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PRODUCTION AND APPLICATION OF NON-METALLIC SORBENTS IN AGRICULTURE

UC/ETH/84/103/11-52

ETHIOPIA

Technical report: Experimental application of bentonites and pumice for soil improvement

Prepared for the Government of Ethiopia by the
United Nations Industrial Development Organization

Based on the work of Josef Petr, expert in the agricultural application of non-metallics

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Explanatory notes

The monetary unit in Ethiopia is the birr (Br).

References to tonnes (t) are to metric tonnes.

Besides the common abbreviations, symbols and terms, the following have been used in this report:

EIAR	Ethiopian Institute of Agricultural Research
EMRDC	Ethiopian Mineral Resources Development Corporation
MSFD	Ministry of State Farm Development
q	quintal (100 kg)

ABSTRACT

As one of the inputs to its project "Production and application of non-metallic minerals in agriculture" (UC/ETH/84/103) the United Nations Industrial Development Organization (UNIDO) fielded an expert in the agricultural application of non-metallics for a total period of one month, starting on 22 May 1986.

In line with the tasks defined in his job description and the overall objective of his mission to improve soil fertility and crop yields, the expert studied the organizational and infrastructural set-up of Ethiopia's agricultural sector as well as the basic agrotechniques being used by the state farms. Based on that information as well as on the test results of soil samples from some state farms, two sites were selected for an experimental application of bentonites and pumice for soil improvement. The expert supervised the execution of the set-up of the test fields, determined the dosage of non-metallics to be added and trained the local staff in the monitoring of the tests based on a methodology developed by him. Those local technicians are now expected to record changes in crop yields and soil properties over the next four harvesting seasons. The data thus collected should provide the necessary parameters for a final evaluation.

In addition to his detailed recommendations concerning the monitoring of the tests, which the expert laid down in a separate short report left with the government authorities concerned, he suggested the introduction of improved agricultural techniques, such as proper ploughing in order to eradicate the undesirable couch grass and other weeds, proper sowing by using suitable sowing machines, a better exploitation of existing fields between the harvests of the main crops by planting animal fodder or other useful products, and the enrichment of the soil by specific chemical fertilizers simultaneous with the application of non-metallic sorbents.

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INTRODUCTION

A. Objectives of the mission

As a part of the ongoing project "Production and application of non-metallic minerals in agriculture" (UC/ETH/84/103) an expert in the agricultural application of non-metallics was fielded for a total period of one month, starting on 22 May 1986.

The duties of the expert were defined in his job description as follows:

(a) To review data and information on locally available raw materials which can be utilized in agriculture as sorbents or as additives to fodder;

(b) To review the infrastructural set-up of the agricultural sector, and the existing network of supply of inputs to the farms and agricultural co-operatives;

(c) To investigate the possibilities of using above mentioned natural resources for agricultural purposes, as soil conditioners, sorbents and additives to fodder;

(d) To assist the Government in selecting and starting up an agricultural demonstrative site, near to one of the raw material deposits and to supervise the preparations in order to conduct harvesting tests during the forthcoming season;

(e) To supervise and train local staff in conducting agricultural tests at the farm site and in reviewing the economic viability of results achieved with respect to crop yield;

(f) To assist the Government in establishing a scheme which would help to promote the use of non-metallics in agriculture on a wider scale.

B. Background

Although geological prospecting in Ethiopia gathered momentum during recent years, only part of the non-metallic sorbents has been evaluated so far. Bentonite deposits were investigated in three localities, and their reserves are in the range of millions of tonnes. Pumice deposits are known to exist in Ethiopia, however, they have not yet been geologically evaluated. The Government decided to continue geological prospecting for non-metallic sorbents, and it is realistic to assume that new deposits will be found. The quality of the available bentonites and pumice was tested abroad and found to be suitable for soil conditioning. However, up to now the agricultural sector of Ethiopia has not been developed to the extent that tests on the application of sorbents as additives of fodder could be made.

The set-up of the agricultural sector was studied and discussed with the government authorities. In order to generate suitable conditions for the application of non-metallics as soil conditioners, the overall situation of farming was analyzed and the following measures were recommended to the Government for immediate implementation:

(a) Application of proper ploughing methods;

(b) Liquidation of couch grass;

(c) Exploitation of fields during the period between main crops;

(d) Improved methods of planting and sowing;

(e) More frequent changes of crops in the fields and ways of rehabilitating rexhausted soils.

It was also recommended to continue the testing of soils from different regions and to compile agricultural maps and documentation on particular areas.

During the negotiations with the government authorities, two regions were selected for the experimental application of non-metallic sorbents into soils, namely Nazareth and Melka Werer. These locations were studied, and bentonites and pumice were applied to the soil. To economize on transport, the nearest available bentonite and pumice deposits were used, i.e. bentonites from Hadar and pumice from Shoa.

While maize and sorghum were planted in the experimental plots of Nazareth, cotton was chosen for the plots of Melka Werer. The expert personally assisted in the practical execution of experimental work. He made recommendations and gave instructions to the government bodies concerned, to assure a proper follow-up of all tests until the time of harvesting.

