A SURVEY OF THE EFFECTS OF IMPROVING MAJOR ENVIRONMENTAL FACTORS TO AGRICULTURE IN EAST AFRICA

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INTRODUCTION

This review was prompted by the recent decline in productivity in most of our economic sectors. The paper attempts to review somewhat selectively, research work related to the development of agriculture in East Africa through the improvement of some elements of the physical environment, and aims at showing the ways man is changing his environment to meet his own ends i.e. increasing productivity. It is contended here that apart from social, economic and political factors, soils and related environmental parameters mitigate against the farming progress in the tropics (Moss, 1968).

The role of soils in planning for agricultural development cannot be overemphasized. From the soils for example, plant roots receive essential nutrients, water, air as well as mechanical support. It is against this background that the following parameters have been selected for discussion: soil fertility, soil moisture availability, soil erosion, and pests and diseases. On the whole the paper will highlight major areas of research in advancing agriculture.

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A somewhat narrow definition of soil fertility will be employed in order to allow for individual parameter assessment. Fertility here means the quantity of nutrients present in the soil in forms available to plants. An understanding of the soil nutrient status indeed forms the basis for a sound evaluation of fertilizer requirements and crop rotation systems.

On soil moisture availability, the discussion centres around methods of utilising unreliable rains of a semi-arid environment. Further, soil moisture conservation through irrigation is considered. The effects of soil moisture conservation on crop yields are shown empirically.

Since agricultural production may be hampered by erosion hazards, soil erosion and its conservation should be considered in the development of agriculture. Although studies on soil erosion and conservation are available in East Africa, it is difficult to conclude whether the results of the experiments are solely a function of soil erosion control, though it is indeed due to the interrelationships of the factors under discussion.

The handling of soil may greatly affect its virulence. Note for example that the burning of residues, the order of crops grown and the addition of chemicals (insecticides) are a reflection of the relation of soil management to insect and disease control. The very fact that some of the pests spend part or the whole of their life cycle in the soil makes their consideration here worthwhile. Studies on the effects of pests and diseases on crop yields are cited and crop varieties resistant to East African hazards are also mentioned.

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There are obvious interrelationships between the parameters considered in this paper. For example by trying to improve soil moisture availability and soil fertility the problem of soil erosion is simultaneously solved. Logically therefore, one of the main shortcomings of the results on individual experimental plots as shown in the proceeding discussion originates from the interrelationships between the factors being investigated. By and large the yield response of a crop to a soil amendiment depends upon the particular crop, climatic conditions and management practices as well as the chemical, physical and biological conditions of the soil.

SOIL FERTILITY

In assessing the fertility of the soil, one has to broadly examine the quality of the land properties within the context of the current agricultural and technological development as well as economic conditions. Notwithstanding the links with other environmental factors, technology and evonomics, it is possible to assess the contribution of soil *sensu stricto* to the productive potential of land. It is on this basis that this subsection will deal with the effects of improved natural fertility on crop productivity.

The main features considered include the effect on yields of: different fertilizers and the rate of their application, appropriate rotation and spacing.

Experiments were conducted in Nachingwea, Tanzania to evaluate the responses of maize, groundnuts, soya and sorghum to different types of fertilizers. The crops were planted in a production farm. Evans and Wilson (1956) report that the fertility level of soils and the soil productivity varied from place to place. Fields were subdivided into blocks for convenience of cropping and access and into panels by conservation terraces.

Maize was planted on two fields, one of which had a belt of very poor soil running through it. Results clearly showed that on poor soils, fertilizer did not give any increase in yield. On the good soil, seedbed and top dressing applications alone had no significant effects but when both types were applied, a highly significant response of 614lb per acre was obtained. On the other good soil, the seedbed application alone and with the top dressing, gave highly significant responses, in the latter case of 877lb per acre.

Mere application of fertilizer is not enough if high yields are to be obtained. It is equally important to consider the quantity of fertilizer per unit area to be applied as well as the cropping system practiced (Ekpete, 1976.).

