https://doi.org/10.1051/e3sconf/202337101023

Research on the geometric dimensions of fine pollutants in cotton

Azimjon Parpiev[1], *Mamura* Shorahmedova[1*], *Saida* Saidbekova[1]

[1]Tashkent Institute of Textile and Light Industry, 100100 Tashkent, Uzbekistan

Abstract. This article is devoted to the study of the geometric dimensions of fine pollutants in cotton and the factors affecting them. Mass and quantitative fractions of small and large pollutants were compared. As an object of cotton cleaning, it was found that cotton contained different proportions in terms of the amount of fine pollutants. Although large pollutants exhibited a higher proportion of the total contamination in terms of weight, these pollutants were verified to exhibit a negligible proportion in terms of numbers. One gram of different selections and industrial varieties of cotton was obtained, in terms of contamination and harvesting type. The pollution amount was determined similar in terms of the total quantity and magnitude. The results of mathematical and statistical processing of the obtained results indicated that the number of pollutants per gram were statistically insignificant and differed among the experimental variants, but the value of the square inequality was higher. The results demonstrated that there exists a need to conduct a wide range of experimental tests in this area to determine the impact and interrelationships among all external factors on the size of the pollutant fraction and proportions.

1 Introduction

The cotton ginning, textile and light industries, involved in the cultivation and processing of cotton, play an important role in the economy of Uzbekistan [1-3]. In recent years, large-scale cotton and textile clusters have been established in Uzbekistan, producing finished products from cotton fiber and bringing these products to the world market. Therefore, to ensure the competitiveness of these textile products in the world market, close attention should be given to the quality of cotton fiber produced by ginners [4-7].

Due to the high demand for high-quality fiber in the textile industry, a number of measures have been implemented in recent years to significantly upgrade the technological equipment of existing ginneries, importing technological equipment manufactured by Lumus, US company and Lebed, a Chinese manufacturer [5-9].

The experience of ginners in the cluster system, especially regarding the analysis of the fiber quality produced by foreign equipment and technology, revealed that it is necessary to increase the efficiency of cotton ginning to obtain high - and good-class fibers [1-4].

[*] Corresponding author: sharakhmedova.mamura@mail.ru

It is accepted that machine-picked cotton exhibits a significantly stronger bond among fibers than that observed for hand-picked cotton [2,3]. As a result of the increase in the volume of machine-picked cotton in Uzbekistan, the fiber quality has been improved. The most important indicators of the produced fiber are the contents of contaminants and defective impurities [7-11].

To obtain high-quality yarn, the amount of fiber contamination and defects should not exceed 2–2.5%. To this end, the cotton contamination level in gin combing should not exceed 0.8–0.9% [4,5].

The contamination level in cotton produced by ginneries reaches 20% and higher, and to obtain high-quality fiber from ginneries, the cleaning efficiency of ginners should reach up to 95% [6-9].

A number of researchers [7-9] have recommended the maximum number of cleaning repetitions in pile and sawdust drums to largely remove pollutants from cotton, and on this basis, the primary processing technology of cotton involves cleaning equipment. However, increasing the cleaning frequency by adding additional cleaning equipment could lead to an increase in defects in the produced fiber [10,11].

Considering that the fibers produced by enterprises contain mainly fine pollutants, which determines the bond strength among fibers, an in-depth study of separation conditions is needed. Although a number of studies on cotton contamination have been conducted [1-7], in the present case, pollutants can be divided into small and large categories if they are smaller and larger, respectively, than 10 mm in size and into organic and mineral types depending on the origin.

However, this pollutant classification is not enough to determine their bonding mechanisms to fibers to determine optimal separation conditions [9-12]. Therefore, the purpose of this article is to deeply study the relationship between the geometric dimensions, mass and number of impurities in cotton. For this purpose, pollutants in cotton produced at a number of ginneries were studied.

2 Materials and methods

In the experiment, pollution was determined by collecting samples from cotton batches of the An-Bayaut, S 65-24 and Bright varieties according to existing standards [1-7].

The pollutants isolated from the samples were divided into 2, 4, 6, 8 and 10 mm. The samples were passed through sieves, and the proportions were determined. In regard to the dimensions, the number of pollutants larger than 0–2, 2.1–4, 4.1–6, 6.1–8, 8.1–10 mm and 10 mm was obtained [2-4].

3 Results and discussion

The experimental results are shown in Fig. 1 and Table 1. The figure shows the proportions of the weight of fine impurities in 300 g of cotton in relation to the total weight of fine impurities, which illustrates the weight of fine impurities between cotton and hand-picked cotton with the same impurity content ($Z = 14.33\%$ and $Z = 14.9\%$). There is a significant difference in the proportions in terms of size.