As far as the economic viability of the exploitation of local non-metallic sorbents is concerned, only main directions for the future were derived, since the sorbents for the pilot tests (6,000 kg of bentonites and 4,000 kg of pumice) were extracted manually and the extracted ores were not beneficiated in the cheapest possible way. However, the government authorities are of the opinion that once the mines will be opened and non-metallic raw materials extracted industrially, the production costs will be lowered by about 50 per cent and non-metallics will be applied in an integrated way not only in the agriculture, but also in the industry and in environmental protection.

The government authorities expressed the opinion that further UNIDO assistance will be needed during the evaluation of all experiments in Ethiopia. Such evaluation should be carried out after each harvest during the next two to three years, in order to obtain average figures of the harvests as a basis for a final economic evaluation which should be made not only from the entrepreneurial point of view but also from the viewpoint of national economy.

Thanks to the excellent preparation of the mission by UNIDO headquarters, the thorough briefing and debriefing, organized upon UNIDO's recommendation, by the UNIDO-Czechoslovakia Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries at Pilsen, and the extraordinary support extended to the expert by the government authorities of Ethiopia in arranging high-level meetings, visits to different agricultural farms and in collecting the necessary information and data, all duties could be accomplished and the objectives of the mission were reached. For a list of persons who assisted the expert in his work, see annex I.

I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

A. Findings

The agricultural production of Ethiopia is managed by the Ministry for State Farm Development. Individual farms differ in their size, ranging from 100 ha up to 10,000 ha. A reorganization of the agricultural sector is expected to start in 1988.

The Ethiopian state farms are divided into four corporations according to their geographical location. The animal husbandry and food-processing enterprises are organized in three corporations.

Due to a shortage of suitable agricultural machinery, ploughing is done in an inefficient way and only during the short rainy period. Because the soil is not ploughed deeply enough, the undesirable couch grass is not being rooted out during that operation but spread out. Furthermore, after the harvesting of a main crop, four to five months elapse before new seeds are put into the soil. During such a long period the fields are getting weedy again.

The distributors used for inserting seeds into the soil, give an uneven distribution of seeds with respect to the surface and the depth of the field and, therefore, the percentage of germinated seeds is relatively low.

The high specialization in farming applied in Ethiopia lead to monocultures where a single product is cultivated for too long a period in the same field. For that reason:

(a) Fields are covered with couch grass and other acclimatized types of weeds;

(b) Occurrences of pests and diseases are increasing;

(c) Soil nutrients are exhausted.

The intensity of chemical fertilizer application is very low. Diammonium phosphate, tri-superphosphate and derivatives of uric acid are applied only in small quantities, and due to the insufficient care devoted to the fields, the yield of farming is, in several cases, decreasing instead of growing.

Soil tests made in Ethiopia show that the pH value is above 7.5. However, all soils have a low humus content and, therefore, a low sorption capacity for main nutrients, trace elements, and a low moisture content which is the limiting factor for increasing the yield of farming. A similar situation is expected to be found in other agricultural regions which have not yet been investigated.

The results of the pilot tests indicate that there is a good possibility of increasing the soil sorption capacity by the application of non-metallic sorbents. According to local geological services, extensive reserves of non-metallic sorbents exist in Ethiopia. However, only three bentonite deposits have been evaluated so far and no pumice deposits.

The two localities selected for experimental tests were Nazareth for maize and sorghum and Melka Werer for cotton. The experiment at Nazareth was conducted on 36 plots of 49 m^2 each, one plot in each row being left empty for comparison. Different combinations of bentonite and pumice were applied in three application blocks. The main factors to be monitored by the local experts were discussed and established as the basis for final evaluation.

The experiment at Melka Werer was realized on 12 plots with cotton plants, because cotton is the predominant crop in that region.

Taking into consideration the quality evaluation made abroad and the transport costs, bentonites from Hadar and pumice from Shoa were applied for soil reclaiming.

Following a request by the Government, the expert prepared a draft terminal report on the spot which was handed over to the respective authorities to enable them to continue the experiments after the expert's departure.

B. Recommendations

1. To eradicate the couch grass, ploughs with three to five shears which can plough deeply into that organic matter and convert it into humus should be used.

2. Between the harvests of main crops, the fields should not lie fallow but be utilized for different plants, e.g. green fodder.

3. The planting of seeds should be improved by using traditional equipment suitable to local conditions.

4. The chemical fertilizers already in use (diamonium phosphate, tri-superphosphate and derivatives of uric acid) should be applied together with soil sorbents, which will enhance the utilization of principal nutrients, such as nitrogen, phosphorus, potassium, magnesium and trace elements.

5. Soil samples should be taken from all state farms during 1986 and submitted to chemical and physical tests. Once the results are known, agricultural maps and documentation on particular regions should be compiled.

6. Depending on the soil characteristics of different regions, available organic fertilizers should be applied.

7. The geological prospecting for further bentonite and pumice deposits, with the aim of lowering transport costs, should be continued.

8. As agreed with the local authorities, all experiments should be monitored during two forthcoming years, with at least one evaluation per year. At the end of two years, soil samples should be taken from the experimental fields for physical/chemical tests, and the results evaluated so as to arrive at a general conclusion for the agriculture in Ethiopia.

II. ACTIVITIES AND OUTPUTS

The work of the expert concentrated on the application of non-metallic sorbents in agriculture which had been evaluated by the geological survey, i.e. bentonite, dolomite and pumice, for the improvement of soil fertility and bentonites as additives of fodder.