Experiments to dertermine the rate and time of fertilizer application were carried out at Uru and Msaranga in Kilimanjaro (Swymerton 1948). The rate of application of ammonium sulphate to onions was studied and the following results were obtained.

At Msaranga a very significant decrease in yield resulted as more fertilizer was applied. It was noted that the application of the sulphate of ammonia at a low rate of 1½ cwt per acre was quite adequate. At Uru, however, the application of 3 cwt per acre was superior to the lower and higher rate. It could thus be deduced that low rates of application of ammonium sulphate of the order 1 to 2 cwt per acre may be expected to make substantial and economic increases in the yields of onions over untreated plots.

Onions were again used in the experiment to establish the best time for fertilizer application. At Msaranga the application of sulphate of ammonia later than 15 days after transplanting showed a significant decrease in yields. The decrease was significantly greater 45 days after transplanting, than 30 days after. At Uru it was noted that fertilizer application 30 days after transplanting was superior to earlier or later applications (Swymerton, 1948).

From the results above it can be concluded that an early application of ammonium sulphate, (within 30 days of transplanting) may be expected to raise the yields of onions appreciably, while later application would show little advantage over untreated plots. In a sense, it is better to apply ammonium sulphate in two instalments, at 15 and 30 days after transplanting but application should be avoided during periods of heavy and continuous rainfall.

The foregoing discussion shows the justification for the use of fertilizer in agriculture if crop yeilds are to be increased. The remaining problem is to further investigate the appropriate dosage, season and method of application of fertilizers on various crops and soil types in given ecosystems in East Africa.

Under the subheading "crop rotation", only case studies that reveal a significant variation in requirements have been cited.

Crop rotation ensures among other things, an economic use of plant nutrients available in the soil. Further, when studying crop rotation it is important to take into account the economics of the crops under consideration. This relationship is very marked in grain crops as shown by Clayton (1956).

Experiments conducted outside East Africa on the appropriate rotations of maize, oats and clover as reported by Clayton (1956) produced the following results.

TABLE I

The above results are typical of those from similar experiments. It is shown in the aboved table that introduction of 25% forage in the second rotation has a beneficial effect on the total grain production when compared with the first rotation of continous maize. However, when a greater acreage of forage is introduced in the third rotation it becomes competitive with grain in that greater hay yield reduces total grain produce. Most soils seem to give this kind of relation.

In East Africa, experiments to determine the most appropriate crop rotations were carried out in Kenya Highlands at Nakuru, Naivasha, Yasin Gishu and Trans-Nzoia. The following rotations were recorded by Clayton (1956).

Naivasha

10 shifts: G—G—G—G—G—G—G—G—G—L

Nakuru

5 shifts: M—G—G—G—L

Uasin Gishu

15 shifts: G—G—M—G—G—M—G—G—M—G—G—M—G—G—L

Trans-Nzoia

5 shifts: M—M—G—M—L

Where G = Grains; M = Maize; L = Rotational forage

There appears to be a variation in the cropping systems of the four named areas. In Nakuru and Trans-Nzoia, the system is soil conserving, resembling what is termed ley farming.

In Uasin Gishu the system is soil depleting. The ley shift in Naivasha and Uasin Gishu is so infrequent that the system is not far removed from grain monoculture. Owing to the undeveloped farms with reserves of untilled land which are used when yields begin to fall in the village areas of the farm, it is difficult to estimate accurately the period of land resting.

The course of wheat and maize yields in the cropping pattern was traced and yields since 1943-54 were collected. During this period, yields of both crops have clearly been maintained and in some areas, slight increases were shown. It was difficult, however, to ascribe the causal relationship between current cropping system and the trend in crop yields because of important changes that occured in the period. Of prime importance was the increased area devoted to these crops between the period. For wheat, this amounted to 51-52% in Naivasha, 44% in Nakuru, and 43% in Uasin Gishu; For maize 26% in Nakuru, 109% in Uasin Gishu and 45% in Trans-Nzoia. The breakage of new land helped to maintain yields per unit area. Other important changes in the period that tended to prevent a fall in yield were a substantial increase in the use of fertilizers and improved seed varieties. These factors, therefore, masked the effects that might have been expected from inadequate resting of crop land.

