FIELDSCOUT®

GreenIndex+

PRODUCT MANUAL

Item # 2910A, 2910B

Spectrum®
Technologies, Inc.

CONTENTS

This manual will familiarize you with the features and operation of your new FieldScout GreenIndex+ App and Target Board. Please read this manual thoroughly before using your instrument. For customer support, or to place an order, call Spectrum Technologies, Inc. at 800-248-8873 or 815-436-4440 between 7:30 am and 5:30 p.m. CST, FAX at 815-436-4460, or E-Mail at info@specmeters.com. www.specmeters.com

Spectrum Technologies, Inc
3600 Thayer Court
Aurora, IL 60504

General Overview

This manual explains how to use the GreenIndex+ as a tool for managing the nitrogen needs of your crop and overall plant health.

The FieldScout GreenIndex+ App captures and processes images from an iPhone, iPod Touch, or iPad and instantly computes the DGCI (Dark Green Color Index) of your leaves. Our GreenIndex+ technology is sensitive to low nitrogen levels in the leaves. DGCI has been correlated to SPAD readings in corn at the V6 growth stage*. This computed SPAD index is displayed by GreenIndex+. Nitrogen uptake increases dramatically at the beginning of the V6 development stage. Corrective measures, based on early diagnosis of severe nitrogen deficiencies, can prevent yield reduction.

Digital images taken in the field typically exhibit variation due to ambient lighting, shadows and texture. Green and yellow reference standards on a pink background provide contrast and aid the imaging processing software. This allows for images to be captured under a broad range of lighting conditions.

FieldScout GreenIndex+ offers digital image analysis of leaves, providing growers with an accurate, low-cost method for managing in-season fertility and helps you deliver improved yield, lower nitrogen costs, and increased profits. All data is logged and geo-referenced, and can be emailed to your PC for further analysis.

Components

- 2010A - GreenIndex+ App -   Must be purchased through the Apple App Store (see link at www.specmeters.com)
- 2910B - GreenIndex+ Pink Target Board with green and yellow disks and gray calibration background
- Camera Equipped iPhone, iPod Touch, iPad running iOS 4.3.5 or later -   Not Included

Target Board

The Target Board (item 2910B) is shipped in a protective manila sleeve. The front side of the board is primarily pink with green and yellow disks set against a gray background at the top. These are used to compensate for different ambient light levels. The back side of the target board has four narrow loops that each have a piece of Velcro hook next to them.

The 9 1/2" strap made of Velcro loop should be woven through two of the loops and attached to the adjacent segments of Velcro hook. The board is designed so the strap can be attached to either side of the board. Choose the side you are most comfortable holding the board from when taking the picture.
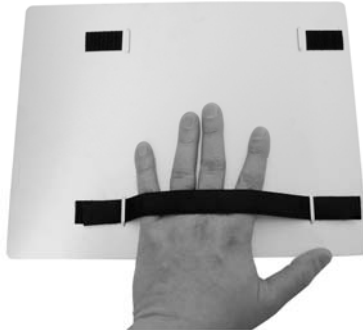
Front   Back

Getting Started

Locate the GreenIndex+ icon on your smartphone. Tap the icon to bring up the application.

The GreenIndex+ App consists of **4** screens; **Take Picture**, **Process**, **Result**, and **Settings**. When the App is brought up, the last active screen will be displayed. Details on the various screens are given in pages 6 to 9. If the smartphone has just been powered up, the **Take Picture** screen will appear first.

Take Picture screen

Process screen

Result screen

Settings screen

"Take Picture" screen

The **Take Picture** screen is used to capture the photographic images GreenIndex+ uses to compute the DGCI (see **About DGCI**, p. 19 and **Collecting Data**, p. 14).

This screen consists of 5 buttons.

CAMERA

Tap this button to take a photo of the leaf. GreenIndex+ will then proceed to the Process screen (See **Process**, p. 7).

SETTINGS

Tap this button to go to the **Settings** screen (See p. 9). The **Take Picture** screen is the only screen with access to the **Settings** screen.

SHARE

Tapping the **Share** button will bring up a screen which gives you the option of Emailing a copy of your logged data file (see **Log File**, p. 18). Select **Email Log** to proceed to the address entry screen. Select the **Cancel** button to return to the **Take Picture** screen.

