

Free-flowing Multicomponent Mixtures for Promoting the Growth of Soil Microorganism Flora and their Use

The knowledge built up by experts in recent years on the seemingly simple process of breaking up soil to promote plant growth and adding fertilizers provides an insight into the highly complex life and exchange processes which take place in this part of the living earth. A comprehensive account and analysis of this area of natural life processes can be found, for example, in the book entitled **"Soil Microbiology and Biochemistry"** by E.A. Paul and F.E. Clark, published by Academic Press, Inc., San Diego, USA, 1989. In particular, this book provides a comprehensive portrayal of the diverse and extremely complex life processes and interactions of the various microorganism flora and the soil-inhabiting microflora and macroflora in exchange therewith (soil is also referred to hereinafter as substrate). The living plant is in continuous exchange through its roots with these life processes of soil microorganisms. Accordingly, crucial importance for the care and control of plant growth attaches to the control and care of this microorganism growth and, above all, the growth of the microorganism flora in the soil. The concentration of the microorganism flora is highest in the soil region which is in direct contact with the plant roots (known among experts as the rhizosphere) and decreases to an increasing extent and dramatically a few millimeters away from that region. Accordingly, crucial importance for the control, care and promotion of plant growth attaches to the exchange of material between plant roots and the microorganism population in the rhizosphere. Deficiencies, for example in regard to the access of oxygen, water and nutrients dissolved therein, can weaken the plants and cause serious damage. This damage can occur both in the root zone, for example nematode infestation, and also in the above-ground part of the

plant. The technical teaching of the present invention as disclosed in the following is based on the concept of optimizing and naturally controlling and promoting microorganism processes in the substrate and, in particular, of securing primary promotion of the growth of microorganism flora.

5 Increasing microbial activity in the soil fosters natural mineralization processes by breaking up the soil and returning the dead parts of plants to the nutrient cycle. The growth-promoted microorganism populations provide food for many small organisms so that, ultimately, the soil is generally stimulated.

10 The improved soil structure provides for the optimal supply of oxygen to the soil and plant roots while the promotion of microbial activity stabilizes the soil matrix. The improved aeration has an accelerating effect on rotting and thus loosens the soil which is also important for the metabolism of the plant roots. Soil compaction attributable to heavy
15 precipitation or incompetent groundcare can be prevented or at least reduced.

DE 44 37 313 describes the use of selected phosphorus- and nitrogen-containing components from the class of phospholipids for improving plant growth. By adding these phospholipids to the substrate in
20 which the plants grow or are intended to grow, it is possible to improve the growth of the plants. According to the document in question, it is assumed that this increase in growth is associated with a stimulation of the substrate-inhabiting microorganisms. Suitable phospholipids are, above all, lecithin, lecithin hydrolyzates and chemically modified lecithins. Even DE 42 18 243
25 describes nutrient mixtures based on liquid aqueous preparations which contain an ester of phosphoric acid as emulsifier and P source and, if desired, one or more water-soluble or water-dispersible N sources. The objective here is the cultivation of microorganisms which are suitable in the context of bioremediation for biologically degrading mineral oil
30 contamination in correspondingly polluted ground and/or waters.

WO 93/01150 describes easy-to-handle fertilizer mixtures for introducing nitrogen into the plant growth process. Together with the mixtures of fertilizers based on macro and micro nutrients for plant growth, water and an oil phase are used in the presence of w/o invert emulsifiers.

- 5 This is said to ensure the formation of, in particular, paste-form mixtures in which the continuous oil phase is supposed to separate or surround the aqueous parts of the mixture in the form of a film. Oils of vegetable origin and mineral oil are mentioned as suitable oil phases.

- Hitherto unpublished **German patent application 197 01 127.6**
- 10 relates to a low-foam wetting aid in the form of a highly concentrated but free-flowing and pourable aqueous surfactant-based concentrate for intensifying the penetration and spreading of water into and around the roots of plants during watering, containing alkyl (poly)glycoside compounds of the o/w type (APG compounds) as an ecologically safe surfactant
- 15 component, olefinically unsaturated alcohols to suppress/inhibit foam and lower water-soluble alcohols to control viscosity. The improvement in plant growth at dry spots in grassed areas affected in particular by so-called thatch which is observed after the introduction of this wetting aid in practice is attributed to the better spreading of water as a life-supporting component
- 20 in and around the roots of the grass.

- The new technical teaching disclosed in the following for promoting and caring for plant growth by controlling the natural growth processes in the substrate is based on the concept of - primarily - promoting, controlling and securing microorganism growth by introducing a multicomponent
- 25 mixture which is described in the following. This primary promotion of microorganism growth would be secured above all in the rhizosphere region, i.e. in that region of the root-permeated substrate which is critical to plant growth. The teaching according to the invention is guided by two dominant concepts: together with phosphorus (P)- and nitrogen (N)-
- 30 containing supporting materials and, if desired, other plant, macro and/or

micro nutrients, selected compounds containing hydrocarbon radicals are now to be introduced into the soil as additional C sources for the growth of the microorganism flora. At the same time, the preparation of these growth aids and the form in which they are used are intended to optimize their spreading, including their introduction into the rhizosphere region of the substrate.

Subject of the invention

In a first embodiment, therefore, the present invention relates to a process for increasing the growth of soil microorganism flora and promoting the microbial break-up of soil (substrate) polluted with an organic substance and - in association therewith - durably improving plant health and promoting healthy plant growth in that substrate. The teaching according to the invention in this embodiment is characterized by the introduction of aqueous preparations containing

- (a) ecologically safe wetting agents of the o/w type together with
- (b) aerobically and anaerobically degradable organic compounds containing lipophilic saturated and/or olefinically unsaturated hydrocarbon radicals of fatty structure as additional C sources for the growth of the microorganism flora,

in conjunction with the simultaneous and/or staggered introduction of

- (c) supporting materials containing compounds of P and/or N at least partly bearing lipophilic radicals, preferably oil-soluble compounds of P and/or N, and, if desired, other macro and/or micro nutrients for plant growth.

