COTTON PLANT MAPPING: PAST, PRESENT, AND FUTURE

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Abstract

Plant mapping has been an important technique in understanding cotton's physiology and response to environmental factors. However, plant mapping is viewed as tedious and time-consuming. We examined the time requirements for post-harvest plant mapping and tested two methods to decrease these time requirements. The first was the introduction of tally counters and direct input of boll weights using a balance-computer interface. The second was the use of a touch screen computer system for counting bolls by node and position, as well as documenting boll rot, green bolls, and partial bolls by node and position. Both the tally counter and the touch screen additions allowed more efficient mapping and decreased mapping time by about 40% from the original method used.

Introduction

Plant mapping has been an important technique in understanding cotton's physiology and response to environmental factors. Cotton varieties vary in their production of bolls by node and fruiting position. Additionally, factors such as insect pressure, fertility, irrigation, and temperature have all been shown to impact fruiting of the cotton plant. Cotton mapping in its various forms has been used for nearly a century (McClelland, 1916). Plant mapping techniques have varied, including mapping in-season flowering, detailing the growth and distribution of bolls, measuring internode lengths, and measuring within-boll yield components.

One drawback to plant mapping is the time required. The time required makes mapping tedious, and there is a limited amount of time and resources that can be devoted to mapping. However, the value of plant mapping means that even with these challenges, many researchers still conduct plant mapping. As with any measurement technique, plant mapping has undergone refinements over time. However, new technologies may further increase the efficiency of plant mapping, making it practical on a wider scale. Most current laboratory digital balances have computer interface options that allow direct porting of balance masses into computer programs, such as Microsoft Excel™. In addition, touch screen technology has become inexpensive enough that monitors with touch screen capabilities are almost as inexpensive as normal LCD monitors. New versions of Microsoft Windows™ even have touch screen components as standard options. In this paper, we discuss these methods to increase post-harvest plant mapping efficiency. If plant mapping can be made more efficient, it can be applied to more locations and give a more in-depth view of in-season growth and fruiting patterns.

Materials and Methods

Plants were harvested at the end of the 2005-2009 growing seasons and subjected to plant mapping, based on an initial plant mapping setup that was designed in the late 1990s by Dr. Craig Bednarz, who was a physiologist in Tifton from 1997-2007. The original system was in itself a pioneering accomplishment; it advanced large-scale post-season plant mapping by node and position using the grid box system. Mapping included removing all bolls from individual plants, counting bolls by node and fruiting position, and weighing all bolls by node and fruiting position. All bolls were placed in grid box compartments corresponding to boll location on the plant. Over time, the process came to be termed box mapping, or box picking. Bolls on vegetative branches and bolls from plants with aborted apical meristems were placed in separate compartments from bolls on fruiting branches to keep them separate from node and position distribution measurements. Differences between box mapping in the years of this study are outlined below.

Original Box Mapping Method (2005-2006)

Plants were harvested and wrapped in butcher paper that had been pre-cut to hold the plants. After the plants were wrapped, the butcher paper was folded over two to three times and stapled using an industrial hand stapler. Location

and plot number were written on the side of each plot bundle, and the plants were moved to storage. At the plant mapping location, box mapping was conducted using a set of two large wooden grid boxes with compartments. Paper bags were placed in individual grid box cells, and cotton was placed in the paper bags. Flat marbles were placed in each compartment to count the number of bolls at each node and position. After a plot was mapped, all of the bags with cotton in them were removed, labeled with node, position, and boll number, rolled up, and placed in a larger plastic bag with the location, plot number, and plant number written on the outside. After all mapping was completed at the box mapping location, the large paper bags were moved to a lab with a laboratory balance, and the bolls were removed from their bags and weighed by node and position for each plot. Weights were either written on a clipboard and entered into a computer, or typed directly into the computer. In 2005 and 2006, 10 feet of row were removed from each plot. In 2007 through 2009, variable distances were removed in order to speed up the process. In order to standardize the comparison between years, a standard distance of 5 feet was used as an example for each year.

Box mapping with Tally Counters and Stretch Wrap (2007-2008)

A roll of 18" stretch wrap (Uline; www.uline.com) was used to wrap the plants, and computer labels with location and plot numbers were printed in advance. Plants were wrapped in the stretch wrap in a manner similar to the butcher paper, but the plastic wrap did not require stapling. Labels were attached as each plot was wrapped, and transport and storage were similar to previous years. Box mapping was conducted using sets of 3 plastic grid boxes (Global Industrial product WB772042; www.globalindustrial.com) with dimensions of 20 ¼ inches x 15 ¼ inches x 7 inches tall and divided into 7 node compartments and 3 position compartments each. Three sets of the boxes were used to allow concurrent mapping and weighing. Instead of marbles, tally counters (www.tallycounterstore.com) were mounted on a 1x4 plank in banks of three. After mapping was completed, boll numbers were called out to the person at the weighing computer, who typed the numbers in. A simple sorting macro in Microsoft Excel™ was used to line up only nodes and positions with bolls. An Acculab VICON Balance (acculab.balances.com) with 0.01 g readability and 210 g capacity was used to weigh samples, and it was connected to the weighing computer using a USB interface cable. The balance was ported into the computer using WinWedge Standard (Taltech instrumental software solutions; www.taltech.com). Data record inputs were set up to move to the next cell with each balance input, so no computer entry was required for standard weighing. After weighing, bolls were placed in paper bags grouped in zones as nodes 4-8, 9-12, 13-17, and 18+. The bolls were not separated by position.