INFORMATION

Tap the **Information** button to go to the **Info** screen that describes the App.

WHITE BALANCE

Used to lock the camera's white balance function (see White Balance Calibration, p. 12)

"Process" screen

The **Process** screen is where you mark the locations of the disks and leaf on the images captured in the **Take Picture** screen so GreenIndex+ can calculate DGCI (see **About DGCI**, p. 19 and **Collecting Data**, p. 14).

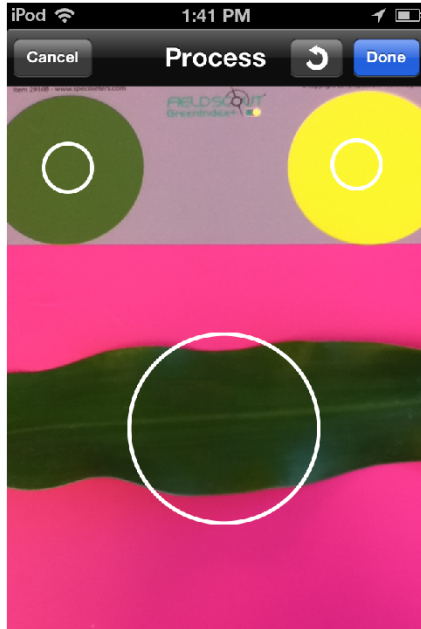This screen consists of 3 buttons.

Done DONE

When you are happy with the placement of the 3 white circles on the image, tap this button to proceed to the **Result** screen where the GreenIndex computations will be displayed. This button will be inactive until all 3 circles have been placed.

↺ UNDO

Tap this button to remove the last circle placed. This button will be inactive until the first white circle (locating the green disk) has been placed.

Cancel CANCEL

Tapping the **CANCEL** button will return you to the **Take Picture** screen. No computations will be made and no data will be saves.

"Result" screen

The **Result** screen is where the computed GreenIndex+ data is displayed. The format of the screen is determined by what options are selected in in the **Settings** screen (see also **Output** p. 16).

This screen consists of 3 buttons.

Done DONE

Tapping the **Done** button will send the data to the log file and return GreenIndex+ to the **Take Picture** screen. If averaging has been enabled in the **Settings** screen, the Picture Count is reset to one and the average DGCI and SPAD equivalent values are cleared.

+ ADD (next image to average)
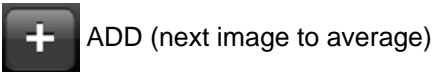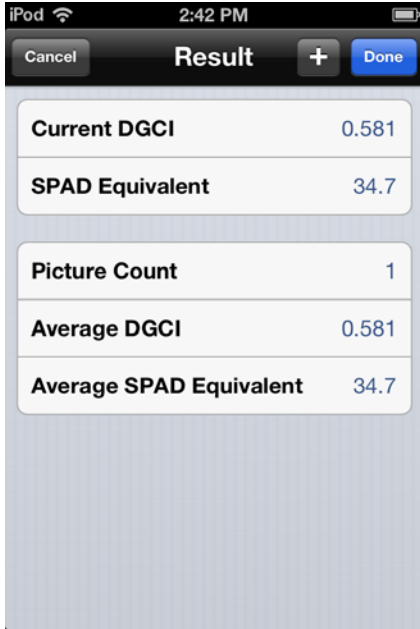
This button is only visible if the averaging option is enabled in the **Settings** screen. Like the DONE button, this button will return you to the **Take Picture** screen and send the data to the log file. When the **+** button is selected, the Picture Count will be incremented for the next image and its DGCI and SPAD equivalent will be included in the running average.

Cancel CANCEL

Tapping the **CANCEL** button will return you to the **Take Picture** screen. The data is not sent to the log file. If averaging has been enabled in the **Settings** screen, the Picture Count is reset to one and the average DGCI and SPAD equivalent values are cleared.

"Settings" screen

The **Settings** screen is where GreenIndex+ is configured. This screen is accessed by tapping the **Settings** button on the **Take Pictures** screen (p. 6). The different options are described in detail in the **Configuring GreenIndex+** section (p. 10).

