem laid before me, that of the improvement of quality. Quality is a relative term and the nature of quality, good or bad, depends on the use to which the material in question is put. Those uses may vary from time to time and it is necessary, therefore, to study these uses and to form an idea of the probable tendencies in what we may term the economic aspect before it is possible to decide what will constitute an improvement.

There are, in fact, two directions from which a problem such as is presented by cotton production may be approached. We may ignore, for the time being, the economic, and concentrate on the agricultural aspect. In so doing, we should concentrate on the biological and physical problems involved, on the biological side, endeavour to ascertain that plant which will give the maximum return under the uncontrollable conditions of the environment, and on the physical side, attempt so to modify the controllable conditions of that environment, that the plant which we have chosen may develop to the full. Or we may commence with the study of the economic aspect, endeavour to ascertain the uses to which the raw product is put and the characteristics which give to that raw product its commercial value; to form an idea of what characteristics are most desirable in as far as their possession is likely to increase the value of the raw material which possesses them and, having arrived, as far as may be, at a definite conclusion on

* 1 *Feddan* = 5,024 sq. yard = 1·04 acre.

this matter, we may attempt to arrive at that standard by means of biological investigation.

The former method assumes an adaptability in the market for the raw material which must be practically unlimited. This assumption may be true, or almost true, of certain agricultural products and in such cases the method may be safely adopted. It is in no sense, however, true of the cotton industry which is built up of a number of very specialized sections the raw material of one of which is unsuited, or even totally useless, for the purpose of another. This method is here, therefore, inapplicable and we are forced back on a study of the economic side of the question if we are to discover the fundamental conditions on which it will be possible to build a sound superstructure of biological investigation. My own personal experience has hitherto been restricted to the so-called short staple cottons of which the underlying economic conditions are fundamentally different from those of the Egyptian cotton, and I have, therefore, devoted some time and trouble during my stay in England in visiting Lancashire and investigating the economic aspect of Egyptian cotton. Such an investigation is essential to a correct formulation of those recommendations which are the more immediate object of my mission. I propose to commence the report by formulating the results of that investigation. Such procedure will simplify the expression of subsequent recommendations inasmuch as it will indicate the objective to which they are directed.

I.

The most prominent feature of the cotton industry, even in that strictly limited section which makes use of Egyptian cotton, is its diversity. Even among the spinners of Egyptian cotton are to be found users who have specialized on certain classes and who prefer those classes to any others. In many cases they may, and do, use other classes but such use is definitely a substitution use, dependent on such questions as limitation of supply or relative price, and is not willingly adopted. There is thus a definite, and natural, conservatism in the trade which opposes free interchange between classes even when such interchange is practicable.

The problem of Egyptian cotton is, therefore, not a simple one; it is, on the contrary, a complex of problems. The unit is a single class which, under normal conditions, meets a particular demand. The value of that class is, to a certain extent, determined by the relation between supply and demand within the class itself and is, in part only, subject to the influence of the relation between total supply and total demand. It may actually occur that the spinner will pay less for an intrinsically superior cotton, in the sense that it will spin finer yarn, than for an inferior one.

We have here, I think, the first consideration that must be clearly borne in mind when approaching the problem from the producers' standpoint. Production is, and must continue to be, diverse. Not only so, but the various classes require to be produced in quantities approximating to the relative demand. Only so will the full intrinsic value for any particular class be realized. The argument applies equally to the lower, as to the higher, qualities; ove--production within the class leads to a low, while under-production leads to a high, price. The step from over-, to under-, production is, fortunately, sufficiently large owing to the flexibility of the market and this flexibility we must now consider a little more in detail.

The substitution of superior quality cotton to do the work of inferior can, naturally, be more readily adopted than the reverse process. The market, therefore, shows greatest flexibility in this direction. But such substitution will only take place, in the absence of any large shortage in total supply, when the price of the superior quality renders the proposition a paying one financially. Such conditions only hold good when the price of superior quality is relatively low or, in other words, when the superior quality is fetching less than its intrinsic value. Such a condition implies a definite loss to the producer. In a country like Egypt, which possesses a monopoly in the production of certain classes of cotton, this probably implies a considerable total loss since the reduction in price affects the entire outturn of the superior quality and not merely that portion which is used as a substitute. The rapidity with which Sakel has replaced other forms in cultivation in Lower Egypt affords an instance of this phenomenon. There is no doubt in my mind that the production of Sakel is far in excess of the demand for the manufacture of those types of thread for which it is peculiarly adapted. Its use has, therefore, been extended to other lines for which it is not so pre-eminently suited and such extension has been effected at the expense of the producer in as far as Sakel is worth less per unit than it would be were only sufficient available to meet the needs of that market which requires the qualities peculiar to Sakel. The present demand is, in fact, a forced one due to the fact that, even at the depreciated price, the money return for the unit area of production is greater than that given by any other form.

That, however, is an illustration of one form of market flexibility merely. There is another, and more subtle, one the effects of which are harder to diagnose and still more difficult to foresee. I may illustrate this again by reference to Sakel. It was pointed out to me that the large increase in the consumption of Sakel coincided with the enormous development in the production of voiles, for the manufacture of which it is pre eminently suited; it would appear, therefore, that, but for this coincident development of a demand and of a means of meeting that demand, the price of Sakel would be lower than it is. We must, however, be careful to distinguish between cause and effect here. There appears to be little doubt that the sudden supply of a class of cotton particularly adapted to the manufacture of voiles is, in itself, in large measure, responsible for the demand which has arisen for that class of cloth. The demand for that material is largely artificial, depending as it does on fashions, and is capable of stimulation or the reverse, and it would appear that the power of directing the demand in such matters lies largely in the hands of the cotton trade. This form of flexibility is all to the good, for it means that the trade is in a position, to a certain extent, to test the qualities of any new form of cotton, to ascertain the classes of goods for which it is particularly suited and to stimulate the demand for that class of goods. We must, however, beware of pressing the possibilities in this direction too far. Cotton is not merely the basis of goods which have an artificial value due to fashions. In many cases the use to which the cloth is to be put will dictate, within very close limits, the qualities that the cotton must possess. Notably we may instance the cloth which is used for aeroplanes and for motor tyres. Here no such flexibility is possible, for the demand is, in no sense, artificial. This case is particularly pertinent in the case of Egyptian cotton, for it is Egyptian cotton which has been found to satisfy this demand more nearly than any other.

This brings us to our second conclusion; the production of new cottons is desirable and the trade is sufficiently flexible to absorb and develop markets for them. But caution must be exercised in their introduction. An initial high price obtained for a small initial bulk may be due to special adaptability for the production of a particular class of goods the demand for which is small. If that high price stimulates largely increased production the price will fall even to make cultivation unprofitable. Especially is it necessary to distinguish between cottons which possess an intrinsic, and those which possess an artificial, value. The former require special care in maintenance.

So far we have confined ourselves to the broad issues as indicated by the characteristics of the trade in general. When we come to a more detailed consideration of the process of manufacture we find a new series of phenomena have to be considered. We need not here go into all the characteristics which go to make up a good spinning cotton. We have seen that diversity is essential to the trade; that it is desirable to produce different classes of cottons. The difference between these classes will, however, include most of those characteristics, such as length, strength, fineness, etc., which affect the behaviour of the cotton in the mill and the particular features of any class will be due to the exact form such characteristics take in that class. But beyond this, the spinner requires something more, something which is not a physical character of the cotton itself in the sense in which length, or strength, or fineness, or twist can be considered such. He requires what is usually known as uniformity; that is, a low range of variability in each one of those characters which go to make up the spinning value of a cotton.

Herein is to be found the third consideration to which we are led by our inquiry from the manufacturers' point of view. While diversity of class is required, uniformity within the class is of equal importance.

The value of cotton is dependent, however, on other characteristics than those which affect its behaviour in the mill, and the more important of these is colour. The importance of colour lies in the fact that Egyptian cotton, till recently, possessed a characteristic brown colour by which it was distinguishable at a glance from other cottons. The point was recognized by the trade and the colour imparted to the cloth was accepted as a ready means of determining the fulfilment of contracts the specification for which included the use of Egyptian cotton. Such a ready method is valuable and there exists a natural conservatism in favour of the retention of that colour character. Colour has, however, no further significance. A premium will, for a time no doubt, be paid for colour owing to the lag which finds its basis in such conservatism. But here, again, the market is flexible and is capable of adaptation to the supply.

I have so far dealt with the trade aspect of Egyptian cotton in its present day form. It is, as must be the case with any highly organized manufacture involving highly specialized mechanical adaptations, very conservative. When, however, we are concerned with problems the solution of which may take years to accomplish, it is desirable to attempt, however imperfectly, to forecast the probable future demand. Such an attempt I have been at some pains to make during my visit to Manchester. The problem is complex and it is impossible to dogmatise. Nevertheless there appears to be a distinct opinion as to the general trend of this demand. This I will attempt to outline.

The complexity arises from two considerations. In the first place the trade is, as we have seen, so highly specialized that prices are affected by the relation of supply to demand within the class, and it is not possible to deal with the Egyptian crop as an entity. We must go lower than this to find the unit. Secondly, the monopoly which Egypt has hitherto possessed as the sole producer of special classes of cotton is gradually passing. Recently cottons which possess the characteristics of Egyptian have been produced in the dry zones of America. Mesopotamia, again, and possibly Sind offer fields which may develop into rivals of Egypt. The monopolist position is, thus, already threatened and there is little doubt that it will at no distant date cease to exist. Such widening of the source of supply must inevitably affect the balance which now exists between the various classes of Egyptian cotton.

I may also refer to yet another aspect of the cotton trade which is likely to have a bearing on the future demand. Egyptian cotton ranks second among the world's cottons and is only surpassed by the so-called Sea Island, the main source of which is certain of the Southern States of America and the West Indies. The Sea Island crop is what is known as a highly speculative one; it has a narrow basis in that its cultivation is restricted to a relatively small tract and, from economic, as well as natural, causes, the supply is a precarious one. Not only is it more troublesome to cultivate, so that the extra price barely compensates for the extra labour and expense involved in the cultivation, but that cultivation is restricted to the more humid and tropical tracts in which the risk of sudden loss through pests and diseases is greatly enhanced. The margin of profit is, thus, insufficient to compensate for the extra risks involved, and the tendency is for the cultivation to diminish.

These facts all have their bearing on the Egyptian problem and, while they indicate an increasing competition from outside sources in the markets for the present standards of Egyptian cotton, they also indicate a probable reduction in the supply of Sea Island. The conclusion, it is true, is highly speculative but the tendency is there and is sufficiently clear to justify the attempt to develop a cotton which will be capable of taking the place of Sea Island in the future.

From the point of view of demand for goods manufactured from the higher grades of cotton I have found the opinion widely held that this demand is large though, at the present time, mainly potential. It is a demand capable of absorbing any amount of the best staple cotton Egypt is likely to be in a position to offer, and of absorbing it at its full relative value. In other words, the trade is sufficiently flexible to develop a demand equal to any supply that can be offered. That this opinion is correct cannot, I think, be doubted, but it requires to be qualified in certain directions if the interests of the grower and dealer in raw cotton are to be adequately guarded.

The opinion has been expressed in the course of discussions on this subject that the facts do not support this view of the potential demand. It has been instanced that a short crop of Mit Affifi in one year has led to the realization of a high relative price for that season's produce and that that price has reacted in the following year in a largely increased crop which, in its turn, has resulted in a heavily depreciated price. That experience is, no doubt, true; but it hardly justifies the conclusion which some would attempt to draw from it. It has already been pointed out that, owing to specialization in machinery and also to the necessity for experience in working a particular cotton if the best results are to be obtained from it, spinners are, as a rule, conservative. They will pay a premium for a class to which they are accustomed rather than change to another class, if the shortage which is responsible for that premium is of a temporary nature. The spinner, at least, knows what he can do with that cotton and his loss is, at most, limited to the amount of the premium he has to pay. The loss with a new cotton is less definite depending, as it does, on the speed with which he attains familiarity with its peculiarities in working. There is, thus, a definite time factor in such arguments the effect and importance of which must not be overlooked.

Before willingly making any change in his raw material, and this is merely another way of saying before he will overcome his natural conservatism, the spinner requires to be assured that the produce to which he turns will be available in sufficient and regular supply. Without such assurance, he will only accept the alternative under compulsion. For like reasons new plant, such as is required to meet the expanding needs of the industry, whether as extensions to existing factories or as new ones, will be adapted to handle the most assured supply capable of producing that class of goods for which the factory is designed. There is, consequently, a lag in the process of adjustment, an interval between the placing of any new class of cotton on the market and the realization of its full intrinsic value, partly, no doubt, due to the fact that it takes time for the particular merits to be appreciated but, also, very largely due to ignorance of the potential supply. It is true that cases are on record of an immediate and rapid extension of the supply of a new class of cotton; this is true of Sakel, but such extension here takes place in spite of that lag which is none the less operative though its operation is masked. There is little doubt in my mind that it is possible that, nay more, that many instances have occurred in which a potentially valuable crop has been lost through too rapid development. The supply has been increased more rapidly than the demand, time has not been afforded to permit a general recognition of the special characteristics to develop and the full price has never been realized before the crop is condemned and passes out of cultivation. Neglect of the time factor is here responsible for the loss of a valuable improvement.

II.

I may now attempt to extract from the above brief review of the economic conditions, which are of influence in determining the value of the raw material of the cotton trade, the fundamental considerations for the development of a sound policy on the part of the producer. And here I may note that it does not necessarily follow that the interests of the individual producer will coincide with those of the producing community. We are, in reality, in the latter case, concerned with the solution of an algebraic problem, namely, to find the values for m, n, p, etc., which will give the maximum value to the following expression :

$amx + bny + cpz + \ldots\ldots\ldots$ where

$a, b, c, \ldots\ldots$ are price units, $x, y, z, \ldots\ldots$ yield units, and $m, n, p, \ldots\ldots$ the number of the units produced of each of different classes A, B, C, ... In the case of Egypt where the limits of area of cotton cultivation are for the moment practically reached, we have the further consideration that

$$m + n + p + \ldots\ldots\ldots = k \text{ a constant.}$$

The problem, so expressed, is clearly incapable of accurate solution owing to the large number of variables; but the attempt is necessary if the maximum value is to be realized for the crop. The need of a solution, if only an approximate one, is especially necessary in a country like Egypt in which practically the entire wealth of the country is due to the one crop with which we are concerned.

If, further, the interests of the individual producer are to be protected, yet another algebraic problem must be solved. It will here be necessary that

$$ax = by = cz = \ldots\ldots\ldots\ldots$$

Unless this condition is fulfilled, supposing, that is, that

$$ax > by > cz \ldots\ldots\ldots$$

the producer of B and, still more, the producer of C, will be placed at a disadvantage as compared with the producer of A. Under such conditions, unless local conditions exercise a selective influence, the cultivation of B, and, to a still greater extent, of C, will diminish while the cultivation of A will extend. The only alternative is the elimination of the economic factor and for Government to control the proportionate cultivation of the different classes—a procedure hardly conceivable when such control must react to the detriment of a proportion of the individual producers.

We have here indicated the first problem to be solved with relation to cotton growing. Diversity is an essential requirement and such diversity will only be maintained if

$$ax = by = cz = \ldots\ldots\ldots$$

The absolute solution of this problem, the equalization of the money returned by unit areas under the various types of cotton, is not possible, for the relative values of $a, b, c, \ldots\ldots\ldots\ldots$ vary from year to year. An approximate solution only can be attained and may be sought in two directions. The various types which yield the different classes differ not only in regard to those lint characters which give these cottons their distinctive features, but they differ in other characters also. These characters we may term physiological, thereby implying a difference in reaction to environment. Egypt, in spite of its comparative uniformity in this respect, is really uniform neither in climate nor in soil, and these differences are, in all probability, sufficient to meet the diverse physiological needs of the various types. It is more than probable that it will be found, in fact it is found, that the type which is best suited to one set of conditions will not be the one best suited to a second; and it will, thus, be possible to demarcate type tracts in each of which the cultivation of that type which responds best to the local environment can be encouraged. I do not overlook the work that has already been done in this direction; the point is appreciated, notably in the case of Ashmouni in Upper Egypt, but I am inclined to think that a large scope still remains for work in this direction on a systematic and predetermined plan.

Such investigation is definitely agricultural and it may, even so, be found that though the yield of B may be increased relatively, and even exceed that of A in certain areas, yet that increase still leaves the product ax greater than by—still leaves, that is, A the more profitable crop. To meet such a case the possibilities of the second method of equalizing the money value must be investigated.

It has been repeatedly pointed out that the commercial cottons of Egypt are impure; that is that they consist of a mixture of a larger or smaller number of types, together with a considerable admixture of crosses between these types. It is to this admixture that the deterioration of quality, so noticeable in most Egyptian cottons, and even that striking phenomenon of the definite limit to the life of any particular variety, is attributable. In such a mixture the total yield is clearly an average one, certain of the component types yielding more, and others less, than the average. Also certain of the types will be better, and others less, adapted in their physiological reaction to the local environment. The replacement of the mixture by those component types, or that component type best adapted to the environment, can have only one result, the raising of the unit yield from that of the mixture to that of the best of the component types. This method is what is commonly termed selection and we may conveniently consider here the third point raised in discussing the economic aspect, the need for uniformity, as well as the question of uniformity just referred to.

I have had occasion to observe that lint diversity, such as exists between the different classes of cotton, is, in practice, associated with a different physiological response to environmental conditions. The converse is equally true; mixtures such as compose and yield the main classes of cotton contain types which not only exhibit these physiological differences but also lint differences. Selection within the limits of the present accepted classes, thus, is not limited in scope to the isolation of what we may term physiological types. It may, and should, be also directed to the isolation, in a condition of purity, of those types yielding lint most nearly approximated to the class standard.

Deterioration has been repeatedly referred to as if it were a condition inherent in the plant. The particular variety is, in this view, supposed to possess a more or less definite span of life after which degeneration sets in and the lint product gradually deteriorates in quality. The word is unscientific and, as commonly and loosely applied, probably covers a number of phenomena. But, in as far as it implies a degeneration in the plant, it is unsound and finds no basis in fact. The cotton plant is notably freely cross-fertilized and the presence of a single impure plant in a field is capable of producing, in the course of a few seasons only, a degree of impurity which will surprise, and hardly be credited by, those who are unfamiliar with the phenomenon. Given initial purity and adequate protection from chance cross-fertilization this explanation of degeneration will be found to be fallacious. In selection and propagation under conditions which adequately meet the ever-present tendency to pass from purity to impurity, will be found the means of maintaining the uniformity desired by the spinner.

There remains the third desideratum expressed in the second conclusion at which we arrived above—that for the development of new classes of cotton; in other words, the introduction of an additional term into our algebraic formula. The history of the Egyptian cotton plant is a comparatively recent one and is too well known to require repetition in the pages of this report. The point I desire to emphasize here is the presence of the Sea Island plant at some stage of the parentage. We are at present too ignorant of the 'unit factors' on which the various lint characters depend, to state with certainty that those factors which are responsible for the special spinning qualities of the Sea Island cotton are bred out in their entirety. It is still possible that these exist here and there; it is even possible that they commonly exist in the present types of Egyptian cotton but are suppressed, masked or inhibited. Under the conditions of the Egyptian cotton field with the mixture of types now prevalent, and with unlimited possibilities for cross-fertilization between these, it would not be a matter for surprise if, now and again, such combinations should occur which will permit the re-expression of those characters. The sporadic occurrence of such 'throw-backs' is not unknown, and there is reason to believe that their occurrence is still taking place at the present time—the history of the origin of Sakel with its superior length is evidence in this direction. Here again selection is the means of preserving and establishing any such variations as may occur, but it is a selection which differs somewhat in form from that previously referred to. The latter can be undertaken within the limits of an experiment station, for what it is desired to select is known to exist, but in the former the entire area under cotton becomes the laboratory through which the search must be conducted.