Experiments on the effects of cultivation of rice land between successive rice crops were conducted in Zanzibar at Kizimbani experimental station. Smith (1964) observed that the following treatments were used on the land between successive annual rice crops.

(1) Control — allowed to revert to weeds and grass growth
(2) Sweet potatoes with farm yard manure at 20 tons an acre grown on the ridges.
(3) Sweet potatoes with no manure grown on ridges
(4) Groundnuts grown on ridges
(5) Green gram on the flat
(6) Clean cultivation throughout the fallow season.

Since 1954, the following alterations have been made: 1958 the dressing of farm yard manure applied to sweet potatoes was reduced to 10 tons per acre. Following the 1959 rice harvest, the clean cultivation treatment was replaced by growing cowpeas on the flat. Prior to 1959 the local variety of rice — Mnazija — was grown. After 1959, Red American was grown in both experiments and also D.52 was used at Nguruweni. All plots of rice received standard fertilizer dressing for rice which consisted of 2 cwt per acre of single superphosphate before sowing. Transplanting was later followed by sulphate of ammonia at 1 cwt per acre applied as top dressing.

It was observed that intensive cultivation of riceland is not detrimental to the maintainance of soil fertility when fertilizers are applied to the rice. But for obvious reasons cultivation between rice crops should be given preference for it provides a return from land which would otherwise be lying idle, facilities cultivation, assist in the control of weeds and results in heavier rice yields (Smith, 1964). Sweet potatoes and groundnuts are recommended to be grown during the fallow season and farm manure dressing should be practised if yields are to excel.

Related to cropping system is spacing. Appropriate spacing is essential if high yields are to be expected. Experiments carried out in Kilimanjaro on the best spacing for onions were reported by Suvynneston (1948).

Table 2: Effects of Spacing to Yield

According to the results on the above table where spacing within rows was constant at 4½", the close spacing of 4½" between rows was markedly superior to either the 6" or 7½" spacing yields. The yields between the 6" and 7½ spacing are not significantly different.

Crop rotation has a marked effect on the increase of the degree of soil aggregation as soil aggregation is most frequently found on land that is supporting an actively growing plant canopy. An actively growing plant canopy is associated with more micro-bial activity because there is continuous addition of organic matter to the soil which serves as food for micro-organisms and helps to maintain soil humus. With all this the plants also reduce the rain drop impact on the soil surface thereby reducing erosion. It can be noted here that crop rotation if appropriately carried out will increase crop yields per unit land. Experiments conducted in Uganda, however, have shown that crop density and spacing are a function of environmental conditions, especially moisture regime (Leakey and Rubaihayo, 1972).

A distinction should be made between the evidence of fertilizer trials on experimental stations and the information relating to results on farms. In essence the results need to reflect a long period of observation carried out on a large expanse of land — an ecological zone. Over and above, it should be established whether increased use of fertilizer is profitable, for increased yields is not an end in itself.

Soil fertility studies are incomplete in the tropics without an assessment of soil moisture availability. As Young (1976) notes it is instructive to consider water in some respects as one of the plant nutrients, in which case it displaces nitrogen as the nutrient most often deficient in the tropics.

SOIL MOISTURE AVAILABILITY

It has been argued that in East Africa, soil moisture is one of the important factors limiting crop yields (Hanna, 1974). Martin in 1925 observed that in Uganda, grave disadvantages accrued from clean weeding of permanent crops. Erosion was severe and the soil lost all its organic matter. Crop yields, (mainly coffee) fell below average, Noticing the deteriorating situation, the agricultural department called attention to the dangers of clean weeding and recommended the use of artificial mulch. The conservation of moisture was the basic idea behind the practise of mulching.