In another embodiment, the present invention relates to water-dilutable aqueous concentrates of growth aids for plant-growth-promoting soil microorganism flora containing components (c) and (a) mentioned above, characterized in that these multicomponent mixtures additionally
5 contain fine-particle emulsifiable and/or dispersible C sources for the growth of the microorganism flora from class (b) mentioned above.

Finally, the present invention relates to the application of the working principle of healthy growth promotion of soil microorganism flora and the resulting stimulation and development of soil fauna by introduction of the
10 above-mentioned multicomponent mixtures for soil rehabilitation with a rotting-accelerating effect (mineralization) and a soil-improving effect (improvement of soil aeration, elimination of anaerobic soil regions) and in particular for use as a vitalizing medium with a plant-strengthening fertilizing effect, preferably of the slow-release type.

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Particulars of the teaching according to the invention

Before the defining elements of the teaching according to the invention are discussed in detail, the working principle of the new technical teaching and the various synergistic result-optimizing effects linked thereto
20 are summarized in the following without any claim to completeness

The disclosure of DE 44 37 313 cited above seeks to improve plant growth in substrates by addition of phospholipids to the substrate. This teaching is based on the observation that even microorganisms living naturally in uncontaminated soil can be stimulated by the addition of these
25 promoters containing P and N and also lipophilic radicals. This results in better growth of the plants growing in the soils thus treated. The teaching according to the invention makes use of this working principle, but goes a crucial step further: in addition to the supporting materials containing P, N and if desired other macro and/or micro nutrients for plant growth, selected
30 C sources are introduced into the soil as an additional growth stimulant for

microorganism flora. These additional carbon sources for microorganism growth introduced in accordance with the invention are aerobically and anaerobically degradable organic compounds containing lipophilic saturated and/or olefinically unsaturated hydrocarbon radicals of fatty structure. The introduction of these components containing organically bound carbon with a large number of energy-rich C-H bonds primarily promotes the growth of organotrophic microorganisms. It is known that most of the bacterial species known today belong to this class of organotrophic organisms. Their increased growth then leads to the stimulation of soil fauna in subsequent, complex secondary steps. However, this is only a fragmentary explanation of the synergistic increase in effect.

Another key component of the multicomponent mixtures according to the invention are ecologically safe wetting agents of the o/w type which, as part of the water-based addition to the substrate, are distinguished by pronounced multifunctionality. The spreading of the aqueous phase applied to the substrate, particularly in and around the roots, is optimized. Water thus comes into direct contact with the root hairs which is crucial to the uptake of water and nutrients. At the same time, however, the pore structure is also cleaned, for example by being washed free from substrate zones with inadequate gas phase exchange which would otherwise lead to the formation of an unwanted anaerobic microorganism population. The use of this wetting aid also leads to the uniform spreading of the microorganism growth promoters and, in particular, the carbon sources introduced in accordance with the invention for the growth of organotrophic microorganisms.

However, the synergistic increase in effect is also reflected in working steps before and during introduction of the growth aids according to the invention. Surface-active wetting aids and, in particular, the APG-type wetting aids preferred in accordance with the invention are

distinguished in their aqueous preparations by a particularly pronounced foaming capacity. It is obvious that such foaming is a major disadvantage in the practical application of the wetting aids in agriculture and forestry. However, it has been found that the joint use of the wetting agents of component (a) according to the invention and the carbon sources containing hydrocarbon radicals of fatty structure for the growth of the microorganism flora (component (b)) leads to such pronounced foam-suppressing or foam-inhibiting effects that no foaming problems arise in the practical application of the multicomponent mixtures according to the invention in aqueous preparations.

Finally, another aspect of the teaching according to the invention which is of both immediate and future importance is discussed in the following. Even today, the evaluation of new and further technological developments is determined to a very large extent by the criterion of sustainability or sustainable development. This additional requirement applies in particular to agrobiological and agrochemical processes of the type addressed by the teaching according to the invention. The elements of the teaching according to the invention described in detail in the following provide for optimization in this regard without ignoring the aspect of economy. Virtually all the components of the nutrient system used in accordance with the invention may be developed as chemicals based on natural substances. The source of all these components is healthy plant growth. It will readily be appreciated that, so far as the natural carbon cycle is concerned, not only are additional problems eliminated, positive steps are also taken to help in reducing and removing existing damage.

Components (a), (b) and (c) of the mixtures according to the invention are discussed in detail in the following:

(a) "Ecologically safe wetting agents of the o/w type"

The wetting agents or rather surfactants discussed here belong in particular to the classes of anionic surfactants and/or nonionic surfactants. An important requirement is biological compatibility and, above all, adequate biodegradability in the substrate. Rapidly and completely
5 biodegradable surfactant compounds from the class of nonionic surfactants represent a preferred class of the auxiliaries under discussion.

Suitable anionic surfactants are, for example, soaps and biodegradable alkyl sulfates, more particularly fatty alcohol sulfates. Non-readily biodegradable or incompletely biodegradable surfactants based on
10 petrochemicals, for example alkyl benzenesulfonate or alkyl ether sulfates, are less suitable. Suitable representatives include the partial esters of phosphoric acid with fatty alcohols and, in particular, corresponding partial esters with straight-chain fatty alcohols, preferably of natural origin and hence with an even number of carbon atoms. For example, corresponding
15 esters of relatively short-chain fatty alcohols, such as those containing 6 to 10 carbon atoms in the fatty alcohol molecule, are suitable. However, alkyl phosphates containing relatively long fatty alcohol molecules, for example with 12 to 24 carbon atoms, are also suitable in principle. The same applies to the comparable fatty alcohol ether phosphates although they are
20 less preferred.

