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- (71) Applicant (for all designated States except US): **MINISTERIET FOR FØDEVARER, LANDBRUG OG FISKERI** [DK/DK]; Danmarks JordbrugsForskning (DJF), Forskningscenter Foulum, P.O. Box 50, DK-8830 Tjele (DK).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **THOMSEN, Anton** [DK/DK]; Østervangsvej 61, DK-8830 Tjele (DK).
- (74) Agent: **PLOUGMANN & VINGTOFT A/S**; Sundkrogs-gade 9, P.O. Box 831, DK-2100 Copenhagen Ø (DK).
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(54) Title: IMPROVED REAL TIME METHOD FOR CONTROLLING APPLICATIONS OF FERTILIZERS AND OTHER YIELD IMPROVING AGENTS TO CROPS

(57) Abstract: A method of controlling the application of fertilisers, fungicides, herbicides or pesticides to a plant crop, comprising simultaneous real time measurements of chlorophyll and/or biomass contents by determining the Reflectance Vegetation Index (RVI) or an equivalent measure for chlorophyll and/or biomass content and crop leaf area by determining Leaf Area Index (LAI) or an equivalent measure, providing such measurement data to a data processing unit which calculates an RVI/LAI ratio or an equivalent ratio as an indication of the chlorophyll content per unit leaf area, said data processing unit is operably connected with a control unit regulating the application of fertilisers, fungicides, herbicides or pesticides to the plant crop.

IMPROVED REAL TIME METHOD FOR CONTROLLING APPLICATIONS OF FERTILIZERS AND OTHER YIELD IMPROVING AGENTS TO CROPS

FIELD OF INVENTION

5 The present invention relates to the field of crop yield management and improvement. In particular there is provided a method whereby the crop leaf area and the chlorophyll content and/or the biomass of the crop is measured simultaneously in real time as a means of optimising the application to the crop of plant yield improving agents such as fertilisers, herbicides, pesticides and fungicides. Specifically, the invention provides a novel dual
10 sensor device that is capable of measuring the leaf area and the chlorophyll/biomass content.

TECHNICAL BACKGROUND AND PRIOR ART

The correct application of plant yield improving agents, e.g. fertilisers such as N-fertilisers,
15 to agricultural crops is a critical factor in crop yield management for several reasons: First, it is a significant cost efficiency requirement to reduce the consumption of such agents to the least possible amount required by the plants at any given growth stage and any given plant density; second, it is a still increasing requirement that application of fertilisers and other yield promoting agents does not lead to inappropriate and unnecessary environ-
20 mental strain due to excess application of such agents which is not utilised by the crop plants. It is also evident that in order to achieve optimum yield of crops, it is imperative that the levels of fertilisers and other auxiliary chemical agents are adequate at any given stage of the growth cycle.

25 The latter requirement is presently difficult to achieve for the entire field of crop, as the crop leaf area per unit area of field may vary considerably. This variation implies that if the application of e.g. N-fertiliser is based solely on measurements of biomass and/or chlorophyll content of the crop as such without correcting for spatial variations in leaf area per unit area, some areas will receive less than the required amount and other areas will re-
30 ceive an excess amount relative to the actual local requirement.

Means for measuring the content of biomass/chlorophyll of crops including mobile sensor devices have been described. As an example, Bennedsen and Guiot reported research on relating visible and near infrared radiation from plant canopies with actual crop parameters
35 to obtain soil adjusted vegetation indices (SAVIs) and normalised difference vegetation indices (NDVIs) which could be correlated to e.g. plant density and N-fertilisation. Similar techniques have been used in the design of remote real time sensing systems including the

Hydro N-sensor™ developed by Norsk Hydro. However, such known systems to control the application of e.g. nitrogen fertilisers to crop fields do not take into account that the leaf area per unit area is subject to substantial variation over a crop field, e.g. due to variations in soil structure. The Hydro N-sensor and other published remote sensing based single
5 instrument systems are not capable of measuring leaf area independent of chlorophyll content and/or biomass. Because of correlation between e.g. estimates of canopy leaf area and chlorophyll content, these systems are not capable of accurately estimating mean leaf chlorophyll content and the crop nitrogen status. Accordingly, the control of fertiliser application and optionally, application of other growth yield improving agents offered by
10 such systems is merely related to the biomass/chlorophyll content of the plant leaves at any given plot of the field, but not to the leaf area index (LAI) of the crop growing in that particular plot, which inevitably will lead to the application of less than optimal amounts of fertiliser or any other agent being applied at plots with a high LAI and conversely, to the application of excesses of agents at plots with a smaller LAI.

