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MANAGING PLANT POPULATION IN COTTON

Curtis Adams, Santanu Thapa, and Emi Kimura*

SUMMARY

Cotton breeding and genetic modifications have made substantial progress in improving the crop for yield, quality, and ease of management. These developments have also increased the cost of seed, with the major cause of higher seed costs being the incorporation of transgenic traits. High seed costs have brought the issue of plant population into greater focus, as cotton producers could benefit from optimizing seed inputs. We sought to provide a clearer understanding of this issue by analyzing reports of lint yield response to plant population in the scientific literature, while compiling other information important in making plant population decisions.

We found that cotton yields did not vary for plant populations ranging from 15,000 to more than 90,000 plants per acre, when plants were evenly spaced. This conclusion was consistent across a wide range of environments and cotton cultivars. There is little scientific information on the yield impacts of uneven stands. We found that the most common plant population recommendation issued by U.S. Cooperative Extension agencies and seed companies was 33,000 plants per acre (2.5 plants per foot on 40-inch rows), though both lower and higher rate recommendations can be found. Experts point out that to achieve a desired plant population, seeding rates should be adjusted upward to account for inevitable seed and plant loss. Such recommended increases range from 20 percent in good conditions to about 50 percent in poor conditions.

In choosing a target plant population and a seeding rate to achieve it, producers should consider several factors, such as known yield response of cotton to plant population, seed and field conditions that may result in stand loss or variability, and the effects of plant population on other factors like crop maturity and harvest efficiency. For most cotton producers, we recommend targeting moderate final plant populations, no less than 20,000 plants per acre, and avoiding excessive populations that inflate production costs.

LINT YIELD RESPONSE TO PLANT POPULATION DENSITY

We reviewed the scientific literature on plant population and conducted our own field research. In the literature, we found studies from diverse cotton-production environments in the U.S. and around the world. Peak yield varied greatly among the studies, primarily reflecting differences in water availability and cotton genetics. However, yield trends with respect to plant population were remarkably similar: lint yield declined only at very low plant populations and yield plateaued across all higher populations tested.

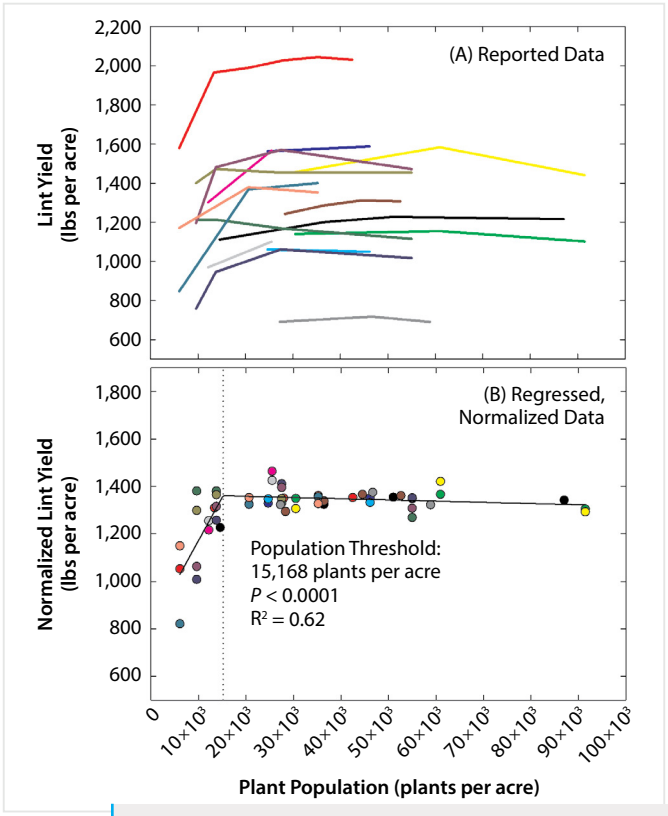


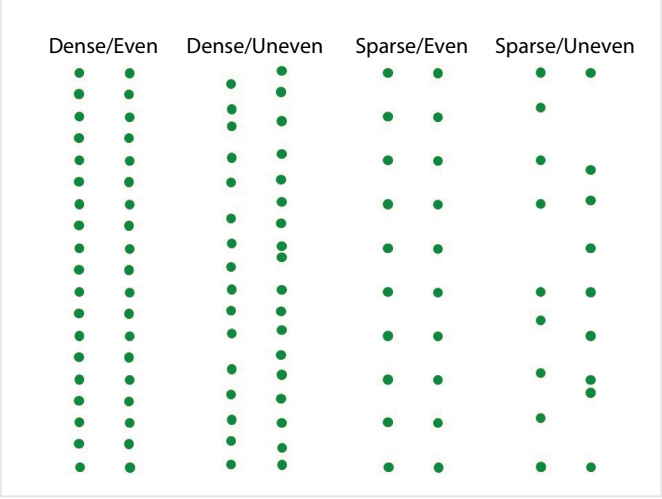
Figure 1. (A) Lint yield response data to ranges in plant population in studies conducted around the world; and (B) the transformed data with the results of our analysis.

*Texas A&M AgriLife Research and Extension

We combined the literature datasets and analyzed them collectively, with the goal of pinpointing a minimum plant population threshold needed to optimize lint yield. To be included in our analysis, the reports had to meet several criteria: 1) Reports were from year 2000 or later, to ensure modern cotton cultivars were planted; 2) studies used fixed row width and intra-row spacing, excluding skip-row or hill drop studies; and 3) studies had to use best management practices, to ensure that background factors (e.g. nutrients) other than population density did not affect the results. It is important to note the spacing between plants within rows was even in the studies, without the gaps between plants that may occur in producers' fields.

