THE EFFECTS OF PLANTER PARAMETERS ON COTTON EMERGENCE, GROWTH, AND YIELD

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Abstract

The advent of new seed meters, planters, and planter technology have now provided the ability for both researchers and producers to be more accurate with seed placement, singulation and seed to soil contact, thus promoting higher and more even rates of successful stand establishment. Traditionally seed cost was seen as an incidental cost of production, however, due to the increased level of technology contained within the seeds and plant, the cost has become of major concern to many producers and replanting can come at a very high cost that will greatly reduce the opportunity for profitability.

The main goal of this study was to begin defining the effects of different planter parameters on cotton production and final yield. This study focused specifically on pre-plant irrigation, planter depth, and row unit downforce. Phytogen 333 WRF was planted on May 11, 2016 and stand counts were taken at approximately three and five weeks after planting along with growth and vigor data such as plant height, leaf area index, and number of nodes to aid in quantifying the planter effect on emergence rate and vigor. The trial was grown to maturity by following UGA Extension Cotton production recommendations and was harvested on October 3, 2016. Initial analysis of the yield data shows an approximately 200 lb/ac lint yield difference between planter settings suggesting that proper planter setup is critical to ensure producers have the opportunity to maximize both yield and profitability based on proper planter settings in varying conditions.

Introduction

In 2014, Georgia produced over 2.5 million bales of cotton from 1.3 million harvested acres, ranking it second in national cotton production. Georgia's cotton production is very important to the state's agricultural industry, valued at $770 million (USDA/NASS). The high value of this industry to the state has created a need to improve production practices and to find ways to increase yield throughout the production season. The highest yield potential begins once the seed leaves the bag from then it is up to the producer to do all they can to maintain that yield potential, this includes proper planting, fertilization, pest and disease management, irrigation, and proper timing of harvest. However, the most important first step is proper placement of the seed in the soil to ensure maximum emergence rates and uniform stand establishment. Proper stand establishment at the beginning of the season will prevent the need for replant early in the season, which not only will reduce profit due to additional seed, labor, and fuel requirements for replanting, but in most cases the second planting also has a lower yield potential than the original.

Planter technology has advanced rapidly in recent years and has provided producers with many options when it comes to properly placing crop seeds in the soil. Some of the advancements include better seed meter systems which promote higher uniformity of seed spacing, variable rate planters which allow producers to better target optimal seeding rates to specific conditions, advancements in seed tubes have provided the opportunity to increase the speed of planting operations by allowing producers to drive faster and still properly place the seed in the trench with near perfect uniformity, and pneumatic and hydraulic downforce control systems have provided producers with better opportunities to match their downforce levels with the current soil textures and conditions. All of these advancements coupled together provide a producer with a technologically advanced tool which can do an excellent job of placing the seeds at the proper depth, with the proper downforce, while maintaining perfect spacing. All of these parameters aid in promoting uniform plant emergence and stand establishment.

Very little research has been conducted in the Southeastern United States exploring the interactions of the depth placement of seeds as it relates to planter downforce and soil moisture. The goal of this study was to begin developing a baseline and relationship as to which parameters on the planter have the largest effect on cotton emergence, growth and development, and final crop yield. These data are needed to provide producers with the knowledge and information required to make informed decisions about how they should set both their depth and downforce on their planter to ensure these settings are matched to the soil-crop environment. Ideally the proper combination of these parameters will not only reduce the occurrence of the need to replant, but will also promote higher yield levels at the end of the season by providing each seed with the best opportunity for germination and emergence.

Objectives

The main objective of this study was to determine which controllable planter parameters had the highest level of influence on cotton emergence, growth, and yield. The secondary objectives of this study were to determine the effect mechanical planter depth, downforce setting, and pre-plant irrigation application on cotton emergence, growth and development, and final cotton yield.