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Garcia et al. describes a method where LAI is measured using a fish-eye image capturing instrument placed below the canopy, a method which is not useful for mobile measurements where the instruments have to be placed above the canopy.

20 Toivonen et al. describes a portable device for determination of chlorophyll in plant by measuring fluorescence.

The present inventor has now discovered that the application of fertilisers and any other crop yield optimising agents such as fungicides, herbicides or pesticides can be optimised
25 substantially by combining real time measurements of plant chlorophyll/biomass content with simultaneous measurements of the plant leaf area, height and density. The type of measurements used depends on the agent (e.g. fertiliser or fungicide) to be applied. The application of fungicides and other surface active agents can be optimised by varying the rate according to especially leaf area but also height and density.

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SUMMARY OF THE INVENTION

Accordingly, the present invention provides in a first aspect a method of controlling the application of fertilisers, fungicides, herbicides or pesticides to a plant crop, the method comprising simultaneous real time measurements of chlorophyll and/or biomass contents
35 by determining the a Vegetation Index (VI) such as Reflectance Vegetation Index (RVI), Red Edge Inflection Point (REIP) or an equivalent measure of chlorophyll and/or biomass content, and crop leaf area by determining the Leaf Area Index (LAI) or an equivalent measure of crop leaf area, providing said measurement data to a data processing unit

which calculates an VI/LAI ration, such as an RVI/LAI ratio, an REIP/LAI ratio or an equivalent ratio as an indication of the chlorophyll content per unit leaf area, said data processing unit is operably connected with a control unit regulating the application of fertilisers, fungicides, herbicides or pesticides to the plant crop.

5

In a further aspect, the invention pertains to a dual sensing device for real time controlling the application of a crop yield improving agent, the device comprising (i) means for determining a VI such as RVI data, REIP data or data for an equivalent measure of chlorophyll and/or biomass content, (ii) means for determining LAI data or data for an equivalent
10 measure of crop leaf area, data processing means to combine the VI and LAI data or data for equivalent measures to an VI/LAI ratio or an equivalent ratio and means for transmitting VI/LAI ratio data or equivalent ratio data to a device controlling the application of the crop yield improving agent. Preferred VI/LAI ratios are the RVI/LAI ratio and the REIP/LAI ratio.

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DETAILED DISCLOSURE OF THE INVENTION

A primary objective of the present invention is to provide the means for optimising agricultural crop yield by designing a method of improved control of the application of crop yield improving agents, in particular fertilisers such as N-fertilisers, but also other improv-
20 ing agents such as fungicides. This is achieved by providing a method of controlling in real time the application of such agents to a plant crop by combining measurements of chlorophyll and/or biomass contents in the crops to which the agent is to be applied by determining a Vegetation Index (VI) such as the Reflectance Vegetation Index (RVI), the Red Edge Inflection Point (REIP) or equivalent measurements of the biomass/chlorophyll
25 content and crop leaf area by determining a leaf area index (LAI) or a corresponding measure of the plant leaf area. The method of the invention is applicable to both monocotyledonous and dicotyledonous plant crops.

By obtaining the ratio between the chlorophyll and/or biomass contents and the crop leaf
30 area simultaneously and over the same area, a highly valuable information about the individual plants in the crop is achieved as the ratio gives an indication of the chlorophyll content at the leaf level of each plant. It is thus possible to distinguish between a situation where a low level of chlorophyll and/or biomass content in a certain part of a field is due to the plants in this given area of the field is nutritionally deficient or are due to the plants in
35 the given area is grown with a high distance between the individual plants.

A critical parameter in determining the ratio between the chlorophyll and/or biomass contents and the crop leaf area is that the crop leaf area is determined accurately and within the same area wherein the chlorophyll and/or biomass content is being measured.

