



(22) Date de dépôt/Filing Date: 2010/11/05

(41) Mise à la disp. pub./Open to Public Insp.: 2012/05/05

(45) Date de délivrance/Issue Date: 2017/06/06

(51) Cl.Int./Int.Cl. *C09K 17/50* (2006.01)

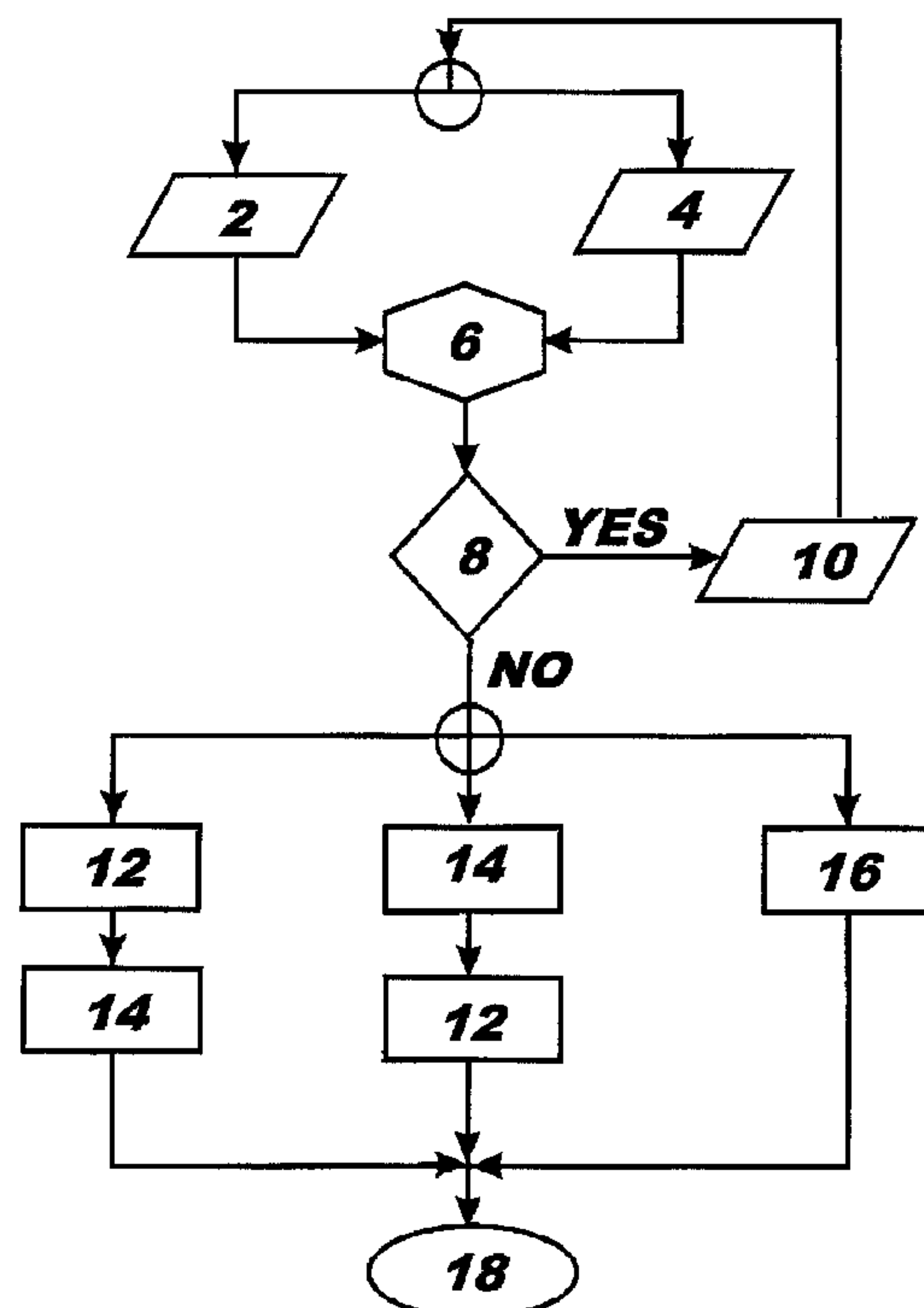
(72) Inventeurs/Inventors:
HORVATH, TIBOR, CA;
WEAGLE, GLENN, CA;
COOKE, JEFF, CA

(73) Propriétaire/Owner:
IPAC CHEMICALS LTD., CA

(74) Agent: SMITHS IP

(54) Titre : PROCEDE ET COMPOSITION VISANT A FORMER UNE CROUTE SOUPLE CONCUE POUR PROTEGER
ET AMENDER LE SOL

(54) Title: METHOD AND COMPOSITION TO FORM A FLEXIBLE CRUST FOR SOIL PROTECTION AND
ENHANCEMENT



(57) Abrégé/Abstract:

The invention relates to a compound of two main components, a polysaccharide and a borate provider, that form a flowable, penetrating liquid when mixed, then cross-link and gel to form a stable, flexible crust when applied to a substrate, such as soil. The crust protects the soil and prevents loss of moisture, but can be softened or mechanically worked to allow access to the soil, for example to provide nutrients or pesticides. Additives may be used to control specific properties and applications of the crust.



ABSTRACT

The invention relates to a compound of two main components, a polysaccharide and a borate provider, that form a flowable, penetrating liquid when mixed, then cross-link and gel to form a stable, flexible crust when applied to a substrate, such as soil. The crust protects the soil and prevents loss of moisture, but can be softened or mechanically worked to allow access to the soil, for example to provide nutrients or pesticides. Additives may be used to control specific properties and applications of the crust.

TITLE OF THE INVENTION**METHOD AND COMPOSITION TO FORM A FLEXIBLE CRUST
FOR SOIL PROTECTION AND ENHANCEMENT****FIELD OF THE INVENTION**

This invention relates to a soil protection and enhancement compound formed from a binary system that can be applied to a substrate to stabilize the substrate, to prevent desiccation of the substrate, and to selectively provide soil and crop enhancement.

BACKGROUND OF THE INVENTION

Treatment to protect soils is important, particularly to avoid moisture loss from the soil, which can prevent crops or other plants from germinating or growing. It is also important to enhance the soil substrate by providing specific soil enhancers, such as nutrients and herbicides, preferentially within the soil in order to achieve maximum benefit of those soil enhancers.

Known anti-desiccant treatments often focus on slowing or preventing transpiration from the plant itself. Products such as Moisturin™, Wilt-Pruf™, Anti-Stress™, and Cloud Cover™ coat the plant leaves or needles with a prophylactic shield of resin or polymer, preventing the leaves or needles from releasing moisture into the air. U.S. Patent No. 7,470,319 to Hunter discloses a foliar prophylactic including a phyllosilicate mineral, a chelating agent and multivalent ions. Another anti-transpirant method, known as a root soak, involves applying product such as abscisic acid to the soil, where the plant roots soak it up. Once the acid passes through the plant system, it chemically triggers the leaf stomata to close, preventing transpiration. In each case, these products are generally described as bio-degradable, but direct application to each individual plant is

often impractical, in cases where expansive fields of crops are being grown. Further, application of chemicals directly to the plant is usually undesirable for crops, particularly food crops.

A known soil enhancing treatment is perlite, an amorphous volcanic glass. When heated to temperatures over 850°C, water trapped in the glass vaporizes, causing tremendous expansion in the structure of the glass. The expanded perlite is a very lightweight product that is useful to promote drainage and aeration in soil; by replacing some of the soil with perlite, the density and compaction of the soil is reduced. The cavities covering the surface of the perlite can hold oxygen, providing improved soil aeration and growing conditions. The cavities also trap and hold moisture in the soil, providing water to the plant roots and preventing the soil from drying out too quickly.

Mulches have also been used to protect soil from environmental effects, such as sunny conditions which would increase water evaporation from the soil. Known mulches include shredded rubber tires or plastic sheets with slits or holes to allow water penetration. An issue with these non-organic mulches is that the mulch is not inherently biodegradable and can be difficult to remove from the soil. Harvesting crops around foreign materials such as rubber pieces or plastic sheets can be difficult, as the foreign material can interfere with the harvesting machinery. Further, plastic sheets must be physically held down over an area, which requires an extra step of burying or otherwise containing each side of the sheet. The cost of using a plastic mulch sheet can be increased because of the burying step and, because there must physically be enough spare sheet to bury, by requiring a sheet that is somewhat larger in area than the field being covered.