For example, the percentage of pollutants with a size of 2.1–4 mm is 31.35% in machine-picked Bright ½ cotton, while in hand-picked An-Bayaut ½ cotton, the percentage of pollutants with sizes of 4.1–6 and 6.1 mm is 11.89%. The percentage of impurities with a size of -8 mm was 11.12% and 8.05% in Bright cotton and 4.19% and 3.75%, respectively, in An-Bayaut cotton. Notably, the proportion of small pollutants was high in the machine-picked cotton. Large pollutants accounted for 20.14% in machine-picked cotton and 62.73% of all pollutants in hand-picked cotton.

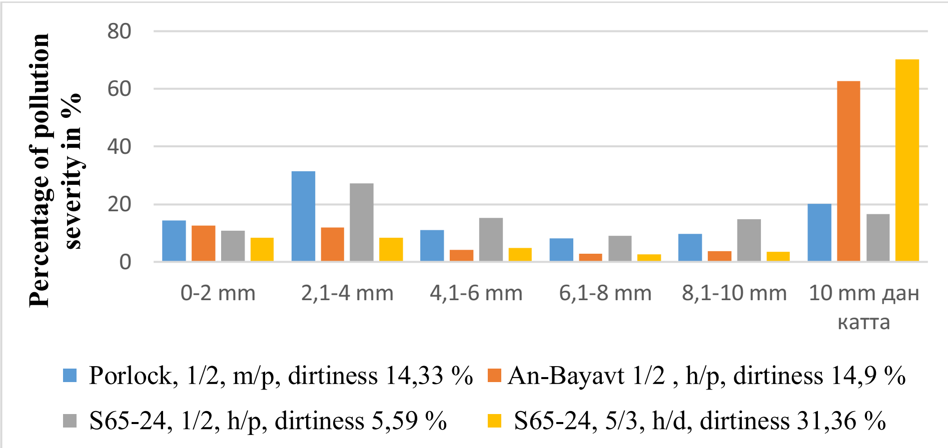

Fig. 1. Percentage by weight of the small pollutants in cotton.

The proportion of minor pollutants in the composition of S 65-24 1/2 cotton with a contamination of Z = 5.59% is 2.1-4; Suitable for cotton in sizes 4,1-6 and 6,1-8 mm, 27,15%, 15,16%, 9,15%, S 65-24 5/3 cotton with pollution Z = 31,36%. 8.27%, 4.84% and 2.72%, respectively. Notably, the number of small-scale impurities in low-contamination cotton is several times smaller. The number of large pollutants, however, is 4.2 times larger in S 65-24 5/3 cotton, with a high content of 70.19%.

In all experimental cases, it was found that the proportion of fine pollutants by weight significantly differed.

Table 1. Distribution of the number of pollutants per gram by size.

#	Sample type, cotton selection and industrial variety, class, harvesting type, pollution level	Pollutant dimensions (mm) and number					Total number
		0–2	2.1–4	4.1–6	6.1–8	8.1–10	
1	Shiny 1/2, machine picking, pollution 14.33%	10740	2556	556	696	704	15525
2	An-Bayaut 1/2, machine picking, pollution 14.9%	10420	2610	630	640	940	15240
3	S 65-24, 1/2, machine picking, pollution 5.59%	10020	2603	694	394	648	14359
4	S 65-24, 5/3, machine picking, pollution 31.36%	10500	3084	668	378	784	15008

One gram of pollutants was obtained via separation in the experiment. Samples were collected, and the number of pollutants in the samples was determined.

As indicated in Table 1, the concentration and number of pollutants 2–10 mm in size in the different machine - and hand - picked selections and industrial varieties were similar between the various categories.

The main pollutant size was 4 mm. The pollution amount was very low, accounting for 0.02–0.06% of the total pollution amount. Fig. 2 shows the proportions of the number of pollutants by size. The proportion of pollutants with dimensions of 0–2 and 2.1–4 mm in all of the experimental cases based on the size category ranged from 85.5% to 90.5%.