To show that the conservation of soil moisture increase crop yields, an experiment was carried out on the Government Station at Bugusege, Uganda. The following treatment was conducted on a 5 × 5 latin square:

A Clean weeding
B green manure (two crops a year)
C banana leaf mulch
D weed cover

E October to March cover

Table III:
Effects of Ground Treatment on the Yield of Coffee

The results to date show that treatments A and C are significantly better than others whilst treatment E is better than B and D. It was further observed that the picking season of C is longer than that of the other treatments, but 80% of its crop was picked within a period of one month. This has to be attributed to the die-back and failure to ripen of all the crop under the clean weeding of 1925. There are indications to show that mulching is giving a more even annual crop as opposed to the big fluctuations normally met in Uganda.

The effect of mulch together with other treatments on young coffee was tested in Lukumbi, Uganda (Hanna, 1971) with the following results: it was observed that there was no significant difference in yields between mulch and the two manuring treatments. The difference in the appearance of trees, however was remarkable; the trees of the mulched plots carried their crop well while the other plots all showed the typical signs of overbearing.

The proceeding demonstrations show the significance of mulching if soil moisture is to be conserved and crop yields increased. These studies therefore commend the use of mulching as the best treatment for coffee yet discovered.

In areas where these is an uncertainty of adequate rainfall, conservation is one of the primary activities in farm operations. Given this constraint such measures as drought -resistant and quick maturing crops have been introduced in semi-arid areas in order that yields may be satisfactory.

Better farming techniques have proved successful in semi-arid areas in various experimental stations in Tanzania. While preparing land for cropping, one of the most essential measures to be taken is adequate dispersal of the surplus storm water during sudden heavy down pours. A convenient way of doing this is to construct sloping contour banks, where surplus water is shed into gullies with farm regular drainage basins. This is a good measure expecially when the drainage lines are protected by suitable grass growth. Thorough ridge-cultivation, parallel to the sloping contour banks, would allow for better penetration of moisture and would further assist in gradual dispersion of excess water.

Adequate soil moisture penetration is the most important aspect in farming improvement in these areas where soil compaction is so prevalent. This can be achieved either by thorough cultivation to allow water to penetrate into the soil, or by obtaining a satisfactory grass cover whose fibrous rooting system reduces surface runoff to a great extent by facilitating structual development.

The reduction of the runoff volume and its subsequent hydraulic force automatically reduce the rate of soil erosion. The case of soil moisture conservation in areas of torrential rains is therefore part and parcel of soil erosion control.

As regards crop varieties for these semi-arid regions, the undermentioned crops have been tested and proved valuable by Rensburg (1955).

Sorghum is said to be a most valuable grain in semi-arid regions that receive precarious and erratic rainfall. The introduction of dwarf, quick-maturing varieties has been an excellent step forward and has resulted in considerable advancement. Among the white-seeded kinds, varieties like double *dwarf Shall 6399 - 3 - 1, Dwarf Feterita* and *Hegari 750* have given satisfactory results.

Sorghum plants have been proven to resist long drought spells with little apparent adverse effects and even under most adverse conditions they produce a crop of sorts. In spite of two severe successive drought seasons, yields of up to 1279lb per acre have been obtained from *D.D. Shallu* and up to 1806 lb per acre from *R.S. Tall* sorghum.

Bulrush millet is a very hard and drought resistant crop found in most areas in central Tanzania. It has proved to be a sturdy crop in drought years, however it takes a long period to mature.

Cowpeas are generally most satisfactory in semi-arid areas and may yield fair crops even when planted as late in the season as March. Groundnuts also do well in semi-arid areas. Apart from being excellent food it is also valuable as a cash crop. A number of varieties of velvet beans tried at Mpwapwa, Tanzania, yielded 1508lb per acre of shelled seeds.