Materials and Methods

Cotton variety Phytogen 333 (Dow Agrosciences Indianapolis, IN) was planted on May 11, 2016 with a four row Monosem (Monosem Inc. Edwardsville, KS) vacuum planter (Figure 1). There was no appreciable rainfall from the period of April 17 through May 17 (no events greater than 0.25 in.). Thus, the soil was allowed to dry until the cotton was planted. Three pre-plant irrigation treatments were applied the night before planting occurred as follows the dry treatment did not receive any irrigation, the "optimal" treatment received 0.5-in., and the wet treatment received 1.0-in. of irrigation. Each treatment was planted under one quarter of a two tower center pivot irrigation system. Thus, each quarter was irrigated independently prior to planting. Composite bulk moisture content samples were collected from each of the fields prior to planting. There were not significant differences in the samples, but they were 7%, 9%, and 10% moisture for the dry, optimal, and wet respectively.

Figure 1. Four row (36 in. wide) Monosem planter used for planting the cotton.

The mechanical depth treatments for the planter were set at 0.5, 1.0, and 1.5 inches deep. This depth was set by using the adjustment knob on each row, measured and set individually for each row prior to planting. The depth measurements occurred on a flat and level surface to aid in the isolation of depth, and it should be stated that the mechanical depth was held consistent. Actual planted depth was not measured in this trial, but based on data and results can be assumed to have changed with adjustments in downforce. The downforce on at Monosem planter is adjusted by tightening and loosening a bolt attached to a spring. Three downforce levels were set on the planter by first finding the lowest downforce that allowed the planter row unit to be in a "weightless" state above the soil surface. The length of the bolt on each row was measured during this weightless state, this length was set as the low downforce treatment, and the medium downforce was set by adjusting the bolt half of its length back out and the high downforce was set by turning the bolt until the spring was fully compressed. Figures two and three represent the two drastically different treatments applied. Figure 2 is the 0.5in., low downforce, and dry soil treatment, and in this case the planter was unable to place the seeds under the soil surface as they can be seen laying on top of the soil. Figure three shows a deep trench that was made due to the 1.5in. depth, high downforce being applied in the wet soil.

Figure 2. Seeds are visible on the soil surface as a result of the low downforce, shallow 0.5in. depth and dry soil.

Figure 3. A trench in the soil was formed by the 1.5in. depth, high downforce, and wet soil.

Emergence data and plants were collected at three (21 DAP) and five weeks (35 DAP) after planting to evaluate treatment effects on crop emergence, growth, and development. Emergence counts were collected by counting the number of plants fully emerged from ten linear row feet of each plot. Plants were cut at ground level from one meter of row during the two data collection periods. The data collected from the meter of row included the number of plants, plant height, and number of nodes, leaf area, and dry weight. Growth and vigor data was calculated by evaluating the differences between the 21 and 35 DAP treatments. The data that was calculated included Crop Growth Rate (CGR), which is the crop growth rate in grams of dry weight per m^2 of ground area per day, generally regarded as an overall measure of above ground productivity. CGR is affected by leaf area index (LAI), and the average photosynthetic efficiency (NAR), thus the plant stand, leaf area per plant and NAR typically affect CGR. Plant growth rate (PGR), which is a measure of individual plant performance in grams of dry weight per plant per day. Net assimilation rate (NAR), or the average photosynthetic efficiency of all leaves in the canopy in grams of dry weight per m^2 of leaf area per day. Last, the LAAI, which is a unit less parameter of m^2 of leaf area per m^2 of land area, and gives an indication of the leaf area available to intercept solar radiation.

The cotton was carried to harvest following the UGA Extension Cotton Production guide for general agronomy production practices and all treatments were irrigated by using the SmartIrrigation Cotton App as a guide. The cotton was harvested on October 3, 2016 using a two row John Deere cotton picker with a bagging attachment in the basket. Each plot was harvested and weighed independently and yield was calculated by dividing the weight of the bag over the plot area harvested and converting to pounds per acre. Average lint turnout was calculated from ginning each of the treatments and taking an average of the lint turnout results.