According to the invention, particularly preferred biodegradable surfactants of class (a) are corresponding compounds of at least predominantly nonionic character which are preferably based at least predominantly on natural substances and which have preferred HLB
25 values of 10 to 18.

In a particularly preferred embodiment of the invention, alkyl (oligo)glucoside compounds of which the alkyl group derives at least predominantly from straight-chain fatty alcohols are used at least partly and, in particular, at least predominantly as component (a). Compounds of
30 this type, which are now also referred to as APG components or

compounds, are surface-active auxiliaries with a wide range of applications. A number of factors are of importance to their use on an industrial scale. As widely known, APG-based wetting agents can be based entirely on natural materials. They are obtained as products of the reaction of fatty
5 alcohols with glucose, oligoglucoses or even - with a simultaneous reduction in chain length - with polyglycosides, such as starch, and correspond to the general formula $R-O-(G)_x$, where R is a primary, preferably linear aliphatic hydrocarbon radical containing at least 6 carbon atoms, preferably 8 to 24 carbon atoms and more preferably 8 to 18 carbon
10 atoms and G is a glucose unit containing 5 or 6 carbon atoms, preferably glucose. In the class of surfactants in question, the degree of oligomerization x - and hence the DP value - which indicates the distribution of monoglycosides and oligoglycosides normally assumes a value of 1 to 10, for example in the range from about 1.2 to 5, preferably in
15 the range from about 1.2 to 4 and more preferably in the range from 1.2 to 2. The extensive expert knowledge and literature on the production and properties of APG compounds of the type in question is documented, for example, in the book by Hill et al. entitled **"Alkyl Polyglycosides"**, VCH-Verlagsgesellschaft mbH, Weinheim, 1997.

20 Although the class of APG compounds of the o/w type under discussion here are the preferred representatives of the wetting agents of class (a) to be used in accordance with the invention, other biodegradable and compatible components with comparable properties may also be used for the purposes of the teaching according to the invention. Examples of
25 such components are sugar partial esters of monocarboxylic acids containing in particular 8 to 24 carbon atoms, sorbitan esters, for example of the sorbitan monostearate or sorbitan monooleate type, and even surfactants of biological origin, for example sophorose lipid, trehalose lipid or the lipopeptides known as metabolism products or membrane
30 constituents of a large number of microorganism strains.

Carbon sources (b) for the growth of microorganism flora

As mentioned above, crucial significance attaches to the type and quantity of these component(s) used in accordance with the invention in relation to the closest prior art, as represented for example by DE 44 37
5 313. The growth promotion of organotrophic microorganisms using this component (b) as a carbon source for microorganism growth is very much in the foreground.

An important characteristic of these added components (b) is the defining parameter that they should be both aerobically and anaerobically
10 degradable by natural degradation processes. The carbon source crucial to organotrophic growth in accordance with the invention are the lipophilic hydrocarbon radicals of fatty structure present in this component and hence the comparatively high concentration of energy-yielding C-H groups. As mentioned above, these hydrocarbon radicals of fatty structure may be
15 saturated and/or at least partly olefinically unsaturated. Further considerations in respect of the physicochemical properties of this component, which are discussed in the following, can also have a defining influence in this regard.

Preferred components (b) are oil-soluble but biologically compatible
20 organic compounds containing fatty molecules of the type mentioned above which contain at least 6 carbon atoms and, in particular, at least 8 carbon atoms. It is preferred to use corresponding components based on linear hydrocarbon radicals or hydrocarbon compounds. Corresponding components which are at least predominantly based on natural materials
25 are particularly important.

Particularly important representatives of the class of compounds (b) under discussion are corresponding hydrocarbon compounds which are at least partly functionalized with oxygen as hetero atom. Typical examples of components of this type are fatty alcohols and/or fatty acids or derivatives
30 and/or salts thereof. Suitable fatty alcohol or fatty acid derivatives are

esters, ethers and/or amides. According to the invention, particular importance is attributed to the fatty alcohols and the esters of fatty acids with monofunctional and/or polyfunctional alcohols. Where polyfunctional alcohols are used, fatty acid esters include both the full esters and partial esters. Which particular components will be the preferred representatives for a particular application will be determined by secondary effects and hence by the presence of possibly desirable synergisms within the system as a whole. Corresponding statements in the earlier hitherto unpublished patent application 197 01 127.6 are cited purely by way of example in this regard:

Surfactant-based aqueous preparations and, in particular, corresponding aqueous APG-based wetting aids are generally distinguished by the high foaming power of these APG-based nonionic surfactant auxiliaries. This can be a decided disadvantage for the field of application with which the invention is concerned. The problem of foaming has to be overcome by using so-called foam suppressors or defoamers. Fatty alcohols, partial esters of, in particular, lower polyfunctional alcohols, for example glycerol, and fatty acids and above all mixtures thereof solve this problem. At the same time, however, they are the carbon sources desired in accordance with the invention for stimulating and increasing microorganism growth in the soil and are therefore optimal representatives for the components (b) as defined in accordance with the invention.

However, the mixing of aqueous APG concentrates with defoamers/foam suppressors based on alcohols and/or on partial esters of fatty acids and polyfunctional alcohols, especially glycerol, can result in the formation of thickened gels which do not flow. By adding limited quantities of lower mono- and/or polyfunctional alcohols, for example by adding limited quantities of ethanol to the thickened gel-like concentrate, flowability and pourability can be re-established, even at room temperature.