The above method for developing new classes of cotton may be termed undirected, for we are dependent on accident for their appearance and merely, so to speak, gather the rose-bud offered to us while we may. The development may, however, be directed. For successful development of the directed method we must form a clear mental impression of what it is desired to produce; select, as parents, those plants which, in one or more of the characters concerned, approach most nearly to that ideal and attempt to combine these in a single individual. It is the method commonly referred to as hybridization. Success will only be obtained if a number of conditions are fulfilled. Purity of stock is essential and, therefore, preliminary selection to obtain that purity is necessary; also clear recognition of the factors on which are based those characters which we desire. The path is strewn with difficulties not the least of which is the exact determination of the ideal, but these difficulties are not insuperable with sustained effort.

We have here considered the methods to be adopted for the introduction of a new term, or new terms, into the algebraic expression given above, and it may be argued that, if the new term conforms to the conditions of equality we have outlined, the advantage to the country from their introduction will be nil; while, if it does not, the already existing types must disappear. The argument is sound, but we must not forget the economic conditions affecting the question. Were these constant, it would be very doubtful whether it would be desirable to attempt the production of types yielding a lint superior to those already in existence. But economic conditions are not constant, notably, as we have already indicated, Egypt is losing her position as a monopolist, and such loss must inevitably lead, in the long run, to a reduction of the profit obtained from the standard classes of cotton produced by her at the present time. She will then be forced to 'go one better' than her competitors in producingfi ner qualities than she has hitherto done or to accept reduced revenues. It is a very real danger that exists and the presence of this danger makes it necessary to attempt the evolution of new classes. We may express the point in another way; while we do not look upon the multiplication of classes as a means of largely increasing the value of the crop, for qualities superior to the best Egyptian cotton have, at the present time, but a limited market and any premium obtained in the early years of low production would soon disappear when that production is largely increased, we do consider that their development is a necessary and vital insurance for the future.

The expression of the problem in the algebraic form given above brings into prominence certain other aspects which we must now consider. We desire that the sum

$$amx + bny + cpz + \dots\dots\dots$$

shall be a maximum while maintaining equality between the values ax, by, cz, ... The latter desideratum requires further consideration in the light of what we have just said. This equality would be necessary to maintain diversity if the country were uniform;

but it is not. The difference which exists between the various types of cotton plant in their physiological response to environment, render it more than probable that, while *ax* may exceed *by* in one tract, the reverse will be the case in another. Such considerations will lead to the development of type tracts and the equality indicated will only develop a practical aspect in those border tracts where the type of cotton to be grown will be determined by the extent of the demand for the alternative classes of cotton these types produce and by the area already under those types. We must, therefore, qualify our earlier statement as to the need for equality in the value of the produce from a unit area. This has no general, but rather a local, significance.

Reverting to the main problem, we have studied certain methods which are directed to the end. They aim at the production of increased yield by purification of the crop and by demarcation of type areas; at the production of increased price through development of uniformity in the produce. We depend here on certain features of the environment which are selective, that is, features to which the different types react differently. There is, however, another series of environmental phenomena which are not to the same extent selective; of such a nature are the more important pests of the cotton plant, especially the boll-worm. Again much importance has rightly been attached to the height of the water table due directly and indirectly, through the canals, to the rise of the Nile. Lastly there is that series of phenomena which we may include under the general designation of cultural---the effect on yield of different spacings, different methods of culture, and such like. With these questions, beyond recognizing their importance and emphasizing the necessity for making adequate provision for their study in any serious attempt to face the cotton problem as a whole, we have no concern. It must not be forgotten, however, that such problems can be approached from both sides. On the one side is the plant, in the first case reacting to an insect and in the second to physical condition of the environment; on the other is the insect and, within limits, a controllable physical state. Not only do the insect and the physical condition require to be studied but also the plants' reaction to these stimuli. In the first case, concurrently with entomological investigation, which has, among other facts, indicated the seasonal character of the epidemic, efforts require to be made to break the present coincidence between the period of the main cotton harvest and the season of the maximum development of the pest. This may be effected from the plant side and a beginning has already been made to stimulate early ripening. It remains, however, to investigate the possibilities of evolving early maturing types.

The second problem is mainly physical but here, again, comes back ultimately to the plant, its water requirement and the depth to which the root penetrates. In all its bearings the field of investigation is a wide one and the fringe has, as yet, only been touched. Apart from the purely physical aspect there is a large opening for physiological investigation.

Such problems as have been outlined in the last few paragraphs are mainly directed towards increasing the value of the yield units $x, y, z, \ldots\ldots\ldots\ldots$ There remains the question of the price units $a, b, c, \ldots\ldots\ldots\ldots$ Evidence is accumulating to show that the quality of a cotton is directly affected by the conditions under which the plant which produces it is grown. It is, no doubt, true that, under the normal conditions of cultivation, these conditions are sufficiently uniform and that even the extreme conditions found here diverge so little from the normal that the quality of the cotton is barely affected. Nevertheless it is not without importance to determine the point at which such effect is begun to be felt and, to ascertain which are the chief environmental conditions concerned in producing the effect noted. The importance of the possession of such knowledge is emphasized if, as seems probable, cultural control aimed at the development of early maturing is to be adopted. The investigations here referred to cover a wide field of pure physiological research.

(To be continued.)

THE EXCRETION OF TOXINS FROM THE ROOTS OF PLANTS.

BY

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SOME years ago the late Mr. Fletcher, when Deputy Director of Agriculture, Bombay Presidency, put forward certain experimental evidence[1] which led him to the conclusion that crop plants excrete substances from their roots which are toxic to other species as well as to themselves. This conclusion was based upon both field experience and the results of experiments by means of water cultures, but the latter were performed with ordinary well water and without any control tests, and the method of experiment led to a considerable concentration of this water and a corresponding concentration of the salts present. This being the case, it was felt that the evidence was not conclusive and that a repetition of the experiments under more stringent conditions was desirable. With this object in view, Mr. Fletcher's scheme of experiment was repeated, with the exception that a synthetic nutrient solution was substituted for the well water, and " control tests " were introduced to check the results. The nutrient solution used was that of Knop and had the following composition :—$Ca(NO_3)_2$ 4 grams; $MgSO_4 7H_2O$ 1 gram; KNO_3 1 gram; KCl 0·5 gram; $FeCl_3$ traces, dissolved in 7 litres of distilled water; the total salt concentration of this solution being 0·11 per cent.

A large number of wheat, *Cajanus* and gram seedlings were grown in this nutrient solution, and at the end of a certain period

[1] *Mem. of Dept. of Agric. in India, Bot. Ser.*, II, No. 3

the solution was allowed to evaporate spontaneously until its volume was reduced to about one-eighth. The "blanks" were allowed to evaporate to one-third to one-fourth the original volume. Jars containing the nutrient solution but bearing no seedlings were also treated in an identical manner and constituted the "blanks." Seedlings were then introduced into these concentrated solutions, supposed to contain the excretions of plant roots, and the progress of crops grown in them was recorded. (For brevity these various concentrated solutions will be called "wheat water," "gram water," etc.) The observations recorded are set forth in the following tabular statement.

TABLE I.

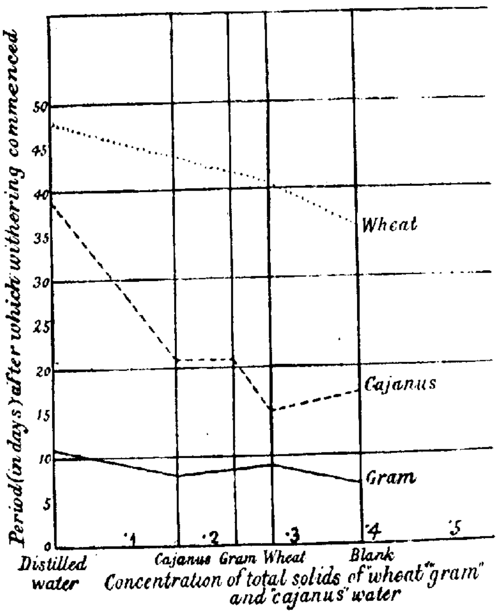
Crops (of which progress is indicated)		Crops which had previously grown in the water			Blank	Distilled water
		Wheat	*Cajanus*	Gram		
GRAM	Period (in days) after which withering commenced ..	9	8	..	7	11
	Transpiration (in grams) ..	15·4	13·8	..	9·5	17·7
Cajanus	Period (in days) after which withering commenced ..	15	21	21	17	39
	Transpiration (in grams) ..	15·0	22·9	17·5	21·5	32·3
WHEAT	Period (in days) after which withering commenced ..	41	..	..	36	48
	Transpiration (in grams) ..	34·3	..	..	31·0	54·0

From the above table it is evident that, in general, the seedlings grown in "wheat," "gram" and "*Cajanus*" water throve better than in the "blank" test solution and that seedlings grown in distilled water fared best. These observations led to the conclusion that the positive results obtained in Mr. Fletcher's experiments were probably due to the concentration of the salts present in the well water and not to toxic excretions. This is confirmed by an estimation of the "total solids" in the solutions obtained in the present series of experiments, the values for which are set forth in Table II.

TABLE II.

Water	Total solids in grams per 100 c.c.
(1) "Wheat" water	0·269
(2) "*Cajanus*" water	0·154
(3) "Gram" water	0·226
(4) "Blank" water	0·382
(5) "Distilled" water	nil

Thus the concentration of "blank" water in which the seedlings grew the worst is the highest, whereas the best results were obtained in the distilled water, and the results obtained from the other "waters" are intermediate in character and approximately proportionate to the concentrations. These relationships are clearly shown by the graph below, where the ordinate represents the period (in days) after which withering of the seedlings commenced, and the abscissa the concentration of total solids in grams per 100 c.c. of "wheat," "gram" and "*Cajanus*" water. It will be observed that the withering in case of all three crops was hastened with the increase of concentration of total solids.



In Mr. Fletcher's original experiment, 18 to 28 litres of well water (including those added for water evaporated and transpired) was used in each case and this was finally reduced to a volume of 1·2 litres by evaporating at ordinary temperature. Some idea of the concentration of salts thus brought about can be obtained from a reference to Table III which gives the average composition of the three well waters of the Dharwar Farm (one of which was used by Mr. Fletcher for his experiment), during December 1907 to May 1908, the period covered by the experiments.

TABLE III.

Mineral salts, parts per 100,000	No. I *Pakka* well in the compound of Dharwar Farm	No. II *Kachha* well, Dharwar Farm	No. III *Pakka* well in the old area of Dharwar Farm
Calcium carbonate	19·10	15·83	7·09
" sulphate	0·08	0·56	..
Magnesium carbonate	4·76	1·98	13·94
" sulphate	0·25	0·53	..
" chloride	1·63	1·45	..
Sodium sulphate	2·13	1·63	27·77
" carbonate	2·57	5·85	15·55
" bicarbonate	..	0·25	14·17
" chloride	2·60	2·47	17·05
" nitrate	1·19	1·23	..
Potassium chloride	0·60	0·61	0·06
" nitrate	0·35	0·25	..
TOTAL SALTS	35·41	38·64	95·60

The concentration of total solids in the above waters varies from 35 to 95 parts per 100,000. Taking the mean concentration as 56 parts per 100,000 or 0·056 parts per 100 c.c., the concentration of the solution (about 23 litres reduced to a volume of 1·2 litres) used in the original experiment for the final water cultures approximates to (0·056 × 20) or 1·12 parts per 100 c.c., a value much higher than is attained in the experiments now under consideration.

The influence of nutrient solutions, covering a wide range of concentration, upon the growth of young plants has been studied by Sachs, Knop, Nobbe, Seigart and many others. In 1860 Sachs[1] proposed the first standard formula for a nutrient solution in which he grew maize, bean, and beet, and concluded that the optimum concentration for maize appeared to be about 0·3 per cent. An investigation of the optimum concentration for a modified Knop's nutrient solution was reported by Nobbe and Seigart[2] for seedlings of barley and buckwheat. The total salt concentration used here ranged from 0·05 to 1·0 per cent., and it was noticed that in low concentrations (0·05, 0·1 and 0·2 per cent.) long and thickly haired roots developed, whereas in solution approaching the highest concentration, the main roots were short and the laterals and root hairs poorly developed. These writers found the period of the life-cycle nearly proportional to the total concentration of the nutrient solution employed and placed the optimum strength of the latter at 0·3 per cent. of total salts. In 1866 Wolf[3] also investigated the solution employed by Nobbe for the growth of buckwheat. He concluded that a concentration of total salts from 0·1 to 0·2 per cent. was the best for Indian corn and wheat.

Studying the effect of the concentration of nutrient solutions on the growth of wheat, Breazeale[4] concluded that concentration, independent of any changes in the chemical or nutrient properties of the solution, seemed to be important in determining plant growth. He placed the best concentration for wheat seedlings at 0·03 per cent. In 1906 Osterhout[5] called attention to the importance of physiologically balanced nutrient solutions. He concluded, in general, that the effect of increased concentration of any given nutrient solution, beyond a certain limit, leads to a toxic effect by some or all

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[1] Sachs, J. "Vegetationsversuche mit Ausschluss des Bodens über die Nahrstoffe und Sonstigen Ernah-rungsbedingungen von Mais, Bohne und anderen Pflanzen." *Landw. Versuchsst.*, **2**, 219–268, 1860.

[2] Nobbe, F., and Seigart, T. "Beiträge zur Pflanzenculture in Wasserigen Nahrstofflosungen. I. Ueber die concentration der Nahrstofflosungen." *Landw. Versuchsst.*, **6**, 19–15, 1864.

[3] Wolf, E. T. "Ueppige vegetation in Wessergen Losungen der Nahrstoffe." *Landw. Versuchsst.*, **8**, 189–215, 1866.

[4] Breazeale, J. F. "Effect of the concentration of the nutrient solution upon wheat cultures." *Science*, N. S., **22**, 146–149, 1905.

[5] Osterhout, W. J. V. "On the importance of physiologically balanced solution for plants. II. Fresh water and terrestrial plants." *Bot. Gaz.*, **44**, 259–272, 1907.

of the component salts present in the solution or the further addition of new compounds.

The investigations of Sachs, Seigart, Nobbe and Wolf, indicated above, all tend to place the optimum strength of the solution at 0·3 per cent. of total salts. The strength of the solution in Mr. Fletcher's experiment works out approximately to 1·12 per cent., a concentration which no doubt would prove toxic to any plant. From Table III, the concentration of the solution, in the original experiment (if well water No. III had been used) with regard to sodium salts, works out to 0·34 per cent. sodium chloride, 0·60 per cent. sodium carbonate and bicarbonate, and 0·56 per cent. sodium sulphate. All these figures taken together exceeds the minimum weight per cent. which Coupin[1] found toxic to wheat plants in his experiment. The presence of an alkaloid, which Mr. Fletcher inferred was the character of the excreted toxin, could not be demonstrated in the present experiments, and, consequently, it is only possible to conclude that the effect which had been ascribed to toxic excretions are, in reality, due to the high concentration of salts in the solutions employed in the final stages of the experiment.

[1] Henri Coupin, M. "Sur la toxicité des composés de sodium, de potassium et de l'ammonium à l égard des végétaux superieurs." *Annales Agronomiques*, XXVI, 1900, 575-577.

A PRELIMINARY NOTE ON THE IMPROVEMENT OF ORANGES.*

BY

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THE Nagpur "Santara" has more than a provincial reputation. It is remarkable for its juiciness, flavour, and sweetness, and is for this reason in demand all over India. Statistics show that the cultivation of this fruit has been steadily increasing, but the methods adopted by the cultivator are generally conventional, with the result that a *Citrus* survey undertaken some time ago indicated that the fruit was gradually deteriorating both in quality and yield.

In order to find out the lines of improvement best suited to local conditions a series of experiments was started in the Botanical Garden in 1913. This paper presents a brief outline of the results achieved.

The soil selected is the usual loamy soil commonly found in Nagpur District. Experience has already demonstrated to the cultivator that the soil best suited for orange cultivation is a well-drained soil containing a large proportion of lime. The experiments, therefore, aimed at gaining information regarding

(1) Stock and nursery.
(2) Lifting of budded plants, packing, etc.
(3) Pruning.
(4) Manures.
(5) Irrigation.

* Paper read at the Seventh Indian Science Congress, Nagpur, 1920.

STOCK AND NURSERY.

Orange trees are propagated by means of budding. Seeds for raising the stocks are sown in the hot weather during March or April, and the young seedlings are fit for transplantation in the monsoon after the first showers of rain are over. The rate of development of the orange tree after planting depends to a great extent on the condition of the stock used. Healthy stocks, one-and-a-half year old, have been found to be the most suitable for budding. The fields in which the seedlings for stocks are planted should have good drainage. The root system in badly drained fields is much impaired and plants raised in such fields seldom recover from the ill effects of water-logged conditions. Different varieties of stocks were planted out in prepared pits on the actual site of the experimental orchard in heavy black cotton soil. Settling of the soil in the pits accompanied by a heavy monsoon caused considerable water-logging. This had a depressing effect on all the stocks employed though the stunted growth in the first year from which many never recovered was much more marked in certain stocks than in others. It was found that the stocks of *Jamberi*, *Attara* lime and *Mahalunga* were hardier than those of Sweet-lime, Pumelo and Sour-lime. Sweet-lime suffered most. In Nagpur and Wardha Districts two kinds of stocks are generally used, *viz.*, (1) *Jamberi* and (2) Sweet-lime. There was a belief among orange-growers that the oranges produced on stocks of *Jamberi* were bigger in size but possessed a rough skin; while those raised from stocks on Sweet-lime produced smooth and tight skin oranges. It was reported, too, that orange trees budded on *Jamberi* grew more vigorously than those budded on Sweet-lime. Experiments were, therefore, started to see the effect of budding on different stocks. The following stocks were raised and budded in all cases from the scion of a typical Nagpur orange tree :- Citron long (*Mahalunga*), Pumelo (*Chakotra*), *Jamberi*, Wild lime, Sweet-lime.

During the first year the growth of the plants budded on *Mahalunga* was the quickest and that of Pumelo was second to it; while the *Jamberi* and Sweet-lime came next in order.

During the second year the plants budded on *Jamberi* over-took the Pumelo and equalled the *Mahalunga*. *Jamberi* continued to grow more vigorously and now heads the whole series. The *Mahalunga*, Pumelo, and Sweet-lime now show more or less equal growth. This is the first year of bearing.

The fruits produced on *Mahalunga* are big in size and the skin is thick and loose. The segments inside are distinctly large, somewhat loose and full of sweet juice. The great defect, however, is the looseness of the skin. The fruits on *Jamberi* stock are on the whole bigger than those produced on Sweet-lime and the skin is looser and shows a greater amount of roughness. The fruits produced on Sweet-lime, although smaller, have smoother and tighter skin than the others, though there are undoubtedly other factors which affect the looseness and character of the skin.

It appears therefore that the nature of the stock plays an important part and that the future success of an orange garden is largely influenced by the early development of the stock and the type of stock employed.

LIFTING OF THE BUDDED PLANTS.

Observations in the method employed by local cultivators in lifting budded plants for planting out in the orchard indicated that these were far from satisfactory. With a view to minimize labour and trouble, the ordinary grower digs out a number of plants rapidly with a fork. He then takes them one by one, attaches a small ball of earth round the roots of each plant and ties it up with leaves. In some places the more intelligent cultivator simply digs out a small ball of earth containing only a few roots of the plant, but in this case also a great majority of the roots are carelessly cut off. It was found that the plants lifted in either of these ways took a very long time to establish themselves, while several never recovered from the injury sustained by the careless cutting away of their roots and died off or remained stunted all their life. Several methods of lifting were tried. The best results were obtained by lifting the plant by digging the earth round it in a slanting manner, so as to obtain a more or less conical ball of earth enclosing the main roots, the base of the cone being above and the apex below (Plate XXVI, fig. 1). For a two-year old plant a conical ball of earth about 6 inches high and

PLATE XXVI.