Results and Discussion

The cotton emergence data show significant differences between treatments and pre-plant irrigation applications. Figure four represents the 21 and 35 DAP emergence data separated by pre-plant irrigation treatment.

There were very low emergence rates three weeks after planting and significant differences were only present in the optimum and wet pre-plant irrigation treatments. The 0.5in. low downforce treatment consistently had the lowest emergence in both the 21 and 35 DAP collections. Similarly the 1.0in. low downforce and all of the 1.5in. treatments had lower emergence especially present in the 35 DAP collection. Consistently the highest emergence rates for both collection times was the high and medium downforce for the 0.5 and 1.0 in. treatments. This suggests that cotton planted at an adequate depths between 0.5 and 1.0 inches deep have the opportunity to maximize emergence, if proper downforce is applied to maintain the target depth.

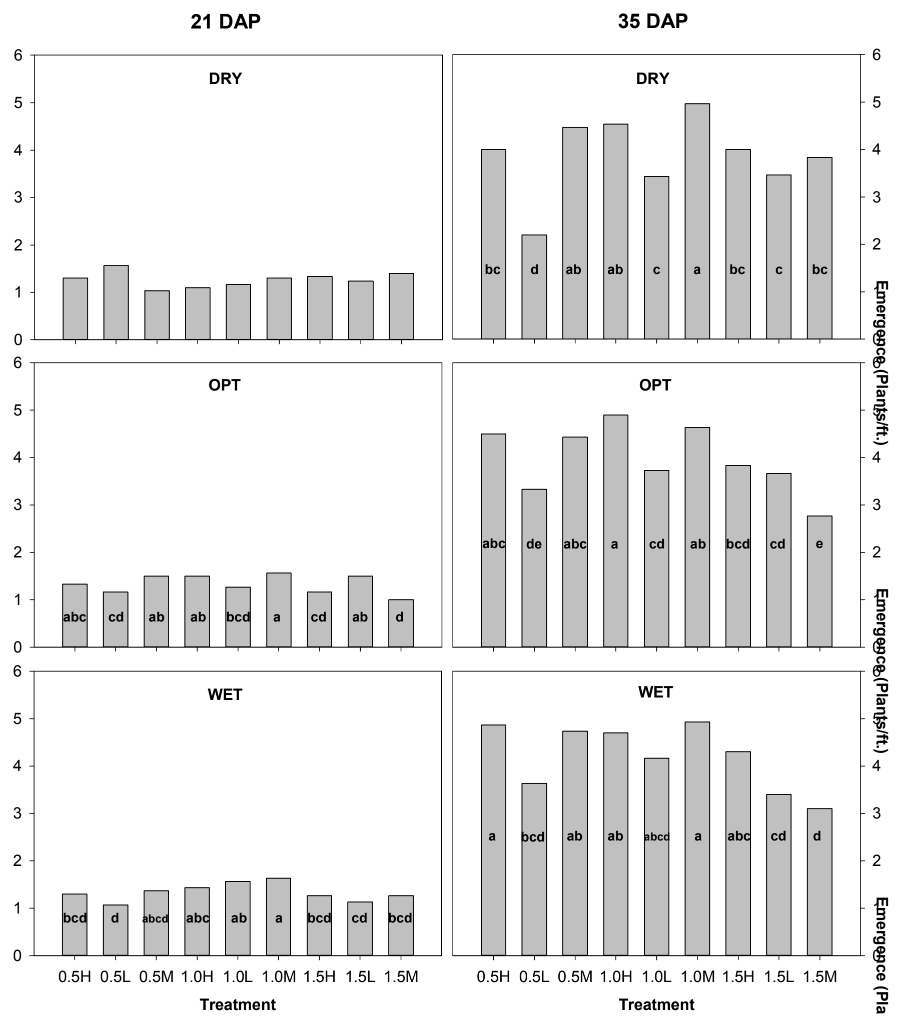

Figure 4. Cotton emergence data for the three and five week after planting collection times.