In preferred embodiments, therefore, the compounds or mixtures of compounds to be used as component (b) in a particular application are determined not only by considerations relating to the optimization of this component as a carbon source for microorganism growth, but also by
5 secondary effects, such as low foaming of the aqueous multicomponent mixture, homogenization of the multicomponent mixture containing lipophilic components together with wetting agents of the o/w type in water and application by dilution with more water and spraying and/or pouring onto the substrate. Earlier application 197 01 127.6 cited above is
10 particularly concerned with these aspects. In order to complete the disclosure of the present invention, the subject of this earlier application is hereby specifically included as part of the disclosure of the present invention.

It can be important, particularly for the uninterrupted introduction of
15 the water-based multicomponent mixtures into the substrate and for the transport of the carbon sources to mixture component (b) according to the invention, to select components (b) which at least partly have pour points of or below 25 to 30°C and, more particularly, of or below 10 to 15°C. Suitable components are, for example, olefinically unsaturated C₁₂₋₂₄ fatty
20 alcohols of natural origin, more particularly at least predominantly C_{16/18} fatty alcohols with a high degree of olefinic double bonds and solidification ranges of or below 20°C and, preferably, of or below 10 to 15°C. Preferred multicomponent mixtures with this component (b) according to the invention are mixtures of fatty alcohols with partial esters of saturated and, more
25 particularly, at least partly olefinically unsaturated fatty acids with polyfunctional alcohols containing 2 to 6 carbon atoms and, more particularly, 3 to 5 carbon atoms. In particular, glycerol partial esters of fatty acids of natural origin can be important mixture components for mixing with the corresponding fatty alcohols, substantially equal quantities of fatty
30 alcohol and fatty acid partial ester or corresponding mixtures with several

times the quantity of partial ester, based on the fatty alcohol, being preferred mixtures. Suitable mixing ratios of fatty alcohol to fatty acid partial glyceride are, for example, about 1:1 to 1:10, preferably 1:1 to 1:5 and more preferably about 1:1 to 1:3 parts by weight. As mentioned
5 above, however, the fatty acid partial esters in question may also be used on their own as component(s) (b). In this case, too, corresponding representatives with pour points in the ranges mentioned above are preferred.

Another crucial defining element according to the invention for the
10 new technical teaching, namely the particular minimum quantities in which the carbon sources for microorganism growth are used in the multicomponent mixtures as a whole to be applied in accordance with the invention, will be discussed in detail at a later stage. Purely for the time being, the following point is made clear: a key element of the teaching
15 according to the invention is the coordination of the quantities of component (b) used with the quantities of the P and optionally other macro and/or micro nutrients introduced by component (c). The source (b) of carbon for microorganism growth is used in such minimum quantities that, based on the phosphorus P introduced through component (c), the ratio by
20 weight of C to P is at least about 5 to 10:1 and preferably at least about 20 to 25:1. However, depending on the condition of the soil and, in particular, the type and quantity of organically bound carbon present in the soil, embodiments in which the C:P ratios are significantly higher may be preferred. Thus, important lower limits are 40:1 and preferably at least
25 50:1. A very much larger excess of the carbon source is generally possible, so that C:P ratios by weight of up to 500:1 or even higher lie within the scope of the teaching according to the invention. Accordingly, the stimulation and support of organotrophic microorganism growth as required in accordance with the invention is achieved through optimized

spreading of this carbon source readily accessible to microorganism growth in the soil and through its transport into the rhizosphere.

The aerobically and anaerobically degradable mixture components (b) with their lipophilic residues of fatty character to be used in accordance with the invention are completely degradable to CO₂, H₂O and biomass. As a result, they do not leave any inert or ecotoxicologically harmful degradation products to accumulate in the soil. The components (b) containing lipophilic residues migrate only slowly through the soil, tending to attach themselves to lipophilic or oleophilic surfaces and hence in particular to root surfaces. They are not significantly washed out into the ground water and are not toxic so that they are safe to use for this reason also. Particular significance regarding the choice of suitable and optimized components for the class (c) of substances discussed in the following is attributed to the above-described interaction between the lipophilic residues of mixture components (b) used in accordance with the invention and other constituents of the substrate or of the multicomponent mixture added in accordance with the invention.

Mixture components (c), i.e. supporting materials containing P, N and, optionally, other macro and/or micro nutrients for plant growth

Finally, the teaching according to the invention provides for the introduction of selected fertilizers or fertilizer mixtures containing both phosphorus and nitrogen into the substrate to be treated. If desired, supporting materials containing other macro and/or micro nutrients for plant growth may be used in this connection, i.e. as sole constituents of component (c). The following preliminary observations are made in this regard:

The mixture component(s) (c) may be introduced at the same time as and together with components (b) and the ecologically safe wetting agents (a) used for them. However, the mixture components (c) may also

be introduced at a different time. This addition at a different time may also be combined with the simultaneous introduction of components (a), (b) and (c).

In one particularly important embodiment of the invention, oil-soluble compounds of P and/or N are used as component (c) at least partly containing lipophilic residues. Accordingly, particularly preferred representatives of these auxiliaries are the phospholipids described in DE 44 37 313 and/or derivatives thereof as key representatives of the components (c). The disclosure of DE 44 37 313 is thus specifically included as part of the disclosure of the present invention, so that particular emphasis is only placed on crucial aspects in the following. It is emphasized even in this document that the effect of the phospholipids added on the microbial soil flora is reflected inter alia in the fact that organic compounds and plant remains present in the soil are degraded more quickly, resulting in an increase in soil bacteria. According to the invention, the lipophilic, flowable components (b) are now additionally made available as carbon sources for microorganism growth. Lipophilic parts of the molecules of components (c) associate with lipophilic residues of the hydrocarbon type from the carbon sources (b) in accordance with the teaching of the invention. The varying microorganism strains of the various soil-inhabiting populations which - in exchange with the plant roots - lead to a durable strengthening of and increase in plant growth are mobilized and strengthened in an unforeseeable manner. It is clear that, as a result, the acceleration of growth, at least in its initial phases, takes place independently of the organic compounds present in the soil, such as plant or root remnants and the like. Nevertheless, the composting process (mineralization) taking place in the soil is again gradually accelerated and dead plant material is more rapidly returned to the biological cycle. Plant nutrients fixed in the substrate become re-available to the plants. Aeration

of the soil or rather the substrate in which the plants grow is improved and water is more uniformly distributed.