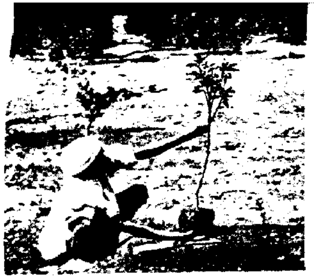

Fig. 1. A properly lifted plant from the nursery.

Fig. 3. Full-grown trees pruned as standards.

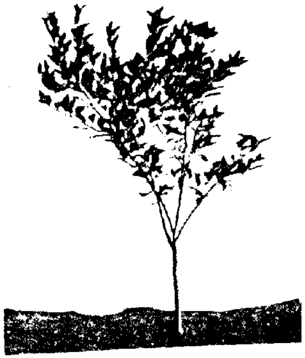

Fig. 2. A well pruned plant.

Fig. 4. Full-grown trees, lateral branches not pruned.

from 3 to 5 inches broad at the base was found to be most suitable. Superfluous roots should be cut clean with sharp pruning scissors and painted with the following ointment: 3 lb. resin, 1 lb. beeswax, and ½ pint linseed oil, melted together, and stirred till properly mixed. This ointment has been found to be very useful. It was used whenever a surface was exposed and the wound healed rapidly and prevented injury by insects, fungus, etc. Next to lifting, packing requires as much careful attention. It is necessary to tie a piece of sack cloth firmly round the ball of earth, thus securing the soil and preventing the exposure of roots by the loosening of the earth even when carried to long distances. Plants thus lifted and packed have travelled well throughout India. It may be interesting to note that a few plants were thus packed and sent to Baghdad which they reached safely and where they are now said to be doing well.

Pruning.

The local orange is rarely touched after planting beyond the removal of stock suckers. The result is that most of the trees develop in a semi-bush form with 2, 3 or more branches on the ground level. In our experiments in the garden it was decided to grow the trees as standards, and with this object in view all lateral branches to a height of 1½ feet to 2½ feet from the ground were pruned off before planting (Plate XXVI, figs. 2 and 3). A certain number of trees were allowed to grow on the usual lines (Plate XXVI, fig. 4). The value of attention to pruning in the early stages of the plant and the building up of a standard in the lines indicated above, carrying 3–5 main branches at the point of forking selected, has been most marked. Early pruning in this fashion produces a well shaped tree with a much bigger fruiting tendency. In addition, fruits are more easily picked, insects have less chances of shelter, and intercultivation is not interfered with.

Manures.

With a view to find out the best combination of manure for the orange tree at a given cost, a series of experiments dealing with nitrogenous and non-nitrogenous manures was started. Of the nitrogenous manures, the following were experimented with: cattle-dung, green manure, castor cake, *mohwa* (*Bassia latifolia*) refuse, and calcium nitrate. The cross dressings consisted of the mineral fertilizers—superphosphate, potash, and superphosphate combined with potash. The weight of the manure given to each tree varied with the kind of manure and the combination used, but in every case the cost was kept limited to the fixed money value. As the result of the disturbing effect of the war, the prices of the manures in the market varied from year to year; but for our experiments the value was kept fixed and maintained throughout for calculations.

In the first year each tree received two annas worth manure, rising by two annas every year to ten annas in the fifth year when they were fully grown and were in bearing.

The manures were analysed and the percentage of nitrogen, phosphoric acid and potash was calculated in each case before applying to the tree in order to adjust them to the fixed money value.

As recommended by Hume, young trees were given a fertilizer containing 6 per cent. of phosphoric acid, 8 per cent. of potash, and 4 per cent. of nitrogen, while the fully grown trees received 8 per cent. P_2O_5, 12 per cent. of potash, and 3½ per cent. of nitrogen throughout the experiments.

The effect of the nitrogenous manures on the vegetative growth and fruiting of the trees is now quite distinct. The lines of trees which were treated with *mohwa* refuse are the most prominent. The foliage on these trees is dense, deep green, the branches are abundant, and the yield heavy. The trees treated with castor cake come second, and the rows of trees treated with cattle-dung and calcium nitrate stand third in order. Thus, to date the organic forms of nitrogenous manures fairly easily procured appear to be the most effective.

The effect of the mineral manures so far cannot be said to be clearly noticeable; but their action in the flowers and in the formation of fruits is being watched in order to deduce definite results. The experiment will thus have to be continued for a few seasons more, and it will then be possible to arrive at definite conclusions as to the nutritive and productive value of each kind of manure used and their effect on the life of the plant.

Irrigation.

The economy of water is of great importance for the success of the orange garden. The right method of giving water at the proper time saves much waste in water and allows the plant to develop vigorously. The local practice of irrigation is expensive, wasteful and not beneficial to the tree. The ordinary cultivator waters the tree by making a saucer shaped circular pit at the base of the tree. The pits are generally 4 inches to 6 inches deep and have a diameter of about 3 feet. The water stands round about the trunk of the tree, which is fully recognized as harmful to the *Citrus* and which indirectly interferes with the spreading of the root system.

Three systems of irrigation were under trial in the garden :— (1) Ring system, (2) Furrow system, and (3) Trench system.

(1) *Ring system.* A trench about a foot wide and 6 inches deep was dug parallel to the rows of trees and round each was made a ring 6 inches deep. The distance of the ring from the tree depends on the size of the tree but the approximate distance is where the shadow of the tree falls on the ground at noon. Each ring was joined to the longitudinal trench by short connecting trenches. The young orange trees were thus irrigated for four years in our garden and the system was found to be very useful and economical. After the water had soaked into the ground the rings were filled in with earth, which prevented the loss of moisture by evaporation. The amount of water given per tree averaged 40 gallons and the total amount of water for young trees in an acre comes to 30,000 to 40,000 gallons per year. The economy of water in this way in the early stages of a garden is great and we had to irrigate 5 to 6 times only from monsoon to monsoon, whereas the cultivator would have irrigated at least 20 times during the same period.

(2) *Furrow system.* As the plants become older their roots spread in all directions and it is then quite easy to irrigate by means

of furrows. This consists in making two temporary furrows by working the monsoon or ridging plough up and down between the two rows of trees (Plate XXVII, fig. 1). Water is allowed to flow slowly down a number of these furrows and the roots thus get their requisite supply of water. It is important to allow the water to run slowly. In our garden the head-channel fed at one time three furrows, each being about 200 feet long, and it took 15 hours. The total amount of water consumed was 60,000 gallons for 132 trees. In a year from monsoon to monsoon the trees received only 5 to 6 irrigations. After each irrigation, as soon as the soil becomes workable, the bullock-hoe (*bakhar*) is worked and all the furrows are obliterated. In this way the soil beneath the trees is kept well mulched and clean and free from weeds. This method entails a bigger watering at each application but the interval between waterings is longer. When irrigation is from a well or from a source where the time during which the canal is open is not too short it is quite satisfactory.

(3) *Trench system.* It was noted, however, that the Irrigation Department, in tracts near Nagpur where orange cultivation was likely to extend under canal irrigation, preferred to supply a large bulk of water for a short time. Though the second system can be used under these circumstances, provided that the cultivator can open up sufficient furrows from his head-channel to deal with the water, in many cases the regulation of a large amount of water is difficult. In such cases it was decided to irrigate by means of straight trenches about 1½ feet wide and about a foot deep made across the slope of the garden half way between the lines of trees (Plate XXVII, fig. 2). In cases in which the land was not practically level, the trenches had to be terraced in order to keep a uniform depth of water throughout its length. In this way each tree gets an equal quantity of water. This system is quite easy to work. In places where the cultivator receives canal water for a fixed number of hours it is distinctly to his advantage to fill in his trenches and to let the roots of the trees gradually absorb the water. As compared with the furrow system, the irrigations have to be given with greater frequency though the amount utilized in each watering

Fig. 1. Furrow system of irrigation.

Fig. 2. A trench running between two rows of trees.

is less. The total amount of water consumed was 45,000 gallons for 132 trees.

These trenches can be used as drains in the monsoon, a most important factor in the Central Provinces where more trees are spoilt by lack of drainage than any other cause. The one disadvantage in this system is a slight one found in interculti-vation. This, however, was easily overcome by using the small double hoe used in cotton rows—one bullock walking on either side of the trench. A single bullock hoe would be even better.

THE "TOP-WORKING" OF INDIAN FRUIT TREES.

BY

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By the term "top-working" we mean the renovation of the whole of the top of a tree by inserting scions on the existing branches, and then arranging that these scions grow while the old branches of the tree are removed. The method is not new. It has been described in various American publications, for example, in Wester's "The Mango"[1] and in Rolfs' "Mangoes in Florida."[2] We believe, however, that the experiments here mentioned are the first of their kind in India.

The problem first presented itself to us in the form of the well-grown but useless mango tree, useless because its fruit was poor and turpentiny. Experiments had already been made in this Presidency in crown-grafting such trees, but with a very small percentage of success. Text-fig. 1 shows what is meant by crown-grafting. The whole top of the tree is cut off, and scions are

[1] *Philippine Bureau of Agriculture Bulletin* 18.
[2] *University of Florida Agricultural Expt. St. Bulletin* 127.

PLATE XXVIII.

Fig. 1. Tree pruned for top-working with pots attached for the inarching of scions.

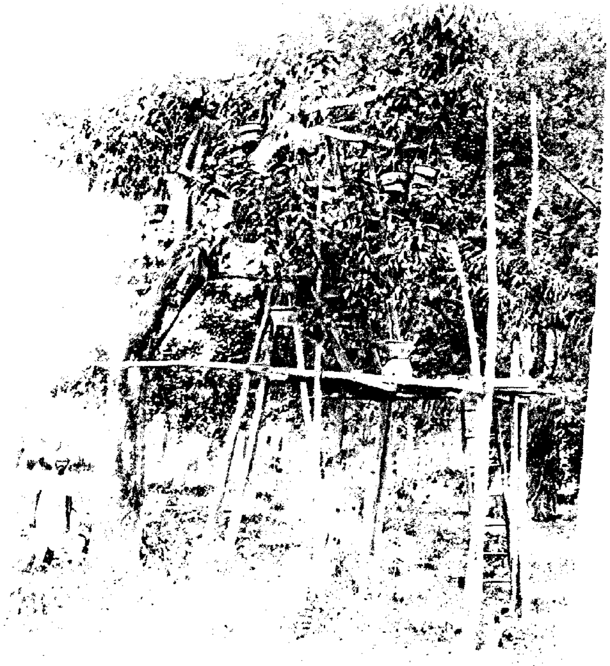
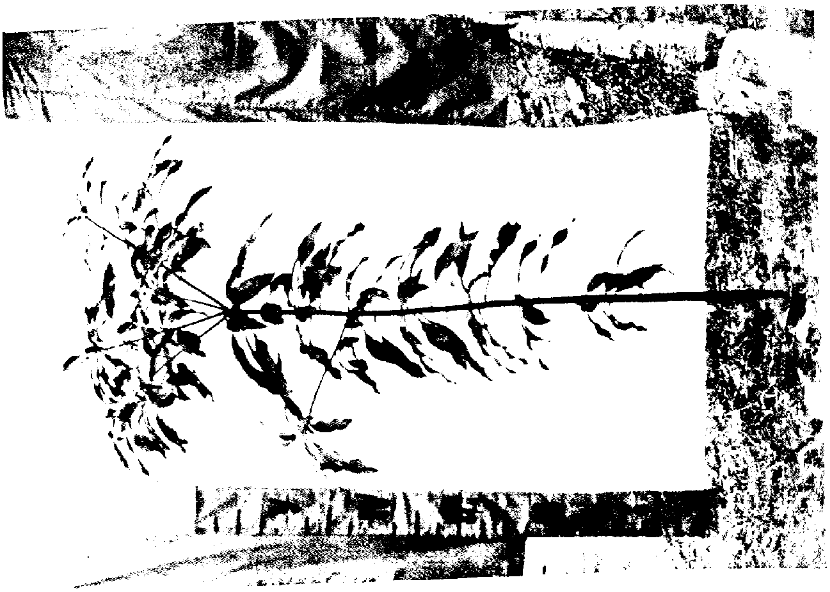
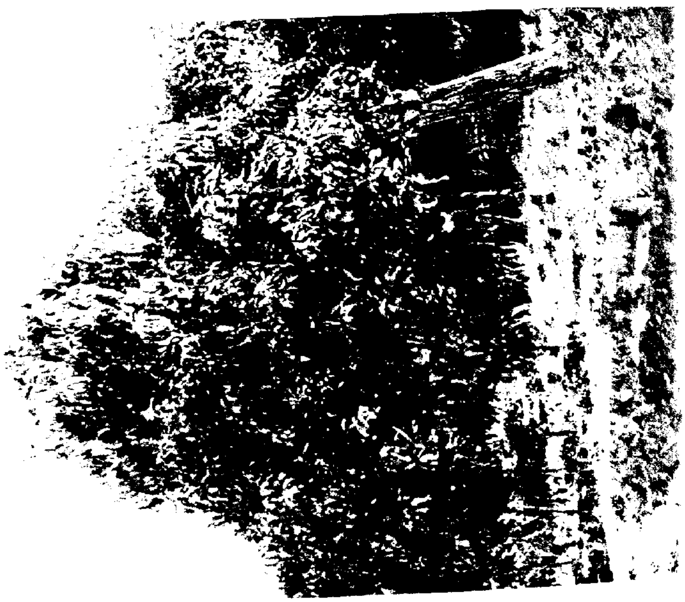


Fig. 2. Top-working in full swing.

PLATE XXI





inserted between the bark and the wood in the manner shown. As can be easily imagined, the cutting off of the whole top of a well-grown tree is a considerable shock to the plant. Moreover, the fact that the scion cannot at once establish its water connection

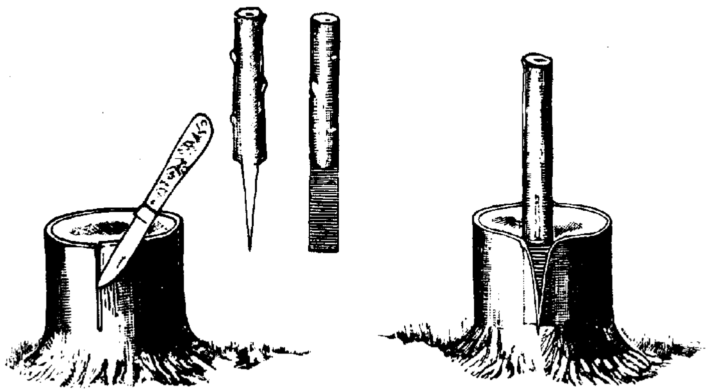


Fig. 1. Crown-grafting.

with the stock and yet has to be out in the field exposed to the sun, and only ineffectively protected by any artificial shading material, makes the likelihood of union very remote.

The method of top-working meets both these difficulties. To begin with, the top of the tree is not entirely removed. Branches may have to be pruned off, to reduce the head, or to stimulate the production of young shoots on which to graft, but the drastic decapitation of the crown-grafting method is avoided (Plate XXVIII, fig. 1).

Second, the scion is not taken away from its original water connections until the new are fully established. In other words, the scion is inarched from a live grafted plant on to the stock, and this means that the scion is attached to its own original plant until union occurs. Text-fig. 2 shows inarching, and Plate XXVIII shows a tree with the inarching going on. Fig. 1 on Plate XXIX is the completely renewed tree.

Fig. 2. Inarching.

The following are a few examples of top-working as done by one of us.

A country mango tree in Bassein on the coast near Bombay, of unknown age, but probably over thirty years old, was heavily cut back on March 6, 1912. Many new shoots sprang up from the stumps, and on these were grafted scions of good varieties on May 22, 1912. The grafting was done by inarching from plants in small pots tied to the tree in various places. On 1st November, 1912, further grafting was done from the now established scions on to new shoots of the stock. Out of a total of 40 scions, 3 flowered in June 1914. As the first and second sets of scions were not distinguished it is impossible to say to which the flowering scions belonged, but it shows that, by top-working, flowers can be got 14 to 20 months after operation. The pot-plants from which these scions were taken did not flower.

The first real crop was got from the tree in June 1916. There were 38 fruits of four varieties. These varieties had all retained their own characters although grafted on the same stock plant.

Fig. 1. The mango seedling inarched (note the tape (marked with X) covering [illegible] ints of grafting.)

Fig. 2. The mango seedling with its top renewed and

Top-working was also done on wild trees belonging to cultivators in some of the coastal districts of the Bombay Presidency, with considerable success, as will be seen from the following letters from these men.

Mr. R. V. Bam, Thana District, writes:

> "As for top-working I prefer it to side-grafting, especially because it requires very little care after the grafts are removed from the trees" (*i.e.*, after the union of the scions has taken place and the pot-plant that was tied to the tree has been removed.—*Authors*). "The tree is not required to be watered and it requires no protection from cattle, the grafts being beyond their reach. The only care required is to remove the new shoots from ungrafted branches. It is the most successful method of converting ordinary trees into grafted ones."

Mr. Gopalrao Mehendale of Belapur says:

> "In my opinion the top-working system is very good. My top-worked trees are growing well. Those who have got wild-mango trees can do best by top-working them. It is only at the beginning that the work requires constant attention."

Top-working for the conversion of useless wild trees into good bearing trees can also be applied with success in the case of *Zizyphus* species. *Mimusops hexandra* can be top-worked with scions of *Achras sapota* (the sapodilla plum or *chiku*).

Another application of top-working is in the starting of new mango plantations. It is a matter of importance to get strong, deep-rooted, straight-stemmed trees. This is seldom got if pot-plants grafted in the pot are afterwards planted out. A better method is to plant the seeds of the stock plants in the field in the place where the tree is wanted and afterwards graft on to the stock when sufficiently grown. Plate XXIX, fig. 2, shows such a seedling of natural shape and strong straight stem. Plate XXX, fig. 1, shows top-working on to each branch of the head, and the second figure on the same plate shows the finally altered tree.

Still another application is that of getting an early flowering from scions whose character one wishes to test. Suppose we have hybridized two varieties of fruit tree. We have the seeds, and grow a hybrid seedling. Now it will take, perhaps, five years for this to come into flower and show us what its fruit is like. We can greatly shorten this time by grafting the seedling (top-working it) on to the well-developed branch system of an adult tree. In the first case of top-working quoted in this paper, flowering took place on the tree where it did not take place in the pot-plants from which the scions were taken. In another set of experiments, seedlings of guava were, in the Ganeshkhind Gardens, grafted on to well-grown trees of 5 years old, on March 20, 1919. The scions flowered on December 27, 1919, and the seedlings in pots, afterwards planted out into the ground, have not yet flowered.

Similar results have been got in America.[1]

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[1] Oliver, G. W. "The Seedling-Inarch and Nurse-Plant Methods of Propagation." *U. S. Bureau of Plant Industry Bulletin* 202.

IMPROVED FURNACES FOR *GUR* MANUFACTURE.*

BY

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FURNACES play an important part in cane industry, as much depends upon their efficiency. A cultivator may take a good deal of trouble and invest large sums of money in producing an excellent crop of sugarcane; but if he is a little slack in adopting improved methods of cane-crushing and *gur* manufacture, he might incur a great loss.

It is now a well-known fact amongst cane-growers that if they crush their cane by wooden mills, instead of iron ones, they lose 20 to 25 per cent. juice after every 100 lb. of cane. With a good crop this loss may amount to Rs. 125 to Rs. 150 per acre per season. By demonstrations and comparative trials made in cane-growing tracts, the cultivators are now so convinced of the superiority of the iron mills over the wooden ones that the latter are now being entirely ousted and their place taken by iron cane-crushing mills.