The growth and vigor data collected at 21 days after planting only had significant differences for Leaf Area and Dry weight, but no significant differences for the plant height and the number of mainstem nodes (Table 1). The lowest leaf areas were observed for the 1.0 and 1.5 in. depths at high downforces for the dry treatment and all of the 1.5 in. depths and the 0.5 in. low downforce. This suggests that the higher downforces and deeper depths are causing developmental problems early in the season just after emergence. Similar trends were observed for the dry weight development which is logical since leaf area development is tied to plant development. However, it is important to note that the dry irrigation pre-plant treatment had the lowest dry weights when compared to the other pre-plant irrigation treatments.

Table 1. Growth data collected at 21 days after planting.

Irrigation	Treatment	Height (inches)	Node	Leaf Area (cm^2/plant)	Dry Weight (g/plant)
DRY	0.5H	3.47	2.00	34^{ab}	0.36
	0.5L	3.21	2.00	33^{abc}	0.32
	0.5M	4.46	1.74	30^{abcd}	0.28
	1.0H	4.05	1.89	25^{cde}	0.23
	1.0L	3.18	1.89	30^{abc}	0.34
	1.0M	3.74	1.94	26^{bcde}	0.28
	1.5H	3.62	1.96	20^{e}	0.24
	1.5L	4.26	1.97	38^{a}	0.35
	1.5M	2.64	1.72	22^{de}	0.24
		P = 0.284	**P = 0.429**	**P = 0.005**	**P = 0.212**
OPT	0.5H	5.00	2.81	46^{a}	0.82^{a}
	0.5L	3.97	1.94	29^{bcd}	0.60^{b}
	0.5M	3.33	3.44	39^{ab}	0.66^{ab}
	1.0H	5.18	3.03	37^{abc}	0.66^{ab}
	1.0L	4.89	1.88	30^{bcd}	0.60^{b}
	1.0M	5.05	1.80	28^{bcd}	0.51^{bc}
	1.5H	4.04	1.86	24^{cd}	0.42^{c}
	1.5L	3.67	2.92	25^{cd}	0.60^{b}
	1.5M	2.56	3.06	21^{d}	0.51^{bc}
		P = 0.319	**P = 0.081**	**P = 0.016**	**P = 0.008**
WET	0.5H	3.91	3.27	33	0.63^{a}
	0.5L	4.90	2.90	36	0.65^{a}
	0.5M	4.99	3.66	28	0.59^{a}
	1.0H	4.42	3.73	29	0.65^{a}
	1.0L	5.70	3.67	38	0.65^{a}
	1.0M	3.74	3.50	33	0.65^{a}
	1.5H	3.70	3.61	24	0.47^{a}
	1.5L	3.94	2.60	30	0.46^{ab}
	1.5M	2.58	3.33	13	0.27^{b}
		P = 0.100	**P = 0.545**	**P = 0.075**	**P = 0.007**

Cotton has an incredible ability to compensate from deficiencies through vegetative growth. Table 2 represents this and shows that there were no significant differences between any of the treatments at the 35 DAP collection.

Table 2. Growth data collected five weeks after planting.