Organic mulches have also been used directly on the soil around plants. U.S. Patent No. 5,163,247 to Weber discloses a type of mulch comprising a fibrous cellulose web with a latex-coated surface. The web is polymeric, based on a self-cross-linking acrylic, styrene-butadiene or ABS. The web is biodegradable and so can naturally compost and disappear before the crop is harvested, or is suitable for composting once the crop is

harvested. Other organic mulches have been found to be susceptible to matting down, which may prevent moisture loss from the soil, but may also prevent water and other nutrients from ever reaching the soil. The organic mulch may tend to trap water before it reaches the soil, as well as actually wicking moisture out of the soil, allowing the water to evaporate even more readily than in unprotected soil.

U.S. Patent No. 6,270,291 to Gamliel discloses a liquid polymer applied to soil to form a plastic mulch membrane film directly on the soil. Gamliel attempts to deal with some of the above issues with mulch by specifying that different levels of protection may be provided by applying different volumes of the plastic mulch; evidently applying a lower volume will create a thinner, more uneven and more porous membrane, which should allow more water penetration. However, as the mulch membrane gets thinner, the level of protection provided by the plastic mulch would likely decrease as well. Gamliel also appears to require several soil preparation steps, such as rotating and compacting the soil to provide a relatively flat, smooth surface to receive the plastic mulch as evenly as possible. Further, gaining optimal protection from the plastic mulch requires the application of two layers of mulch compound, each preferably a different composition from 8% to 40% polymer. Such additional steps take time and energy and will increase the costs associated with growing the crops.

U.S. Patent No. 4,320,040 to Fujita discloses a hydrophilic gel including acrylic acid or methacrylic acid in the presence of polyvinyl alcohol that may be used as a water retaining agent for plants, although no detail as to that specific application is provided.

U.S. Patent No. 6,558,705 to O'Brien discloses application of a composition containing higher fatty alcohols (alkanols) to suppress water evaporation in soil. Specifically, the higher fatty alcohol is mixed with slaked agricultural lime or acidified gypsum.

U.S. Patent No. 6,322,724 to Sanderson discloses a coating comprising a cross-linked absorbent polymer combined with a low molecular weight compound. The combination

reduces the rate at which water evaporates from the polymer, providing a source of water for the soil.

In prior art patents such as Fujita, O'Brien and Sanderson, a potential drawback is that the coating or covering applied to the soil sits on top of the soil, providing protection only to the very top layer of the soil. In cases where the coating itself is actually providing or holding moisture for the crops, such superficial protection may not provide enough water to plant roots buried deep under the soil. Further, the coating provides protection only vertically, above or below the top level of soil, which does not prevent water loss to drainage in horizontal directions. Finally, if the coating is damaged, it tends to be unable to repair itself, leaving a hole through which water evaporates relatively quickly.

It is also known to apply mulch or similar soil covering not only to protect the soil, but to deliver soil enhancers into the soil. For example, U.S. Patent No. 4,705,816 to Pole discloses liquid rubber mulch composed of natural or synthetic rubber, chloroprene, polyisoprene, nitrile rubber or similar compounds, along with binders, fillers, surfactants, viscosity control chemicals and soil enhancers such as nutrients, fertilizers or herbicides. The liquid mulch creates a friable crust over the soil that is intended to reduce evaporation while still allowing post-applied chemicals to enter the soil. The soil enhancers are released into the soil over time. An issue with this type of mulch is similar to that of shredded rubber mulches, namely that the mulch is not inherently biodegradable and can be difficult to remove from the soil. With respect to the effectiveness of the delivery of the soil enhancers, the depth of penetration of the enhancers is likely relatively shallow, slow and uneven.

PCT Publication No. WO 00/47037 to MacAlister discloses a soil-enhancing mulch sheet impregnated with a soil enhancer, such as fertilizers or herbicides, which is released into the soil when water saturates the sheet. While the rate and duration of release of the soil enhancer may be controlled by changing the water solubility and mechanical durability of the film, the depth of penetration of the enhancers into the soil is likely only shallow and is difficult to control.

It is therefore an object of the invention to provide a compound to form a flexible crust for a soil substrate that overcomes the foregoing deficiencies.

It is a further object of the invention to provide a compound to form a flexible crust that can be applied under most practical working conditions.

It is a further object of the invention to provide a compound to form a flexible crust in which the viscosity of the compound over time can be controlled, in order to customize the properties of the flexible crust.

It is a further object of the invention to provide a compound to form a flexible crust that can be broken up and worked into the soil, without contaminating the soil.

It is yet a further object of the invention to provide a compound to form a flexible crust that is non-toxic, biodegradable and environmentally safe.

It is a further object of the invention to provide a compound to form a flexible crust for a soil substrate that is controllably porous, to allow soil enhancers to penetrate the crust and reach the seeds or plants in the soil substrate.

It is yet a further object of the invention to provide a soil-enhancing compound that can deliver soil enhancers to a selected part of the soil substrate, to provide maximum benefits to the crop.

It is yet a further object of the invention to provide a soil-enhancing compound that that can deliver soil enhancers to the soil substrate over an extended period of time, as appropriate to provide maximum benefit to the soil substrate.

It is yet a further object of the invention to provide a compound to form a flexible crust that can reform or repair small defects in the crust.

These and other objects of the invention will be appreciated by reference to the summary of the invention and to the detailed description of the preferred embodiment that follow. It will be noted that not all objects of the invention are necessarily realized in all possible embodiments of the invention as defined by each claim.

SUMMARY OF THE INVENTION

The invention relates to a soil protecting and enhancing compound comprising a binary system which forms a matrix that binds with the top layers of a soil substrate, effectively producing a flexible crust. Upon mixing, the components of the binary compound begin to complex, or weakly cross-link, such that the viscosity of the compound increases at a controlled rate.

The formation of the crust takes place in the top layers of the soil substrate, at a depth that can be selected to match the specific application, such as the likely depth at which the seeds are planted, or to which the roots of the crop to be planted will reach in a given time frame, depending on when the crust is being applied. The depth chosen is controlled by controlling the rate at which the viscosity of the binary compound increases.

The porosity of the final crust is also influenced by the amount of binary compound and the depth to which it penetrates. This allows the user to apply soil enhancing agents as needed, and be assured that those agents will reach the crop through the crust.

Controlling the rate of viscosity increase also allows the viscosity increase to occur predominantly within the soil substrate, rather than within the holding, mixing or application apparatus, thereby simplifying the application process. The binary nature of the compound allows the different components to be used as a soil pre-treatment, to be applied directly to the soil substrate at any stage of the crop-growing process, such as

at seeding or post-germination, and to be used as a slow-release carrier to provide soil enhancers to the soil.

Once formed, the crust significantly reduces the amount of water that can escape from the soil, by retaining water within the bound layers of the soil within the crust matrix. However, because the crust is only weakly cross-linked, it can be physically broken up if it is manipulated mechanically, so the soil substrate can be accessed easily if required for further processing. Nor does the crust contain any strong or toxic chemicals, so it may be incorporated directly into the soil substrate material without adversely affecting the properties or value of the soil substrate.

The weak-cross-linking of the crust is also reversible, which provides a self-healing property to the crust. This characteristic may be useful if the crust is damaged by an impact, such as a stone, branch or other foreign object falling onto the crust.

Various additives may also be used to tailor the properties of the crust to specific application conditions and/or to an application process. The compound may also be manipulated to allow the compound to perform a specific application, such as preventing desiccation, providing moisture, allowing post-application of soil enhancers and/or providing soil enhancers at a controllable rate.

In one aspect, the invention comprises a method of forming an anti-desiccant crust on a soil substrate comprising the steps of combining a first component with a second aqueous component, the first component comprising a polysaccharide and the second component comprising a borate provider, to form a compound; applying the compound to the soil substrate; allowing the compound to penetrate the soil substrate to a pre-determined depth, thereby forming the anti-desiccant crust; wherein the compound further comprises an alkaline component in an amount effective to facilitate release of borate into the compound from the borate provider. The crust may form substantially independently of any evaporation of ingredients of the first and second components.

In yet another aspect, the invention comprises a soil substrate anti-desiccant compound comprising a first component, comprising a polysaccharide, which may be a starch, and may further be a modified starch; a second aqueous component, comprising a borate provider; an alkaline component in either the first component or the second component, in an amount effective to facilitate release of borate from the borate provider; wherein mixing the first and second components forms cross-links within the compound at a controlled rate; and wherein the compound is immediately applicable to a soil substrate. The alkaline component, which may be a hydroxide, selected from the group comprising sodium hydroxide, ammonium hydroxide and potassium hydroxide, may be selected to provide a pH of at least 12 to the compound. The controlled rate is preferably selected to allow a majority of the cross-links to form within the soil substrate.