What is true with the mills is also true with the furnaces. An efficient furnace means saving in money and time and production of a finer quality of *gur* which will fetch better rates in the market.

Cane-growers in these provinces used to boil their juice on most primitive and inefficient furnaces before the attention of the Agricultural Department was drawn to this question. This furnace consists of a pit 4′-6″ in diameter and depth. A feeding hole 2′ × 1′-6″ is kept in the front. For want of any arrangement for the draught, ash pit, and exit passage for smoke and hot gases, the

* Paper read at the Seventh Indian Science Congress, Nagpur, 1920.

working of this furnace is very defective. A trial boiling taken on such a kind of furnace showed that it required 4½ hours to boil 500 lb. of juice. The quantity of fuel used was simply enormous. In the first place, firewood was utilized for the boiling. Then the megass and trash was exhausted; but still the boiling was not complete. Consequently the stock of fuel had to be supplemented by feeding *til* (sesamum) stalks. As it took such a long time to boil a small quantity of juice, the quality of the finished product was distinctly inferior. In comparison with this type of local furnace the introduction of the Poona furnace was looked upon as a decided improvement. The cultivators at once appreciated its obvious advantages at demonstrations carried out by the department. There are three main points of advantage in this furnace, *viz.*, the ash pit, draught passage, and exit hole for smoke. Unlike the country furnace, this furnace is double storied. It is 7′ in diameter. The ash pit is 3′ in diameter at surface level. It is dug up to a depth of 3½′ and broadens as it goes deeper so that the diameter at the bottom remains 5′. A narrow draught passage 1½′ wide communicating with this pit opens out on one side of the furnace at ground level, through which the draught of air is constantly supplied to the burning fire. Over the top of the ash pit is put an iron sheet with a hole 9″ square in the centre. The upper wall of the furnace is 3′-6″ in height. An opening 1′-6″ × 2′-6″ is kept in the front for feeding fire. To make the working of this furnace more effective, an exit hole 9″ in diameter is kept at the left side of the feeding mouth. This communicates with a chimney about 6′ high. The working of this furnace was so successful that it has ousted the local furnaces wherever demonstrations showing comparative trials were held. It required no extra fuel as all the boiling could be done on megass and trash, which means a saving of at least 15 cartloads of fuel worth Rs. 20 per acre of cane. It boiled the same quantity of juice in nearly half the time than that required for the local furnace. The quality of *gur* was, therefore, considerably improved. With all these obvious advantages, it is no wonder, therefore, if this furnace has been adopted by all the cane-growers who have seen its working side by side with their local furnace.

The Sindewahi furnace evolved on the Sindewahi Farm, however, is even a far greater improvement over the Poona furnace. From trials made it has been conclusively proved that this furnace is simpler, cheaper, more efficient and economical than the Poona furnace. The construction of this furnace may be described as follows :—

Select a level piece of ground somewhere adjoining the cane area to save extra expenses of carting cane. For a pan of 7′ diameter dig a pit 6′-6″ in diameter and 18″ deep with sloping sides, so that the diameter at the bottom will remain 4′-9″. Construct a mud wall in the centre, 1′ in height and 4″ broad, leaving 6″ on both sides for smoke and hot gases to gain access to the passage leading to the chimney. The most important part of this furnace is the grating over which fuel is fed and through which the draught is supplied. It should be made of $\frac{1}{2}$″ round iron bars, each 20″ in length, fixed up $\frac{1}{4}$″ apart to two pieces of 1″ broad flat iron. The size of the grating should be 14″ × 20″. It should face towards the direction from which wind generally blows. It should be fixed in such a way that its bottom touches the lower rim of the furnace whilst the upper edge is fixed in a slanting direction at a point 8″ from the upper rim at the surface level and 3″ deep. This leaves an opening 14″ × 7″ between the pan and furnace for feeding megass.

A perpendicular cut is made from the lower rim of the grating, 1′-6″ deep, 15″ wide and 3″ long. In continuation with the upper edge of the grating, flat stones should be fixed up to a length of 3′. These will cover up the air passage and allow space for the feeder to sit upon. A sloping air passage 5′ × 2′ communicates with the passage below the grating, and thus gives a continuous supply of draught to the burning megass.

The outlet for smoke and hot gases is situated behind the mud wall just opposite to the grating. Its size is 15″ × 7″. This opening is continued to a distance of 8′ where a chimney 1′ × 9″ is constructed. The height of the chimney should be at least 8′. The passage for smoke is closed by covering with bricks or stones flush with the ground, taking care to see that no smoke gets out from any joint.

Comparative trials have shown that this furnace has several advantages over the Poona furnace.

(1) This furnace costs very little. The grating is the only part which has to be got made by the village smith. With normal prices of iron, this furnace will not cost more than Rs. 5. A *kutcha* Poona furnace costs not less than Rs. 10, including the cost of iron sheet. Such a furnace built in *pucca* bricks costs Rs. 25.

(2) It effects a considerable saving in fuel as all the boiling can be done on megass alone, there being some balance left out even of this stuff at the end of the crushing season. The whole of the trash can, therefore, go into the manure pit or be ploughed into the cane land. From experiments carried out it has been proved that the manurial value of trash from an acre of land (about 5 tons) is equal to that of 30 cartloads of cattle dung. From this point of view, the Sindewahi furnace is of far greater importance, as cattle dung is getting scarce day by day and its price is rising by leaps and bounds. By adopting this furnace, the cane-grower can depend upon his trash to supply the necessary quantity of bulky manure, which he can supplement by concentrates like oil-cakes or nitrates at a later period in the growth of the crop.

(3) It totally dispenses with the necessity of having a strong man for feeding fire. The megass can be fed by a boy or girl by putting in handfuls at a time. The feeder can sit up in an easy position all the while that the boiling continues. Fire-feeding which was so long looked upon as the most difficult task in *gur* manufacture can now, with this furnace, be considered as an easy job which can be managed by anybody.

(4) It boils the juice in comparatively less time than that required for the Poona furnace.

(5) The lifting of the pan when the *gur* is ready is much easier than in Poona furnace.

From all these points, it is obvious that the Sindewahi furnace is a decided improvement over the Poona furnace in several respects, *viz.*, simplicity, cost, and efficiency. This furnace has been introduced in the cane-growing tracts and is being looked upon everywhere as a boon to the cultivators.

GUR-MAKING FROM THE JUICE OF THE DATE-PALM (*PHŒNIX SYLVESTRIS*) IN THE THANA DISTRICT OF THE BOMBAY PRESIDENCY.*

BY

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Gur-making from the date-palm juice is not carried on on an industrial scale by the people of the Thana District as in Bengal and Madras Presidencies. Three or four years ago this work was taken up by the Bombay Agricultural Department, and investigations were made in connection with *gur* making from the date-palm juice and also in connection with the improvement of the quality of *gur* in colour, crystalline consistency, etc. The experiments were conducted at Sanjan and Tadgaum in the Thana District.

In the jungles and also on the coast-line of Thana District, date-palm trees grow in abundance but no economical use of them is made by the people. Only some trees out of an enormous number are tapped for toddy (fermented juice). Hence there is ample scope there to start an industry of *gur* or sugar-making from the juice of date-palm trees. A number of trials were made for preparing *gur* from the date-palm juice under different conditions. There are two collections of juice: one is the night collection (removed in the morning) and the other is known as the day collection (removed in the evening). The juice of the night collection is clear, colourless, and transparent, when collected in new pots after washing the exposed part of the tree. It resembles the juice of coconut both

* Paper read at the Seventh Indian Science Congress, Nagpur, 192 .

in appearance and taste though it is sweeter than the cocoanut juice. This juice is known as *nira*, and is free from fermentation and hence can be used for *gur*-making. If the juice is kept exposed even for a short time, the acidity increases and fermentation sets in very rapidly with the increase of temperature. This juice is known as sweet toddy which takes two days to complete the process of fermentation when it becomes real toddy of drinking. Neither the *sweet* (fermenting juice) nor the *real* toddy (fermented juice) is of use for *gur*-making. The day collection is always fermented and is never used for *gur*-making. The *nira* (unfermented juice of the date-palm) has a decided advantage over the juice of sugarcane for *gur*-making inasmuch as the skimmings from the date-palm juice when boiled are trifling. There is no great change in the colour of the boiling juice till it reaches the *ghagara* stage (when frothing ceases), after which the colour changes from the reddish yellow to dark red or brown.

From *nira* the *gur* easily sets to solid crystalline consistency and gets the characteristic dark brown colour. The *gur* smells slightly of the date-palm juice and its taste also differs from cane *gur* to some extent. The *gur* prepared at Sanjan compared well with low quality cane *gur*. The average proportion of *gur* to juice was one to ten, *i.e.*, 10 per cent. The percentage of sucrose in the juice varies from 7 to 10. As fermentation proceeds, reducing sugars increase to as much as 50 to 60 per cent. of the total sugars within 10 hours. In a good sample of juice, the reducing sugars do not exceed 1·8 per cent. A large number of trials were made to have a solid crystalline *gur* from the date-palm juice. The investigation was carried on mainly with the following two points in view :—

(1) To get the best juice (*nira*) suitable for *gur*-making, and

(2) to get *gur* of solid crystalline consistency.

In order to secure the first point, earthen pots were used for the collection of the juice. Some of the pots were lime-coated, some were smoked and some new, while some were treated with formalin (six drops of 40 per cent. formalin per pot) and some with chloroform (10 drops per pot). In every case proper care was taken to clean the cut surface of the tree with a view to avoid contamination. The pots were suspended on the tree rather late in the evening and the collections were removed early in the morning at about 5 A.M. The boiling of the contents of the pots subjected to different treatments was done separately in open iron pans at 7 A.M., and *gur* was prepared in the same way as with cane juice. The best temperature for ripe boiling was found to be 108° to 110°C.

The acidity of all the collections was determined before they were taken to the pan for boiling. Formalin was found to be the best preventive of fermentation, though the increase of acidity in others was not very high (only 0·06 gramme of caustic potash was required to neutralize 100 c.c. of juice). The results of all these experiments were as follows :—

(1) The juice treated with formalin gave solid *gur* of good grain.

(2) The juice treated with chloroform gave solid *gur* but with no grain.

(3) The juice with other treatments gave only semi-solid *gur*.

In the other set of experiments the acidity was neutralized by lime water and sodium carbonate separately, and the result was that no solid *gur*, but only a dark sticky mass, was obtained.

Slow or rapid boiling was found to have no great effect on the quality or nature of *gur* obtained. Our experience seemed to indicate that continuous stirring, till the point of solidification or setting, prevented the *gur* from becoming sticky. The following precautions were found to be essential to getting juice fit for *gur*-making.

(1) Special care was required to clean the exposed surface of the tree and also the slit.

(2) The leaves down which the oozing juice trickles into the pots should be fresh every day and should reach the bottom of the pot.

(3) Fresh pots should be used every day or the used ones should be burnt or smoked before they are used a second time.

(4) Pots should be fixed late in the evening and should be removed early in the next morning (one hour before sunrise).

(5) Fermentation of the juice on account of exposure, etc., should be avoided by adding some such preservative as formalin.

In February 1918, another set of experiments was conducted on a large scale in which the Bengal method of tapping the trees was practised. This method differs from the Thana method in three chief points:—(1) Surface cutting as against deep cutting, (2) collecting the juice in smoked pots, and (3) collecting the juice for three successive days and then allowing the trees to rest for two days so as to harden the exposed surface.

The juice obtained by this method gave slightly different properties with regard to acidity, alkalinity, and fermentation. The pure juice, instead of being acid, was found to be amphoteric. The juice collected over-night and tested in the morning was clearly alkaline to methyl orange and acid to phenolphthalein. The Thana method was improved on the model of the Bengal method except in regard to that of cutting. Several experiments were performed on practical and economic lines to get *gur* from the date-palm juice collected from trees tapped both by the Bengal method and the improved Thana method respectively. These experiments proved successful in giving us solid *gur* of good grain. But the *gur* obtained had a dark brown colour characteristic of the date-palm *gur*. This unattractive colour lowered the value of the *gur* to an appreciable extent and led us to devote our energies to find out means to improve the colour of *gur*.

It is well known that when alkalies are boiled with reducing sugars, black-coloured products are formed. This suggested to us that the distinctly alkaline nature of the juice must be the cause of the darkening of *gur*. Hence, to improve the colour of the *gur* the following scheme was planned :—

(1) To find out the extent of alkalinity or acidity together with their variations in different samples.

(2) To see the effect of boiling on the alkalinity and acidity.

(3) Neutralization of the alkalinity by various organic acids in different proportions and the effect on the colour of *gur*.

Samples of juice from different plants were separately collected under various conditions and their alkalinity and acidity were determined. Acidity is expressed in terms of grammes of caustic potash per 100 c.c. of juice, as determined by using phenolphthalein as the indicator, and alkalinity is expressed in terms of grammes of sulphuric acid per 100 c.c. of juice as determined by using methyl orange as the indicator.

	First day's collection	Second day's collection
Alkalinity	0·086 to 0·151	0·047 to 0·165
Acidity	0·019 to 0·038	0·014 to 0·053

The slight acidity that is present in the fresh juice changes, and the juice, when made to boil, becomes alkaline in reaction to both phenolphthalein and methyl orange. This indicates the presence of some alkaline bicarbonates and the formation of some alkaline salts from alkali metals and organic acids. The alkalinity may also be due to the presence of some basic nitrogenous organic compounds.

From different samples of juice, *gur* was prepared separately. Formalin and smoke treatment gave better results than lime or no treatment. The keeping quality of the juice was determined from the amount of fermentation and acidity formed.

In working out the second part of the scheme the organic acids taken for the neutralization of the alkalinity were citric, tartaric and acetic acids. The samples of juice taken for various trials of *gur*-making were first analysed as to the amount of alkalinity and acidity present. The alkalinity was partly or wholly neutralized by the action of the required amount of citric acid before the juice was boiled. Each sample was divided into four parts consisting of two litres. One was boiled without any treatment to compare with the others under different treatments of acids. That trial which gave the best results was done on a large scale.

We found out that the neutralization of alkalinity by citric acid, partly or wholly, always gave light and bright colour to the *gur* though differing in crystalline consistency. As the result of the final trials, it was found that the addition to the juice of one-fourth the amount of citric acid required to neutralize the alkalinity, before the juice is taken for boiling, always gave lighter and brighter colour to the *gur* with good grain fairly comparable with the best Poona yellow-coloured cane *gur*.

Gur samples from the juice treated with acetic acid were rather soft and sticky with no good taste, although the colour was light.

Gur samples from the juice treated with tartaric acid were solid and crystalline. There was some change in the colour, but it was towards deep red and not towards light and bright yellow colour (the one which is so much desired).

From calculations made in accordance with the above results it was found that for eighty-four gallons of juice about a pound of citric acid would be necessary to get the best quality of *gur*. Taking that 7 per cent. of citric acid is present in the lemon juice, about 17 pounds of lemon juice would be necessary for 100 gallons of date-palm juice.

The work of getting lighter coloured *gur* by the use of citric acid was done independently (an original idea in February 1918) and long before the publication of a similar work done by Messrs. Annett, Pal and Chatterjee (*Mem. of the Dept. of Agric. in India, Chem. Series*. Vol. V, No. 3, September 1918). The detailed report of the work will soon be published as a Bulletin on toddy by the Deputy Director of Agriculture for whom the work was done.

The results about the analyses and other important determinations are given in the tabulated statements below.

Analyses of gurs *treated in different ways.*

Kind of treatment	Percentages on *gur*				Alkalinity in terms of grammes of sulphuric acid per 100 grammes of *gur* with methyl orange	Acidity in terms of grammes of caustic potash per 100 grammes of *gur* with phenol-phthalein
	Moisture	Ash	Non-reducing sugars	Reducing sugars		
Dark-coloured *gur* prepared on a large scale by ordinary process and put in blocks	9·30	1·55	78·35	5·50	0·763	0·387
Dark-coloured *gur* prepared on a large scale by ordinary process and put in earthen pots ..	9·33	1·80	70·75	4·60	0·477	0·339
Semi-solid *gur* by ordinary process	7·35	..	..	..	0·572	0·290
Solid *gur* with no treatment (on a small scale) ..	5·60	..	..	..	0·477	0·290
Gur with one-fourth the amount of citric acid required to fully neutralize the juice	4·95	..	.	..	0·858	0·290
Gur with one-half the amount of citric acid required to fully neutralize the juice	7·05	..	..	..	0·763	0·677
Gur with whole amount of citric acid required to fully neutralize the juice..	3·95	..	..	..	0·572	0·677
Gur with no treatment ..	5·80	..	.	..	0·477	0·290
Gur with small amount of tartaric acid	5·75	..	..	..	0·668	0·242
Gur with one-third the amount of tartaric acid ..	5·80	..	..	..	0·667	0·484
Gur with acetic acid	9·85	..	..	..	0·572	0·677

Effect of boiling on the alkalinity and acidity of the juice.

		(INDICATOR METHYL ORANGE)	(INDICATOR PHENOLPHTHALEIN)	(INDICATOR PHENOLPHTHALEIN)
	Colour	Alkalinity in terms of grammes of sulphuric acid per 100 c.c. of juice	Alkalinity in terms of grammes of sulphuric acid per 100 c.c. of juice	Acidity in terms of grammes of caustic potash per 100 c.c. of juice
No. I				
Fresh juice (composite sample) ..	Dull	0·119	...	0·048
At scum forming (Temp. 70 to 80°C.) ..	Brownish	0·119	0·014	nil
At boiling (Temp. 98°C.) ..	Brownish	0·109	0·018	nil
No. II				
Fresh juice (composite sample) ..	Clear	0·095	nil	0·033
At boiling ..	Brownish	0·095	0·018	nil
No. III				
Fresh juice (composite sample) ..	Dull	0·104	nil	0·038
At boiling ..	Brownish	0·104	0·018	nil

After boiling, the juice became alkaline to phenolphthalein (which was acid before to the same indicator).

THE INFLUENCE OF STOCK AND SCION AND THEIR RELATION TO ONE ANOTHER.*

BY

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Introduction.

In foreign literature much has been written regarding this subject. Knight [1] gave an account of the injurious influence of the plum stock upon the apricot as far back as 1823. An article also appeared in *Gardener's Chronicle* in 1853. Fuller treats this subject at some length in his book on the "Propagation of Plants" written in the year 1887. Amongst the modern and leading horticulturists, Bailey has dealt with this question in his "Nursery Book."

But the fruit plants dealt with by these writers are unsuitable to Western India. In the Bombay Presidency there is very little on record bearing on the above subject, though work on it was commenced in the Ganeshkhind Botanical Gardens in 1909. In this article it is intended to put together all the available material regarding some important fruit trees and other plants of importance, with a view to invite suggestions and criticism.

The union by grafting may be made between plants of different varieties of the same species or of species of the same genera. It may also be made between plants of different genera of the same natural order. The method may be employed for the following reasons:—

(1) To induce early bearing.

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* Paper read at the Seventh Indian Science Congress, Nagpur, 1920.

[1] *Horticultural Transactions*, Vol. V, p. 287.

(2) To produce superior varieties.

(3) To encourage strong and vigorous growth of plants.

(4) To multiply plants of those species which fail to seed or which cannot be propagated by any other vegetative methods of reproduction.

(5) To dwarf the size of plants.

(6) To minimize the number of thorns.

Let us now consider the effect of different stocks on the scions.

Preference of some stocks to particular scions.

