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This variety is not cultivated to any large extent anywhere in the State. A few plants are grown in some banana gardens at Kozhencheri and other places in Central Travancore. The pseudostems are about 12 feet high and about 26 inches in girth at the base. The leaves are narrow and about 8 feet in length. The lamina base on the left side is two inches longer than the right and is acuminate on the petiole, while the right side is truncate. The petiole is about 16 inches long. The margins of the petiole are dark red to a width of a sixteenth of an inch. Peduncle is pubescent. Bracts and the male flowers are persistent. Bunches are rather closely packed and heavy. Fruits are nearly terete and are about 6 inches long without a distinct apex and with part of the style persisting. The skin of the fruit does not turn yellow on ripening but remains green in colour. The fruits are sweet and have good flavour. It deserves to be cultivated extensively.

My thanks are due to Sri T. R. Naganatha Ayyar for assisting me in this investigation.

The Deleterious After-effects of Sorghum—A Review.

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The deleterious effects of sorghum on crops that follow have been extensively reported upon by American workers—Bennet (1897), Ten Eyck and Shoe Smith (1906), Snyder and Osborn (1915), Willaman et. al. (1919), Vinall and Ghetty (1921), Breazeale (1924) and Conrad (1927, 1928, 1932 and 1937). Fletcher (1912) observed the adverse effects of sorghum on a succeeding crop of *Sesamum indicum* in experiments conducted by him in Surat, Bombay. Ramanatha Ayyar and Sundaram (1941) have recorded that similar to their observations on the black soils of Tinnevelly, the harmful effects of sorghum have been noted under conditions obtaining in the Coimbatore, Salem and South Arcot districts of the Madras Presidency. Breazeale (l. c.) however states that in China, sorghum is grown year after year upon the best land and that no injurious effects have been visible.

Causes of sorghum injury. American workers attribute the deleterious effects of sorghum on the succeeding crops to one or more of the following.

a) Toxic products of decay of roots and stubbles which harm the succeeding crop.
b) Decomposition products of crop residues encouraging the growth of certain micro-organisms which in turn compete with the succeeding crops for essential food elements.
c) Toxic root excretions.
d) Depletion of plant food by the heavier feeding sorghum.
e) Depletion of moisture.

In the black soils of the Tinnevelly district, however, where the injurious after-effects of sorghum on the succeeding cotton crop is a well known feature, intensive studies by Ramanatha Ayyar and Sundaram (l. c.) showed that the "sorghum effect" observed in this tract was due to none of the above causes. It was concluded by them that the effect was primarily due to the rise of replaceable sodium in the soil and consequent alkalinity produced by the growth of the sorghum crop. They however point out that the "sorghum effect" under the 'Tinnies' conditions is very much different from that met with in America where the effects are reported on shallow rooted cereals like wheat and small grains, while in the 'Tinnies' tract the effects felt are on the deep rooted cotton crop.

Toxic products of decay of sorghum residues. The idea that the decomposition products of sorghum roots and stubbles give rise to products that are injurious to the succeeding crop has found favour with several workers. Sewell (1923) observed that in pot cultures where wheat received its moisture solely from water percolating through perforated trays in which corn and kafir crops were growing, the growth of the kafir plants inhibited the development of wheat. From this he concluded that there are decomposition products from the crop residues of kafir which have a retarding effect on the growth of wheat which follows. Breazeale (l. c.) grew wheat in water cultures containing chopped up pieces of kafir stubble and found that a toxic property was developed during the decomposition of the stubble that was injurious to wheat plants. From a mixture of kafir stubble and water he distilled off a poisonous compound that would kill wheat plants in a few hours. He found, however, that the toxic body resulting from the decomposition of the stubble was quickly decomposed into non-toxic substances. He also observed that while the toxic body is in the soil, the flora that generates CO_2 is to a large extent killed, and this tended to produce deflocculation in the soil. Hawkins (1925) found that the sorghum root residues are not so detrimental to plant growth as are the stalks. He observed that the detrimental effects disappeared in a few months, and that certain crops like field peas which do not use the upper parts of the soil as do the sorghum plants are not depressed in growth following a crop of sorghum. Ramanatha Ayyar and Sundaram (l. c.) however, found that in the black soils of Koilpatti the addition or removal of sorghum stubble did not make any difference in yields in succeeding cotton. The toxicity of sorghum stubble was also sought to be eliminated by ploughing in the residues early (as recommended by Breazeale) but it was found that the ploughing had not produced any more beneficial effect than the treatment 'not ploughed'.

