CONTAMINANTS ISSUE AND HANDLING IN COTTON GINNING

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Abstract

Concerted preventative measures, practices in cotton harvesting and ginning, together with the use of technology can lead to drastic reduction of plastic contamination in cotton and can make contamination-free cotton a reality. Advanced technology has been employed to detect contaminants and other extraneous matters in cotton with a high degree of accuracy, but there is still a need for a practical and economical technology, methodology, and procedure to solve the plastic contaminants issue from the stream of cotton being processed in the gin, in real-time.

Introduction

Contaminants in ginned cotton are a persistent problem that has been studied and has changed practices in the industry. Solutions are continually being sought because contaminants are still negatively impacting the value and quality of the end products particularly in textile, and most recently plastic contaminants are dominating the issue. Plastic has been recently identified as a contaminant that has costed producers millions of dollars of losses, solutions must be found in order to eliminate or minimize its presence in the cotton bales (smith, 2017). A plastic fragment embedded in a cloth can now be traced back to the bale it came from, the penalty to the producer can be significant not only financially, but also in loss of confidence or even in loss of contracts. The cotton industry has responded to the issues of plastic contamination by initiating various public education initiatives, guidelines (NCCA 2018), implementing changes in practice, and by the enactment of new classing codes (Robbin et al. 2017). This paper is a review of the current state of extraneous matter issues focusing on the plastic contaminants including mitigation efforts, existing detection, and removal methodologies.

Materials and Methods

Economics of Plastic Contamination in Cotton

According to the guideline of the USDA Agricultural Marketing Service (USDA-AMS), extraneous matter in cotton is “any substance in the cotton other than fiber or leaf” (USDA-AMS 2018). The amount of extraneous matter in the cotton is determined by the classing office which reports it as level 1 or level 2, with level 2 indicating the heavier degree of contamination. A coded numbering system is used to indicate the types and levels of contamination. Plastic contamination is coded 71 for level 1 and 72 for level 2, these are relatively new code numbers, they came into effect on July 1 of 2018. A discount point system is used to quantify “penalty” associated with extraneous matter, for example, the discount point for 2019 ELS Cotton Extraneous Matter for plastic level 1 is -715 (negative 715 points), and for level 2 is -1035 (negative 1035 points) (USDA-FSA 2018). Discount points affect the Loan Rate of cotton, which is published annually (price per unit (bale)) (USDA Commodity Loan Rate 2019), which is calculated according to certain procedure. Computing tool such as the Loan Rate Calculator from the Cotton Incorporated is used to help users with calculating the impact of discount points (Cotton Inc. 2019). Roughly speaking, a discount of -715 for level 1 plastic contamination is about 7.15 cents per pound, or around $35.75/bale. The relatively high discount points of plastic contamination are a strong indicator that plastic contamination is very undesirable from producers’ point of view and from the point of views of the entire supply chain, because they affect profitability.

Current Methods of Detecting and Removal of Contaminant

Obviously, the most effective and logical method of managing plastic contamination in cotton is by preventing it from getting into the system in the first place. Concerted efforts that have been undertaken by the cotton industries include public education, awareness campaign, outreach, continual training of field workers, ginners, and producers, and development of guidelines, and the development of new standards. The National Cotton Council of America published a set of guidelines and educational materials on the subject of Contamination-Free Cotton (NCCA

Contamination-Free Cotton 2019). In the guideline, it was identified that sources of plastic contaminants include: Plastic Twine (Figure 1), module cover materials, plastic shopping bags, poly pipe, mulch, pieces of shop rags, paper towels, Styrofoam, and others. It was further reported that in 2017 the majority of the plastic contamination incidences were attributed to the round module plastic wrapper (over 88%) (NCCA 2019), and consequently, increased amount of educational information has been made available from organizations such as the National Cotton Council of America, the Cotton Incorporated, USDA-AMS, and manufacturers of machineries to help reduce the incidence. New variants of wrapper plastic with markings to help reduce improper cutting have been introduced to make their uses as "fool proof" as possible. Standard procedures have been recommended such as: in-field removal of debris, and looking for loose ditch liners and poly pipe, residual plastics or mulch, prior to harvesting; during harvesting – on how to inspect and maintain harvesting equipment, properly handle plastic wrapping system of the harvester, proper transporting and handling of modules to prevent tearing of plastic wrap, and proper choice of staging locations for modules, and proper alignment and spacing of modules to enable proper module truck pickups; communication between producers and ginners to facilitate preventive measures such as handling damaged modules; at the gin – proper handling and removal of damaged and undamaged wraps.

Proper handling of cotton from the field to the gin is a large part of the process for preventing plastic contaminants from being introduced into the seed cotton entering the gin machineries. Although in-field guidelines are followed properly, plastic contaminants can still be introduced into the gin machineries from torn plastic wraps and other contaminants due to other mechanical contacts at the ginning site and from other sources. Once plastic contaminants get into the cotton ginning machineries the issue becomes technological and more complex. The process of ginning cotton involves multiple stages of drying, separation (removal of seed, leaves, stick, and extraneous matters), lint cleaning and mote baling. Majority of the contaminants are removed in the seed-cotton separation/cleaning stages, additional lint cleaning is done after the lint-cotton passes the gin stand and prior to being baled. The cleaning process in the gin involves the use mechanical systems consisted of circular saws and brushes. Some of the contaminants in the cotton get cut into smaller sizes as they go thru each of these cleaning stages that involve sawing, making them more difficult to detect and to remove.

