INFLUENCE OF PLANTER WIDTH ON DOUBLE-PLANTED ACREAGE IN COTTON FIELDS

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Abstract

Many cotton producers are looking for new ways to reduce planting time, whether the objective is getting the seeds in the ground faster during a narrow planting window or to increase the number of acres in their farming operation. One particular time saving investment that producers are considering is purchasing wider planters. Decisions farmers must make when purchasing planters are the width and whether or not to invest in Automatic Section Control (ASC). ASC technology utilizes the Global Positioning System (GPS) and coverage maps to automatically turn on or off individual row units or planter sections within predefined field boundaries, no-plant zones, and previously planted areas to eliminate double-planting on end rows and point rows, and along terraces and waterways. Eliminating these double-planted areas reduces input costs and increases planting efficiency. A study was conducted in 28 cotton fields, totaling 1,122 acres, to investigate the relationship between planter width and double-planted areas in irregularly-shaped fields. Real-Time-Kinematic (RTK) GPS positions of the planter in the field and planter status were recorded every 1/10th of a second. High accuracy planting maps for each field were generated for three different planter widths, 38-, 57-, and 76-foot using ESRI's ArcMap software. The percentage of double-planted area was found to be dependent on field geometry (i.e., shape, size, and inclusion of terraces and waterways) as well as planter width. The percent minimum double-planted areas across all fields ranged from 0.1% to 9.8% with an average of 2.1% for a 38-foot wide planter. As expected, fields that were more rectangular-shaped and had few or no point rows were found to have less than 1.0 % double-planted areas. Fields that were very irregularly-shaped and had numerous point rows or included terraces or waterways were found to have minimum double-planted areas greater than 3.0%. The number of passes required to plant each field decreased as planter width increased, however the percentage of double-planted area increased. The total double-planted acreages across all 28 fields were calculated to be 13.8, 31.0, and 44.1 acres for the 38-, 57-, and 76-foot wide planters, respectively.

Introduction

Planters equipped with ASC eliminate double-planted areas on end rows and point rows and along terraces and waterways where planter overlap is unavoidable. ASC technology for planters are toggled by using a GPS signal to differentiate the areas of a field the planter has already been over from areas the planter has not been over yet. When the planter overlaps a previously planted area, the ASC technology engages and disrupts seed flow. When the planter is back on ground that has not been planted, the ASC technology disengages and allows seed flow. Eliminating double-planted areas has the potential to reduce input costs and increase yield in these areas. Fulton et. al. (2010) conducted a study to investigate the potential input savings that result from investing in ASC technology. This study reported ranges of input savings from as little as 1% to as high as 12% for each planter pass in the field. The fields used in this study resulted in an average of 4.3% seed cost savings and they concluded that ASC technology would pay for itself in about two years without taking into account any potential yield losses. According to Halfmann et. al. (2005), cotton has compensating abilities to produce the same number of bolls per unit area regardless of plant density. This means in high plant density areas, such as double-planted areas, individual cotton plants produce less lint because they are trying to compensate for the extra plants. In theory, this would not be a problem if cotton in these areas could be completely harvested with a picker. However, in practice, since pickers must be operated in line with planted rows and double planted areas have crossing rows, some of the cotton plants will be tracked over resulting in a downed crop. Once the cotton plants have been downed, they are no longer available for harvest, therefore resulting in a yield loss.

Many producers are considering purchasing wider planters to reduce the time devoted to planting. Producers want to reduce planting time because of narrower planting windows caused by cool, wet springs and to be able to incorporate more acreage to their farm. In order to reduce planting time, cotton producers have three choices; they can increase their planting speed, work longer hours, or invest in a wider planter. All three choices have pros and cons. Farmers are less likely to increase their planting speed since faster speeds increase the risk of poor seed placement and equipment breakdowns. Most cotton producers also have other farm enterprises to consider during the spring so longer hours may not be an option. Thus, many are considering purchasing wider planters. However, wider planters have the potential to increase double-planted areas, especially in irregular shaped fields.