Increased growth of micro-organisms that compete with the succeeding crops. It was estimated by Conrad (l. c. 1) that sorghum roots may contain as much as 15 times the amount of sugar as is contained in the roots of corn and that when this is liberated into the soil after harvest, it stimulates the growth of certain micro-organisms which in turn compete with the succeeding crops for nitrogen and possibly other essential elements. The sorghum root decay may also depress nitrification. He believes, along with others, that the after-effects disappear in a few months and that this period may be hastened by the removal of stalks and stubble and by inducing rapid decomposition. Wilson and Wilson (1928) suggest that the injurious after-effects of sorghum may be associated with the comparative ease with which its roots are oxidised in the soil. This process which is accompanied by an increase in the number of soil organisms and an increase in the assimilation of nitrate nitrogen would tend to deplete the soil of nitrate nitrogen. The extent to which these forces are operative in the soil when young plants are in need of nitrogen, may determine the amount of injury which the sorghum crop exerts on those crops that follow.

Toxic root excretions. The question of toxic excretion from roots of sorghum was investigated by Ramanatha Ayyar and Sundaram (l. c) by studying the effect of the soil leachates from plots cropped with sorghum and *Pennisetum typhoides* as well as from fallow plots. These leachates were used to irrigate cotton plants raised in sand-cultures. No differences were observed in the growth of the cotton plants.

Depletion of plant foods. Holter and Fields (1899) and Harper and Murphy (1930) were of the opinion that the deleterious after-effects of sorghum were due to the greater depletion of plant foods by the sorghum plants. Sewell (l. c.) observed that kafir removes more fertilising elements from the soil than corn, but that this does not sufficiently explain the effect of kafir in depressing the yield of wheat. He also observed that the growth of kafir does not affect the ability of the soil to liberate nitrogen. Ball (l. c.), McKinley (1931) and Miller (1931) were not in favour of the view that the heavier feeding of sorghum sufficiently explains its deleterious effect upon succeeding crops. Ramanatha Ayyar and Sundaram (l. c) found that in the black soils of Koilpatti, neither the application of manures to correct possible depletion nor the reduction of dry matter produced by the sorghum crops as effected by growing sorghum in thinner stands, showed any improvement in the deleterious effects of sorghum on the cotton crop which followed it. They concluded that in the conditions existing in the black soils of Koilpatti, soil exhaustion was not the cause of the deleterious effects observed.

Depletion of moisture. It has been suggested that under certain conditions where moisture is a limiting factor, the depletion of moisture by sorghum may account in part for its deleterious after effects (Ball, l. c.; Breazeale, l. c.; Conrad, l. c. 1, l. c. 4). On the other hand, Ramanatha Ayyar and Sundaram (l. c.) found that in spite of the low rainfall, the aridity and the close spacing for sorghum adopted in the black soils of Koilpatti, the deleterious after-effects of sorghum on the succeeding cotton crop could not have been brought about by deficiencies in soil moisture.