- 5 The RVI is typically measured by means of a sensing device that is capable of measuring the reflectance (ρ) of the crop in the visible light spectrum, such as the red light spectrum and in the near infrared (NIR) spectrum and combining the measurement values into the spectral index, RVI. It has been found that RVI measurements are closely related to the biomass and chlorophyll content of crops. RVI may be influenced by the altitude of the sun
 10 which implies that RVI measurements can only be made with high precision around noon.

Another preferred measure of plant biomass/chlorophyll content is the "Red Edge Position" (REP) spectral index – hereinafter called Red Edge Inflection Point (REIP) – which is measured by using at least three channels. REIP is a good candidate for the estimation of
 15 canopy chlorophyll density (CCD) in dense canopies, and REIP is furthermore insensitive to solar zenith angle and also insensitive to light composition.

Yet another measure of plant biomass/chlorophyll content is the second soil adjusted vegetation index (SAVI2).
 20

The REIP and SAVI2 is examples of "an equivalent measure of plant biomass/chlorophyll content". The formulas of three VIs are given in Table 1.

Table 1

Acronym	Name	Vegetation Index (VI)
RVI	Ratio vegetation index	$RVI = \frac{\rho_{NIR}}{\rho_{red}}$
SAVI2 ^a	Second soil adjusted vegetation index	$SAVI2 = \frac{\rho_{NIR}}{\rho_{red} + b/a}$ $a = 1.39, b = 1.94$
REIP ^b	Red edge inflection point	$\rho(\lambda) = c_0 + c_1\lambda + c_2\lambda^2 + c_3\lambda^3 + c_4\lambda^4 + c_5\lambda^5 + c_6\lambda^6$ REIP = root of the second derivative ($\rho''(\lambda) = 0$)

25 ^a The soil line coefficients a and b are derived from the relationship $\rho_{800} = a * \rho_{650} + b$ using spectral measurements performed at different soil moisture contents.

^b $c_0, c_1, c_2, c_3, c_4, c_5$ and c_6 are coefficients associated with a polynomial curve fit over the vegetation red edge region (670 – 780 nm).

A canopy reflectance model (ProSAIL (Jacquemoud et al., 2000)) can be employed to simulate spectral reflectance with 10 nm band spacing of a range of similar canopies. The selected range of model input parameters represent a wheat crop. The mathematical form of the ProSAIL model is

5

$$\rho(\lambda) = f(\theta_s, \psi_s, \theta_v, \psi_v, MTA, LAI, N, C_{ab}, C_w, C_{DM}, s, Vis, \rho_s(\lambda))$$

where ρ is reflectance at wavelength λ , $\theta_s(^{\circ})$ and $\psi_s(^{\circ})$ represent the solar zenith and azimuth angles, $\theta_v(^{\circ})$ and $\psi_v(^{\circ})$ represent the view zenith and azimuth angles, $MTA(^{\circ})$ is the mean leaf tilt angle, $N(-)$ is a parameter describing the leaf mesophyll structure (Jacquemoud and Baret, 1990), $C_{ab}(\mu\text{g}/\text{cm}^2)$ is the leaf chlorophyll concentration, $C_w(\text{cm})$ is the leaf water depth, $C_{DM}(\text{g}/\text{cm}^2)$ is the leaf dry matter content, s is the Kuusk hot spot size parameter (Kuusk, 1991), and ρ_s is the soil background reflectance at wavelength λ . The ProSAIL model builds on the following assumptions regarding canopy morphology:

- 15
- the canopy is horizontal, homogenous and infinitely extended
 - the canopy consist of small green flat leaves and is characterised by a uniform leaf azimuth distribution.

A presently preferred method of measuring the crop leaf area index is by applying a scanning laser instrument that, when applied to the crop field area and moved herein, is capable of continuously recording, at a high precision level, the leaf area of the crop, the reflection of the plant organs and the height and density (canopy cover fraction) of the crop plants. The leaf area index (LAI) is calculated on the basis of measurements of canopy gap fractions by means of a model for light penetration in a crop and numerical inversion of the model. Other means of obtaining LAI data are conceivable such as e.g. ultrasonic measurements, and such means are within the scope of the present invention.