Cost calculators have been developed to calculate the rate of return on investment for ASC technology given certain farm scenarios such as average field perimeter, number of passes required to plant a field, average angle coming into the end rows, and equipment width etc., Dhuyvetter et. al. (2010). This cost calculator can aid producers in making important decisions about purchasing ASC technology but some require a considerable amount of farm records to complete.

Objectives

The objectives of this study were to: 1) Analyze the effects of increased planter width and field geometry on double-planted area, 2) Classify the fields used in this study based on percentage of double-planted area so that producers can compare these fields to their own fields, and 3) Eventually develop a map-based method that can accurately calculate the percentage of double-planted area in any field based on planter width and field geometry so that this value may be used in a cost calculator.

Materials and Methods

A study was conducted in West Tennessee using 28 cotton fields that totaled 1,122 acres. All 28 fields were planted with a 12-row planter on 38-inch row spacings. This planter configuration and row spacing resulted in a 38-foot wide planter pass. Ten of the fields were planted with one planter pass (38-foot wide) along the end and turn rows and the remaining fields were planted with two planter passes (76-foot wide). Real-Time-Kinematic (RTK) GPS position of the planter and planter status were recorded every $1/10^{th}$ of a second with plus or minus 1-inch positional accuracy. Data was collected using a Trimble EZ-Guide 500 monitor with a built-in GPS receiver, a Trimble AgGPS 25 antenna, an Intuicom RTK Bridge cellular modem connected to the Tennessee Department of Transportation (TDOT) VRS network and a netbook computer to record the real-time corrected latitude and longitude position of the planter while in the field. The GPS antenna was mounted on either the planter or the tractor depending on the type of equipment that was being used at each field. The GPS antenna was placed so that it was in line with the center of the planter. Planter status for each individual GPS position was recorded using an implement switch placed on a row unit. The switch was closed when the planter was down and actually planting and open when the planter was up and not planting (i.e. turning, crossing drainages, etc.).

Data Analysis

Data was imported into ESRI's ArcMap software and projected using the NAD 1983 UTM Zone 16 Coordinate System for editing. Each individual data point represented the latitude and longitude position of the planter that was recorded while in the field. These point features had attributes that signified the status of the planter so for simplicity; the points were separated into two new features that represented whether the planter was up (not planting) or down (planting). New polyline layers were created that connected the points with a status of planting. These lines represented the centerlines of the tractor and planter as it moved across the field. The next step was to offset planter boundaries half the distance of the planter width on each side of the centerlines to represent the planted area in each pass. In order to accurately depict the double-planted areas, polygons were drawn over the top of all overlapping planter boundaries to determine the minimum double-planted area for each end of the planter pass (Figure 1). These polygon areas were converted to acres and summed to represent the minimum double-planted acres that occurred in each field (Figure 2). The total double-planted acreage divided by the total field acreage was the percent of double-planted area. In an effort to determine the effects of increased planter width, super-imposed 18-row (57-foot wide) and 24-row (76-foot wide) planter boundaries were added to each map based on the field boundaries generated from the original 12-row (38-foot wide) planting maps (Figure 3). The first planting pass was assumed to begin on the longest, straightest edge of the field boundary for each super-imposed 18- and 24-row planting map.

