Analysis of parameters of classical yarn produced from biological cotton fibres.

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1. Ecological Cotton.

By ecological cotton it should be understood cotton that during all cycle of vegetation, after harvesting and in transportation was not treated with any chemical substances which have negative influence upon natural environment and people. The list of prohibited chemical substances was established by Directive of the European Union.
Additionally the term of biological or organic cotton is used. Ecologicalness of such cotton is strengthened by not applying fertilisation with artificial manure. One more condition must be fulfilled namely, that the field on which the cotton grows has been fertilised with organic fertiliser by three years before harvesting of ecological cotton. Such cotton is harvested manually.
According to accessible data the harvest of ecological cotton in 1994 amounted to 12000 tons, which constitutes only 0.02% of global production. 75% of that amount falls to the U.S.A. {1}. In the Table 1 is presented production of ecological cotton in 12 countries, which together produced about 5300 tons.

Table 1. Production of biological cotton – estimated quantities.

Country	Year	**Cultivated area (ha)**	**Production of cotton fibre (tons)**
Argentina	1994/95	400	120
Australia	1993	700	479
Egypt	1994	607	600
Greece	1994/95	470	333
India			
-Gujarat	1994/95	687	25
-Madhya Pradesh	1994/95	540	yarn 150
-Maharashtra	1995	**-**	100
Peru	1995	675	484
Turkey	1993	25	15
USA	1994/95	3869	3000
Nicaragua	1994/95	50	8
Tanzania	1994/95	162	10
Uganda	1994/95	50-100	21
Senegal	1995/96	-	15
Total		**8260**	**5360**

Additional activity in the direction of ecology is naturally coloured cotton. Such cotton should not be dyed. Presently brown and green shades of cotton are produced in little

quantities. Further scientific – growing works are under way and they aim to produce, amongst others, black and blue cotton for jeans production.
A special certificate that is issued by authorised entity issuing certificates confirms ecologicalness of cotton. It is done upon full documentation and audit of such cultivated cotton, from the selection of seeds through vegetation, harvesting, ginning and preparation for sale.

Production of biological cotton is significantly more expensive and that is why its price is higher which in consequence is resulted in the price of the final product. For example compared prices of the same product from "conventional",biological and naturally coloured cotton in Switzerland amounted respectively 2.30, 8,25 20,0 CHF/kg.
Price of raw biological cotton in 1994 ranged from 2.50 up to 3,50 EUR/kg.

In the U.S.A. where the production is best developed all chemical substances used in agriculture must be tested and admitted to application by EPA (Environmental Protection Agency) and FDA (Food and Drug Administration). For example, criteria in force in the U.S.A concerning some agricultural chemical substances used for cotton do not allow any minute quantities of toxic action left in the raw material. It concerns, for example, such chemical substances as: Lindan, DDT, PCP pentachlorophenol – used as protective substances against mildew, which minute quantities are allowed according to ÖKO-TEX criteria.

2. Physical-mechanical parameters of biological cotton.

Four types of biological cotton coming from West Africa (Benin) were used. They underwent laboratory analysis with application of USTER AFIS instrument. Benin has its own cotton classification. In Table 2.1 are included respective African standards to American classification.

Table 2.1 Comparison of African standards to American classification.

	Name of the type	African standard	American standard
1	KABA/S	0+	Barely Good Middling
2	KABA	0	Strict Middling
3	BELA	1	Middling Color, Strict Middling Leaf
4	BELA/C	1	Middling Light Spotted, Strict Middling Leaf
5	BELA/T	1	Middling Leaf, Strict Low Middling Color
6	ZANA	1.1/2	Strict Low Middling Leaf Standard Spotted
7	ZANA/C	1.1/2	Strict Low Middling Leaf Standard Tinged
8	ZANA/T	B1.1/2	Strict Low Middling Leaf Low Middling Color
9	KENE	2	Low Middling Leaf-Standard very Spotted
10	BATI	2.1/2	Strict Good Ordinary Leaf Standard Stained

The results of the laboratory analysis performed by means of USTER AFIS instrument for biological cotton tests are included in Table 2.3. In the Table 2.2 are presented fibre parameters of conventional cotton. Both conventional and biological cottons came from Benin.

Table 2.3 Parameters of conventional cotton fibres.

Parameter	Unit	I test	II Test	III Test	IV Test	V Test
L(w)	Mm	24,8	27,0	26,0	24,4	25,2
$CV_{L(w)}$	%	34,1	34,1	34,3	34,0	33,6
UQL (w)	mm	30,3	32,8	31,7	29,5	30,4
SFC (w)	%	10,2	7,1	8,1	8,3	7,1
5%	mm	34,8	37,8	36,1	34,0	35,2
2,5%	mm	37,9	40,9	38,6	36,7	38,1
Fineness	mtex	159	157	160	152	152
IFC	%	7,7	8,8	7,9	7,6	7,5
Mat Rario	-	0,93	0,92	0,93	0,89	0,90
Neps	l/g	242	174	211	328	288
SCN	l/g	30	20	28	-	-
Trash	l/g	35	26	24	25	36
Dust	l/g	195	411	366	196	274
Total	l/g	230	437	390	221	310
Mean Size	mm	303	205	212	277	272
VFM	%	0,79	0,89	0,60	0,80	1,05