Additives, such as a retardant, which may be selected from the group comprising water, alcohols and glycols, may be added to manipulate the controlled rate of cross-linking. Other additives may include surfactants, thickeners and plasticizers, each of which will affect the crust properties and penetration of the crust into the soil substrate and can be manipulated in order to precisely control the delivery of the binary compound.

In another aspect, the invention comprises use of a compound comprising a first component, comprising a polysaccharide; a second component, comprising a borate provider; an alkaline component in either the first component or the second component, in an amount effective to facilitate release of borate from the borate provider; wherein mixing the first and second components in the presence of water forms cross-links within the compound at a controlled rate, as an anti-desiccant for a soil substrate.

In another aspect, the invention comprises use of a compound comprising a first component, comprising a polysaccharide; a second component, comprising a borate provider; an alkaline component in either the first component or the second component, in an amount effective to facilitate release of borate from the borate provider; wherein mixing the first and second components in the presence of water forms cross-links within the compound at a controlled rate, as a soil enhancer for the soil substrate.

In another aspect, the invention comprises a soil enhancing compound to provide controlled release of a soil enhancer within a soil substrate, comprising a first component, comprising a polysaccharide; a second component, comprising a borate provider; an alkaline component in either the first component or the second component, in an amount effective to facilitate release of borate from the borate provider; and a carrier holding the soil enhancer; wherein mixing the first and second components in the presence of water forms cross-links within the compound at a controlled rate within the soil substrate.

In yet another aspect, the invention comprises use of a compound comprising a first component, comprising a polysaccharide; a second component, comprising a borate provider; an alkaline component in either the first component or the second component, in an amount effective to facilitate release of borate from the borate provider; and a carrier holding the soil enhancer; wherein mixing the first and second components in the presence of water forms cross-links within the compound at a controlled rate within the soil substrate, as a soil enhancer for the soil substrate.

The foregoing was intended as a broad summary only and of only some of the aspects of the invention. It was not intended to define the limits or requirements of the invention. Other aspects of the invention will be appreciated by reference to the detailed description of the preferred embodiment and to the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the invention will be described by reference to the drawings in which:

Fig. 1 is a flowchart showing the preferred steps in the method to create a binary soil protection and enhancement compound;

Fig. 2 is a graph showing the viscosity (centipoise) versus time (minutes) of various compounds made according to the invention as well as some reference compounds;

Fig. 3 is a table showing the viscosity of various polysaccharides dissolved in water; and

Fig. 4 is a table showing the viscosity change over time of various polysaccharide compounds prepared according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

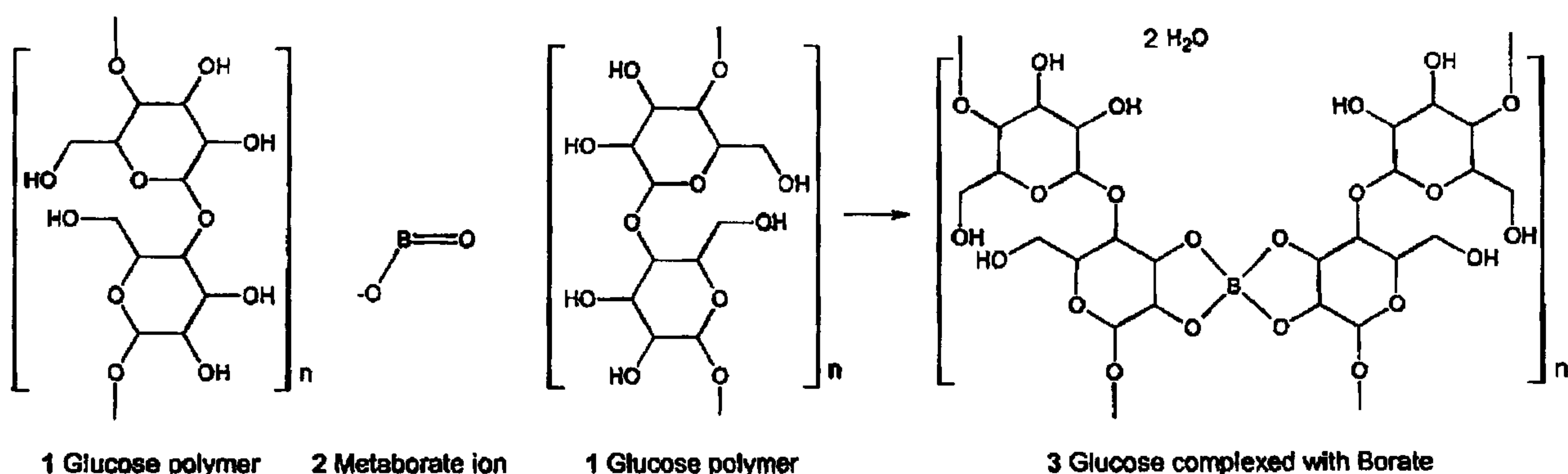
The soil protection and enhancement compound of the invention is a binary system comprising two main components, which, when mixed in the presence of water, create a compound whose viscosity begins to increase at a controlled rate, as a result of the complexation, or weak bonding, that begins within the compound upon mixing.

The first main component of the binary compound is a mixture containing 0.1 to 15% by weight of a polysaccharide such as starch, a modified starch or other polysaccharide. Suitable polysaccharides include starches having amylase or amylopectin, alpha- or beta-glucan, cellulose, dextrans, pectin, chitosan, modified glucan including glucan with gluten protein, acid- or alkaline-treated starch, enzyme-treated starch, bleached starch, oxidized starch, monostarch phosphate, distarch glycerol, distarch phosphate esterified with sodium trimetaphosphate, phosphated or acetylated distarch phosphate, starch acetate esterified with acetic anhydride or vinyl acetate, acetylated distarch adipate or glycerol, hydroxypropyl starch, hydroxypropyl distarch phosphate, hydroxypropyl distarch glycerol, starch sodium octenyl succinate, carrageenan and gums including xanthan gum, guar gum, guaran, carob gum and locust bean gum. The first component is preferably an aqueous mixture, encompassing aqueous polysaccharide solutions, dispersions or any other combination of polysaccharide in a flowable medium; however, the first component may be a dry powder mixture of a polysaccharide, such as starch

alone or starch mixed with guar gum, in a 20:1 ratio. A dry powder mixture could be mixed with water at a staging area associated with the soil to be protected. A suitable mixture of starch/guar gum powder would be 0.5% to 5% powder in water.

The second component of the binary compound is a mixture containing approximately 0.1 – 20% of a borate provider, such as borax or boric acid.

Once the two components are combined in the presence of water to form the binary compound, the polysaccharide molecules, particularly the glucose molecules, begin to link with the borate supplied by the borate provider at a controlled rate. This process, referred to as complexation, forms weak covalent bonds, comparable to weak cross-links in a polymer, within the polysaccharide matrix, as shown in the following diagram:



The complexation reaction results in an increase of viscosity throughout the mixture as starch molecules bond with borates. The bonds formed by the complexation reaction are preferably weaker than those formed when a conventional cross-linker is added to a starch solution. The immediate result is a liquid gel; over time, the liquid gel continues to cross-link until a final matrix is formed. The final matrix has some strength and flexibility, but does not become extremely hard or substantially indestructible. Nor does the matrix necessarily form a completely cohesive, closed film. This may be preferred, in order to allow soil enhancers, such as water, nutrients and biocides, to penetrate through the crust to reach the intended target in or on the soil substrate.

Further, matrix formation is controlled by the rate and amount of polysaccharide-borate cross-linking within the mixture. This provides a substantial advantage in wet conditions, as the matrix will soften if it is dampened or soaked with water. This softening is caused by the breaking of some of the weak links in the matrix, essentially reversing the earlier cross-linking reaction. However, the matrix will still maintain its inherent cross-linked structure, and some of the links broken when the matrix is wetted will reform in new ways as the water evaporates or is absorbed by the underlying soil or plant seeds or roots. This means that the crust will re-harden, and can in fact re-form to cover small areas that had previously been damaged, providing a new level of protection.

