

Bogotá, 5 de junio de 2024

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REF.: SOLICITANTES : YARA INTERNATIONAL ASA

TITULO : MÉTODO Y DISPOSITIVO PARA UNA
RECOMENDACIÓN DE FERTILIZANTE PARA
CAFÉ

No. de Solicitud : PCT/EP2022/081068
Internacional

**ENTRADA A FASE NACIONAL EN COLOMBIA CON LAS MODIFICACIONES QUE
SE LLEVARON A CABO EN FASE INTERNACIONAL BAJO ARTÍCULO 34
(CAPÍTULO II)**

HELENA CAMARGO WILLIAMSON, mayor de edad y vecina de Bogotá D.C., identificada como aparece al pie de mi firma, en mi condición de apoderada de la sociedad **YARA INTERNATIONAL ASA**, adjunto este memorial con el fin de brindar mayor claridad al Examinador a la hora de revisar los documentos radicados. Así, me permito señalar que la presente solicitud entrara a fase nacional en Colombia con las modificaciones que se llevaron a cabo en fase internacional presentadas en Capítulo II bajo le artículo 34.

Así las cosas, me permito adjuntar la traducción de la solicitud con modificaciones bajo artículo 34 (Capítulo II), el cual comprende las reivindicaciones modificadas, además, de la traducción de la descripción, reivindicaciones y resumen originalmente presentados en fase internacional. Y, por último, adjuntamos algunos de los documentos que se han presentado y emitido durante la fase internacional, tales como la publicación internacional, el reporte de búsqueda y opinión escrita, el reporte preliminar internacional de patentabilidad (IPRP), entre otros.

De acuerdo con todo lo anterior, amablemente solicitamos que proceda a llevar a cabo el trámite de la solicitud y el estudio de patentabilidad a las reivindicaciones radicadas y basadas en las modificaciones bajo el artículo 34 (capítulo II) de la solicitud internacional. Así las cosas, considero que la presente invención cumple con todos los requisitos formales de acuerdo con el numeral 5.2.5. del Título X de la Circular Única de la Superintendencia y la Decisión 486.

De la Señora directora,

POSSE HERRERA RUIZ



**HELENA CAMARGO WILLIAMSON
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MÉTODO Y DISPOSITIVO PARA UNA RECOMENDACIÓN DE FERTILIZANTE PARA CAFÉ

Campo técnico

La presente divulgación se refiere al campo de la agricultura y pretende proporcionar una recomendación de fertilizante específica para plantaciones de café.

Antecedentes

Los enfoques descritos en esta sección son enfoques que podrían abordarse, pero no son necesariamente enfoques que se han ideado o abordado previamente. Por lo tanto, a menos que se indique lo contrario, no se debe asumir que cualquiera de los enfoques descritos en esta sección califican como estado de la técnica meramente en virtud de su inclusión en esta sección.

La determinación de la cantidad adecuada de fertilizante que necesita un cultivo es una de las decisiones más importantes que tomará un agricultor. Un déficit en nitrógeno reducirá el rendimiento, mientras que un exceso producirá pérdidas económicas y daño al medio ambiente. Un déficit y/o desequilibrio de otros nutrientes llevará a pérdidas de rendimiento, defectos del cultivo y una calidad de cultivo reducida. Esto es más importante con cultivos de valor más alto, como el café. El género *Coffea* comprende más de 120 especies perenne. Los dos más conocidos son *Coffea arabica* (conocida como "Arabica") y *canephora* (conocida como "Robusta") y se cultivan en más de 70 países, principalmente en las regiones ecuatoriales de Centroamérica y Sudamérica, África y el sudeste de Asia, y sus semillas, denominadas granos de café, se utilizan para saborizar bebidas y productos alrededor del mundo. El café es uno de los cultivos comerciales más valiosos del mundo, pero la mayoría de las plantaciones de café son de pequeña escala con poco acceso a las tecnologías de agricultura modernas para mejorar su rendimiento.

Usualmente, la producción de café puede llevarse a cabo en sistemas agroforestales, en donde otras plantas y árboles se intercalan con las plantas de café para proporcionar sombra y otras ventajas en general tales como aumentar la biodiversidad local, la reducción de la erosión, la mejora en el almacenamiento de agua en los suelos y similares, y todas estas mejoran la ganancia del agricultor. Según la especie, el café se puede cultivar en regiones ubicadas en altitudes que varían del nivel del mar a 2000 m. Mientras que las temperaturas debajo de 7 °C y por encima de 33 °C reducen la producción y el tamaño del grano y la calidad del brebaje, las

temperaturas promedio óptimas están comprendidas entre 15-25 °C y sus necesidades de fertilizante se deberían ajustar convenientemente para estos y otros factores.

Los enfoques conocidos para la determinación de una recomendación de fertilizante se basan en un análisis químico detallado del suelo y de los tejidos de las plantas y mediciones específicas del rendimiento y tamaño de las plantas de café. Un ejemplo de tal enfoque se puede encontrar en BR102019002078 A2, en donde el método incluye diferentes etapas que comprenden la cosecha de la fruta y el procesamiento subsiguiente para un análisis químico. El documento US 9652840 B1 divulga un método y un sistema para gestionar el nitrógeno aplicado mediante un equipo de aplicación de nitrógeno que determina una etapa de crecimiento para la región geográfica mediante el uso de un módulo de cultivo.

Por lo tanto, es el objetivo de la presente solicitud lograr un método y dispositivo para determinar una recomendación de fertilizante de nutriente específico para plantas de café que apoye a los agricultores en su toma de decisiones. Formas de realización adicionales que comprenden un aparato agricultor para llevar a cabo la recomendación de fertilización se incluyen dentro del alcance de la presente solicitud.

SÍNTESIS DE LA INVENCIÓN

La presente divulgación pretende proporcionar una recomendación de fertilizante rápida y precisa para el cultivo de café que no requiere las largas etapas de proceso requeridas por un análisis químico de la planta y que considera diversos factores para el crecimiento de la planta y adsorción de nutrientes como la temperatura del aire promedio y las condiciones de sombra.

De acuerdo con un primer aspecto de la presente divulgación, este y otros objetivos se logran mediante un método implementado por computadora para determinar una recomendación de fertilizante para plantas de café, en donde el método comprende las etapas de determinar un campo agrícola en donde al menos se comprende una plantación de café, recibir datos de densidad de planta de la al menos una plantación de café, recibir datos de especies de plantas y datos de etapa de crecimiento de cultivo de la al menos una plantación de café, en donde los datos de etapa de crecimiento de cultivo definen una etapa de cultivo vegetativo o una etapa de cultivo productivo; en donde el método comprende además determinar una demanda básica y la demanda básica se basa en una demanda vegetativa si el cultivo está en una etapa vegetativa y la demanda básica se basa en la suma de una demanda vegetativa y una productiva si la plantación está en una etapa productiva, en donde la

demanda vegetativa se basa en los datos de densidad de planta y un factor de demanda vegetativa de nutriente específico basada en los datos de especie de planta.

Después de este enfoque, se logra una recomendación de fertilizante específica basada en las diferentes etapas de crecimiento de una planta.

De acuerdo con una forma de realización adicional, determinar la demanda productiva comprende recibir datos de rendimiento y determinar una demanda productiva basada en los datos de rendimiento y un factor de demanda productiva de nutriente específico basada en los datos de especies de plantas.

Después de este enfoque, la recomendación de fertilizante se adapta al rendimiento y la especie de planta del campo agrícola.

De acuerdo con una forma de realización adicional, el método comprende además ajustar la demanda vegetativa mediante un coeficiente de temperatura, en donde determinar el coeficiente de temperatura comprende recibir datos de altitud y/o una temperatura de aire promedio del campo agrícola y el coeficiente de temperatura se determina en función de la temperatura de aire promedio y/o la altitud.

Siguiendo este enfoque, la recomendación de fertilizante se adapta a la temperatura.

De acuerdo con una forma de realización adicional, el método comprende además recibir una temperatura de aire promedio del campo agrícola de los datos meteorológicos y ajustar la temperatura de aire promedio en función de la altitud del campo agrícola.

Siguiendo este enfoque, se logra una determinación más precisa de la compensación de temperatura.

De acuerdo con una forma de realización adicional, el método comprende además recibir una cantidad de tallos productivos de las plantas presentes en la plantación, y en donde la demanda vegetativa se ajusta adicionalmente en función de la cantidad de tallos productivos.

Siguiendo este enfoque, se logran las demandas específicas de las plantas en función de la cantidad de tallos productivos.

De acuerdo con una forma de realización adicional, la demanda básica se ajusta mediante un factor de eficacia de nutriente específico, en donde determinar un factor de eficacia de nutriente específico comprende recibir al menos uno de datos de producto de fertilizante, o datos meteorológicos, y datos de suelo del campo agrícola, y el factor de eficacia se determina en función del al menos uno de los datos de producto de fertilizante, los datos meteorológicos, o los datos de suelo.

Siguiendo este enfoque, se pueden considerar condiciones límite adicionales.

De acuerdo con una forma de realización adicional, el método comprende además determinar una condición de sombra del campo agrícola, y en donde la demanda básica se ajusta en función de la condición de sombra.

Siguiendo este enfoque, la recomendación de fertilizante se adapta a las condiciones de sombra del campo agrícola.

De acuerdo con una forma de realización adicional, el método comprende además determinar al menos una posición para que la determinación de sombra se lleve a cabo.

Siguiendo este enfoque, las condiciones de sombra del campo se determinan de forma más precisa.

De acuerdo con una forma de realización adicional, el método comprende además recibir datos de suelo del campo agrícola, y en donde la demanda de nutriente total se ajusta en función de un factor de disponibilidad de nutriente de suelo.

Siguiendo este enfoque, la recomendación de fertilizante se adapta a los nutrientes existentes del campo.

De acuerdo con una forma de realización adicional, se prevé un dispositivo para determinar una demanda de fertilizante para plantas de café, configuradas para llevar a cabo un método de acuerdo con cualquiera de las formas de realización anteriores para permitir que el usuario lleve a cabo los métodos mencionados anteriormente.

De acuerdo con una forma de realización adicional, el dispositivo comprende medios de entrada y salida y una interfaz de usuario gráfica dedicada, en donde la condición de sombra se determina de acuerdo con una imagen gradualmente ajustable que muestra diferentes imágenes de condición de sombra predefinida basada en la entrada de usuario.

Siguiendo este enfoque, el usuario puede obtener una determinación confiable de la condición de sombra.

De acuerdo con una forma de realización, el dispositivo puede determinar al menos una posición y visualizar la al menos una posición mediante una unidad de visualización para que el usuario lleve a cabo la determinación de sombra.

De acuerdo con una forma de realización adicional, la al menos una posición determinada por el dispositivo para proporcionar una determinación de sombra confiable se puede determinar en función del campo agrícola.

De acuerdo con una forma de realización adicional, la al menos una posición se

determina adicionalmente en función de la posición relativa y la orientación del campo agrícola.

Siguiendo estos enfoques, se logra una determinación más confiable de la condición de sombra y se reduce la cantidad de posiciones a muestrearse.

De acuerdo con una forma de realización adicional, el dispositivo comprende una unidad de localización para determinar datos posicionales del dispositivo, y la elevación del campo agrícola se determina en función de los datos posicionales del dispositivo.

Siguiendo este enfoque, se proporciona al usuario una determinación confiable de la altitud del campo agrícola.

De acuerdo con una forma de realización adicional, el dispositivo se configura adicionalmente para recibir datos meteorológicos, y en función de los datos posicionales y la elevación, determinar una temperatura de aire promedio del campo agrícola.

Siguiendo este enfoque, se logra un ajuste de temperatura confiable para la recomendación de fertilizante.

De acuerdo con formas de realización adicionales, se prevén un aparato de procesamiento de datos, un medio de almacenamiento legible por computadora y un producto de programa informático configurado para llevar a cabo los métodos divulgados anteriormente dentro de la presente divulgación.

BREVE DESCRIPCIÓN DE LAS FIGURAS

Los dibujos adjuntos, que se incluyen para proporcionar un entendimiento adicional de la presente divulgación se incorporan en la memoria descriptiva y constituyen una parte de esta, ilustran formas de realización de la divulgación y, junto con la descripción, sirven para explicar los principios de la divulgación.

La Figura 1 muestra un ejemplo de una plantación de café con algunas de las características consideradas importantes para la presente divulgación.

La Figura 2 describe un dispositivo de acuerdo con una de las formas de realización principales de la presente divulgación.

La Figura 3 muestra una forma de realización de la interfaz de usuario gráfica que muestra una imagen para determinar el factor de sombra.

La Figura 4 muestra otra forma de realización de la interfaz de usuario gráfica, en donde se muestra una pluralidad de posiciones para determinar el factor de sombra.

La Figura 5 muestra un diagrama de flujo de un método de acuerdo con una

forma de realización de la presente divulgación.

Los dibujos adjuntos se utilizan para ayudar a entender fácilmente la idea técnica de la presente divulgación, y se debe entender que la idea de la presente divulgación no está limitada por los dibujos adjuntos. Se debe interpretar que la idea de la presente divulgación se extiende a cualquier alteración, equivalente y sustituyente además de los dibujos adjuntos.

DESCRIPCIÓN DETALLADA

Los términos "que comprende", "comprende" y "compuesto de" como se utilizan en la presente son sinónimos de "que incluye", "incluye", o "que contiene", "contiene", y son inclusivos o ilimitados y no excluyen miembros adicionales no mencionados, elementos o etapas de métodos. Se apreciará que los términos "que comprende", "comprende", y "compuesto de" como se utilizan en la presente comprenden los términos de "que consiste en", "consiste" y "consiste en".

La recitación de rangos numéricos por valores límite incluyen todos los números y fracciones incluidas dentro de los rangos respectivos, como también los valores límite recitados.

El término "alrededor de" o "aproximadamente" como se utiliza en la presente, cuando se refiere a un valor medible tal como un parámetro, una cantidad, una duración temporal, y similares, pretende abarcar variaciones de $\pm 10\%$ o menos, específicamente $\pm 5\%$ o menos, más específicamente $\pm 1\%$ o menos, y aún más específicamente $\pm 0,1\%$ o menos de y desde el valor especificado, en tanto que tales variaciones sean adecuadas para llevar a cabo en la solicitud divulgada. Se debe entender que el valor al que el modificador "alrededor de" o "aproximadamente" se refiere, también se divulga específicamente.

Mientras que los términos "uno o más" o "al menos uno", tal como uno o más o al menos un miembro de un grupo o miembros, son claros por sí mismos, mediante ejemplificación adicional, el término abarca, entre otras cosas, una referencia a cualquiera de dichos miembros, o a cualquiera de dos o más de dichos miembros, tales como, por ejemplo, cualquiera ≥ 3 , ≥ 4 , ≥ 5 , ≥ 6 o ≥ 7 etc. de dichos miembros, y hasta todos dichos miembros.

A menos que se definan de otro modo, todos los términos utilizados para divulgar la solicitud, que incluyen los términos técnicos y científicos, tienen el significado que entiende normalmente una persona del oficio de nivel medio a quien pertenece esta solicitud. Mediante orientación adicional, las definiciones terminológicas se incluyen para apreciar de mejor manera la enseñanza de la presente

solicitud.

En los siguientes pasajes, se definen diferentes aspectos de la solicitud con más detalle. Cada aspecto así definido se puede combinar con cualquier otro aspecto o aspectos a menos que se indique claramente lo contrario. En particular, cualquier característica que se indica como preferida o ventajosa se puede combinar con cualquier otra característica o características que se indican como preferidas o ventajosas.

La referencia a lo largo de esta memoria descriptiva a "una forma de realización" significa que una característica, estructura o rasgo particular descrito en relación con la forma de realización se incluye en al menos una forma de realización de la presente solicitud. Por lo tanto, no todas las apariciones de las frases "en una forma de realización" en diversos lugares a lo largo de esta memoria descriptiva se refieren necesariamente a la misma forma de realización, pero pueden. Además, las características o estructuras particulares se pueden combinar de cualquier forma adecuada, como sería evidente para una persona del oficio de nivel medio a partir de esta divulgación, en una o más formas de realización. Por otro lado, mientras que algunas formas de realización descritas en la presente incluyen algunas, pero no otras características incluidas en otras formas de realización, las combinaciones o características de diferentes formas de realización pretenden estar dentro del alcance de la solicitud, y formar diferentes formas de realización, como entenderían las personas del oficio de nivel medio. Por ejemplo, en las reivindicaciones adjuntas, cualquiera de las formas de realización reivindicadas se puede utilizar en cualquier combinación.

En la presente descripción de la solicitud, los numerales de referencia entre paréntesis o en negrita fijados a elementos respectivos meramente ejemplifican los elementos a modo de ejemplo, con lo que no se pretende limitar los elementos respectivos. Se debe entender que se pueden utilizar otras formas de realización y que se pueden hacer modificaciones estructurales o lógicas sin apartarse del alcance de la presente solicitud. La siguiente descripción detallada, por lo tanto, no se debe interpretar en un sentido limitativo, y el alcance de la presente solicitud se define mediante las reivindicaciones adjuntas.

La terminología utilizada en la presente tiene como propósito describir formas de realización de ejemplo particulares solamente, y no pretende ser limitativa. Como se usa en la presente, se puede pretender que las formas singulares "un", "una" y "el" y "la" incluyan las formas plurales también, a menos que el contexto indique

claramente lo contrario.

El uso de la expresión "al menos" o "al menos uno" sugiere el uso de uno o más elementos, ya que el uso puede ser en una de las formas de realización para lograr uno o más objetos o resultados deseados.

La Figura 1 muestra una representación esquemática de las plantaciones de café en sistemas agroforestales, en donde un campo agrícola 10 se muestra con las formas de copas de árboles usuales 30 que crean una región de sombra resultante 20 para fines de ilustración. Usualmente, los agricultores determinarían sus prácticas en función de experiencias previas sin la consideración de factores externos. Además, los productos de fertilizantes usuales presentan una relación fijada de macronutrientes y micronutrientes que hace difícil un ajuste fino adecuado de acuerdo con la dosis óptima de nutrientes. La ley del mínimo, desarrollada por Justus von Liebig y basada en el trabajo del botánico Carl Sprengel, establece que el crecimiento de las plantas se relaciona con el nutriente más limitativo. Entre los nutrientes más importantes para los propósitos agrícolas, nitrógeno (N), fósforo (P), potasio (K), magnesio (Mg), calcio (Ca), y azufre (S) son parte de los macronutrientes necesarios para el desarrollo de planta. Otros elementos como sodio (Na), hierro (Fe), manganeso (Mn), boro (B), cobre (Cu), molibdeno (Mo), y Zinc (Zn) se consideran micronutrientes debido a su baja concentración usual presente en los tejidos de plantas. Como tal, la falta de dosis o la dosis incorrecta de cualquiera de los nutrientes mencionados anteriormente tiene una influencia perjudicial hacia el desarrollo de cultivos y su rendimiento de producción.

Diversos factores influyen en la recomendación correcta de nutrientes para una fertilización correcta. Por ejemplo, el suelo, la disponibilidad del agua, el clima, y otros parámetros tienen una influencia directa en el consumo de nutrientes. En el caso del café, algunos factores específicos relacionados con la planta de café, y los parámetros ambientales derivados de las condiciones límite presentes en el sistema de producción se pueden considerar de especial importancia. Por ejemplo, se ha descubierto que la cantidad de tallos productivos tienen una relación lineal directa para la demanda de fertilizante vegetativo de plantas de café; las condiciones de temperatura tienen una relación directa a la demanda vegetativa, mientras que las condiciones de sombra tienen una influencia directa en la cantidad total de nutrientes necesarios. Mientras que la demanda de nutriente específico puede ser diferente con respecto a los nutrientes individuales, gracias al enfoque de nutrientes específicos de la presente divulgación, se puede lograr una recomendación de nutrientes balanceada y optimizada. Dentro de

la presente divulgación, un ajuste o corrección de nutrientes específicos se refiere a las variaciones de la recomendación de fertilizante que se lleva a cabo por nutrientes diferentes, es decir, las correcciones o ajustes son diferentes para cada nutriente específico.

La Figura 2 muestra un ejemplo de un dispositivo 100 de acuerdo con la presente divulgación. El dispositivo 100 puede comprender diversos componentes tales como una unidad de memoria 110, un procesador 120, una unidad de comunicación cableada/inalámbrica 130, una unidad de localización 180 (que incluye GPS y un medio de orientación como una brújula), y una unidad de entrada/salida 140 que se describirá adicionalmente a continuación.

El método de la presente divulgación comprende recibir datos relacionados con el campo agrícola donde se ubica la plantación de café. Para la forma de realización principal de la presente divulgación, recibir datos de la plantación comprende recibir al menos los datos de densidad de planta, especie de planta, datos de estado de crecimiento, y datos de rendimiento de la temporada anterior o esperados.

Se prevén diferentes formas de realización para la provisión del campo y datos de cultivo. En una forma de realización, los agricultores pueden proporcionar los datos mediante una interfaz dedicada. Sin embargo, el método implementado por computadora de la presente divulgación puede comprender además recibir datos de campo y cultivo de un servidor situado remotamente o de unidades de memoria accesibles localmente.

El dispositivo 100 puede comprender un motor de recomendación agrícola 220 al que el sistema puede estar conectado remotamente mediante una unidad de comunicación 130, y puede ser de una naturaleza remota. En este caso, el motor de recomendación agrícola 220 puede estar representado por una computadora, un servidor accesible remotamente, otras arquitecturas de servidor de cliente o cualquier otro dispositivo electrónico usualmente abarcado en el aparato de procesamiento de datos terminológicos. El dispositivo 100 puede estar representado también por una computadora portátil o un dispositivo portátil, con un motor de recomendación agrícola integrado 150 que se puede operar completamente en la ubicación de la finca y puede comprender una unidad GPS o cualquier otro medio de localización adecuado 180.

Debe entenderse que la presencia de motores de recomendación remotos e integrados no se excluyen mutuamente. El motor de recomendación agrícola integrado 150 puede ser una copia local de motor de recomendación agrícola 220 o una versión más liviana de este para respaldar períodos de baja conectividad de red y trabajo fuera

de línea. El dispositivo 100 y el motor de recomendación agrícola o integrado puede comprender datos de la finca y el campo y datos externos y/o estar configurado para recibir dichos datos, por los cuales los datos externos comprenden datos meteorológicos, datos de imágenes de satélites y datos adicionales proporcionados por proveedores de pronóstico del tiempo y otros terceros. Los datos de campo pueden comprender, entre otros, datos actuales y previos de al menos uno de los siguientes: identificadores geográficos y de campo con respecto a la geometría de los límites del campo agrícola, que incluyen la presencia de áreas dentro del campo agrícola que no se gestionan, datos topográficos, identificadores de cultivos (variedad y tipo de cultivo, etapa de crecimiento de cultivo, datos y fecha de plantaciones, nutrición de plantas y estado de salud) de cultivos actuales o previos, datos de cosecha (rendimiento, valor, calidad de producto, valores estimados o históricos registrados), datos de suelo (disponibilidad de nutrientes, tipo de suelo, pH, materia orgánica de suelo (SOM) y/o capacidad de intercambio de catión, CEC). Los datos de la finca pueden comprender datos adicionales con respecto a tareas planeadas y previas como prácticas de mantenimiento de campo y prácticas agrícolas, datos de aplicación de fertilizantes, datos de aplicación de pesticida, datos de irrigación y otros informes de campo como también series históricas de los datos, que permiten la comparación de los datos con datos previos, y el procesamiento de datos administrativos adicionales como turnos de trabajo, registros, y otros datos de organización. Las tareas planeadas y previas pueden comprender actividades adicionales como la supervisión de las plantas y plagas, aplicación de pesticidas, funguicidas o productos de nutrición de cultivos, mediciones de al menos un parámetro de la finca o el campo, mantenimiento y reparación de equipamiento de suelo y otras actividades similares.

El dispositivo 100 puede estar configurado para recibir y/o retirar datos de suelo de bases de datos de suelo en línea disponibles como SoilGrids de la Información mundial de suelo, SURGO (Base de datos geográfica de estudios de suelo del departamento de agricultura de los Estados Unidos) o cualquier registro de datos de suelo similares, como también mediante una entrada de usuario. Los datos de suelo se pueden utilizar directamente en la recomendación de fertilización si un contenido de nutriente está disponible en los registros de datos accedidos, pero también se puede usar para adaptar la recomendación y/o planear la aplicación del fertilizante en función de otros datos de suelo (por ejemplo, se puede tener en cuenta la textura y/o humedad del suelo cuando se determina una aplicación de fertilizante de variable y/o la cantidad

óptima de aplicación y las cantidades respectivas).

