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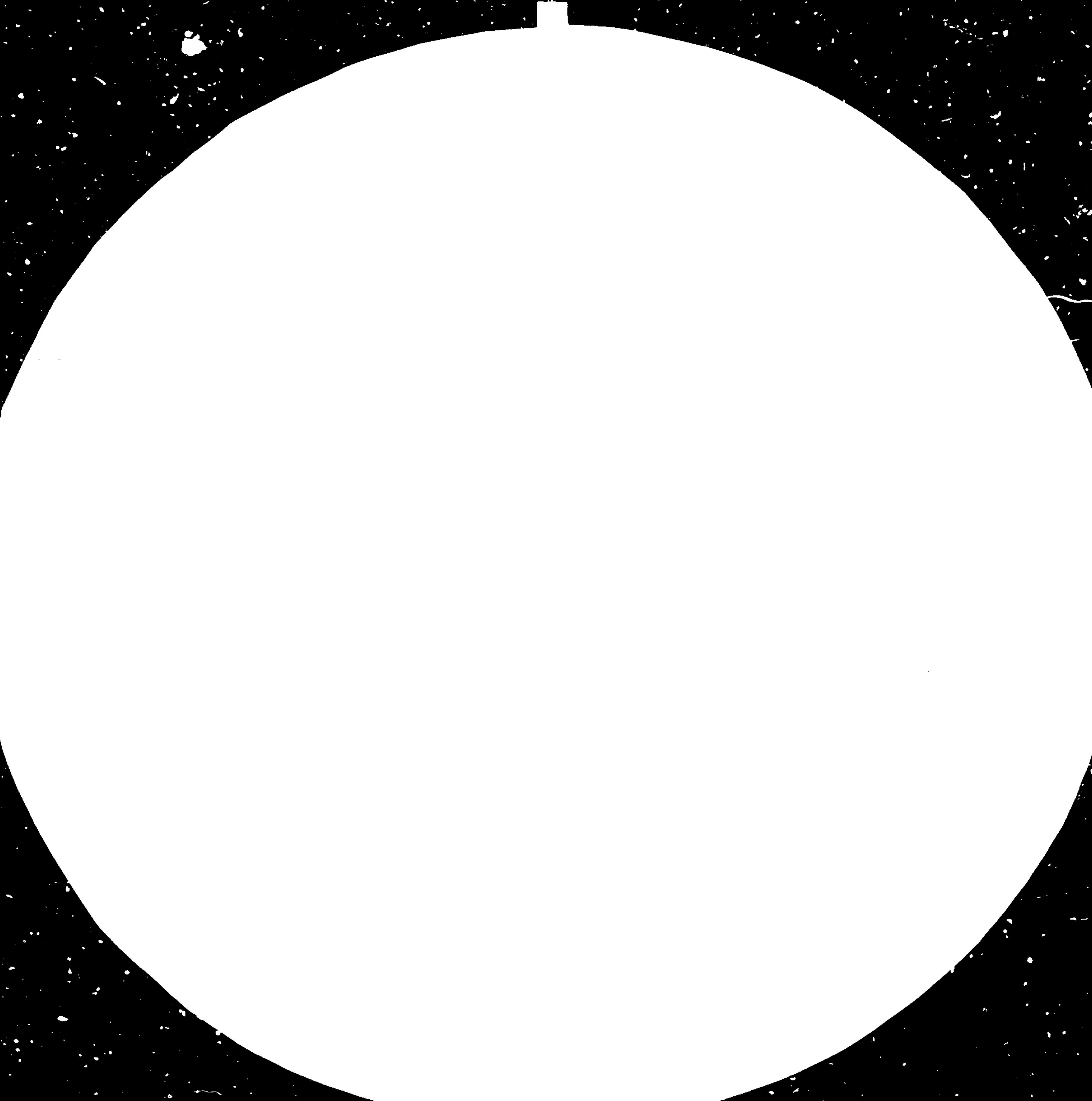
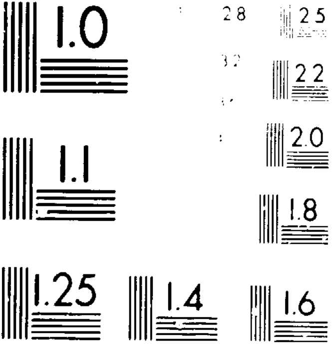
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org





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PRODUCTION AND USE OF PEAT-BASED FERTILIZER

SI/BDI/78/801

BURUNDI

Technical report: Organic materials, soil amendments and fertilizers based on peat and the technology for their production. *

Prepared for the Government of Burundi
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of [illegible],
expert in the production of peat-based fertilizers

United Nations Industrial Development Organization
Vienna

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Summaries

The republic of Burundi disposes of large peat reserves /about 500 million tons/ representing an enormous treasure among the raw material resources of the country. Peat is exploited on several sites, the most important are: Kashiru-Ijenda, Gishubi-Matana, Kuruyange-Kisozi and Buyungwe.

Exploitation has low productivity because it is mainly carried out by hand power or it is partly mechanized. Due to up-to-date technology in Gishubi-Matana, peat exploitation is going on systematically and on high technical level. The greatest part of the obtained peat is used as fuel, for industrial and household purposes as well as for producing thermoelectric energy; only a small part is applied in agriculture, primarily for the improvement of soils which are, in Burundi, poor in organic matter and have low adsorption capacity. The soils are generally acidic /pH 4.1 - 6.5/ and need to be limed; lime /4-5 kg/m^2/ is often mixed with peat. On the ISABU-Kisozi experimental station the composting of peat with cow manure, lime and raw phosphate is carried out by hand power. The obtained product is of very good quality /2.5 - 3 % N, 0.4 - 0.6 % P_2O_5 and 1.5 - 2.0 % K_2O/ and is applied in the experiments as well as on the neighbouring coffee, tea and banana plantations.

The study by K.H. Richard on the exploitation of Burundi peats, and that by F. Penningsfeld dealing with peats and soils provide data as to the exploitation and rational use of this material. In addition to these very important reports, however, a better knowledge of Burundi peats is needed to decide on the possibilities of the application on the basis of their quality. Present work has the aim to give a guide concerning the technology of large-scale production of different peat based organic amendments, materials and preparations as well.

As shown by the chemical and physical analyses carried out and compared with the international standard, the peats are of medium quality owing to their ash and low nutrient contents as well as low water retention capacity. The peats can be ranged

into II and III classes and keeping this in view should the methods of their use and the needed technology be selected. Adhering to the technological prescription and adding different materials as lime, raw phosphate, organic composts, etc. to the II and III class peat, good quality and widely applicable organic amendments can be produced. These are soil ameliorants, good quality composts for the fertilization of coffee,tea,banana plantations, mulches, soil conditioners for the use in horti- and floriculture and afforestation, etc.

The above-listed materials are required mainly for inland consumption, but the possibility of exporting some products of special composition is not excluded. Thus, for instance, the mixture of selected I and II class peat and vermiculite could be added as conditioning material to sandy and garden soils.

As for the minerals found in Burundi, thorough studies have to be carried out on their applicability in agriculture, especially as supplements to organic amendments on peat base. Sites of rock phosphate, vermiculite, mica and feldpaths should be explored for exploitation and processing.

The examination of peat sites is necessary to select and qualify the most suitable material for technological processing. This selection will show the quantitative distribution of I class peats and those of low quality according to the different regions. These examinations could be regularly carried out by ISABU to ensure that peats of suitable quality are processed for obtaining final products of standard composition.