Either solution may be modified by addition of a caustic, such as sodium hydroxide, ammonium hydroxide or potassium hydroxide, in order to increase the amount and rate of cross-linking. The caustic improves the release of borate from the borax or boric acid in solution, as borax and boric acid tend to polymerize in alkaline solutions, creating more borate ions to cross-link with the starch molecules. Depending on the particular starch used, a suitable amount of caustic is preferably in the range of up to 20%, for a borax solution, preferably a 2% caustic to 2% borax ratio. The effect of the caustic is to increase the pH of the borax solution, which leads to an increased level of borate being released, which in turn improves the complexation rate with the starch. If boric acid is used, a slightly higher level of caustic is generally required, in the range of 2% caustic to 0.96% boric acid. Typically, a more alkaline mixture will create a more effective cross-linking reaction.

The complexation reaction can be further manipulated by changing the ingredients in the two main components of the binary compound. Adding a retardant to delay or slow the rate at which the binary compound increases viscosity can be beneficial; it may be preferable in some situations to transport or store the mixture rather than applying it immediately after combining the solutions. Further, having the compound viscosity increase within the layers of the soil substrate allows the depth of penetration to be

controlled and allows the compound to be manipulated and applied under practically any circumstances without the need for heating or mixing.

Either component may therefore be modified by adding a retardant to slow the complexation reaction. This allows the rate of complexation and the corresponding increase in viscosity of the resulting mixture to be controlled according to the needs of the specific application. For example, the soak time, during which the mixture is flowable enough to penetrate the soil substrate to which it is applied, can be adjusted by controlling the rate of increasing viscosity. By adjusting the soak time, the amount of interaction of the mixture with the soil substrate (including the depth of penetration of the mixture into the soil substrate) can be controlled, allowing the amount of soil substrate material captured by the mixture and encapsulated in the final crust matrix to be controlled. The flexibility and toughness of the resultant crust is also impacted by the amount of soil substrate material within the crust matrix and can therefore be controlled by controlling the soak time. The soak time is therefore dependent on the application. For example, in a soil anti-desiccant application, the desired depth of penetration is likely to a depth at least equivalent to the approximate depth at which the seeds are planted, such that moisture is readily available to the seeds. For anti-desiccant protection post-germination, the desired depth of penetration may be deeper, to provide ready moisture to the root system of the plant, as it embeds itself more firmly in the soil. The properties of the compound can be controlled to provide penetration of mere centimetres or even completely through the depth of the soil substrate, as required by the application and soil properties.

Different retardants can be added in different amounts, allowing the mixture properties to be further tailored for the application. Preferred materials for the retardant include water, alcohols, such as methanol, and glycols, such as propylene glycol. Water has the advantage of being inexpensive, environmentally friendly, and generally available at most application sites. However, although water can be used at most application temperatures, it is less suitable for sub-zero applications. An alcohol with a lower freezing point can be used in that case, to lower the freezing point of the main solutions

and to ensure that the mixture remains flowable for as long as necessary. Good retardant and freezing point suppression results have been observed with ranges of 1 – 30% of methanol and glycol. The resulting compounds can then be applied at most practical working temperatures, including the preferred range of -5°C to +40°C.

In some cases, less penetration of the binary compound into the soil substrate is preferred, such as in highly porous or sandy soil substrates. In these cases, thickeners may be added to either solution in order to further tailor the properties by slowing the penetration of the mixed compound as the complexation reaction occurs. Thickeners may be either inorganic, organic, natural, synthetic or combinations thereof. Examples of inorganic thickeners include kaolinite clays, montmorillonite clays, and bentonite, while some examples of natural organic thickeners include casein, guar gum, pectin, gum taraganth, gum karaya, xanthan gum, and starch. The organic or inorganic thickeners may be modified with natural or synthetic products to enhance their properties. Examples of synthetic organic thickeners may include modified or unmodified cellulose ethers such as methyl cellulose, hydroxyethyl cellulose hydroxypropyl cellulose, as well as polymers or copolymers of acrylic acid and its esters, methacrylic acid and its esters, vinyl acetate and its hydrolyzates, and polyurethane and derivatives.

Another possible additive is a surfactant, which will generally improve the wetting ability of the binary compound, affecting the depth of permeation of the compound into the soil substrate, as well as the porosity of the final crust. Some preferred surfactants include alkyl ethoxylates, alkyl propoxylates, block EO/PO, alkyl sulfonates and/or benzyl sulfonates. Generally, a surfactant is preferably added in approximate concentrations of up to 25% of the compound. Depending on the application, a surfactant type and concentration may be chosen to provide the desired soil substrate penetration, the desired porosity, and to be compatible with the soil substrate.

If a more flexible crust is preferred, glycerine or a similar plasticizer can also be added to the crust to increase the flexibility. Glycerine may be added to either component and

can be present in the mixture at a concentration of up to 50%. Glycerine may also have a freezing-point suppressing effect.

The method of making the binary compound is shown in the flowchart in Fig. 1. A first component 2 comprising a polysaccharide and a second component 4 comprising an aqueous mixture containing a borate provider are provided, along with an alkaline agent as an ingredient in either the first or second component. The separate components are delivered 6 to a staging area associated with the soil to be protected. The staging area may also be a site from which an airborne applicator, such as a helicopter, can be loaded and launched. If a significant delay 8 is required between the time of mixing and the time of application, retardant 10 may be added to either of components 2 and 4 at the staging area or before delivery thereto. At the staging area, the first and second components are mixed 12 to create a liquid compound. The liquid compound is applied 14 to the surface of the soil before the compound undergoes a substantial increase in viscosity and while the compound can still easily be distributed over the soil, and will be able to penetrate the soil; the liquid compound can therefore reach the desired penetration depth within the soil before the compound reaches a high viscosity, at which it is essentially no longer flowable. At this point, crust 18 has been formed. Alternatively, mixing 12 can take place any time subsequent to application 14. This might occur, for example, if component 2 is applied to the soil first, followed by component 4, or if a dual nozzle applicator is used. In the further alternative, the mixing and application processes can be combined into a single process 16.

The method may be modified by predetermining a desired delay period for the liquid compound to reach its maximum viscosity and adding a retardant to the liquid compound, in an amount effective to correlate the time before the compound undergoes a substantial increase viscosity to that desired delay period, in order to facilitate storage, handing or transport of the mixture if necessary before it is applied to a soil substrate.

Controlling the rate of viscosity change in the binary compound is important in producing a final crust having the desired properties. As shown in Fig. 2, the viscosity over time of

binary compounds having similar components, in varying ratios, can produce compounds having different maximum and minimum viscosities, which are reached at different times. Binary compounds can therefore be tailored for various applications and application conditions. In Fig. 2, the viscosity of the liquid gel formed from the compound is plotted against time. The lines represent different borax to caustic ratios, each tested in a solution having a starch concentration of 4%. $x\text{B}$ indicates the amount of borax in the second component. For example, 2B indicates 2% borax in the second component. As the liquid gel is made up of 90% of the starch component and 10% of the second component, 2B denotes a compound having 0.2 % borax. Similarly, $x\text{N}$ stands for percent caustic (in this set of compounds, sodium hydroxide (NaOH) is the caustic) in the second component. 4N – 2B therefore denotes for a compound having 0.4% caustic and 0.2% borax.

The binary compound may be applied at any stage of the crop growing process. If applied during seeding, the depth at which the seeds are planted would influence the depth to which the crust is applied. Further, maximum protection from the elements and predators, such as birds, might be preferred, and a firmer, less porous crust might be applied. At a later stage of crop growth, such as immediately post-germination, a thicker crust might be preferred, in order to encourage the crop roots to penetrate more deeply by providing a deeper source of moisture. A more porous crust may be also be preferred at this stage, to allow for the application of nutrients to help the crops grow, or of herbicides to combat weeds.

Because the compound properties can be controlled very closely, the compound itself can be applied under most practical working conditions, without the need to wait once the solutions are combined. This saves man-hours, as it allows more soil substrate to be protected in a given time. Conversely, the solutions can be modified to allow for a longer time prior to forming the final matrix, if it is necessary to pre-mix the solutions some time before the mixture is applied to the soil substrate. This might be necessary if a mixture has to be stored for some period of time, or transported to a different location before being applied to a soil substrate. For example, if the mixture is being applied

from an airborne vehicle, such as a helicopter, it would be preferable to simply spray the final mixture, instead of being concerned with carrying the various solutions and having to combine them in the proper proportions immediately before application.

The binary compound can also be modified so that it is applicable even at temperatures below the freezing point of water, without the need for special equipment to heat the mixture before applying. Conversely, the binary compound can be modified to be unaffected by higher atmospheric temperatures.