Irrigation	Treatment	Height (inches)	Node	Leaf Area (cm^2/plant)	Dry Weight (g/plant)
DRY	0.5H	10.12	6.24	242	2.35
	0.5L	10.02	6.68	331	3.03
	0.5M	10.39	6.29	280	2.59
	1.0H	9.52	6.06	257	2.28
	1.0L	9.94	6.13	327	2.74
	1.0M	9.76	6.39	264	2.51
	1.5H	10.11	6.08	257	2.43
	1.5L	10.22	6.30	334	3.17
	1.5M	9.79	5.52	279	2.59
		P = 0.975	**P = 0.713**	**P = 0.426**	**P = 0.599**
OPT	0.5H	12.11	7.23	373	4.18
	0.5L	10.33	6.25	305	2.79
	0.5M	12.47	7.26	400	4.17
	1.0H	10.95	7.32	319	4.45
	1.0L	11.61	7.50	322	3.28
	1.0M	12.14	7.82	394	4.53
	1.5H	10.66	7.77	369	3.70
	1.5L	11.88	6.97	360	3.66
	1.5M	9.53	6.6	298	3.10
		P = 0.282	**P = 201**	**P = 0.901**	**P = 0.165**
WET	0.5H	10.19	6.60	185	2.13
	0.5L	11.60	7.28	390	3.78
	0.5M	12.27	7.22	333	3.72
	1.0H	11.92	6.89	379	3.35
	1.0L	11.42	7.29	344	3.68
	1.0M	9.67	6.89	315	3.25
	1.5H	9.46	6.59	253	2.45
	1.5L	11.16	7.70	357	3.45
	1.5M	9.88	7.36	321	3.17
		P = 0.485	**P = 0.772**	**P = 0.203**	**P = 0.712**

The growth and vigor data calculated from the data collected at three and five weeks after planting is represented in Table 3. There were only significant differences between the CGR and LAI parameters. The CGR is affected by LAI and NAR, so it would be expected that plant stand, leaf area per plant, and NAR impact CGR. It is important to note that the effect is only significant for the optimal treatment. Similarly LAI was only significant for the optimal treatment. Similar to the results observed during the 21 DAP collection, the low 0.5 in. downforce and deeper depths hindered the both the CGR and LAI development.

Table 3. Cotton growth and vigor data calculated from the data collected at three and five weeks after planting.

Irrigation	**Treatment**	**CGR** $g\ m^{-2}\ d^{-1}$	**PGR** $g\ plant^{-1}\ d^{-1}$	**NAR** $g\ m^{-2}\ d^{-1}$	**LAI**
DRY	0.5H	1.65	0.14	16.7	0.14
	0.5L	1.24	0.20	16.1	0.11
	0.5M	1.54	0.16	15.3	0.14
	1.0H	1.36	0.14	16.4	0.12
	1.0L	1.02	0.17	14.1	0.10
	1.0M	1.28	0.15	15.4	0.11
	1.5H	1.41	0.15	17.8	0.12
	1.5L	1.30	0.20	13.8	0.12
	1.5M	1.24	0.16	17.6	0.10
		P = 0.712	**P = 0.685**	**P = 0.697**	**P = 0.667**
OPT	0.5H	2.27^{ab}	0.24	16.3	0.19^{a}
	0.5L	0.82^{d}	0.15	12.4	0.09^{cd}
	0.5M	1.95^{abc}	0.25	17.8	0.16^{ab}
	1.0H	2.17^{ab}	0.27	28.4	0.12^{bcd}
	1.0L	1.27^{bcd}	0.19	16.4	0.12^{bcd}
	1.0M	2.31^{a}	0.28	20.2	0.17^{ab}
	1.5H	1.62^{abcd}	0.23	18.2	0.13^{abc}
	1.5L	1.43^{abcd}	0.21	18.6	0.12^{bcd}
	1.5M	0.92^{cd}	0.18	19.4	0.07^{d}
		P = 0.039	**P = 0.219**	**P = 0.791**	**P = 0.016**
WET	0.5H	1.06	0.10	14.6	0.09
	0.5L	1.29	0.22	12.9	0.12
	0.5M	1.95	0.22	18.5	0.15
	1.0H	1.70	0.19	15.4	0.18
	1.0L	1.98	0.21	16.1	0.16
	1.0M	1.11	0.18	11.8	0.11
	1.5H	1.23	0.14	16.2	0.11
	1.5L	1.38	0.21	15.7	0.13
	1.5M	0.85	0.20	19.3	0.06
		P = 0.689	**P = 0.719**	**P = 0.958**	**P = 0.164**