The production of the amendments of peat base mentioned in the report requires certain technical level. These preparations cannot be produced by hand power or simple mixing of low productivity, as the obtained materials should have constant composition and quality; all these need large-scale technology. For this purpose the "Sopron-Peat technology is advisable, the max. annual production capacity of which is 250 thousand tons. Naturally a plant of lower capacity /e.g. 50 thousand t/year/

may also be established, which, as pilot plant, could master the operation of large-scale technology and produce different assortments from the selected peats. The products of the pilot plant would satisfy inland demands or offer export possibilities.

For the setting up of the pilot plant at the peat bog of Kashiru-Ijenda may be taken into consideration from the aspect of the quality of peat and acessability of the plant by road.

It would be practical to set up the pilot plant on a central site of ONATOUR where the infrastructure /roads, electricity/ is suitable and to which the basic materials /peat, compost, lime, raw phosphate etc./ can easily be transported. These central premises should be situated in the vicinity of those agricultural areas where the final product will be utilized

The ISABU-Kisozi experimental station may also be taken into account insofar as the transportation of peat and of its final products can be solved. In that case ISABU would carry out the examination of the peat and of the final product. A further advantage of establishing a pilot plant at this place would be that the peat based organic materials could be utilized on areas which ISABU has previously examined and designated for rural development.

Already in 1984 occasion should be created in the ISABU laboratory for the preliminary selection of the product assortment according to the technology, for the qualification of the preparations and their testing in pot experiments following the expert's directives.

The establishment of the pilot plant could be supported by the UNIDO and similarly the UNIDO may organize in Spring 1984 the visit of the ONATOUR and ISABU leaders in Hungary and following this the training of 3 to 4 technical employees in this country.

The expert consulted with Mr. Ernst Zachmann, project manager of the UNIDO /Bujumbura/ and with Mr.Luigi Spinato, expert of CPI /Centre de Promotion Industrielle,Bujumbura/, who considered the introduction of large scale technology to be desirable and realizable in Burundi.

Contents | Page

I. Introduction

1. Peat as a source of organic material

In the past only farmyard manure was considered as the only source of organic material in fertilization. In our modern economy, the function and demands of fertilization and the source of organic materials have changed. Formerly, manuring had the unique role of nutrient supply, nowadays, soil physics, water management and environmental protection have become dominant as well. Instead of farmyard manure liquid manure is obtained from up-to-date livestock keeping, the utilization of which is of primary interest. Peat was found to be a new source of organic material and is applied in plant nutrition as a supplement with mineral fertilizers or as carrier for liquid manures. Industrial and agricultural wastes, sewage sludge etc. are further sources of organic materials, but their use is limited by tight control /e.g. due to bacteriological and heavy metal contamination/. Peat plays an important role in composting organic wastes.

The countries rich in peat may be considered to be fortunate as the organic material energy supply of peats represents an enormous value. Peat as a source of energy is suitable for replacing crude oil and other energy carriers. The peat is suitable for agricultural utilization in different ways and it is mostly applied in mixtures under trade names such as orgaphosphate, biosuper etc.

The rational use of peat is paid world-wide attention as

- i a soil amendment
- ii a product on peat base
- iii fertilizer mixture on peat base

2. General aspects of the production of organic materials on peat base

The first step is the assessment of peat reserves and quality in the given country. Besides elemental analyses, detailed data are needed on the chemical composition and physical properties of peats used for producing organic materials. These are:

- i pH value
- ii organic matter content
- iii ash content
- iv moisture content
- v specific volume
- vi structure
- vii structure stability
- viii water retention capacity
- ix nutrient content
- x humic acid content

The analytical data listed above are necessary for the qualification and classification of peats. According to the classification the good quality peats are ranged into the I and II class, the poor quality peats and good quality marsh soils into the III class. The applicability of peat is determined by this qualification, e.g. I class material is needed for nutrient cubes /Chapter 5 /, but III class one is suitable as soil improving material /Chapter 6 and 7/.

3. Aim of the mission

As it is known, peat as organic material can equally be used for industrial and agricultural purposes. In the industry it plays a role either a energy carrier when is applied as fuel, or in metallury /e.g. nickel/ as reductant. The utilization of peat in agriculture has much wider ranges: as soil improving material, humus amendment or as organic products on peat base in floriculture and vegetable growing. Burundi is very rich in peat, its reserves are estimated to be around 500 million tons. Mineral resources are not abundant in this country thus the utilization of peat seems reasonable. It can be taken into account as fuel in the households, avoiding thereby the clearing of forests in this country poor in woodland. Burundi soils are poor in humus and are acidic, by the use of peat mixed with limestone or dolomite the humus content would be increased and acidity moderated. According to the informations raw phosphate, mica, feldpath and vermiculite are also to be found in this country; these may serve as basic material in the production of mixtures and preparations containing peat. ONATOUR /Organisation national de la tourbe/ deals with the exploitation of peat and ISABU /Institut des Sciences agronomiques du Burundi/ with the research of its agricultural use.

During his two-week stay in Burundi /Sept.26 - Oct.10, 1983/ the expert consulted several times with the leaders of the mentioned two organizations and visited 3 peat bogs: Kashiru-Ijenda, Gishubi-Matana and Kuruyange-Kisozi, as well the ISABU laboratories and its experimental station. The task of the expert was to study the suitability of Burundi peats for the production of soil conditioners, soil amendments and organic preparations and if they are suitable, to decide which technologies can come into consideration. Besides inland consumption, exporting possibilities were also studied. To give answers to these important questions, the expert took peat samples, analysed and evaluated them. The qualification method is described in the Chapter II 3.

II. Results

1. Visited peat sites

During his visit at ONATOUR and ISABU, the expert was informed that main importance is attached to the possibilities of inland utilization of peats. Thus, the methods and technology are to be elaborated in this respect. According to the general opinion the production costs of the fertilizers on peat base should be as low as possible and besides, a part of the preparatons could be sold abroad, too.

Surveying the Kashiru-Ijenda, Kuruyange-Kisozi and Gishubi-Matana bogs, the expert could get preliminary information on the quality of peats. The classification of the peats, however is to be performed on the basis of analytical data.

After the consultations with the ONATOUR and ISABU leaders and considering the experience obtained at the above mentioned peat bogs, the following preliminary statements can be made:

a- The Kashiru-Ijenda peat is moderately fibrous and is, at present, mainly used as fuel in households and industry. But this peat could be composted as well and in this form utilized on the neighbouring farms.

b- At the ISABU-Kisozi experimental station peat is successfully composted by mixing with cow manure in equal ratios; lime and row phosphate are added, too. This compost obtained after aerobic fermentation is very good quality, favourable texture and high nutrient content.

c- Some part of the Kuruyange-Kisozi peats have strongly fibrous structure. Separated by sieving, this fibrous peat can be used with good results as mulch on the plantations or as litter in stables, further as basic material in biogas productior

d- At the Gishubi-Matana bog peat is exploited with up-to-date technology. The dried peat blocks are used as fuel in household and industry.

2. Analysis of the peats

Samples were taken from each of the visited sites, and an avarage sample was also taken to characterize by and large the whole peat area.

The data of the chemical analysis are compiled in Table 1, those of the physical properties in Table 2. It is seen that the pH of the peats is low and they are poor in available nutrients, as phosphorus /P_2O_5/ and potassium /K_2O/, however their nitrogen /N/ supplying power is good. In the Kuruyange-Kisozi peat the high hydrolyzable N content may presumably be attributed to the fibrous structure. The physical data refer to the volume weight. Due to the high plant fibre content in samples Nos 8 and 9 the percentage values of dry matter are lower.