Because the rate of viscosity increase is controlled, it is possible to apply the binary compound using any known application means, including various spray applicators. Spray applicators configured in various ways may be used, including an external dual spray gun where the two components are mixed as they leave the gun nozzles. Alternatively, the two components may be mixed as they exit the nozzles of a dual-nozzle spray applicator. If further ingredients are employed to control the increase in viscosity, it is also possible to pre-mix the ingredients and apply them with a single nozzle applicator. The solutions might also be mixed in a mixing chamber just as they enter the spray applicator, or even within the spray applicator nozzle. The viscosity increase may also be controlled to allow some delay, during which the mixture may be transported to the soil where it is to be applied. Any spray application system may be used, as no special equipment or supplies are required to control the properties of the compound.

In addition to spray-application of a liquid form of the binary compound, other application methods may successfully be used. For example, either of the main components of the compound (i.e. the polysaccharide or the borate provider) may be applied directly to the soil substrate in dry solid or powder form. As soon as it is desired to form a crust, the second component of the crust can be applied in an aqueous form, providing the water and the rest of the components required to begin the complexation reaction, thus beginning the formation of the soil enhancing and protecting crust. Similarly, both components may be applied in a powder form, and allowed to simply sit

in an inactive form on the soil substrate. Water, either in the form of rain, or applied by spraying, will begin the complexation reaction and lead to crust formation.

It will be understood that the two components may be applied at different times, whether the components are applied in dry or aqueous forms. This time delay, which may supplement the time delay provided by the controlled viscosity increase within the binary compound, can allow time to treat or otherwise deal with the soil substrate or the plants or seeds in the soil substrate, before providing the full protection afforded by the complete binary compound.

The binary compound may also be used as a pre-treatment for bagged soil or soil mixtures. In this application, one of the main components may be pre-mixed with the soil, while the second component may be provided separately. Only upon mixing of the pre-treated soil and the second component in the presence of water would the complexation reaction begin, forming the binary compound. Of course, if the second component is provided in an aqueous form, the reaction would begin upon mixing, without the need for additional water. As a further application, both components could be pre-mixed into the bagged soil in dry form, as long as care is taken to keep the soil relatively dry.

In another application, the binary compound may be used to enhance the soil substrate, by carrying specific soil-enhancing additives, such as water, pigments, nutrients, fertilizers, fungicides, herbicides, pesticides, other biocides or combinations of these, to a controllable depth within the soil substrate. Because the specific depth to which an additive should be delivered will vary with the plant and/or the additive, being able to control the depth to which the additive is carried by the binary compound allows the user to obtain the maximum benefits from the additive by delivering it to the depth that is most advantageous for the plant. For example, water should be placed close to the roots of a plant, rather than staying at the surface of the soil substrate. Pesticides, on the other hand, might be preferentially deposited closer to the surface, for pests that attack the leaves of a plant or for pests that crawl over the soil substrate to reach the

plant. Such selectivity and flexibility in application of various soil enhancing additives allows the user to obtain the maximum effect of the additives applied, as well as possibly decreasing the amount of additive needed to reach that level of effectiveness. Applying the additive using the binary compound of the present invention can also prevent run-off and loss of the additive before it can be absorbed by the plant or before it performs its intended function, by holding the additive within the crust.

In a further refinement of the soil enhancing application, the binary compound may be used to provide a long term or slow-release soil enhancement. In this application, the soil-enhancing additive, such as water, pigments, nutrients, fertilizers, fungicides, herbicides, pesticides, other biocides or combinations of these, may be encapsulated within or otherwise held by a carrier, which is then mixed with one or both components of the binary compound, and incorporated into the soil substrate. When the compound penetrates the soil substrate, the carrier is moved to the same depth as the compound, allowing the user to target the area of the soil substrate at which the additive would be most effective.

The carrier is preferably composed of porous or semi-porous particles that are impregnated with or otherwise hold the additive. Expanded perlite is an example of a suitably porous carrier. When exposed to the desired additive, the pores and cavities over the surface of the perlite will absorb and hold the additive. When the perlite is added to the soil enhancing compound, the particles are carried to the desired depth, where the additive may be released from the pores of the perlite over a period of time. The duration of the release of the compound from the porous particle may be controlled by adjusting the particle's physical properties such as overall size, internal cellular structure, and shell porosity, and can also be enhanced by utilizing chemical or natural treatments to alter the hydrophilicity or hydrophobicity of the particle. Thus it will be understood that the desired release rate can be achieved through judicious selection of various carriers having different physical properties, and exposing those carriers to different impregnation methods. Again, because the location and containment of the additive are controlled, this application can decrease the amount of additive needed to

effectively perform its intended function, and can prevent unnecessary loss or run-off of the additive before it has performed that function.

Experiment 1: Germination Trial for Binary Compound as Anti-desiccant

Treatment 1. Control: Seeds + water. Under this treatment, trays were checked daily and hand watered as needed for optimum germination for the duration of the trial.

Treatment 2. Seeds + no water + binary compound. For this treatment, trays were watered at seeding but not watered again for the duration of the trial. The binary compound was created by adding 1.0 litre of polysaccharide component to 2.5 litres of water, agitating, then adding 0.1 litre of borate provider component, and gently shaking. The solution was sprayed evenly over the trays using a backpack sprayer.

Treatment 3. Seeds + no water. In this treatment, the soil was watered at seeding but the trays were not watered again for the duration of the trial.

Plastic trays with 32 individual cells for soil and seeds were planted with either marigold or pea seeds. Twenty trays (ten of each species) were planted for each treatment. To begin, all sixty trays were placed side by side on a bench in a greenhouse, and blocked into the three treatments, leaving approximately 30cm buffer zones between treatments. The marigold and pea trays for each treatment were kept separate from each other but blocked together. At seeding, all trays were thoroughly watered. The anti desiccant compound was sprayed on Treatment 2 trays. Three fans were set up to blow air across all treatments. After two weeks, the number of cells with germinated seed was counted in each tray.

There was a significant difference among the three treatments in the number of cells in trays with germinated seeds for pea (Table 1) and marigold (Table 2). For both crops, germination was significantly lower in Treatment 3, which had no binary compound or

water than in the Control (Treatment 1, regular watering). Germination in Treatment 2, in which plants were treated with the binary compound but without further water, fell between the other two treatments. While there was no significant difference between individual pairs of treatments in the trial, the trend was for improved germination in un-watered seeds with the binary compound, although not as much improvement as in the regularly watered Control treatment.

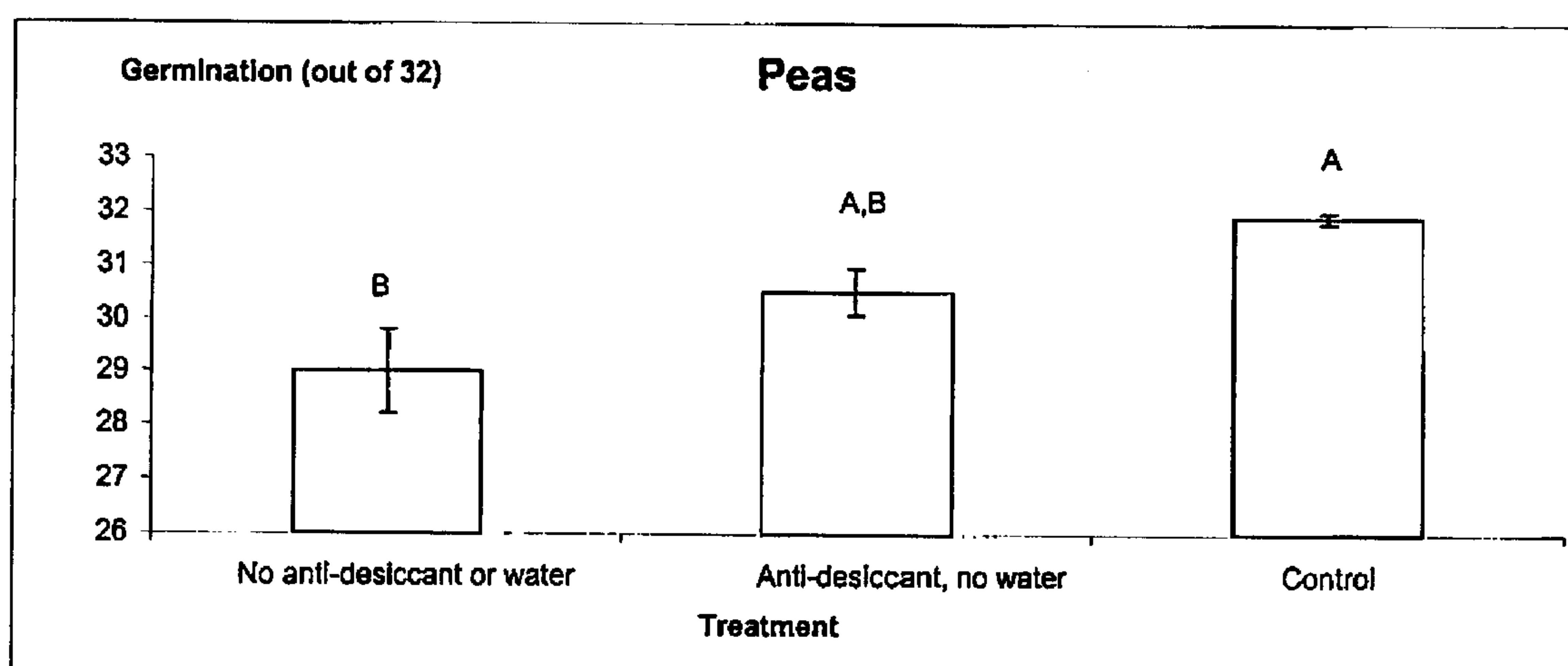


Table 1. Effect of anti-desiccant treatment on mean ($\pm$ s.e.m.) pea seedling germination ($n = 10$ /treatment).