Semi-arid areas are characterized by erratic rainfall. A study of crop production in relation to rainfall reliability has been conducted. At a reasonable accurate estimation, say near the rain-gauges, it has been shown that good yields of groundnuts of 800lb of kernels per acre and of maize 2,000lb per acre can be harvested on 23 and 21 inches of rainfall provided that this amount falls within 120 days and 100 days respectively, of planting. Further field observations showed that maize planting before 22nd December is likely to be hazardous in terms of harvesting conditions, since the crop will be mature when an average of just over 30'' of rain per fortnight can be expected for at least two fortnights. On the other hand, maize planted after 29th December will be ready for harvest when an average of 1.25'' can be expected in the next fortnight. The planting season of sorghum begins early February with the seasonal totals from 10 February to 4 May averaging 17.1''. Data on the relationship between rainfall totals and good yields (1800lb per acre of Dubbs, a tall growing variety) is scanty but suggest that 17'' and over should give good yields. Thus after 10 February good crops could be expected for planting in only 50% of the season (Rensburg, 1955).

The foregoing discussion shows that if such soil moisture conservation techniques as mulching, manuring, adequate dispersal of surplus storm water, planting of drought resistant and quick maturing crops and the establishment of proper dates for planting, there is a great likelihood of increasing in crop yields.

Where irrigation is planned, a study of soil moisture conditions has an added significance. Irrigation of agricultural land is an example of soil moisture control on the broadest possible scale. It diminishes one of the great hazards in crop production, namely inadequate and unreliable water supply, and ensures a more stable and higher crop.

Irrigation is by no means a simple a process as is supposed by those who have not studied it in practice (Boeree 1971). Wherever irrigation has been successfully conducted, there appears to be an increased crop production per unit of land. Studies reviewed here, have been conducted in Tanzania and aim at showing the success and failure of irrigation schemes at village level. (Large scale irrigation schemes have been overlooked as they are both capital intensive and operate under high level managerial skills which are beyond the capability of the peasants in rural East Africa). The villages are located in the semi-arid regions of Tanzania, namely Dodoma and Singida, where soil moisture availability is a major limiting factor in agricultural production. (Berry *et al,* 1970).

Mang'onyi, a village in Singida, was by 1956 served by irrigation water from the Mianji river. The dam built by Water Development and Irrigation Department could maintain a flow of 25 cusecs. The canal was constructed to make irrigation possible. After laying down the basic irrigation structures, experiments were carried out to prove that crop yields increase with the availability of soil moisture obtained by irrigation methods. The results of the experiments were found to be quite promising. Coffee, a perenial crop, was grown with some success. Also other crops such as bananas, chillies and onions produced high yields.

The results of these experiments were promising, attracting commercial farmers and a peasant cash-cropping irrigated agriculture was planned.

By 1960, there were about 80 farmers on the site and everybody was encouraged to take up 1.25 hectares of irrigated plots with other land not under irrigation made available. This marked the start of small holder irrigation.

1961 saw the coming of an exceedingly dry season which forced the dam to dry up and most farmers abandoned the scheme. Other problems also contributed to the closure of the scheme: land tenure, water salinity, elephants and other wild animals looking for drinking water caused great crop destruction. This was the first phase of the scheme.

After 1962 some slow progress was noted but the scheme continued to operate well below its maximum capacity. By 1967, there were 68 farmers on the scheme and about 87 hectares were under irrigation. Water shortages, however, continued to be a problem during the dry years and some of the soils in the scheme deteriorated due to lack of drainage.

In 1968 there were 101 households cultivating 166 hectares of land of which approximately 51% was under irrigation, with the rest in rain fed agriculture.

Crops grown in Mang'ony village consisted of maize, groundnuts, beans, sugar cane, maize-bean mixture, cotton and small amounts of tobacco, potatoes, cassava and millet. Sugar cane and most of the beans were grown both with and without the aid of irrigation.

Studies made in 1969 on the Mang'onyi settlement showed that a good food supply for the farmers and some small cash crops were gained from the project. With an estimated cost of Shs. 1,140/= per capita it is doubtful if these gains could justify the cost. It is obvious that a higher input is necessary to make the project a viable economic venture.