In order to ascertain the best stock on which to bud any variety of orange, pumelo, lemon, etc., trials were made in the Ganeshkhind Botanical Gardens, since 1909, by Mr. H. P. Paranjpe, Assistant Economic Botanist, in which all the available varieties of *Citrus* in the Deccan were budded on the following stocks, *viz.*, *Mahalunga* (*Citrus medica*, proper), *Jamberi* (*Citrus medica*, var.), orange, and *Reshmi* orange (*Citrus aurantium*). The following results were obtained :—

The Nagpur and Poona oranges, as also Ladoo and Kawla oranges, were found to be indifferent in growth on *Mahalunga* stock. *Mosambi*, *Mahalunga*, *Sakhar-limbu*, *Jamberi* and Pumelo plants were in good condition on this stock. If conclusions are to be drawn from seven years' trials it may be said that scions of hardier varieties with thick bark from large round stems did well on *Mahalunga* stock.

If the *Mahalunga* stock preferred some particular scions to others, the *Jamberi* stock welcomed all. The bark of *Jamberi* is very mucilaginous and separates more easily from the wood below than that of *Mahalunga*, and this seems to be one of the reasons why the *Jamberi* is preferred as a stock plant.

The orange has not been found to be a good stock especially for thick-skinned scions such as Pumelo, *Sakhar-limbu* and *Mosambi* as the part above the insertion of the bud quickly dries up after pruning and turns black.

Fig. 1. Shows the tall and vigorous growth of Kagdi lemon (*Citrus medica*, var. *acida*) plant on Jamberi stock (*Citrus medica*, var.).

Fig. 2. Shows the bushy habit of growth of Kagdi lemon (*Citrus medica*, var. *acida*) plant on Mahalunga stock (*Citrus medica*, var. *proper*).

INFLUENCE OF STOCK ON THE VIGOUR, HABIT OF GROWTH AND YIELD OF THE SCION.

Apart from the question of the more ready union made by some stocks, there is another and most important question. This concerns their capacity to increase the hardiness of the scion. The following are examples :—

"With regard to mangoes[1] it was found that the Bombay grafts were seriously affected by frost, each year, when grown at Pagara. The *khuds* and ravines of the Pachmarhi Hills are full of wild mangoes and it has now been found that if the Bombay varieties are grafted on the wild Pachmarhi seedlings the resulting trees, without deteriorating in quality, are quite frost-resistant, a fact which is worth noting by many growers in the Central Provinces, who are troubled by the annual destruction caused by frost."

In the Ganeshkhind Botanical Gardens, during the flood of 1912, the *Mahalunga* plants on their own roots were greatly affected. Leaves on the parts that had been submerged withered and dropped. The twigs bearing such leaves also succumbed in some cases. But the *Mahalunga* plants on *Jamberi* stocks in another submerged part of the same garden did not suffer in any way.

These two examples indicate that the stock has a definite ability to communicate to the scion its own power of resistance.

Besides, the habit of growth of the plants is affected in a marked degree by the stocks used. A tall-growing variety induces the scion to come up to a good height in contrast to a scion grown on a bushy stock. In the Ganeshkhind Botanical Gardens six plants of each type of *Citrus* were planted in 1910 on stocks of *Jamberi*, *Mahalunga*, *Reshmi* orange, and orange. In this plantation it is peculiar to note that plants on *Jamberi* stock are decidedly superior, both in height and appearance, to those on other stocks, and that plants on *Mahalunga* stocks are decidedly bushy in habit as compared with those on other stocks (Plate XXXI). Sorauer[2] says: "It

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[1] *Agricultural and Co-operative Gazette*, Nagpur, Vol. IX, September 1915, p. 15.
[2] "Treatise on the Physiology of Plants," p. 195.

is well known that certain stocks have a very pronounced effect upon the habit of growth of the scion. Apples grafted on Paradise stock or dwarf stock (*Pirus præcox*) remain of short stature and often produce flowers in the year following the grafting. Grafted on the Doucin, the varieties become bigger and fruit later; on the crab-apple the tree retains a normal growth, but the crown does not produce flowers for a considerable time."

The following is another example: *Crescentia alata* is a plant belonging to the order Bignoniaceæ the flowers of which scarcely set fruit in Poona. Only once in the course of ten years has it produced two fruits in the Ganeshkhind Botanical Gardens, but these dropped down before they became fully ripe. Vegetative methods of reproducing this plant, *viz.*, by *gooty*, cuttings, and layerings, adopted by the writer in the rains of 1913, failed, though a considerable amount of callus was formed at the cut ends. Hence, recourse had to be taken to reproduce these plants by grafting on a sister species, *viz.*, *Crescentia cujete*. Three grafts of these were obtained in 1914 but all of these are making very slow growth, scarcely attaining three feet and remaining very dwarf in size, thus indicating the effect of stock on the growth of the scion.

Regarding the influence of stock on the productive capacity of the scion, very little information is at hand. The experiments on grapes conducted by Mr. H. V. Gole, the well-known grape grower of Nasik, and mentioned in the "Agricultural Journal of India," Vol. XIV, Pt. 1, pp. 119–120, show that *Phakadi* variety, which is a shy bearer, if grafted on *Bhokari*, a prolific bearer, has been found to give an extra yield of 2 lb. per plant.

In the Ganeshkhind Botanical Gardens the *Phakadi* scions were inserted on *Bhokari* in the rains of 1915. Six plants of these are now in the ground. They have not as yet flowered.

UNDESIRABLE COMBINATION OF STOCK AND SCION.

So far I have dealt with the influence of stock on the scion, but there are cases in which the affinity between stock and scion is slight. If the stock and scion plants have different periods of dormancy or activity, or if one be a tree and the other a small plant, and if such plants, though belonging to the same genera, are grafted, the result is that the active part temporarily grows but soon fails, ultimately causing the death of the tree. The following are some of the examples :—

On 27th May, 1913, ten Venarch grafts of *Neem* (*Azadirachta indica*) were made on *Bakan* (*Melia Azedarach*) stocks by the writer. Besides, 25 buddings of the same were done on *Bakan* stocks in May and June 1913. Nine grafts and five buddings in all succeeded, and these were planted on 17th July, 1914. These grew well for a year when two grafted and three budded plants withered. One budded plant flowered and fruited in March 1915 and 1916. The fruits had the normal characters of the *Neem*. This plant as well as other budded plants withered in June 1917. By this time only four grafted plants were doing well, but they had formed a big knotty excrescence at their grafted portion with shoots from the stocks constantly appearing. This knotty excrescence seems to arise from the obstruction which the descending sap of the *Neem* tree meets at the junction with the *Bakan* stock, for the effects produced upon the growth of the tree are similar to those which occur when the descent of sap is impeded by a ligature.

Formation of a big knotty excrescence at the point of grafting. Stock—Bakan ; Scion—Neem.

The fig plant (*Ficus carica*) was grafted on the *Umber* (*Ficus glomerata*) in the rains of 1909. Three successful grafts were obtained and were planted in June 1910. These grew well for about a year but afterwards failed as the fig began to wither at the resting period of *Umber*.

To cite another instance, *Ipomœa Horsfalliœ* is an ornamental creeper, attractive for its large and rich, glossy, rose-coloured flowers. Each single plant costs Rs. 3 on account of the difficulty of propagation. Attempts were made by Mr. P. G. Joshi, Superintendent, Ganeshkhind Botanical Gardens, to increase the plant by grafting it on *Ipomœa carnea*, a plant commonly found in gardens and easily multiplied by cuttings. One graft made in October 1917 succeeded after two and a half months. The plant grew well for about ten months when it withered as the stock plant was then at its resting time.

If thus the period of activity or the rate of growth of stocks and scions are entirely different, there is a considerable check in the flow of sap with the result that the plants succumb.

Influence of scion on the stock.

Let us now consider the influence of scion on the stock. As a rule, in all fruit plants the scion has a preponderating influence; and the plant bears the same quality of fruit as the scion. It is generally believed that oranges grafted on *Sakhar-limbu* or orange plants become much more sweet than oranges on *Jamberi* stock, but experience teaches otherwise. In all cases of such grafting the quality of the scion alone predominated. This phenomenon is explained by Sorauer[1] as follows: "The Cambium is a tissue the young cells of which have inherited from their first formation the tendencies of their mother cells and therefore continue to function in the same way, forming the same sort of cell-wall and cell contents as their predecessors did. The characters of the scion as well as those of the stock will develop themselves separately in their several tissues."

The position of the scion, however, does influence the flowering. The following are examples :—In August 1914, in the Ganeshkhind Botanical Gardens, a thirty-year-old Shaha-buddin mango-tree was

[1] "Treatise on the Physiology of Plants," p. 194.

used as stock and five branches from grafted plants in pots were transferred to it by grafting. The scions were grafted on to the end of well-ripened branches. In January 1915, two of the scions bore inflorescences but did not develop fruits.

Also in August 1914, one branch of Borsha, a grafted mango plant in pot, was transferred to a big country plant and this bore two well developed fruits in May 1915.

In both the above cases the pot-plants from which the scions were taken produced no inflorescences, although branches similar to the scions were purposely left to see how they would behave.

In Bassein Garden, a country mango-tree of about 39 years old was heavily cut back on March 6, 1912. Many new shoots sprang up from stumps and on these shoots were grafted scions of Alphonse and Sakharia varieties on May 22, 1912. Grafting was done by enarch from plants in small pots tied near the branches of the stock. Out of 40 scions thus placed, three flowered on January 22, 1914. The first crop of 38 fruits was obtained from this tree in June 1916. The original plants in the pots from which the scions were taken had not flowered by this time. It seems rational to assume that the position at the end of a branch in the system of a big tree is likely to accelerate flowering.

In the above instances, the scions were of mature wood, but if young and immature scions are inserted, one would not naturally expect such early flowering.

In the Ganeshkhind Botanical Gardens, 28 one-year-old mango seedlings were transferred, in August 1914, on to branches of ripened wood that were likely to bear inflorescences in 1915, on country and Shaha-buddin mango-trees; but none of these transferred young seedlings bore any inflorescences, though similar shoots, bearing no grafted seedling branches, had passed three flowering stages. Similarly, on a five-year-old guava plant 24 scions of Sind Hyderabad variety of four months old were transferred on 19th January, 1919. Twenty-one of these survived but none of these have flowered though the plant passed one flowering stage. From the above it may be seen that mature scions produce flowers early and that immature scions go on making vegetative growths, no matter where they are situated, and produce flowers when sufficient plastic material has been formed in the shoots. This condition may, to a certain extent, be hastened by the stock of an advanced age. The results are, however, still inconclusive, but the question has an important practical bearing, as, if early flowering is induced on such young transferred branches, considerable saving of time would be assured, and such plants as hybrid and polyembryonic mangoes, seedless guavas, etc., would be forced to reveal their characters at an early date.

INSERTION OF MORE SCIONS THAN ONE.

Very often more scions than one can be inserted on the different branches of the stock. This is done more for curiosity than for any practical utility. In Goa the writer has seen three different scions inserted, *viz.*, Fernadin, Musherad, and Pairi on three branches of a country mango. These were all in fruits. On a top-worked country mango-tree in Bassein garden, the following varieties were harvested from a single plant in June 1916:—

30 Pairi fruits.
2 Alphonse „
4 Batlee „
2 Sakharia „

In the Ganeshkhind Botanical Gardens, on an Edward rose plant the following eleven varieties were budded in January 1913, (1) Madam Furtado, (2) Cook Peach, (3) Devoniensis, (4) La-France, (5) Madam Halphen, (6) Glorie de Dijon, (7) L'Avenir, (8) Nephetos, (9) Belle Lyonnaise, (10) Annie Laxton, and (11) Aimee Vibert. Of these, numbers 10, 3 and 7 grew with more vigour than the rest. Nos. 4, 9, 6, 3 and 5 were in flowers in January 1914, but none of them gave as many blooms as they would otherwise have done. This is as one would naturally expect, as the distribution of sap is not equal in all cases.

It is, however, not desirable to put in more varieties than one on single stock, as the one that is more vigorous draws a larger amount of nourishment from the stock to the detriment of others with the result that they ultimately starve and die.

Grafting between different genera of the same natural order.

There is now only one aspect of the question with which I wish to deal, and it is in regard to the influence of stocks and scions of different genera but belonging to the same natural order. Collins [1] says:—"It is said that in Martinique the mango has been successfully grafted on the cashew tree (*Anacardium occidentale*) and it is further stated that seedling mangoes, so grafted, produce fruit double in size, free from fibre, and with the seed so reduced that it is frequently without the power to germinate. The fruit, although melting and very juicy, is said to be without flavour." Collins comments: "These results as reported are so radically opposed to those usually obtained from similar experiments that they are not likely to be generally accepted until verified."

In the Ganeshkhind Botanical Gardens, the following experiments were conducted by the writer:—Grafting of mango scions on stocks of *Semecarpus Anacardium* was done in July 1910 by the crown whip, saddle and tongue grafting methods. The scions remained fresh a little time and then died. Similar graftings were made on *Spondias mangifera* and *Spondias acuminata* but without success. A similar experiment was made in 1914 when 12 mango scions were enarched on to *Semecarpus Anacardium* stocks on August 12 and November 3. Two mango scions were also enarched on to *Holigarna grahamii* stock but none of these took.

In the Anacardiaceæ, therefore, grafting between different genera has met with failure.

The propagation of *Chiku* (*Achras sapota*) by seeds is a matter of considerable difficulty. The nursery-men, therefore, often employ *Ryan* (*Mimosops hexandra*) seedlings as stocks and graft them with *Chiku* for commercial purposes. Such plants no doubt are vigorous growers, but it has been found by experience in Bassein garden that they do not yield more than 15 fruits per tree though *Chiku* plants grafted on their own stocks yield more than 200 fruits.

[1] "The Mango in Porto-Rico," p. 19. Quoting Jumelli's Cultures Coloniales, p. 201.

CONCLUSIONS.

The following are the conclusions arrived at :—

1. Some stocks have a distinct preference for particular scions while others have no such preference.

2. The stock plays a great part in influencing the habit of growth and hardiness of the scion.

3. The formation of a big knotty excrescence that takes place at the grafted portion in plants, whose rate of growth is not similar, considerably checks the growth of these plants.

4. Plants composed of parts which have different periods of resting fail to grow into big plants when grafted.

5. The scion has a preponderating influence in producing its own quality of fruit.

6. The position of the mature scion at the end of a branch in a big tree does influence the flowering.

7. It is undesirable to insert scions of more than one variety on the branches of a single stock.

8. The grafting between different genera, though taking place in some cases, has not been found successful in the mango.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

IV.

THE clump or bunch of canes in the field consists of the total output of shoots from one planted set. It is usually made up of several perfectly independent plants, each of which has arisen from a separate bud on the set. The growth of these separate plants, depending on the amount of food and space available, varies a great deal, some being large and dominating the whole clump while others are often small and insignificant, and the canes and shoots belonging to all of them interlace in all directions. We have seen that to make out the branching systems of the distinct plants, a rather tedious process of dissection is necessary, but that, after this has been done, we can construct a formula for each plant. And, when we dissect a number of plants of any one variety, we can obtain an average varietal formula which tends to become simpler and more symmetrical the more dissections are made. We can, in the same way, obtain a formula of each group of cane varieties, and we have seen that these group formulæ show considerable differences from one another, so that the way in which a cane branches becomes an important character in classification.

In our formulæ we have used different letters to indicate branches of different orders. Thus, if we call the main shoot from the original bud on the set *a*, the branches arising directly from it *b*, those from *b*, *c*, and so on, we can put down the system in algebraical

* Reproduced from the *International Sugar Journal*, February 1920.

form and our plant formula runs somewhat as follows: $a + xb + yc + zd + \ldots\ldots\ldots$ These formulæ for the individual plants are of great service for obtaining the averages of the varieties and ultimately of the groups, but we have found that, for the purpose of visualizing the branching in a plant, we must use another method, that of diagrams. In the 767 plants dissected for this piece of work, we have made a diagram of each as it lay on the table, and in these diagrams it has been possible to include many points for which the formulæ were unsuited. In the diagram the intricate interweaving of the branches is supposed to be unravelled and the whole plant laid out in an orderly manner on the table. Such a diagram is given in Plate XXXII, namely, that of a plant of *Saccharum arundinaceum*, a tall, thick-stemmed, wild cane of India. It will be seen that in this diagram certain conventions have been introduced which will require explanation, and for their elucidation we have selected another diagram, that of a very strongly grown *Yuba* plant (Fig. 1)

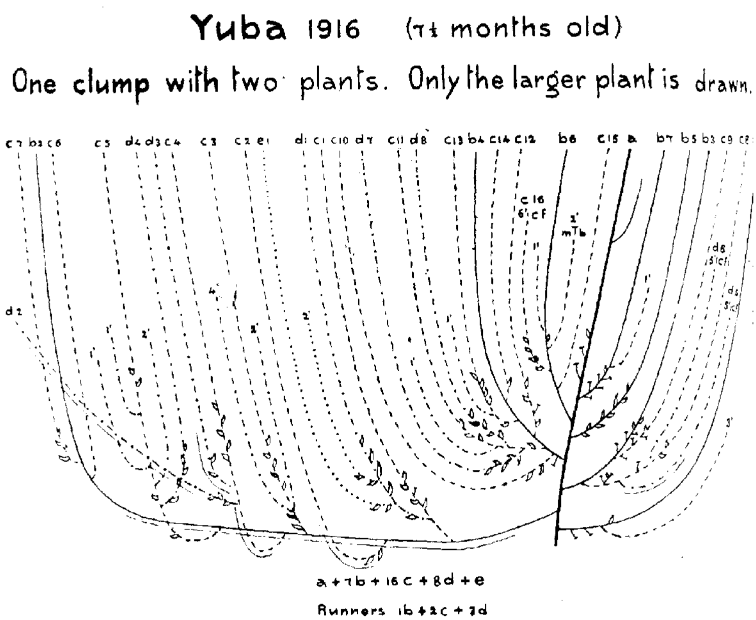

Fig. 1.