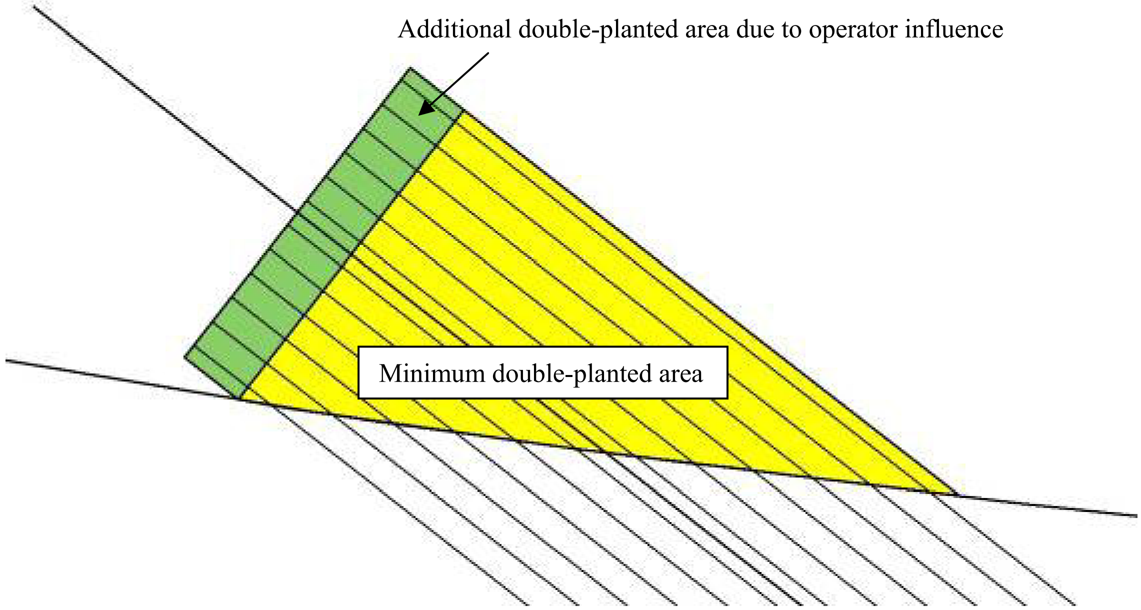

Figure 1. Representation of minimum double-planted area and additional double-planted area caused by operator

Classification of Fields

Once the percentage of double-planted area in each field was calculated, the 28 fields were grouped together based on each field's double-planted percentage to try to identify the relationship of field geometry and double-planting. Fields were placed into three classifications; low cost (< 1% double-planted), moderate cost (1 - 3% double-planted), and high cost (> 3% double-planted). The purpose of grouping these fields was to allow producers to determine the kinds of fields that typically have more double-planting in them so that they can compare these fields to their own. If a producer observes that the majority of their fields are very irregular (high cost), they should be able to realize the return on investment of ASC technology faster than a producer with more moderate cost or low cost fields.

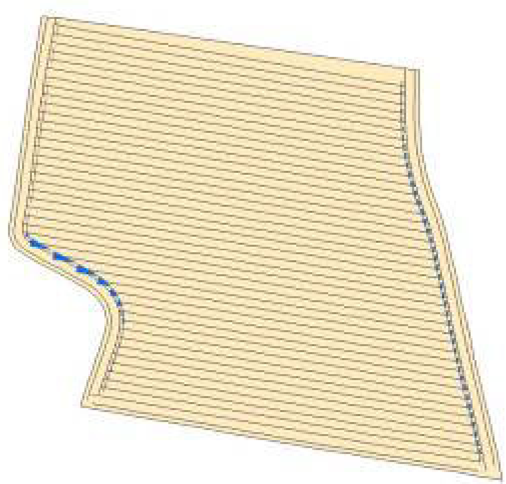

Figure 2. 38-foot wide planter (12-row) map generated in ArcMap

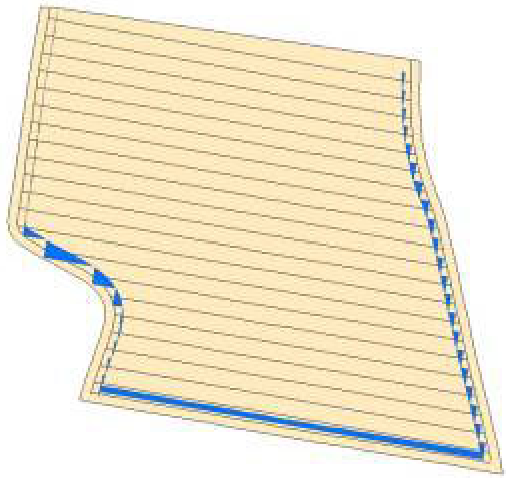

Figure 3. 76-foot wide planter (24-row) super-imposed on the 38-foot (12-row) planter boundaries

Results

Field size and shape varied from a 4.1-acre very irregularly-shaped field (field 28) with point rows running the length on one side of the field to a 106-acre, nearly rectangular-shaped field (field 7). The total minimum double-planted acres that would be planted in these 28 fields without automatic section control was found to be 13.8 acres. The percent minimum double-planted areas across all fields ranged from 0.1% to 9.8%. The average percent minimum double-planted area was 2.1%. As expected, the percent of minimum double-planted areas was highly influenced by field geometry (i.e., shape, size, and inclusion of terraces and waterways). Fields that were more rectangular-shaped and had little or no point rows (Figure 4) were found to have less than 1.0% double-planted areas (fields 1 - 10). Fields that were very irregularly-shaped and had numerous point rows (Figure 5) were found to have minimum double-planted areas greater than 3.0% (fields 20 - 28).