This screen consists of 2 buttons.

DONE

Tapping the **Done** button saves the selected options and returns you to the **Take Picture** screen.

BACK

Tapping the **Back** button will return you to the **Take Picture** screen without saving any newly selected options.

SHOW LOG/RESET LOG
These buttons are used to manage the on-App display of the Log file (see **Log File**, p. 18).

Configuring GreenIndex+

GreenIndex+ is configured in the **Settings** screen. The different options are described below. When the configuration is complete, tap the DONE button in the upper right corner. Tapping the BACK button will exit the configuration process without making any changes.

Averaging
It may be desirable to sample several leaves in a single location and make decisions based on the average of these samples rather

than on any one individual reading. When the **Averaging** option is enabled, GreenIndex+ will output both the individual reading and the running average in the **Result** screen. To continue adding readings to the running average, you must tap the PLUS button before taking further readings.
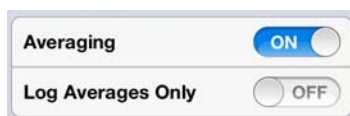
When **Averaging** is enabled, you have the option of logging all data points or only the averages. If you are planning to do statistical analysis, it may be desirable to have every reading stored in the data log. If you are simply looking to make management decisions, averages alone may be sufficient. To log average readings only, enable the **Log Averages Only** option.

Compare Indexes
If the **Averaging** option is disabled, the **Log Averages Only** option will be replaced by the **Compare Indexes** option. Ena-

bling this option allows you to compare two separate leaves or two portions of the same leaf. The procedure for collecting data for this option is outlined in **Collecting Data** (p. 14). If the **Compare Indexes** option is also disabled, only data related to the most recent measurement will be displayed on the **Result** screen.

Calculations

In addition to DGCI and raw data values, GreenIndex+ also offers the ability to compute and display a nitrogen recommendation (see **Output**, p. 16). This feature is activated and deactivated by tapping on the current selection in the **Calculations** option. Doing so will bring up the **Select Calculation** screen. From this screen select the desired mode and then hit the BACK button in the upper right corner.

Calculations	None >

Calculations	Corn Nitrogen Level >

iPod	5:19 PM	
Back	**Select Calculation**	
None		✓
Corn Nitrogen Level		

HSB Display/Log

If the **HSB Display/Log** option is enabled, GreenIndex+ will

HSB Display / Log	⭘ OFF

display and store the raw Hue, Saturation, and Brightness values in addition to the DGCI and SPAD equivalent values (see **Output**, p. 16).

Save Images

If **Save Images** is enabled, the device will save the pho-

Save Images	⭘ OFF

tographs to the camera roll. This feature is intended for diagnostic purposes. During normal operation, this option should be set to OFF.

White Balance Calibration

Before taking readings, the device camera's white balance feature should be locked. This is done with the "balance scale" and "lock" buttons in the lower left of the **Take Picture** screen (see figures 1 and 2). The first button puts the meter in dynamic white balance (DWB) mode, which is the default setting. In this mode, the camera's white balance will constantly adjust to differing light levels. This is ideal for taking standard photographs but causes problems when using the camera to collect data. The second button puts the meter in static white balance mode (SWB). When this option is selected, the camera's white balance settings are locked in.
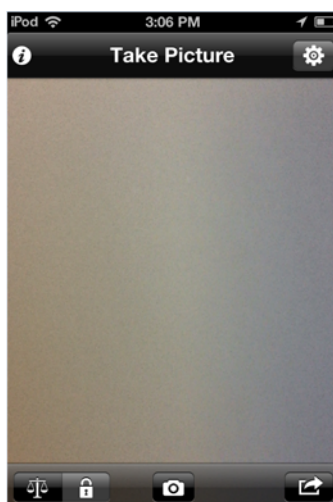

Fig. 1: Dyamic White Balance (DWB)

Fig. 2: Static White Balance (SWB)

To optimize the GreenIndex+ App for data collection, white balance should be calibrated to a gray standard. This only needs to be done at the beginning of a sampling session. If the device goes into power-saving mode, the white balance calibration should be retained. However, the locking procedure will have to be repeated whenever the camera returns to DWB mode. This will be the case, for example, whenever the device is powered up or if the device's camera is opened in a different App.