Production of alkalinity and injury to soil texture. Hawkins (l. c.) observed that soils cropped with sorghum are poor in physical condition. He attributed this in part to the fact that sorghum plants as they approach maturity have much more abundant roots as compared with corn in the upper 6—8 inches of soil. It was also noted by him that certain crops like field peas which do not use this upper part of the soil as do the sorghum roots are not depressed in growth. Ramanatha Ayyar and Sundaram (l. c.) found that in the black soils of Koilpatti, the well marked physical condition of the sorghum soils, viz., "lower cracking", "earlier erodability", reduced percolation, higher dispersion values and cloddy condition could be explained by the increased alkalinity exhibited by such soils. They observed that the growing of both *P. typhoides* and sorghum disturbed differently the Na-ion contents of the soil. In soils cropped with sorghum, the rise of replaceable sodium was greater with the growth of the crop but its later decline was much slower than that in the case of *P. typhoides* plots. As a consequence, the former soils were left more alkaline at the time of sowing of the succeeding crop of cotton, which condition would appear to be responsible for the lower yields recorded after sorghum crops. They also noted that the seed setting and duration of sorghum influenced the intensity of the deleterious effects of sorghum, since the effect was not manifest in the crop cut at the shot blade. This phenomenon they ascribed to the normal penetration of the sorghum roots into the alkaline region of the soil below the second foot. They could not get conclusive results regarding the correctives they tried for this alkalinity, but it was surmised that the application of correctives in the lower layers might show some response. Ploughing experiments showed that these soils were not benefited by cultivating them prior to the sowing of cotton; therefore a saving in the cost of cultivation could be effected by reducing preparatory cultivation to the minimum. Thick sowing of cotton improved the yields of cotton in 'after sorghum' plots both in good and poor seasons of rainfall.

Remedies suggested. Conrad (l. c. 1) suggests that since sugars and possibly other carbohydrates are the primary source of injury, every means should be adopted to reduce the amounts entering into the soil by the removal of stalks and stubble, growing sorghum in thinner stands and planting varieties whose roots develop only low percentages of sugars. He also recommends ploughing the land immediately and then irrigating it to induce the sorghum roots and stubbles to decompose rapidly. In his view certain naturally inoculated legumes make good growth after sorghum.

Ramanatha Ayyar and Sundaram (l. c.) found that for cotton following sorghum in the black soils of Koilpatti, neither the removal of stubbles, nor ploughing in the residues early, nor the growing of sorghum in thinner stands gave any beneficial effects. They found that thick sowing of cotton improved its yields after sorghum. They suggest that the application of correctives for alkalinity in the lower layers of soil may have some beneficial effects.

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From Mineral Power to Plant Power*

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Some twenty years ago I read a book by an American on the "Coming of Coal". The thesis of the author was that modern civilization had been built on the surplus energy furnished by iron, coal and oil. The use of these minerals was the basis of the Industrial Revolution. Nations which possessed such materials in their countries became powerful. Others sought to gain possession of such countries in their search for power. In India, iron and coal are present but in restricted quantities. Oil is barely available. With difficulty and with the help of tariffs, India has been able to build up a steel industry. Her coal has been of an inferior grade. Oil she has had to import in large quantities. India has been therefore obliged to be content largely with the production of raw materials for the industries of other nations who were richer than she in iron, coal and oil.

During the last decade, there has arisen a change in the position as regards the sources of power. Countries which had not enough of petrol have developed producer gas engines. In several countries as a result of war conditions, a considerable part of motor transport has changed or is

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changing over from petrol to charcoal power. In this, Madras has led the way in India. The scarcity of kerosene oil has produced an urgent need for vegetable oil to replace it for lighting. Several lamps have been devised. The Madras Government will shortly undertake demonstration and propaganda for the use of satisfactory lamps burning vegetable oil. It has been calculated that all the requirements of oil for lighting in this Province can be met by the groundnut grown on seven lakhs of acres whereas our total annual cultivation of groundnut in this Province touched 45 lakhs of acres a couple of years back. Experiments made by the Government on the use of groundnut oil as power for Diesel engines have shown that vegetable oil can be satisfactorily used for such machines. On the basis of the results actually achieved, it is now permissible to state that the power of coal and oil mined from the earth can be replaced by the power of fuel and oil seeds grown in our farms and forests.

Besides coal and oil, the industrial revolution has used iron as the vehicle for power. During the last decade, the use of wood for iron for many purposes for which iron alone has been used hitherto has been developed with the help of methods of wood preservation, one of the most effective of which has been developed by a Madrassi Engineer at the Forest Research Institute, Dehra Dun. Wood has yet been used as a vehicle only for potential energy. Its use as a vehicle for the transformation of potential energy into kinetic energy remains yet to be developed. The position thus is that of the three minerals, iron, coal and oil, on which modern civilization has been built, it is now possible to replace mineral sources by plant sources almost entirely as regards coal and oil and partially as regards iron. We are thus witnessing a revolution in power. The revolution has as yet taken place in principle. Its bulk extension is a matter of time and organization.