Table 3 presents the values of humic acid content and humus stability. The Q and K values of humus stability express the correlation between the optical density of humic matter extracted by 1% NaF and 0.5% NaOH, resp. That is, the humus stability coefficient is obtained if the average of the quotients

$$\frac{e\ NaF}{e\ NaOH}$$

of fluoric and alcaline extinction /Q/ measured in the visible light region, is correlated with the soil's total organic matter content /K/. The low values indicate the low stability of humic matter of the peat, i.e the medium quality of the peats. Due to the low humus stability, the humic acid content of the peat is only of medium degree. Thus the analysed peats cannot be considered as I class.

3. Qualification and classification of peats

On the basis of the above-mentioned aspects the characteristic samples of 3 peat bogs wer qualified and ranged into classes /Table 4/.

Considering the data, I class quality peats have not been found. Kashiru-Ijenda and Gishubi-Matana peats are II classes, whereas the average Kuruyange-Kisozi samples were regarded as III class. The data, of course, do not mean that, after appropriate selection, I class peats cannot be found on these sites.

In any case the qualification scores and classes indicated in Table 4 should be considered for the utilization of peats. E.g. the Kuruyange-Kisozi fibrous peat, receiving the lowest, 20.91 score and taken as II class quality, could theoretically be used in some peat preparations dealt with in Chapter II 5. However, owing to the rigidity of Papyrus fibres, appropriate chopping is recommended. Besides, in its original fibrous form this peat can appropriately be used as litter in cow stables.

On the basis of the analytical data, the Kashiru-Ijenda peat /score:24.32, class:II/ with its lower ash /4.59%/ and relatively high organic matter /47.26%/ contents is suitable for wide-range utilization in composts, soil conditioners, different organic materials to enrich garden soils, etc. Though its water retention capacity is lower as compared to that of the others, the loosening effect of this peat in the soil and mixtures will anyway become manifested.

The organic materials and preparations produced from Burundi peat after appropriate selection, are dealt with in Chapters II 4-5-6-7. The simplest manual, semi-industrial and mechanical mixing methods, which can be applied on the given technical level are reviewed. It is to be stated that the adaptation of modern technologies is one of the conditions required to reach a certain technical level.

4. Soil amendments on peat base

Soil improvement may be carried out in a traditional way, i.e. by spreading out peat followed by liming or in the reverse order; then comes fertilization, and all these materials are ploughed into the soil. A more up-to-date method is the mixing of prefabricated amendments into the soil by means of cultivation machines constructed particularly for this purpose.

Amendments on peat base may have very different compositions depending on the soil to be improved and on the crop to be grown. The advisable method may also display much diversity.

The most important types of amendments are described as follows:

a. <u>Mixture of peat and farmyard manure</u>

It may also be composed of II and III class peat, so the addition of 20-30 weight per cent farmyard manure is effective. The NPK amounts added to the mixture are always adjusted to the requirement of the crop.

The simplest and most reasonable process of soil improvement is to disperse peat, then farmyard manure and fertilizer together. In the lack of a mixing machine, these components can be spread out separately on the soil surface to be ploughed into the proper 30-40 cm depth.

Another method is the carpet-like placement of organic material 50-60 cm deep into the soil. It is carried out easily by digging ditches 40-50 cm in lenght and depth with a ploughing-turning machine constructed for this purpose and by placing the organic material in 0.5 - 1 cm thick layers into the ditches. In the following step the machine excavates the adjacent ditch, the soil of which is turned into the previously opened one, and it is continued in this way. The method is especially advisable in the case of soils with good water permeability /sand,latosol/ under arid climatic conditions in the greatest part of the year.

Further possibility of application is offered e.g. for coffee-shrub plantations when 15-30 kg of the amendment is placed at the bottom of the planting pit.

While improving the soil, care is to be taken in eliminating soil acidity to the measure required by the crop; namely together with the amendment $CaCO_3$ should be added in amounts corresponding to hydrolytic acidity or as calculated on the basis of soil pH. These amounts are generally between 1 and 10 t/ha.

Amendment dosis used for improvement of light textured soils:

Humus content	Amendment dosis t/ha		
	Peat	Farmyard manure	Mineral fertilizer
0. - 0.5	70	20	NPK: according to the requirement of the crop. Min.: 75 kg N, 50 kg P_2O_5,120 kg K_2O/ha
0.5 - 1.0	60	15	
1.0 - 1.0	50	10	

b. Ammoniated peat

The treatment of exploited peat on the spot with liquid ammonia promotes nitrogen fixation by absorption in the peat. In the course of the best known procedure, a product of 1.5 per cent N, 1 per cent P_2O_5 and 0.85 per cent K_2O contents could be obtained. The nitrogen release of the amendment is uniform and steady, which is very favourable in plant nutrition. It is regarded as a material of good humus supplying capacity, positively affecting the inrease in the soil's humus content.

c. Soil amendments on humus-clay base

For preparing the basic mixture at least II class peat /with maximum 30 per cent moisture content/ and swelling clay minerals /montmorillonite, vermiculite/ are used. The ratios of peat and clay minerals present large-scale variations between 10 and 90 per cent in function of the soil's humus content and water permeability. In the case of low humus content, the product contains more peat /50-90 weight%/, and the higher water permeability requires more clay minerals / above 50 weight%/. Under tropical conditions a fifty-fifty mixture may be advised for acidic latosols. The clay mineral, favourably powdered bentonite of Ca-type /10-60 micron/, supplied with fertilizers /1.0 - 1.5% NPK + trace elements/ is thoroughly mixed in a mixing machine /cylinder or drum grinder/. The obtained amendment, spread on the soil surface in amounts of 10-20 t/ha and ploughed into about 30 cm depth is to be used for field crops. For trees and shrubs /e.g. coffee/ the product should be mixed into the soil under foliage.

d. Soil amendment on humus-clay-polymer base

It can be produced from I and II class peat /30-40 per cent moisture content/ which is mixed with bentonite and fertilizers as well as 1-2 weight per cent linear polymeric solution /e.g. hydrolysed polyacryl nitryle/ in a Z-armed mixer, preferably heated to 60 °C. The swollen material is the dried and granulated /1-2 mm in size/ or powdered. The product serves as basic material for several soil amendments, e.g. as additional component up to 10-50 weight per cent to be used in flower crops and preparing nutrient cubes.

5. Products on peat base for horticultural purposes

The following products are mainly used for pot flowers and for planting vegetables.

a. Peat pot

It has the advantage of being much cheaper than earthenware pots and weigh only one tenth compared to the latter. The plant roots penetrating through the elastic and porous pot walls can extend and can get fixed in the soil. Plantation is performed together with the pot, so the roots are not damaged.

b. Swelling peat plant block

About 35 to 38 peat blocks /4-5 cm long and compressed to 1 cm thickness/ piled up on a plastic tray are easily transportable in dried state. By addition of fertilizers, their nutrient contents can be adjusted to N 150, P 75, K 300, Ca 1000, Mg 250, S 150 and Na 10 mg/litre. The block can swell about a tenfold of its volume.

c. Swelling peat disk

These round-shaped preparations are similar to the above described ones. They are ussd one by one, placing the seeds or seedlings into the hole in the middle of the disks, which are then irrigated. The disks swell to a five-tenhold of their volume. For the developing plant, humidity and nutrients are provided for a considerable period.

d. Swelling peat granules

Granules of 1-2 cm in diameter are prepared from I or II class peat by adding 20 weight per cent perlite, 1 weight per cent NPK and trace elements. They are applicable in floriculture, pot fowers etc.

e. Enriched peat

I or II class air-dry fibrous peat /30-40% humidity/ is mixed homogeneously with 1% N, 1% P_2O_5, 1.5% K_2O + Mg and trace elements. It serves as basic material for garden soils and flowers growing in green houses.