Yield data exhibited differences both between pre-plant irrigation treatments and within individual treatments within each pre-plant irrigation treatment (Table 4). Overall the dry pre-plant irrigation treatment had lower average yields at 966 lbs/ac than the optimal at 1062 lbs/ac and the wet at 1044 lbs/ac treatments. The overall highest yielding treatment was the optimal pre-plant irrigation planted at 0.5in. deep with high downforce. The high downforce more than likely pushed the seed deeper in the ground, thus placing it at a more suitable depth, maximizing emergence and growth rates which translated to end of season yield. The depths that performed the best independent of downforce were the 0.5in. depth in the optimal pre-plant irrigation treatment and the 1.0in. depth in the wet pre-plant treatment. Both of these treatments had average yields of 1122 lbs/ac independent of applied downforce.

Thus, based on the yield data, it can be inferred that in a dry environment that the practice of "dusting" in the seeds provides the opportunity for the plant to perform just as well as recommended depth and downforce settings. However, it is important to note, that this treatment did not perform well from the perspective of the physiological growth data parameters. Thus, the plants may not always be able to compensate and overcome the hindrance to growth due to the improper placement of seeds. As stated earlier a shallower depth and a high downforce was able to produce the highest yield overall in the trial. This, however, suggests that the more optimum depth for cotton in this situation was between the 0.5 and 1.0 inch depths applied in this study. The high downforce applied in this case pushed the seed deeper than 0.5 inches into the soil, and placed it in a more optimum environment for germination and emergence. In a wet pre-plant environment the recommended depth of 1.0 in. consistently produced the highest yield level. This suggests that when ample moisture is available there is no advantage to placing the seed deeper or shallower in the soil profile. In all cases for the 1.5in., depth had the lowest average yield independent of pre-plant soil moisture and downforce, suggesting that cotton should not be planted deeper than 1.0 inch in the soil profile.

Table 4. Cotton lint yield data divided by pre-plant irrigation treatment, depth and downforce.

Irrigation	Treatment	Lint Yield (lbs/ac)
DRY	0.5H	910
	0.5L	1018
	0.5M	908
	1.0H	999
	1.0L	969
	1.0M	1047
	1.5H	937
	1.5L	972
	1.5M	935
OPT	0.5H	1205
	0.5L	1088
	0.5M	1069
	1.0H	1143
	1.0L	1084
	1.0M	975
	1.5H	1000
	1.5L	950
	1.5M	1041
WET	0.5H	1025
	0.5L	1010
	0.5M	1010
	1.0H	1112
	1.0L	1102
	1.0M	1153
	1.5H	1030
	1.5L	923
	1.5M	1029

Conclusions

The first year of this multi-year study has provided a good base of information as to which controllable planter parameters are most important in maximizing cotton germination, emergence, growth, and yield. Treatment effects were found in pre-plant irrigation treatments for emergence rate, growth and development and final yield suggesting that the soil moisture in which the seed is placed should be considered when setting the planter properly. This data has shown that there is not one specific planter parameter that can provide the optimum levels of emergence, growth and development, and final yield for every planting situation and environmental condition. This suggests that producers should carefully evaluate their planting conditions and properly monitor planter performance to make informed decisions as to which settings they should change to ensure proper placement of the seed into the seed bed.

A depth by downforce interaction was found during this study, meaning that if the proper downforce is not selected and the planter is unable to maintain the selected mechanical depth due to an incorrect downforce, the planted depth will be either too deep or too shallow, causing both emergence and final yield penalties. Cotton's ability to compensate through vegetative growth for deficiencies was observed during the 35 DAP collection, however, some of the early season deficiencies still translated to yield reductions at the end of the season. Overall in this study the recommended 1.0in. depth performed the best across all environments, however it should be noted that this study was conducted in a loamy sand soil, and more data are needed to draw conclusions about other soil types.

References

"USDA/NASS 2014 State Agriculture Overview for Georgia." Nass.usda.gov. USDA, 30 Nov. 2015. Web. 30 Nov. 2015.