Two agricultural regions selected for soil reclaiming were visited, namely Nazareth and Melka Werer. In these regions, suitable agricultural enterprises with research stations were chosen to carry out pilot tests on the application of bentonite and pumice during 1987 and 1988.

The agreed task reflects the social demand towards the agricultural sector, i.e. to provide a sufficient quantity of suitable, economically viable basic products for the nourishment of mankind.

To meet that objective, research insitutes and agricultural specialists will have to concentrate on the enhancement of soil fertility and on its more effective exploitation. Soil fertility depends on the transformation of ores and minerals in the upper layers of the crust of the earth. The reclaiming process can be speeded up considerably by applying organic and industrial fertilizers, suitable non-metallic sorbents and proper agrotechniques. Under such conditions, not only the yield would increase, but, at the same time, the process of accumulation of organic matters and biologically important substances would be accelerated by an increased activity of plants and micro-organisms which influences substantially soil fertility.

The second principle in the enhancement of soil fertility is a suitable rotation of cultivated plants.

Another task arising in connection with the development of the vegetal production and the solution of the principal problem of feeding mankind, is the production of a sufficient quantity of quality fodder.

A. The set-up of the agricultural sector in Ethiopia

The agricultural production of Ethiopia is administered by the Ministry of State Farm Development (MSFD) which has replaced the former State Farms Authority.

At its establishment, MSFD took over agricultural farms with a total area of 67,000 ha, represented mainly by nationalized farms previously controlled by private entrepreneurs and foreign corporations.

Since 1979 state farms have been extended significantly, and in 1986, the total agricultural land administered by MSFD was 204,196 ha, consisting of 54 farms of 100 to 10,000 ha. This situation will remain unchanged until 1988, when a reorganization is expected to be realized. The development plan for the following 10 years foresees a further extension of state farms which should reach a total area of 470,000 ha.

According to available data, 4 per cent of the cultivated land in Ethiopia are at present controlled by state farms. The remaining 96 per cent are in the hands of private farmers and peasants producers' co-operatives i.e. associations of peasants working in a traditional way. The only advantage of these co-operatives is that they share the execution of the agricultural work under the professional leadership of consultants of the Ministry of Agriculture.

At present, those co-operatives have no mechanical equipment, they do not apply organic or mineral fertilizers, and they are not using chemicals for plant protection to a sufficient extent.

The agricultural production of the private, small peasants caters mainly for the needs of their own families, and only a very small portion of their production is sold on the market. Consequently, the state farms have to cater for the processing industry and the market.

According to their location, the state farms are organized in four so-called corporations, namely:

(a) The North-Western Agricultural Development Corporation;

(b) The Southern Agriculture Development Corporation;

(c) The Awash Agriculture Development Corporation;

(d) The Horticulture Development Corporation.

The operation of the first three corporations is limited to a particular region of the country, while the fourth one operates country-wide. All four are concerned exclusively with vegetal production.

There are also three corporations dealing with animal breeding and services in Ethiopia, namely:

(a) The Livestock and Meat Development Corporation;

(b) The Agricultural Equipment and Technical Services Corporation;

(c) The Ethiopian Seed Corporation.

North-Western Agricultural Development Corporation

This Corporation consists of the following four enterprises:

(a) Welega Agricultural Development Enterprise, comprising eight state farms with a total area of 36,980 ha, of which 33,000 ha are devoted to planting cereals (29,240 ha for maize and 3,760 ha for sorghum). A small part, about 1,200 ha, is dedicated to sunflower, 1,400 ha to capsicum and 1,380 ha to kenaf, soya and ground-nut;

(b) Gojjam-Gonder Agricultural Development Enterprise, comprising five state farms with a total area of 19,275 ha, of which 13,264 ha are used for cereals (8,750 ha for maize, 3,700 ha for sorghum and 814 ha for wheat). Capsicum is planted on an area of 1,700 ha, sesame on 1,500 ha, soya on 850 ha and sunflower, ground-nut and beans on 1,961 ha;

(c) Keffa, consisting of only one state farm, which plants 650 ha with maize, 60 ha with pineapple and 50 ha with spices;

(d) Lubador, also comprising only one state farm planting 1,500 ha with maize.

Southern Agricultural Development Corporation

That Corporation is composed of the following three enterprises:

(a) Arsi Agricultural Development Enterprise, including five state farms with a total area of 33,437 ha, planting 25,689 ha with wheat, 6,824 ha with barley and 960 ha with rape;

(b) Bale Agricultural Development Enterprise, consisting of six farms with a total area of 45,306 ha, planting 41,436 ha with wheat, 3,150 ha with barley and 720 ha with rape;

(c) Sidamo Agricultural Development Enterprise, comprising seven farms with a total area of 23,630 ha, of which 13,161 ha are used for maize, 1,870 ha for wheat, 4,810 ha for cotton, 1,297 ha for sisal, 1,294 ha for beans, 1,000 ha for sunflower and 199 ha for bananas, citrus fruit and tomatoes.

Awash Agricultural Development Corporation

The two enterprises under that Corporation are:

(a) Middle Awash Agricultural Development Enterprise with five farms and a total area of 13,355 ha, of which 12,915 ha are used for planting cotton and 440 ha for bananas;

(b) Tendaho Agricultural Development Enterprise with five farms and a total area of 20,368 ha, planting cotton on 20,068 ha and bananas on 300 ha.