7. Peat-humic acid preparations

From peat, pure humic acid can be extracted by appropriate procedure. The quality of peat or of the above listed preparations can be improved by mixing pure humic acid to them in suitable ratios. Peats treated in this way have a stimulating effect on planth growth.

After appropriate chemical preparation, pure humic acid can be used as basic material for foliar nutrients.

Peat-humic acid preparations, treated with certain chemical methods and supplemented with swelling polymers as additives, can be made suitable to increase the swelling capacity of products under items II a-e. Thus, the water absorbing capacity of peat containing preparations, activated in this way, will be multiplied.

6. Fertilizers on peat base

a. Fertilizers and fertilizer mixtures on peat base

They contain a maximum 50 per cent peat. The peat:NPK ratios are generally 10:90, 25:75, 50:50. The choice of the right composition depends on soil properties. For soils poor in humus /0.5%/ the preparation of a 50:50 ratio is advisable. Due to their low peat content they are used as fertilizers in amounts calculated on the basis of the crop's nutrient requirements and soil analytical data. The low humus and organic matter contents of these soils may be increased; the physical properties, water and nutrient retaining capacities improved.

Two types of fertilizers can be produced by the use of:

i rapidly acting NPK fertilizers /urea, superphosphate, potassium salt/

ii slow-release NPK fertilizers /ureaform, metal ammonium phosphate, potassium metaphosphate/

The slow-release types have the advantage of not becoming leached out of the soil by heavy rains. These products may be really advisable in Burundi.

b. Peat containing fertilizer suspension

The most up-to-date and economic forms of plant nutrients are fertilizer suspensions. Their advantage is the possibility of being spread uniformly on the soil surface or injected in the soil at desired depth. Placing in rows and injecting of suspensions can be successfully carried out in plantations. The suspensions contain maximum 5-10 per cent peat.

7. Technology of producing organic materials, amendments, fertilizers and other preparations on peat base

a. Production by mixing

Considering that the products reviewed consist of several components, the simplest way is to mix them in succession. To begin with, the peat of suitable class and humidity is chopped into pieces and sieved: then in a cylinder or drum mixer, the calculated amount of $CaCO_3$ is added to adjust the pH of the products. In the second step the macro and micro elements are supplied. The product is put on the market in bulk or in granulated form. The machines needed: 1 grinder, 1 sieving machine, 1 or 2 cylinder or drum mixers, 1 granulating machine are operated by 5 persons. The disadvantage of this technology is that it demands much manpower and that the daily production capacity, calculated for 1 mixing unit, amounts only to 5-10 tons.

b. Large-scale mechanized production of organic mixtures on peat base

With the following technology, a large sortiment of articles can be produced from the simple peat + NPK mixtures upto the multi-component peat-fertilizers ones. The technologie is given, the selection of components, however, is subject to previous analysis and calculations.

1- Selection of components

An important requirement is the analysis of the basic materials of this multi-component product. The main materials are: peat, compost, clay, sand, $CaCO_3$, fertilizers /NPK/. For composing the product at least the following analyses are to be carried out: for the peat see chapters I 2 and II 2; for compost, clay and sand: pH, $CaCO_3$%, plasticity and capillary rising height /in mm/. From the data obtained the ratio of peat, compost, clay etc. is to be established to reach the end-product of the desired composition and pH. In this product the peat ratio should vary between wide ranges /10-90%/; thus, it is very important to consider the quality of peat. The Burundi peats are very acidic, so the amounts of the other components /clay, $CaCO_3$, compost/ are to be selected to make the production of a great variety of mixtures with pH between 3.5 and 8.

The Figure 1 demonstrates the variety of products obtainable in the peat-sand and peat-clay two-component systems.

2- Technology and machines for producing peat based fertilizers

The technology consists of two parts, since the components must be satisfactorily prepared. Then the different machines should be grouped according to convey the components /peat, compost, clay, sand, $CaCO_3$, mineral fertilizers etc./ in this prepared state into the mixing-feeding machine. The production process is seen in Figure 2, the technology in Figure 3.

Machine lines for part technologies:

- i peat /clay, compost, $CaCO_3$ etc./ preparations
- ii mineral fertilizer preparation
- iii mixing-feeding unit
- iv packing
- v additional works, e.g. making peat pot, plant blocks etc.

Among the part-technologies peat preparation plays an important role. The peat of suitable humidity /30–40%/ and class gets into the feeding machine, is chopped, sieved and finally stored in silage. Mineral fertilizers /NPK/ are usually ground, then sieved and mixed according to the preparations and ultimately stored in silage or in plastic sacks. Fertilizer mixtures, containing the nutrients in different ratios, should be adjusted to the requirement of the crops. The prepared components get into the 5 partitioned feeding silage /with separate boxes for peat, compost, lime, clay and fertilizer mixtures/ from where, by regulating the opening, the calculated amounts of materials are forwarded to the belt-conveyer and then to the mixing and chopping belt. The end-product stored in silage will be divided into uniform packs of the wanted sizes /2.5, 10, 25 and 50 kg/ by means of an automatic weighing balance. The product can be put on the market in bulk, too, when it is used as soil amendment.

The rate of discharge from the feeding silage, i.e. the size of the opening slit, varies according to different materials like in case of peat, compost, lime etc. The capacity of the feeders is to be adjusted for each material; it is the function of larger opening and accordingly larger doses. The transported amounts of the different components are illustrated by the graph in Figure 4. The amounts leaving the feeder depend on the moisture content and volume weight of the component in question as well.

III. Recommendations

1. The experiences of the visit on the peat sites, the talks with the leaders of the ONATOUR and ISABU as well as the analytical data of peat samples led to the conclusions that after appropriate selection the Burundi peats are suitable for technological processing. As for the utilization of the different peats, the following recommendations may be given.

a- The Kashiru-Ijenda peat has medium fibrous structure, low ash /4.59%/ and high organic matter content /47.2 %/ and low water retention capacity /23.97%/. Presently it is used as fuel. According to the recommendations it should be composted and in this form it could serve to provide the neighbouring family farms with organic manure. Peat of higher water retention capacity, selected on the site could serve as basic material for the above-described large-scale peat processing technology /Chapter II 7b/. Kashiru-Ijenda may be the first basis for the introduction of the mentioned technology.

b- The Gishubi-Matana peat is exploited with the latest method. The raw peat mass is brought on the surface through the narrow slit of the machine, then pressed to eliminate superfluous humidity. The material is spread out on the surface in the form of 15 cm thick endless cylinder and cut into 30-40 cm long blocks. After drying in the sun, the peat blocks are used as fuel in the industry and households; they may also serve for producing energy in the thermoelectric plants. This peat has the highest ash /9.16%/ and lower organic matter /43.63%/ content and its water retention capacity is of medium degree /60.00%/ as compared to the others. Lying far off the main road, the simplest technology is recommended on this site, unless the establishment of a mixing plant with higher output would seem economic because of the adjacent plantations. After mixing with additional materials /lime, raw phosphate etc./ and composting, the obtained preparations could ensure the supply with organic materials of the small neighbouring farms.

c- Some of the Kuruyange-Kisozi peats have strongly fibrous structure where non-decomposed fibres and leaves of Cyperus papyrus and Cyperus latifolius plants are observable. The ash content is low /2.39%/ and water retention capacity /100.72%/ are high. Among the analysed peats this is the most acidic /pH 3.0-3.5/ and the richest in nutrients /hydrolysable N 115.9-139.9, available P_2O_5 36-39, available K_2O 19-30 mg/100 g/ After appropriate separation it can be used as litter in cow stables or for biogas production when mixing e.g. with coffee-shell residue. This fibrous material is advantageously applied for mulching on the plantations, but in that case its acidity must be buffered by the addition of lime.