El dispositivo 100 puede estar configurado adicionalmente para recibir cualquiera de los datos mencionados anteriormente y datos de campo adicionales de una cantidad predeterminada de ubicaciones dentro o cerca de la región analizada, introducidos manualmente por los agricultores mediante la unidad de entrada/salida 140 o recibida por la unidad de comunicación 130 de sensores dedicados 270. Además, el dispositivo 100 y el motor de recomendación agrícola 150 o 220 puede estar configurado para recibir datos meteorológicos de estaciones meteorológicas cercanas 260 y/o sensores de finca/cultivos externos o dispositivos de detección 270, como también mediante la unidad de entrada/salida 140. Las estaciones meteorológicas cercanas 260 y/o sensores de finca/cultivos externos 270 están configurados para comunicarse a través de una o más redes. En otra forma de realización, los datos meteorológicos se proporcionan por compañías de pronóstico de tiempo externas. Los datos meteorológicos pueden incluir además series de datos actuales y previos de la al menos una de las siguientes: temperaturas (por ejemplo, promedio, mínima y máxima), precipitación acumulada, humedad relativa, velocidad de viento, radiación solar, horas de sol acumuladas, como también pronósticos, etc.

El dispositivo 100 puede estar conectado operativamente a un aparato agrícola 300. Los ejemplos del aparato agrícola 300 incluyen tractores, cosechadoras, recolectoras, plantadoras, camiones, equipo de fertilizante, y cualquier otro ítem de maquinaria física o equipamiento, generalmente maquinaria móvil, y que se puede utilizar en tareas asociadas con la agricultura. En una forma de realización, el dispositivo 100 puede estar configurado para comunicarse con el aparato agrícola 300 mediante redes inalámbricas para establecer una prescripción de solicitud de tasa variable para el cultivo determinado, o alternativamente, para determinar la región de medición como una destinación indicada. El dispositivo 100 puede estar configurado además para producir un archivo de comandos legible por máquina para el aparato agrícola para llevar a cabo la aplicación de fertilizante.

El método de acuerdo con la presente solicitud comprende, por lo tanto, determinar una recomendación de fertilizante o demanda para plantas de café en función de los datos recibidos. En una forma de realización principal, recibir datos 3000 puede comprender recibir datos de especies de plantas y de densidad de planta de la al menos una plantación de café presente en el campo agrícola junto con datos de etapa de crecimiento de cultivo, en donde los datos de etapa de crecimiento de cultivo 3100 definen una etapa de cultivo vegetativo o una etapa de cultivo productivo,

en donde el método comprende determinar una demanda básica para la plantación y la demanda básica se basa en una demanda vegetativa si el cultivo está en una etapa vegetativa 3200 y la demanda básica se basa en la suma de una demanda vegetativa y una demanda productiva si el cultivo está en una etapa de crecimiento productivo 3300, en donde la demanda vegetativa se basa en la densidad de planta y un factor de demanda vegetativa de nutriente específico en función de los datos de especie de planta. El método de acuerdo con la presente solicitud puede comprender además una etapa de ajuste 3400 de la recomendación de fertilizante y/o determinar 3500 la solicitud de la recomendación del fertilizante.

En una forma de realización adicional, el método puede comprender recibir datos de rendimiento y determinar la demanda productiva en función de los datos de rendimiento y un factor de demanda productiva de nutriente específico.

En una forma de realización adicional, el método puede comprender además ajustar la demanda vegetativa mediante un coeficiente de temperatura, en donde determinar el coeficiente de temperatura comprende recibir datos de altitud o una temperatura de aire promedio del campo agrícola y en donde el coeficiente de temperatura se determina en función de la temperatura de aire promedio o la altitud. Con elevación, las temperaturas usuales y la densidad del aire cambian la dinámica de la adquisición de nutrientes y el desarrollo del cultivo y tal ajuste mejora la recomendación de fertilizante.

En una forma de realización adicional, el método comprende además recibir una temperatura de aire promedio del campo agrícola de los datos meteorológicos y ajustar la temperatura de aire promedio en función de la altitud del campo agrícola. Debido al cultivo usual del café en las regiones de colinas y montañas, la demanda de fertilizante se puede ajustar de forma conveniente en la altitud del campo agrícola y los datos meteorológicos. En este caso, los datos meteorológicos locales se pueden perfeccionar precisamente debido a las variaciones de temperatura con la altitud.

En una forma de realización adicional, el método comprende además recibir una cantidad de tallos productivos de las plantas presentes en la plantación en el campo agrícola y la demanda vegetativa se ajusta adicionalmente en función de la cantidad de tallos productivos.

En una forma de realización adicional, la demanda básica se ajusta mediante un factor de eficacia de nutriente específico, en donde determinar un factor de eficacia puede comprender además recibir al menos uno de datos de producto de fertilizante, o datos meteorológicos, o datos de suelo del campo agrícola, y el factor de eficacia se

determina en función del al menos uno de los datos de producto de fertilizante, los datos meteorológicos, o los datos de suelo. La eficacia del fertilizante viene determinada por varios factores: en función los datos del producto fertilizante, puede tenerse en cuenta la volatilidad de los compuestos que forman el fertilizante. Los factores influyentes adicionales como la humedad del suelo y los datos meteorológicos se pueden incluir en la determinación por sí mismos o en combinación con los datos de producto. Por ejemplo, la precipitación influye en la cantidad de parasitismo al que el nitrógeno en el suelo se puede someter. Se debe resaltar especialmente que el parasitismo es un proceso químico específico del nitrógeno y, por lo tanto, solo se relaciona con el factor de eficacia de nitrógeno. Además, el parasitismo puede ocurrir a diferentes tasas, según el tipo y textura del suelo. Por ejemplo, los suelos arenosos tienen menos retención de agua y aumentan el parasitismo. Por lo tanto, el factor de eficacia puede ajustarse aún más en función de los datos del suelo.

En una forma de realización adicional, el método comprende además determinar una condición de sombra y la demanda básica se ajusta adicionalmente en función de la condición de sombra, como se aclarará a continuación.

Como se evidenciará a partir de las ecuaciones siguientes, una condición de sombra puede representarse por cualquier factor o coeficiente que tenga en cuenta la cantidad de sombra por zona de cultivo de al menos un área del campo agrícola. Por lo tanto, en las ecuaciones se incluye un factor dependiente de la sombra o un coeficiente dependiente de la sombra que ajusta los valores de los requisitos de fertilizante y se determina en función de la condición de sombra, en donde el factor dependiente de la sombra o el coeficiente dependiente de la sombra puede ser un factor de escala de valor apropiado como se define a continuación. A modo de ilustración, en una de las formas de realización, el factor dependiente de la sombra se ha definido como un valor entre 0 y 1 en función del porcentaje de la condición de sombra.

Cabe señalar que los términos "factor dependiente de la sombra" utilizados en la presente pueden denominarse "factor de sombra". De manera similar, los términos "coeficiente dependiente de la sombra" pueden denominarse "coeficiente de sombra".

En una forma de realización adicional, el método comprende además recibir datos de suelo y la demanda de nutriente total además se ajusta en función de un factor de disponibilidad de nutriente de suelo. Debido a las prácticas de manejo agrícola pasadas y a la naturaleza de los suelos, existe una alta variabilidad en la disponibilidad de nutrientes ya existentes. Los agricultores pueden tener a su

disposición datos de análisis de suelo previos en laboratorio o datos de sensores de suelo específicos, así como datos de campo ya almacenados. A partir de los datos de disponibilidad de nutrientes se determina un factor de disponibilidad de nutrientes del suelo que toma en consideración dicha variabilidad.

Como tal, una expresión matemática que comprende todas las formas de realización descritas de la presente divulgación para una plantación de café en etapa de cultivo productivo se puede representar de la siguiente manera:

$$F_T = \frac{C_{Shade} * C_{Soil}}{C_{EF}} * [F_{BASIC}];$$

en donde F_{BASIC} se determina de acuerdo con los datos de la etapa de crecimiento del cultivo. Cuando el cultivo se encuentra en etapa de cultivo vegetativo, $F_{BASIC} = F_{VEG}$, mientras que cuando el cultivo se encuentra en etapa productiva, la demanda básica se define como $F_{BASIC} = F_{VEG} + F_{PROD}$, y por el cual, la demanda vegetativa y productiva se definen de la siguiente manera.

$$F_{VEG} = C_{VEG} * D * C_T * n$$

$$F_{PROD} = C_{PROD} * Y$$

en donde:

- F_T , F_{VEG} , F_{PROD} son la demanda de nutrientes (kg/ha);
- C_{Shade} es un coeficiente dependiente de la sombra;
- C_{EF} es un factor de eficacia específico de un nutriente;
- C_{VEG} es el factor de demanda vegetativa específico de nutrientes (kg/planta/año);
- D es la densidad de plantas en la finca (plantas/ha);
- C_T es un coeficiente dependiente de la temperatura que ajusta la velocidad de crecimiento potencial vegetativo;
- n es el número de tallos productivos presentes por planta en la plantación;
- C_{PROD} es el factor de demanda productiva específico de un nutriente, en función de datos específicos de variedades y/o especies;
- Y es un valor de rendimiento esperado para la temporada actual (kg/ha);
- C_{Soil} es un factor de corrección específico de nutrientes en función de la disponibilidad de nutrientes en el suelo;

La ecuación mostrada anteriormente puede expresarse de forma escalar para cada nutriente independiente o matricialmente mediante un vector que comprende el al menos uno de los diferentes nutrientes de importancia en la fertilización del café. Por ejemplo, en un ejemplo no limitativo, los factores y demandas específicos de nutrientes

pueden comprender filas para al menos uno de los siguientes nutrientes: N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu o componentes equivalentes que actúan como portadores de nutrientes como P_2O_5 , K_2O , CaO , MgO .

C_{Shade} representa un factor dependiente de la sombra o un coeficiente dependiente de la sombra que se puede agregar para tener en cuenta el efecto de las condiciones del sol en el cultivo, en donde el factor toma el valor 0 cuando la cobertura de sombra del cultivo es $>60\%$, es 1 si la cobertura de sombra es $<20\%$ y toma valores intermedios. En una forma de realización adicional, el factor dependiente de la sombra se puede determinar preferentemente entre dicho 20% y 60% mediante una ecuación con un término cuadrático negativo y un término lineal positivo en función del porcentaje de sombra al interpolar los valores límite de 0 y 1 en 20 y 60 %.

F_{VEG} y F_{PROD} son coeficientes específicos de nutrientes dependientes de las especies de plantas que dan cuenta de la demanda vegetativa y productiva, que pueden definirse de la siguiente manera para la demanda vegetativa (kilogramos de nutriente/planta/año):

Nutriente	Factor de demanda
	kg/planta/año
	Robusta
N	0,01
P	0,0027
K	0,018
Ca	0,01
Mg	0,0018
S	0,00018
Fe	0,00001
Mn	0,00036
B	0,0000018
Zn	5,4E-06
Cu	7,2E-06

y correspondientemente para la demanda productiva.

C_{EF} es un factor de eficacia específico de un nutriente que puede agregarse

para tener en cuenta la eficacia de absorción de cada uno de los nutrientes (N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu) o componentes equivalentes presentes en el fertilizante en función de al menos uno de los datos del producto fertilizante, datos del suelo y/o datos meteorológicos. Por ejemplo, en función de los datos conocidos del producto, la eficacia de absorción de nitrógeno puede ajustarse únicamente según el tipo de producto (por ejemplo, según el componente activo, como urea o información de identificación del producto, o tipo de recubrimiento) o combinarse ventajosamente con datos climáticos (por ejemplo, el nitrógeno es muy susceptible a la lixiviación y, por lo tanto, datos de precipitación importantes para determinar la eficacia de absorción). Por lo tanto, siguiendo la representación anterior, el factor de eficacia específica de nutrientes se puede representar de la siguiente manera para un producto y condiciones climáticas y de suelo dados, en donde los factores de eficacia específicos de nutrientes están comprendidos entre 0 y 1.

Nutriente	Factor de eficacia
N	0,75
P	0,3
K	0,75
Ca	0,6
Mg	0,75
S	0.9
Fe	0.9
Mn	0,6
B	0,6
Zn	0.9
Cu	0.9

C_{Soil} es un factor de corrección específico de nutriente en función de la disponibilidad en el suelo del nutriente que se puede agregar, en donde los datos del suelo del análisis del suelo pueden ser ingresados por los agricultores o proporcionados por sensores del suelo o datos de campo adecuados, como se mencionó anteriormente. En función de la disponibilidad respectiva de cada nutriente específico se puede generar un factor de corrección para cada nutriente, en donde el factor puede estar en particular entre 0,3 y 1,15. El factor puede ajustarse correspondiente e individualmente en función de la respectiva disponibilidad de nutrientes y está configurado para tener en cuenta la presencia de nutrientes

específicos en el suelo.

C_T es un coeficiente dependiente de la temperatura que podría agregarse para determinar la velocidad de crecimiento potencial vegetativo, en donde el coeficiente puede limitarse en particular al rango comprendido entre 0,0952 y 2,3 para los rangos de temperatura entre 14 y 30 °C y puede ajustarse para diferentes especies.

D , Y , n son otros números que se pueden sumar para adaptar la fertilización en función de la densidad de plantas, el rendimiento planificado o esperado y el número de tallos productivos. Los agricultores suelen podar activamente las plantas de café durante el crecimiento y a lo largo de los años para rejuvenecerlas, ya que los viejos tallos productivos se pudren durante la producción. De esta manera, los agricultores conocen el promedio de tallos productivos presentes en su finca y pueden designarlo como un factor diferenciador. Además, los agricultores conocen los datos de densidad de la plantación en el momento de la siembra. Algunos de estos factores se pueden determinar automáticamente en función de datos de imágenes y/o datos de imágenes remotas. Por ejemplo, en función de la ubicación conocida del campo agrícola, se pueden analizar datos de imágenes remotas para determinar la densidad de plantas dentro del campo agrícola. Además, se puede procesar una imagen de las plantas para determinar el número de tallos productivos por planta.

F_{BASIC} es la demanda específica de nutrientes básicos para un cultivo en etapa de cultivo productivo, que es la suma de la demanda de nutrientes vegetativos y productivos y puede tener en cuenta al menos una de las influencias de la temperatura, el rendimiento esperado/planificado, la densidad de plantas en el campo agrícola y número de tallos productivos.

Una vez que se ha determinado la demanda total de fertilizante, el método de la presente divulgación se puede configurar en una forma de realización adicional para determinar el número deseado de aplicaciones y la fecha de aplicación. Habitualmente, dependiendo de la etapa de crecimiento del cultivo y otros factores determinantes como la temperatura media del aire y la especie de planta, la cantidad de aplicaciones puede variar entre 1 y 4. Por ejemplo, en las regiones del sur de Colombia, los ciclos de cultivo son entre septiembre y junio del año siguiente, mientras que, en México, los ciclos de cultivo habituales ocurren entre abril y febrero del año siguiente. El método de la divulgación actual puede configurarse además para determinar la cantidad de aplicaciones en función de los aportes del agricultor y, según las fases del cultivo, dividir la demanda total de fertilizante entre las diferentes fechas determinadas de aplicación de fertilizante.

De acuerdo con la presente divulgación, se prevé un dispositivo configurado para llevar a cabo el método de la presente solicitud. En los siguientes pasajes, se describen diferentes formas de realización de dispositivos electrónicos, interfaces de usuario para dichos dispositivos y procesos asociados para usar dichos dispositivos. En algunas formas de realización, el dispositivo es un dispositivo de comunicaciones portátil, como un teléfono móvil, que también contiene otras funciones, lo que permite al usuario llevar a cabo el método de la divulgación actual en el sitio. También debe entenderse que, en algunas formas de realización, el dispositivo no es un dispositivo de comunicaciones portátil, sino que también puede ser una computadora de escritorio o portátil.

En una forma de realización, el dispositivo electrónico puede ser un dispositivo móvil o de escritorio con una interfaz gráfica de usuario (GUI) dedicada para apoyar y guiar al usuario en la determinación de los factores a introducir para la recomendación de fertilizante. En esta forma de realización, el dispositivo electrónico puede comprender medios de entrada (por ejemplo, un teclado) y de salida (por ejemplo, una pantalla) como se conocen generalmente, que también podrían combinarse en forma de una pantalla táctil sensible al tacto y el teclado tomar la forma de un teclado virtual. Sin embargo, otros medios de entrada como un ratón no están excluidos de la presente.

La interfaz gráfica de usuario se puede configurar para mostrar y recibir entradas del usuario de los diferentes tipos de datos y determinar entradas adicionales como la etapa del cultivo, fase vegetativa o productiva, el número deseado de aplicaciones, datos de rendimiento esperado u otros datos relacionados con el rendimiento de cultivos anteriores y otras señales que mejoran la recomendación de fertilizante como se explicó anteriormente.

Para empezar, se le puede permitir al usuario determinar un campo agrícola que contenga la plantación de café a partir de una pluralidad de sus campos gestionados. Esto se puede lograr mediante la entrada del usuario en una interfaz de mapa o en función de la ubicación del dispositivo, en donde el dispositivo puede determinar además la extensión del campo agrícola en función de datos de imágenes remotas mediante algoritmos de detección de límites. El dispositivo puede configurarse además para recibir entradas del usuario que comprenden datos de campo del campo agrícola.

El dispositivo puede configurarse en etapas adicionales para recibir información sobre la etapa de desarrollo del cultivo, la especie de café y variedad de plantas

presentes en el campo agrícola o para recibirla automáticamente a partir de datos de campo almacenados previamente en el dispositivo.

El dispositivo se puede configurar además en una etapa adicional para determinar el número de aplicaciones de fertilizante. En función de la etapa del cultivo, su ubicación y otros factores determinantes, es habitual espaciar en el tiempo la cantidad de fertilizante en varias aplicaciones.

En una forma de realización adicional, el dispositivo puede configurarse para recibir los datos de rendimiento esperados o pasados. El dispositivo puede configurarse para proporcionar una variedad de datos de rendimiento permitidos en función de los datos del campo (por ejemplo, el tamaño de la finca) para guiar a los agricultores y proporcionar información sobre los potenciales de rendimiento bajo, promedio y alto para el campo agrícola determinado. Esto es de mayor ayuda para que los agricultores evalúen la productividad de su plantación, además de proporcionar límites a los valores, de modo que mejora la solidez de los datos introducidos.

En una forma de realización adicional, el dispositivo podrá configurarse para recibir el número de tallos productivos presentes en las plantas de café del campo agrícola. Generalmente, el agricultor decide cuántos tallos productivos deben tener las plantas mediante una poda adecuada. Luego, el agricultor puede introducir un número fijo de tallos productivos por planta para todo el campo agrícola o para diferentes subáreas del campo agrícola.

En una forma de realización adicional, recibir el número de tallos productivos puede comprender además obtener los datos a partir de datos de imágenes de una planta adquiridas por los agricultores en el campo agrícola. En esta forma de realización, el dispositivo puede configurarse además para procesar los datos de la imagen y obtener automáticamente el número de tallos productivos de la planta representada mediante procesamiento de imágenes y determinar el número apropiado de tallos productivos.

La Figura 3 muestra un ejemplo de una interfaz gráfica de usuario 1000 dedicada, en donde al menos una imagen 1100 se muestra con un factor de condición de sombra asociado mostrado 1200. Las imágenes que se mostrarán pueden configurarse para representar tipos de copa de árbol estándar presentes en la región del campo agrícola o pueden configurarse para recibir datos relacionados con el tipo de copa de árbol a partir de la entrada de usuario. En una forma de realización, el agricultor puede introducir datos de tipo de copa de árbol, que luego son utilizados por

el dispositivo electrónico para generar los datos de imagen que se mostrarán. La Figura 3 muestra un escenario que se adapta en función del control deslizante.

En una forma de realización adicional, el dispositivo electrónico está configurado para determinar la condición de sombra en función de la entrada de usuario. En esta forma de realización, el dispositivo electrónico puede mostrar una pluralidad de imágenes que muestran diferentes formas de copas de árboles con una condición de sombra asociada. En una forma de realización adicional, el dispositivo electrónico puede configurarse para mostrar la al menos una imagen de la copa de un árbol, de modo que una condición de sombra (por ejemplo, alrededor de 40 %, 50 % o similar) esté asociada con la al menos una imagen de una copa de árbol. El dispositivo electrónico puede configurarse además para mostrar una pluralidad de imágenes de la copa de un árbol o una combinación de estas. El usuario puede entonces, en función de al menos una de las imágenes mostradas, determinar una condición de sombra. Como tal, el usuario es guiado hacia una entrada significativa y es capaz de determinar una condición de sombra adecuada.

En una forma de realización adicional, mostrar al menos una imagen de una copa de árbol y determinar la condición de sombra en función de una entrada de usuario comprende además mostrar una barra deslizante 1300, en donde la barra deslizante 1300 comprende un rango predeterminado y un cursor que se puede mover libremente a lo largo la barra deslizante 1300. El usuario, al proporcionar una entrada en la barra deslizante 1300, puede desplazar el cursor a lo largo de la barra deslizante. En esta forma de realización, el dispositivo puede configurarse además para mostrar una de la pluralidad de imágenes en función de la posición del cursor en el control deslizante. Después de esta forma de realización, se proporciona al usuario una interacción guiada continuamente que mejora la determinación de la condición de sombra. En función del cambio gradual de la imagen mostrada, el usuario está en una mejor posición para juzgar y determinar la imagen que mejor muestra la condición de sombra del campo agrícola, como se puede ver en la Figura 3.

En una forma de realización adicional, el dispositivo electrónico puede configurarse además para recibir datos de imagen de una fotografía tomada por los agricultores de la vegetación circundante para determinar el tipo de copa de árbol y/o la condición de sombra.

En una forma de realización adicional, el dispositivo electrónico 100 puede configurarse además para recibir información de posición junto con los datos de imagen. Mediante la posición y orientación determinadas, la imagen tomada puede

servir para una determinación más precisa del estado de sombra. Una vez determinada la posición, en función de la posición relativa del sol y la Tierra para las diferentes estaciones, se puede determinar una condición de sombra en función de datos remotos, en donde se puede determinar la condición de sombra promedio del campo durante las diferentes estaciones.

En una forma de realización adicional, el dispositivo electrónico 100 puede guiar a los agricultores a través de diferentes posiciones en el campo agrícola para determinar la condición de sombra en diferentes ubicaciones representativas del campo agrícola. En esta forma de realización, el dispositivo puede configurarse además para determinar al menos una posición 50 dentro del campo agrícola 10 o en las proximidades y configurarse para mostrar la al menos una posición mediante la unidad de visualización 140 por medio de mapas o menús de navegación apropiados, como se puede observar en la Figura 4. Como tal, los agricultores pueden recibir al menos una posición dentro o cerca del campo agrícola donde se puede determinar la condición de sombra. En función de la condición de sombra en la al menos una posición, se puede lograr una condición de sombra más completa de todo el campo agrícola.

En una forma de realización adicional, la al menos una posición determinada por el dispositivo para proporcionar una determinación de sombra confiable se puede determinar en función de la forma y/u orientación del campo agrícola. En función de la ubicación del campo se puede determinar la posición del sol en cualquier momento del año. Por lo tanto, el proceso de determinación de la sombra se puede mejorar al guiar al usuario hacia las posiciones dentro del campo agrícola que sean convenientes para la determinación. El dispositivo puede configurarse además para determinar una orientación o dirección en la que se debe llevar a cabo la determinación de la sombra.

En una forma de realización adicional, la al menos una posición se determina adicionalmente en función de la posición relativa y la orientación del campo agrícola. A través de una selección adecuada de posiciones relevantes en función de la posición relativa y la orientación del campo agrícola, se puede reducir el número de posiciones donde se realizan las posiciones de muestreo, de modo que mejora la cantidad de tiempo necesario para una evaluación completa del campo.

En una forma de realización adicional, el dispositivo electrónico puede configurarse además para recibir la información de la temperatura promedio del aire para el campo agrícola como se describe en las siguientes formas de realización. En una forma de realización, el dispositivo electrónico puede configurarse además para

recibir información de elevación (metros sobre el nivel del mar). En una forma de realización adicional, el dispositivo electrónico está configurado para determinar la ubicación del usuario por medio de una unidad GPS y en función de la ubicación del usuario determinar la altitud, que puede derivarse mediante triangulación satelital de una pluralidad de satélites, o al derivar la elevación del suelo a partir de un mapa de elevación global en función de la ubicación y/o un sensor de presión. En una forma de realización adicional, el dispositivo electrónico puede configurarse además para recibir datos meteorológicos desde la ubicación determinada. De acuerdo con los datos meteorológicos proporcionados, la temperatura promedio del aire se puede ajustar según la información de elevación.

Sin embargo, debe entenderse que el dispositivo puede recibir los datos mencionados anteriormente por medio de una unidad de comunicación, accediendo a datos agrícolas y de campo desde un depósito central que se podría haber construido en función de datos ingresados previamente por el usuario u otras bases de datos existentes.

En una forma de realización adicional, el dispositivo electrónico puede configurarse para comunicarse de forma inalámbrica (o no) con un dispositivo de medición de nutrientes de cultivos como el N-Tester, al proporcionar datos de calibración para la recomendación de fertilizante. Dichos dispositivos de medición de nutrientes de cultivos pueden proporcionar un estado de nutrientes de una o varias plantas, al relacionar el estado de nutrientes con los niveles de clorofila u otros indicadores. Como tal, el método de recomendación de fertilizantes puede configurarse además para ajustar la recomendación en función de una lectura de medición de nutrientes del cultivo.