Horticulture Development Corporation

That Corporation consists of three enterprises:

(a) Nura Era Horticulture Development Enterprise, having only one farm with a total area of 7,080 ha, of which 1,857 ha are planted with citrus fruit, 1,539 ha with tomatoes, beans and onions, and 3,684 ha with cotton, tobacco, sorghum and flowers;

(b) Eritrea Agricultural Development Corporation with only one farm of 251 ha, planting fruit trees (citrus) on 128 ha, vegetables on 113 ha and maize on 10 ha;

(c) Small Farms Co-ordination Office, comprising six farms with a total area of 2,217 ha, for the production of fruits and vegetables.

Livestock and Meat Development Corporation

That Corporation is engaged in the production of milk, butter, cheese, eggs and poultry.

The meat production is secured mainly by fattening-up the livestock of lower weight categories (cattle, sheep and goats) bought from private farmers.

Two farms, with their own slaughter-houses and meat processing shops, are concerned with pig breeding, the production of concentrated fodder and the trading of hay and straw.

Agricultural Equipment and Technical Services Corporation

This Corporation imports and distributes agricultural machinery, tools, spare parts and protective chemicals.

Ethiopian Seed Corporation

The Seed Corporation is responsible for the distribution of seeds for sowing, including their cleaning and protective soaking. Its function in the production and preparation of seed would need further improvement.

B. Experimental application of non-metallic sorbents

For the reasons stated earlier in this report, the application of non-metallic sorbents seems to be the best means to improve soil fertility and enhance its sorption capacity. Once the chemical and physical analyses of agricultural soils in the selected regions was completed, the realization of pilot experiments started directly in the agricultural farms.

To embrace by the experiment different climatic conditions and different altitudes, state farms at Nazareth and Melka Werer were selected.

Nazareth State Farm

Area of agricultural land	450 ha
Altitude	1,550 m
Rainfalls	702 mm
Temperature - minimum	14 °C
- maximum	28 °C
Humidity	54%
Wind speed	8.88 m/sec

The pilot experiment is being carried out in a field near the Melkasa-Asela road on an area of about 12 ha (127 x 30 m). As shown in annex II, the area was divided into 36 plots of 7 x 7 m (49 m^2) each. The area of the plots was not determined accidentally, but in accordance with the used cultivating tools. Between the plots strips of 3 m were left barren.

Three application blocks were selected to prove, with respect to the location of particular plots therein, the reliability of the experiment.

Different portions of sorbents were applied, based on the soil analyses, professional knowledge and practical experience of the expert. The determined amounts of sorbents (bentonite and pumice) were weighed, distributed regularly onto the soil surface and ploughed in by a cultivator into a depth of 0-20 cm.

The basic manuring should consist of 0.018 kg/m^2 of nitrogen and 0.046 kg/m^2 of phosphorous pentoxide (P_2O_5). During vegetation the dosage of nitrogen should be increased to 0.046 kg/m^2.

Data sheet

1. Type of plant
2. Date of sowing
3. Date of germination
4. Quantity of seed (kg/m^2)
5. Basic manuring
6. Soil treatment during vegetation: (a) Chemical
   (b) Mechanical
7. Rainfalls and daily temperature
8. Occurrence of pests - species
   Occurrence of diseases - type
   Occurrence of weeds - species

9. Beginning of blooming
10. Date of ripening
11. Date of cropping - volume weight of the product from particular plots

The pilot experiment will be monitored during the next two years, i.e. in 1987 and 1988, and evaluated each year. After the 1988 harvest, soil samples will be taken and physical/chemical tests conducted.

Melka Werer State Farm

Area of agricultural land	400 ha
Altitude	750 m
Rainfalls	614 mm
Temperature - minimum	19.6 °C
- maximum	34.8 °C
Humidity	48%
Wind speed	5.97 m/sec

The pilot experiment is being conducted in a field not specifically marked, near the farm where cotton is planted. As shown in annex III, the area was divided into 12 plots of 7 x 7.2 m (50.4 m^2) each, to comply with the cultivating tools used for planting cotton. Only one application was chosen for this experiment since the soil in question was of homogeneous chemical and physical composition. Therefore, further applications would not bring different results but would require a good deal of laborious manual work, especially during the second year of the experiment. These plots were not separated by barren strips, since the whole area is intensively cultivated and irrigated and should be exploited as a whole.

The plots are separated from each other by irrigation channels so that the borders are permanently and visibly marked.

The sorbents were put manually into a depth of 10 cm. For the next crop, when the plots will be ploughed, the depth will be 20 cm. The volume (m^3) of treated soil will, therefore, double in 1986, while the quantity of sorbent per m^2 will remain unchanged. The depth of sowing in the first year does not influence the results of the experiment. The composition of the portions of sorbents applied was based on the soil analyses showing the content of organic matter, pH value, content of basic nutrients and main physical properties.

During the years 1986 to 1988 the experimental plots will be irrigated. Based on the information recorded on the data sheets (same as for Nazareth farm), a final evaluation of the experiment (increase in crop yield and chemical and physical properties of the soil) will be made in 1988.

Monitoring of the experiments

The experiments in the two state farms are promising, but will depend on the proper recording and evaluation of the results. The official responsible for the monitoring of the experiment at Nazareth is Ato Solomon, farm manager, and at Melka Werer, Geremew Ethicha, plant manager.