The less fibrous peat of Kuruyange-Kisozi contains more ash /7.13%/ and has lower water retention capacity /47.62%/. It is recommended for composting, especially when mixed with fibrous peat in at least 1:1 ratio, whereby the water retention capacity of the obtained compost increases, too.

d- On the ISABU-Kisozi experimental station composting is done in well organized manner: farmyard manure and peat is mixed in equal ratios, lime and rock phosphate is added and composted together. One of the basic material, cow manure, is obtained from the neighbouring farmyard /150 cows/. The good quality, mature compost is applied as soil ameliorant on ferrisols and ferralsols and as organic manure on coffee and tea plantations. The capacity and production of this technology entirely based on hand power is extremely low. On the ISAPU-Kisozi experimental station the establishment of a compost plant of higher capacity and operating with simpler technology would be advisable /Chapter II 7a/. At the same time, one should consider the introduction of large-scale technology on the adjacent peat bog /Chapter II 7b/, because the skilled staff of ISABU could be employed. Namely, the specialists of this institute would be able, after appropriate technological training, to operate the machine lines and to organize the efficient agricultural utilization as well. It is to be taken into account that the chemical analysis of the basic materials and end products, further the qualification of the preparations could be carried out in the ISABU laboratory. In this way the direction of the technology and utilization would be in one hand ensuring thereby the production of adequately composed wide range preparations for soil amelioration and fertilization.

2. According to the obtained informations Burundi disposes of valuable raw materials, as rock phosphate, limestone, dolomite, clay minerals, mica, feldpath etc. These could, or even must be utilized in the large scale production of organic manures increasing in this way the value of the end products. It is well known that Burundi peats are acidic /pH 3.0-4.6/ and the soils are generally also of acidic charecter /pH 4.5-6.6/. Thus, the enrichment of composts and organic materials with lime is anyway reasonable, even necessary in order to increase their pH. As the soils have low humus content and they are poor in organic and inorganic colloids, it is obvious that after appropriate technological preparation, large amounts of organic materials - in the present case peat - should be added to the soil. The enrichment in inorganic colloids is attained by adding clay minerals to the compost and thereby to the soil. The swelling clay mineral vermiculite, as one of the components in the mixture, can increase the water retention and cation adsorption capacity of the soils. Mica and feldpath supply plant with potassium and rock phosphate releases phosphorus nutrient. These minerals should be utilized in finely powdered form, there appropriate preparation /separation, chopping, grinding etc./ is thus indispensable.

It is recommended to exploit the sites of these mineralogical raw materials, to survey the reserves and to realize processing. It should be noted that these minerals themselves are valuable export materials, as well.

3. With the aid of the advised large scale technology a wide range of organic manures and preparations on peat base can be produced /Chapters II 4-7/ which are utilizable in soil amelioration, horti- and floriculture, vegetable growing etc. At the same time with the introduction of large scale technology,

or eventually before it, pot experiments should be conducted with the different preparations produced from the analysed and selected peats. On the basis of the acquired experience the assortment of products and their most effective use for the given soil type and crop can be established. Valuable data are also obtained concerning the adaptation of large scale technology.

It would be desirable to commission the expert for about 6 month to select peats and carry out their analyses at Bujumbura in the ISABU laboratory. He would also have to task to select the products considered to be suitable for exporting.

4. The possibility of extracting humic acid from peat was discussed with the leaders of ONATOUR. The use of humic acid chelates as foliar nutrient is well known, but pure humic acid is also demanded in commerce. The analysed peats, however, have low humic acid contents. The material of the samples did not reach to carry out fulvic acid and humic acid fractionation. Thus, the problem could not be solved. It is suggested that during his next visit to Burundi, the expert should do the necessary analyses with an increased sample material.

5. Owing to the fact that the infrastructure /electricity, road network, etc./ necessary for operating large scale technology is partly existing in Burundi /and where it does not exist, the problem is to be solved/ the establishment of a pilot plant with the capacity of 50 thousand t/year is recommended. Kashiru-Ijenda or the peat bog in the vicinity of ISABU-Kisozi experimental station are suitable for this purpose. Theoretically a pilot plant could be established at the other peat sites, too, if justified by the local conditions. The costs of the establishment as well as the training of the technical staff /3-4 persons/ would be met by the UNIDO. The 3-week training would take place in Hungary according to the program organized by the Soil Amelioration Enterprise of Győr-Sopron County. Correspondence to Mr.L. Bertha, director, H-9400 Sopron, Kossuth Lajos Street 45, Hungary.

6. In order to study the large scale technology and in general peat exploitation in Hungary, a 10-day visit of Mr. Daniel Kinigi, director, and Mr.Leonce Sinzynkayo, technical director ONATOUR, as well as of Mr.Joseph Gafurera, general director of ISABU would be very important and therefore emphatically recommended. The journey would be organized by the UNIDO and effected by the Soil Amelioration Enterprise of Győr-Sopron County.

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Table 1

Chemical analysis of peat samples

No.	Origin of peat samples		pH $/H_2O/$	Quantity of nutrients mg/100 g N hydrolysable	P_2O_5 available	K_2O available
	Kashiru-Ijenda					
1	Perimetre	A	4.3	41.3	35.5	7.0
2	"	B	4.0	47.6	36.0	15.0
3	"	D	4.6	54.1	45.0	26.0
	Gishubi-Matana					
4	Perimetre	A	3.3	62.3	38.0	15.0
5	"	B_1	4.0	59.9	36.0	15.0
6	"	B_2	3.8	130.8	38.0	18.0
	Kuruyange-Kisozi					
7	Perimetre	A	3.5	47.6	35.5	12.5
8	"	C	3.0	139.9	39.5	30.0
9	"	D	3.3	115.9	36.7	19.0

Table 2

Physical analysis of peat samples

No.	Origin of peat samples	Volume weight g/cm³ Fresh	Dry	% dry matter
	Kashiru-Ijenda			
1	Perimetre A	0.90	0.61	67.77
2	" B	0.86	0.66	76.74
3	" D	0.89	0.56	62.92
	Gishubi-Matana			
4	Perimetre A	0.88	0.65	73.86
5	" B_1	0.91	0.68	74.72
6	" B_2	0.88	0.68	77.27
	Kuruyange-Kisozi			
7	Perimetre A	0.89	0.55	61.79
8	" C	0.66	0.26	39.39
9	" D	0.85	0.34	40.00

Table 3

Humic acid content and humus quality of peats

No.	Origin of peat	Humic acid %	Stability of humus Value Q	Value K
1	Kashiru-Ijenda	3.6	0.02166	2.38×10^{-4}
2	Gishubi-Matana	6.2	0.31572	3.84×10^{-3}
3	Kuruyange-Kisozi	2.4	0.03646	4.29×10^{-4}
4	Kuruyange-Kisozi /fibrous/	4.5	0.05684	6.01×10^{-4}

Table 4

Qualification of peats on the basis of average samples

No.	Origin of peat	Moisture content %	Ash %	Organic matter %	Water retention capacity	Score	Class
1.	Kashiru-Ijenda	48.15	4.59	47.26	23.97	24.32	II
2.	Gishubi-Matana	47.21	9.16	43.63	60.00	22.56	II
3.	Kuruyange-Kisozi	52.04	7.13	40.83	47.62	29.24	III
4.	Kuruyange-Kisozi /fibrous/	58.31	2.39	39.30	100.72	20.91	II