Figure 1 (A) presents all the datasets included in our analysis, showing the wide differences in yield but similarity in yield trends among studies. Figure 1 (B) shows the same data following a statistical transformation and the analysis of the data. **Through the analysis, we identified a yield threshold in plant population at about 15,000 plants per acre (1.1 plants per foot on 40-inch rows) with even spacing. Yield declines abruptly below 15,000 plants per acre and there is no yield benefit to higher plant populations.**

The cotton plant has an extensive capacity to adapt its branching and other growth patterns to accommodate changes in plant population. The studies and analysis presented here show this, though the results are most applicable to cotton stands with even plant-to-plant spacing. In the following figure, four types of cotton stands are illustrated. In the dense/even stand, optimal yield would be expected. Optimal yield would also be expected in the dense/uneven stand, which may include doubles and missing plants but does not have substantial gaps. Optimal yield would even be expected in the sparse/even stand, if population did not decline below about 15,000 plants per acre. Yield loss would be expected in the sparse/uneven stand scenario and seeding rate decisions should be made to avoid this.



FACTORS THAT RESULT IN SEED AND PLANT LOSS

Cotton producers need to make both seeding rate and plant population decisions. Seeding rate refers to the number of seeds planted per unit area or row length. Plant population is the rate of plants that survive, which determines yield. Seed and plant loss occur to various extents following planting, which necessitates seeding at a relatively high rate to achieve a desired plant population. Seeding rate and plant population decisions are made on a case-by-case basis, considering the soil, weather, and seed conditions. The following factors and considerations can cause seed and plant loss:

- Low seed viability
  - Newly purchased seed should have high viability, if handled properly, and seed viability should be listed on the label.
  - If storing seeds, keep them at low temperature and low humidity.
  - Test the germination of older seed and adjust the seeding rate accordingly.
- Planter errors
  - Seed skips and doubles are similar to missing plants.
- Soil crusting
  - This occurs when soil is wet at or shortly after planting, followed by surface drying.
  - This may cause the seed to germinate, but not emerge.
  - It is more common in disturbed soils with limited residue cover and in heavier soils.
- Rapid soil drying
  - This occurs when planting into moisture, followed by high evaporation.
  - If the seed absorbs water and germinates, it can die in dry soil.
  - It is more common in sandier soils.
- Sand blasting
  - High winds blow sand and damage or bury plants, especially young plants.
- Disease and pests
  - These impacts can hit at any time, but many can be managed.

OTHER CONSIDERATIONS IN PLANT POPULATION MANAGEMENT

In addition to achieving a stand that will produce optimally, tradeoffs can be created by a variety of crop responses to plant population. Many, though not all, of these factors are described below. Some factors may vary by production environment.

Higher population density can result in:

- More fruit production along the main stem of the plant, creating consistency and earlier timing of boll maturity and improved fiber quality.
- Decreased average boll size, which can affect harvest efficiency, as lint recovery is generally lower from smaller bolls.
- Fruit shed may be higher, due to increased canopy shading.
- Improved cotton competitiveness with weeds in the later season.
- In humid environments, high plant populations accelerate canopy closure, increasing canopy humidity and increasing foliar diseases and boll rot.

Lower population density can result in:

- Increased fruit set on secondary branches, causing wider variation and overall later maturity among bolls, decreasing fiber quality.
- The potential for reduced harvest efficiency, due to more extensive branching and thicker stems.
- Overall increase in boll size, which may improve harvest efficiency.
- Fruit retention may be higher.

COTTON POPULATION RATE RECOMMENDATION AND ECONOMIC CONSIDERATIONS

We searched for plant population rate recommendations from U.S. Cooperative Extension agencies and seed companies. The most common recommendation found for final plant population was 33,000 plants per acre (2.5 plants per foot on 40-inch rows), though lower and higher rate suggestions are also common. Seeding as high as about 50,000 seeds per acre (4 seeds per foot on 40-inch rows) was recommended for very challenging conditions. A seeding rate 20 percent greater than the desired final plant population was recommended in ideal conditions. Greater seeding rate excesses, up to about 50 percent greater, were recommended in poor planting conditions.

We suggest targeting a final plant population of no less than 20,000 plants per acre, in ideal conditions, to mitigate the risk of yield loss and avoid stand-related drawbacks of very low populations. Targeting higher populations is necessary to mitigate risk when significant seed and plant loss are expected. Using excessive seeding rates should be avoided. The table below summarizes seed costs for relevant seeding rate and seed price values (assuming 250,000 seeds per bag), illustrating the economic argument for optimizing seeding rate and plant population decisions.

For more details on the analysis and studies referenced in this publication see: Adams, C., S. Thapa, and E. Kimura. 2019. *Determination of a plant population density threshold for optimizing cotton lint yield: A synthesis*. Field Crops Research 230:11–16.

SEEDING RATE	PRICE OF COTTON SEED (PER BAG)						
	$350	$400	$450	$500	$550	$600	$650
(seeds per acre)	(seed costs, $ per acre)						
25,000	$35	$40	$45	$50	$55	$60	$65
30,000	$42	$48	$54	$60	$66	$72	$78
35,000	$49	$56	$63	$70	$77	$84	$91
40,000	$56	$64	$72	$80	$88	$96	$104
45,000	$63	$72	$81	$90	$99	$108	$117
50,000	$70	$80	$90	$100	$110	$120	$130