Si bien la presente divulgación se ha ilustrado mediante una descripción de varias formas de realización y aunque estas formas de realización se han descrito con considerable detalle, no es la intención del solicitante restringir o limitar de ninguna manera el alcance de las reivindicaciones adjuntas a tal detalle. Las personas del oficio de nivel medio apreciarán fácilmente ventajas y modificaciones adicionales. La divulgación no se limita a las formas de realización, versiones o ejemplos descritos, que se incluyen para permitir que una persona del oficio de nivel medio haga y utilice la divulgación cuando se combina con información y conocimientos disponibles para la persona del oficio de nivel medio.

Por lo tanto, la descripción detallada de esta no debe interpretarse como restrictiva en todos los aspectos sino como ilustrativa. El alcance de la divulgación

debe determinarse mediante una interpretación razonable de las reivindicaciones adjuntas y todos los cambios que se encuentren dentro del alcance equivalente se incluyen en el alcance de la divulgación actual.

Las etapas del proceso, etapas del método, algoritmos o similares pueden describirse en orden secuencial, en donde dichos procesos, métodos y algoritmos pueden configurarse para funcionar en órdenes alternativos. En otras palabras, cualquier secuencia u orden de etapas que pueda describirse no necesariamente indica un requisito de que las etapas se realicen en ese orden. Las etapas de los procesos descritos en la presente se pueden realizar en cualquier orden práctico. Además, algunas etapas pueden realizarse simultáneamente, en paralelo o al mismo tiempo. Se pueden practicar varios métodos descritos en la presente al combinar uno o más medios de almacenamiento legibles por computadora que contienen el código según la presente divulgación con hardware informático estándar apropiado para ejecutar el código contenido en estos. Un aparato para practicar diversas formas de realización de la presente divulgación puede implicar una o más computadoras (o uno o más procesadores dentro de una sola computadora) y sistemas de almacenamiento que contienen o tienen acceso a la red a programas informáticos codificados de acuerdo con varios métodos descritos en la presente, y las etapas del método de la divulgación podrían lograrse mediante módulos, rutinas, subrutinas o subpartes de un producto de programa informático.

Si bien se ha preferido el uso de sustantivos en plural en toda la divulgación cuando se hace referencia a personas (los usuarios, los agricultores) para permitir una redacción del texto neutral en cuanto al género, por la presente no se pretende limitar el número de personas con las que la presente divulgación debe considerarse relacionada. Esto se ha llevado a cabo a la luz de las modificaciones de las directrices que entraron en vigor el 1 de marzo de 2021 en apoyo de la neutralidad de género y como ejemplo para otros.

REIVINDICACIONES

- 1.- Un método implementado por computadora para determinar una recomendación de fertilizante para plantas de café, en donde el método comprende las etapas de:
 - i. determinar un campo agrícola en donde se comprende al menos una plantación de café,
recibir datos de densidad de plantas de la al menos una plantación de café,
recibir datos de especies de plantas y datos de la etapa de crecimiento del cultivo de la al menos una plantación de café, en donde los datos de la etapa de crecimiento del cultivo definen una etapa de cultivo vegetativo o una etapa de cultivo productivo;
en donde el método comprende además determinar una demanda básica y la demanda básica es en función de una demanda vegetativa si el cultivo está en una etapa de cultivo vegetativo y la demanda básica es en función de la suma de una demanda vegetativa y una demanda productiva si la plantación está en una etapa productiva del cultivo,
en donde la demanda vegetativa es en función de los datos de densidad de plantas y un factor de demanda vegetativa específico de nutrientes en función de los datos de especies de plantas.
- 2.- Un método de acuerdo con la reivindicación 1, en donde determinar la demanda productiva comprende recibir datos de rendimiento y determinar una demanda productiva en función de los datos de rendimiento y un factor de demanda productiva de nutriente específico en función de los datos de especies de plantas.
- 3.- Un método de acuerdo con la reivindicación 1 o 2, en donde el método comprende además ajustar la demanda vegetativa mediante un coeficiente de temperatura, en donde determinar el coeficiente de temperatura comprende recibir datos de altitud y/o una temperatura de aire promedio del campo agrícola y el coeficiente de temperatura se determina en función de los datos de la temperatura de aire promedio y/o la altitud.
- 4.- Un método de acuerdo con cualquiera de las reivindicaciones anteriores, en donde el método comprende además recibir una cantidad de tallos productivos de las plantas presentes en la plantación, y en donde la demanda vegetativa se ajusta adicionalmente en función de la cantidad de tallos productivos.
- 5.- Un método de acuerdo con cualquiera de las reivindicaciones anteriores, en donde la demanda básica se ajusta mediante un factor de eficacia de nutriente específico, en donde determinar un factor de eficacia de nutriente específico comprende recibir al menos uno de datos de producto de fertilizante, o datos meteorológicos, y datos de

suelo del campo agrícola, y el factor de eficacia se determina en función del al menos uno de los datos de producto de fertilizante, los datos meteorológicos, o los datos de suelo.

6.- Un método de acuerdo con cualquiera de las reivindicaciones anteriores, en donde el método comprende además determinar una condición de sombra del campo agrícola, y en donde la demanda básica se ajusta en función de la condición de sombra.

7.- Un método de acuerdo con la reivindicación 6, en donde determinar una condición de sombra del campo agrícola comprende además determinar al menos una posición para que la determinación de sombra se lleve a cabo.

8.- Un método de acuerdo con cualquiera de las reivindicaciones anteriores, en donde el método comprende además recibir datos de suelo del campo agrícola, y en donde la demanda de nutrientes total se ajusta en función de un factor de disponibilidad de nutrientes de suelo.

9.- Un dispositivo para determinar una demanda de fertilizante para plantas de café, configurado para llevar a cabo el método de acuerdo con cualquiera de las reivindicaciones 1 a 8.

10.- Un dispositivo de acuerdo con la reivindicación 9, configurado para llevar a cabo el método de acuerdo con la reivindicación 7, en donde el dispositivo comprende medios de entrada y salida y una interfaz de usuario gráfica dedicada, en donde la condición de sombra se determina de acuerdo con una imagen gradualmente ajustable que muestra diferentes imágenes de condición de sombra predefinida en función de la entrada de usuario.

11.- Un dispositivo de acuerdo con la reivindicación 9 o 10, en donde el dispositivo comprende una unidad de localización para determinar datos posicionales del dispositivo, y la elevación del campo agrícola se determina en función de los datos posicionales del dispositivo.

12.- Un dispositivo de acuerdo con la reivindicación 11, en donde el dispositivo se configura adicionalmente para recibir datos meteorológicos, y en función de los datos posicionales y la elevación, determinar una temperatura de aire promedio del campo agrícola.

13. Un aparato de procesamiento de datos que comprende medios para llevar a cabo el método de acuerdo con cualquiera de las reivindicaciones 1 a 8.

14.- Un medio de almacenamiento legible por computadora que comprende instrucciones que, cuando son ejecutadas por un sistema informático, hacen que la

computadora lleve a cabo el método de acuerdo con cualquiera de las reivindicaciones 1 a 8.

15.- Un producto de programa informático que comprende instrucciones que, cuando el programa es ejecutado por un sistema informático, hacen que la computadora lleve a cabo el método de acuerdo con cualquiera de las reivindicaciones 1 a 8.

RESUMEN

La presente invención se refiere a un método implementado por computadora para determinar una recomendación de fertilizante específica para plantas de café, en donde el método comprende una demanda vegetativa y productiva y diferentes factores de ajuste. Se prevé un dispositivo para la implementación del método, mediante el cual se posibilita y mejora la determinación de los diferentes factores.

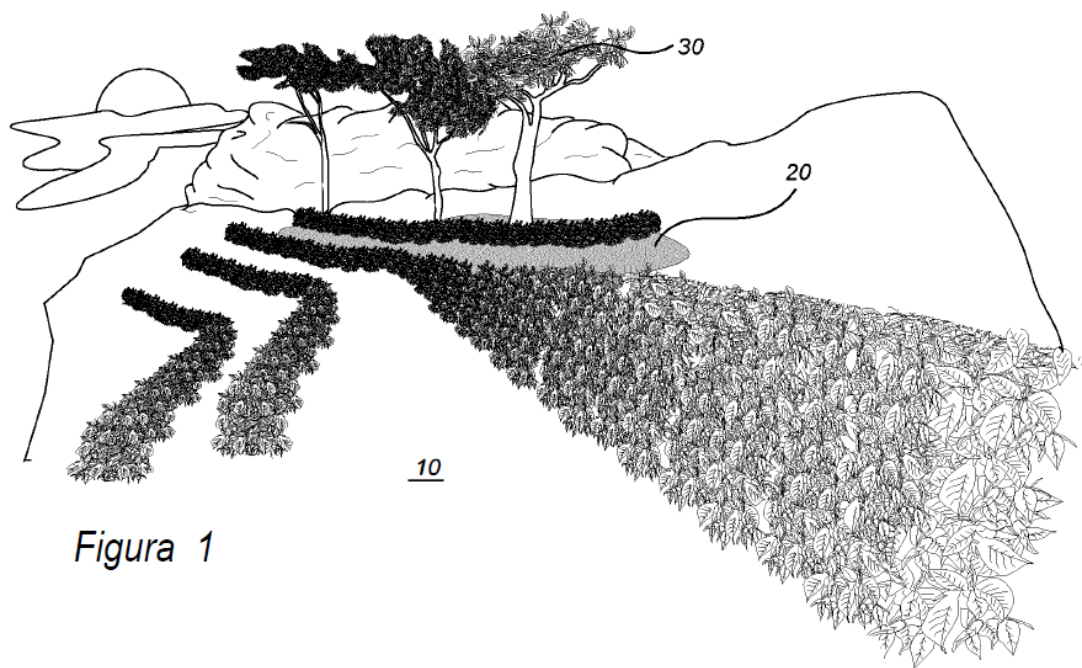


Figura 1

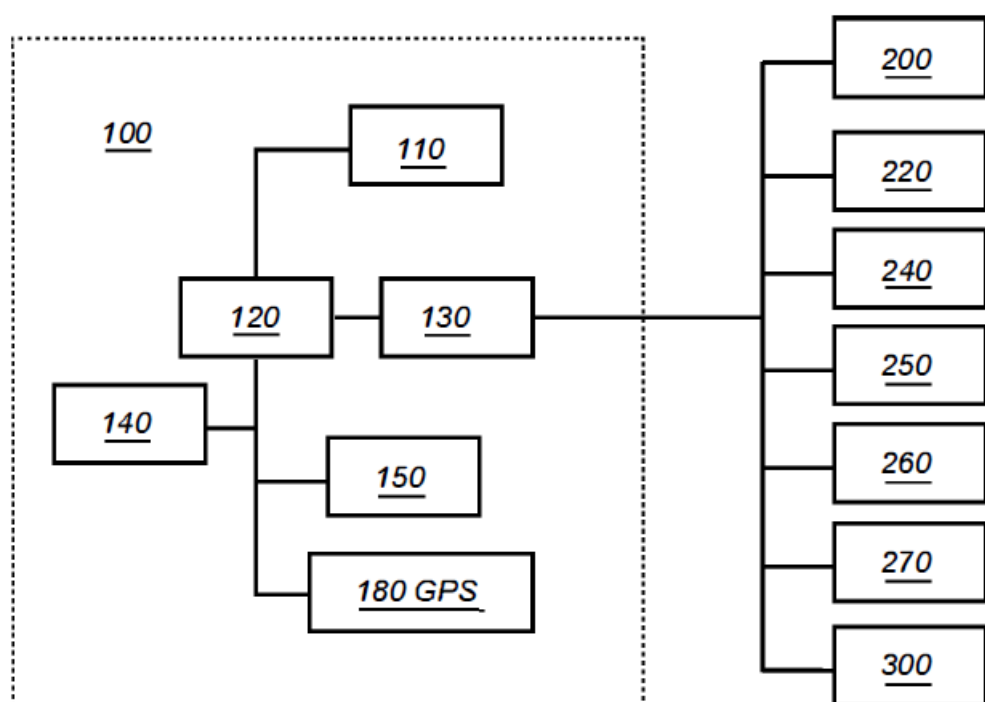


Figura 2

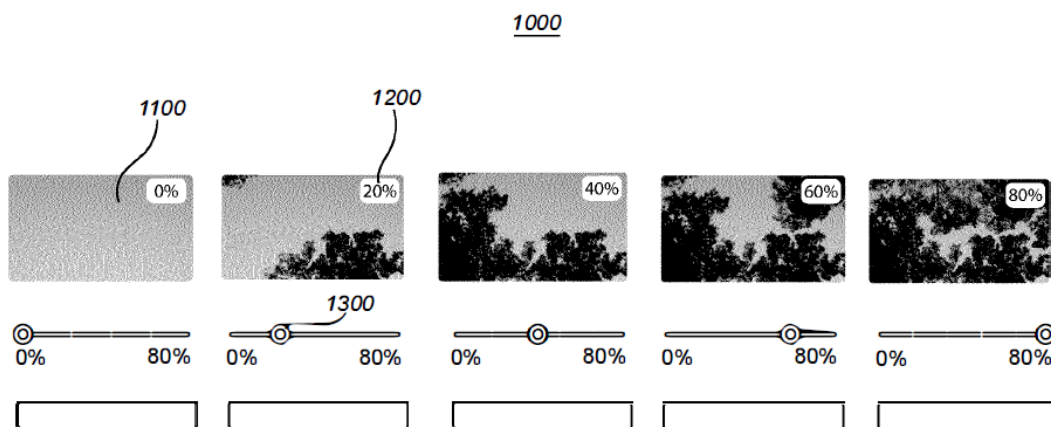
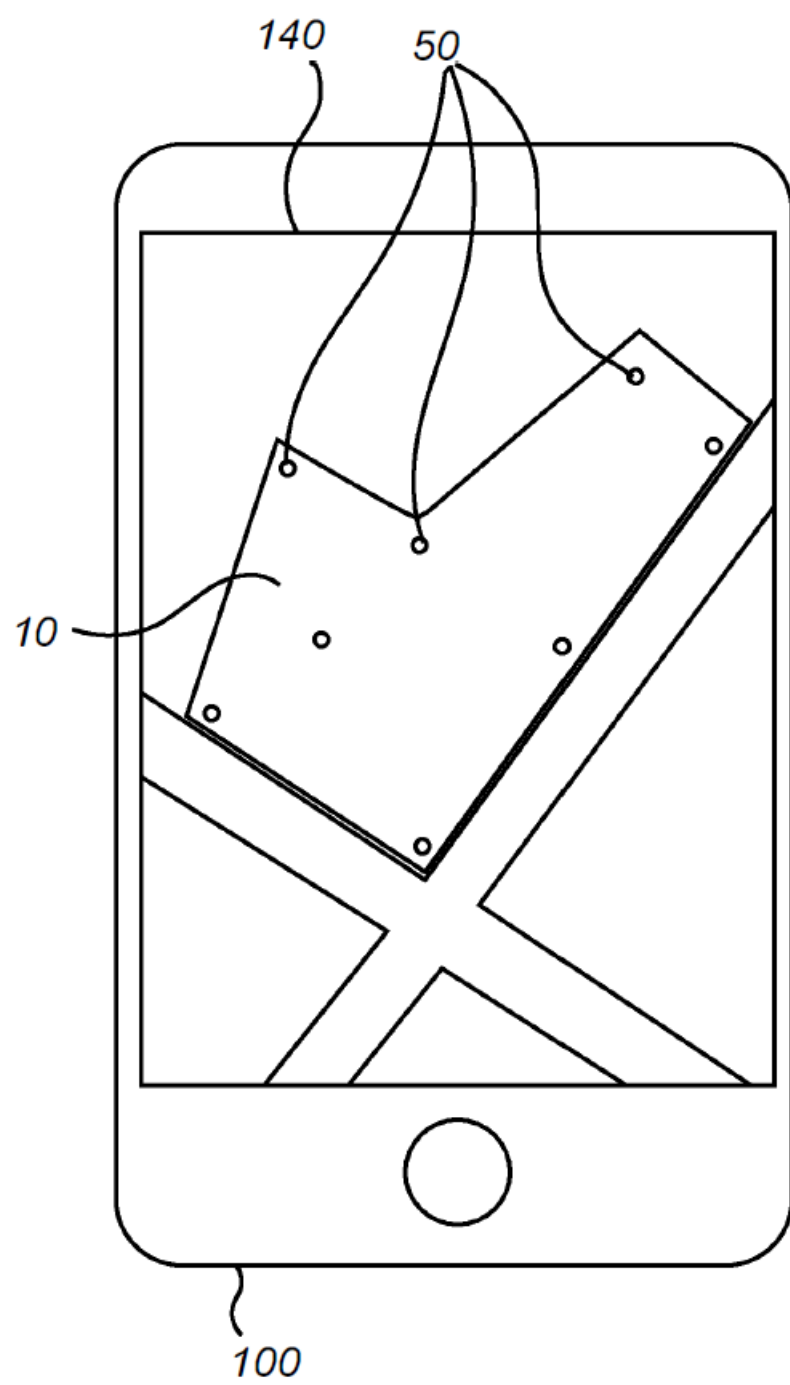
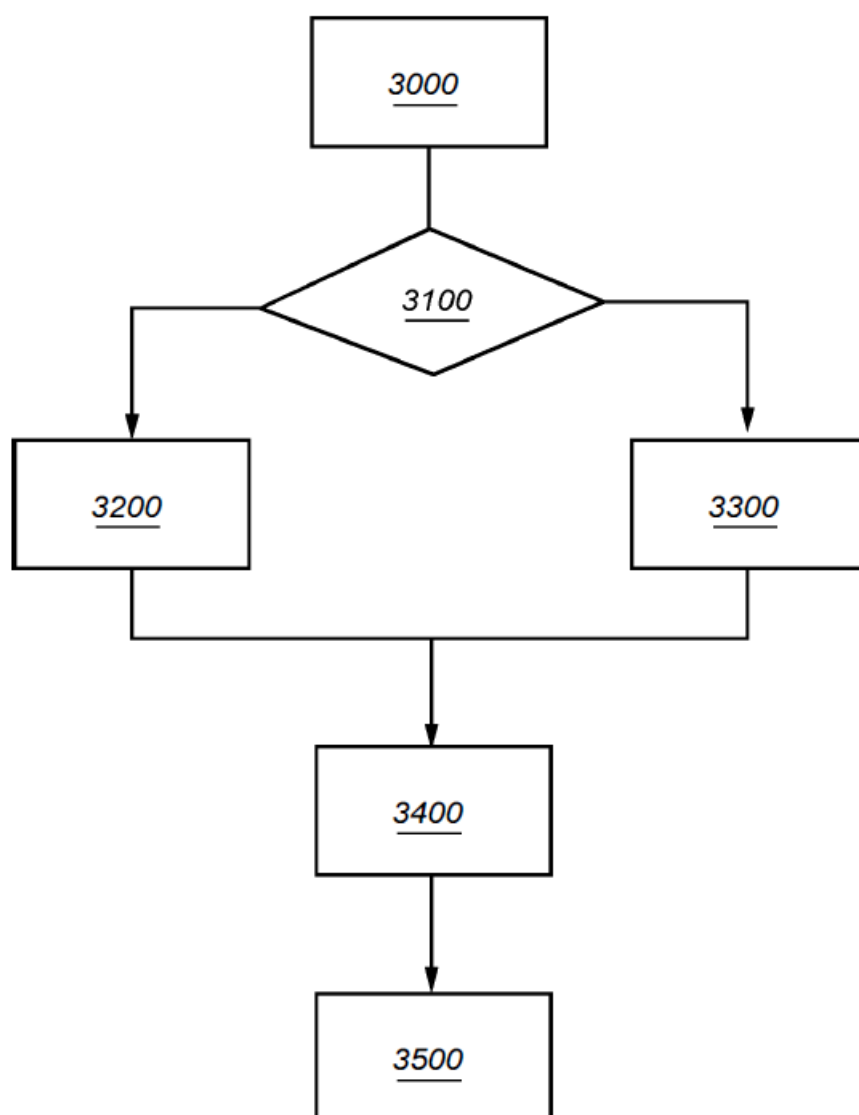