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When the scanning laser instrument is applied to the crop field area and moved herein, the crop leaf area, height and density is being determined from a number of scan lines perpendicular to the direction of travelling of the vehicle carrying the instrument, i.e. the scan is crosswise of the plant rows.

30

Measurement of standard parameters such as LAI, height and density is important for the regulation of the application of surface active compounds such as fungicides and in part also pesticides.

35

Measurements of RVI and corresponding values have been used previously in several experiments aiming at describing the development of a variety of crops and the harvest

yield hereof under varying N-applications. These measurements have been performed both as manual and position determined mobile measurements. The spectral index is, as mentioned above, closely related to green biomass of a crop and the amount of chlorophyll per unit area of ground. Accordingly, the RVI/LAI ratio is a measure of the chlorophyll content per unit leaf area, which in turn is a measure of the nitrogen content of the leaves and the nitrogen requirement of the crop.

Measurements of REIP (Broge et al) have shown that REIP is associated with high REN values (relative equivalent noise "REN"; (Baret and Guyot, 1991)) for prediction of both LAI and CCD at low vegetation densities, because this index is sensitive to the leaf area. For this reason, REIP is not suited as an integrated measure of crop development under field conditions during the very early development stage, because leaf chlorophyll content and leaf area index may vary independently. However, at intermediate and high vegetation densities REIP provide the most accurate estimate of the photosynthetic potential of the canopy (CCD).

Accordingly, the REIP/LAI ratio is a measure of the chlorophyll content per unit leaf area, which in turn is a measure of the nitrogen content of the leaves and the nitrogen requirement of the crop.

20

If LAI is known, then the important parameter C_{ab} (the leaf chlorophyll concentration in $\mu\text{g}/\text{cm}^2$) can be estimated from REIP with a high degree of accuracy irrespective of the position of the sun. A scanning imaging NIR laser prototype for characterization of canopy architecture has been developed by the present inventor at Research Centre Foulum. This technology has proven very interesting in this context because it allows for the calculation of a spectrally independent measure of canopy structure.

When spectral reflectance is the only source of information regarding crop development in sparse canopies, the traditional indices based on ρ_{red} and ρ_{NIR} such as RVI are to be preferred over REIP. However, canopy photosynthetic potential for intermediate to dense canopies is best estimated using REIP.

Accordingly, simulations with canopy reflectance models and field measurements with a specially designed four band sensor for simultaneous measurement of RVI and REIP has recently shown that RVI should be applied to the early stages of canopy development and that REIP is the best index to use for estimating the leaf chlorophyll content when the leaf area index exceeds approximately 2. If measurements are made during early morning or late afternoon conditions, REIP is preferable for leaf area indexes exceeding approximately 1. In general REIP is almost insensitive to the solar position and allows measurements to

be made during daylight conditions whereas the use of RVI should be restricted to the middle of the day.

The crop nitrogen status is achieved by the direct measurement of canopy structural parameters (leaf area, height and density), and the herein described system thus allows a more accurate application of e.g. N-fertilisers and/or plant protection agents as compared to previously described systems which are not capable of measuring leaf area independently of chlorophyll content and/or biomass.

10 When, in accordance with the method of the invention, the RVI/LAI data or REIP/LAI data or any equivalent data have been provided, the data are transmitted to a data processing unit operably linked to measuring device, which unit calculates an RVI/LAI ratio or an equivalent ratio as an indication of the chlorophyll content per unit leaf area. The data processing unit is in turn operably connected with a control unit regulating the application
15 of fertilisers, fungicides, herbicides or pesticides to the plant crop being measured.

The above simultaneous measurements of RVI, REIP or an equivalent measure and LAI or an equivalent measure is preferably carried out by means of a dual sensing device comprising (i) means for determining RVI, REIP or the equivalent thereof and (ii) means
20 for determining LAI or the equivalent thereof which conveniently is mounted on a tractor or any other vehicle carrying a device for application of a fertiliser, a fungicide, a herbicide or a pesticide in such a manner that the dual sensing device is operably linked to the sensing device.