From the study of Mang'onyi settlement the following observations can be made: (i) Lack of integrated planning led to partial miscarriage of the project; (ii) the 1961 drought season caused water shortage, therefore irrigation could no longer be carried out. As season like that of 1961 are likely to reoccur there is a need for a careful study of the water supply for irrigation to ensure that there is sufficient water even in the dry years: (iii) There was not an adequate market to stimulate the growth of more cash crops. An irrigation scheme should encourage the growth of crops that will command a supraregional market, in order that the cost of the scheme may be met. The problems of food shortage in Tanzania would be largely solved if the irrigation potential is tapped.

SOIL EROSION

The removal of the top soil means less soil is available to hold water and nutrients and for the mechanical support of the crop. This automatically leads to soil unproductivity and subsequently, low yield of crops.

The damage done to agricultural land by soil erosion has been studied at Lubaga experimental station in Shinyanga, Tanzania (Harrison, 1935). The area is subject to wind and sheet erosion and gully formation. One of the best methods that has proved successful in this 'cotton region' is the use of contour ridges. They should not be continuous but furrows below the ridges should be filled in at intervals of 10 feet or so in order to prevent flow. With hills, it is wise to make a high contour bank all around, near the top and not to allow cultivation above such a bank. Acassia or other trees should be planted on the contour and within a few years the land between the belt and the scrub on the hill top will be protected. The above measures are recommended in land preparation for cotton growing.

According to the studies made in Uganda it was deduced that mulch as an antierosion measure is very effective from a purely mechanical standpoint. It is evident that the force of the rain on reaching the soil is sufficient to detach the clay particles so that the liquid percolating is muddy and tends to clog the soil pores. Muddy water reduces percolation and enhances the possibility of surface runoff. It is clear, therefore, that any sort of artificial mulch will protect the surface soil from the force of the rain drops and reduce the chances of muddy percolating liquid.

Studies made in Kenya on the general fertility of a coffee soil showed that the soil can be dealt with by preventing soil erosion and maintaining the humus content of the stationary surface soil (Gethin-Jones 1935).

A suitable level of humus in the soil aids percolation of water and hence reduces surface runoff. The growth of subsidiary crops during rains helps to conserve much of the nitrates which would otherwise be leached from the surface soil by percolating water. The availability of humus and nitrates in the soil gives it better physical properties and makes it more resistant to erosion. It can therefore be deduced that the conservation of general fertility is the summation of the conservation of the surface soil, soil humus, soil moisture, desirable physical factors, and the resistance to erosion.

Experiments carried out at Mpwapwa, Tanzania in 1946 showed that as soil erosion increases, crop yields diminish (Van Ransburg, 1955 p. 228—31). It was discovered that although the erosion figures were highest on bare uncultivated land, followed by bare flat cultivated land, even when cropped, and using the usual methods of flat cultivation, erosion was extremely serious, especially in areas where moisture is the chief limiting factor in crop yields and where fertility of soil is generally low. It was further noticed that as the duration of cultivation increased, the crop yields deteriorated, while during the past two drought years the sorghum plants were barely 12'' high and did not bear any seed. The same variety planted on fields where continous cropping was not being carried out for so long and where thorough cultivation with ridge planting for optimum water conservation was practiced, the grain yield amounted to 1279ld and other varieties 1806lb per acre.

Further observations in Kenya by Maher (1935) revealed that constant ploughing in the light soils derived from gneisses and schists resulted in the loss of the crumb structure of the soil, the acceleration of soil erosion and the washing out of the valuable soil colloids which retain most of the phosphate and lime reserves of the soil.

The soil condition deteriorates further, if ploughing is carried out for many years in the dry season, during which the crumb structure of the soil is destroyed. The consequence of this is the creation of a state whereby maximum amount of soil wash occurs with the onset of the long rains.

In maize growing areas of Kenya it was further observed that an interplanted crop of green manure, say cowpeas, when planted and left on the soil over the dry weather, may shield the soil form the baking sun thereby maintaining a soil structure that is resistant to crosion. Similiarly the weeds which might have grown among the maize subsequent to the last cultivation may produce the same result.

Most experiments on soil erosion have been designed to measure the amount of both water and soil loss. Since Data on crop yields is inadequate, little data has so far been quoted in this text.