Figura 3

*Figura 4*

*Figura 5*

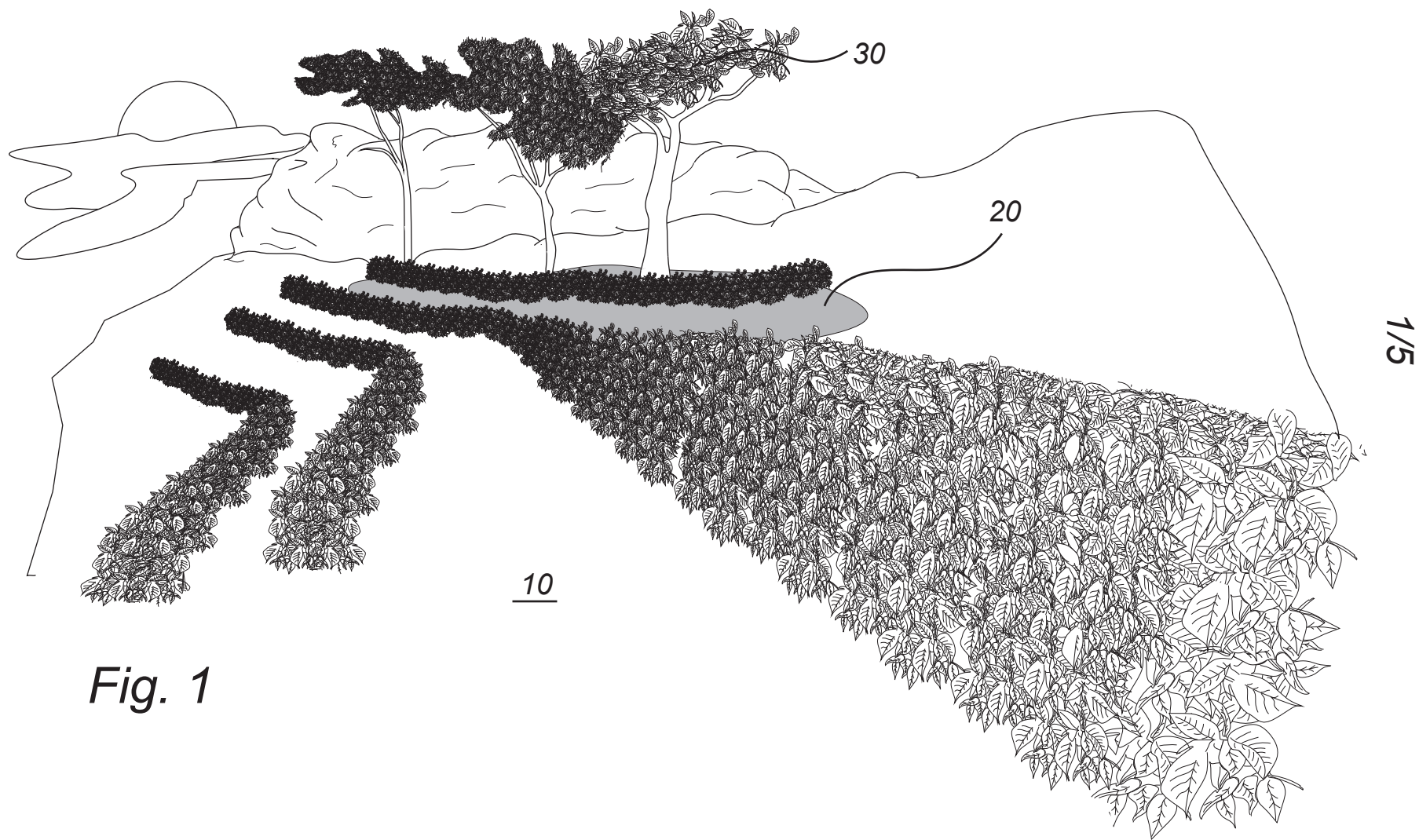


Fig. 1

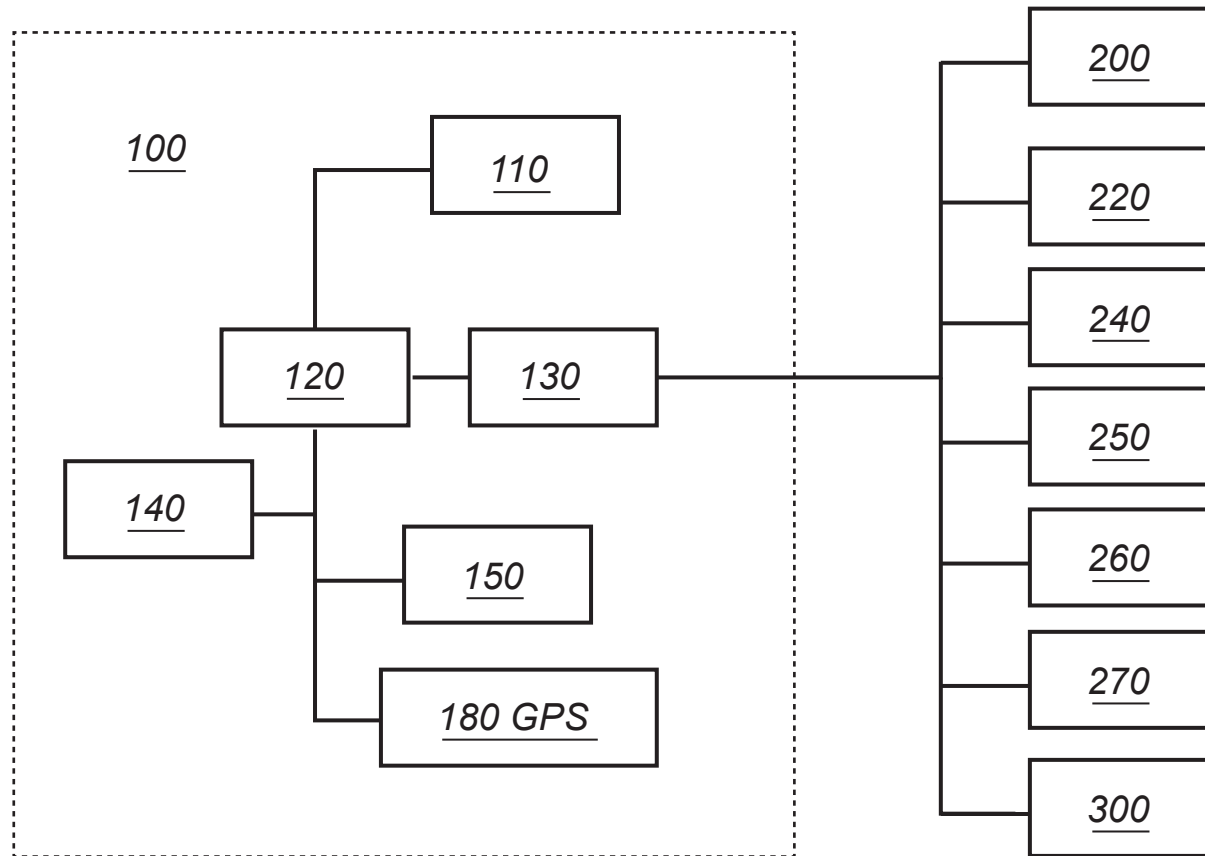


Fig. 2

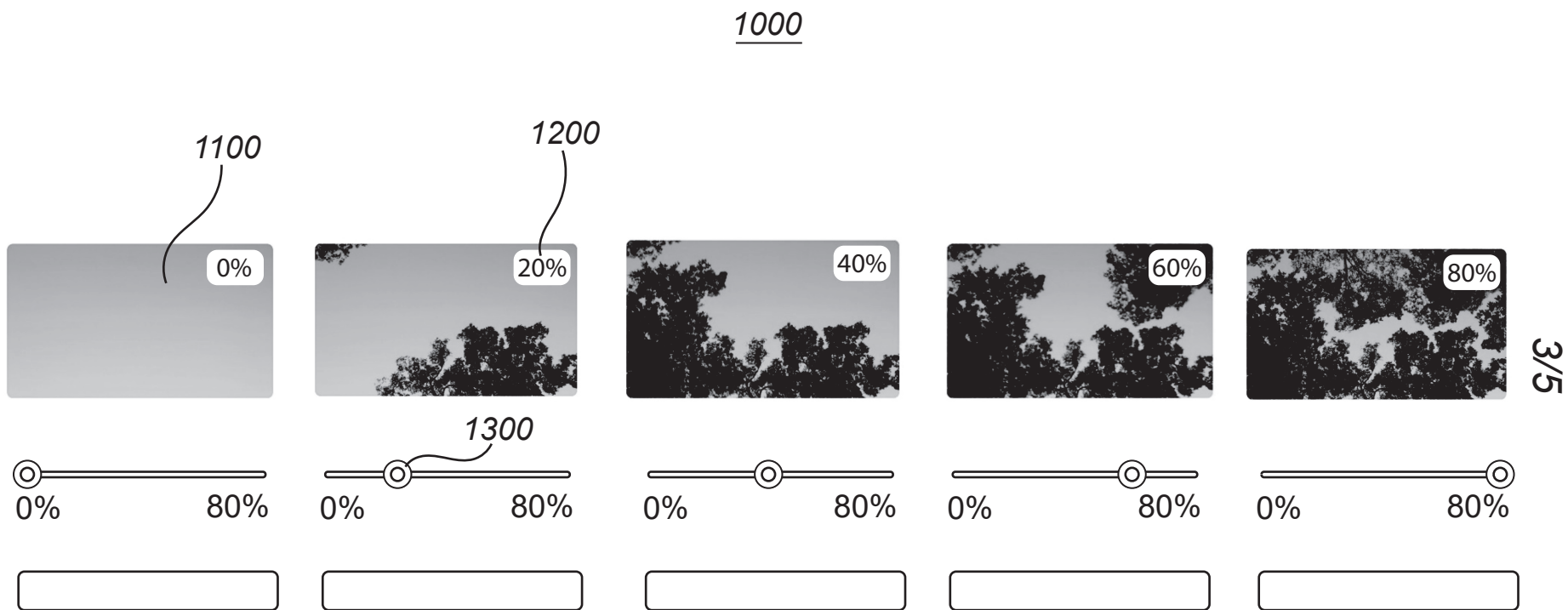
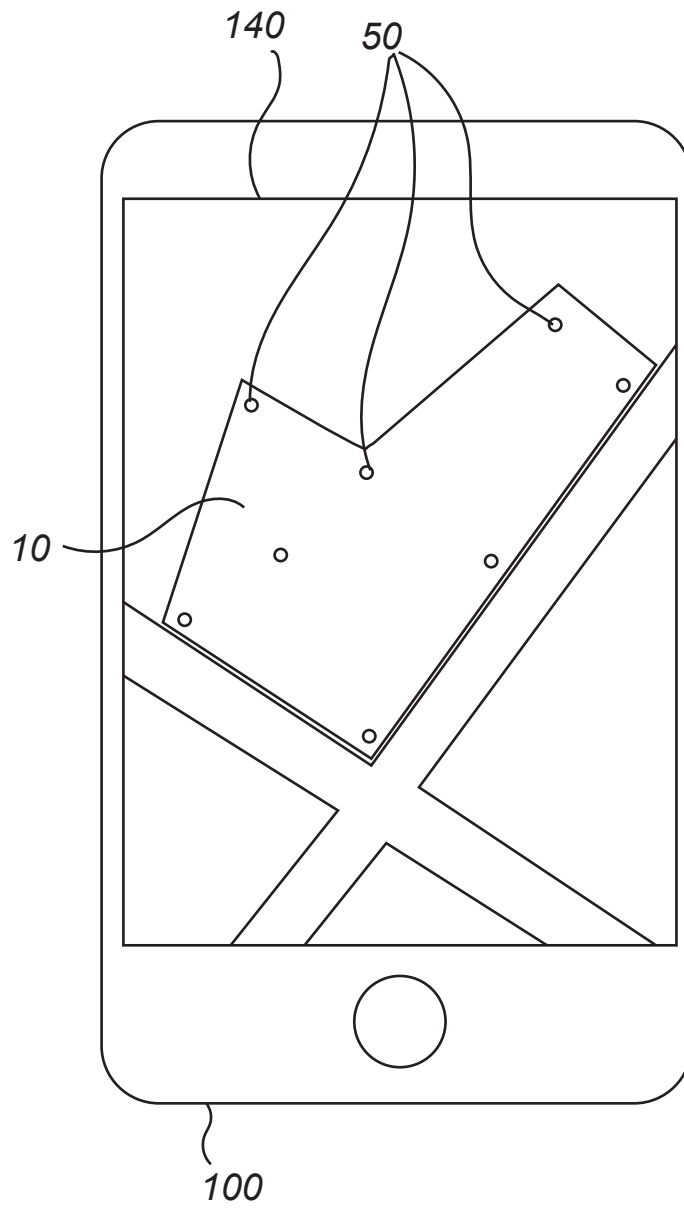


Fig. 3

*Fig. 4*

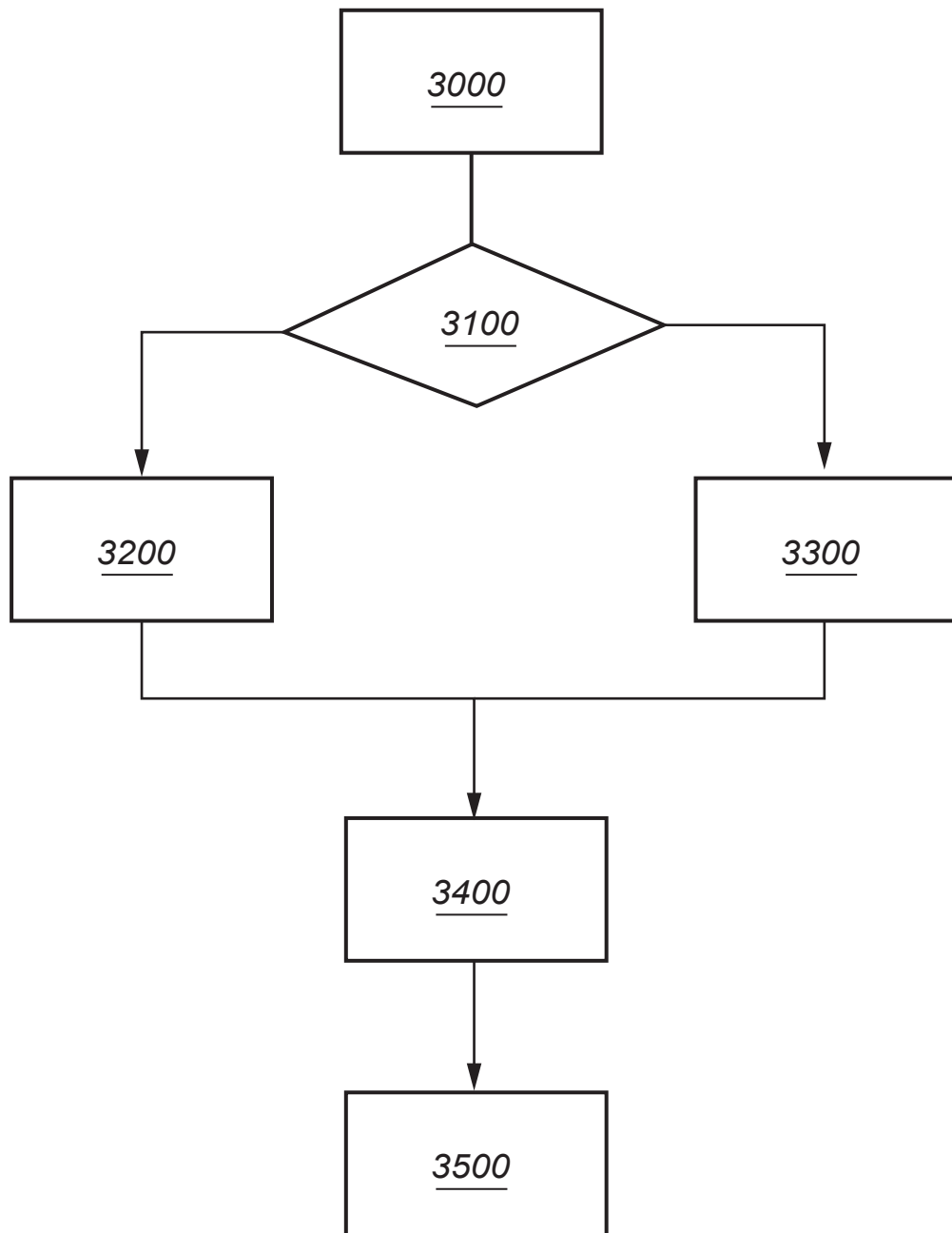


Fig. 5

Method and Device for a fertilizer recommendation for Coffee

Technical field

The present disclosure relates to the field of agriculture and aims at providing a specific fertilizer recommendation for coffee plantations.

Background

The approaches described in this section are approaches that could be pursued, but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be assumed that any of the approaches described in this section qualify as prior art merely by virtue of their inclusion in this section.

Determining the appropriate amount of fertilizer a crop needs is one of the most important decisions a farmer will encounter. A deficit in nitrogen will reduce yield, while an excess will produce economic losses and damage the environment. A deficit and/or unbalance of other nutrients will lead to yield losses, crop defects and reduced crop quality. This is of greater importance with higher value crops, like coffee. The genus *Coffea* comprises more than 120 perennial species. The two most popular are *Coffea arabica* (known as “Arabica”) and *canephora* (known as “Robusta”) and are cultivated in over 70 countries, mainly in the equatorial regions of Central and South America, Africa and South-East Asia and their seeds, called coffee beans, are used to flavor beverages and products across the globe. Coffee is one of the world’s most valuable commodity crops, but the majority of coffee plantations are smallholders with little access to modern agriculture technologies to improve their yield.

Usually, coffee production may take place in agroforestry systems, wherein other plants and trees are intercropped with the coffee plants to provide shade and other advantages in general such as increasing local biodiversity, erosion reduction, improvement of water storage in soils and the like, all these improving the farmers income. Depending on the species, coffee may be cultivated in regions located at altitudes ranging from sea level to 2000 m. While temperatures below 7 °C and above 33 °C reduce production and bean size and brew quality, optimal mean temperatures are comprised between 15-25 °C and their fertilizer needs should be conveniently adjusted for these and other factors.

Known approaches for the determination of a fertilizer recommendation are based on detailed chemical analysis from soil and plant tissues and specific measurements of the coffee plants yield

and size. An example of such an approach can be found in BR102019002078 A2, wherein the method includes different steps comprising the harvest of the fruit and the subsequent processing for a chemical analysis. Document US 9652840 B1 discloses a method and system for managing nitrogen applied by a nitrogen application equipment determining a growth stage for the geographic region using a crop module.

It is therefore the aim of the current application to achieve a method and device for determining a nutrient specific fertilizer recommendation for coffee plants which support the farmers in their decision making. Further embodiments comprising an agricultural apparatus to carry out the fertilization recommendation are included within the scope of the current application.

SUMMARY OF THE INVENTION

The present disclosure aims at providing a quick and accurate fertilizer recommendation for coffee cultivation which does not require the lengthy process steps required by a chemical analysis of the plant and which takes into consideration several different factors for the plant growth and the nutrients absorption like average air temperature and shade conditions.

According to a first aspect of the present disclosure, this and other objectives are achieved by means of a computer-implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage; wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative stage and the basic demand is based on the sum of a vegetative and a productive demand if the plantation is on a productive stage, wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

Following this approach, a specific fertilizer recommendation based on the different growth stages of a plant is achieved.

According to a further embodiment, determining the productive demand comprises receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

Following this approach, the fertilizer recommendation is adapted to the yield and plant species of the agricultural field.

According to a further embodiment, the method further comprises adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude.

Following this approach, the fertilizer recommendation is adapted to the temperature.

According to a further embodiment, the method further comprises receiving an average air temperature of the agricultural field from weather data and adjusting the average air temperature based on the altitude of the agricultural field.

Following this approach, a more precise determination of the temperature compensation is achieved.

According to a further embodiment, the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

Following this approach, the specific demands of the plants based on the number of productive stems is achieved.

According to a further embodiment, the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

Following this approach, additional boundary conditions can be taken into consideration.

According to a further embodiment, the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.

Following this approach, the fertilizer recommendation is adapted to the shade conditions of the agricultural field.

According to a further embodiment, the method further comprises determining at least one position for the shadow determination to be carried out.

Following this approach, the shade conditions of the field are more accurately determined.

According to a further embodiment, the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.

Following this approach, the fertilizer recommendation is adapted to the existing nutrients on the field.

According to a further embodiment, a device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the previous embodiments is envisaged to allow the user to carry out the above-mentioned methods.

According to a further embodiment, the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.

Following this approach, the user can obtain a reliable determination of the shadow condition.

According to a further embodiment, the device may determine at least one position and display the at least one position by means of the display unit for the user to carry out the shadow determination.

According to a further embodiment, the at least one position determined by the device to provide a reliable shadow determination may be determined based on the agricultural field.

According to a further embodiment, the at least one position is further determined based on the relative position and orientation of the agricultural field.

Following these approaches, a more reliable determination of the shadow condition is achieved and the number of positions to be sampled are reduced

According to a further embodiment, the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.

Following this approach, the user is provided with a reliable determination of the altitude of the agricultural field.

According to a further embodiment, the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.

Following this approach, a reliable temperature adjustment for the fertilizer recommendation is achieved.

According to further embodiments, a data processing apparatus, a computer-readable storage medium and a computer program product configured to carry out the above discussed methods are envisaged within the present disclosure.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings, which are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain the principles of the disclosure.

Figure 1 shows an example of a coffee plantation with some of the considered features of importance for the current disclosure.

Figure 2 describes a device according to one of the main embodiments of the current disclosure.

Figure 3 shows an embodiment of the Graphical User Interface showing an image to determine the shadow factor.

Figure 4 shows another embodiment of the Graphical User Interface, wherein a plurality of positions for determining the shadow factor are shown.

Figure 5 shows a flowchart of a method according to an embodiment of the current disclosure.

The accompanying drawings are used to help easily understand the technical idea of the present disclosure and it should be understood that the idea of the present disclosure is not limited by the accompanying drawings. The idea of the present disclosure should be construed to extend to any alterations, equivalents and substitutes beside the accompanying drawings.

DETAILED DESCRIPTION

The terms "comprising", "comprises" and "comprised of" as used herein are synonymous with "including", "includes" or "containing", "contains", and are inclusive or open-ended and do not exclude additional, non-recited members, elements or method steps. It will be appreciated that the terms "comprising", "comprises" and "comprised of" as used herein comprise the terms "consisting of", "consists" and "consists of".

The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

The term "about" or "approximately" as used herein when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/- 10% or less, specifically +/-5% or less, more specifically +/-1% or less, and still more specifically +/- 0.1% or less of and from the specified value, insofar such variations are appropriate to perform in the disclosed application. It is to be understood that the value to which the modifier "about" or "approximately" refers is itself also specifically disclosed.

Whereas the terms "one or more" or "at least one", such as one or more or at least one member(s) of a group of members, is clear per se, by means of further exemplification, the term encompasses inter alia a reference to any one of said members, or to any two or more of said members, such as, e.g., any ≥ 3 , ≥ 4 , ≥ 5 , ≥ 6 or ≥ 7 etc. of said members, and up to all said members.

Unless otherwise defined, all terms used in disclosing the application, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this application belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present application.

In the following passages, different aspects of the application are defined in more detail. Each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present application. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to a person skilled in the art from this disclosure, in one or more embodiments. Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the application, and form different embodiments, as would be understood by those in the art. For example, in the appended claims, any of the claimed embodiments can be used in any combination.

In the present description of the application, parenthesized or emboldened reference numerals affixed to respective elements merely exemplify the elements by way of example, with which it is not intended to limit the respective elements. It is to be understood that other embodiments may be used and structural or logical changes may be made without departing from the scope of the present

application. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present application is defined by the appended claims.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise.

The use of the expression "at least" or "at least one" suggests the use of one or more elements, as the use may be in one of the embodiments to achieve one or more of the desired objects or results.

Figure 1 shows a schematic representation of coffee plantations in agroforestry systems, wherein an agricultural field 10 is shown with the usual tree canopy forms 30 creating a resulting shade region 20 for illustration purposes. Usually, farmers would determine their practices based on previous experiences without consideration of external factors. Moreover, usual fertilizer products present a fixed ratio of macro- and micro-nutrients which renders difficult a proper fine tuning according to the optimal dosage of nutrients. The law of the minimum, developed by Justus von Liebig and based upon work by the botanist Carl Sprengel, states that plant growth is related to the most limiting nutrient. Amongst the most important nutrients for agricultural purposes Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca) and Sulfur (S) are part of the macronutrients needed for plant development. Other elements like Sodium (Na), iron (Fe), Manganese (Mn), Boron (B), Copper (Cu), Molybdenum (Mo), and Zinc (Zn) are considered micronutrients due to their usual lower concentration present in plant tissues. As such, the lack or incorrect dosage of any of the above-mentioned nutrients has a detrimental influence towards the development of crops and their yield production.

Several factors influence the correct recommendation of nutrients for a correct fertilization. For example, soil, water availability, weather and other parameters have a direct influence in the uptake of nutrients. In the case of Coffee, some specific factors related to the coffee plant, and environmental parameters derived from the boundary conditions present in the production system can be considered of special importance. For example, the number of productive stems has been found to have a direct linear relationship for the vegetative fertilizer demand of coffee plants; temperature conditions have a direct relation to the vegetative demand, whereas shade conditions have a direct influence in the total amount of nutrients needed. While the specific nutrient demand might be different with respect to the individual nutrients, thanks to the nutrient specific approach of the current disclosure a balanced and optimized nutrient recommendation can be achieved. Within the present disclosure, a nutrient specific adjustment or correction refers to variations on the

fertilizer recommendation carried out for different nutrients, i.e. corrections or adjustments are different for each specific nutrient.

Figure 2 shows an example of a device 100 according to the present disclosure. Device 100 may comprise several components such as a memory unit 110, a processor 120, a wired/wireless communication unit 130, a localization unit 180 (including GPS and orientation means like a compass), and an input/output unit 140 which will be further described below.

The method of the current disclosure comprises receiving data related to the agricultural field where the coffee plantation is located. For the main embodiment of the present disclosure, receiving data of the plantation comprises receiving at least plant density data, plant species, growth stage data and expected or past season's yield data.

Different embodiments are envisaged for the provision of the field and crop data. In an embodiment, the farmers may provide the data by means of a dedicated interface. However, the computer implemented method of the current disclosure may further comprise receiving field and crop data from a remotely situated server or from locally accessible memory units.

Device 100 may comprise an agricultural recommendation engine 220 to which the system may be remotely connected by means of the communication unit 130, may it be of a remote nature. In this case, the agricultural recommendation engine 220 may be represented by a computer, a remotely accessible server, other client-server architectures or any other electronic devices usually encompassed under the term data processing apparatus. Device 100 can be represented as well by a laptop computer or handheld device, with an integrated agricultural recommendation engine 150 which can be fully operated at the farm's location and may comprise a GPS unit or any other suitable localization means 180.

It is to be understood that the presence of remote and integrated recommendation engines are not mutually excluding. Integrated agricultural recommendation engine 150 can be a local copy of remote agricultural recommendation engine 220 or a light version of it to support periods of low network connectivity and offline work. Device 100 and remote or integrated agricultural recommendation engine may comprise field and farm data and external data and/or be configured to receive said data, whereby external data comprises weather data, satellite imagery data and further data provided by weather forecast providers or other third parties. Field data may comprise amongst others current and past data of at least one of the following: field and geographic identifiers regarding the geometry of the boundaries of the agricultural field, including the presence of areas within the agricultural field which are not managed, topographic data, crop identifiers (crop variety and type, crop growth stage, planting data and date, plant nutrition and health status) of current and

past crops, harvest data (yield, value, product quality, estimated or recorded historic values), soil data (nutrient availability, soil type, pH, soil organic matter (SOM) and/or cation exchange capacity, CEC). Farm data may comprise further data regarding to planned and past tasks like field maintenance practices and agricultural practices, fertilizer application data, pesticide application data, irrigation data and other field reports as well as historic series of the data, allowing the comparison of the data with past data, and the processing of further administrative data like work shifts, logs and other organizational data. Planned and past tasks may comprise further activities like surveillance of plants and pests, application of pesticides, fungicides or crop nutrition products, measurements of at least one farm or field parameter, maintenance and repair of ground hardware and other similar activities.

The device 100 may be configured to receive and/or retrieve soil data from available online soil databases like SoilGrids from the World Soil Information, SSURGO (Soil Survey Geographic Database from the United States Department of Agriculture) or any similar soil data repository, as well as by means of user input. Soil data may be used directly in the fertilization recommendation if a nutrient content is available in the accessed data repositories, but may be as well used for the adapting the recommendation and/or planning of the fertilizer application based on other soil data (e.g. soil texture and/or moisture may be taken into consideration when determining a variable fertilizer application and/or the optimum number of application and the respective amounts).

Device 100 may be further configured to receive any of the above mentioned data and further field data from a predetermined number of locations within or nearby the analyzed region, inputted manually by the farmers by means of the input/output unit 140 or received by the communication unit 130 from dedicated sensors 270. Further, device 100 and agricultural recommendation engine 150 or 220 may be configured to receive weather data from nearby weather stations 260 and/or external crop/farm sensors or sensing devices 270, as well as by means of the input/output unit 140. Nearby weather stations 260 and/or external crop/farm sensors 270 are configured to communicate via one or more networks. In another embodiment, weather data is provided by external weather forecast companies. Weather data may further include present and past series of data of the at least one of the following: temperatures (e.g. average, minima and maxima), accumulated precipitation, relative humidity, wind speed, solar radiance, accumulated sun hours, as well as forecasts, etc.