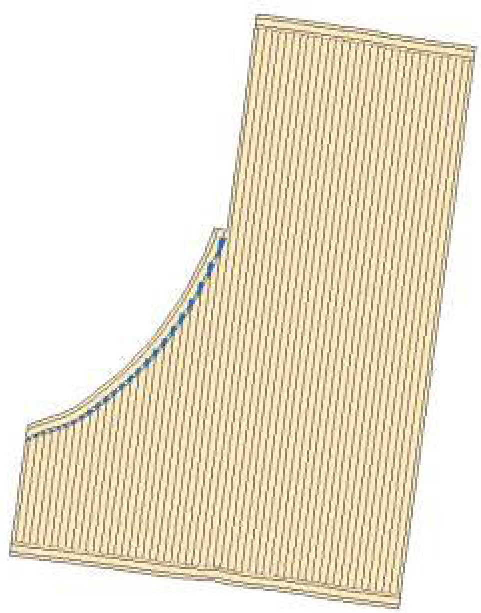

Figure 4. Field 7 planting map with a minimum double-planted area of less than 1%

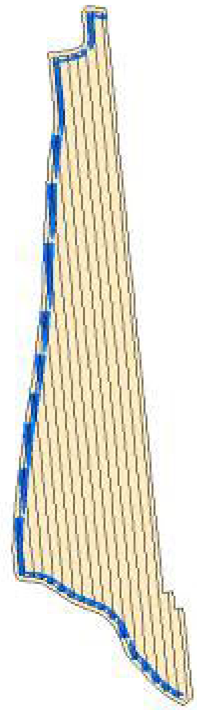

Figure 5. Field 25 planting map with a minimum double-planted area greater than 3%

As shown in Table 1, fields that were classified as low cost had an average of 0.4% of the field double-planted, 2.0% for the moderate cost fields and 3.8% for the high cost fields. Fields that fell in the low cost classification were typically large, more rectangular-shaped fields, with few or no point rows. Moderate cost fields were on average smaller than the low cost fields and had more irregular-shaped field boundaries. High cost fields were very irregular in shape with numerous point rows, such as narrow river bottom fields, or contained terraces or waterways. A summary of field area and shape characteristics along with double-planted information and planter pass data for all 28 fields can be seen in Table 2.

Table 1. Fields classified as low cost, moderate cost and high cost based on percentage of double-planting

Field Classification	***Low Cost***	***Moderate Cost***	***High Cost***
Range % DP	< 1%	1 – 3%	> 3%
Average % DP	0.4%	2.0%	4.4%
Total Acres	702	253	166
Average Field Size (Acres)	70	25	23

Equipment Operator Reaction Time

The width of the end and or turn rows influenced the equipment operator reaction time at the start and end of each planter pass. Operators who planted fields with one planter pass (38-foot wide) along the end and or turn rows tended to drop the planter too late at the start of the planter pass and picked up too early at the end of the pass. This left barren triangular areas that became glyphosate-resistant pigweed sanctuaries. These areas result in additional costs to the producer because of the extra management required to fight weeds and the potential yield that could have been made in these areas had they been planted. Operators who planted fields with two planter passes (76-foot wide) along the end and or turn rows tended to drop the planter too early at the start of the planter pass and picked up too late at the end of the pass. On average, the operators planting these fields missed their mark by an average of 7.1 feet per planter pass, thus creating additional double-planted area above the minimum. Based on this average extra travel distance, the double-planted areas in these fields increased by an additional 5.5 acres. These areas have additional increased seed costs and potential yield losses associated with them.