25 It has been found that in the method of the invention the LAI is conveniently measured by measuring canopy gap fractions by means of a laser diode such as an IR laser diode. Presently preferred LAI measuring parameters for the laser diode include: a small measuring area (spot), e.g. less than 1 mm including less than 0.75 mm, less than 0.50 mm or less than 0.25 mm, measurement of the strength of the reflected signal and a relatively
30 high measuring frequency such as at least 25 kHz, at least 50 kHz, at least 75 kHz or at least 100 kHz. Preferably, the laser diode is connected with a scanning unit and preferably the entire LAI measuring device is adapted to mobile measurements. Although the above laser instrument parameters are those presently preferred it will be appreciated by the person of skill in the art that any laser instrument and any parameters which are capable
35 of providing the required LAI data can be used.

In one preferred embodiment of the method of the invention, RVI or an equivalent measure of the biomass/chlorophyll content is determined by means of combining measurement data for crop reflectance of visible light and near infrared light. Thus, the inverse re-

flectance of visible light is e.g. carried out within the red light spectrum such as at about 650 nm. Any type of spectral analysis equipment that is capable of providing spectral data that are correlated to chlorophyll and/or biomass content of growing plants can be used in the present method. E.g. may such equipment which also functions appropriately in vary-
5 ing daylight intensities and solar altitudes and/or in artificial light be particularly useful.

In a further aspect there is provided a dual sensing device for real time control of the application of a crop yield improving agent. As mentioned above, such a device comprises means for determining RVI data or equivalent data and means for determining LAI data or
10 equivalent data. The device further comprises appropriate data processing means including software programmes to convert the signals received from the sensors to digital data, data processing means for combining the obtained RVI and LAI data or the equivalents thereof into an RVI/LAI ratio or equivalent ratio and means for interfacing such ratio data with a
15 device controlling the application of the crop yield improving agent. Such a controlling device should include adequate mechanical means permitting the adjustment of the flow of the fertiliser or other yield improving agent to the crop or the soil.

In yet a further aspect there is provided a dual sensing device for real time control of the application of a crop yield improving agent. As mentioned above, such a device comprises
20 means for determining REIP data or equivalent data and means for determining LAI data or equivalent data. The device further comprises appropriate data processing means including software programmes to convert the signals received from the sensors to digital data, data processing means for combining the obtained REIP and LAI data or the
25 equivalents thereof into an REIP/LAI ratio or equivalent ratio and means for interfacing such ratio data with a device controlling the application of the crop yield improving agent. Such a controlling device should include adequate mechanical means permitting the adjustment of the flow of the fertiliser or other yield improving agent to the crop or the soil.

30 Alternatively, a 4 channel portable multispectral radiometer developed at Research Centre Foulum (Thomsen et al., 2002) may be employed. This system is capable of calculating both REIP and RVI.

In a preferred embodiment, the means for measuring LAI is adapted to measure canopy
35 gap fractions by means of a laser diode e.g. having functional characteristics as it is described hereinbefore.

A significant aspect of the sensing device of the invention is that it can be used for real time simultaneous field monitoring of RVI and LAI data, REIP and LAI data, RVI and REIP

and LAI data or equivalent data. It will be appreciated that such monitoring may be carried out by using portable device units e.g. connected wirelessly to agent application control devices mounted on a tractor or a similar vehicle carrying the means for applying the fertiliser or other yield improving agent. However, in preferred embodiments of the invention, the dual sensing device is mounted directly on the tractor or other vehicle and is therefore provided with means for mounting it on a tractor or vehicle or on another device or part mounted on the tractor or vehicle.

It will be appreciated that the means for measuring RVI, REIP and LAI, respectively or measures equivalent with such indices can be separate means used or mounted separately, i.e. used or mounted as separate units. However, it may be preferred that said measuring means are located within the same housing, i.e. as a single unit comprising the two sensing means. In both cases, it is important that the sensing devices are within single housing or separate housings that are made of a material having a strength and form that provide sufficient protection of the sensors towards mechanical and physical "hardship".