Device 100 may further be operatively connected to an agricultural apparatus 300. Examples of agricultural apparatus 300 include tractors, combines, harvesters, planters, trucks, fertilizer equipment, and any other item of physical machinery or hardware, typically mobile machinery, and which may be used in tasks associated with agriculture. In one embodiment, device 100 may be

configured to communicate with the agricultural apparatus 300 by means of wireless networks in order to set a variable rate application prescription for the determined crop, or alternatively, to determine the measurement region as indicated destination. Device 100 may be further configured to produce a machine-readable script file for the agricultural apparatus to carry out the fertilizer application.

The method of the current application comprises therefore determining a fertilizer recommendation or demand for coffee plants based on the received data. In a main embodiment, receiving data 3000 may comprise receiving plant species and plant density data of the at least one coffee plantation present in the agricultural field together with a crop growth stage data, wherein the crop growth stage data defines 3100 a vegetative crop stage or a productive crop stage, wherein the method comprises determining a basic demand for the plantation and the basic demand is based on a vegetative demand if the crop is in a vegetative stage 3200 and the basic demand is based on the sum of a vegetative demand and a productive demand if the crop is in a productive growth stage 3300, wherein the vegetative demand is based on the plant density and a nutrient specific vegetative demand factor based on the plant species data. The method of the current application may further comprise an adjustment step 3400 of the fertilizer recommendation and/or determining 3500 the application of the fertilizer recommendation.

In a further embodiment, the method may comprise receiving yield data and determining the productive demand based on the yield data and a nutrient specific productive demand factor.

In a further embodiment, the method may further comprise adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data or an average air temperature of the agricultural field and wherein the temperature coefficient is determined based on the average average air temperature or the altitude. With elevation, usual temperatures and air density changes the dynamics of nutrient acquisition and crop development and such an adjustment improves the fertilizer recommendation.

In a further embodiment, the method further comprises receiving an average air temperature of the agricultural field from weather data and adjusting the average air temperature based on the altitude of the agricultural field. Due to the usual cultivation of coffee in hills and mountain regions, the fertilizer demand may be conveniently adjusted on the altitude of the agricultural field and the weather data. In this case, local weather data can be precisely refined due to the variations of temperature with the altitude.

In a further embodiment, the method further comprises receiving the number of productive stems of the plants present in the plantation in the agricultural field and the vegetative demand is further adjusted based on the number of productive stems.

In a further embodiment, the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining an efficiency factor may further comprise receiving at least one of fertilizer product data, or weather data or soil data from the agricultural field and the efficiency factor is determined based on the at least one of the fertilizer product data, weather or soil data. Fertilizer efficiency is determined by several factors: based on the fertilizer product data, volatility of the compounds forming the fertilizer can be taken into account. Further influencing factors like soil moisture and weather data can be included in the determination by themselves or in combination with the product data. For example, precipitation influences the amount of leeching which nitrogen in the soil may be subjected to. It is specially to be remarked that leeching is a nitrogen specific chemical process and therefore only related to the nitrogen efficiency factor. Moreover, leeching may occur at different rates depending on the soil type and texture. For example, sandy soils have less water retention and increase leeching. Hence, the efficiency factor may be further adjusted based on soil data.

In a further embodiment, the method further comprises determining a shadow condition and the basic demand is further adjusted based on the shadow condition as it will be made clear below.

As it will be clear from the equations below, a shadow condition may be represented by any factor or coefficient which takes the amount of shade per crop zone of at least an area of the agricultural field into consideration. Hence, a shadow dependent factor or shadow dependent coefficient which adjusts the values of the fertilizer requirements is included in the equations and is determined based on the shadow condition, wherein the shadow dependent factor or shadow dependent coefficient may be a scaling factor of appropriate value as defined below. For illustration, in one of the embodiments, the shadow dependent factor has been defined as a value between 0 and 1 as a function of the percentage of the shadow condition.

It should be noted that the terms “shadow dependent factor” used herein may be referred to as “shadow factor”. Similarly, the terms “shadow dependent coefficient” may be referred to as “shadow coefficient”.

In a further embodiment, the method further comprises receiving soil data and the total nutrient demand is further adjusted based on a soil nutrient availability factor. Due to past farming management practices and the nature of the soils, a high variability in the availability of already existing nutrients is present. Farmers may have at their availability data from previous soil laboratory

analysis or data from dedicated soil sensors as well as from field data already stored. Based on the nutrient availability data, a soil nutrient availability factor is determined which takes into consideration said variability.

As such, a mathematical expression comprising all described embodiments of the current disclosure for a coffee plantation in productive crop stage may be represented as follows:

$$F_T = \frac{C_{Shade} * C_{Soil}}{C_{EF}} * [F_{BASIC}];$$

wherein F_{BASIC} is determined according to the crop growth stage data. When the crop is in a vegetative crop stage, $F_{BASIC} = F_{VEG}$, whereas when the crop is in a productive stage, the basic demand is defined as $F_{BASIC} = F_{VEG} + F_{PROD}$, and whereby the vegetative and productive demand are defined as follows.

$$F_{VEG} = C_{VEG} * D * C_T * n$$

$$F_{PROD} = C_{PROD} * Y$$

wherein:

- F_T, F_{VEG}, F_{PROD} are the demand of nutrients (kg/ha),;
- C_{Shade} is a shadow dependent coefficient;
- C_{EF} is a nutrient specific efficiency factor;
- C_{VEG} is the nutrient specific vegetative demand factor (kg/plant/year);
- D is the density of plants in the farm (plants/ha);
- C_T is a temperature dependent coefficient adjusting the vegetative potential growing rate;
- n is the number of productive stems present per plant in the plantation;
- C_{PROD} is the nutrient specific productive demand factor, based on specific variety and/or species data;
- Y is an expected yield value for the current season (kg/ha);
- C_{Soil} is a nutrient specific correction factor based on the in-soil availability of nutrients;

The above displayed equation may be expressed in a scalar way for each independent nutrient or matrix-wise by a vector comprising the at least one of the different nutrients of importance in the fertilization of coffee. For example, in a non-limiting example, the nutrient specific factors and demands may comprise rows for at least one of the following nutrients: N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu or equivalent components acting as carriers of the nutrients like P_2O_5 , K_2O , CaO , MgO .

C_{Shade} represents a shadow dependent factor or shadow dependent coefficient which may be added to take into consideration the effect of the sun conditions on the crop, wherein the factor takes the value 0 when the shadow coverage of the crop is >60%, is 1 if the shadow coverage is <20% and takes values in between. In a further embodiment the shadow dependent factor may be preferably determined between said 20% and 60% by means of an equation with a negative quadratic term and a positive linear term based on the percentage of shadow interpolating the boundary values of 0 and 1 at 20 and 60%.

F_{VEG} and F_{PROD} are plant species dependent nutrient specific coefficients which account for the vegetative and productive demand, which may be defined as follows for the vegetative demand (kilograms of nutrient / plant / year):

Nutrient	Demand Factor
	kg/plant/year
	Robusta
N	0,01
P	0,0027
K	0,018
Ca	0,01
Mg	0,0018
S	0,00018
Fe	0,00001
Mn	0,00036
B	0,0000018
Zn	5,4E-06
Cu	7,2E-06

and correspondingly for the productive demand.

C_{EF} is a nutrient specific efficiency factor which may be added to take into consideration the absorption efficiency of each of the nutrients (N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu) or equivalent components present in the fertilizer based on at least one of the fertilizer product data, soil data and/or weather data. For example, based on known product data the absorption efficiency for Nitrogen may be solely adjusted based on the product type (e.g. based on active component, like urea or product identification information, or coating type) or advantageously combined with weather data (e.g. Nitrogen is very susceptible to leeching and therefore precipitation data of

importance for determining the absorption efficiency). Hence, following the above representation, the nutrient specific efficiency factor may be represented as follows for a given product and weather and soil conditions, wherein the nutrient specific efficiency factors are comprised between 0 and 1.

Nutrient	Efficiency factor
N	0,75
P	0,3
K	0,75
Ca	0,6
Mg	0,75
S	0,9
Fe	0,9
Mn	0,6
B	0,6
Zn	0,9
Cu	0,9

C_{Soil} is a nutrient specific correction factor based on the in-soil availability of the nutrient which may be added, wherein the soil data from soil analysis may be inputted by the farmers or provided by soil sensors or suitable field data, as mentioned above. Based on the respective availability of each specific nutrient, a correction factor for each nutrient can be generated, wherein the factor may be comprised, in particular, between 0.3 and 1.15. The factor may be correspondingly and individually adjusted based on the respective nutrient availability and is configured to take the presence of specific nutrients in the soil into consideration.

C_T is a temperature dependent coefficient which might be added to determine the vegetative potential growing rate, wherein the coefficient may be in particular limited to the range comprised between 0.0952 and 2,3 for the temperature ranges between 14 and 30 °C and may be adjusted for different species.

D , Y , n are further numbers which may be added to adapt the fertilization based on the plant density, planned or expected yield and number of productive stems. Coffee plants are usually actively pruned during growth and over years for rejuvenating by farmers, since old productive stems decay in production. As such, the farmers are aware of the average productive stems present in their farm and can be designated as a differentiating factor. Moreover, density data of the plantation is known by the farmers at planting time. Some of these factors can be automatically determined based on image data and/or remote imagery data. For example, based on the known location of the

agricultural field, remote imagery data can be analyzed to determine the plant density within the agricultural field. Further, an image of the plants may be processed to determine the number of productive stems per plant.

F_{BASIC} is the basic nutrient specific demand for a crop in productive crop stage, which is the sum of the vegetative and productive nutrient demand may take into account at least one of the influence of temperature, expected/planned yield, plant density in the agricultural field and number of productive stems.

Once the total fertilizer demand has been determined, the method of the current disclosure may be configured in a further embodiment to determine the desired number of applications and the application date. Usually, depending on the crop growth stage and other determining factors like average air temperature and plant species, the number of applications may vary between 1 and 4. For example, in the southern regions of Colombia, crop cycles are between September and June of the following year, whereas in Mexico, usual crop cycles happen between April and February of the following year. The method of the current disclosure may be further configured to determine the number of applications based on farmer's input and according to crop phases split the total fertilizer demand amongst the different determined dates of fertilizer application.

According to the present disclosure, a device configured to carry out the method of the current application is envisaged. In the following passages, different embodiments of electronic devices, user interfaces for such devices and associated processes for using such devices are described. In some embodiments, the device is a portable communications device such as a mobile telephone, that also contains other functions, allowing the user to carry out the method of the current disclosure on site. It should also be understood that, in some embodiments, the device is not a portable communications device, but may as well be a desktop or a laptop computer.

In an embodiment, the electronic device may be a mobile or desktop device with a dedicated Graphical User Interface (GUI) to support and guide the user in the determination of the to be introduced factors for the fertilizer recommendation. In this embodiment, the electronic device may comprise input (e.g. a keyboard) and output (e.g. a display) means as generally known, which might as well be combined in the form of a touch sensitive touchscreen and the keyboard take the form of a virtual keyboard. However, other input means like a mouse are not excluded from the current disclosure.

The Graphical User Interface may be configured to display and receive user input of the different types of data and determine further inputs like the stage of the crop, vegetative or productive phase,

the desired number of applications, expected yield data or other yield related data from previous crops and further cues which improve the fertilizer recommendation as explained above.

As a start the user may be allowed to determine an agricultural field containing the coffee plantation from a plurality of his managed fields. This can be achieved by means of user input on a map interface or based on the device location, wherein the device may further determine the extent of the agricultural field based on remote imagery data by means of boundary detection algorithms. The device may be further configured to receive user input comprising field data from the agricultural field.

The device may be configured in further steps to receive the input regarding the crop development stage, the coffee species and variety of the plants present in the agricultural field or to receive it automatically from field data stored previously in the device.

The device may be further configured in a further step to determine the number of fertilizer applications. Based on the crop stage, crop location and other determining factors, it is a usual approach to space in time the fertilizer amount over several application.

In a further embodiment, the device may be configured to receive the expected or past yield data. The device may be configured to provide a range of allowable yield data based on the field data (e.g. the size of the farm) to guide the farmers and provide feedback of low, average and high yield potentials for the determined agricultural field. This is of further help for the farmers to evaluate the productivity of their plantation as well as providing boundaries to the values, improving the robustness of the introduced data.

In a further embodiment, the device may be configured to receive the number of productive stems present in the coffee plants of the agricultural field. Usually, the farmer decides how many productive stems the plants should have by means of appropriate pruning. The farmer may then input a fixed number of productive stems per plant for the whole agricultural field, or for different sub-areas of the agricultural field.

In a further embodiment, receiving the number of productive stems can further comprise obtaining the data from image data of a plant acquired by the farmers at the agricultural field. In this embodiment, the device may be further configured to process the image data and obtain automatically the number of productive stems of the pictured plant by means of image processing and determine the appropriate number of productive stems.

Figure 3 shows an example of a dedicated Graphical User Interface 1000, wherein at least one image 1100 is displayed with a displayed associated shadow condition factor 1200. The images to be

displayed may be configured to represent standard canopy types present in the region of the agricultural field or can be configured to receive data regarding the canopy type from user input. In an embodiment, the farmer can introduce canopy type data, which is then used by the electronic device to generate the image data to be displayed. Figure 3 shows a scenario which adapts as a function of the slider.

In a further embodiment, the electronic device is configured to determine the shadow condition based on user input. In this embodiment, the electronic device may display a plurality of images displaying different tree canopy forms with an associated shadow condition. In a further embodiment, the electronic device may be configured to display the at least one image of a tree canopy, such that a shadow condition (e.g. approx. 40%, 50% or the like) is associated with the at least one image of a tree canopy. The electronic device may further be configured to display a plurality of images of a tree canopy or a combination thereof. The user may then, based on at least one of the displayed images, determine a shadow condition. As such, the user is guided towards a meaningful input and is able of determining an appropriate shadow condition.

In a further embodiment, displaying at least one image of a tree canopy and determining the shadow condition based on a user input further comprises displaying a sliding bar 1300, wherein the sliding bar 1300 comprises a predetermined range and a cursor which can be freely moved along the sliding bar 1300. The user, upon providing an input on the sliding bar 1300 is then able of displacing the cursor along the sliding bar. In this embodiment, the device may be further configured to display one of the plurality of images based on the position of the cursor on the slider. Following this embodiment, the user is provided with a continuously guided interaction which improves the shadow condition determination. Based on the gradual change of the displayed image, the user is in a better place to judge and determine the image which best displays the shadow condition of the agricultural field, as it can be seen in Figure 3.

In a further embodiment, the electronic device may be further configured to receive image data from a picture taken by the farmers of the surrounding vegetation to determine the canopy type and/or the shadow condition.

In a further embodiment, the electronic device 100 may be further configured to receive position information together with the image data. By means of the determined position and orientation, the taken image can serve for a more precise determination of the shadow condition. Having determined position, based on the sun and earth relative position for the different seasons a shadow condition can be determined based on remote data, wherein the average shadow condition of the field over the different seasons can be determined.

In a further embodiment, the electronic device 100 may guide the farmers through different positions in the agricultural field in order to determine the shadow condition at different representative locations of the agricultural field. In this embodiment, the device may be further configured to determine at least one position 50 within the agricultural field 10 or in the vicinities and configured to display the at least one position by means of the display unit 140 by means of appropriate maps or navigation menus, as it can be seen in Figure 4. As such, the farmers may receive at least one position within or nearby the agricultural field where the shadow condition may be determined. Based on the shadow condition at the at least one position, a more complete shadow condition of the whole agricultural field may be achieved.

In a further embodiment, the at least one position determined by the device to provide a reliable shadow determination may be determined based on the shape and/or orientation of the agricultural field. Based on the location of the field, sun position at any given moment throughout the year can be determined. Hence, the shadow determination process may be improved by guiding the user as to the positions within the agricultural field which are convenient for the determination. The device may be further configured to determine an orientation or direction in which the shadow determination should be carried out.

In a further embodiment, the at least one position is further determined based on the relative position and orientation of the agricultural field. Through a suitable selection of relevant positions based on the relative position and orientation of the agricultural field, the number of positions where the sampling positions may be reduced, improving the amount of time needed for a full assessment of the field.

In a further embodiment, the electronic device may be further configured to receive the average air temperature information for the agricultural field as it is described in the following embodiments. In an embodiment, the electronic device may be further configured to receive elevation information (meters above sea level). In a further embodiment, the electronic device is configured to determine the location of the user by means of a GPS unit and based on the location of the user determine the altitude, which can be derived using satellite triangulation from a plurality of satellites, or by deriving the ground elevation from a global elevation map based on the location, and/or a pressure sensor. In a further embodiment, the electronic device may be further configured to receive weather data from the determined location. Based on the given weather data, the average air temperature can be adjusted based on the elevation information.

However, it should be understood that the device may receive the above-mentioned data by means of a communication unit, accessing farm and field data from a central repository which might have been built based on previous user inputted data or other existing databases.

In a further embodiment, the electronic device may be configured to wirelessly (or not) communicate with a crop nutrient measurement device like the N-Tester, providing calibration data for the fertilizer recommendation. Said crop nutrient measurement devices may provide a nutrient status from one or a plurality of plants, relating the nutrient status to chlorophyll levels or other indicators. As such, the fertilizer recommendation method may be further configured to adjust the recommendation based on a crop nutrient measurement reading.

While the present disclosure has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The disclosure is not limited to the described embodiments, versions or examples, which are included to enable a person having ordinary skill in the art to make and use the disclosure when combined with information and knowledge available to the person having ordinary skill in the art.

Accordingly, the detailed description thereof should not be construed as restrictive in all aspects but considered as illustrative. The scope of the disclosure should be determined by reasonable interpretation of the appended claims and all changes that come within the equivalent scope are included in the scope of the current disclosure.

The process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously, in parallel, or concurrently. Various methods described herein may be practiced by combining one or more machine-readable storage media containing the code according to the present disclosure with appropriate standard computer hardware to execute the code contained therein. An apparatus for practicing various embodiments of the present disclosure may involve one or more computers (or one or more processors within a single computer) and storage systems containing or having network access to computer program(s) coded in accordance with various methods described herein, and the method steps of the disclosure could be accomplished by modules, routines, subroutines, or subparts of a computer program product.

While the use of plural nouns has been preferred throughout the disclosure when referring to persons (the users, the farmers) in order to allow a gender-neutral drafting of the text, there is hereby no limitation intended as to the number of persons which the current disclosure should be considered related to. This has been carried out in light of the amendments to the guidelines entered in force on 1st of March 2021 supporting gender-neutrality and as an example for others.

Claims:

1.- A computer implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of:

- i. determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage;
wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

2.- A method according to claim 1, wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

3.- A method according to claim 1 or 2, wherein the method further comprises adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude data.

4.- A method according to any one of the preceding claims, wherein the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

5.- A method according to any one of the preceding claims, wherein the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

6.- A method according to any one of the preceding claims, wherein the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.

7.- A method according to claim 6, wherein determining a shadow condition of the agricultural field further comprises determining at least one position for the shadow determination to be carried out.

8.- A method according to any one of the preceding claims, wherein the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.

9.- A device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the claims 1 to 8.

10.- A device according to claim 9, configured to carry out the method according to claim 7, wherein the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.

11.- A device according to claim 9 or 10, wherein the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.

12.- A device according to claim 11, wherein the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.

13. A data processing apparatus comprising means for carrying out the method of any one of the claims 1 to 8.

14.- A computer-readable storage medium comprising instructions which, when executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 8.

15.- A computer program product comprising instructions which, when the program is executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 8.

Claims:

1.- A computer implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of:

- i. determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage;
wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data, wherein the method further comprises adjusting the vegetative demand by a temperature coefficient;
wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

2.- A method according to claim 1, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude data.

3.- A method according to any one of the preceding claims, wherein the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

4.- A method according to any one of the preceding claims, wherein the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

- 5.- A method according to any one of the preceding claims, wherein the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.
- 6.- A method according to claim 5, wherein determining a shadow condition of the agricultural field further comprises determining at least one position for the shadow determination to be carried out.
- 7.- A method according to any one of the preceding claims, wherein the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.
- 8.- A device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the claims 1 to 7.
- 9.- A device according to claim 8, configured to carry out the method according to claim 6, wherein the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.
- 10.- A device according to claim 8 or 9, wherein the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.
- 11.- A device according to claim 10, wherein the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.
12. A data processing apparatus comprising means for carrying out the method of any one of the claims 1 to 7.
- 13.- A computer-readable storage medium comprising instructions which, when executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 7.
- 14.- A computer program product comprising instructions which, when the program is executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 7.



(51) International Patent Classification:
A01C 21/00 (2006.01)

(21) International Application Number:
PCT/EP2022/081068

(22) International Filing Date:
08 November 2022 (08.11.2022)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
21208031.1 12 November 2021 (12.11.2021) EP

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(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
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TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, CV,
GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

(54) Title: METHOD AND DEVICE FOR A FERTILIZER RECOMMENDATION FOR COFFEE

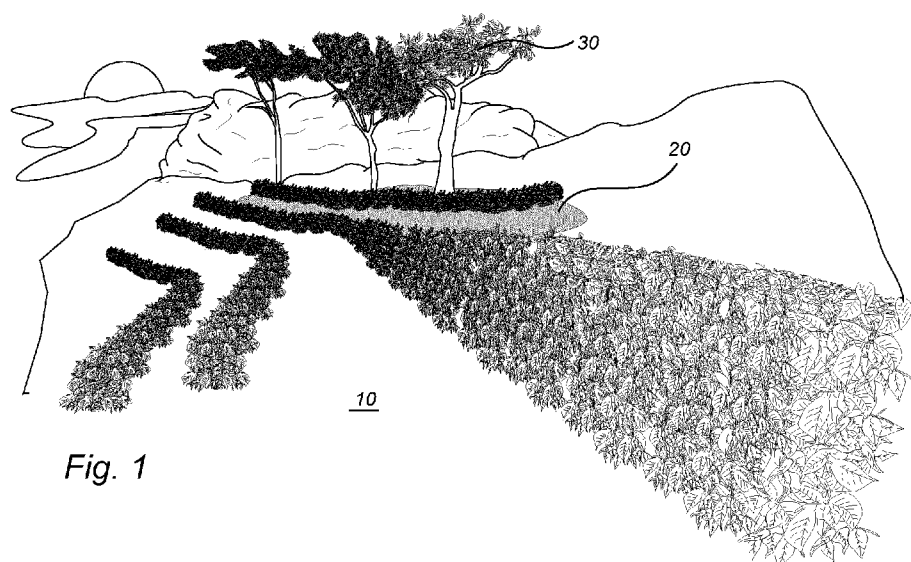


Fig. 1

(57) Abstract: The present invention relates to a computer-implemented method for determining a fertilizer recommendation specific to coffee plants, wherein the method comprises a vegetative and a productive demand and different adjustment factors. A device for the implementation of the method is envisaged, by means of which the determination of the different factors is enabled and improved.



LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI,
SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed
contained color or greyscale and is available for download
from PATENTSCOPE*

Method and Device for a fertilizer recommendation for Coffee

Technical field

The present disclosure relates to the field of agriculture and aims at providing a specific fertilizer recommendation for coffee plantations.

Background

The approaches described in this section are approaches that could be pursued, but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be assumed that any of the approaches described in this section qualify as prior art merely by virtue of their inclusion in this section.

Determining the appropriate amount of fertilizer a crop needs is one of the most important decisions a farmer will encounter. A deficit in nitrogen will reduce yield, while an excess will produce economic losses and damage the environment. A deficit and/or unbalance of other nutrients will lead to yield losses, crop defects and reduced crop quality. This is of greater importance with higher value crops, like coffee. The genus *Coffea* comprises more than 120 perennial species. The two most popular are *Coffea arabica* (known as “Arabica”) and *canephora* (known as “Robusta”) and are cultivated in over 70 countries, mainly in the equatorial regions of Central and South America, Africa and South-East Asia and their seeds, called coffee beans, are used to flavor beverages and products across the globe. Coffee is one of the world’s most valuable commodity crops, but the majority of coffee plantations are smallholders with little access to modern agriculture technologies to improve their yield.

Usually, coffee production may take place in agroforestry systems, wherein other plants and trees are intercropped with the coffee plants to provide shade and other advantages in general such as increasing local biodiversity, erosion reduction, improvement of water storage in soils and the like, all these improving the farmers income. Depending on the species, coffee may be cultivated in regions located at altitudes ranging from sea level to 2000 m. While temperatures below 7 °C and above 33 °C reduce production and bean size and brew quality, optimal mean temperatures are comprised between 15-25 °C and their fertilizer needs should be conveniently adjusted for these and other factors.

Known approaches for the determination of a fertilizer recommendation are based on detailed chemical analysis from soil and plant tissues and specific measurements of the coffee plants yield

and size. An example of such an approach can be found in BR102019002078 A2, wherein the method includes different steps comprising the harvest of the fruit and the subsequent processing for a chemical analysis. Document US 9652840 B1 discloses a method and system for managing nitrogen applied by a nitrogen application equipment determining a growth stage for the geographic region using a crop module.

It is therefore the aim of the current application to achieve a method and device for determining a nutrient specific fertilizer recommendation for coffee plants which support the farmers in their decision making. Further embodiments comprising an agricultural apparatus to carry out the fertilization recommendation are included within the scope of the current application.