No.1.: /48.15 + 4.59/ - /23.63 + 4.79/ = 24.32 score
2.: /47.21 + 9.16/ - /21.81 + 12 / = 22.56 "
3.: /52.04 + 7.13/ - /20.41 + 9.52/ = 29.24 "
4.: /58.31 + 2.39/ - /19.65 + 20.14/ = 20.91 "

Figure 1

Graphical representation of two-component systems

a./ Peat-sand combinations

b./ Peat-clay combinations

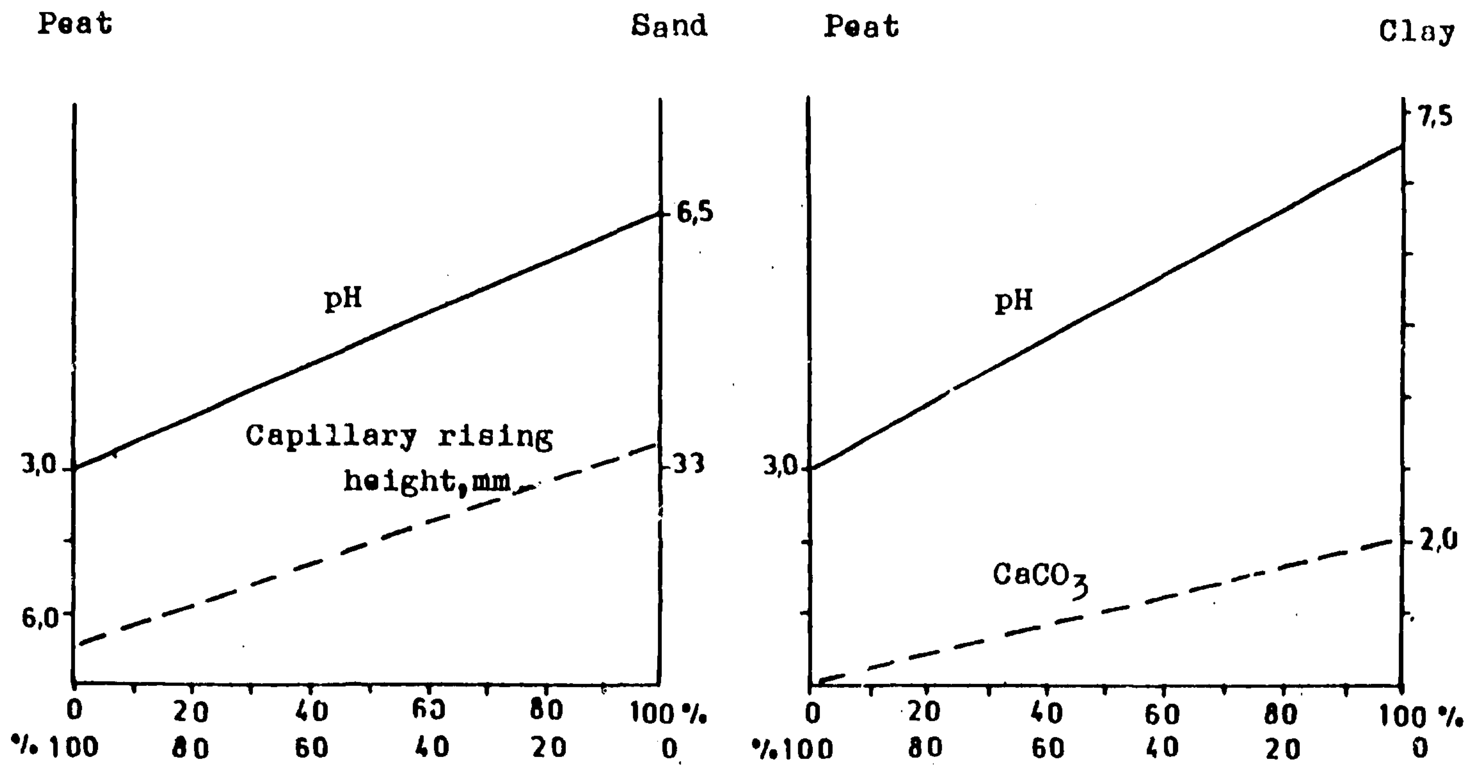


Figure 2

Production scheme of peat mixtures

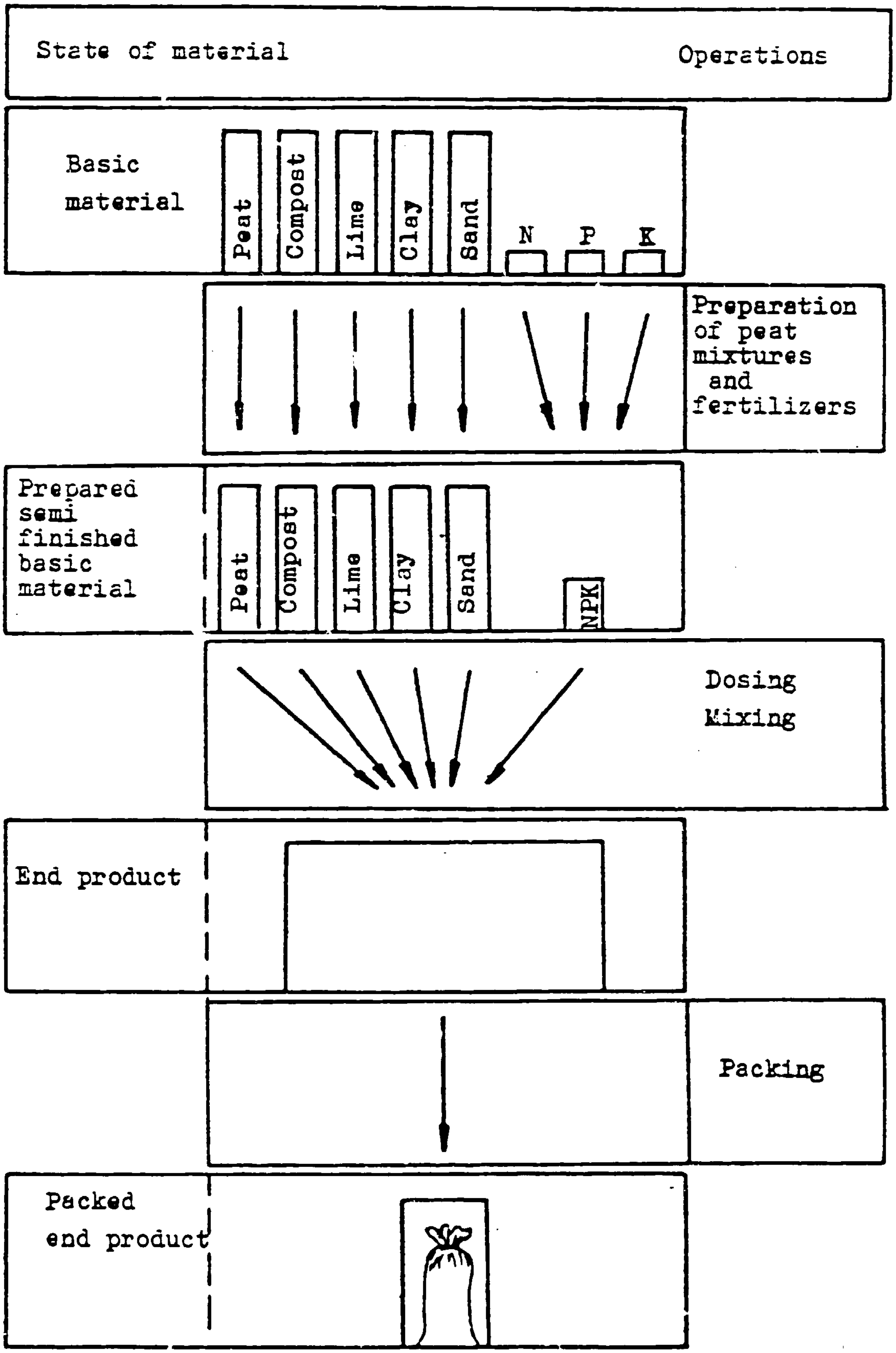
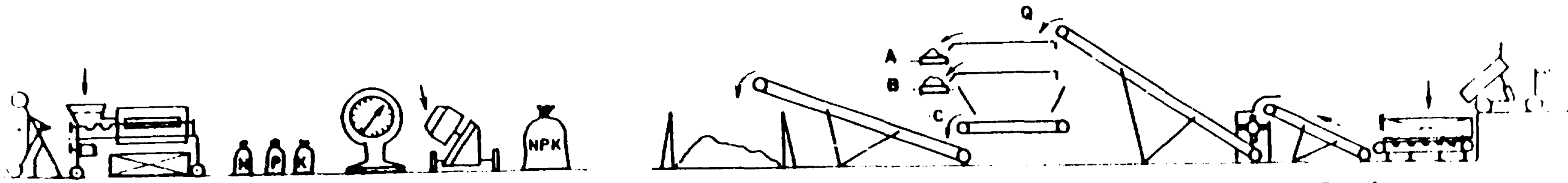