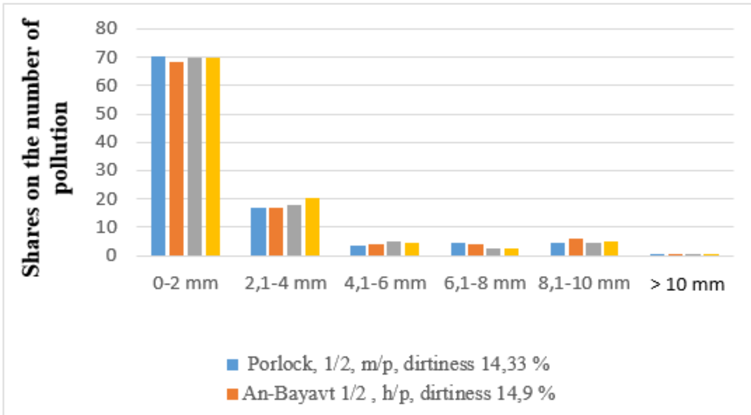

Fig. 2. Similar percentages of the pollutants by size.

The number of large pollutants was very small but accounted for 0.02–0.06% of the total pollution amount. The obtained results were mathematically and statistically processed to determine the cotton harvesting type, selection and industrial variety, and the effect of the primary contaminants on the number of contaminants per 1 g was obtained, while the quantitative characteristics of the contaminants were determined, as presented in Table 2.

Table 2. Numerical characteristics of the pollutant indicators.

#	**Dimensions of the pollutant, mm**	$\dot{V}_{med}$	$S^2\{V\}$	$S\{V\}$	$V_{R\,min}$	$V_{R\,max}$	V_T	$C\{V\}$
1	0–2	10420	89600	299	1.546	1.236	1.693	2.87
2	2.1–4	2713	61666	248	0.732	1.729	1.693	9.14
3	4.1–6	637	3607	60	1.561	1.098	1.693	9.42
4	6.1–8	527	27093	164.6	1.046	1.187	1.693	31.23
5	8.1–10	769	16111	126.9	1.102	1.558	1.693	16.5
6	Larger than 10 mm	6	8	2.83	0.817	1.634	1.693	47.17
7	Total	14965	175693	419.2	1.617	0.791	1.693	2.8

The following equations were used to obtain numerical characteristics [2]. Mean values of the exponent $\bar{V}$ and variance $S^1\{V\}$ were determined as follows:

$$\bar{V} = \frac{1}{m}\sum_{i=1}^{m} \bar{V}_i \tag{1}$$

$$S^2\{V\} = \frac{1}{m-1}\sum_{i=1}^{m}(V_i - \bar{V})^2 \tag{2}$$

The minimum values $V_{R\,min}$ and maximum values $V_{R\,max}$ of the indicators significantly differed.

$$V_{R\,min} = \frac{(\bar{V} - V_{i\,min})}{S\{V\}}\sqrt{\frac{m}{m-1}} \tag{3}$$

$$V_{R\,max} = \frac{(\bar{V} - V_{i\,max})}{S\{V\}}\sqrt{\frac{m}{m-1}} \tag{4}$$

The square inequality $C\{V\}$ can be calculated as:

$$C\{V\} = \frac{S\{V\}}{\bar{V}} * 100\% \tag{5}$$

where $m -$ lines (number of options), with $m = 4$;

$i -$ number of indicators, with $i = 4$;

$V_i -$ indicator value in the various cases;

$V_{i\,min}$ and $V_{i\,max}$ – minimum and maximum indicator values, respectively, in the experimental cases; and

$V_T -$ table value of the Smirnova Grabs criterion. The critical value of the V_T criterion was determined based on a specific table [Appendix 17.1].

If the $V_{R\,min}$ and $V_{R\,max}$ values are lower than the critical value V_T, the values of the pollution indicators are significantly different. Notably, the influence of the cotton selection and industrial variety, initial pollution level, and harvesting type can be neglected; otherwise, the influence of external factors can be notable.

As indicated in Table 2, considering all dimensions of the contamination fraction (except 2.1–4 mm), the $V_{R\,min}$ and $V_{R\,max}$ values are lower than the critical value V_T.

However, it should be noted that for all variants, except for impurities with a size of 0–2 mm, the value of the square inequality C {V} is large and ranges from 9.14% to 47.17%.

4 Conclusions

It was found that the cotton selection and industrial variety, pollution dimensions, and harvesting type can significantly affect the mass fraction of contaminants in cotton.

It was found that there is a large difference in the distribution of the composition of the fraction of impurities by the size of the mass and numerical fractions.Analysis of the numerical characteristics of the pollution fraction in cotton, including the harvesting type, selection and industrial variety, revealed that the value of the square inequality is large, but the effect of the initial pollution level was nonsignificant.

This finding indicates that it is necessary to conduct a comprehensive study in this area to determine the factors influencing the proportions of the pollution fraction in cotton.

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