SUMMARY OF THE INVENTION

The present disclosure aims at providing a quick and accurate fertilizer recommendation for coffee cultivation which does not require the lengthy process steps required by a chemical analysis of the plant and which takes into consideration several different factors for the plant growth and the nutrients absorption like average air temperature and shade conditions.

According to a first aspect of the present disclosure, this and other objectives are achieved by means of a computer-implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage; wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative stage and the basic demand is based on the sum of a vegetative and a productive demand if the plantation is on a productive stage, wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

Following this approach, a specific fertilizer recommendation based on the different growth stages of a plant is achieved.

According to a further embodiment, determining the productive demand comprises receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

Following this approach, the fertilizer recommendation is adapted to the yield and plant species of the agricultural field.

According to a further embodiment, the method further comprises adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude.

Following this approach, the fertilizer recommendation is adapted to the temperature.

According to a further embodiment, the method further comprises receiving an average air temperature of the agricultural field from weather data and adjusting the average air temperature based on the altitude of the agricultural field.

Following this approach, a more precise determination of the temperature compensation is achieved.

According to a further embodiment, the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

Following this approach, the specific demands of the plants based on the number of productive stems is achieved.

According to a further embodiment, the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

Following this approach, additional boundary conditions can be taken into consideration.

According to a further embodiment, the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.

Following this approach, the fertilizer recommendation is adapted to the shade conditions of the agricultural field.

According to a further embodiment, the method further comprises determining at least one position for the shadow determination to be carried out.

Following this approach, the shade conditions of the field are more accurately determined.

According to a further embodiment, the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.

Following this approach, the fertilizer recommendation is adapted to the existing nutrients on the field.

According to a further embodiment, a device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the previous embodiments is envisaged to allow the user to carry out the above-mentioned methods.

According to a further embodiment, the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.

Following this approach, the user can obtain a reliable determination of the shadow condition.

According to a further embodiment, the device may determine at least one position and display the at least one position by means of the display unit for the user to carry out the shadow determination.

According to a further embodiment, the at least one position determined by the device to provide a reliable shadow determination may be determined based on the agricultural field.

According to a further embodiment, the at least one position is further determined based on the relative position and orientation of the agricultural field.

Following these approaches, a more reliable determination of the shadow condition is achieved and the number of positions to be sampled are reduced

According to a further embodiment, the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.

Following this approach, the user is provided with a reliable determination of the altitude of the agricultural field.

According to a further embodiment, the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.

Following this approach, a reliable temperature adjustment for the fertilizer recommendation is achieved.

According to further embodiments, a data processing apparatus, a computer-readable storage medium and a computer program product configured to carry out the above discussed methods are envisaged within the present disclosure.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings, which are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain the principles of the disclosure.

Figure 1 shows an example of a coffee plantation with some of the considered features of importance for the current disclosure.

Figure 2 describes a device according to one of the main embodiments of the current disclosure.

Figure 3 shows an embodiment of the Graphical User Interface showing an image to determine the shadow factor.

Figure 4 shows another embodiment of the Graphical User Interface, wherein a plurality of positions for determining the shadow factor are shown.

Figure 5 shows a flowchart of a method according to an embodiment of the current disclosure.

The accompanying drawings are used to help easily understand the technical idea of the present disclosure and it should be understood that the idea of the present disclosure is not limited by the accompanying drawings. The idea of the present disclosure should be construed to extend to any alterations, equivalents and substitutes beside the accompanying drawings.

DETAILED DESCRIPTION

The terms "comprising", "comprises" and "comprised of" as used herein are synonymous with "including", "includes" or "containing", "contains", and are inclusive or open-ended and do not exclude additional, non-recited members, elements or method steps. It will be appreciated that the terms "comprising", "comprises" and "comprised of" as used herein comprise the terms "consisting of", "consists" and "consists of".

The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

The term "about" or "approximately" as used herein when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/- 10% or less, specifically +/-5% or less, more specifically +/-1% or less, and still more specifically +/-0.1% or less of and from the specified value, insofar such variations are appropriate to perform in the disclosed application. It is to be understood that the value to which the modifier "about" or "approximately" refers is itself also specifically disclosed.

Whereas the terms "one or more" or "at least one", such as one or more or at least one member(s) of a group of members, is clear per se, by means of further exemplification, the term encompasses inter alia a reference to any one of said members, or to any two or more of said members, such as, e.g., any ≥ 3 , ≥ 4 , ≥ 5 , ≥ 6 or ≥ 7 etc. of said members, and up to all said members.

Unless otherwise defined, all terms used in disclosing the application, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this application belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present application.

In the following passages, different aspects of the application are defined in more detail. Each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present application. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to a person skilled in the art from this disclosure, in one or more embodiments. Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the application, and form different embodiments, as would be understood by those in the art. For example, in the appended claims, any of the claimed embodiments can be used in any combination.

In the present description of the application, parenthesized or emboldened reference numerals affixed to respective elements merely exemplify the elements by way of example, with which it is not intended to limit the respective elements. It is to be understood that other embodiments may be used and structural or logical changes may be made without departing from the scope of the present

application. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present application is defined by the appended claims.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise.

The use of the expression "at least" or "at least one" suggests the use of one or more elements, as the use may be in one of the embodiments to achieve one or more of the desired objects or results.

Figure 1 shows a schematic representation of coffee plantations in agroforestry systems, wherein an agricultural field 10 is shown with the usual tree canopy forms 30 creating a resulting shade region 20 for illustration purposes. Usually, farmers would determine their practices based on previous experiences without consideration of external factors. Moreover, usual fertilizer products present a fixed ratio of macro- and micro-nutrients which renders difficult a proper fine tuning according to the optimal dosage of nutrients. The law of the minimum, developed by Justus von Liebig and based upon work by the botanist Carl Sprengel, states that plant growth is related to the most limiting nutrient. Amongst the most important nutrients for agricultural purposes Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca) and Sulfur (S) are part of the macronutrients needed for plant development. Other elements like Sodium (Na), iron (Fe), Manganese (Mn), Boron (B), Copper (Cu), Molybdenum (Mo), and Zinc (Zn) are considered micronutrients due to their usual lower concentration present in plant tissues. As such, the lack or incorrect dosage of any of the above-mentioned nutrients has a detrimental influence towards the development of crops and their yield production.

Several factors influence the correct recommendation of nutrients for a correct fertilization. For example, soil, water availability, weather and other parameters have a direct influence in the uptake of nutrients. In the case of Coffee, some specific factors related to the coffee plant, and environmental parameters derived from the boundary conditions present in the production system can be considered of special importance. For example, the number of productive stems has been found to have a direct linear relationship for the vegetative fertilizer demand of coffee plants; temperature conditions have a direct relation to the vegetative demand, whereas shade conditions have a direct influence in the total amount of nutrients needed. While the specific nutrient demand might be different with respect to the individual nutrients, thanks to the nutrient specific approach of the current disclosure a balanced and optimized nutrient recommendation can be achieved.

Within the present disclosure, a nutrient specific adjustment or correction refers to variations on the

fertilizer recommendation carried out for different nutrients, i.e. corrections or adjustments are different for each specific nutrient.

Figure 2 shows an example of a device 100 according to the present disclosure. Device 100 may comprise several components such as a memory unit 110, a processor 120, a wired/wireless communication unit 130, a localization unit 180 (including GPS and orientation means like a compass), and an input/output unit 140 which will be further described below.

The method of the current disclosure comprises receiving data related to the agricultural field where the coffee plantation is located. For the main embodiment of the present disclosure, receiving data of the plantation comprises receiving at least plant density data, plant species, growth stage data and expected or past season's yield data.

Different embodiments are envisaged for the provision of the field and crop data. In an embodiment, the farmers may provide the data by means of a dedicated interface. However, the computer implemented method of the current disclosure may further comprise receiving field and crop data from a remotely situated server or from locally accessible memory units.

Device 100 may comprise an agricultural recommendation engine 220 to which the system may be remotely connected by means of the communication unit 130, may it be of a remote nature. In this case, the agricultural recommendation engine 220 may be represented by a computer, a remotely accessible server, other client-server architectures or any other electronic devices usually encompassed under the term data processing apparatus. Device 100 can be represented as well by a laptop computer or handheld device, with an integrated agricultural recommendation engine 150 which can be fully operated at the farm's location and may comprise a GPS unit or any other suitable localization means 180.

It is to be understood that the presence of remote and integrated recommendation engines are not mutually excluding. Integrated agricultural recommendation engine 150 can be a local copy of remote agricultural recommendation engine 220 or a light version of it to support periods of low network connectivity and offline work. Device 100 and remote or integrated agricultural recommendation engine may comprise field and farm data and external data and/or be configured to receive said data, whereby external data comprises weather data, satellite imagery data and further data provided by weather forecast providers or other third parties. Field data may comprise amongst others current and past data of at least one of the following: field and geographic identifiers regarding the geometry of the boundaries of the agricultural field, including the presence of areas within the agricultural field which are not managed, topographic data, crop identifiers (crop variety and type, crop growth stage, planting data and date, plant nutrition and health status) of current and

past crops, harvest data (yield, value, product quality, estimated or recorded historic values), soil data (nutrient availability, soil type, pH, soil organic matter (SOM) and/or cation exchange capacity, CEC). Farm data may comprise further data regarding to planned and past tasks like field maintenance practices and agricultural practices, fertilizer application data, pesticide application data, irrigation data and other field reports as well as historic series of the data, allowing the comparison of the data with past data, and the processing of further administrative data like work shifts, logs and other organizational data. Planned and past tasks may comprise further activities like surveillance of plants and pests, application of pesticides, fungicides or crop nutrition products, measurements of at least one farm or field parameter, maintenance and repair of ground hardware and other similar activities.

The device 100 may be configured to receive and/or retrieve soil data from available online soil databases like SoilGrids from the World Soil Information, SSURGO (Soil Survey Geographic Database from the United States Department of Agriculture) or any similar soil data repository, as well as by means of user input. Soil data may be used directly in the fertilization recommendation if a nutrient content is available in the accessed data repositories, but may be as well used for the adapting the recommendation and/or planning of the fertilizer application based on other soil data (e.g. soil texture and/or moisture may be taken into consideration when determining a variable fertilizer application and/or the optimum number of application and the respective amounts).

Device 100 may be further configured to receive any of the above mentioned data and further field data from a predetermined number of locations within or nearby the analyzed region, inputted manually by the farmers by means of the input/output unit 140 or received by the communication unit 130 from dedicated sensors 270. Further, device 100 and agricultural recommendation engine 150 or 220 may be configured to receive weather data from nearby weather stations 260 and/or external crop/farm sensors or sensing devices 270, as well as by means of the input/output unit 140. Nearby weather stations 260 and/or external crop/farm sensors 270 are configured to communicate via one or more networks. In another embodiment, weather data is provided by external weather forecast companies. Weather data may further include present and past series of data of the at least one of the following: temperatures (e.g. average, minima and maxima), accumulated precipitation, relative humidity, wind speed, solar radiance, accumulated sun hours, as well as forecasts, etc.

Device 100 may further be operatively connected to an agricultural apparatus 300. Examples of agricultural apparatus 300 include tractors, combines, harvesters, planters, trucks, fertilizer equipment, and any other item of physical machinery or hardware, typically mobile machinery, and which may be used in tasks associated with agriculture. In one embodiment, device 100 may be

configured to communicate with the agricultural apparatus 300 by means of wireless networks in order to set a variable rate application prescription for the determined crop, or alternatively, to determine the measurement region as indicated destination. Device 100 may be further configured to produce a machine-readable script file for the agricultural apparatus to carry out the fertilizer application.

The method of the current application comprises therefore determining a fertilizer recommendation or demand for coffee plants based on the received data. In a main embodiment, receiving data 3000 may comprise receiving plant species and plant density data of the at least one coffee plantation present in the agricultural field together with a crop growth stage data, wherein the crop growth stage data defines 3100 a vegetative crop stage or a productive crop stage, wherein the method comprises determining a basic demand for the plantation and the basic demand is based on a vegetative demand if the crop is in a vegetative stage 3200 and the basic demand is based on the sum of a vegetative demand and a productive demand if the crop is in a productive growth stage 3300, wherein the vegetative demand is based on the plant density and a nutrient specific vegetative demand factor based on the plant species data. The method of the current application may further comprise an adjustment step 3400 of the fertilizer recommendation and/or determining 3500 the application of the fertilizer recommendation.

In a further embodiment, the method may comprise receiving yield data and determining the productive demand based on the yield data and a nutrient specific productive demand factor.

In a further embodiment, the method may further comprise adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data or an average air temperature of the agricultural field and wherein the temperature coefficient is determined based on the average average air temperature or the altitude. With elevation, usual temperatures and air density changes the dynamics of nutrient acquisition and crop development and such an adjustment improves the fertilizer recommendation.

In a further embodiment, the method further comprises receiving an average air temperature of the agricultural field from weather data and adjusting the average air temperature based on the altitude of the agricultural field. Due to the usual cultivation of coffee in hills and mountain regions, the fertilizer demand may be conveniently adjusted on the altitude of the agricultural field and the weather data. In this case, local weather data can be precisely refined due to the variations of temperature with the altitude.

In a further embodiment, the method further comprises receiving the number of productive stems of the plants present in the plantation in the agricultural field and the vegetative demand is further adjusted based on the number of productive stems.

In a further embodiment, the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining an efficiency factor may further comprise receiving at least one of fertilizer product data, or weather data or soil data from the agricultural field and the efficiency factor is determined based on the at least one of the fertilizer product data, weather or soil data. Fertilizer efficiency is determined by several factors: based on the fertilizer product data, volatility of the compounds forming the fertilizer can be taken into account. Further influencing factors like soil moisture and weather data can be included in the determination by themselves or in combination with the product data. For example, precipitation influences the amount of leeching which nitrogen in the soil may be subjected to. It is specially to be remarked that leeching is a nitrogen specific chemical process and therefore only related to the nitrogen efficiency factor. Moreover, leeching may occur at different rates depending on the soil type and texture. For example, sandy soils have less water retention and increase leeching. Hence, the efficiency factor may be further adjusted based on soil data.

In a further embodiment, the method further comprises determining a shadow condition and the basic demand is further adjusted based on the shadow condition as it will be made clear below.

As it will be clear from the equations below, a shadow condition may be represented by any factor or coefficient which takes the amount of shade per crop zone of at least an area of the agricultural field into consideration. Hence, a shadow dependent factor or shadow dependent coefficient which adjusts the values of the fertilizer requirements is included in the equations and is determined based on the shadow condition, wherein the shadow dependent factor or shadow dependent coefficient may be a scaling factor of appropriate value as defined below. For illustration, in one of the embodiments, the shadow dependent factor has been defined as a value between 0 and 1 as a function of the percentage of the shadow condition.

It should be noted that the terms “shadow dependent factor” used herein may be referred to as “shadow factor”. Similarly, the terms “shadow dependent coefficient” may be referred to as “shadow coefficient”.

In a further embodiment, the method further comprises receiving soil data and the total nutrient demand is further adjusted based on a soil nutrient availability factor. Due to past farming management practices and the nature of the soils, a high variability in the availability of already existing nutrients is present. Farmers may have at their availability data from previous soil laboratory

analysis or data from dedicated soil sensors as well as from field data already stored. Based on the nutrient availability data, a soil nutrient availability factor is determined which takes into consideration said variability.

As such, a mathematical expression comprising all described embodiments of the current disclosure for a coffee plantation in productive crop stage may be represented as follows:

$$F_T = \frac{C_{Shade} * C_{Soil}}{C_{EF}} * [F_{BASIC}];$$

wherein F_{BASIC} is determined according to the crop growth stage data. When the crop is in a vegetative crop stage, $F_{BASIC} = F_{VEG}$, whereas when the crop is in a productive stage, the basic demand is defined as $F_{BASIC} = F_{VEG} + F_{PROD}$, and whereby the vegetative and productive demand are defined as follows.

$$F_{VEG} = C_{VEG} * D * C_T * n$$

$$F_{PROD} = C_{PROD} * Y$$

wherein:

- F_T, F_{VEG}, F_{PROD} are the demand of nutrients (kg/ha),;
- C_{Shade} is a shadow dependent coefficient;
- C_{EF} is a nutrient specific efficiency factor;
- C_{VEG} is the nutrient specific vegetative demand factor (kg/plant/year);
- D is the density of plants in the farm (plants/ha);
- C_T is a temperature dependent coefficient adjusting the vegetative potential growing rate;
- n is the number of productive stems present per plant in the plantation;
- C_{PROD} is the nutrient specific productive demand factor, based on specific variety and/or species data;
- Y is an expected yield value for the current season (kg/ha);
- C_{Soil} is a nutrient specific correction factor based on the in-soil availability of nutrients;

The above displayed equation may be expressed in a scalar way for each independent nutrient or matrix-wise by a vector comprising the at least one of the different nutrients of importance in the fertilization of coffee. For example, in a non-limiting example, the nutrient specific factors and demands may comprise rows for at least one of the following nutrients: N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu or equivalent components acting as carriers of the nutrients like P_2O_5 , K_2O , CaO , MgO .

C_{Shade} represents a shadow dependent factor or shadow dependent coefficient which may be added to take into consideration the effect of the sun conditions on the crop, wherein the factor takes the value 0 when the shadow coverage of the crop is >60%, is 1 if the shadow coverage is <20% and takes values in between. In a further embodiment the shadow dependent factor may be preferably determined between said 20% and 60% by means of an equation with a negative quadratic term and a positive linear term based on the percentage of shadow interpolating the boundary values of 0 and 1 at 20 and 60%.

F_{VEG} and F_{PROD} are plant species dependent nutrient specific coefficients which account for the vegetative and productive demand, which may be defined as follows for the vegetative demand (kilograms of nutrient / plant / year):

Nutrient	Demand Factor
	kg/plant/year
	Robusta
N	0,01
P	0,0027
K	0,018
Ca	0,01
Mg	0,0018
S	0,00018
Fe	0,00001
Mn	0,00036
B	0,0000018
Zn	5,4E-06
Cu	7,2E-06

and correspondingly for the productive demand.

C_{EF} is a nutrient specific efficiency factor which may be added to take into consideration the absorption efficiency of each of the nutrients (N, P, K, Ca, Mg, S, Fe, Mn, B, Zn, Cu) or equivalent components present in the fertilizer based on at least one of the fertilizer product data, soil data and/or weather data. For example, based on known product data the absorption efficiency for Nitrogen may be solely adjusted based on the product type (e.g. based on active component, like urea or product identification information, or coating type) or advantageously combined with weather data (e.g. Nitrogen is very susceptible to leeching and therefore precipitation data of

importance for determining the absorption efficiency). Hence, following the above representation, the nutrient specific efficiency factor may be represented as follows for a given product and weather and soil conditions, wherein the nutrient specific efficiency factors are comprised between 0 and 1.

Nutrient	Efficiency factor
N	0,75
P	0,3
K	0,75
Ca	0,6
Mg	0,75
S	0,9
Fe	0,9
Mn	0,6
B	0,6
Zn	0,9
Cu	0,9

C_{Soil} is a nutrient specific correction factor based on the in-soil availability of the nutrient which may be added, wherein the soil data from soil analysis may be inputted by the farmers or provided by soil sensors or suitable field data, as mentioned above. Based on the respective availability of each specific nutrient, a correction factor for each nutrient can be generated, wherein the factor may be comprised, in particular, between 0.3 and 1.15. The factor may be correspondingly and individually adjusted based on the respective nutrient availability and is configured to take the presence of specific nutrients in the soil into consideration.

C_T is a temperature dependent coefficient which might be added to determine the vegetative potential growing rate, wherein the coefficient may be in particular limited to the range comprised between 0.0952 and 2,3 for the temperature ranges between 14 and 30° C and may be adjusted for different species.

D , Y , n are further numbers which may be added to adapt the fertilization based on the plant density, planned or expected yield and number of productive stems. Coffee plants are usually actively pruned during growth and over years for rejuvenating by farmers, since old productive stems decay in production. As such, the farmers are aware of the average productive stems present in their farm and can be designated as a differentiating factor. Moreover, density data of the plantation is known by the farmers at planting time. Some of these factors can be automatically determined based on image data and/or remote imagery data. For example, based on the known location of the

agricultural field, remote imagery data can be analyzed to determine the plant density within the agricultural field. Further, an image of the plants may be processed to determine the number of productive stems per plant.

F_{BASIC} is the basic nutrient specific demand for a crop in productive crop stage, which is the sum of the vegetative and productive nutrient demand may take into account at least one of the influence of temperature, expected/planned yield, plant density in the agricultural field and number of productive stems.

Once the total fertilizer demand has been determined, the method of the current disclosure may be configured in a further embodiment to determine the desired number of applications and the application date. Usually, depending on the crop growth stage and other determining factors like average air temperature and plant species, the number of applications may vary between 1 and 4. For example, in the southern regions of Colombia, crop cycles are between September and June of the following year, whereas in Mexico, usual crop cycles happen between April and February of the following year. The method of the current disclosure may be further configured to determine the number of applications based on farmer's input and according to crop phases split the total fertilizer demand amongst the different determined dates of fertilizer application.

According to the present disclosure, a device configured to carry out the method of the current application is envisaged. In the following passages, different embodiments of electronic devices, user interfaces for such devices and associated processes for using such devices are described. In some embodiments, the device is a portable communications device such as a mobile telephone, that also contains other functions, allowing the user to carry out the method of the current disclosure on site. It should also be understood that, in some embodiments, the device is not a portable communications device, but may as well be a desktop or a laptop computer.

In an embodiment, the electronic device may be a mobile or desktop device with a dedicated Graphical User Interface (GUI) to support and guide the user in the determination of the to be introduced factors for the fertilizer recommendation. In this embodiment, the electronic device may comprise input (e.g. a keyboard) and output (e.g. a display) means as generally known, which might as well be combined in the form of a touch sensitive touchscreen and the keyboard take the form of a virtual keyboard. However, other input means like a mouse are not excluded from the current disclosure.

The Graphical User Interface may be configured to display and receive user input of the different types of data and determine further inputs like the stage of the crop, vegetative or productive phase,

the desired number of applications, expected yield data or other yield related data from previous crops and further cues which improve the fertilizer recommendation as explained above.

As a start the user may be allowed to determine an agricultural field containing the coffee plantation from a plurality of his managed fields. This can be achieved by means of user input on a map interface or based on the device location, wherein the device may further determine the extent of the agricultural field based on remote imagery data by means of boundary detection algorithms. The device may be further configured to receive user input comprising field data from the agricultural field.

The device may be configured in further steps to receive the input regarding the crop development stage, the coffee species and variety of the plants present in the agricultural field or to receive it automatically from field data stored previously in the device.

The device may be further configured in a further step to determine the number of fertilizer applications. Based on the crop stage, crop location and other determining factors, it is a usual approach to space in time the fertilizer amount over several application.

In a further embodiment, the device may be configured to receive the expected or past yield data. The device may be configured to provide a range of allowable yield data based on the field data (e.g. the size of the farm) to guide the farmers and provide feedback of low, average and high yield potentials for the determined agricultural field. This is of further help for the farmers to evaluate the productivity of their plantation as well as providing boundaries to the values, improving the robustness of the introduced data.

In a further embodiment, the device may be configured to receive the number of productive stems present in the coffee plants of the agricultural field. Usually, the farmer decides how many productive stems the plants should have by means of appropriate pruning. The farmer may then input a fixed number of productive stems per plant for the whole agricultural field, or for different sub-areas of the agricultural field.

In a further embodiment, receiving the number of productive stems can further comprise obtaining the data from image data of a plant acquired by the farmers at the agricultural field. In this embodiment, the device may be further configured to process the image data and obtain automatically the number of productive stems of the pictured plant by means of image processing and determine the appropriate number of productive stems.

Figure 3 shows an example of a dedicated Graphical User Interface 1000, wherein at least one image 1100 is displayed with a displayed associated shadow condition factor 1200. The images to be

displayed may be configured to represent standard canopy types present in the region of the agricultural field or can be configured to receive data regarding the canopy type from user input. In an embodiment, the farmer can introduce canopy type data, which is then used by the electronic device to generate the image data to be displayed. Figure 3 shows a scenario which adapts as a function of the slider.

In a further embodiment, the electronic device is configured to determine the shadow condition based on user input. In this embodiment, the electronic device may display a plurality of images displaying different tree canopy forms with an associated shadow condition. In a further embodiment, the electronic device may be configured to display the at least one image of a tree canopy, such that a shadow condition (e.g. approx. 40%, 50% or the like) is associated with the at least one image of a tree canopy. The electronic device may further be configured to display a plurality of images of a tree canopy or a combination thereof. The user may then, based on at least one of the displayed images, determine a shadow condition. As such, the user is guided towards a meaningful input and is able of determining an appropriate shadow condition.

In a further embodiment, displaying at least one image of a tree canopy and determining the shadow condition based on a user input further comprises displaying a sliding bar 1300, wherein the sliding bar 1300 comprises a predetermined range and a cursor which can be freely moved along the sliding bar 1300. The user, upon providing an input on the sliding bar 1300 is then able of displacing the cursor along the sliding bar. In this embodiment, the device may be further configured to display one of the plurality of images based on the position of the cursor on the slider. Following this embodiment, the user is provided with a continuously guided interaction which improves the shadow condition determination. Based on the gradual change of the displayed image, the user is in a better place to judge and determine the image which best displays the shadow condition of the agricultural field, as it can be seen in Figure 3.