Figure 3

Technology and equipment for producing peat mixtures

Machines for preparing fertilizers — **Machines for preparing peat mixtures**



Grinding, sieving of fertilizers NPK grinder Sieve

Mixing NPK according to prescriptions, Dial scale Mixer

NPK storage

Storage of peat Silage between walls

Belt conveyer

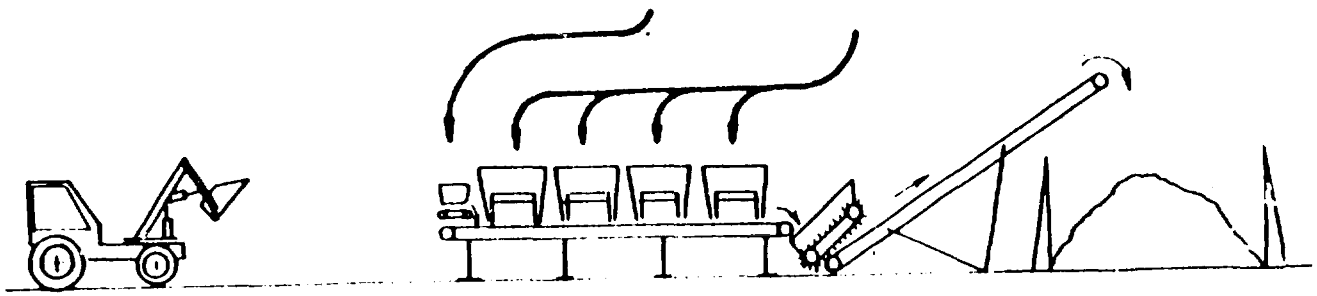
Sieving Vibration plane sieve

Chopping Hammer chopper

Dosing Feeder

Transport

Machines for mixing - Mixing-feeding unit



Loading
Self-propelled
loader

Dosing: peat, compost,
lime, clay, sand, NPK
Feeders

Mixing
Chopping-
belt

Storage of end product
Silage between walls

Machines for packing

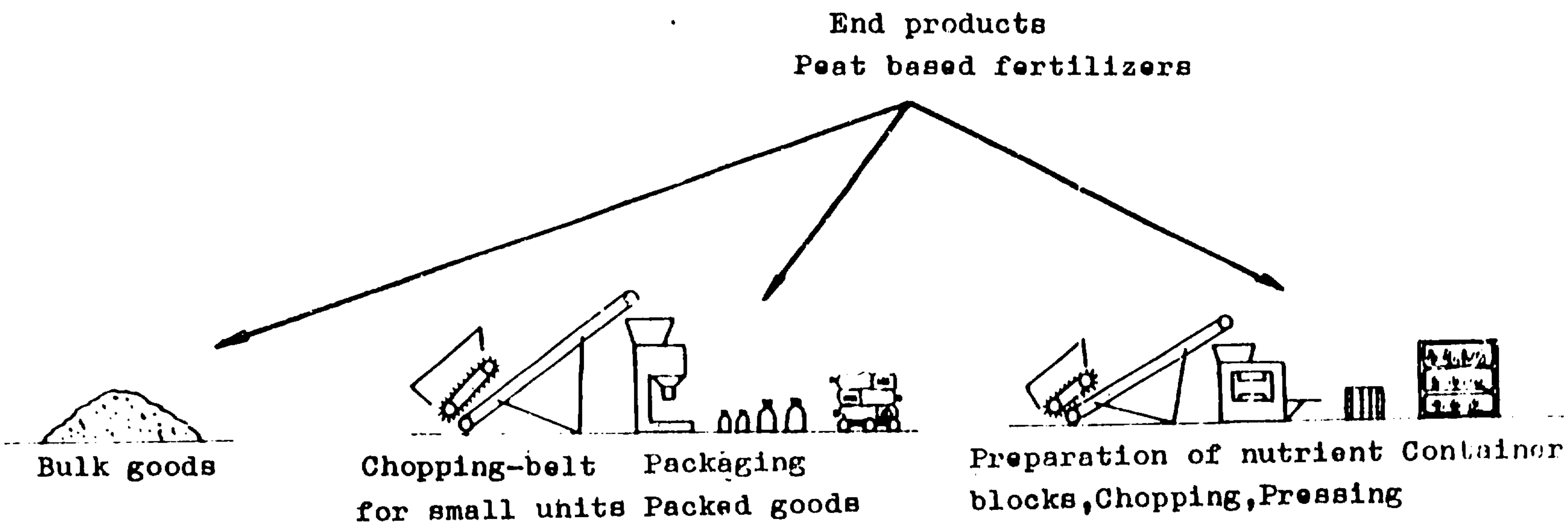
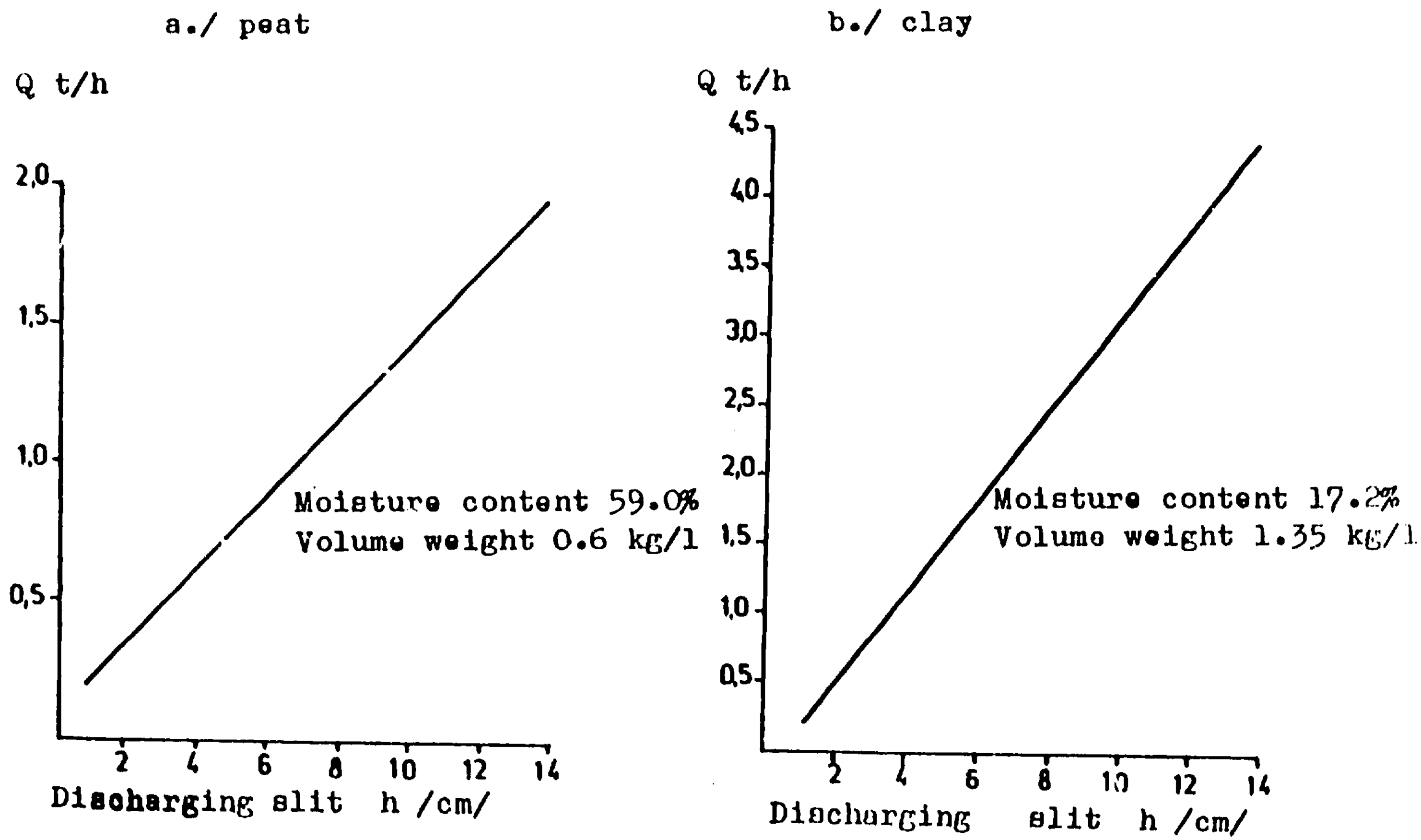