The supervision of the established pilot experiments and any required professional assistance during the two-year period will be extended by Taya Bekele, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa.

III. UTILIZATION OF RESULTS

The present project of soil reclaiming in Ethiopia would increase the agricultural production and solve some pressing problems in that sector. It is oriented predominantly to state farms administered by MSFD. It is, however, expected that the experience gained in the enhancement of soil fertility will be transferred successively to co-operatives and private farmers. Being a demanding task, it will require the support of governmental and departmental authorities, and a responsible management in the state farms who has to monitor the project objectives, thus ensuring that the desirable outputs, i.e. a considerable increase of the vegetal production and animal husbandry in Ethiopia, will be reached.

A. Analysis of soil samples

In 1985, soil samples from the agricultural regions of Melka Werer, Mieso-Asebot and Nazareth were taken. Their analysis (see annex IV) shows that the soils are suitable, in case of proper cultivation and application of adequate agrotechniques, to afford increased yields under existing climatic conditions.

The soils tested display an acidic reaction, their pH value being higher than 7.5, a low content of organic matter, and, therefore, a low sorption capacity of principal nutrients, trace elements and, above all, water, which is a limiting factor to the achievement of higher yields in those regions. A similar situation is expected to exist in other regions where no soil analyses have been made so far.

During the years 1986 to 1988 soil samples should be taken at all state farms and submitted for chemical and physical testing. Based on the results, agronomic maps, of particular tracts of land if applicable, should be compiled.

Depending on the test results, agrotechnical measures, with the aim of enhancing the soil fertility, will have to be determined, including:

(a) An increase of the humus content through the addition of organic matter and organic fertilizers. An acceptable level of humus content, is not however, likely to be reached before 10 years;

(b) An increase of the sorption capacity by adding non-metallic sorbents which are abundant in the country according to the geological prospecting. Chemical tests confirmed their suitability for such application.

B. Application of non-metallic sorbents to reclaim agricultural land in selected areas of Ethiopia

Characteristics of available non-metallic sorbents

Ethiopia has deposits of plastic and non-plastic sorbents for soil reclaiming. The basic characteristics of bentonite from Melle Wollo and pumice from Welenchiti Shoa are indicated below.

	Bentonite	Pumice
Chemical composition (%)		
Loss on ignition	9.43	4.58
SiO_2	58.45	68.77

	Bentonite	Pumice
Al_2O_3	11.31	9.93
Fe_2O_3	10.38	4.74
TiO_2	1.43	0.31
CaO	2.46	1.82
MgO	3.55	0.59
K_2O	1.53	4.64
Na_2O	1.31	4.53
Mineralogical composition (%)		
Montmorillonite	75	-
Illite	5	-
Silica	5	91.5
Quartz	10	3.8
Cristoballite	5	-
Feldspar	-	4.7
Physical and chemical properties		
Water adsorption at 75% of relative humidity (%)	18.21	1.05
Adsorption of methylene blue ($mol.kg^{-1}$)	0.780	0.001
Ion-exchange capacity ($mol.kg^{-1}$)	0.556	0.622
Mg^{2+}	0.118	0.011
Ca^{2+}	0.331	0.554
Na^{1+}	0.058	0.023
K^{1+}	0.030	0.016

Influence of bentonite

According to the latest research, the function of non-metallic sorbents is twofold:

(a) They reduce the wash-out of fertilizers, improve the ability of the soil to retain water within the ploughing depth and improve the soil quality with respect to its ion-exchange capacity;

(b) They release nutrients (N, P, K) and trace elements (MgO, Al_2O_3, MnO) direct to the plants thus increasing yields by 10 to 40 per cent according to the type of plant cultivated, the content of humus, the soil acidity, the granularity and ultimately the climatic conditions.

Tests and practical trials carried out in Czechoslovakia showed that the effects of industrial fertilizers increased by 15 to 25 per cent in case of a simultaneous application of bentonite. The use of bentonite would, therefore, seem to be most appropriate for the Ethiopian agriculture, where only small quantities of industrial fertilizers are applied and where nutrients, especially nitrogen, are being washed out owing to irregular rainfalls.

The efficiency of bentonite application in relation to soil fertility and crop yield depends on its quality which can vary considerably as far as its chemical reaction, moisture content, and the content montmorillonite, bivalent Fe and kaolinite are concerned. But the analyses of Ethiopian bentonites indicated that they would be well suited for agricultural purposes.

Since an exact specification of the required properties of bentonites is very important, it is necessary to test the material regularly, during extraction as well as before agricultural application.

In farms with a larger number of animals (cattle, sheep, goats or pigs), bentonite should be used as bedding. Thanks to its high absorbtiveness, bentonite saturated by liquid and solid excrements constitutes an excellent organic fertilizer.

Influence of pumice

The addition of pumice to soil has two main effects:

(a) It enhances the water retention capacity considerably and lowers the desiccation of light and excessively permeable substrates;

(b) In heavier soils, it lowers the bulk density and enhances the porosity and permeability, thus improving the conditions of water movement and increasing the amount of water available to plants. This property can be considered decisive for the soils in Ethiopia, especially in the Nazareth and Melka Werer regions.

C. Improvement of basic agrotechniques

After the harvest of the main crop, stubble-breaking should be carried out immediately, for which disc ploughs can be used.