Table 2. Summary of field area and shape characteristics, double-planted information, and planter pass data

					Planter Passes				
	Field Information		**Double-Planted**		**Length (ft.)**				
	Acres	**Perimeter**	**Acres**	**Percent**	**Number of Passes**	**Longest**	**Shortest**	**Mean**	**Total**
	Low Cost Fields								
1	105.5	9515	0.1	0.1	39	3252	1738	2913	115589
2	79.9	7626	0.1	0.1	59	1488	1351	1413	83379
3	66.5	7986	0.1	0.2	25	2958	2825	2888	72190
4	77.5	7916	0.2	0.3	65	1536	444	1299	84425
5	71.4	7925	0.2	0.3	31	2845	488	2493	77271
6	21.9	4083	0.1	0.5	19	1150	1358	1258	23908
7	106	9718	0.5	0.5	55	2877	556	2040	112192
8	69.3	7308	0.4	0.6	24	1855	1500	1648	70870
9	15.6	4083	0.1	0.6	11	1556	1423	1497	16461
10	88.7	7944	0.7	0.8	46	2116	884	1984	95220
	Moderate Cost Fields								
11	18.2	4064	0.2	1.1	14	1430	1085	1284	17975
12	8.1	3601	0.1	1.2	6	1470	1435	1444	8664
13	40.5	7141	0.6	1.5	24	1951	233	1277	42124
14	22.7	6039	0.4	1.8	12	2672	354	2082	24987
15	26.4	4620	0.5	1.9	28	1426	127	1023	28650
16	22.5	4345	0.5	2.2	23	1420	188	956	21984
17	20.4	3716	0.5	2.5	25	954	208	803	20077
18	32.3	5209	0.8	2.5	31	1515	663	1120	34722
19	32	5259	0.8	2.5	28	1840	63	1226	34318
	High Cost Fields								
20	30.3	4976	0.9	3.0	33	1612	307	923	30463
21	16.4	3886	0.5	3.0	19	1481	115	865	16435
22	58.8	14017	1.8	3.1	27	5818	366	2465	66563
23	32	7850	1	3.1	47	912	104	663	31196
24	16.3	4170	0.6	3.7	15	1334	263	1051	15771
25	23.4	6336	1	4.3	17	2736	235	1495	25415
26	6.6	2147	0.3	4.5	14	391	42	174	2437
27	8.4	4457	0.4	4.8	5	1980	1925	1941	9705
28	4.1	2221	0.4	9.8	6	874	139	542	3253
Total	**1121.7**		**13.8**		**748**				**1186244**
Average	**40.1**		**0.5**	**2.1**					

Relationship Between Planter Width and Double-Planted Area

Increasing planter width reduced the number of passes required to plant each field; however, it increased the percentage of double-planted area. The percentage of double-planted area was dependent on the width of the planter as well as the field geometry. As shown in Figure 6, total double-planted area for each planter width was 13.8, 31.0, and 44.1 acres for the 38-, 56-, and 76-foot wide planters, respectively. An interesting phenomenon that was observed was how much the percentage increased as planter width increased. For example, a 33.3% increase in planter width (i.e. going from a 38- to a 56-foot wide planter) increased the double-planted area by 55.5%. A 50% increase in planter width (i.e. going from a 38- to a 76-foot wide planter) increased the double-planted area by 68.7%. As shown in Table 3, some of this increase in double-planted area occurred at the beginning and end of the planter passes, while the remaining occurred in the last planter pass. Fields in the study had been planted with 12-row planters for so long, the fields "had grown to fit" a 12-row planter. When planter width increased, there was usually some double-planting that occurred in the last pass of the field. Only one of the fields in the study had any double-planting in the last pass when planted with the 12-row planter. When the same fields were represented with 56- and 76-foot wide planter boundaries, roughly 60% of the double-planted area occurred in the end rows where double-planting is expected, while the remaining 40% occurred in the last pass. This happened because the 56-foot wide planter would either end up with 0, 6, or 12 rows double-planted on the last pass and the 76-foot wide planter would either end up with 0 or 12 rows double-planted on the last pass. With a 56-foot wide planter, the number of passes required to plant a field with a 38-foot wide planter had to be evenly divisible by three for no double-planting to occur in the last pass. With a 76-foot wide planter, the number of passes required to plant a field with a 38-foot wide planter had to be an even number for no double-planting to occur in the last pass.