Preferred components (c) are lecithin, lecithin hydrolyzates and/or chemically modified lecithins which are preferably used in admixture with other N-containing supporting materials. Urea and urea derivatives are particularly suitable in this regard. Urea as a nitrogen source has proved to be particularly accessible for the control and promotion of microorganism growth by component (c). At the same time, urea acts as a preservative against unwanted microbial contamination in the nutrient concentrate, so that corresponding concentrates have high stability in storage. Urea derivatives which may be used as a nitrogen source for plant growth may be produced by any of the methods generally known among experts, cf. for example **DE 196 13 794**.

As mentioned above, the representatives individually named here for P- and/or N-yielding components belonging to class (c) are particularly preferred representatives. However, the teaching according to the invention is by no means confined to these particular representatives. Basically, known water- and/or oil-soluble compounds of P and/or N, as known from conventional fertilizer technology, may also be used.

As mentioned above, the components or mixtures (c) used in accordance with the invention may be used together with components (a) and (b) and also separately therefrom and, above all, at different times. If the components or mixtures (c) are to be separately used, it is again advisable to use them in the form of corresponding aqueous preparations, as described in detail in the repeatedly cited **DE 44 37 313**. In this case, surface-active auxiliaries will again generally be used in the aqueous preparations, including in particular components belonging to class (a) according to the invention, although they will be used in comparatively small quantities. Accordingly, limited quantities of APG compounds of the o/w type may be used for these aqueous mixtures of components (c) to be

separately applied to the substrate. Reference is made in this regard to the observations made in this connection in the foregoing.

On the subject of suitable in-use concentrations of these P- and N-yielding auxiliaries, there is one important difference in relation to the specific disclosures of the relevant prior art literature: according to the teaching of DE 44 37 313, the corresponding auxiliaries based on phospholipids are applied in quantities of about 0.5 to 30 g/m² substrate surface and introduced into the substrate. A quantity range of 1 to 20 g/m² substrate surface is mentioned as preferred for the application of the phospholipid.

By contrast, the modified technical teaching according to the invention enables the quantity in which the components of class (c) are added to be distinctly reduced. Quantities well below the values specifically mentioned in the prior art literature are generally suitable. Thus, preferred in-use concentrations for the components of class (c) are lower than in the cited prior art literature by at least about one power of ten. In the broadest version of this preferred embodiment of the teaching according to the invention, the phospholipids used as P and N sources are introduced in quantities of 0.01 to 10 g/m² substrate surface and preferably in quantities of 0.1 to 5 g/m² substrate surface, preferred upper limits to these quantities being 3 g/m² or even 1 g/m² substrate surface.

The quantity ratio of components (b) preferably applied in accordance with the invention is crucially determined by the quantity of component(s) (c) used in each particular case. The components (b) covering the carbon demand of the microorganisms are used in such a quantity ratio to components (c) that, as explained above, ratios by weight of C to P of at least about 10 to 50:1 and preferably of at least 80 to 150:1 are established. It may be appropriate to use the components (b) in much larger quantities so that, for example, the ratio by weight of C to P may reach values of 500:1 or even higher. Any hydrocarbon radicals of fatty

character present in the surface-active component (a) may be included in this calculation, providing this surface-active component (a) shows equally rapid degradability. Another preferred rule for the quantities of phosphorus, nitrogen and degradable hydrocarbon radicals to be used in the
5 multicomponent mixtures according to the invention is that ratios by weight of P:N:C of at least about 1:10:10 to about 1:10:100 should be established.

Other typical macro and/or micro nutrients for plant growth may be introduced into the substrate to be treated at a different time from and/or together with the multicomponent mixtures (a) to (c) introduced in
10 accordance with the invention. General expert knowledge of fertilizers may be applied in this regard also, cf. for example the above-cited WO 93/01150 and the extensive relevant scientific literature, for example **Landwirtschaftliche Lehrbuch K.-U. Heyland "Allgemeiner Pflanzenbau", Verlag Eugen Ulmer, Stuttgart, 7th Edition, page 255.**
15 Besides the elements mentioned, macro nutrients are, in particular, potassium, magnesium, lime and sulfur. The micro nutrients or even trace elements include boron, copper, iron, manganese and many other components known to experts.

One important embodiment of the teaching according to the
20 invention is characterized by the use of selected microorganism starter cultures which promote healthy plant growth and which may be selected in particular from corresponding bacterial and/or mycorrhizer strains. By using these selected starter cultures and the strengtheners according to the invention for the rapid development of the selected microorganism
25 strains, selected microorganism populations in the substrate and, hence, the desired secondary promotion of plant growth can both be optimized.

The use of the multicomponent mixture according to the invention and the associated working principle of selective promotion of the growth of the desired microorganism flora in the soil leads to a broad range of
30 practical applications. First, however, the following important aspect should

be mentioned in this regard: the multicomponent mixtures according to the invention may be made up without any fertilizers or fertilizer components of animal origin. The multicomponent mixtures according to the invention may be of purely vegetable origin and, optionally, vegetable/mineral origin.

- 5 Accordingly, any potential epidemic-related concerns are ruled out from the outset.