In a further embodiment, the electronic device may be further configured to receive image data from a picture taken by the farmers of the surrounding vegetation to determine the canopy type and/or the shadow condition.

In a further embodiment, the electronic device 100 may be further configured to receive position information together with the image data. By means of the determined position and orientation, the taken image can serve for a more precise determination of the shadow condition. Having determined position, based on the sun and earth relative position for the different seasons a shadow condition can be determined based on remote data, wherein the average shadow condition of the field over the different seasons can be determined.

In a further embodiment, the electronic device 100 may guide the farmers through different positions in the agricultural field in order to determine the shadow condition at different representative locations of the agricultural field. In this embodiment, the device may be further configured to determine at least one position 50 within the agricultural field 10 or in the vicinities and configured to display the at least one position by means of the display unit 140 by means of appropriate maps or navigation menus, as it can be seen in Figure 4. As such, the farmers may receive at least one position within or nearby the agricultural field where the shadow condition may be determined. Based on the shadow condition at the at least one position, a more complete shadow condition of the whole agricultural field may be achieved.

In a further embodiment, the at least one position determined by the device to provide a reliable shadow determination may be determined based on the shape and/or orientation of the agricultural field. Based on the location of the field, sun position at any given moment throughout the year can be determined. Hence, the shadow determination process may be improved by guiding the user as to the positions within the agricultural field which are convenient for the determination. The device may be further configured to determine an orientation or direction in which the shadow determination should be carried out.

In a further embodiment, the at least one position is further determined based on the relative position and orientation of the agricultural field. Through a suitable selection of relevant positions based on the relative position and orientation of the agricultural field, the number of positions where the sampling positions may be reduced, improving the amount of time needed for a full assessment of the field.

In a further embodiment, the electronic device may be further configured to receive the average air temperature information for the agricultural field as it is described in the following embodiments. In an embodiment, the electronic device may be further configured to receive elevation information (meters above sea level). In a further embodiment, the electronic device is configured to determine the location of the user by means of a GPS unit and based on the location of the user determine the altitude, which can be derived using satellite triangulation from a plurality of satellites, or by deriving the ground elevation from a global elevation map based on the location, and/or a pressure sensor. In a further embodiment, the electronic device may be further configured to receive weather data from the determined location. Based on the given weather data, the average air temperature can be adjusted based on the elevation information.

However, it should be understood that the device may receive the above-mentioned data by means of a communication unit, accessing farm and field data from a central repository which might have been built based on previous user inputted data or other existing databases.

In a further embodiment, the electronic device may be configured to wirelessly (or not) communicate with a crop nutrient measurement device like the N-Tester, providing calibration data for the fertilizer recommendation. Said crop nutrient measurement devices may provide a nutrient status from one or a plurality of plants, relating the nutrient status to chlorophyll levels or other indicators. As such, the fertilizer recommendation method may be further configured to adjust the recommendation based on a crop nutrient measurement reading.

While the present disclosure has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The disclosure is not limited to the described embodiments, versions or examples, which are included to enable a person having ordinary skill in the art to make and use the disclosure when combined with information and knowledge available to the person having ordinary skill in the art.

Accordingly, the detailed description thereof should not be construed as restrictive in all aspects but considered as illustrative. The scope of the disclosure should be determined by reasonable interpretation of the appended claims and all changes that come within the equivalent scope are included in the scope of the current disclosure.

The process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously, in parallel, or concurrently. Various methods described herein may be practiced by combining one or more machine-readable storage media containing the code according to the present disclosure with appropriate standard computer hardware to execute the code contained therein. An apparatus for practicing various embodiments of the present disclosure may involve one or more computers (or one or more processors within a single computer) and storage systems containing or having network access to computer program(s) coded in accordance with various methods described herein, and the method steps of the disclosure could be accomplished by modules, routines, subroutines, or subparts of a computer program product.

While the use of plural nouns has been preferred throughout the disclosure when referring to persons (the users, the farmers) in order to allow a gender-neutral drafting of the text, there is hereby no limitation intended as to the number of persons which the current disclosure should be considered related to. This has been carried out in light of the amendments to the guidelines entered in force on 1st of March 2021 supporting gender-neutrality and as an example for others.

Claims:

1.- A computer implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of:

- i. determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage;
wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

2.- A method according to claim 1, wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

3.- A method according to claim 1 or 2, wherein the method further comprises adjusting the vegetative demand by a temperature coefficient, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude data.

4.- A method according to any one of the preceding claims, wherein the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

5.- A method according to any one of the preceding claims, wherein the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

- 6.- A method according to any one of the preceding claims, wherein the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.
- 7.- A method according to claim 6, wherein determining a shadow condition of the agricultural field further comprises determining at least one position for the shadow determination to be carried out.
- 8.- A method according to any one of the preceding claims, wherein the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.
- 9.- A device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the claims 1 to 8.
- 10.- A device according to claim 9, configured to carry out the method according to claim 7, wherein the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.
- 11.- A device according to claim 9 or 10, wherein the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.
- 12.- A device according to claim 11, wherein the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.
13. A data processing apparatus comprising means for carrying out the method of any one of the claims 1 to 8.
- 14.- A computer-readable storage medium comprising instructions which, when executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 8.
- 15.- A computer program product comprising instructions which, when the program is executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 8.

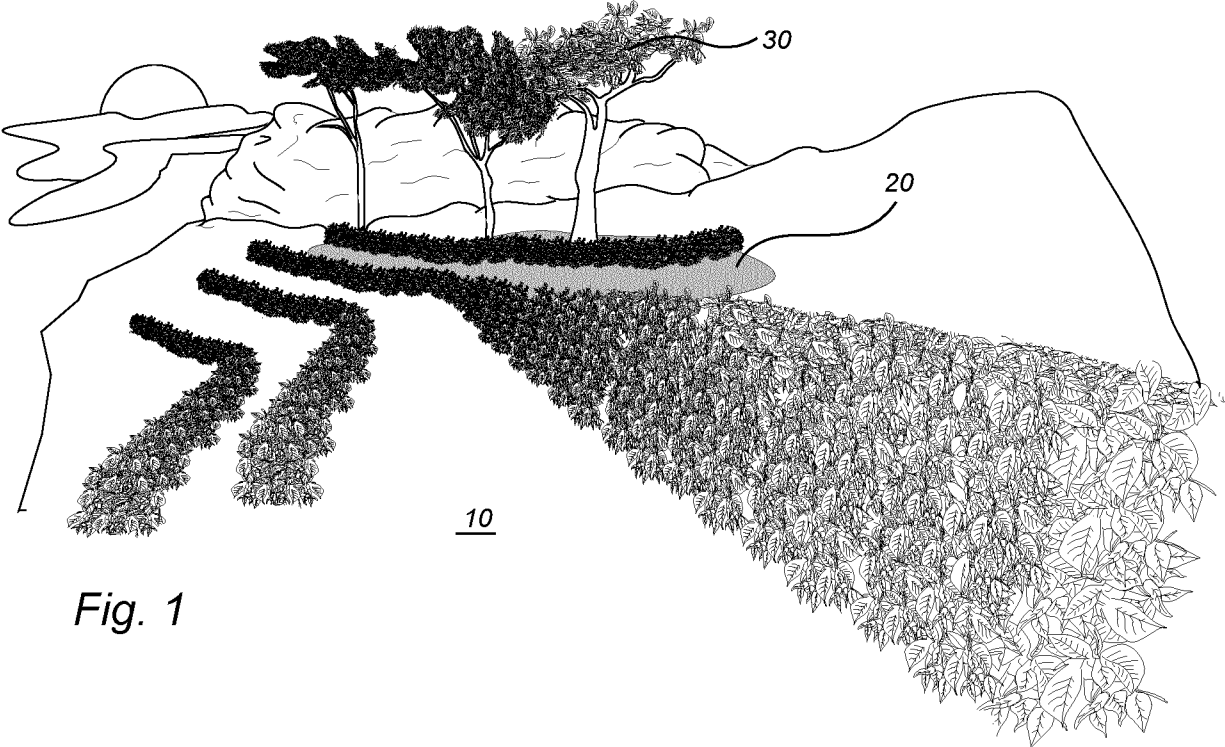


Fig. 1

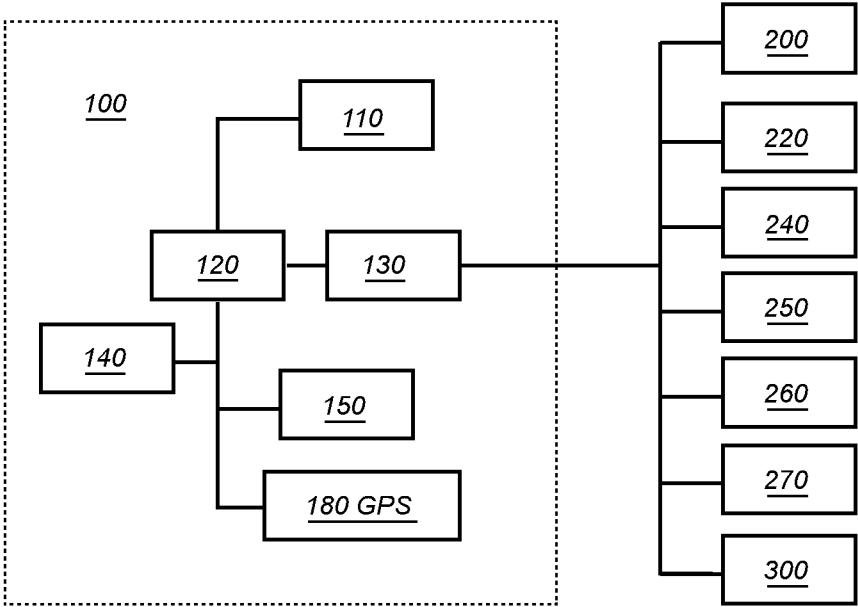


Fig. 2

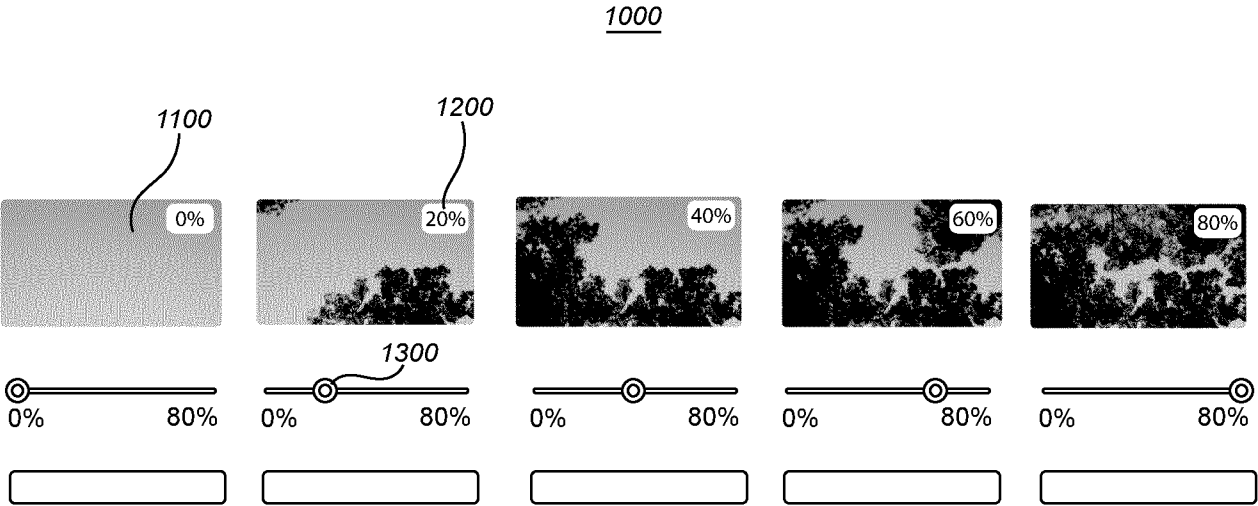


Fig. 3

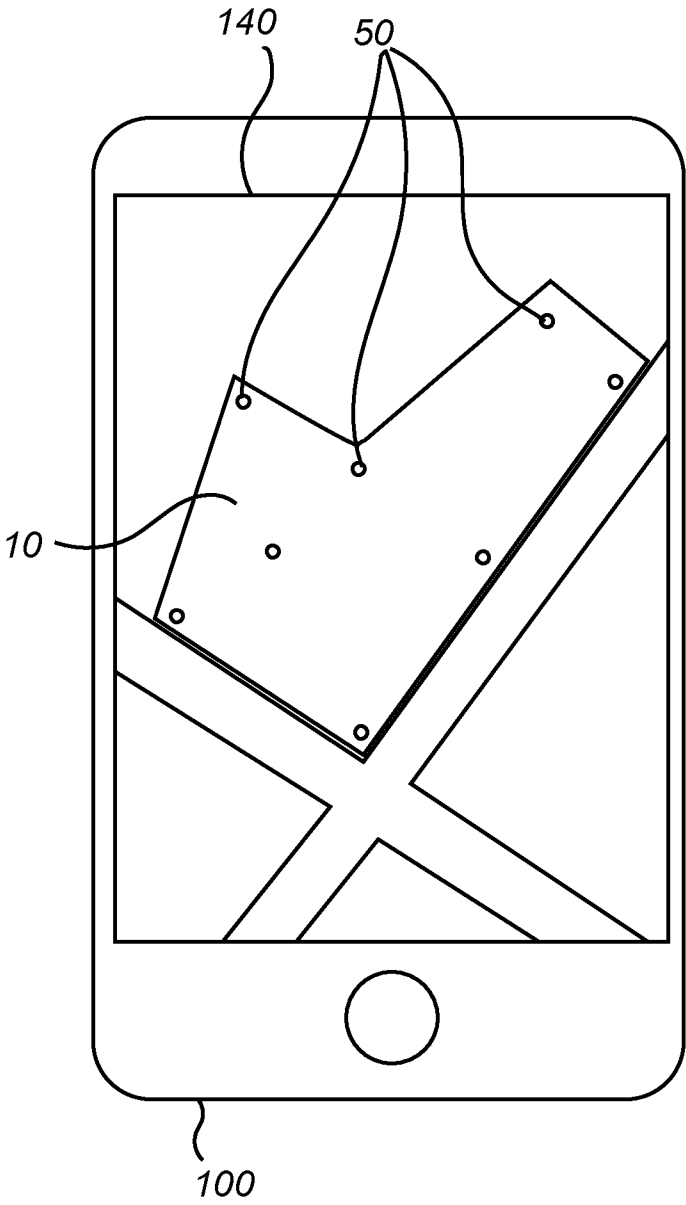
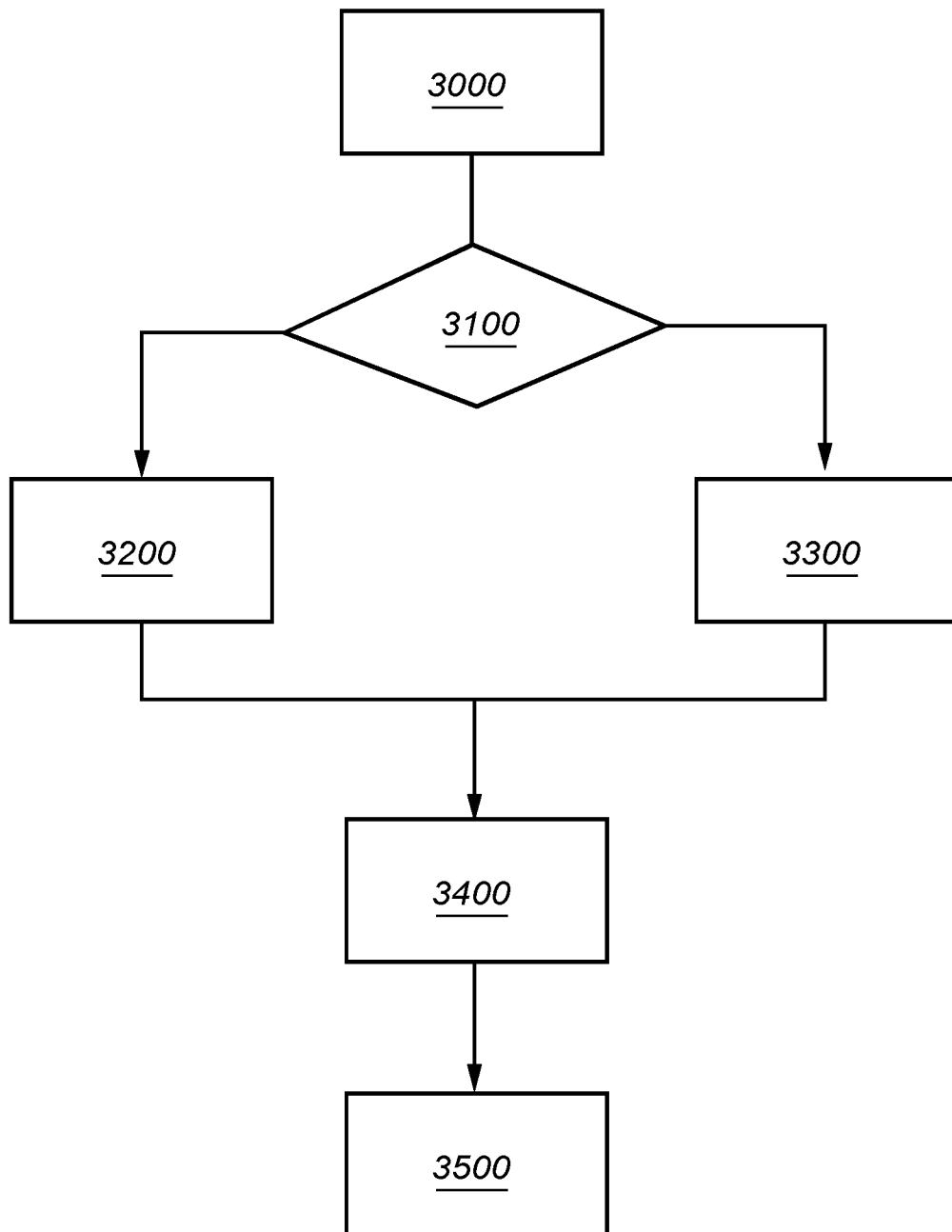


Fig. 4

*Fig. 5*

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/081068

A. CLASSIFICATION OF SUBJECT MATTER

INV. A01C21/00

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 9 652 840 B1 (SHRIVER JOHN [US] ET AL) 16 May 2017 (2017-05-16) abstract column 5, line 24 - line 67 column 6, line 1 - line 46 column 9, line 43 - line 60 column 12, line 10 - line 27 column 14, line 58 - line 67 column 15, line 1 - line 55 column 25, line 51 - line 64 claims; figures ----- -/--	1-5, 8, 9, 11-15 6, 7, 10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

6 February 2023

Date of mailing of the international search report

14/02/2023

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2

NL - 2280 HV Rijswijk

Tel. (+31-70) 340-2040,

Fax: (+31-70) 340-3016

Authorized officer

Oltra García, R

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/081068

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017/147682 A1 (CROP PRODUCTION SERVICES INC [CA]) 8 September 2017 (2017-09-08) abstract page 1, paragraphs 1,4,5 page 2, paragraphs 7,8 page 5, paragraphs 31,32 claims; figures -----	1-15
A	US 3 990 181 A (DO VALLE FERNANDO RIBETRO) 9 November 1976 (1976-11-09) abstract column 4, line 41 - line 68 column 5, line 1 - line 3 claims; figures -----	1,13-15
A	GB 1 535 854 A (BARNES D; ANDERSONS PLANTATION PTY ET AL.) 13 December 1978 (1978-12-13) the whole document -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/081068

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9652840	B1	16-05-2017	US 9652840 B1 16-05-2017
			US 2017213083 A1 27-07-2017
			US 2018322344 A1 08-11-2018
			US 2019034726 A1 31-01-2019
			US 2022277561 A1 01-09-2022
WO 2017147682	A1	08-09-2017	CA 3016216 A1 08-09-2017
			US 2019059203 A1 28-02-2019
			WO 2017147682 A1 08-09-2017
US 3990181	A	09-11-1976	NONE
GB 1535854	A	13-12-1978	AU 497144 B2 30-11-1978
			GB 1535854 A 13-12-1978
			KE 3122 A 15-05-1981
			MY 8100326 A 31-12-1981
			NZ 180258 A 19-10-1981
			ZA 761330 B 27-04-1977

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 21136602	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/EP2022/081068	International filing date (<i>day/month/year</i>) 8 November 2022 (08-11-2022)	(Earliest) Priority Date (<i>day/month/year</i>) 12 November 2021 (12-11-2021)
Applicant YARA INTERNATIONAL ASA		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed
☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 1
☒ as suggested by the applicant
☐ as selected by this Authority, because the applicant failed to suggest a figure
☐ as selected by this Authority, because this figure better characterizes the invention
b. ☐ none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/081068

A. CLASSIFICATION OF SUBJECT MATTER INV. A01C21/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A01C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 9 652 840 B1 (SHRIVER JOHN [US] ET AL) 16 May 2017 (2017-05-16) abstract column 5, line 24 - line 67 column 6, line 1 - line 46 column 9, line 43 - line 60 column 12, line 10 - line 27 column 14, line 58 - line 67 column 15, line 1 - line 55 column 25, line 51 - line 64 claims; figures ----- -/--	1-5, 8, 9, 11-15 6, 7, 10
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
6 February 2023		14/02/2023
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Oltra García, R

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/081068

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017/147682 A1 (CROP PRODUCTION SERVICES INC [CA]) 8 September 2017 (2017-09-08) abstract page 1, paragraphs 1,4,5 page 2, paragraphs 7,8 page 5, paragraphs 31,32 claims; figures -----	1-15
A	US 3 990 181 A (DO VALLE FERNANDO RIBETRO) 9 November 1976 (1976-11-09) abstract column 4, line 41 - line 68 column 5, line 1 - line 3 claims; figures -----	1,13-15
A	GB 1 535 854 A (BARNES D; ANDERSONS PLANTATION PTY ET AL.) 13 December 1978 (1978-12-13) the whole document -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/081068

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9652840	B1	16-05-2017	US 9652840 B1 16-05-2017
			US 2017213083 A1 27-07-2017
			US 2018322344 A1 08-11-2018
			US 2019034726 A1 31-01-2019
			US 2022277561 A1 01-09-2022

WO 2017147682	A1	08-09-2017	CA 3016216 A1 08-09-2017
			US 2019059203 A1 28-02-2019
			WO 2017147682 A1 08-09-2017

US 3990181	A	09-11-1976	NONE

GB 1535854	A	13-12-1978	AU 497144 B2 30-11-1978
			GB 1535854 A 13-12-1978
			KE 3122 A 15-05-1981
			MY 8100326 A 31-12-1981
			NZ 180258 A 19-10-1981
			ZA 761330 B 27-04-1977

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

AWA Sweden AB
P.O. Box 45086
104 30 Stockholm
SUÈDE

PCT

WRITTEN OPINION OF THE INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY (PCT Rule 66)

Applicant's or agent's file reference 21136602		REPLY DUE within <u>2</u> month(s) from the above date of mailing
International application No. PCT/EP2022/081068	International filing date (day/month/year) 08.11.2022	Priority date (day/month/year) 12.11.2021
International Patent Classification (IPC) or both national classification and IPC INV. A01C21/00		
Applicant Yara International ASA		

- ☒ The written opinion established by the International Searching Authority:
☒ is ☐ is not
 considered to be a written opinion of the International Preliminary Examining Authority.
- This second opinion contains indications relating to the following items:
 - ☒ Box No. I Basis of the opinion
 - ☐ Box No. II Priority
 - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - ☐ Box No. IV Lack of unity of invention
 - ☒ Box No. V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - ☐ Box No. VI Certain documents cited
 - ☒ Box No. VII Certain defects in the international application
 - ☒ Box No. VIII Certain observations on the international application
- The applicant is hereby **invited to reply** to this opinion.
When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(e).
How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 55.3 and 66.8.
Also: For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4bis. For an informal communication with the examiner, see Rule 66.6. For an additional opportunity to submit amendments, see Rule 66.4.
If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.
- The final date by which the international preliminary report on patentability (Chapter II of the PCT) must be established according to Rule 69.2 is: 12.03.2024

Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016	Authorized Officer Oltra García, R Telephone No. +31 70 340-3734	
---	--	---

Box No. I Basis of the opinion

1. With regard to the **language** , this opinion has been established on the basis of:
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into ,
which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b)).
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a) and (b))
2. With regard to the elements of the international application, this opinion has been established on the basis of
(*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

Description, Pages

1-20 as originally filed

Claims, Numbers

1-14 filed in electronic form on 28-09-2023

Drawings, Sheets

1/5-5/5 as originally filed

- ☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
4. ☐ This opinion has been established as if (some of) the amendments listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
5. ☐ This opinion has been established:
- ☐ taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 66.1(d-bis)).
 - ☐ without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 66.4bis).