The change of power from mineral to plant has many implications. Mineral power is derived from the dead earth while plant power is derived from the living sun. The former is limited. What iron and coal and oil there are already in the bowels of the earth, men can mine. No more. It has indeed been calculated that all the petrol supplies will be exhausted in a few decades at the rate at which petrol has been used. Plant power is however unlimited. It is derived from sunlight. Compared with the earth, the sun is almost immeasurable in size and mass and almost eternal in time. Mineral power becomes available through great heat which destroys while the power of plants and also of animals and men becomes available by life constructing its food into more complex plant and animal tissue. The same food that builds a man can also yield heat to move an engine. But a living body produces more power by the consumption of its food than a machine does with the same material. The living machine is thus more efficient than a machine of matter. Mineral power being limited leads to greed and war. Plant power, provided its production is fairly organized, will by its derivation from an unlimited reservoir of power enable men to live and let live.

The industrial revolution with its use of mineral power has been a laboratory for a large scale organization of man's power. It has shown the possibilities of quantitative expansion. Hereafter man cannot go back to the small scale and isolationist life of the pre-industrial revolution period. But the germ of the new construction will be not matter but life. The industrial revolution was a revolution in power—from man power to mineral power. To-day we are again witnessing a revolution in power—from power of matter to the power of life, of plant life in the first instance. This revolution is necessary to adjust our economic conditions to our social ideas. We have come to recognize the basic rights of all men. But on the basis of mineral power, there is not enough to give equally to all and enough to each. We have thus built a world where progress for any is possible only by denial to some. Our social ideas are compatible only with the production of enough to meet the basic needs of all. For this the surplus of energy produced by iron, coal and oil on which the civilization of the last two centuries has been built is too inadequate. We want food and power for each as freely as there is air for each to breathe. The power of life alone can keep pace with the needs of life. Only the power of the sun fed through plants can meet the needs of all men.

We who are witnessing this revolution have to prepare for the problems that arise during and after the revolution period. Plants have hitherto been treated as sources of food for men and animals. They were not treated as sources of power for machines which man has built up for his use. Life is both an end and a means. Plant life may now be treated as a means for serving the needs of men in all ways. Take the groundnut. It gives food to man. It gives food to animals and manure for plants. It also, we have now found, gives power for machines. The difference between the power of life and the power of matter as sensed before the industrial revolution was that the former could be had only in small quantities while the latter could be got in large quantities. A man using the power of his body could do but little work. A machine with coal and oil moved large loads. But now we find that the small groundnut creeper produced on a sufficient area can be used to give practically all the power that mineral oil could give. Research will, I believe, enable vegetable oil to serve indeed all the purposes for which mineral oil is used. The large multiplication of small living things is an equivalent to the power compressed in coal and oil during centuries. Coal and oil are limited. The cultivation of groundnut can be carried on without limit of time. So too fuel can, by planned production, yield us all the power which petrol gives to move motor vehicles. Petrol can be exhausted. The growth of trees for fuel can go on indefinitely. In the past agriculture has been cramped by being viewed too exclusively as a means for providing food for men and animals. Food for men and animals is a form of power. The bodies of men and animals convert the potential energy of food into kinetic energy. But there are other forms of power which plant life can yield. Plants which are not suitable as food can yet move machines of matter. Edible nuts can be both food and other power. Unedible nuts cannot be food but yet be a source of power. There are trees which yield food or timber. But almost all plants can supply fuel. If the function of plant culture is recognized to be not only the production of food but also the production of power, the scope of agriculture is enormously increased. The bogey of over cultivation of food is removed. There can be no fear of a slump in prices with an extension of irrigation. Irrigation can be used first for all the food man needs. He does not get enough now. Then it can be used to produce fodder and build up herds of valuable animals. Next it can produce valuable manure for plants. Last it can grow timber and fuel plants. The scope of agriculture with the help of irrigation is thus tremendously increased. It is not enough to say "Grow more food". We need food. But we also need other things. We need motor vehicles, for which we must produce charcoal or alcohol or oil. We need lighting. For this we have to produce vegetable oil. Our slogan must be widened from "Grow more food" to "Grow more power". For mineral power, you dig; plant power, you grow.