A broad range of potential applications is opened up, the principle of promoting healthy microbiological growth processes in the substrate or soil structure to achieve soil rehabilitation being in the foreground. The
10 following applications are mentioned by way of example without any claim to completeness:

- Soil rehabilitation with a rotting-accelerating effect (mineralization), soil rehabilitation with a soil-improving effect (improvement of soil erosion, elimination of anaerobic soil), soil rehabilitation with a plant-strengthening
15 effect, more particularly a slow-release fertilizing effect initiated by natural microorganism growth processes.

Particular importance attaches to another aspect: the strengthening and recuperation of the desired microorganism growth in the substrate leads to a strengthening of the defences of the plants growing in this
20 substrate against disease and pest attack. Both the roots and the above-ground parts of the plants are strengthened in their defences against pest attack. The overall strengthening of soil and plants is durable. The microorganism growth controlled and promoted in accordance with the invention leads to the required stimulation of microflora and soil flora in
25 general not only in the living phase of the microorganisms, the biomass of the dying part of the microorganisms remaining behind in the soil is also available as a valuable fertilizer mixture for continuing microorganism and plant growth processes. Thus, the teaching according to the invention opens up new possibilities for making and keeping substrates used for
30 agriculture and/or forestry healthy.

Example 1

The tests described in the following for improving plant growth by application of the mixtures of components (a), (b) and (c) according to the invention were carried out on a hitherto conventionally maintained golf course. The mixtures were applied to the greens. Areas of grass which, despite regular care, showed patches of damage were particularly targeted. These included in particular so-called dry patches, patches particularly affected by thatch and, finally, patches suffering in known manner from serious fungal infestation (pythium, ophiobolus, etc.). It is known that, in general, the damage or damaged areas can only be eliminated to a limited extent, if at all, by conventional watering, including the application of fungicides. Harmful organisms in the soil and turf lead primarily to partial hydrophobicizing of the soil so that aqueous nutrient solutions are unable to penetrate into the green. Thatch forms very quickly on the greens and other grassed areas because the root mass of the grass quickly reforms and grass cuttings are sometimes left as they lie. The biological activity of the soil bacteria is limited. The thatch thus represents a significant source of fungal infections to the grasses. A common complicating factor is that the turf is comparatively poor in nutrients so that the biological activity of the bacterial strains is low.

Following the teaching according to the invention, aqueous preparations of the following concentrates are introduced into the test greens.

(1) Concentrate of components (a) and (b) according to the invention

45% by weight of APG as wetting agent of the o/w type with an APG active substance content of 60% by weight, rest water (commercial product APG 220 UP of Henkel KGaA with predominantly C_{8/10} fatty alcohol radicals in the APG structure)

5% by weight of C_{16/18} fatty alcohol (commercial product HD Ocenol 80/85 of Henkel KGaA, iodine value 80 to 85)

5 15% by weight of glycerol monooleate (commercial product Edenor GMO of Henkel KGaA)

15% by weight of ethanol

rest water.

10

(2) Concentrate of component (c) according to the invention

19.9% by weight of urea (N source)

15 19.8% by weight of enzymatically hydrolyzed soya lecithin (commercial product Lipotin NE) as P and N source

20 1.0% by weight of the APG-based o/w wetting agent predominantly containing C_{12/14} fatty alcohol radicals marketed as "APG 600" as emulsion stabilizer

rest water.

25 In a first step, mixture (1) - components (a) and (b) - diluted with water is introduced with a Hydro-Ject into the greens to be treated. The diluted mixture is injected into the soil in the form of fine jets of water. The jets are broken up in the soil, the aqueous solution is dispersed therein and, at the same time, soil aeration is initiated. Mixture (1) is applied in a quantity of 2 cm³ of concentrate with the composition shown above per m²
30 of green.

The treated greens have made a significant recovery after only a few days. However, there is no evidence of any effect on the areas damaged by fungal diseases. Even the use of fungicides has hardly any effect there.

After 14 days, an aqueous solution of mixture (2) is applied in a
5 quantity of 20 g/m², again based on the concentrate. The surface
previously treated with mixture (1) is covered in strips with mixture (2) in
such a way that strips of green treated on the one hand with both
concentrates and on the other hand with concentrate (1) only adjoin one
another. It is important to ensure that this strip-by-strip coverage also takes
10 in the dry patches including patches affected by fungal disease.

After only 10 days, there is a distinct improvement in grass growth in
the areas treated both with mixture (1) and with mixture (2). Not only is the
color of these areas much greener than the other parts of the greens, the
grass is also denser and yields more cuttings. By way of demonstration,
15 the areas in question were mown by hand and no other nutrients were
applied. The synergistic increase in effect is reflected particularly
impressively in the so-called grass rings which had been formed by the
grass diseases mentioned. These areas also turned green in the strips
covered twice with the overall combination of components (a), (b) and (c)
20 although no grass grew there before.

Over and above these visible effects, the following observations
were made:

Under the climatic conditions of the test period, the greens treated in
accordance with the invention were dew-free in the mornings although the
25 dew was very heavy at this time, as could be seen on the untreated areas.
This is a clear indication of the highly activated growth of the
microorganism flora. It is well-known that, besides the formation of CO₂
and H₂O, the growth of this microorganism flora releases energy. The
energy released under the working conditions would appear to be
30 responsible for the absence of dew.

Example 2

Field trials for growing corn were carried out on an agricultural test plot using components (a), (b) and (c) according to the invention or mixtures thereof in a plurality of variants as shown in Table 1 below. The
5 treated plots were then compared with untreated plots.

Each plot measures 6 x 12 meters and each variant was repeated four times with a random plot arrangement.