For ploughing, the principal soil-cultivating operation, ploughs with three to five shares should be used which, when properly adjusted and operated, loosen the soil evenly and plough in the remaining organic matter, including weeds. With the disc ploughs used at present, the roots of digitaria sp. (couch grass) are only cut into pieces which causes its further spreading.

Before sowing, the soil should be prepared by smoothing drags and blade planes which both crush the soil and smooth the surface. Subsequently toothed harrows should be used to loosen the soil and lift the weeds up to the surface.

Exhausted soils should also be supplemented with nutrients (N, P, K) and trace elements by adding mineral fertilizers, which are now being tested in the pilot experiments at Nazareth and Melka Werer.

For sowing traditional sowing machines should be used, which secure a uniform distribution of the seeds.

To make better use of the soil between main crops, intermediate products such as oats, vetch, rape or green fodder, should be planted. Weeds or green fodder, if not used as such, should be ploughed in and converted to the so-called green manure with a simultaneous application of non-metallic sorbents.

The application of the above-mentioned techniques should result in an accelerated soil recovery together with an enrichment of the soil by trace elements, a decrease in weed occurrence and an improvement of the soil structure and, ultimately, an increase of the yields. Annex V gives the scheduled yields and total crops for 1985 and 1986, and annex VI, for comparison, the yields recorded by state farms from 1979 to 1986.

IV. NON-METALLIC SORBENTS FOR SOIL RECLAMATION AVAILABLE IN ETHIOPIA

Although the reserves of bentonite and some other non-metallic raw materials have been evaluated during geological prospecting in Ethiopia, it is not possible to arrive at final conclusions since not all deposits of non-metallics have been geologically determined.

The following bentonite deposits have been relatively well assessed:

(a) Waseiso-Wollo: calculated reserve 7,006,660 m^3 average thickness 5.58 m;

(b) Hadar-River-Wollo: calculated reserve 925,450 m^3 average thickness 1.42 m;

(c) Ledi-Wollo: calculated reserve 1,784,000 m average thickness 3.20 m;

(d) Gewani-Harar: calculated reserve 77,034,611 m^3 average thickness 11.83 m.

The properties of bentonites from the four localities are comparatively uniform and they can find many industrial applications, especially in foundries, in civil engineering, in the ceramic and food industries and also as animal feed stock. They are very suitable for the reclamation of sandy soils as confirmed by laboratory tests. The high sorption and ion-exchange capacity (Ca and Mg) will influence positively the high salinity of some agricultural soils in the Melka Werer region, where they can be effective in reducing the drainage of water (bentonite and lime).

As the geological survey continues, there is a realistic presumption that new exploitable deposits will be found.

Deposits of pumice are known, but not geologically verified. The pumice deposit at Shoa was considered for exploitation because of its economically acceptable distance. The Shoa deposit is situated near the Addis Ababa-Assab highway, between Welenchiti and Metehara, 44.5 km east of Welenchiti. Pumice was found on the face of a hill. The thickness of the pumice breccia layer is approximately 8 to 13 m, covered by 1 m of overburden. The reserves were not calculated, but they seem to be sufficiently large for mining on an industrial scale. Grinding and classification of that pumice is necessary if it is to be used for soil reclaiming.

Among other agricultural non-metallic sorbents, tuffs are to be mentioned which occur 15 km south of Dera and 2 km west of the highway Addis Ababa-Asela. The thickness of welded tuff layer is about 5 m under 2 to 3 m of overburden. Geological reserves were not calculated; however, a geological survey has been recommended since the tuff is industrially interesting. Tuff can be applied for soil reclaiming after grinding and screening.

There are also deposits of other non-metallic raw materials which could be used in agriculture:

(a) Diatomite in the Sidamo region;

(b) Bentonitic clay in the same region;

(c) Dolomite in the area Galetti-Kuni.

The management of EMRC agreed to the extraction of bentonite and pumice required for the agricultural experiment, and only 6 t of bentonite and 4 t of pumice were extracted manually. The costs of that operation were as follows:

	Br
Manual extraction	205
Crushing	300
Transport	377
Total	882

The cost per 1 t of raw material therefore equals Br 88.2.

However, no further conclusions should be drawn from that calculation. According to the responsible managers it will be necessary to resort to an integrated exploitation of non-metallic raw materials in Ethiopia, both for industrial and agricultural purposes, in order to warrant a suitable mechanization and to achieve a full exploitaton of the deposits.

At present, the highest portion of the costs is attributable to transport and sorbent beneficiation. In discussions with the responsible management, it was stressed that the needs of non-metallic sorbents for agricultural purposes have to be covered from the nearest deposits. Furthermore, the possibility of exposing the extracted bentonite and pumice to sunshine and rain in order to achieve a suitable disintegration of the material for agricultural purposes will be tested. Detailed economic data will be available in 1988 together with the final figures of the two-year experiments.

Based on a final evaluation, the economic profitability of the exploitation of non-metallic sorbents and their application in the agriculture of Ethiopia will be considered by agricultural experts.