Calibration Procedure

1. While in the **Take Picture** screen, check that the camera is in dynamic white balance (DWB) mode. If it is not, tap the "balance scale" button to shift to DWB.

2. Hold the device such that only the gray portion of the GreenIndex Board is visible in the viewing area.

3. Tap the "lock" button to lock the white balance.

Collecting Data

Open up GreenIndex+ and go to the **Take Picture** screen . Using the newest fully developed leaf on the plant, gently lay it over the middle of the target board so that the green and yellow disks and the plant leaf are all visible on the screen of the smart device you are using. Take great care to avoid any shadows and glare. In the field, it may be necessary to remove the leaf before laying it on the board.

Standard Procedure

1. Capture the image by tapping the camera icon located at the bottom center of the screen. This will advance GreenIndex+ to the **Process** screen.

2. GreenIndex+ will prompt you to tap the green color disk. This will create a white circle where the screen is tapped. Once placed, this circle cannot be moved. The circle should be completely within the green color disk. If it is not, tap the UNDO button to re-locate the circle.

3. Repeat step 2 for the yellow color disk

4. GreenIndex+ will then prompt you to tap the screen near the portion of the leaf you want to measure. This circle can be moved and resized. The circle is moved by sliding your finger along the screen.   It is resized by pinching the image with your finger and thumb. Manipulate the circle until it is surrounds the desired portion of the leaf. It does not matter if any of the pink background is included in this circle. However, take care that neither the green or yellow is included in the leaf selection.

5. When the 3 circles are satisfactorily placed, tap the **Done** button. GreenIndex+ will then proceed to the **Result** screen to display the results of the measurement (see **Output**, p. 16).

Note: At any point, you can tap the Cancel button to re-do the photo.

14

<u>Compare Indexes Procedure</u>

If the **Capture Indexes** option is selected in the **Settings** screen (see **Configuring GreenIndex+**, p. 10), you will take two standard images (see previous page) before GreenIndex+ will display the results (see **Output**, p. 16). The procedure is intended for comparing two leaves on the same plant. It is outlined below.

1. Place the first leaf on the board. Instead of the title, **Take Picture**, the screen will instead be labeled **Picture #1**. Snap a picture as in the Standard Procedure. The screen will proceed to the **Process #1** screen. Process the screen as you would in the Standard Procedure.

2. GreenIndex+ will then proceed to the **Picture #2** screen. Proceed as in step 1.

3. Press the DONE button to proceed to the **Results** screen.

15

Output

After an image is captured and processed (see **Collecting Data,** p. 14), the GreenIndex+ results are displayed on the **Result** screen. The appearance of this screen depends on what options are selected in the **Settings** screen (see **Configuring GreenIndex+**, p. 10).

Standard Screens

The **Result** screen will always display the DGCI value (see **About DGCI**, p. 19) and an equivalent SPAD value.

DGCI	0.749
SPAD Equivalent	47.6

The following screens will appear if the appropriate option is selected in the **Settings** screen.

If the **HSB Display/Log** option is enabled, GreenIndex+ will display the raw Hue, Saturation and Brightness values for the green and yellow color disks as well as

Green Disk HSB	154 / 20% / 31%
Yellow disk HSB	57 / 67% / 99%
Leaf HSB	88 / 28% / 40%

for the selected leaf segment. The color values are displayed in groups of 3. The first value is Hue, the second is Saturation, and the third is Brightness. These values will also be stored in the log file.

If the **Calculations** option is set to "Corn Nitrogen Level", GreenIndex+ will display suggested nitrogen fertilizer amounts that will

Recomended N		
90% Yield	63 kg/ha	56 lb/ac
95% Yield	88 kg/ha	78 lb/ac

allow the crop to reach 90 or 95% of their yield potential. These values are based on data collected on nitrogen rate trials and are included as an advisory value. Your ideal nitrogen amount will vary depending on yield goal, hybrid, soil type, and fertilizer history.