6. ☐ Supplementary international search report(s) from Authority(ies) have been received and taken into account in drawing up this opinion (Rule 45*bis*.8(b) and (c)).

Box No. V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	No:	Claims
Inventive step (IS)	No:	Claims 1-14
Industrial applicability (IA)	No:	Claims

2. Citations and explanations:

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1: US 9 652 840 B1 (SHRIVER JOHN [US] ET AL) 16 May 2017

D2: WO 2017/147682 A1 (CROP PRODUCTION SERVICES INC [CA]) 8 September 2017

D3: US 3 990 181 A (DO VALLE FERNANDO RIBETRO) 9 November 1976

D4: GB 1 535 854 A (BARNES D; ANDERSONS PLANTATION PTY ET AL.) 13 December 1978

2 As an introductory note, the applicant has filed a new version of the claims incorporating into claim 1 the features of original claim 2 plus part of the features of original claim 3, referring to the use of a temperature coefficient for adjusting the vegetative demand.

However, the remaining features of original claim 3, referring to how this temperature coefficient is determined, have been omitted in claim 1 and are now new claim 2. In his letter of reply the applicant does not provide arguments supporting the allowability of this intermediate generalisation. At this stage there is doubt concerning the allowability of this amendment, as if the patentability would be based on the use of such temperature coefficient for adjustment of the vegetative demand, it can be argued that said features are essential for the invention as they are specific for coffee plantations, and no other examples are mentioned in the description.

In the arguments presented below, this authority explains that this feature cannot support the presence of an inventive step, and hence it has been considered that such allowability objection is not applicable. However, if this feature becomes relevant for supporting the presence of an inventive step, the applicant is advised to provide a careful argumentation for the allowability of such an intermediate generalisation.

- 3 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.
- 4 Document D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses:
- A computer implemented method (see column 25, lines 51-64) for determining a fertilizer recommendation for ~~coffee~~ plants (nitrogen prescription), wherein the method comprises the steps of:
 - i. determining an agricultural field (see column 2, lines 24-35: "geographic region" or "field"; see also step "a" of claim 1) wherein at least one ~~coffee~~ plantation (crop) is comprised, receiving plant density data of the at least one ~~coffee~~ plantation (column 6, lines 47-56: "seed density" and "crop density"), receiving plant species data (implicit, crop species must be known) and crop growth stage data (column 6, lines 33-46; see also step "b" of claim 1) of the at least one ~~coffee~~ plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage (see column 14, line 58 to column 15, line 12: vegetative phase and reproductive phase are mentioned); wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage (see column 15, lines 37-55: the demand - or uptake - to get to a determined growth stage implicitly includes both the vegetative and, if present, the productive demand. Note that both vegetative performance and expected yield are parameters used in this document), wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data (implicit: yield is taken into account and depends on plant density. Crop hybrid or variety is also taken into account, see column 24, lines 52-61).
- 5 The subject-matter of claim 1 therefore differs from this known method in that:
- a. the crop is specifically a coffee plantation;
 - b. the vegetative demand is adjusted by a temperature coefficient; and in that

- c. determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

6 The problem to be solved by the present invention may be regarded as adapting the new method to provide specific recommendations optimized for coffee plantations.

7 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

7.1 The applicant contested that the following features are disclosed in D1:

- wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
- and wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

7.1.1 To this respect it, this authority notes the following:

In document D1 the basic demand (nitrogen uptake) is calculated according to the growth stage of the crop and can be predicted for future growth stages, and this can include the nitrogen uptake for the crop to grow from one growth stage to a current or future growth stage (see D1, column 15, lines 37-55). As such it is considered that this method discloses a basic demand that can be implicitly composed of a vegetative demand (1st growth stage) and a productive demand (uptake needed to grow from vegetative stage to productive stage), and the calculation done in D1 includes the sum of the two.

Regarding the second feature, and as explained above, this demand is nutrient specific (nitrogen) and requires the specific data related to this nutrient for the specific crop. Also, plant density is explicitly mentioned as a factor taken into account (see D1, column 6, lines 50 and 56, for instance).

Therefore, this authority considers that the above features are disclosed in D1.

7.2 Regarding the differentiating features:

7.2.1 Document D1 provides a few examples of crop to which this known method of providing nitrogen fertilizer recommendations can be applied. These examples include corn, soy, alfalfa, wheat, rice and sugarcane (see D1, column 6, lines 6-12). All these examples refer to yearly crops, whereas coffee is a plant that remains in production for years. Therefore, some specific adaptations are required which are not disclosed or suggested in D1.

Temperature is only taken into account as part of the general weather parameters, and are incorporated as aggregate parameters over a certain time period (D1 column 7, lines 6-14). This time period usually refers here to the crop cycle for the mentioned yearly crops. A skilled person would easily be able to adapt this temperature aggregate parameter to a coefficient usable by permanent crops like coffee, if so wished, without the use of inventive skill. It is noted that temperature is one of the basic parameters taken into account by agronomists, and that multiple coefficients are available in tables and text books for the production of coffee in the geographic areas where coffee is produced.

Therefore, and as explained in the previous communication, differentiating features "a" and "b" do not support the presence of an inventive step.

7.2.2 Regarding differentiating feature "c", D1 clearly and unambiguously discloses the use of both historic and predicted yield for the specific nutrient used - nitrogen, see D1, column 23, lines 43-67. Linking this information with the disclosed calculation of nitrogen uptake for different growth stages (column 15, lines 37-55) that calculating the productive demand in D1 includes these factors. Hence, feature "c" is disclosed in combination with the crops mentioned in D1. For the skilled person, however, it would be trivial to adapt these calculations to a permanent crop such as coffee. No inventive skill is required.

- 7.3 It has to be concluded that the adaptation of the method of claim to a permanent crop such as coffee is trivial and that the additional features now included in claim 1 are well known practices that agronomist will follow in accordance with the circumstances to solve the problem posed, without the need to use inventive skill.

Hence, the subject-matter of claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.

- 7.4 With respect to claims 12, 13 and 14, document D1 also discloses the corresponding data processing means, the computer readable storage medium and the computer program product: see D1, column 25, lines 51-64. Hence, the same reasoning applies to these claims and their subject-matter is considered not to involve an inventive step in the sense of Article 33(3) PCT.

- 8 Dependent claims 2-4, 7, 8, 10-11 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step:

- Claim 2: These additional features are trivial to the calculation of temperature coefficients, and will be used by a skilled person, in accordance with the circumstances, without the use of inventive skill;
- Claim 3: Not inventive, the number of productive stems is related to crop or seed density, which is already used in D1;
- Claim 4: Soil and weather data are used in D1 to adjust the prescription, see column 6, line 47 to column 7, line 42;
- Claim 7: As explained before, soil data is used in D1;
- Claim 8: Known from D1. See the system described in column 4, line 7 onwards in D1;
- Claims 10 and 11: Not inventive, in D1 the prescription obtained is specific for different locations of the field. Although not mentioned in D1, the use of GPS systems for obtaining positional data for performing the fertilization with the agricultural equipment mentioned in D1 is very well known in this field of technology.

- 9 The combination of the features of dependent claims 5, 6, 9 is neither known from, nor rendered obvious by, the available prior art. The reasons are as follows:

A determination of the average area of the field covered by shadows and its influence in the fertilization needs is not taken into account in any of the available citations. For the skilled person it would not be possible to arrive to this combination of features without the use of inventive skill.

Re Item VII

Certain defects in the international application

- 10 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

- 11 The application does not meet the requirements of Article 6 PCT, because claims 6, 7 and 10 are not clear.
- 11.1 Claims 6, 7 and 10 are not clear in the sense that a skilled reader cannot determine what a "shadow condition" of a field is. For the purposes of this opinion, however, this expression has been construed, based on an interpretation from the description, as the average percentage of the field covered by shadows that limit the solar radiation received by the crop.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(PCT Rule 71.1)

To:

AWA Sweden AB
P.O. Box 45086
104 30 Stockholm
SUÈDE

Date of mailing
(day/month/year)

21.02.2024

Applicant's or agent's file reference
21136602

IMPORTANT NOTIFICATION

International application No.
PCT/EP2022/081068

International filing date (day/month/year)
08.11.2022

Priority date (day/month/year)
12.11.2021

Applicant
Yara International ASA

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international
preliminary examining authority:



European Patent Office P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
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Authorized Officer

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 21136602	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/EP2022/081068	International filing date (day/month/year) 08.11.2022	Priority date (day/month/year) 12.11.2021	
International Patent Classification (IPC) or national classification and IPC INV. A01C21/00			
Applicant Yara International ASA			
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>10</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☒ a total of <u>5</u> sheets, as follows: ☒ sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions). ☐ sheets containing rectifications, where the decision was made by this Authority not to take them into account because they were not authorized by or notified to this Authority at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4bis, 70.2(e), 70.16 and 91.2). ☐ superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)). b. ☐ a separate electronic file containing a sequence listing (<i>sent to the International Bureau only</i>)			
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☐ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☐ Box No. VI Certain documents cited ☒ Box No. VII Certain defects in the international application ☒ Box No. VIII Certain observations on the international application			
Date of submission of the demand 11.09.2023		Date of completion of this report 21.02.2024	
Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016		Authorized officer Oltra García, R Telephone No. +31 70 340-3734	



Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a) and (b))
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

1-20 as originally filed

Claims, Numbers

1-14 filed in electronic form on 28-09-2023

Drawings, Sheets

1/5-5/5 as originally filed

- ☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
5. ☐ This report has been established:
- ☐ taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).
 - ☐ without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91(Rules 66.4bis and 70.2(e)).

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2022/081068

6. ☒ With regard to top-up searches (Rules 66.1 *ter* and 70.2(f)):
- ☒ A top-up search was carried out by this Authority on 13.02.2024 (all discovered documents are listed in the Supplemental Box Relating to Top-up Search).
 - ☐ Additional relevant documents have been discovered during the top-up search.
 - ☐ No top-up search was carried out by this Authority because it would serve no useful purpose.
7. ☐ Supplementary international search report(s) from Authority(ies) has/have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).

* If item 4 applies, some or all of those sheets may be marked "superseded".

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-14</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	<u>5, 6, 9</u>
	No: Claims	<u>1-4, 7, 8, 10-14</u>
Industrial applicability (IA)	Yes: Claims	<u>1-14</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1 Reference is made to the following documents:
 - D1: US 9 652 840 B1 (SHRIVER JOHN [US] ET AL) 16 May 2017
 - D2: WO 2017/147682 A1 (CROP PRODUCTION SERVICES INC [CA]) 8 September 2017
 - D3: US 3 990 181 A (DO VALLE FERNANDO RIBETRO) 9 November 1976
 - D4: GB 1 535 854 A (BARNES D; ANDERSONS PLANTATION PTY ET AL.) 13 December 1978
- 2 The amendment filed with the International Bureau under Article 19(1) introduces subject-matter which extends beyond the content of the application as filed, contrary to Article 19(2) PCT. The amendment concerned is the following:
 - 2.1 New claim 1 comprises the features of original claims 1, 2 and part of 3, while another part of original claim 3 is now claim 2.

The feature from original claim 3 introduced in claim 1 refers to the method further comprising:

 - "adjusting the vegetative demand by a temperature coefficient".

This step has been isolated from the remaining features of original claim 3, which refer to the determination of the temperature coefficient comprising:

 - "receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude data".

- 2.2 It is therefore clear that the isolated features are inextricably linked to the other features of the embodiment of original claim 3, as they explain how to determine the temperature coefficient that needs to be used in the method.
- In addition, the overall original disclosure, doesn't justify the isolation of this feature, as the whole embodiment was always presented together (see e.g. page 3 and page 10) and no other examples of how to determine the temperature coefficient are mentioned.
- Therefore, it has to be concluded that this amendment constitutes an unallowable intermediate generalisation, as the scope of claim 1 is now broader than the original application documents would allow, including methods of determining the temperature coefficient that were not originally disclosed.
- 2.3 In the arguments presented below and for completeness, this authority examines the presence of novelty and inventive step of present claim 1, without regard to the above objection based on Article 19(2) PCT, indicating later with respect to the dependent claims the corresponding opinion on present claim 2.
- 3 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.
- 4 Document D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses:
- A computer implemented method (see column 25, lines 51-64) for determining a fertilizer recommendation for ~~coffee~~ plants (nitrogen prescription), wherein the method comprises the steps of:
 - i. determining an agricultural field (see column 2, lines 24-35: "geographic region" or "field"; see also step "a" of claim 1) wherein at least one ~~coffee~~ plantation (crop) is comprised, receiving plant density data of the at least one ~~coffee~~ plantation (column 6, lines 47-56: "seed density" and "crop density"), receiving plant species data (implicit, crop species must be known) and crop growth stage data (column 6, lines 33-46; see also step "b" of claim 1) of the at least one ~~coffee~~ plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage (see column 14, line 58 to column 15, line 12: vegetative phase and

reproductive phase are mentioned); wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage (see column 15, lines 37-55: the demand - or uptake - to get to a determined growth stage implicitly includes both the vegetative and, if present, the productive demand. Note that both vegetative performance and expected yield are parameters used in this document), wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data (implicit: yield is taken into account and depends on plant density. Crop hybrid or variety is also taken into account, see column 24, lines 52-61).

- 5 The subject-matter of claim 1 therefore differs from this known method in that:
- a. the crop is specifically a coffee plantation;
 - b. the vegetative demand is adjusted by a temperature coefficient; and in that
 - c. determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

- 6 The problem to be solved by the present invention may be regarded as adapting the new method to provide specific recommendations optimized for coffee plantations.

- 7 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

- 7.1 The applicant contested that the following features are disclosed in D1:

- wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
- and wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data.

7.1.1 To this respect it, this authority notes the following:

In document D1 the basic demand (nitrogen uptake) is calculated according to the growth stage of the crop and can be predicted for future growth stages, and this can include the nitrogen uptake for the crop to grow from one growth stage to a current or future growth stage (see D1, column 15, lines 37-55). As such it is considered that this method discloses a basic demand that can be implicitly composed of a vegetative demand (1st growth stage) and a productive demand (uptake needed to grow from vegetative stage to productive stage), and the calculation done in D1 includes the sum of the two.

Regarding the second feature, and as explained above, this demand is nutrient specific (nitrogen) and requires the specific data related to this nutrient for the specific crop. Also, plant density is explicitly mentioned as a factor taken into account (see D1, column 6, lines 50 and 56, for instance).

Therefore, this authority considers that the above features are disclosed in D1.

7.2 Regarding the differentiating features mentioned under point 5 above:

7.2.1 Document D1 provides a few examples of crops to which this known method of providing nitrogen fertilizer recommendations can be applied. These examples include corn, soy, alfalfa, wheat, rice and sugarcane (see D1, column 6, lines 6-12). All these examples refer to yearly crops, whereas coffee is a plant that remains in production for years. Therefore, in order to solve the problem posed some specific adaptations are required which are not disclosed in D1.

Temperature is only taken into account as part of the general weather parameters, and is incorporated as aggregate parameters over a certain time period (D1 column 7, lines 6-14). This time period usually refers here to the crop cycle for the mentioned yearly crops. A skilled person would easily be able to

adapt this temperature aggregate parameter to a coefficient usable by permanent crops like coffee, if so wished, without the use of inventive skill. It is noted that temperature is one of the basic parameters taken into account by agronomists, and that multiple coefficients are available in tables and text books for the production of coffee in the geographic areas where coffee is produced.

Therefore, and as explained in the previous communication, differentiating features "a" and "b" do not support the presence of an inventive step.

7.2.2 Regarding differentiating feature "c", D1 clearly and unambiguously discloses the use of both historic and predicted yield for the specific nutrient used - nitrogen, see D1, column 23, lines 43-67. Linking this information with the disclosed calculation of nitrogen uptake for different growth stages (column 15, lines 37-55) that calculating the productive demand in D1 includes these factors. Hence, feature "c" is disclosed in combination with the crops mentioned in D1. For the skilled person, however, it would be trivial to adapt these calculations to a permanent crop such as coffee. No inventive skill is required.

7.3 It has to be concluded that the adaptation of the method of claim to a permanent crop such as coffee is trivial and that the additional features now included in claim 1 are well known practices that agronomist will follow in accordance with the circumstances to solve the problem posed, without the need to use inventive skill.

Hence, the subject-matter of claim 1 does not involve an inventive step in the sense of Article 33(3) PCT.

7.4 With respect to claims 12, 13 and 14, document D1 also discloses the corresponding data processing means, the computer readable storage medium and the computer program product: see D1, column 25, lines 51-64. Hence, the same reasoning applies to these claims and their subject-matter is considered not to involve an inventive step in the sense of Article 33(3) PCT.

8 Dependent claims 2-4, 7, 8, 10-11 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step:

- Claim 2: These additional features are trivial to the calculation of temperature coefficients, and will be used by a skilled person, in accordance with the circumstances, without the use of inventive skill;
- Claim 3: Not inventive, the number of productive stems is related to crop or seed density, which is already used in D1;
- Claim 4: Soil and weather data are used in D1 to adjust the prescription, see column 6, line 47 to column 7, line 42;
- Claim 7: As explained before, soil data is used in D1;
- Claim 8: Known from D1. See the system described in column 4, line 7 onwards in D1;
- Claims 10 and 11: Not inventive, in D1 the prescription obtained is specific for different locations of the field. Although not mentioned in D1, the use of GPS systems for obtaining positional data for performing the fertilization with the agricultural equipment mentioned in D1 is very well known in this field of technology.

- 9 The combination of the features of dependent claims 5, 6, 9 is neither known from, nor rendered obvious by, the available prior art. The reasons are as follows:

A determination of the average area of the field covered by shadows and its influence in the fertilization needs is not taken into account in any of the available citations. For the skilled person it would not be possible to arrive to this combination of features without the use of inventive skill.

Re Item VII

Certain defects in the international application

- 10 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1 is not mentioned in the description, nor are these documents identified therein.

Re Item VIII

Certain observations on the international application

- 11 The application does not meet the requirements of Article 6 PCT, because claims 6, 7 and 10 are not clear.

- 11.1 Claims 6, 7 and 10 are not clear in the sense that a skilled reader cannot determine what a "shadow condition" of a field is. For the purposes of this opinion, however, this expression has been construed, based on an interpretation from the description, as the average percentage of the field covered by shadows that limit the solar radiation received by the crop.

EUROPEAN PATENT OFFICE
80298 MUENCHEN
DEUTSCHLAND

Malmö
11 September 2023

Your ref

AWA ref
21136602

FILED VIA EPOLINE ONLINE FILING

Demand

Application number PCT/P2022/081068

Dear Sir / Madam,

herewith a Demand for international preliminary examination (Art. 31 PCT) is filed. Together with this accompanying letter, an amended set of claims and an amended description are filed under Art. 34(2)(b) PCT, each in a version with marked changes and in a clean version. Hereinafter, a basis for the amendments is provided, together with a rebuttal to the objections raised in the Written Opinion of the ISA (WO-ISA) and detailed arguments in support of patentability of the amended claims.

Amendments – Art. 34(2)(b) PCT

Claim 1 has been amended to include the following features:

- wherein the method further comprises adjusting the vegetative demand by a temperature coefficient;
- wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

These features are based on claims 2 and 3 as originally filed and therefore fulfil the requirements of Art. 34(2)(b) PCT. Consequently, original claim 2 has been deleted and the remaining claims have been renumbered accordingly.

It is politely considered that an appropriate basis for the amendments has herewith been demonstrated, such that the requirements of R. 66.8(a) PCT have been met.

Patentability Amended Claims

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In the WO-ISA, it is stated that D1 implicitly discloses, in column 15, lines 37-55, that the demand is based on the sum of a vegetative demand and a productive demand, if the plantation is in a productive crop stage.

The Applicant can respectfully not follow this interpretation of D1 and kindly refers to arguments regarding this point as already forwarded in the PCT Direct Letter, see specifically page 2 thereof.

Nevertheless, for the sake of procedural efficiency, claim 1 has been amended to now further specify that only the vegetative demand is adjusted by the temperature coefficient and that only the productive demand is adjusted based on the yield data and a nutrient specific productive demand factor based on the plant species data.

Hence, the subject-matter of amended claim 1 differs from the method known from D1 at least in that it includes the following distinguishing features:

- determining a fertilizer recommendation for coffee plants,
- wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage,
- wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data, wherein the method further comprises adjusting the vegetative demand by a temperature coefficient; and
- wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

As it was already acknowledged in the WO-ISA that original claim 1 is novel, the subject-matter of amended claim 1 is, consequently, also novel.

The problem to be solved by the distinguishing features can be seen in adapting a general fertilizer recommendation to coffee production.

Firstly, it is noted that D1 is completely silent about coffee (see par. 32 of D1, wherein only cereals and yearly crops are mentioned) and therefore does not address the specificities and needs of coffee plants (see page 7 of the description of the application as filed). Coffee plants grow over years and fertilizing recommendations for coffee plants are therefore adapted to address this multi-year growth, as well as the specificities of influencing factors like temperature. As such, the distinguishing features specifically define said adaptations and clearly differentiate from the disclosure of D1.

Secondly, D1 only mentions generally (see column 14, line 58 - column 15, line 12 and column 15, lines 37-55) that a vegetative performance value is determined based on one or more received images to determine whether a crop is in a vegetative phase and/or reproductive phase and a corresponding growth phase model is used to predict a growth stage. However, D1 is fully silent on how the specific contributions of the vegetative and/or reproductive phase are with respect to the basic demand. Furthermore, D1 is also totally silent on the specific influence of the temperature only for the vegetative demand and the of the yield data for the productive demand.

Therefore, the skilled person, starting from D1, would not get a single hint towards the present solution of amended claim 1. When combining D1 with common technical knowledge, the skilled person would therefore not implement the modifications required to arrive at the present solution. Furthermore, since none of the further cited documents point towards the present solution either, it is respectfully submitted that the subject-matter of amended claim 1 is based on an inventive step.

Yours sincerely,

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Claims:

1.- A computer implemented method for determining a fertilizer recommendation for coffee plants, wherein the method comprises the steps of:

- i. determining an agricultural field wherein at least one coffee plantation is comprised, receiving plant density data of the at least one coffee plantation, receiving plant species data and crop growth stage data of the at least one coffee plantation, wherein the crop growth stage data defines a vegetative crop stage or a productive crop stage; wherein the method further comprises determining a basic demand and the basic demand is based on a vegetative demand if the crop is in a vegetative crop stage and the basic demand is based on the sum of a vegetative demand and a productive demand if the plantation is on a productive crop stage, wherein the vegetative demand is based on the plant density data and a nutrient specific vegetative demand factor based on the plant species data, wherein the method further comprises adjusting the vegetative demand by a temperature coefficient; wherein determining the productive demand comprises, receiving yield data and determining a productive demand based on the yield data and a nutrient specific productive demand factor based on the plant species data.

2.- A method according to claim 1, wherein determining the temperature coefficient comprises receiving altitude data and/or an average air temperature of the agricultural field and the temperature coefficient is determined based on the average air temperature and/or the altitude data.

3.- A method according to any one of the preceding claims, wherein the method further comprises receiving the number of productive stems of the plants present in the plantation, and wherein the vegetative demand is further adjusted based on the number of productive stems.

4.- A method according to any one of the preceding claims, wherein the basic demand is adjusted by means of a nutrient specific efficiency factor, wherein determining a nutrient specific efficiency factor comprises receiving at least one of a fertilizer product data, or weather data, and soil data of the agricultural field, and the efficiency factor is determined based on the at least one of the fertilizer product data, the weather data, or the soil data.

- 5.- A method according to any one of the preceding claims, wherein the method further comprises determining a shadow condition of the agricultural field, and wherein the basic demand is adjusted based on the shadow condition.
- 6.- A method according to claim 5, wherein determining a shadow condition of the agricultural field further comprises determining at least one position for the shadow determination to be carried out.
- 7.- A method according to any one of the preceding claims, wherein the method further comprises receiving soil data of the agricultural field, and wherein the total nutrient demand is adjusted based on a soil nutrient availability factor.
- 8.- A device for determining a fertilizer demand for coffee plants, configured to carry out the method according to any one of the claims 1 to 7.
- 9.- A device according to claim 8, configured to carry out the method according to claim 6, wherein the device comprises input and output means and a dedicated Graphical User Interface, wherein the shadow condition is determined according to a gradually adjustable image showing different pre-defined shadow condition images based on the user input.
- 10.- A device according to claim 8 or 9, wherein the device comprises a localization unit to determine positional data of the device, and the elevation of the agricultural field is determined based on the positional data of the device.
- 11.- A device according to claim 10, wherein the device is further configured to receive weather data and based on the positional data and the elevation determine an average air temperature of the agricultural field.
12. A data processing apparatus comprising means for carrying out the method of any one of the claims 1 to 7.
- 13.- A computer-readable storage medium comprising instructions which, when executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 7.
- 14.- A computer program product comprising instructions which, when the program is executed by a computer system, cause the computer to carry out the method of any one of the claims 1 to 7.

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