Annex I

PERSONS WHO ASSISTED THE EXPERT IN THE FIELD

Wodaje Abebe, General Manager, EMRDC

Lakew Tezera, Head of Industrial Minerals Division, EMRDC

Shiferaw Demissie, Head of Mineral Reserves Study Department, EMRDC

Alemaychu Zewdu, Geologist of Exploration Department, EMRDC

Taya Bekele, Research and Extension Co-ordinator, EIAR

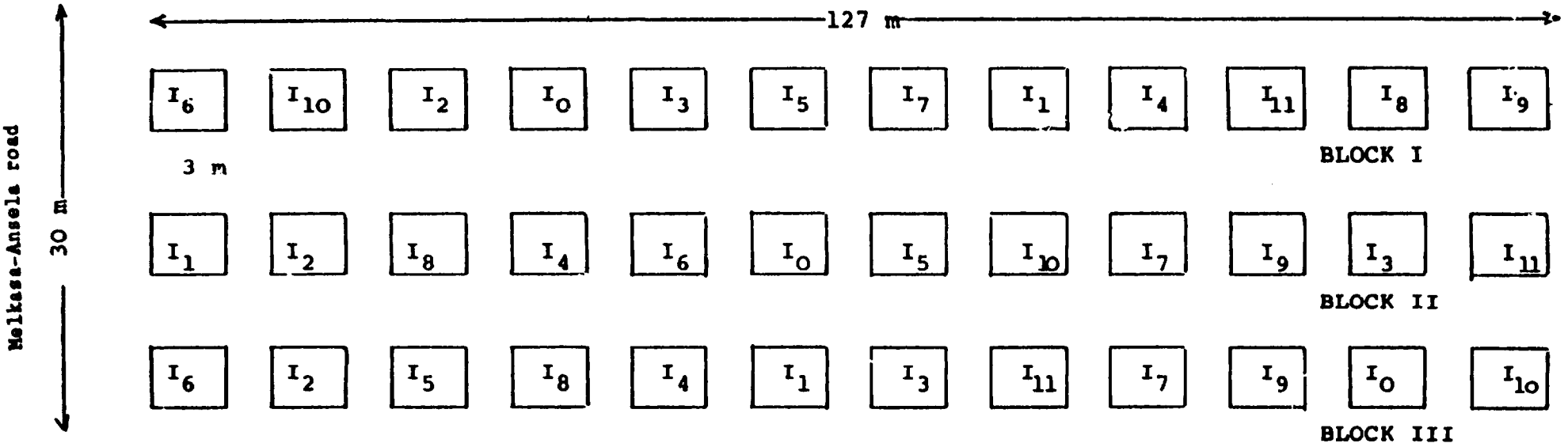
Tsedeke Abate, Head of Department of Crop Protection, EIAR

Tadele G. Selassie, Officer-in-Charge, Melka Werer Research Station

Annex II

EXPERIMENT AT NAZARETH STATE FARM

A. Layout of plots



Note:

Plot size 7 x 7 m (49 m^2)
Ploughing depth 0.2 m
Volume of soil in each plot 7 x 7 x 0.2 = 9.8 m^3
Crop-maize and sorghum

B. Application of non-metallic sorbents to individual plots

Plot No.	Dosage per plot (kg)		Dosage of bentonite			Dosage of pumice		
	Bentonite	Pumice	kg/m^3	kg/m^2	t/ha	kg/m^3	kg/m^2	t/ha
I_1	33.0	-	3.0-	0.7	7			
I_2	66.0	-	6.0	1.4	14	-	-	-
I_3	99.0	-	10.0	2.0	20	-	-	-
I_4	132.0	-	13.4	2.69	26.9	-	-	-
I_5	-	34.2	-	-	-	3.49	0.7	7
I_6	-	58.8	-	-	-	6.0	1.2	12
I_7	-	78.4	-	-	-	8.0	1.6	16
I_8	33.0	19.6	3.0	0.7	7	2.0	0.4	4
I_9	66.0	39.6	6.0	1.4	14	4.0	0.8	8
I_{10}	99.0	58.8	10.0	2.0	20	6.0	1.2	12
I_{11}	132.0	78.4	13.4	2.69	26.9	8.0	1.6	16
I_0	Comparative plot							

Annex III

EXPERIMENT AT MELKA WERER STATE FARM

A. Layout of plots

T_6 Bentonite 88 kg Pumice 127.4 kg	T_7 Bentonite 98 kg Pumice 147 kg	T_8 Bentonite 122.5 kg Pumice 171 kg	T_9 Bentonite 147 kg Pumice 196 kg	T_{10} Pumice 196 kg	T_{11} Pumice 245 kg
T_0	T_1 Bentonite 88 kg	T_2 Bentonite 98 kg	T_3 Bentonite 122.5 kg	T_4 Bentonite 147 kg	T_5 Bentonite 196 kg

Awash River

Note:

Plot size 7 x 7.2 m (50.4 m^4)
Ploughing depth 0.1 m
Volume of soil in each plot 7 x 7.2 x 0.1 = 5.04 m^3 (in the first year of the experiment)
Crop - cotton

B. Application of non-metallic sorbents to individual plots

Plot No.	Dosage per plot (kg)		Dosage of bentonite			Dosage of pumice		
	Bentonite	Pumice	kg/m^3	kg/m^2	t/ha	kg/m^3	kg/m^2	t/ha
T_1	88	-	17.4	1.74	17.4	-	-	-
T_2	98	-	19.4	1.94	19.4	-	-	-
T_3	122.5	-	24.3	2.43	24.3	-	-	-
T_4	147	-	29.1	2.91	29.1	-	-	-
T_5	196	-	38.8	3.88	38.8	-	-	-
T_6	88	127.4	17.4	1.74	17.4	25.2	2.52	25.2
T_7	98	147	19.4	1.94	19.4	29.1	2.91	29.1
T_8	122.5	171	24.3	2.43	24.3	33.9	3.39	33.9
T_9	147	196	29.1	2.91	29.1	38.8	3.88	38.8
T_{10}	-	196	-	-	-	38.8	3.88	38.8
T_{11}	-	245	-	-	-	48.6	4.86	48.6
T_0	Comparative plot							