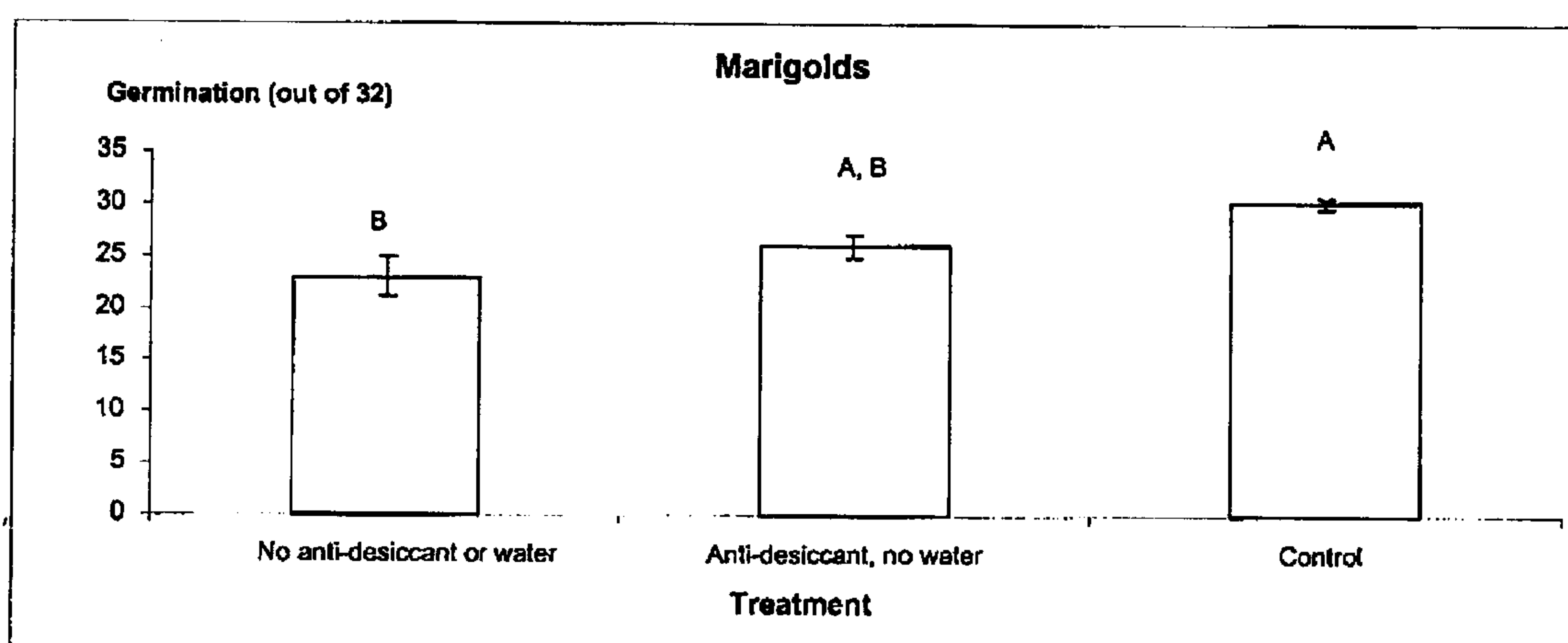


Table 2. Effect of anti-desiccant treatment on mean ($\pm$ s.e.m.) marigold seedling germination ($n = 10$ /treatment).

Based on these test results, the binary compound was shown to provide protection against desiccation both for the pea seeds, which have relatively larger water reserves, and for the marigold seeds, which have less metabolic water stored in relatively small seeds.

Experiment 2: Seedling Survival Trial for Binary Compound as Anti-desiccant

Treatment 1. Control: Seeds + water. Under this treatment, trays were checked daily and hand watered as needed for optimum growth before and after germination.

Treatment 2. Seeds + water + anti-desiccant. Under this treatment, seedlings were hand watered as needed for optimal growth before and after germination. At the cotyledon stage (first leaves) the binary compound was mixed by adding 1.0 litre of polysaccharide component to 2.5 litres of water, agitating, then adding 0.1 litre of borate provider component, and gently shaking. The solution was sprayed evenly over the trays with a backpack sprayer.

Treatment 3. Seeds + no water. In this treatment, the seedlings were watered before germination, but not after.

Treatment 4. Seeds + no water + anti-desiccant. In this treatment, seedlings were watered before but not after germination. At the cotyledon stage (first leaves) the binary compound was mixed and applied as in Treatment 2.

Plastic trays with 32 individual cells for soil and seeds were planted with either marigold or pea seeds. Twenty trays (ten of each species) were planted for each treatment. To begin, all sixty trays were placed side by side on a bench in a greenhouse, and blocked into the four treatments, leaving approximately 30cm buffer zones between treatments. The marigold and pea trays for each treatment were kept separate from each other but

blocked together. At seeding all flats were thoroughly watered. After germination (approximately 1 week later) the anti desiccant compound was applied to the trays in Treatments 2 and 4, as noted. Four fans were set up to blow air across all treatments. Two weeks after application, seedling survival results were compiled.

There was a significant difference among the four treatments in the number of seedlings surviving for both pea (Table 3) and marigold (Table 4) seeds. For both crops, seedling survival was highest in the Control and anti-desiccant + water treatments and significantly lower in the treatments without anti-desiccant or water.