The invention will now be illustrated in the following non-limiting example and the drawing wherein

Fig. 1 shows the development in RVI and RVI/LAI ratios recorded in winter wheat plots fertilised with varying quantities of nitrogen (0 N to 200 N = 0 to 200 kg nitrogen/ha).

EXAMPLE

With reference to the diagram in Fig. 1 it is illustrated how the RVI/LAI index measurements provided by the method of the invention can be applied for controlling the application of nitrogen to crops. Assuming that a first nitrogen application is carried out at an early stage of the growth season, e.g. in March/April and a second application in May and further that the soil quality and the expected yield requires a "standard" nitrogen application of 160 kg/ha.

30

In the diagram two measuring points are shown for RVI values of 12.5 and 10, respectively. The point at the lowest RVI value represents a point with a relatively low plant density and a low amount of biomass and a correspondingly better nitrogen supply and higher chlorophyll content in the leaves. By interpolating in the diagram between the measuring points and the line for 160 kg/ha nitrogen application a local nitrogen application of 85 kg/ha and 45 kg/ha, respectively can be derived.

It should be noted that the diagram correctly assigns the point having a low density of plants the lowest amount of nitrogen. However, had the fertiliser application been made merely on the basis of the spectral measurements (biomass measurements), the result had been the opposite.

5

As it can also be derived from the diagram, it will at a uniform plant density secure an optimal nitrogen application and uniform crop yield all over the field. In fields with a substantial variation in growth conditions e.g. related to differences in soil structure. the diagram is used in combination with a digital map showing the variation in the "standard" nitrogen application. The application of nitrogen in the individual points is calculated as the interpolated difference between the measuring point and the standard nitrogen application.

10

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CLAIMS

1. A method of controlling the application of fertilisers, fungicides, herbicides or pesticides
5 to a plant crop, the method comprising simultaneous real time measurements of chloro-
phyll and/or biomass contents by determining at least one Vegetation Index (VI) or an
equivalent measure of chlorophyll and/or biomass content, and crop leaf area by de-
termining the Leaf Area Index (LAI) or an equivalent measure of crop leaf area, providing
10 said measurement data to a data processing unit which calculates an VI/LAI ratio or an
equivalent ratio as an indication of the chlorophyll content per unit leaf area, said data
processing unit is operably connected with a control unit regulating the application of fer-
tilisers, fungicides, herbicides or pesticides to the plant crop.
2. A method according to claim 1 wherein simultaneous real time measurements are car-
15 ried out by means of a dual sensing device comprising (i) means for determining said at
least one VI or an equivalent measure and (ii) means for determining LAI or an equivalent
measure.
3. A method according to claim 2 wherein the dual sensing device is mounted on a tractor
20 carrying a device for application of a fertiliser, a fungicide, a herbicide or a pesticide, said
device is operably linked to the sensing device.
4. A method according to any of claims 1-3, wherein the VI is selected from the group
consisting of Reflectance Vegetation Index (RVI), Red Edge Inflection Point (REID) and the
25 second soil adjusted vegetation index (SAVI2).
5. A method according to any of claims 1-4 wherein the fertiliser is nitrogen.
6. A method according to any of claims 1-5 wherein the LAI is measured by measuring
30 canopy gap fractions by means of a laser diode.
7. A method according to any of claims 1-6 wherein the RVI is determined by means of
combining measurement data for crop reflectance of visible light and near infrared light.
- 35 8. A dual sensing device for real time controlling the application of a crop yield improving
agent, the device comprising (i) means for determining VI data or data for an equivalent
measure of chlorophyll and/or biomass content, (ii) means for determining LAI data or
data for an equivalent measure of crop leaf area, data processing means to combine the VI

and LAI data or equivalent data to a VI/LAI ratio or an equivalent ratio and means for transmitting VI/LAI ratio data or equivalent ratio data to a device controlling the application of the crop yield improving agent.

5 9. A sensing device according to claim 7 where the LAI is measured by measuring canopy gap fractions by means of a laser diode.

10 10. A sensing device according to claim 8 or 9, wherein the VI is selected from the group consisting of Reflectance Vegetation Index (RVI), Red Edge Inflection Point (REID) and the second soil adjusted vegetation index (SAVI2).