There are two major problems which I would suggest to you for research in regard to plant culture and plant technology. The first is the supply of pure water. Pure water is as vital to plant culture as steel is to mineral technology. Water is the carrier of food from the soil to the plant. In South India we have land and sun-light but not enough of fresh water. *Ryots* when they dig wells more often get brackish water than fresh water. The fresh water that comes to us through rivers is largely wasted into the sea. It is a shock to most people to hear that only four per cent of the Godavari river water that reaches the anicut is used for irrigation and the rest wasted into the sea. Of the Krishna river water, only three per cent is so used. The need for increased irrigation is obvious. The fear of producing more plant growth than is needed for food need not hereafter stand in the way of an increased use of the Godavari and Krishna waters. But simpler than the building of new irrigation systems, and indeed, in addition to such new irrigation as is undertaken, there is, I believe, scope for the reclamation of brackish water, including sea water. The sea has over 97 per cent of fresh water. Enormous masses of this water lie by the shore of South India. That fresh water can be made from sea water is known. But the process which is distillation is not cheap enough. I suggest it as a problem for South Indian intelligence that a way of making fresh water from sea water, and indeed all brackish water, must be found. Ten years ago, it was my dream to replace kerosene oil by vegetable oil for lighting our homes. To-day the dream has come true. I believe that the other dream of mine about making fresh water from water containing over 97 per cent of fresh water will yet come true. When it does, South India with land, sunlight and fresh water will be a paradise on earth. It will witness the conversion of sunlight into power needed for human progress on a gigantic scale. So much for the major problem of plant culture.

The major problem of plant technology that I would place before you is the making of engines with low temperatures. Mineral power is transformed into kinetic energy through great heat. Hence iron needs to be its vehicle. Yet millions of engines including ourselves are working at the temperatures of men and animals and plants, and efficiently transforming food into energy. For such low temperatures, wood can be a vehicle. The condition requisite for replacing iron by wood is the discovery of low temperature engines. It should be possible to do it because Nature is making such engines and working them. Cannot man find the secret of Nature? Man seeing birds fly has learnt to fly. Let man seeing Nature make fresh water from sea water and making engines work at low temperatures learn to do so too.

With this new power what new civilization shall we build? The industrial civilization of the last two centuries was built out of limited material. The power released by the new revolution will be from unlimited material. The limits of development under the old revolution were narrow. The new revolution has scope for limitless development. The ethics of a civilization based on mineral power when if one man has, another man has not, will be replaced by the ethics of a civilization based on vital power when if one man has, another man may have too. Based on the limitless power of the sun, our new civilization will attain levels of plenty, grandeur of conception and execution, width of vision and ranges of goodness and greatness, which the old civilization confined to the narrow walls of material power dug from the bowels of the earth could never reach.

We shall indeed be no longer children of the earth alone. We shall also be the children of the sun, members of a great confederacy of planets with the sun as the centre. The sun shall sustain us as our father while the earth our mother takes us to her bosom.

It is a great vista that opens before us through the revolution from mineral to plant power. In this, the Agricultural Research Institute may play a great part. I would, if and when I could, develop this Institute of Agriculture into an Institute of Plant Culture and Technology. You have learnt to play the role of Brahma the Creator. I ask you to play also the lesser but not easier role of Viswakarma the technician.

I have a great faith in Indian intelligence which with Chinese intelligence has made the oldest and longest contribution to civilization. India and China, according to the great Russian scientist, Vavilov, have domesticated more than half the plants and animals that serve civilized man. They have harnessed the forces of life for the progress of man, and preached and practised tolerance towards all life. May they again take the lead in the arts and crafts of a new Age!