If by conserving the general fertility of the soil, soil moisture and soil humus are maintained, with a consequent diminishing of soil erosion, then it can be deduced that by controlling soil erosion, crop yields can be increased per unit area of cultivatable land.

PESTS AND DISEASES

Even if the moisture available in the soild was conserved, fertilizers applied, crop rotation practiced and soil erosion controlled, crop production would be affected by yet another factor — pests and diseases. There are numerous pests and diseases so far recorded in East Africa and numerous others that have not reached the attention of researchers. A few examples will be cited to prove that by preventing pests and diseases crop yields can be raised.

At the experimental station in Amani, Tanzania, Fuggles — Couchman (1935) reported a parasitic plant whose several roots were found attached to the roots of sorghum. The parasite was identified as *Bhamphicarpa veronicaefolia vatke*. This weed is widespread in Kilosa, and is known by peasants as "Lalizi". The plant is well supplied with foliage and has chlorophy 11 which makes it semi-parasitic. Attachment to the sorghum roots is by means of small haustoria. It has no marked effect during the growing season but appears in great numbers at the time when the plant is seeding. It affects the crop by producing light grains and poorly fitted heads.

To control this parasite peasants were advised to uproot and burn all the stalks after harvesting. It has been found that wherever energetic uprooting has been carried out, very small stands are seen. When gazetting it under the Plant Pests and Diseases Ordinance the plant was classified as an noxious weed. (Fuggles — Couchman, 1935).

At Kamolet and Mboga Vale, Kenya in 1922, a leaf eating catapillar of coffee was first recorded (Notley, 1935). Similar pests have been recorded in Bukoba and Buganda. Outbreaks of this *Metadrepana andersoni* used to occur between the months of July and November but have since occured every month of the year. If steps are not taken it is reported that the outbreak may defoliate 50 to 100 acres of coffee. After a tree has been defoliated results show that coffee yield is below average for a considerable number of years. Owing to the lack of data the total loss of the crop due to the pest cannot be estimated but it is considerably greater than would be expected.

The most convenient method to induce rapid recovery so far known, is by stamping the tree. The use of insecticides is recommended, the most effective being stomach poison. It is estimated that on the average 100 gallons of spray are sufficient for 200 - 300 trees.

Further experiments have been designed to establish the optimum growing season and the effect of insecticides on crop yields. At Ilonga experimental station in Tanzania, tests were made on cotton with the following results:

Table IV Effect of Spraying to Yield

The effect of planting time on yields is important on both protected and unprotected crops. Although insects caused heavy damage on all the cotton crop, it was noted that early planting resulted in good yields in spite of this constraint. Economically it would be most profitable to plant early and to use insecticides as the above table demonstrates. This study clearly stated that the best yields were obtained by planting the cotton as soon as rainfall made this possible.

Peasants, assisted by field agricultural officers, should be responsible for the control of pests and diseases. If the peasants could control pests and disease by alteration of planting dates, better prunning techniques, weeding and removal of alternate hosts, crop yields would definately be raised, other things being equal. In other words, insecticides, costly as they are, should be applied as the last resort.

In an attempt to combat pests and diseases certain crop varieties have been bred and proved useful in an East African environment.

A Rosette-resistant groundnut variety was bred in Nachingwea area, Tanzania (McKinley, 1956). The variety is known as *'Asrya Mwitunde'* and has proved useful in combating rosette disease of groundnuts which was severe in Urambo area. In Nachingwea area the disease is reported to have once almost eliminated the crop. Other than at the early stages of growth, *Asrya Mwitunde* is very tolerant to the disease. This observation is confirmed by simulated experiments on the effects of armyworm damage on crop - loss (Brown and Mohamed, 1972).

Experiments carried out in Nachingwea in 1963 clearly mark the significance of this variety. The first trial yielded 710 — 1040lb of Kernels per acre compared with the Natural Common, (the other variety) which yielded 0 — 650lb per acre in a year when rosette was severe. Thereafter, the variety was grown generally and in a few instances the diseased crops could be identified.