11. A sensing device according to claim 10 where the RVI is determined by means of combining measurement data for crop reflectance of visible light and near infrared light.

15 12. A sensing device according to any of claims 8-11 which is provided with means for mounting it on a tractor or another device mounted on the tractor.

20 13. A sensing device according to any of claims 8-12 where the means for determining VI data or equivalent data and the means for determining LAI data or equivalent data are within the same housing.

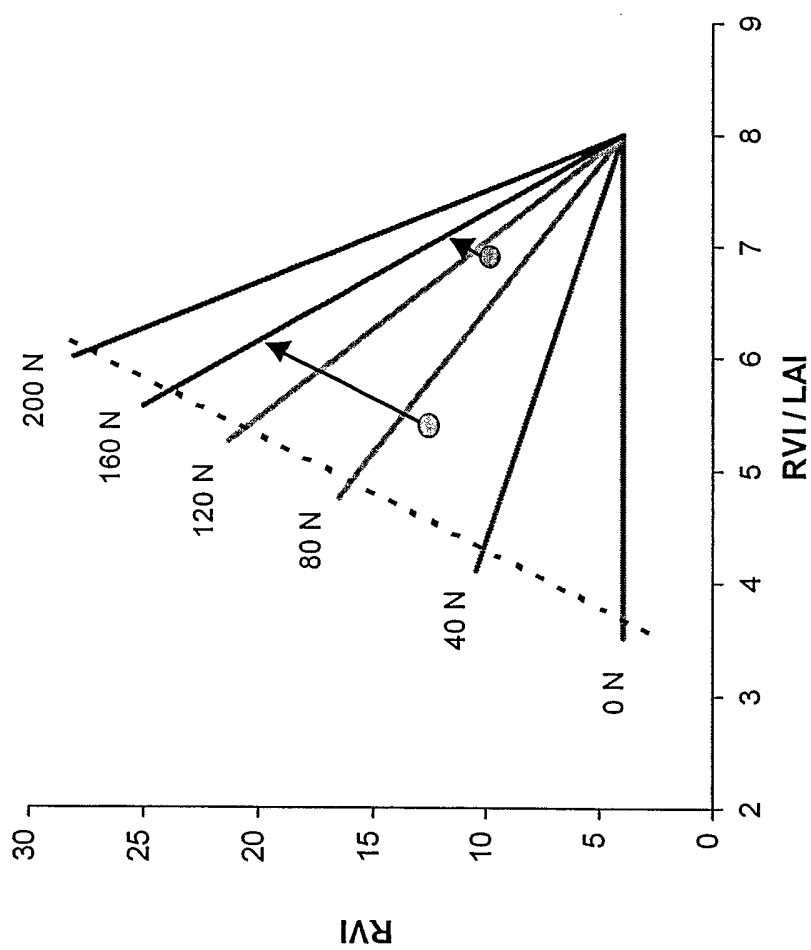


Fig. 1

Fig. 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DK 02/00512

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 G01N33/48 G01N21/00 A01C21/00		
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) IPC 7 G01N A01C A01N		
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 practical, search terms used) WPI Data, BIOSIS, INSPEC, EPO-Internal, PAJ		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DATABASE WPI Section PQ, Week 200062 Derwent Publications Ltd., London, GB; Class P11, AN 2000-638839 XP002218526 & CA 2 299 941 A (JAPAN HOKKAIDO NAT AGRIC), 5 September 2000 (2000-09-05) abstract --- -/--	1-13
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input type="checkbox"/> Patent family members are listed in 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 document 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 28 October 2002		Date of mailing of the international search report 25. 11. 02
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer LARS WALLENTIN/JA A

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DK 02/00512

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	<p>DAUGHTRY C S T ET AL: "Estimating corn leaf chlorophyll concentration from leaf and canopy reflectance." REMOTE SENSING OF ENVIRONMENT, vol. 74, no. 2, November 2000 (2000-11), pages 229-239, XP002218522 ISSN: 0034-4257 page 229, column 2, line 17-28 page 230, column 1, line 31-40 page 235, column 1, line 19-26 -----</p>	1-13

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information on patent family members

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