Table 3. Relationship between planter width and double-planted area for all 28 fields

	Double-planted Area (acres)		
Width (ft.)	Ends	Last Pass	Total
38	13.8	0	13.8
57	18.8	12.2	31.0
76	25.6	18.5	44.1

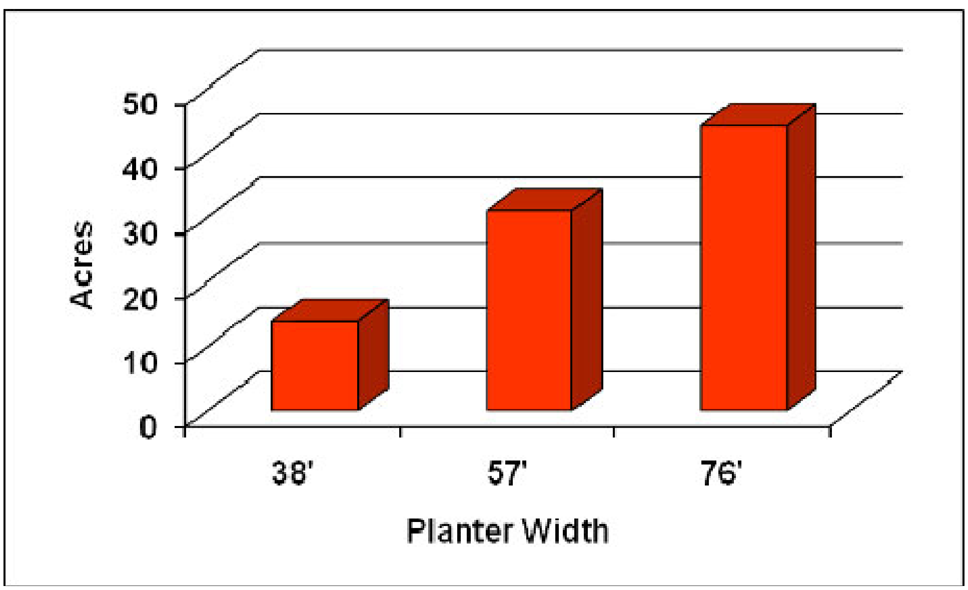

Figure 6. Double-planted acres as a function of planter width

Conclusion

Total minimum double-planted acres that would be planted in these 28 fields without automatic section control was found to be 13.8 acres. The percent minimum double-planted areas across all fields ranged from 0.1% to 9.8% with an average across all fields of 2.1%. As expected, the percent of minimum double-planted areas was highly influenced by field geometry (i.e., shape, size, and inclusion of terraces and waterways). Fields that were more rectangular-shaped and had few or no point rows were found to have less than 1.0 % double-planted areas. Fields that were very irregularly-shaped and had numerous point rows were found to have minimum double-planted areas greater than 3.0%. It was also determined that an increase in planter width has the potential to increase the amount of double-planted area that will occur in the end and turn rows and double-planting that may occur in the last pass of the field. The total double-planted area as a function of planter width was 13.8, 31.0, and 44.1 acres for the 38-, 56-, and 76-foot wide planters, respectively. Based on these results, a 33.3% increase in planter width (i.e., going from a 38- to 56- foot width) increased the minimum double-planted area by 55.5% over a 38-foot wide planter. Doubling the planter width (i.e., going from a 38- to 76-foot width) increased the double-planted area by 68.7%.

If a producer's fields are very irregular and would normally have a significant amount of double-planted areas, the returns on the investment of ASC technology would be realized faster than if the majority of his fields were larger with the end rows nearly perpendicular to the main rows. Future plans are to develop a map-based method to accurately calculate the percentage of double-planted area for any field based on planter width and field geometry so the costs of ASC technology can be justified to overcome the seed costs and potential yield losses associated with double-planted areas. Optimally, a program will be developed using Visual Basic in ArcMap in which a producer can input a shapefile of a field boundary and percentage of double-planted area for different planter widths so that this value may be used in a cost calculator.

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