Apart from the control plots where none of the components or mixtures according to the invention are used, the following components or
10 mixtures were applied (cf. Example 1):

(1) Concentrate of components (a) and (b) according to the invention:

Composition corresponds to Example 1.

(2) Concentrate of components (c) according to the invention

15 The mixture mentioned in Example 1 is slightly modified by the use of potassium pyrophosphate. It has the following composition:

20% by weight of urea (N source)

20% by weight of the commercial product "Lipotin NE"

7% by weight of $K_4P_2O_7$

20 2% by weight of the APG-based o/w wetting agent (commercial product "APG 600")

rest water

The concentrates (1) and (2) are used both individually and in admixture with one another, the components or mixtures being applied in
25 different concentrations in each of the tests. The respective test compositions are shown in Table 1 below. The seeds were applied to all the test plots on the same day. The components or mixtures were applied on the following day.

Table 1

Variant number	Product	Quantity of product and water
1	Control, no addition	-
2	Concentrate (1)	2 g/m ² in 0.1 l/m ²
3	Concentrate (1)	4 g/m ² in 0.1 l/m ²
4	Concentrate (2)	2 g/m ² in 0.1 l/m ²
5	Concentrate (2)	20 g/m ² in 0.1 l/m ²
6	Concentrate (1) + concentrate (2)	2 g/m ² + 2 g/m ² in 0.1 l/m ²
7	Concentrate (1) + concentrate (2)	2 g/m ² + 20 g/m ² in 0.1 l/m ²

On the comparison plots used in this test, the soil infiltration rate is first repeatedly measured *in situ* (in the field) during the vegetation period in order to determine the quantity of water percolating per unit of time as a measure of the air and water distribution in the soil. The measurements are carried out with a double ring infiltrometer (manufacturer: Eijkelkamp, Agrisearch Equipment, Giesbeek, Netherlands).

A first measurement is carried out 12 days after application of the product. The average values of the results obtained are set out in Table 2 below.

Table 2

1st Measurement variants	Infiltration rate liters per m ² in the crop
1= Control	1.17
2	2.53
3	1.41
4	1.53
5	1.14
6	1.81
7	1.73

The infiltration rate is measured for a second time, again in situ (in the field), 3 months after application of the product. The results obtained are set out in Table 3 below.

Table 3

2nd Measurement variants	Infiltration rate liters per m ² in the crop
1= Control	0.27
2	0.76
3	1.22
4	1.73
5	0.21
6	1.79
7	2.64

Comparison of the results set out in Tables 2 and 3 shows that, by separately applying the surface-active component (1), the infiltration rate can be doubled briefly, but not durably by the surfactant effect (Table 2, variant 2). A clear lasting improvement in the infiltration rate is achieved by the mixtures of components (a), (b) and (c) according to the invention, cf. Table 3, variants 6 and 7. This reflects the effects of the working principle according to the invention of healthy growth development of the soil microorganism flora and the resulting stimulation and development of the soil fauna.

Other measurements of the aggregate stability of soil samples carried out repeatedly during the vegetation period as a measure of the tendency of a soil towards surface siltation also show distinctly increased percolate values for the soil samples treated in accordance with the invention at depths of 0 to 2 cm and 2 to 6 cm by comparison with corresponding soil samples from the control variant or variants 2 to 5 in Table 1.

**CLAIMS**

1. A process for increasing the growth of soil microorganism flora and promoting the microbial break-up of soil (substrate) polluted with an organic substance and - in association therewith - durably improving plant health
5 and promoting healthy plant growth in that substrate, characterized by the introduction of aqueous preparations containing
- (a) ecologically safe wetting agents of the o/w type together with
(b) aerobically and anaerobically degradable organic compounds
10 containing lipophilic saturated and/or olefinically unsaturated hydrocarbon radicals of fatty structure as additional C sources for the growth of the microorganism flora,
- in conjunction with the simultaneous and/or staggered introduction of
15
- (c) supporting materials containing compounds of P and/or N at least partly bearing lipophilic radicals and, if desired, other macro and/or micro nutrients for plant growth.
- 20 2. A process as claimed in claim 1, characterized in that at least predominantly nonionic biodegradable surfactants which are preferably at least predominantly based on natural substances and which have preferred HLB values in the range from 10 to 18 are used as component (a).
3. A process as claimed in claims 1 and 2, characterized in that alkyl
25 (oligo)glucoside compounds (APG compounds) of which the alkyl group derives at least predominantly from linear fatty alcohols are used at least partly and preferably at least predominantly as component (a).
4. A process as claimed in claims 1 to 3, characterized in that APG compounds of glucose and, more particularly, fatty alcohols based on

natural substances and containing at least 6 and preferably 8 to 24 carbon atoms and having DP values of 1.2 to 5 are used.

5. A process as claimed in claims 1 to 4, characterized in that oil-soluble but biologically compatible organic compounds containing aliphatic and/or olefinically unsaturated, preferably at least predominantly linear hydrocarbon radicals containing at least 6 carbon atoms and, in particular, at least 8 carbon atoms are used as component (b).
6. A process as claimed in claims 1 to 5, characterized in that components (b) at least partly functionalized with oxygen as hetero atom are used, the use of fatty alcohols and/or fatty acids or derivatives thereof, such as esters or partial esters, ethers and/or amides, being preferred.
7. A process as claimed in claims 1 to 6, characterized in that the components (b) are at least predominantly based on natural substances.
8. A process as claimed in claims 1 to 7, characterized in that the components (b) at least partly have pour points of or below 25 to 30°C and, more particularly, of or below 10 to 15°C.
9. A process as claimed in claims 1 to 8, characterized in that olefinically unsaturated C₁₂₋₂₄ fatty alcohols of natural origin, more particularly at least predominantly C_{16/18} fatty alcohols with a high degree of olefinic double bonds and solidification ranges of or below 20°C and preferably of or below 10 to 15°C, and/or fatty acid partial esters, such as glycerol monooleate, are used as component (b), mixtures of such components (b) being preferable.
10. A process as claimed in claims 1 to 9, characterized in that the fatty alcohols and partial esters are used in mixing ratios of 1:1 to 1:10, preferably 1:1 to 1:5 and more preferably 1:1 to 1:3 parts by weight.
11. A process as claimed in claims 1 to 10, characterized in that oil-soluble compounds of P and/or N are used as the compounds at least partly bearing lipophilic radicals of component (c).