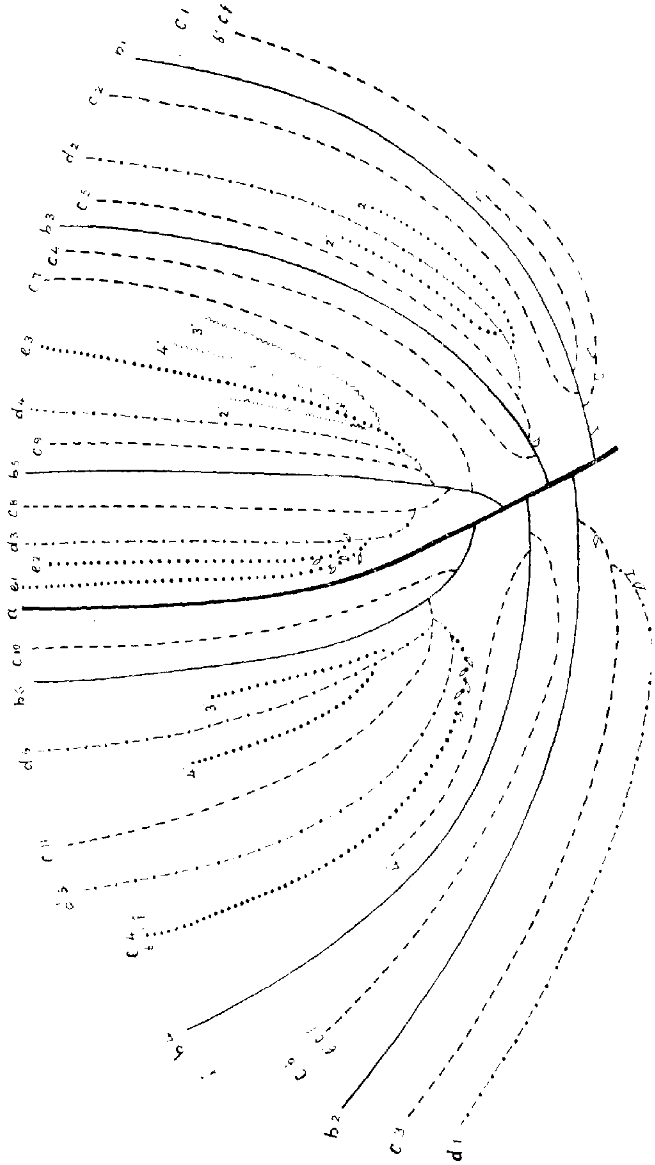

DIAGRAM OF THE BRANCHING SYSTEM IN A PLANT OF *SACCHARUM ARUNDINACEUM.*

which, it will be remembered, belongs to the Pansahi group of Indian canes. The canes and shoots in this plant were in a veritable tangle, this being caused by the great growth of *b2*, which has developed a number of runners, to be referred to directly. In this diagram the main stem and the branches of different orders are marked by their appropriate letters at their ends, and a different form of line is used for each. The main stem *a* is indicated by a thick line, *bs* by thinner lines, *cs* by lines made up of a series of dashes, *ds* by alternate dots and dashes, *es* by dots, *fs* (Plate XXXII) by zigzags. The formulæ were, from the first, merely intended to give a statement of the canes at harvest, and only those branches in the diagram have letters attached which would, in our opinion, form canes during the season. But, because of the length of time taken in the dissections (that of the *Yuba* shown took some three days, and the work was spread over several months each year), many of them had to be dealt with some time before harvest time. This is shown in the diagram. Those branches already forming full-grown canes are brought up to the upper limit of the figure. Of the immature shoots, those which are cane-forming at their base and would have time to mature by crop time are marked *cf* at their ends, and the length of each immature shoot is given in feet. All resting buds are ignored, as taking no part in the growth of the plant, but such as have begun to grow, either by great swelling or actual bursting, are included in the diagram. Cane varieties differ very much in their development of shoots at the base at reaping time, some having practically none while others have a regular sheaf of them, and this character finds its place in the diagram. As is well known, many deaths occur in the dense mass of the bunch, and these have always received careful attention in the dissections. A dead branch is marked by a short cross line at its end, and a similar convention is applied to dead buds, which are shown as very short lines with a cross line at the end. Lastly, in their struggle to place themselves in a suitable space for unimpeded growth, shoots are capable of altering their position by forming runners underground. These are distinguishable by the intercalation of several long, thin joints between series of very short ones, and occur before the cane commences to increase in thickness. They are marked in the diagram by thin lines placed under the elongating part. Where the cane is attacked by insects an asterisk is inserted, generally with letters indicating the kind of attack. Thus *m. b.* signifies moth-borer, *w. a.* white ants, and so forth. All of these conventions are illustrated in the *Yuba* diagram, especially a large number of runners, owing to the great effort made by *b*2 in its growth.

On the sheet containing the diagram of any plant dissected various memoranda are written down, some of which are mentioned here and others reserved for the next article. In the *Yuba* plant described we have the following :—

Canes formed, $a + 7b + 15c + 6d + e$.

Canes at harvest, $a + 7b + 16c + 8d + e$.

Shoots not cane-forming, $b + 3c + 7d + e$.

Bursting buds, $b + 13c + 48d + 25e + 4f$.

Deaths, $2b + 9c + 7d$.

Runners, $b + 2c + 3d$.

Considering the great irregularity shown by the plant in its growth, it is somewhat remarkable how nearly the canes at harvest come to a perfectly symmetrical formula. The great number of bursting buds shows how healthy the plant is and this is borne out by the very deaths in such a large number of buds and shoots in active growth. There are few shoots not cane-forming, which seems to indicate that the plant is maturing properly.

It was early noted that the members of the Pansahi group of Indian canes were marked by great regularity in their branching systems, and sometimes the way in which the canes grew was distinguished by almost mathematical evenness. Thus many facts of interest in the growth of cane were first noticed in the dissections of members of this group. It would have been impossible to have discovered these facts in the Saretha group, although they were afterwards traced there too, for the Saretha varieties are very irregular and untidy in their habit, crossing and falling about in every direction, showing many deaths and developing many runners. It is somewhat curious that a similar distinction can be drawn between the two cane-forming wild *Saccharums* of India, *S. arundinaceum* and *S. spontaneum* (the other wild species of this genus do not form solid canes but are seen as great tufts of grass). There are many points of likeness between the formulæ of growth of Pansahi and *S. arundinaceum* and there are also marked resemblances between those of Saretha and *S. spontaneum*, suggesting the possibility of genetic connexion between the two pairs respectively. But although this certainly holds with the Saretha-*S. spontaneum* likenesses, all attempts to find additional morphological connexions between Pansahi and *S. arundinaceum* have failed completely. Enough details have, however, been collected to suggest that the Indian canes, at present classed together with the thick canes of the tropics under the species *S. officinarum*, may have arisen from several distinct wild parents (some of which like *S. spontaneum* are still living, whereas others have not persisted in their wild form), while the thick canes may be the descendants of a different though closely allied form.

We have dealt somewhat fully with the branching system of the members of the Pansahi group of cane because they are of special interest at the present moment. This group includes, as we have seen, the *Yuba* cane of Natal and, according to local descriptions, also the *Agaul* recently imported to Natal from India; *Kavangire* also appears to belong to, and is considered by some as identical with, *Yuba*; perhaps the *Zwinga* and other canes in Brazil may also be included. These are canes inferior in many respects to the thick, juicy, tropical ones, but it is evident that they have their uses, because of their general hardiness in unfavourable conditions, their great tillering power and suitability to the extra-tropical cane-growing regions. It seems likely, from the latest reports, that they will enter more and more into the tropical cane industry, wherever, for some reason or other, thick canes are having a temporary set-back.

In the nature of the case, the thick canes will appear to have received less attention than the groups of Indian canes, but this is because they have been taken together as one group in the dissections. They have by no means been neglected, for as many as 53 plants of various thick canes have been dissected. They present, on the whole, a much simpler form of branching than the Indian groups, and it would be interesting to determine how far the differences noted in this and the next paper may be traced in different varieties of tropical canes. There is little doubt that such differences exist, but no work has at present been done on them in this direction. In Plate XXXIII, fig. 1, the dissection is shown of the three plants of a rather poorly developed clump of a variety of unknown origin named *Java* in South India. It is in a young stage, but it does not appear likely to produce any more canes at harvest than those shown. In Fig. 2 on the same plate a first ratoon of *Red Mauritius* ready for cutting is shown and in both cases the original set is still attached to the plant, so that the whole system is displayed, including, in the ratoons, the cut ends of the canes reaped in the first year. Text-fig. 2 gives the

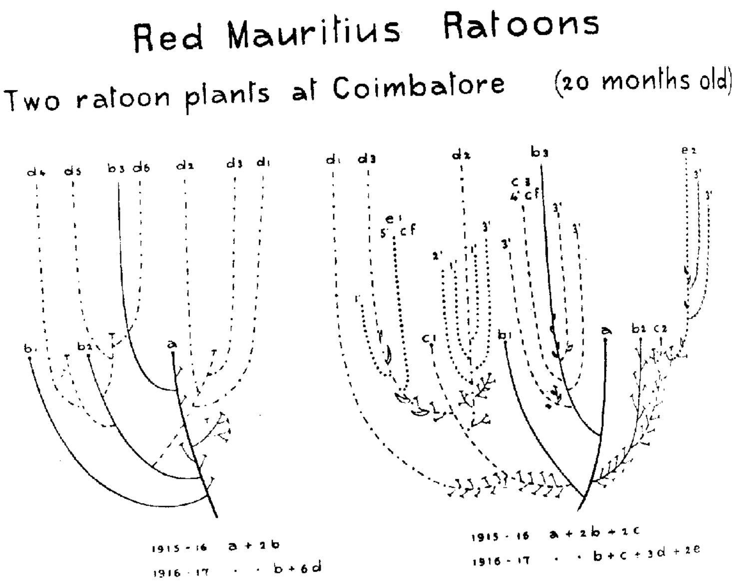

Fig. 2.

diagram of this ratooned plant, the dots at the ends of the branches signifying canes cut at harvest. There were three canes reaped in the first year and seven are ready for reaping in the ratooned plant. There are no shoots forming, nor are any buds bursting;

Fig. 1. Dissection of a "Java" clump of canes, consisting of three plants (5½ months old).

Fig. 2. Dissection of a "Red Mauritius" ratoon (20 months old).

deaths are few, as only 13 can be counted in the two years. The diagram on the right is also one of a ratooned *Red Mauritius* cane, dissected at the same time and place. It is apparently a much more well developed plant. There were five canes in the first year, but the number of canes in the ratoon crop are seven as in the former case. There are 15 bursting buds, 10 young shoots, and as many as 63 deaths. It would be a matter of great interest if the growth of these two canes could be carried one year farther, as it is to my mind doubtful as to which of the two would produce more canes then, because of the great number of deaths in the bigger plant. One is tempted to compare the two with two runners arriving at the same moment at the winning post. One has used up every ounce of his strength while the other has plenty of spare energy which he has not however made the best use of.

Now a good deal of this rather intricate description of this part of the growth of the cane will, at first sight, appear to be rather of academic than practical interest. In the next article we shall study the characters of the canes of different orders of branching, and we shall see that they not only differ in the rapidity with which they grow and mature, but that the joints differ in length and thickness and in the richness of their juice at harvest time. These are all points of great importance in the crop, especially with regard to determining the best time for cutting the canes.

WATER HYACINTH: A MENACE TO NAVIGATION.*

BY

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FLORISTS in southern California offer for sale a beautiful aquatic plant called water hyacinth (*Eichornia crassipes* Solms.). This plant, so highly prized in aquaria, and its near relatives, the pickerel weeds, have come into ill repute among navigators in tropical and subtropical waters, and more especially in the Gulf States, where the enormous sums expended in clearing streams of this pest have earned it the name of "million dollar weed." The history of its establishment is not known, but it was certainly introduced as an ornamental aquatic, and is said to have been planted in a pond near Falatka, Florida, where it soon became so abundant as to necessitate control measures, and it was taken up and thrown into the St. Johns River.

In addition to interfering with navigation the abundance of water hyacinth in the St. Johns River and its tributaries at one time caused an annual loss of about one-fourth the value of the logs rafted down the river from the valuable forests of cypress, pine, and red cedar bordering on that stream. The fishing industry also suffers, because of the difficulty encountered by fishermen in setting their nets. In time of flood, the bridges have sometimes been too low to allow the collected mass of plants to pass under, and the

* Reprinted from the *California Monthly Bulletin*, Vol. IX, No. 3.

pressure has overturned them. Moreover, the rank and decaying vegetation has been declared a menace to health and sanitation, as it not only affords a shelter and breeding place for disease-carrying insects, but interferes with the disposal of sewage.

Fig. 1. Water hyacinth (*Eichhornia crassipes* Solms.).

A description of the plant and its habits, with a view to considering the possibility of its becoming established in the navigable streams of California, and a consideration of the methods whereby its control has been attempted, is the object of this paper.

Description.

The plant is a floating perennial, the leaves forming in rosettes usually one to two feet in height from the surface of the water. The leaves are of two kinds: those below the surface of the water are long and narrow, while those above the water line are usually broad, obovate to nearly circular. The leaf stems are enlarged into oval bulbs filled with aircells, especially in young plants and when the plants are growing in small groups. When the leaves are crowded the bladder-like petioles are not so large.

Fig. 2. An inland creek completely covered with water hyacinth.

The stem which bears the flower is about a foot long, with a single leaf and several wavy-margined sheaths at and above the middle. This stem bears about eight flowers in a loose terminal spike. The flowers are funnel-shaped, pale violet in colour, with six lobes, the upper of which is larger than the others and has on it a large patch of blue with an oblong or pear-shaped spot of bright yellow in the centre. The stamens are all curved toward the tip, three of them long and three short. The seed pod is three-celled, becoming an egg-shaped or elongated capsule with the withered perianth remaining attached.

The plant produces numerous seeds. At maturity, the stem bends so as to immerse the pod. Propagation is also by means of runners which send out roots from the nodes.

The roots are of two kinds: horizontal roots, which are often thick and fleshy and pieces of which will grow readily; and vertical roots with a slender, wirelike stem, often as long as two feet, covered with small fibrous roots which give them a feathery appearance. The roots are exceedingly numerous, forming a dense brushy mass. Where the water is shallow, the roots penetrate the soil and become anchored, but in deeper water they float freely.

The tops are easily killed by frost, for the plant is a native of tropical South America, but the root system is kept alive by its immersion in water. The growth is most vigorous in spring. During

Fig. 3. Floating masses of water hyacinth.

the season of low water the leaves become yellowish and growth appears to be retarded. After the plant has been established in any locality for a number of years, the growth is less vigorous than when young, but after a flood it resumes its vigorous growth in response to the new supply of nutrient material. It is quite sensitive to salt water, but thrives in subsaline or brackish water.

CONTROL.

The water hyacinth is so abundant in Florida, Louisiana, and Texas as to obstruct navigation in the waters emptying into the Gulf of Mexico. Its eradication was entrusted in 1899 to the United States Engineer's Office of the War Department, to which was given "authority to remove the plant by any chemical, mechanical, or other means whatever." From that time the Engineer Office has worked continuously on eradication, and has spent hundreds of thousands of dollars in attempting to remove it from navigable streams.

No method has ever been found which will completely remove the plant at a reasonable cost, although every known chemical has been experimented with; but the solution which has been found most effective is an arsenical spray.

The water hyacinth is eaten with relish by stock, and in Florida its use as a feed had become so well established that it was considered necessary, in making an appropriation by the Rivers and Harbours Act of 1905 for the removal of the plant from the St. Johns river and other navigable streams of Florida, to insert a proviso that "no chemical process be used injurious to cattle." It was at first attempted to break up the masses of the plant and push the pieces into the current, but this was found unsatisfactory and exceedingly expensive. Since 1909 an elevator fixed to a barge has been used which gathers the plant in much the same way as kelp is gathered. Fixed booms are maintained across non-navigable streams to prevent the plant floating into navigable streams, and movable and semi-automatic booms to prevent its floating from one navigable stream into another. Labourers and watchmen are employed to detect or prevent the spread of the plant.

In the other Gulf States, the use of chemicals is not prohibited, and although some difficulties are encountered by owners of stock along the streams allowing their animals to eat the sprayed plant, with fatal results, in general local co-operation is obtained in combating the pest.

In Louisiana, two barges, propelled by gasoline launches, and equipped with tanks for mixing and pumps for spraying the chemical solution, are kept continually in service from about April 1 to December 1 of each year. It is necessary also to maintain booms across the stream as in Florida.

To make the solution used in spraying the water hyacinths, 600 pounds of white arsenic and 600 pounds of sal soda are placed in a tank with about 600 gallons of water. The mixture is brought to a boil and kept boiling for two hours. It is then drained off and diluted with cold water to 9,600 to 12,000 gallons, depending on the strength of solution desired.

For spraying the solution over the hyacinths a duplex Worthington pump $4\frac{1}{2}$ inches by $2\frac{3}{4}$ inches by 4 inches is used, with one-inch six-ply steam hose and a Fuller nozzle which is designed to give a very fine spray. The pressure on the hose is usually 50 pounds. On warm sunshiny days, one gallon of the diluted solution is ordinarily sufficient to destroy ten square yards of hyacinths. If the day is cloudy or cool, a larger quantity is necessary. Where the hyacinths are very tall, the spray does not reach the shorter plants, and a second application becomes necessary to reach those not killed at first. In the year ending June 30, 1919, the two barges sprayed 1,613,383 square yards of the hyacinth in Louisiana waters, using 201,908 gallons of solution, at a total cost of $ 13,464·21, or $ 0·0083 per square yard.

In spite of the enormous quantities of this pest destroyed annually since the work was first undertaken in 1899, it is still necessary to repeat the control measures year after year. So insidious is this floating menace to navigation that wherever the strictest precautions are not observed, a stream or harbour may be over night rendered impassable.

It is hardly likely that this tropical plant could become established naturally in the waters of the Sacramento and San Joaquin rivers in California, but it is extremely probable that if once transplanted here, it would spread rapidly and soon prove as great a menace to navigation as it is in the waters emptying into the Gulf of Mexico.

BRITISH CROP PRODUCTION.*

BY

EDWARD J. RUSSELL, F.R.S.

(*Concluded from Vol. XV, Pt. IV, p. 459.*)

FODDER and hay crops play a more important part than cereals in the economy of the farm, because they are the raw materials for a highly important part of the farmer's business—the production of meat, milk, or butter. They are too bulky to transport in any quantity and farmers use only as much as they themselves grow. The output of meat and dairy produce is, therefore, limited by the quantities of these crops at the farmer's disposal. The quantities produced just before the war and in 1918 were :—

Production of fodder and hay crops.

	YIELD PER ACRE 1908–17		ACREAGE, MILLIONS OF ACRES				Total produce, millions of tons	
	England and Wales	United Kingdom	England and Wales		United Kingdom			
	Tons	Tons	1914	1918	1914	1918	1914	1918
Swedes ..	13·0	14·6	1·04	0·91	1·75	1·60	24·2	22·8
Mangolds ..	19·5	19·5	0·43	0·41	0·51	0·50	9·5	10·3
	Cwt.	Cwt.						
Hay (temporary)..	29·1	32·2	1·55	1·45	2·90	2·80	4·2	4·4
Permanent grass ..	22·6	27·9	4·79	4·30	6·49	5·95	8·2	7·9

* Discourse delivered at the Royal Institution in February 1920. Reprinted from *Nature*, dated 15th April, 1920.

Like cereals and potatoes, these crops are greatly affected by artificial fertilizers, especially by phosphates, which increase not only the yield, but also the feeding value per ton. This is strikingly shown in the case of swedes and turnips, which receive a large part of the superphosphate made in this country. Mangolds respond remarkably well to potassic fertilizers and to salt. There is much to be learned from a systematic study of the influence of artificial manures on the composition and feeding value of these crops under the varied conditions of this country.

A further reason for the important part played by these crops in the economy of the farm is that they profoundly affect the fertility of the soil. They do not remove from the soil all the fertilizing constituents which must be added to secure maximum growth; some of these constituents are left behind in the soil to benefit the next crop—a rare instance of double effectiveness for which the farmer ought to be profoundly thankful. In the second place, even the fertilizing constituents which are absorbed by the crop are not entirely retained by the animal; considerable quantities are excreted and pass into the manure, and again are added to the soil. There is, therefore, the possibility of constant improvement of the soil; larger fodder crops enable more livestock to be kept, more livestock make more manure, and more manure gives still larger crops. It is sometimes argued that meat or milk production is in some way opposed to corn production, but on this method there is no antagonism; on the contrary, each helps the other. The production of more meat is consistent with, and indeed involves, the production of more corn.

The simplest way of utilizing animal excretions without loss is to allow the animals to consume the crop on the land where it grows, and this is frequently done excepting where the soil is so sticky as to become very unpleasant in wet weather. Sheep are the best animals for the purpose, as they are easily penned in by light hurdles, these being moved as each portion of the field is cleared; this folding is a common occurrence on the chalky and sandy soils of the Southern and Eastern Counties.

Bullocks are less tractable, and cannot be enclosed by light hurdles; they are, therefore, generally kept in yards, roofed in if possible, but oftentimes open. Sufficient straw is added to provide them with bedding and to soak up the excretions. In this way the fertilizing constituents of the straw as well as of the food are returned to the soil.

In the case of dairy cows the treatment is rather different; they have to be housed properly in quarters which are sometimes palatial, and for hygienic reasons they are allowed but little bedding. Their manure is removed once daily—sometimes oftener the primary object being to get it away without contaminating the milk. The investigations already referred to for which Lord Elveden provides the funds are now being extended to the dairy farm to see how far it is possible to save the manure without prejudice to the purity of the milk.