There is a great need for research on better breeds which are able to withstand the East African hazards if crop production is to be raised (de Purry, 1968).

CONCLUSION

This paper contends that a sound knowledge of soils forms the basis for agricultural land use planning. Our knowledge about the nature and properties of tropical soils is too scanty (Smith 1965) for agricultural planning. There is an urgent need to carry out intensive soil survey works throughout areas of agricultural potential. There are very few such studies in Tanzania (Cook, 1975) as well as in Kenya and Uganda. It is also important that soils information available in a given region be incorporated in the planning document and implementation, in order to bridge the gap between regional planners on the one hand and soil surveyors on the other (Rugumamu, 1979).

In maintaining soil fertility, research should be directed towards the determination of the fallow period. Studies on how the fallow period could be reduced or eliminated altogether and substituted with a rotation which keeps the soils constantly productive should be undertaken by agronomists. Furthermore the advantages of animal and compost manure over chemical fertilizers cannot be overemphasized. Research should be carried out on the treatment of different plant and animal residues in order to maintain and/or improve soil fertility.

Soil moisture availability research should be directed towards investigating the exact amount of water requirements by crops and crop varieties at different stages of growth in East Africa. This will form the basis for crop selection and breeding, especially in the marginal areas where rainfall is both low and erratic. The unrealibility and inadequancy of available moisture can be offset by irrigation.

A successful irrigation agriculture requires among other things, a knowledge of the soil properties of the area (Rugumamu, 1975) and the consumptive use requirements of the crop in order to regulate water supply to the farm (Israelsen and Hansen, 1965). As for soils, attention should be paid to slope of the land, soil texture and presence of salts, especially sulphate, and chlorides which might be increased to toxic levels with use.

Soil erosion should be studied in the context of its damage potential as well as economics of conservation works. The less the cost of such works the more appropriate the recommendations are. This calls for training of agricultural engineers at all levels and the creation of an engineering base. Soil surveys should identify processes both genetic and man-made which result in soil erosion and chart out the extent of different types of soil erosion in a region.

At the background of all these improvements stands the peasant. Experience has shown that most of the results of research work cited above have been made available to too few peasants in rural East Africa (Sprague, 1971). Of what value then is research if it cannot be used to enhance a change for the better? In agriculture, the transmission of new knowledge lies in the hands of agricultural extension officers who are expected to act as middlemen between research officers on the one hand and peasants on the other.

Vigorous agricultural growth is needed to give impetus to social and economic development, by relieving food shortages, combating malnutrition, curbing inflation and above all, alleviating pressure on the balance of payments.

TABLE I

Effect of Crop Rotation on Yield

Cropping System		Total Production	
	Percentage Hay	Grain	Hay
(i) C	0	180,320	—
(ii) C-O-O-Cl	25	217,360	85000
(iii) C-O-Cl	35	182,333	132660

C = Maize; O = Oats; Cl = Cloves

Source: East African Agricultural Journal: 22 No. 1 p.33

TABLE II

Effects of Spacing on Yield

Spacing	Tons of dry onions per acre	
	Uru	Msaranga
4½" between rows	7.85	7.94
6" between rows	7.01	6.43
7½" between rows	6.79	6.22

Source: East African Agricultural Journal: 22 No. 1 p.23

TABLE III

Effects of Ground Treatment on the Yield of Coffee

	Yields in Pounds of Cherry					
	1930	1931	1932	1933	1934	Total
A	190	408	3731	2798	1512	8630
B	184	315	3713	1707	1202	7116
C	168	390	4211	1988	1760	8517
D	205	255	2844	1909	558	5771
E	192	405	4465	2290	493	7845

Source: East African Agricultural Journal 1 p.132

TABLE IV
Effect of Spraying on Yield

	Yields in lb of seed per acre	
Date of Planting	Sprayed (lb)	Not sprayed (lb)
January 28th 1955	3191	1733
February 25th 1955	2469	482
March 29th 1955	1620	94

Last significant difference 5% level 262
1% level 257

Source: East African Agricultural Journal: 22 No 1. p.20

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