* C L N S *



12. A process as claimed in claims 1 to 11, characterized in that oil-soluble compounds of P and/or N are used as the compounds at least partly bearing lipophilic radicals of component (c).
13. A process as claimed in claims 1 to 12, characterized in that lecithin, lecithin hydrolyzates and/or chemically modified lecithins, preferably in admixture with other N-containing macro nutrients, are used as component (c), urea and/or urea derivatives in particular optionally being used as other N-containing components.
14. A process as claimed in claims 1 to 13, characterized in that the components (c) are also introduced into the substrate in the form of aqueous preparations, again preferably using ecologically compatible wetting agents.
15. A process as claimed in claims 1 to 14, characterized in that the components (b) and - assuming the components (a) are biodegradable - the mixtures of components (b) and (a) are used in such quantity ratios to the components (c) that ratios by weight of C to P of at least 10 to 50:1 and preferably of at least 80 to 150:1 are established although values of up to 500:1 or higher can also be achieved.
16. A process as claimed in claims 1 to 15, characterized in that, in practice, ratios by weight of P to N to C of at least about 1:10:10 to 1:10:100 are adjusted by co-ordinating the quantities of components (a)/(b) and (c) introduced into the substrate.
17. A process as claimed in claims 1 to 16, characterized in that, where phospholipids are used as the P source of component (c), they are applied in quantities of 0.01 to 10 g/m² substrate surface and preferably in quantities of 0.1 to 5 g/m² substrate surface while components (a)/(b) are applied in a quantity adapted to the desired molar ratio of C to P.
18. Water-dilutable aqueous concentrates of supporting materials for increasing the growth of plant-growth-promoting soil microorganism flora containing

- supporting materials at least partly containing oil-soluble compounds of P and/or N and, if desired, other macro and/or micro nutrients for plant growth
- 5 - together with biologically compatible and, in particular, microbiologically degradable wetting agents of the o/w type,

characterized in that they additionally contain

- 10 - fine-particle emulsifiable and/or dispersible C sources for the growth of microorganism flora from the class of aerobically and anaerobically degradable organic compounds containing lipophilic saturated and/or olefinically unsaturated hydrocarbon radicals of fatty structure.

15

19. Multicomponent mixtures as claimed in claim 18, characterized in that they contain as C sources oxygen-functionalized organic compounds at least predominantly of fatty structure which preferably belong to at least one of the following classes: fatty alcohols and/or fatty acids or salts and
20 derivatives thereof, such as esters or partial esters with mono- and/or polyfunctional alcohols, ethers and/or amides.

20. Multicomponent mixtures as claimed in claims 18 and 19, characterized in that they contain the C sources - in co-ordination with the P-containing components - in such quantities that C:P ratios (quantities by
25 weight and, in the case of the C source, based on the organic components of fatty structure) of at least 10 to 50:1 and preferably of at least 80 to 100:1 are guaranteed.

21. Multicomponent mixtures as claimed in claims 18 to 20, characterized in that they contain APG compounds of glucose and in
30 particular fatty alcohols based on natural substances which contain at least





6 and preferably 8 to 24 carbon atoms as wetting agents of the o/w type, the APG compounds having DP values of 1 to 5 and preferably of 1.2 to 3 and HLB values of 10 to 18.

22. Multicomponent mixtures as claimed in claims 18 to 21,
5 characterized in that they contain P- and N-containing mixture components at least partly in the form of lipophilic organic compounds, the use of corresponding phospholipids being preferable.

23. Multicomponent mixtures as claimed in claims 18 to 22,
10 characterized in that they contain lecithin, lecithin hydrolyzates and/or chemically modified lecithins as phospholipids.

24. Multicomponent mixtures as claimed in claims 18 to 23,
characterized in that they additionally contain urea and/or urea derivatives as N source.

25. The application of the working principle of healthy growth promotion
15 of soil microorganism flora and the resulting stimulation and development of soil fauna by introduction of in particular aqueous preparations of supporting materials at least partly containing oil-soluble compounds of P and/or N and, if desired, other macro and/or micro nutrients for plant growth at the same time as and/or at a different time from the additional
20 introduction of C sources for the growth of microorganism flora based on aerobically and anaerobically degradable organic compounds containing lipophilic saturated and/or olefinically unsaturated hydrocarbon radicals of fatty structure for soil rehabilitation with a rotting-accelerating effect (mineralization) and a soil-improving effect (improvement of soil aeration,
25 elimination of anaerobic soil regions) and in particular as a vitalizing medium with a plant-strengthening fertilizing effect, preferably of the slow-release type.

26. The application claimed in claim 25, characterized in that at least the
C sources for the growth of the microflora are present together with
30 microbiologically degradable wetting agents of the o/w type and are

introduced into the soil in the form of a dilute aqueous solution, emulsion and/or suspension.

27. The application claimed in claims 25 and 26 for supplying and enriching degradable C sources, particularly aerobically degradable C sources, to and in the rhizosphere region so that they come into direct contact with the surface of the plant roots.

28. The application claimed in claims 25 to 27, characterized by the use of microorganism starter cultures which promote healthy plant growth, more particularly from the groups of corresponding bacterial and/or mycorrhiza strains.