Figure 4

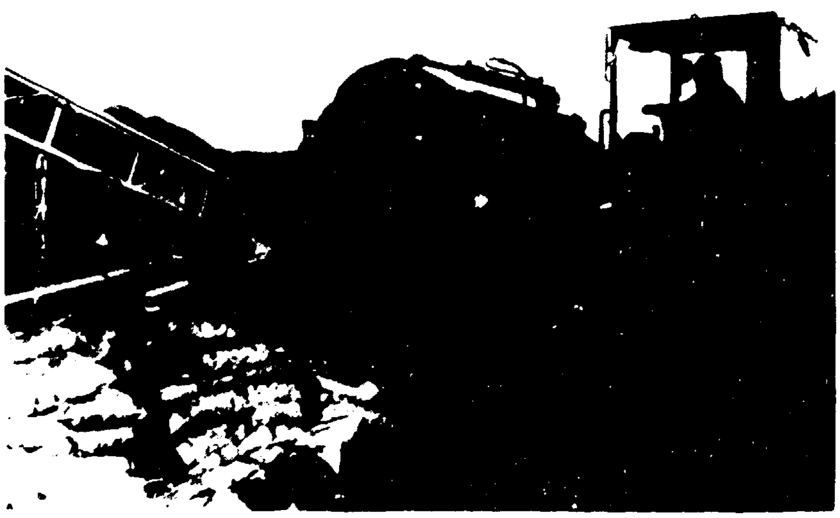
Amounts of materials removed from the feeder



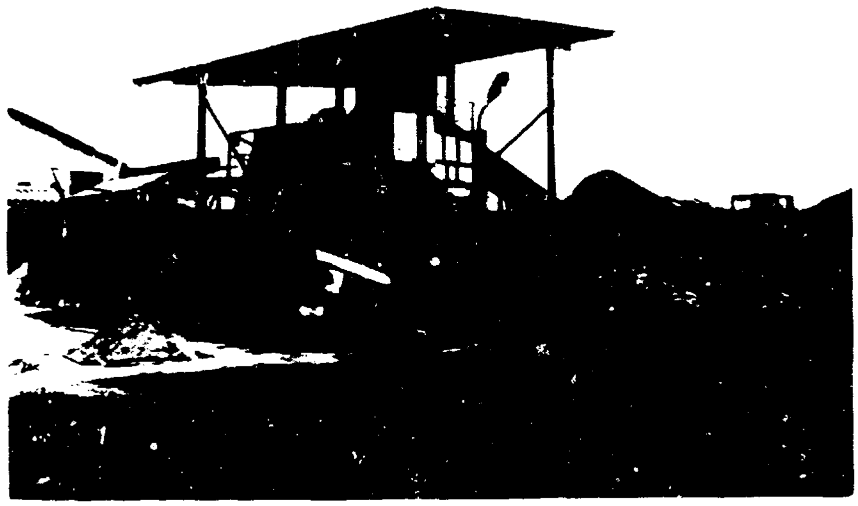
Photos. "Sopron-Peat" technologie

1. Grinding, sieving

2. Belt conveyer



Dosing: peat, compost, lime, clay, NPK

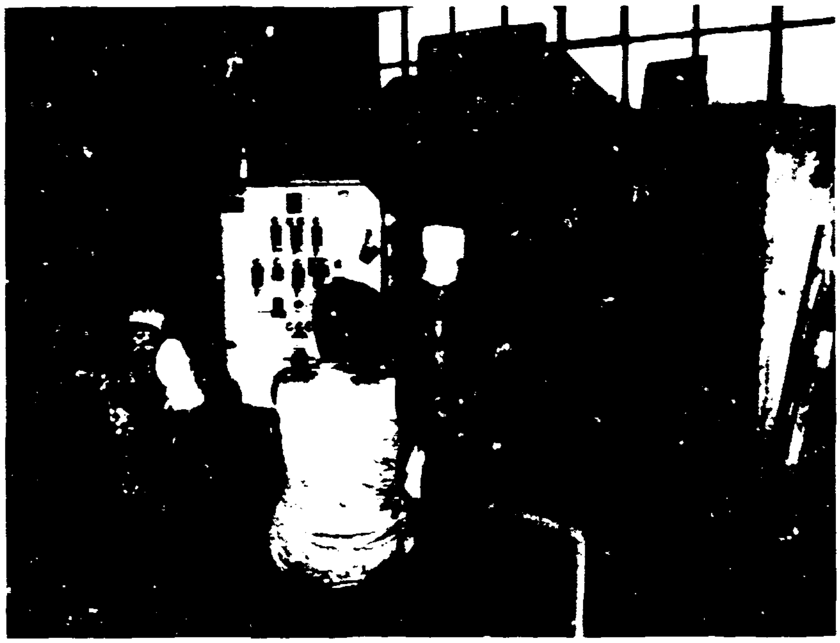


5 partitioned feeding silage

Mixing, chopping belt

Packing machine for 5 kg

Packing machine for 25 kg



Storage