If the **Averaging** option is en-
abled, GreenIndex+ will display
average DGCI and SPAD equiva-
lent values.   Readings will be
added to the averages as long as

Picture Count	3
Average DGCI	0.349
Average SPAD Equivalent	16.8

the PLUS button (rather than the DONE button) is tapped
after viewing the measurement in the **Result** screen. The
number of images included in the average is shown in the
Picture Count field.

Compare Indexes Screens

If the **Averaging** option is disabled, GreenIndex+ will re-
place the **Log Averages Only** option (see **Configuring
GreenIndex+**, p. 10) with the **Compare Indexes** option.
This allows for easy comparison of readings of two leaves
on the same plant. See **Collecting Data** (p. 14) for de-
tails on collecting data for this option. GreenIndex+ will
display the DGCI and SPAD equivalent for both images
as well as the difference between the two (Figure A). If
"Corn Nitrogen Level" is selected in the **Calculations** op-
tion (p. 9), N recommendations for each leaf will be dis-
played. If the **HSB Display/Log** option is enabled, the
raw Hue, Saturation, and Brightness for both images will
also be displayed (Figure B).

#1 DGCI	0.240
#2 DGCI	0.632
#2 DGCI less #1 DGCI	0.392
#1 SPAD Equivalent	8.5
#2 SPAD Equivalent	38.6
#2 SPAD less #1 SPAD	30.1

A

#1 Green Disk HSB	47 / 55% / 29%
#1 Yellow Disk HSB	55 / 89% / 100%
#1 Leaf HSB	32 / 39% / 42%
#2 Green Disk HSB	55 / 49% / 27%
#2 Yellow Disk HSB	55 / 89% / 100%
#2 Leaf HSB	66 / 0% / 21%

B

Log File

<u>Transferring Data</u>

All readings taken by GreenIndex+ are stored in internal memory on your device. The data is transferred to an external computer via an Email attachment. The Email screen is accessed by tapping the SHARE button on the **Take Picture** screen. Select the **Email Log** option to continue. Tap **Cancel** to return the **Take Picture** screen. Once in the Email screen, type the address(es) to which you would like the data sent. A default Subject line is provided but can be edited to better identify what data is being sent by this transmission. It is also possible to type a message in the text field to convey any additional information to the recipient(s). Tap the SEND button to send the Email. You must have internet access to successfully complete the transmission. If you do not want to complete the transmission, tap the CANCEL button. This will bring up a question box that will ask if you wish to delete or save this draft. Hitting the cancel button in the question box will return you to the Email screen.

<u>Show Log/Log Screen</u>

In addition to sending the data file to a computer, GreenIndex+ also allows you to view the log on the device. The **Log** screen can be accessed by tapping the **Show Log** button on the **Settings** screen. This screen is intended to confirm that the readings are being stored as expected; It is not designed for on-device analysis.

<u>Reset Log</u>

Data will be written to the log file every time a new reading is made. After data has been successfully transferred, or if it is otherwise not needed, it can be deleted from the device's memory with the **Reset Log** button. You will be asked to confirm this request.

About DGCI

One way to assess the health of a crop is by evaluating the greenness of the leaves. This is an indicator of the chlorophyll levels which are impacted by stresses caused by inadequate nutrition and moisture, pest pressure, or excessive compaction levels. Over the years, several objective greenness indexes have been developed and incorporated into portable devices used to evaluate plant health.   Among these are the SPAD value or the Normalized Difference Vegetative Index (NDVI). These indexes are calculated from data collected by devices which measure spectral reflectance or transmittance of pre-selected wavelengths of light. These devices require specialized light emitters and/or filters to make these measurements.

In 2003, researchers at the University of Arkansas developed a method for measuring greenness using images captured with a digital camera. This method was later adapted for use in corn. GreenIndex+ uses this same technique to quantify plant greenness using the camera contained in a smartphone.

A digital camera captures an image as a series of pixels that have different levels of Red, Green, and Blue (RGB) color. However, for the purposes of quantifying plant greenness, it is not accurate to just use the Green parameter from this color scheme. This is because the amount of Red and Blue also affect how green a plant looks. Therefore, the RGB color scheme must first be converted into Hue, Saturation, and Brightness (HSB).