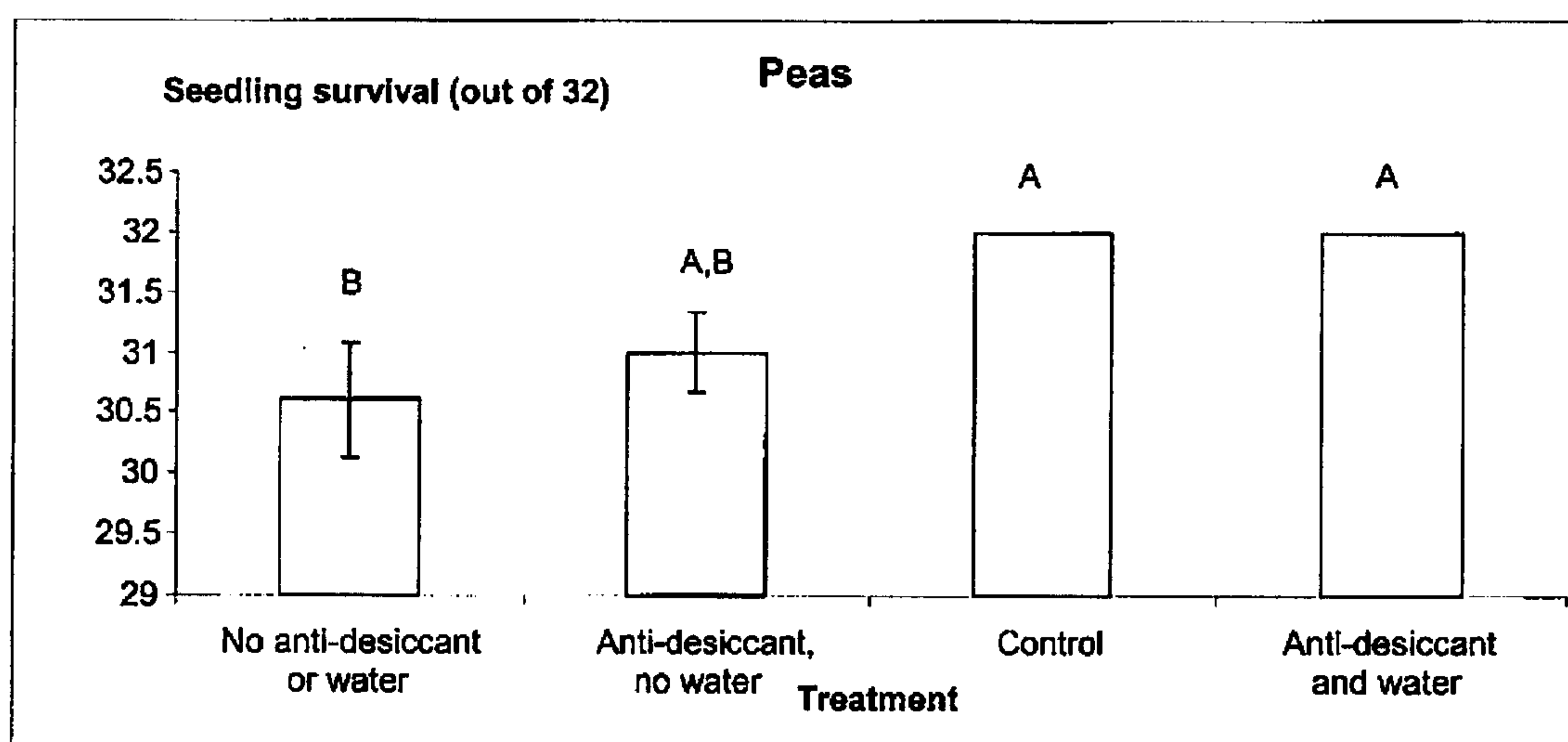


Table 3. Effect of anti-desiccant treatment on mean ($\pm$ s.e.m.) number of surviving pea seedlings (n = 10/treatment).

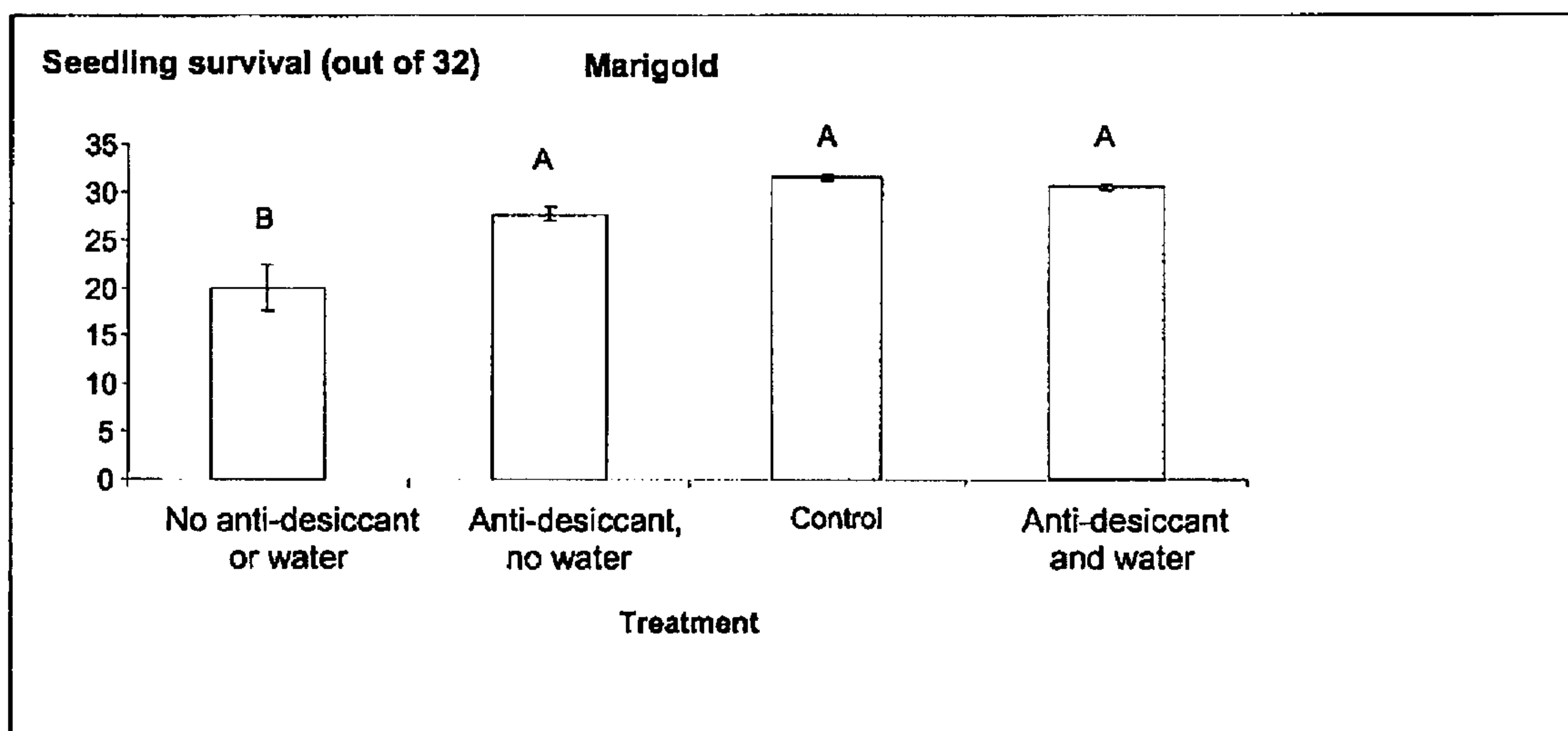


Table 4. Effect of anti-desiccant treatment on mean ($\pm$ s.e.m.) number of surviving marigold seedlings ($n = 10/\text{treatment}$).

As for germination, the trend was for the binary compound to protect the pea seedlings from desiccation. The improvement in survival in marigold was significantly higher with the anti-desiccant treatment than for the untreated un-watered seedlings.

It will be appreciated by those skilled in the art that other variations to the preferred embodiment described herein may be practised without departing from the scope of the invention, such scope being properly defined by the following claims.

CLAIMS

What is claimed is:

1. A method of forming an anti-desiccant crust on a soil substrate comprising the steps of:

combining a first component with a second aqueous component, said first component comprising a polysaccharide and said second component comprising a borate provider, to form a compound;

applying said compound to said soil;

allowing said compound to penetrate said soil to a pre-determined depth, thereby forming said anti-desiccant crust;

wherein said compound further comprises an alkaline component in an amount effective to facilitate release of borate into said compound from said borate provider.
2. The method of claim 1, wherein said step of combining said components is carried out prior to said step of applying said compound.
3. The method of claim 1, wherein said step of combining said components is carried out during said step of applying said compound.
4. The method of claim 3 using a dual-nozzle spray applicator to carry out said combining and applying steps.
5. The method of claim 1 wherein said step of applying said compound is carried out at a temperature range of -5°C to +40°C.
6. The method of claim 1 wherein said pre-determined depth is up to 10 cm.

7. The method of claim 1 wherein said anti-desiccant crust is formed independently of any evaporation of ingredients of said first and second components.
8. A soil substrate anti-desiccant compound comprising:
 - a first component, comprising a polysaccharide;
 - a second aqueous component, comprising a borate provider;
 - an alkaline component in either said first component or said second component, in an amount effective to facilitate release of borate from said borate provider;
 - wherein mixing said first and second components forms cross-links within said compound at a controlled rate; and
 - wherein said compound is immediately applicable to a soil substrate.
9. The compound of claim 8, further comprising a retardant to manipulate said controlled rate.
10. The compound of claim 9 wherein said retardant is selected from the group comprising water, alcohols and glycols.
11. The compound of claim 8 wherein said alkaline is a hydroxide.
12. The compound of claim 11 wherein said hydroxide is selected from the group comprising sodium hydroxide, ammonium hydroxide and potassium hydroxide.
13. The compound of claim 8 wherein said polysaccharide is a starch.
14. The compound of claim 13 wherein said starch is modified.
15. The compound of claim 8, further comprising glycerine.