In the old days, when farmyard manure was the only manure and the old type of implements alone were available, farmers had to arrange their crops on a definite plan in order to get through their work and maintain permanently the productiveness of the land. There thus grew up a system known as the rotation of crops, which contributed very largely to the agricultural developments of the sixties, and ultimately became a rigid rule of husbandry strictly enforced over large parts of the country. Modern cultivation implements and fertilizers justify much more latitude, however, and no good farmer ought to be restricted in his cropping, provided, of course, that he maintains the fertility of his land. It is sometimes a convenience on the dairy farm to grow the same crop year after year on the same land and the Rothamsted experiments show that this can be done excepting only in the case of clover. With this exception there is no more need to have a rotation of crops than there is to have a rotation of tenants in a house. It is essential, however, that the land should be kept free from other competitors and from disease germs. Freedom from competition means the exclusion of weeds. In the old days this had to be effected by periodical bare fallows. Nowadays a different course is possible; modern cultivation implements worked by a tractor allow great scope for the suppression of weeds. There is, however, one crop that must be grown periodically to ensure the best results—clover or a mixture of clover and grass. Clover affords valuable food for cattle during winter, and it also enriches the soil in highly valuable nitrogenous organic matter. Much of this is the work of the plant itself, and could equally well be done by grass; but the enrichment in nitrogen is the work of bacteria residing in the nodules in the clover-roots and is unique among the phenomena of the farm.

Unfortunately, clover, unlike other crops, cannot be grown frequently on the same land, and, consequently, the farmer is unable to make as much use of it as he would like. Investigators have for many years been trying to increase the effectiveness of the clover organism, but without result. Inoculation of the soil with virulent strains has been tried, but it was unsuccessful in this country, although results are claimed in the United States. The problem has recently been taken up at Rothamsted, and one reason found for the previous failure. The organism has several stages in its life-history, one of which is a period of rest; some conditions favour a long rest, others a shorter one, and Mr. H. G. Thornton is endeavouring to find out how to increase the activity of the organism in the soil and ensure that its work shall be done. Attention is being devoted also to the causes of failure of the crop. The clover crop furnishes some of the most important problems in arable farming before us.

In the meantime, a working solution lies in growing an admixture of grasses with the clover. This reduces the risk of failure while considerably benefiting both soil and farmer.

A typical arable district is thus a busy region in which both farmers and workers are kept constantly occupied. The crops claim attention all through the year, and particularly in summer, while in winter the animals need attention. Four or more men can be regularly employed per 100 acres. An organized village life has developed, having distinctive characteristics of its own and presenting endless scope for the intelligent social worker.

Grass farming, on the other hand, stands out in sharp contrast with all this. The grass farmer puts his animals into the fields, and Nature does the rest; when they are fat he sells them to the butcher. It is essentially summer work; the winters are left free. As no man can long remain idle, there has been an extensive development of hunting and its attendant occupation, horse-breeding, in the English grass regions. While the grass farmer's life is not all idyllic joy, it is, at any rate, free from much of the worry and uncertainty of arable farming, and it brings in sufficient money to ensure a modest competence. One can quite understand the reluctance of the farmer to quit this path of safety.

If one could accept the doctrine that a man could do what he liked with his land, the grass farmer could be left alone and reckoned among Virgil's too happy husbandmen. But this doctrine is now somewhat out of court, and the needs of the community have also to be taken into account. From this point of view grass husbandry, in spite of its safeness for the individual farmer, is not so good for the community as arable farming, since it is less productive per acre of ground. This was realized before the war, and was vividly brought to the notice of farmers by Sir Thomas Middleton, who drew up the following table :—

Number of persons who could be supplied with energy for one year from the products of 100 acres of

Poor pasture converted into meat	2-4
Medium pasture ditto	12-14
Rich pasture ditto	25-50
Arable land producing corn and meat	100-110

The area of rich pasture is very restricted. An improvement can often be made in poor and medium pasture by the use of basic slag, by drainage, and in other ways, but the results could probably never surpass those now obtained on rich pasture. None of them approach the results obtained on arable land.

During the war, therefore, the policy of the Food Production Department was to convert grassland into arable, and much was done; but now that the element of compulsion has disappeared some of the arable has gone back to grass. It is not that the farmer is trying to avoid work; he is impressed by the greater risk of arable farming,* and, above all, he desires to keep to the well-established principle that his system of husbandry must suit the local conditions. This is strikingly shown by the following returns from a large number of farms :—

Collected by the Agricultural Costings Committee.

	Income per acre			Expenditure per acre			Profit† per acre			Capital per acre		
ENGLAND AND WALES—	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Mixed farms ..	9	12	5	10	2	11	1	7	2	13	9	0
Dairy farms ..	14	17	6	13	18	5	1	7	4	15	7	0
Corn and sheep ..	7	7	1	7	4	10	1	14	2	12	16	9
Large sheep farm ..	1	4	3	0	17	6	0	8	5	1	7	10
All-Scottish ..	5	10	9	4	15	10	1	4	11	7	7	9

The profit per acre from the large sheep farm is small in itself, but it is large in proportion to the capital and the expenditure, and, given a sufficient acreage, the farm is more lucrative than the more risky mixed or dairy farms. The risk of corn production can, and probably will, have to be met by some system of insurance or guarantee, but the need to conform to local conditions will always remain.

The problem therefore arises: Can a system of husbandry be devised which suits the natural conditions as well as grass, and is as productive of total wealth as arable crops? I believe this can be done. Grass is not the only crop adapted to moist conditions or

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* On our ordinary farm at Rothamsted (distinct from the experimental land) the expenditure on arable land is continuously increasing, while that on the grassland is much less. The figures are :—

	1913–14		1917–18		1918–19	
	£	s.	£	s.	£	s.
Wheat	5	7	10	14	14	0
Oats	6	4	9	7	14	5
Roots	17	10	20	18	36	0
Potatoes	21	1	37	11	46	0
Grass (hay) ..	3	12	4	16	6	0
" (grazing) ..	2	15	2	4	3	0

Direct wage payments account for about 40 per cent. of the expenditure on arable land, but for less than 15 per cent. of that on grassland.

† Including change in valuation.

heavy soils, and appropriate for the production of meat and milk. Many other leaf or root crops serve as well, some of which yield much more food per acre than does grass. Vetches, rape, mangolds, kale, and marrow-stem kale can all be used direct, and there are various mixtures of oats with peas, tares, vetches, etc., that can be fed green and made into hay or silage as the farmer may wish. The use of these crops in the place of grass for the feeding of livestock is known as the soiling system.

We are only just beginning to discover the combinations of crops best suited to particular conditions. An interesting experiment is in progress at the Harper Adams Agricultural College, which, however, should be repeated elsewhere. Each crop is governed by the same general laws as hold for cereals. In each case the yield and feeding value can both be increased by the proper use of artificial fertilizers, and there is the further possibility of great improvement by the plant-breeder.

It is in this direction that I think British agriculture will develop in the future. The system is strictly in accordance with the laws of science, and therefore it needs a minimum amount of artificial support. It gives the farmer abundant scope for the production of livestock, which he has always regarded as his sheet-anchor, and the community an abundant production of food per acre. Most important of all, while retaining the best features of our present arable and grass systems, it allows of considerable further development.

I shall not venture any opinion as to how far we could go in feeding ourselves. The accompanying table shows what we did before the war, and what, on our present technical knowledge, we could do now, assuming that the insurance problem of covering the extra risks of arable farming were solved, and assuming also a reasonable increase in the efficiency of labour.

In this country we can certainly hope to find the solution of the insurance problem, and I hope and believe of the labour problem also. Our output per acre of the arable crops is distinctly above that of many other countries, though we no longer lead as we did in the sixties. Our output per man, however, is not particularly good, and is open to considerable improvement. Those who know the agricultural labourer best have the fullest faith that his sterling qualities will enable him to rise to the new levels of industrial capacity which the man of science and the engineer have opened out for British agriculture. There are anxious days ahead, but with wise and sympathetic treatment the difficulties can be solved and our future assured.

Consumption and production of human food in the United Kingdom. Million tons per annum.

	Consumption (1909-13)	Home production		
		Pre-war	1919*	Estimated attainable
Wheat, barley and oats	13·4	6·5	7·0	10·0
Other cereals	3·5	..	..	..
Potatoes	5·5	4·8	6·3	7·0
Dairy produce	5·2	4·7	..	5·0
Meat	3·0	1·8	..	2·5

* Mr. McCurdy gives the following details for 1919 (see *Times*, February 18, 1920):—

Consumption and production of food in the United Kingdom, 1919.

Commodity	Estimated total consumption	Proportion of home-grown and imported produce included	
		Home-grown	Imported
	Tons	Per cent.	Per cent.
Wheat	7,395,000	27	73
Barley	1,956,000	64	36
Oats	1,297,000	92	8
Beef and veal	995,000	66	34
Mutton and lamb	368,000	57	43
Bacon and hams	447,000	19	81
Butter	180,000	58	42
Cheese	145,000	30	70

Notes. **Cereals**: The quantities are given after deduction for seed, and in the cases of **wheat** for tailings also. **Bacon**: The quantities given are for bacon as smoked or dried.

THE ORIGIN OF THE SUGARCANE.*

TRACING the passage of any cultivated plant from its wild conditions is always a fascinating amusement. Language, history, botany, all three lines have to be carefully followed out, and it is only by the convergence of the three that any certainty can be attained, especially when the cultivated form is no longer directly traceable to any wild ancestor. In the case of the sugarcane, all three of these lines are available in south-eastern Asia, and the result arrived at is that the sugarcane is thought to have arisen from a wild grass. widely spread over India and the parts of Asia east of it and extending over some of the islands of the Pacific. The presence of a very ancient language and literature in India has perhaps somewhat obscured the claims of oceanic islands which have none of these advantages. As to whether the Pacific Islands have a right to be considered as a home of the original plant from which the cultivated sugarcanes have arisen, this must be left to the last named line of study, namely, that of botany.

Saccharum spontaneum is the only wild species in the genus which has close botanical relations with the sugarcane, which is named botanically *Saccharum officinarum*. It is found in every part of India and shows itself remarkably sensitive in its varieties to the moisture of the locality. Thus in the Punjab it is a small wiry grass which causes considerable trouble in the fields; this form extends as far as the Central Provinces, but further south it is confined to wet places, ditches and river banks, and shows no inclination to become thicker and more cane-like in the tropical conditions of the Madras Presidency. In Bengal, Assam, and Burma, however,

* Reprinted from the *International Sugar Journal*, May 1920.

where the air is moister, a number of thicker forms are found with broader leaves, some of which, such as that met with in the ponds around Dacca, show a close approximation to the more primitive groups of indigenous Indian canes. The botanical evidence, therefore, suggests that the transition from the wild to the cultivated form may be most reasonably sought less in the tropical parts of India than around the north of the Bay of Bengal, and this is the view usually held. Even in the Punjab, where the wild cane is a field weed, the cultivator points to it as the ancestor of the sugarcane, and there is some evidence that in former times the thicker Bengal form was occasionally crushed, on the banks of the Hooghly, for its half-sweet juice.

But the fact must not be lost sight of that there are a number of distinct groups among Indian sugarcanes, and it is only in the primitive Saretha series that this line of derivation is clearly seen. Many of the members of this group show marked resemblances to the wild *Saccharum spontaneum*. The varieties differ a great deal among themselves and, starting with primitive forms in the Punjab, extend east and south ever increasing in size as they approach more congenial conditions of climate. The Sunnabile group, with a similar distribution, show some evidence of being derived from the same source, in that its most primitive forms in the Punjab are with some difficulty distinguished from the smaller Saretha varieties. But the connexion between these two groups and the Mungo, Nargori, and Pansahi are obscure, and if they are to be traced also to *Saccharum spontaneum* one can only suggest that, at some former time, the whole species passed through a mutational period whereby a series of new forms were developed which have served as the starting points for these three groups. They are among themselves much more homogeneous, and as distinguished from the Saretha and Sunnabile give rather the impression of being merely cane varieties which have undergone slight modifications through being long grown under special climatic conditions. They would thus appear to be of later origin and are, as might be expected, much more restricted in their geographical range. The same line of development might be suggested lastly for the thick cane group, if we are to regard them also as having arisen in India from a wild ancestor. But it occurs to the writer that, in considering their characters, we may have to look to another place for the origin of the tropical forms. The common origin of the whole of the cultivated sugarcanes was assumed at a time when no careful morphological studies had been made of them. During the past eight or nine years this part of our knowledge of the sugarcane has made great strides, and various systems of natural classification have been worked out, founded on variations in the character of the different vegetative organs of the plant. A serious attempt has, at the same time, been made to form a continuous series, commencing with the wild *Saccharum spontaneum*, passing through the indigenous Indian canes, and culminating in the thick tropical varieties which form the main sources of our commercial sugar in the tropics.

In many sugar-growing countries, where the conditions have proved adverse to these comparatively delicate thicker canes, members of the Indian groups have effected a footing. The most important, from our point of view, of these introductions has been that into South America, for it appears to have occurred so long ago that no one can say exactly when it took place; and it has only been by the exact study of the Indian groups that the source of the immigrant has been definitely settled. This throws some light upon the theory, somewhat loosely held, that the thicker tropical forms have been derived from the more primitive Indian forms by long acclimatization in warmer, moister regions. Influenced by this belief, a series of the North Indian forms were brought down to Madras some eight or nine years ago, and grown continuously under the same conditions as the tropical canes usually planted there. It was desired to see if any change in the direction of thick cane characters would take place. The period is of course far too short for any reliable opinion to be formed, but it may be recorded that there appears to be no trace of any change. The discovery that the South American thin canes were of the Pansahi group, still retaining all the peculiar morphological characters of that class, was at once recognized as of importance in the enquiry; and it was this that first suggested to the writer that the gulf between the Indian canes and those of the tropics was insuperable within the limits of agricultural time. The idea of a separate origin of the thick cane group has recently been strengthened by an appreciation of the fact that, at one time and another, the finest of the tropical canes have been received from among the islands of the Pacific, where no careful agricultural selection was likely to occur. The supposed origin of the Bourbon cane from Malabar need not be taken very seriously, for anyone acquainted with the character of the canes growing there will find it difficult to believe that such a form could have been otherwise than a temporary introduction by the Portuguese, if ever it got there. Quite recently a magnificent series of new canes, fully equal to any that have brought wealth in the past to the cane-growing countries of the tropics, have been discovered in the unexplored recesses of New Guinea, a place sufficiently remote to make it practically impossible that these could have been derived from India. We are driven then to conclude that the thick cane group, essentially different in so many respects from the indigenous Indian ones, has arisen from a separate centre, namely, the mountainous islands of the Malay Archipelago and Polynesia. It is interesting to note that *Saccharum spontaneum* is recorded as indigenous in many of these islands as well as in India, so that we have still the possibility of this species being the ancestor of the thick canes. But it seems to the writer probable that, in the absence of connecting links, it is more reasonable to assume that the thick canes as a group arose rather from an allied species now lost in the wild state. This separate origin would do away with the anomaly that, while in the Indian series the capacity of producing fertile flowers and seedlings steadily diminishes with distance from the wild form, it returns in full force with the thick canes, which in any connected series from a common origin would presumably be the most highly developed of the cultivated varieties and groups. [C. A. B.]

Notes

THE GINNING PERCENTAGE OF COTTON IN ITS RELATION TO THE SEASON.

During the past four years the Padu Experimental Station (Sagaing District, Burma) has experienced one exceptionally unfavourable season for upland cultivation, and in that season the ginning percentages as well as the yields of all the cottons under cultivation uniformly dropped. The writer has nowhere seen it recorded that the character of the season has such a marked influence upon the proportion of lint to seed and he is seeking to know whether this has been the experience of others.

In the accompanying table it will be seen that, whilst the relative ginning percentage of the different strains remains nearly the same, they have each dropped roughly about 3 per cent. during the year 1918-19. In the following normal season those of which the cultivation has been continued have returned to their normal ginning percentages of the previous years.

Ginning percentages of cotton in relation to season.

Year	Climatic conditions (especially as regards rainfall	Ginning percentages of cotton: Selection No. 2001	Selection No. 2002	Selection No. 2005	Selection No. 2006	Selection No. 2103	Selection No. 2106	Selection No. 2107	Selection No. 2108	Local mixture
1916–17 ..	Rainfall heavy (38·58 inches), favourable to upland cultivation	33·53	34·11	33·94	32·00	32·87	35·75	36·21	34·48	30·98
1917–18 ..	Rainfall very good (33·69 inches), season very favourable to upland cultivation ..	33·49	33·89	33·86	34·21	30·33	36·79	38·58	35·29	32·45
1918–19 ..	Rainfall poorest on record (20·10 inches) and badly distributed, very unfavourable season for upland cultivation	(a) 30·38 (b) 30·47 av. 30·42	(a) 30·78 (b) 30·85 av. 30·81	(a) 30·68 (b) 31·31 av. 30·99	(a) 29·27 (b) 29·89 av. 29·58	(a) 30·00 (b) 30·49 av. 30·24	(a) 31·25 (b) 32·30 av. 31·77	(a) 32·17 (b) 33·79 av. 32·98	(a) 33·86 (b) 33·11 av. 33·48	28·91
1919–20 ..	Rainfall good (29·92 inches), favourable to upland cultivation		(a) 34·28 (b) 34·01 (c) 34·41 av. 34·25	(a) 33·33 (b) 33·56 (c) 33·34 av. 33·41	..	..	..	(a) 36·54 (b) 36·88 (c) 36·59 av. 36·66	(a) 35·29 (b) 35·33 (c) 36·36 av. 35·67	32·67

The Padu Experimental Station is situated in a dry tract growing principally wheat, gram, cotton and sesamum—the two last being cultivated almost entirely on the coarse, red, sandy soils of the uplands only. The rainfall is a capricious one, and if it be the case that the season has so marked an effect the ginning percentage of cotton from this region will be very difficult to maintain from year to year. [E. THOMPSTONE.]

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AGRICULTURAL EDUCATION IN MADRAS.

THE question of attracting a better class of students to the Agricultural College at Coimbatore has for some time past been under consideration of the Government of Madras. The present courses at the college were introduced in 1914 when the old three years' course was replaced by one extending to three years and a half. The first two years of the course formed in itself a separate (certificate) course mainly devoted to agriculture, while the remaining one and a half years' course, devoted to sciences allied to agriculture, formed a continuation of the first and qualified for a diploma. The working of this course and the standard attained by students admitted under it have, however, been the subject of some discussion, and the Local Government have now decided that the certificate and the diploma courses should be separated from the beginning; and that, while the qualification for admission to the certificate course should ordinarily be a Secondary School-Leaving Certificate, that of the diploma course should be the Intermediate Examination of the University with Physics, Chemistry or a Biological Science. The Local Government have further authorized the Director of Agriculture to award annually scholarships of the value of Rs. 25 each per mensem to students not exceeding twenty in number. It has also been decided that tuition and lodging will, as heretofore, continue to be provided free of charge. [EDITOR.]

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SEED ELECTRIFICATION.