Hue has a value between 0 and 359, Saturation and Brightness have values between 0.0 and 1.0. DGCI is then calculated from the HSB values as follows:

$$DGCI = \frac{1}{3}[(\frac{Hue-60}{60}) + (1 - Saturation) + (1 - Brightness)]$$

It is recommended that the DGCI be used with a specially prepared reference strip that has adequate fertilizer and water. Management or experimental treatment areas can then be compared to the reference strip.

Field Sampling

There are two aspects to taking readings with GreenIndex; proper leaf sampling and the creation of a nitrogen-rich reference strip.

Leaf Sampling
You will need to take readings from 10 to 30 plants to capture a representative sample. Select healthy leaves that are fully emerged. Avoid readings from plants that vary from the average plant spacing for the field.

For corn, it is recommended that GreenIndex readings be taken 1/2" from the leaf edge and at a point on the leaf about 1/2 to 3/4 of the leaf length from the leaf base. The best results will be attained after the corn has reached the V6 stage.

The ideal stage to sample wheat is at the Feekes 5 stage. Acceptable readings can also be made at the Feekes 6 stage. Sample the first fully expanded, collared leaf from the top of the plant. Take readings midway between the base and tip of the leaf and halfway between the leaf edge and the mid-rib.

Reference Area
In addition to N status, factors such as hybrid, water stress and temperature can affect the greenness of the leaf. Therefore, the DGCI of any site must be interpreted in conjunction with simultaneous readings in a specially prepared high N reference area. The reference area can be a strip through the field or rectangular area made up of portions of several rows. Do not select a reference area that is in an area of extreme (high or low) yield potential. The reference area should receive an excessive amount of nitrogen to assure the plants achieve optimum chlorophyll levels. Readings from the sampling sites should then be compared to the reference DGCI levels to determine plant health.

Frequently Asked Questions

1. Does the number of pixels affect the GreenIndex+ reading?
No. The number of pixels required to do the DGCI computations is much smaller than are found in a standard smartphone camera image.

2. What is the effect of light?
The color disks are designed to compensate the GreenIndex+ readings for differences in light levels. However, it is important to ensure that the board is uniformly illuminated with no shadow or glare.

3. How does the position of the board impact the readings?
To maintain consistency, the board should be held in a similar manner for all readings. Hold the board at a comfortable angle and distance such that the disks and leaf are all visible.

4. What is the effect of light?
The green and yellow color disks are of known color and are used to compensate for different ambient light levels.

5. Why is the board colored pink?
So GreenIndex+ can distinguish between the leaf material and the background.

6. How does DGCI compare to SPAD readings or NDVI?
In University studies, DGCI has shown good correlation to SPAD, NDVI, and leaf nitrogen concentration.

7. What is the impact of different hybrids?
Because different hybrids will have different color characteristics, the optimum DGCI value will vary from one to another.

8. Can I enter a yield goal for my field?
This feature is not available. The nitrogen recommendations are based on optimal yield seen in the study from which they were derived.

9. Should readings be taken inside or outside?
GreenIndex+ is a field tool, readings should be taken outside. The leaf should remain on the plant

10. Can GreenIndex+ be used with crops other than corn?
Yes, the DGCI value is relevant to any plant and can be used for diagnostic or comparative purposes

11. Does a change from dynamic white balance to static white balance change other camera functions on the phone (i.e. camera roll)?
The white balance lock is only active for the GI+ app. If another camera app is run, the white balance will be lost and have to be re-done when GI+ is re-opened.

12. Will the GI+ app work with an older iPhone?
Older iPhones and the cameras they possess are more than adequate for GI+ purposes.

Warranty

The GreenIndex Board is warranted to be free from defects in material or workmanship for one year from the date of purchase. During the warranty period Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty does not cover damage due to improper installation or use, lightning, negligence, accident, or unauthorized modifications, or to incidental or consequential damages beyond the Spectrum product. Before returning a failed unit, you must obtain a Returned Materials Authorization (RMA) from Spectrum. Spectrum is not responsible for any package that is returned without a valid RMA number or for the loss of the package by any shipping company.

Spectrum
Technologies, Inc.

3600 Thayer Court
Aurora IL 60504
(800) 248-8873 or (815) 436-4440
Fax (815) 436-4460
E-Mail: info@specmeters.com
www.specmeters.com