1/4

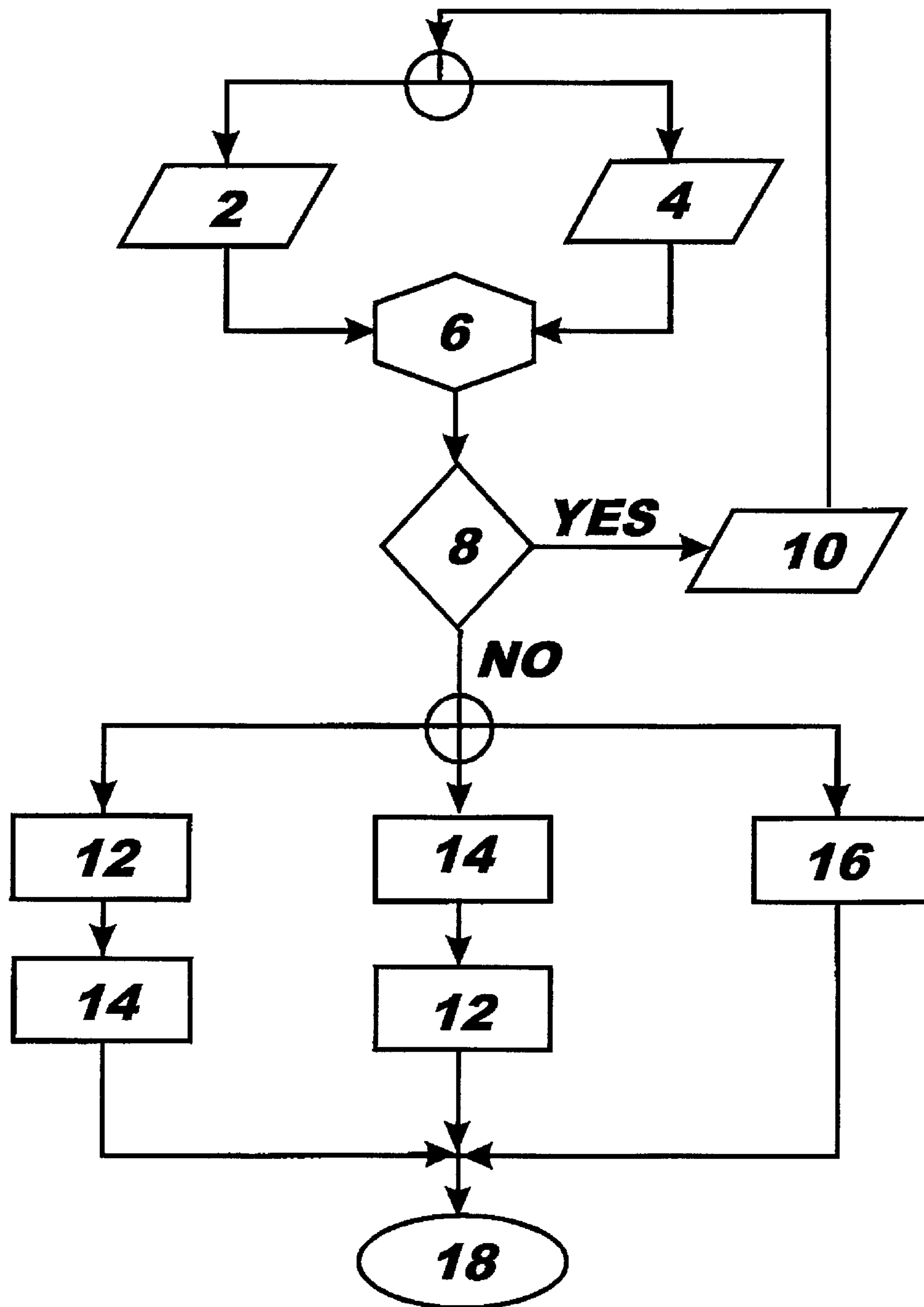


FIG. 1

2/4

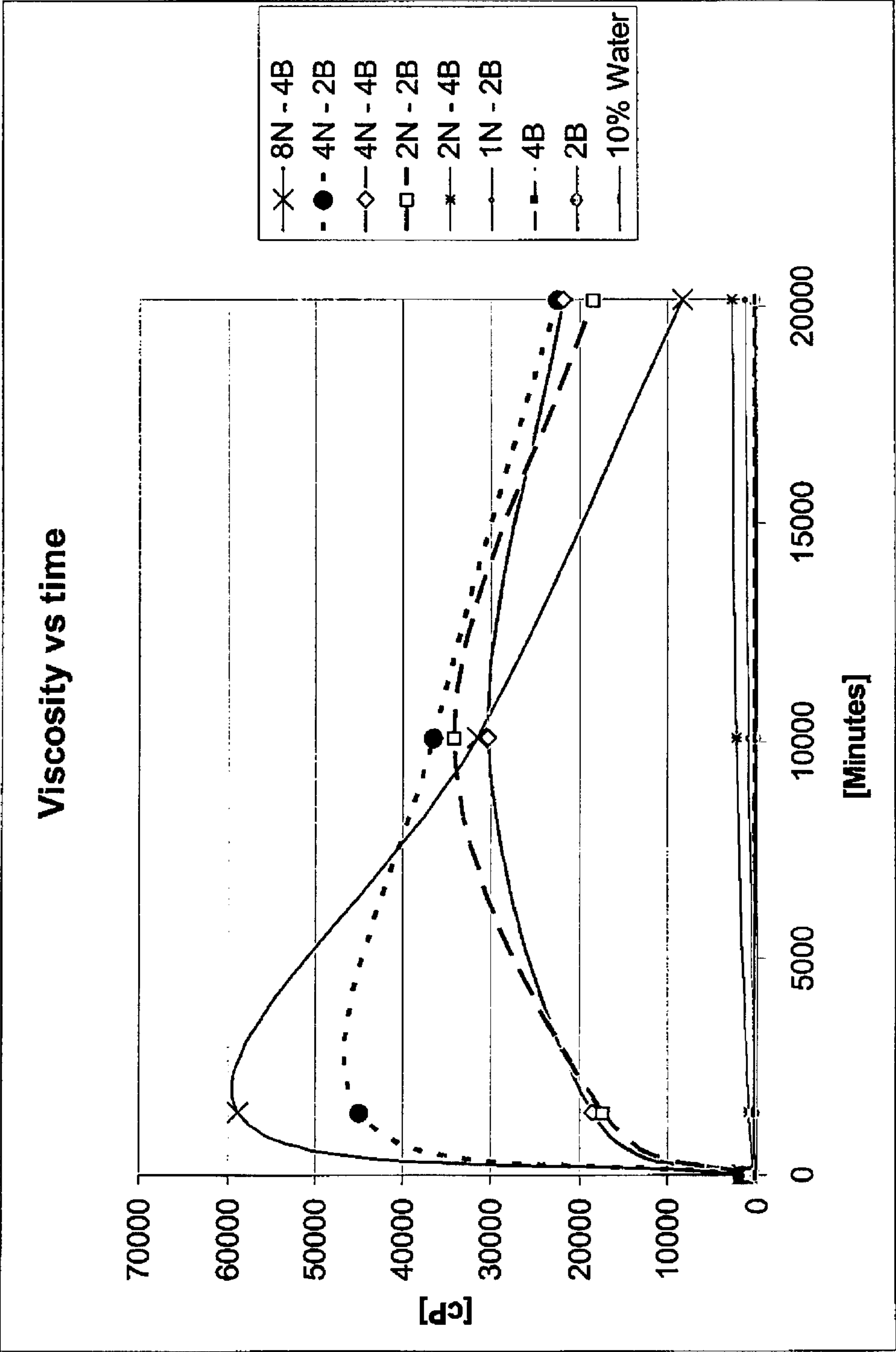


FIG. 2

3/4

Polysaccharide	Immediate Viscosity [cP]
3.8 % Hydrolyzed starch	47.7
0.95 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	14.8
1.9 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	20.5
2.4 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	38.3
2.9 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	84.3
3.8 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	2724
1.9 % Modified starch	12.2
2.9 % Modified starch	32.3
3.8 % Modified starch	2364
4.8 % Modified starch	2004

FIG. 3

4/4

Polysaccharide	Immediate Viscosity [cP]	Viscosity after 1 day [cP]
3.8 % Hydrolyzed starch	3528	2760
0.95 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	21.8	26.8
1.9 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	628.8	1046
2.4 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	6276	1128
2.9 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	36840	21780
3.8 % Amylopectin, hydrogen phosphate 2-hydroxypropyl ether	69600	80160
1.9 % Modified starch	324.6	N/A
2.9 % Modified starch	1656	59.7
3.8 % Modified starch	8580	N/A
4.8 % Modified starch	15360	3072
3.8 % Gelatine	9.2	N/A
0.9 % Guar Gum	Very high	N/A
0.5 % Xanthum gum	14340	N/A
3.8 % Cooking starch	67680	72000
3.8 % flour	481.5	405

FIG. 4