MESSRS. SUTTON AND SONS, Reading, have published an interesting contribution to the literature on seed electrification. This bulletin (No. 11) presents the results of a number of germination and field tests carried out in 1919 with seeds of carrot, swede, cabbage, and mangold. The best-known process of seed electrification, *viz.*, the Wolfryn process, consists in immersing the seeds in a solution either of common salt and water or of calcium chloride and water, through which an electric current is then passed. After this treatment the seeds are dried at a temperature of 100°F., and they are then ready for sowing. Obviously two processes are here involved, seed immersion and seed electrification, and the Reading experiments were designed primarily to test the value of the Wolfryn process, and secondarily, if there are advantages, to decide whether they are due to the immersion, to the electrification, or to both agents combined. Tests were made with untreated seeds, with seeds electrified by the Wolfryn process, with seeds soaked in a solution of sulphate of ammonia, and with seeds soaked in a solution of salt and water, the strength of the solution being the same as that used in the Wolfryn process. After immersion the seeds were dried at 100°F. and then sown. Regarding the tests as a whole, they do not reveal any advantage from seed electrification, the only possible exception occurring in the case of mangolds, where the germination of the electrified seed was 94 per cent. compared with 82 per cent. for the untreated seed and 86 per cent. for the seed soaked in the salt solution, while in the field tests the electrified mangold seed yielded 62 lb. per pole more than the untreated seed. In all other cases either the electrified seed gave a lower yield than the seeds treated in other ways, or the increase following electrification was so small as to be negligible. [*Nature*, May 13, 1920.]

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LOW-GRADE SUGARCANE MOLASSES (BLACKSTRAP).

THERE is, perhaps, no stock-feeding material that has aroused so much general interest among stockowners and feeders in this country (Louisiana) as low-grade sugarcane molasses, or "blackstrap.". . . .

The term "blackstrap" is given to the low-grade uncrystallizable residue of the sugar-making, or sugar-refining, process, which at one time, in Louisiana at least, was discarded as of no economic value and, consequently, wasted, so far as its feeding importance was concerned.

The use of molasses as an appetizer and tonic for stock has been in vogue with owners and feeders for quite a length of time, however; but as a food nutrient of the carbohydrate class, its extensive and intelligent adoption dates back only to more recent years, and it is being utilized now, not only as a regular ingredient of mixed rations on plantations and farms, but by the commercial world in the various so-called "sweet feeds" that are to be found upon the market.

It should be understood, however, that while blackstrap is a most valuable food of its class it is not a perfectly-balanced food in itself, as it supplies, in the main, only one of the nutritive elements (carbohydrates) of a mixed and balanced ration.

It is valuable for at least four very good reasons, *viz.*, (1) its palatability; (2) under normal conditions, its cheapness as a source of the carbohydrate element-sugar; (3) its high carbohydrate content approximating 53 per cent.; and (4) the almost complete digestibility of its contained carbohydrates.

It is the writer's opinion that the marked success which has attended its adoption during the past number of years is almost wholly due to its palatability; its condimental effect in promoting more perfect digestion of other feeds fed with it; and the readiness with which it can be absorbed into the blood system of the animal for purposes of nutrition.

The earlier analysis of blackstrap showed a somewhat higher percentage of carbohydrates—sugar; but owing to the increased efficiency in the process of producing sugar to-day, the percentage of its carbohydrates has been reduced to some extent.

The following may be taken as an average of its composition at the present time:

Dry matter	Water	Ash	Carbohydrates
%	%	%	%
77·75	22·25	8·13	53·58

Some years ago the writer addressed a questionnaire to some forty-seven large sugar-plantation-owners in Louisiana to try to obtain some more or less definite information regarding results they might have had after utilizing their blackstrap in the feeding of their work mules, the number of which approximated 4,500 head. In the replies received, practically everyone conceded to a considerable saving in the amount of his feed bills ranging from ten to fifty per cent. or more; and all seemed to refer to the marked diminution in the number of cases of dietetic troubles, such as colic, etc.; and that the health, and, therefore, the capacity of the animals for work, was very much improved.

One could scarcely wish for a higher endorsement of any food product, in the case of horses and mules at least.

The feeding of molasses is not now confined to horses and mules, however; it is being used with equal success in the feed-lot; in the dairy; in the hog-pen, etc.

From inquiries received, it would seem that some feeders not hitherto accustomed to the use of molasses do not appear to quite understand how it should be used to the best advantage.

Here it may be stated that its economic use would depend upon the availability and cost of other carbohydrate concentrates.

For example, if corn should be expensive, and molasses considerably cheaper, it would reduce the cost of the ration if part of the corn should be replaced by its equivalent weight of molasses, as the sugar in the latter, while not quite equal to in amount, approximates the starch in the corn, both of which have the same chemical composition. However, we do not deem it altogether advisable to make a complete substitution; but a partial substitution will frequently economize in the use of corn under high-priced conditions.

Again, it is better to feed molasses where the other ingredients of the ration are in a crushed or mealy condition so as to insure better mastication, or chewing of the whole. When fed with whole grains alone, such as oats or corn, there is a tendency or liability on the part of the animals, especially horses or mules, to "bolt" their food without the necessary chewing of the grains.

For different classes of animals, we submit the following example.

For horses or mules weighing 1,000 lb. doing hard work and per day:

Lb.

2 Cottonseed meal,
6 Cracked corn or chops,
6 or 7 Blackstrap,
12 Peavine, alfalfa, lespedeza, or any of the good leguminous hays.

[W. H. DALRYMPLE in the *Louisiana Planter and Sugar Manufacturer*, Vol. LXIV, No. 20.]

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A NOTE ON SOME PRELIMINARY EXPERIMENTS FOR STUDYING CROP IRRIGATION.

THE usual bed method of irrigating garden crops in the Bombay Presidency, even when small ridges are made and the water is impounded, is open to many criticisms, chief of which is that it causes the formation of a crust. when the water sinks into the soil, from which evaporation goes on at a rapid rate. Moreover, while the water is standing over the soil, the circulation of the air in the soil is checked if not altogether stopped.

When water remains impounded for some time, as is often the case in sugarcane cultivation, thus stopping the circulation of air, the oxygen for the growth of the roots and the soil organisms become deficient and their activities stop or proceed at a very low rate. If anaerobic conditions continue those organisms which are injurious may become established. Denitrification of the manurial substance may occur or pathological changes in the plants. due to such organisms as sugarcane red rot (*Colletotrichum falcatum*) and ginger soft rot (*Pythium gracile*). may result.

Continued wetting of the soil in bed irrigation has a puddling effect, as the fine particles of the soil are washed downward and become packed into the interstices so that capillary movement and even percolation become reduced, often to such an extent as to make the soil unsuitable as the home of plant roots and of those beneficial nitrifying bacteria which effect the transformation of manurial matter into plant food.

When small beds are made, the useful operations of after-tillage so necessary to keep the soil in a healthy condition are hindered as all that can be done must be accomplished by inefficient and expensive hand-work.

The curtailment of intertillage necessitated by the small bed system allows the soil puddling and evaporation to go on unhindered.

The ideal soil condition requires that the finer particles must be united into granules to form a crumb-like structure over the particles of which a film of capillary moisture will freely move in all directions and through the interstices between the granules the soil air will circulate freely as it is acted upon by the wind at the surface and the changes of temperature. Under such conditions the roots and the beneficial soil organisms make their maximum growth, while morbid and denitrifying organisms are destroyed or held in check.

How can irrigation be applied so as to enable us to maintain the soil in this condition as near as possible and at the same time avoid as much loss by percolation below the reach of plants and through surface evaporation is the problem.

This condition of the soil can only be obtained by suitable and thorough cultivation together with the application of abundant supplies of organic matter, and is maintained by timely after-tillage operations and the application of irrigation water by such methods as will have the least possible tendency to destroy the condition of the soils described above.

The actual method of achieving this desirable result has been the subject of considerable experiment at Manjri and Poona College stations.

It is plain that it is easier to protect as far as possible the area from becoming injured through standing water than to restore its physical condition, or in other words we should aim at wetting the least possible amount of the soil surface. This means that wide strips of soil on which water has not been impounded should alternate with the narrowest possible furrows which receive water and a high degree of tilth be maintained on the dry surface soil which would act as a mulch to prevent evaporation. The granulated soil below this mulch having a highly developed capacity for capillary movement will speedily draw the moisture from the wet furrows.

The plant roots should develop in this sub-surface layer of capillary-fed soil below the dry mulch.

A certain amount of time is required for water to spread by capillary movement from the furrow throughout the strips, which may be called growth strips of the field, and water should be kept in the furrows sufficiently long to enable it to thoroughly permeate the growth strip. The time for this process will vary according to the nature of the soil and the width of the strip. The water in the furrow may be maintained for the necessary length of time by two ways. First by impounding a large furrow full. This necessitates level furrows and is accompanied with considerable loss by downward percolation if the soil is at all pervious; moreover it wets a wider strip than necessary, thus producing the injurious action of stagnant water over the part wetted, which must be overcome by later operations, else there will be a loss in the total production of the field as well as a loss of water. The other method which seems to me to be the only rational system for irrigation practical in this part of India is to allow a very small stream to trickle down each furrow.

Experiments have been made at Manjri with the rates of current required to wet a five feet growth strip, and it has been found that a rate of one hundred feet per thirty or forty minutes when the land does not slope over one inch in three hundred feet gives the best results. The rate at which the water should be allowed to move down the furrow depends upon the following conditions :—

1. The capillarity of the soil which depends upon the natural texture, its composition and the state of granulation brought about by the tillage and manure.
2. The width of the growth strip.

3. The length between cross distributing furrows.
4. The slope of the furrow.
5. The depth of soil which is in a condition to hold capillary water and which the plant roots can reach.
6. The amount of water that is necessary to keep the growing strip in the optimum moisture content (*wafsa*).

The width which should be assigned to the growing zone depends upon the conditions named above in one, five and six.

Having determined the rate at which the water should flow either by actual experiment or experience, it is maintained by regulating the size of the stream with the head available.

For regulation I have found tile dams for each furrow to be the simplest and cheapest. These can be made with different sizes of openings and the stream can be varied by sloping the dams, thus increasing the head at their discharge. Work is going on to determine the rate of flow for different types of soil and crops.

The lower ten feet will usually get sufficient water if the holes in the tiles are plugged with mud when the water reaches within ten feet of the end. In order that the work may be completed as expeditiously as by the bed system a large number of furrows must be receiving water at the same time.

I feel that if this system of watering could be generally introduced the water duty of our canals and wells could be increased to an almost incredible extent and waterlogging or salt land trouble become unknown. [J. B. KNIGHT in the *Poona Agric. College Magazine*, Vol. XI, No. 4.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WE deeply regret to record the death of Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, which sad event took place at Mussoorie in the morning of Friday, the 20th August, 1920, after a serious operation. We offer our heartfelt condolences to his mother in her bereavement.

THE HON'BLE RAO BAHADUR B. NARASIMHESWARA SARMA GARU has been appointed an Ordinary Member of the Council of the Governor-General of India, in charge of the Department of Revenue and Agriculture.

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MR. J. HULLAH, I.C.S., is confirmed in the appointment of Secretary to the Government of India, Department of Revenue and Agriculture, with effect from the 27th June, 1920.

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MR. S. MILLIGAN, M.A., B.Sc., Director of Agriculture, Bengal, has been appointed Agricultural Adviser to the Government of India, and Director, Agricultural Research Institute, Pusa, with effect from the 18th June, 1920.

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THE names of the following officers have been added to those brought to the notice of the Secretary of State for War for valuable services rendered in India in connection with the war :—

COLONEL G. H. EVANS, C.I.E., C.B.E., A.D.C., Indian Army (Superintendent, Civil Veterinary Department, Burma).

LIEUTENANT (TEMPORARY MAJOR) K. HEWLETT, O.B.E., Indian Defence Force, Veterinary Corps (Principal, Bombay Veterinary College).

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WE congratulate Dr. C. A. Barber, C.I.E., late Sugarcane Expert to the Government of Madras, on his appointment by the Board of Agricultural Studies, Cambridge University, as a Lecturer in Tropical Agriculture for a period of five years.

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DR. E. J. BUTLER., M.B., F.L.S., Imperial Mycologist and Joint Director of the Agricultural Research Institute, Pusa, has been granted privilege leave for two months, with effect from the 22nd July, 1920.

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MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, is appointed to officiate as Joint Director of the Agricultural Research Institute, Pusa, *vice* Dr. E. J. Butler on leave.

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MR. W. MCRAE, M.A., B.Sc., F.L.S., Government Mycologist, Madras, has been appointed to officiate as Imperial Mycologist, Pusa, *vice* Dr. E. J. Butler on leave.

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MR. G. EVANS, C.I.E., M.A., Deputy Director of Agriculture, Central Provinces, whose services have been placed at the disposal of the Government of Bengal, has been appointed Director of Agriculture, Bengal, *vice* Mr. S. Milligan.

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DR. R. V. NORRIS, Government Agricultural Chemist, Madras, has been appointed to act as Principal, Agricultural College, Coimbatore, during the absence of Mr. W. McRae on other duty.

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MR. G. R. HILSON, B.Sc., Deputy Director of Agriculture, II and III Circles, Madras, has been appointed Government Economic Botanist, Madras, for work on cotton, with headquarters at Coimbatore, with effect from the date of his return from leave.

MR. F. WARE, M.R.C.V.S., Superintendent, Civil Veterinary Department, Madras, has been granted combined leave for eight months.

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MR. S. SUNDARARAMAN, M.A., has been appointed to act as Government Mycologist, Madras, *vice* Mr. W. McRae on other duty.

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MR. E. BALLARD, B.A., F.E.S., Government Entomologist, Madras, has been granted privilege leave for one month, Mr. T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., officiating.

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MR. F. T. T. NEWLAND, Government Agricultural Engineer, Madras, has been granted privilege leave for two months, Mr. V. Rangachar Avargal officiating.

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THE HON'BLE MR. H. M. LEAKE, M.A., F.L.S., Officiating Director of Agriculture, United Provinces, has been confirmed in that appointment with effect from the 26th May, 1920.

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MR. G. CLARKE, F.I.C., Offg. Principal, Agricultural College, Cawnpore, has been confirmed in that appointment.

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MR. W. YOUNGMAN, B.Sc., Offg. Economic Botanist to Government, United Provinces, has been confirmed in that appointment.

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BABU RAM PRASAD, Assistant to the Economic Botanist, has been appointed to officiate as Assistant Economic Botanist to Government, United Provinces.

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MAJOR E. W. OLIVER, M.R.C.V.S., F.Z.S., Superintendent, Civil Veterinary Department, United Provinces, has been granted combined leave for seven months and seven days.

CAPTAIN S. G. M. HICKEY, M.R.C.V.S., Second Superintendent, Civil Veterinary Department, United Provinces, will hold charge of Major Oliver's office, in addition to his own duties, during the latter officer's absence.

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MR. D. MILNE, B.Sc., Economic Botanist to Government, Punjab, has been granted combined leave for eight months. Lala Jai Chand, M.Sc., officiates.

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MR. T. A. MILLER BROWNLIE, C.E., M.I.W.E., M.I.M., I.C.E., Agricultural Engineer, Punjab, has been granted combined leave for eight months. Mr. P. A. MacCormack, retired Executive Engineer, P. W. D., officiates.

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MR. F. J. WARTH, M.Sc., Agricultural Chemist, Burma, took over charge of the duties of Deputy Director of Agriculture, Southern Circle, Burma, in addition to his own duties, on the 11th June, 1920.

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THE Secretary of State for India has granted to Mr. T. Rennie, M.R.C.V.S., Second Superintendent, Civil Veterinary Department, Burma, an extension of furlough for 15 days.

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ON return from the combined leave granted to him, Mr. J. H. Ritchie, M.A., Deputy Director of Agriculture, is posted to the Northern Circle, Central Provinces.

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MR. C. P. MAYA DAS, M.A., B.Sc., Officiating Deputy Director of Agriculture, Western Circle, Central Provinces, is granted combined leave for three months.

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RAI SAHIB BHAIYALAL DUBE, Officiating Deputy Director of Agriculture, Northern Circle, Central Provinces, has been posted to the Western Circle, *vice* Mr. Maya Das on leave.

MR. S. T. D. WALLACE, B.Sc., Assistant Director of Agriculture, Nagpur, has been appointed to officiate as Principal, Agricultural College, Nagpur, *vice* Mr. Nand Kishore reverted as Extra Assistant Director of Agriculture, Jubbulpore.

Reviews

The Cultivation of Ragi in Mysore.—By LESLIE C. COLEMAN, M.A., Ph.D. [Department of Agriculture, Mysore State, Bulletin No. 11. Pp. 67+20 plates+1 map.]

THIS bulletin records the results of a very complete series of experiments conducted by the Mysore State Department of Agriculture with a view to the ultimate improvement of the *ragi* crop (*Eleusine coracana*). This millet covers over one-third of the total cultivated area of the State and is said to be the staple food of four-fifths of its people. The crop is grown chiefly on the laterite soils of the State, which, as a rule, are poor in the more important plant food constituents. These soils in addition possess a low water-holding capacity and dry out rapidly. It, therefore, follows that in addition to varietal tests, experiments with manures and tillage are of first-rate importance.

From a perusal of the bulletin it will be seen that considerable success has been obtained along these three main lines of investigation. For instance, one of the selected strains, Hebbal 22, possessing drought-resistant qualities and freedom from 'shedding' gives a superior yield of grain and straw estimated at over 7 per cent. above the best purified local variety. It is considered that it will not prove a difficult matter to extend the area under this variety to 50,000 acres, representing a money outturn of Rs. 25 lakhs per annum, within the next 5 years. Manurial experiments have demonstrated the great value of leguminous green manures, and it is estimated that the value of a suitable green manure is equivalent to the application of from 6 to 10 cartloads of cattle manure. In the tests, cowpeas and sann-hemp have proved the most suitable green manure plants, and, as the cost of sowing and ploughing in green manure does not exceed Rs. 5 per acre, these results may be considered of first-rate economic importance to *ragi* cultivation in the Mysore State.

Good results have also been obtained by earlier and better cultivation which enables the soil to absorb early rains and which increases its moisture capacity. Illustrations are given of the most suitable cultivation implements including barshare plough, which, on account of its easy adjustment to wear, has proved the most satisfactory type. The disc harrow has proved useful for preliminary cultivation in cases where there is insufficient moisture for the plough. It is stated that after several runs with this implement it is possible to produce sufficient mulch in even the hardest soils to save the moisture from the first showers which is too often lost in hard baked land. The cost of the implement, however, is rather a serious factor against its general introduction.

The last chapter of the book is devoted to diseases and pests of *ragi* and in the appendix a great deal of useful information regarding the crop is given.

Dr. Coleman and his staff are to be congratulated on the thorough manner in which the improvement of this important crop has been studied and the large measure of success which has attended their efforts.—[EDITOR.]

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Ammonification of Manure in Soil. By J. W. BRIGHT and H. J. CONN. [New York Agr. Expt. Sta. Technical Bulletin No. 67, April, 1919.]

THIS bulletin is divided into two parts.

Part I by J. W. Bright deals with the soil organisms which take part in the ammonification of manure. The author finds that non-spore-formers like *Ps. fluorescens* and *Ps. caudatus* are the most important ammonifiers of manure in the soil, while spore-formers like *B. cereus* do not take part in the process. The author's results are based chiefly on the evidence furnished by platings before and after addition of organic manure. The statement that there is no evidence that *B. cereus* takes part in this process has to be accepted, however, with caution, because the author has already shown that although colonies of *B. cereus* do not develop in the presence of *Ps. fluorescens*, still *B. cereus* is a vigorous ammonifier converting large amounts of organic nitrogen into ammonia acting by itself when inoculated in soil which has been sterilized after addition of organic manure.

Besides, although large number of non-spore-formers like *B. fluorescens* have been observed to be active after addition of organic manures, their true function may not be ammonification, but probably the destruction of carbohydrate material and the production of CO_2 as indicated by a close similarity of curves for bacterial numbers and CO_2 in many other cases.

In the second part, which is by H. J. Conn, we find a detailed description of the two organisms *Ps. fluorescens* and *Ps. caudatus* as an aid to their identification by others. A bibliography is appended.—[N. V. J.]

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