Annex IV

ANALYSIS OF SOIL SAMPLES TESTED IN ETHIOPIA

	Melka Werer		Mieso-Asebot		Nazareth	
Sample number	1	2	12	13	25	26
Depth of layer (cm)	0-15	15-30	0-15	15-30	0-15	15-60
Electrical conductivity	2.11	2.28	0.65	0.65	0.72	0.22
pH content	7.70	7.70	8.05	8.10	7.60	8.20
Organic matter (%)	0.345	0.449	0.690	1.932	1.208	0.690
Total content of N (%)	0.056	0.028	0.154	0.140	0.126	0.084
Exploitable P (ppm)	8.8	8.0	2.4	2.4	traces	4.0
Exploitable K (ppm)	21.8	14.7	13.5	12.8	23.7	22.8
Granularity (wt. %)						
Sand above 50 m	31.08	33.08	39.08	41.08	53.08	45.08
Loess, 50 - 2 m	53.62	55.62	33.62	43.62	31.62	44.00
Clay under 2 m	15.30	11.30	27.30	15.30	15.30	10.92

Annex V

PLANTED AREA, YIELD AND TOTAL CROP OF ETHIOPIAN STATE FARMS, 1985 AND 1986

Plant	1985 Area (ha)	1985 Yield/ha (q)	1985 Total crop (q)	1986 Area (ha)	1986 Yield/ha (q)	1986 Total crop (q)
Maize	53 796	29.79	1 602 600	65 024	29.84	1 940 200
Wheat	69 809	17.82	1 244 000	70 110	18.82	1 319 400
Sorghum	7 460	10.12	75 500	8 710	11.16	97 200
Barley	9 974	21.46	214 000	8 443	22.73	191 900
Beans	1 694	9.50	16 100	1 041	9.22	9 600
Soya	1 630	8.04	13 100	1 630	8.04	13 100
Sunflower	2 690	9.22	24 800	2 490	9.32	23 200
Sesame	1 600	2.06	3 300	1 600	2.06	3 300
Ground-nut	400	7.00	2 800	400	7.00	2 800
Rape	1 680	8.15	13 700	2 940	8.40	24 700
Cotton	39 103	23.01	909 400	39 548	24.06	951 400
Sisal (m^3)	1 297 a/			1 699 a/		
	800	22.00	17 600	603	22.06	13 300
Kenaf	1 000	10.00	10 000	2 000	10.00	20 000
Tobacco	1 100	12.00	13 200	1 300	12.00	15 600
Vegetables	2 529	127.00	321 700	2 584	122.10	315 500
Fruits	3 560 a/			5 660 a/		
	1 184	165.88	196 400	808	301.23	243 400
Capsicum	3 170	9.09	28 800	3 170	9.09	28 800
Spices	50	50.00	2 500	50	50.00	2 500
Other	1 645			1 645		
Total	204 196			220 053		

a/ The upper figure represents the total allocated area, the lower one the area actually cultivated in the respective year, together with the yield.

Annex VI

YIELDS OF ETHIOPIAN STATE FARMS, 1979 TO 1986
(In quintals)

Plant	1979	1980	1981	1982	1983	1984	1985	1986 (scheduled)
Maize	27.58	28.83	28.02	20.17	21.25	23.53	29.79	29.84
Wheat	12.10	18.50	13.02	15.78	12.87	15.08	17.82	18.82
Sorgham	10.57	11.87	7.91	5.87	8.38	8.02	10.12	11.16
Barley	13.39	18.94	18.30	23.51	12.10	12.95	21.46	22.73
Beans	3.87	3.94	3.80	3.76	3.57	3.21	9.50	9.22
Teff	5.86	5.16	5.60	5.31	3.24	2.78	-	-
Soya	4.47	2.89	2.50	4.64	2.40	3.29	8.04	8.04
Sunflower	10.73	2.65	2.14	4.69	3.65	4.79	9.22	9.32
Sesame	1.84	1.86	1.96	0.28	3.44	0.10	2.06	2.06
Ground-nut	4.83	2.05	2.85	4.38	9.82	5.41	7.00	7.00
Rape	8.04	4.33	6.24	4.48	4.42	5.21	8.15	8.40
Cotton	20.37	22.81	22.48	17.00	17.19	22.17	23.01	24.06
Sisal (m^3)	-	-	-	18.03	23.19	10.82	22.00	22.06
Kenaf	5.92	3.25	5.16	2.95	-	3.73	10.00	10.00
Tobacco	6.44	11.95	11.80	7.87	12.82	12.54	12.00	12.00
Vegetables	49.81	55.71	63.28	62.21	76.44	138.64	127.00	122.00
Fruits	127.82	102.20	120.03	112.69	116.94	53.65	165.00	301.00
Capsicum	8.18	2.40	3.63	1.95	4.04	3.50	9.09	9.09