Byler reported on the efficacies of existing cotton ginning equipment in removing plastic contaminants from cotton (Byler et. al, 2013). The work provided better understanding on how well the equipment in a cotton gin removed plastic contaminants from the cotton stream. The study introduced seven type of plastic contaminant into the seed cotton being ginned. The materials chosen were of different sizes that were typically found in harvested cotton. The contaminants were collected at each stage of the processes with collection trays and were quantified as weights and percentages. The study collected information on weight of plastic removed in each stage of the cleaning process and the percentages of plastic remained in with the cotton lint. The study found that an average of 88% of plastic contaminants introduced into the system were accounted for. The study concluded that the majority of the plastic contaminants got removed in that stage of the stick machines, but there was still a significant amount of the contaminants found in the lint (17%). It was mentioned from similar study that Plastic removal by a cylinder cleaner was affected by the air flow rate and plastic size (Hardin et. al 2016).

The majority of literature found that were related to extraneous matter contamination in cotton were in methodologies of detection, and there have been some contaminant detection and removal technologies made available in the marketplace. The efforts in detecting foreign matters in cotton dated since the early nineties ranging from spectral analyses to computer vision. The USDA-ARS has a library of near and far infrared spectral properties of contaminants in cotton to aid in the development of various optical detectors. Computer algorithms utilizing optical detectors and the library were developed including the works reported Loudermilk et.al (Loudermilk et al. 2008).

Short wave infrared has been used to detect plastic contaminants in cotton (Zhang, et. al, 2016). This is a hyperspectral (wavelengths of 900 to 1700 nm) reflective method using a liquid crystal tunable filter to detect contaminants in cotton lint. The authors used this technology to discriminate different types of contaminants, including plastic. It was reported that they achieved classification accuracies of up to 96.5%. The computing performance needed in their study included a vector machine, a dedicated electronic hardware accelerator for processing images. The shortwave infrared hyperspectral method demonstrates that it is a non-contact method that can detect/discriminate foreign matters in cotton lint with high accuracy.

Mehta, et al. (Mehta et al.) reported a method of detection using color hue saturation intensity (HSI) of images captured by a CCD camera. Their study found that the method had a processing time that was slightly faster than using YCbCr (a member of a family of color spaces in a color image) method.

Other methods for improving the performance in detecting foreign matters in cotton include the use of Fuzzy Logic and Neural Network. Hughes, et al. reported the development of a fuzzy logic computer algorithm for discriminating and quantifying trash types in cotton in conjunction with an image capturing system (Siddaiah et al. 1999). They found that the method was effective in both identifying and quantifying trash contents in cotton (correlation coefficient 0.9988 relative to results obtained from the Southwestern Cotton Ginning Research Laboratory (SWCGRL).

Recent published, ongoing research efforts on the subject of plastic contamination issues in cotton include Research Project #435029 of the USDA-ARS Cotton Ginning Research Laboratory (Sui 2018). The study focused on several objectives including: the use of UAV (unmanned aerial vehicle) as a means to map plastic contamination in a cotton field prior to harvest; development of a camera system and image-analysis techniques for identifying contaminants at the module feeder of a gin; study of flow dynamics related to ginning, such as relative seed cotton velocity and drag force over a range of operating parameters; modeling of drag force, heat transfer, mass transfer, and turbulence, of the seed cotton-air system; and simulation of seed cotton drying system.

Commercial cotton contamination cleaning machines include the GENN G2U (Genn), and Uster Jossi Magic Eye (Uster). The Genn G2U series Cotton Contamination Cleaner Machine introduced by the Genn Group of India claimed that it had a capacity of cleaning contaminants at a rate of 1 ton per hour, but there have been no published data supporting the claim. The operation as illustrated in the product's brochure was based on ultrasound and imaging with a pneumatic ejector that ejected contaminated cotton from the stream to an ejection port (See Figure 2.) The Uster Jossi Magic Eye claimed the ability to detect the finest white and transparent plastics including the ability to identify and remove polypropylene and polyester from bale. Similar to the Genn machine there is no published data to show the efficacy of these machines.

Figures and Tables

Figure 1. In-Field Plastic Contaminants – plastic bags and twines.

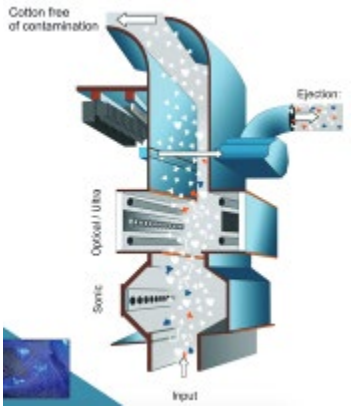

Figure 2. Genn G2U series Diagram Depicting Detection Removal. Curtesy of Genn G2U product brochure.

Summary

Most of the methodologies developed for detecting contaminants in cotton today involve optical detection and imaging, and most of the published techniques boasted enhancements in delineating contaminants from lint. All of the detection techniques reviewed have their utility in different sector of the process chain such as in classing office, textile lay-out inspection stage, etc. Although technologies for detection and removal of contaminants in cotton are commercially available, they have not been made economical enough for widespread adaptation in cotton gins. Research efforts in contamination detection and removal are ongoing, an effective, economical system for detection and removal of plastic contaminants in a stream of cotton in a gin in real-time, is still needed.

Disclaimer

Mention of trade names, proprietary product, or specific equipment does not imply approval of the product and to the exclusion of others that may be available.

Acknowledgements

This project is funded by the USDA-ARS non-Assistance Cooperative Agreement 58-6066-038, and by the USDA Multi-state Project W3009/MIS-119070.

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