Box mapping with Touchscreens and Stretch Wrap (2009)

Harvesting and analysis were the same as with the tally counter system, except for the following changes. The 18" stretch wrap was replaced with 30" stretch wrap to allow easier wrapping of plants. Box mapping was conducted using the same boxes, but the tally counters were replaced with a touch screen system of 1 to 3 Mimo UM-740 USB Touch Screen computer monitors (www.amazon.com). The monitors can be plugged into a USB slot, so they do not require additional video cards. Originally, three monitors were used, but we found it to be as quick and easy to use one touch screen and have one person type in the values while others removed the bolls. The touch screen buttons were set up in Microsoft Excel using code based on the convention listed below:

```
Sub a05_1()
'
' a05_1 Macro
' Macro recorded 8/27/2009 by GLR
'
    Application.Run "PlayWAV"
' Copy existing data to allow undo
For Each Cell In Worksheets("Data").Range("AA2:AA16")
    Cell.Value = Cell.Offset(0, -23)
    Next Cell
' Increase range corresponding with node and position by 1
Worksheets("Data").Range("D2") = Worksheets("Data").Range("D2") + 1
    Application.ScreenUpdating = True
End Sub
```

Statements following a "'" represent comments in the code. Each node and position had code written that corresponded with individual cells. The data table ran in the background, so the user was only required to punch

buttons based on boll location, as well as buttons to mark vegetative bolls, green bolls, bolls with boll rot, and bolls with missing locules. There were also button to undo accidental entries, as well as to load new plots. This allowed more oversight of the cotton condition during mapping than was had previously. The touch screen computer was connected to the weighing computer using a LAN crossover cable, and the computers were set up on a workgroup so that both computers had access to both the mapping and weighing files. An intermediate file was set up to allow mapping and weighing functions to be performed concurrently without the risk of affecting files that were in use. A print command was added to the macro that moved data from the mapping file to the weighing file, so that there would be a hard copy of all data as it was collected. The goal of the files was to simplify the transfer process to the point where someone without experience with the software would be able to run it without problems, and the system was tested with someone without extensive computer experience.

Results and Discussion

Table 1 shows the relative person-time required per plot from harvest to box mapping completion. This is an estimate of how much time it would take one person to complete all of the tasks associated with box mapping a single plot. The original system resulted in about 60% more time per plot than either the tally counter method or the touch screen method. Much of this difference was in the preparation and labeling of the butcher paper, placing and labeling the paper bags, placing and counting the marbles, and the multiple steps of placing the cotton in bags and removing cotton from the bags.

Another disadvantage observed with the original system were the occasional stray marble ending up in a bag with the cotton bolls or falling into the wrong compartment. Sometimes this was observed and corrected, but sometimes it was difficult to determine whether the marble had ended up in the correct compartment. A further complication was that sometimes multiple bags for a plot would be labeled with the same node and position. Since there was a time delay between box mapping and weighing, it was impossible to determine bags that were incorrectly labeled.

Both the tally counter method and the touch screen method allowed fewer steps in the processing of the plants, and the differences in the time required were minimal. The tally counter system was ideal for a box picking operation with limited technical resources, since it required only one computer. Hand-typing boll weights would also eliminate the need for a connection between the computer and the scale, as well as port software. However, this would introduce another potential for error, as well as slowing the process down.

Table 1. Relative time for three box mapping methods. Times were determined on a single person basis.

	Person*Time per Plot		
	Original System	**Tally counter and plastic wrap**	**Touch Screen system with plastic wrap**
Prepare butcher paper	30 s		
Print out labels		3 s	3 s
Cut and wrap plants	7 min	7 min	7 min
Staple wrapped plants	30 s		
Write plot number and location on wrapped sample	30 s		
Attach label to wrapped sample		10 s	10 s
Moving/Storage	1 min	1 min	1 min
Count bolls by node and position	30 min	30 min	30 min
Count marbles/ Write numbers on bags	10 min		
Place samples in bags	2 min	1 min	1 min
Enter boll numbers into computer	3 min	2 min	
Label new bags	2 min		
Transport bags to lab for weighing	2 min		
Re-sort bags by node and position	1 ½ min		
Weigh samples	10 min	5 min	5 min
Enter weights into computer	7 min	0 (part of weighing)	0 (part of weighing)
Cutting plastic wrap/Computer and balance setup		47 s	47 s
Total time per plot	92 min	57 min	55 min
Total time (210 plots)	322 hr	199 hr 30 min	192 hr 30 min

Summary

The touch screen system's primary advantages were the capability to measure additional plant mapping parameters, such as green bolls, boll rot, and partial bolls. However, the system was not off-the-shelf, so there was no technical support if the computers or touch screens were not functioning properly. As a result, one of the studies in 2009 was picked using the tally counters, rather than take time trying to troubleshoot the touch screens. The problem was fairly easy to solve and did not recur, but it emphasized the risks of a computer-only box picking system.

Another observation was the relative advantages and disadvantages of using stretch wrap instead of butcher paper. The stretch wrap was easier to transport and did not require pre-cutting. It was also not subject to tearing. However, the plastic wrap was more difficult to unwrap, requiring scissors to cut it off. In humid conditions, the plastic wrap was not subject to weakening like the paper, but occasionally condensation would form on it. Wherever possible, the plants should be stored in a location that minimizes excess humidity and has protection from rodents. Originally, the plastic wrap was wrapped tightly around the bundles of plants to prevent bolls from being shaken off during transport. However, it was determined that there was more boll loss due to interlocked plants in tightly wrapped bundles than from loss to jarring in loosely wrapped bundles. Lost cotton using loosely wrapped plastic bundles was comparable to losses with paper bundles.

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References

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