Notation:

L(w) – average length for weight in weight concentration,
$CV_{L(w)}$ – coefficient of variation for weight in weight concentration
UQL (w) –25% of fibres of the length not shorter than this length
SFC(w) – contents of short fibres < 12,7 mm,
5% - contents of the fibres of the length not shorter than this length,
2,5% - contents of the fibres of the length not shorter than this length,
Fineness – linear mass of fibres,
IFC – contents of immature fibres (maturity < 0.25),
Mat Ratio – degree of maturity,
SCN – neps from seed husks,
Neps – number of neps,
Tresh – contents of impurities of the diameter > 500 μm,
Dust - contents of impurities of the diameter < 500 μm,
Total – total contents of impurity,
Mean Size – average quantity of impurities,
VFM – contents of visible foreign matters

Obtained parameters were compared with the Uster Statistics 2001 standards. Conclusions are following:

1. Contents of neps place the tests 1, 2 and 3 at the level of 25% of global production of fibres whereas tests 4 and 5 at the level of 50% of global production.
2. Contents of short fibres for test 1 concerns 50% of global production. For tests no. 2,3,4 and 5 at the level of 5% of global production. It means that only 5% of

the global production of cotton have such good indices concerning contents of short fibres.

3. Contents of impurities of the diameter > 500 μm, according to Uster standards all tests are placed at the level of 5% of global production.
4. Contents of impurities of the diameter < 500 μm for tests 1,4 and 5 places them at the level under 5% of global production. It means that less than 5% of global cotton production in the given range of fibre length has such low number of impurities. The other tests can be classified at the level of 25% of global production.
5. Contents of visible foreign matters in tests 2 and 5 place them at the level of 25% of global production, whereas the rest of the tests around the level of 5% of global production of fibrous mass.

It should be ascertained that the examined batches of fibres were characterised by the high quality due to the low contents of impurities, proper degree of maturity (Micronaire within the range between 3,9 and 4,0) and low contents of short fibres. Linear mass of the fibres range from 1,52 – 1,6 dtex, fineness factor of the fibre 15,5 – 16,5.

Table 2.3 Parameters of biological cotton fibres.

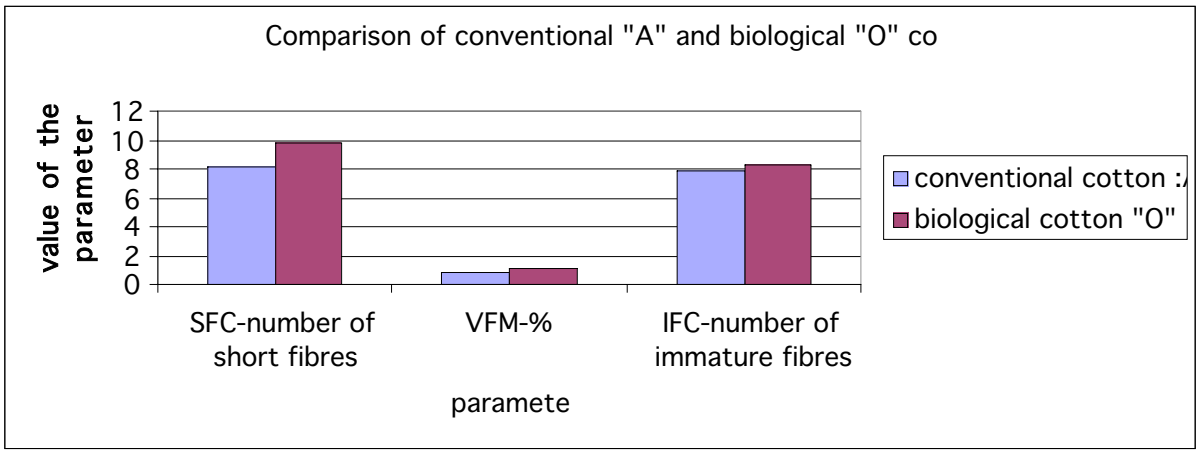
Parameter	**Unit**	**Types of cotton**			
		Bela	**Bela/C**	**Bela/T**	**Zana**
L(w)	Mm	24,4	24,1	24,3	24,4
$CV_{L(w)}$	%	38,0	35,0	36,4	35,0
UQL (w)	mm	30,3	29,3	29,7	29,7
SFC (w)	%	11,0	9,0	9,9	9,1
5%	mm	34,8	33,9	34,5	34,1
2,5%	Mm	37,7	36,9	37,5	36,9
Fineness	Mtex	145	148	146	147
IFC	%	9,3	7,8	8,3	7,9
Mat Rario	-	0.88	0.91	O,89	0,91
Neps	L/g	696	711	695	696
SCN	L/g	276	210	266	231
Trash	L/g	43	35	40	48
Dust	L/g	491	377	371	477
Total	L/g	534	412	410	525
Mean size	mm	247	226	242	250
VFM	%	1,27	0,83	0,99	1,60

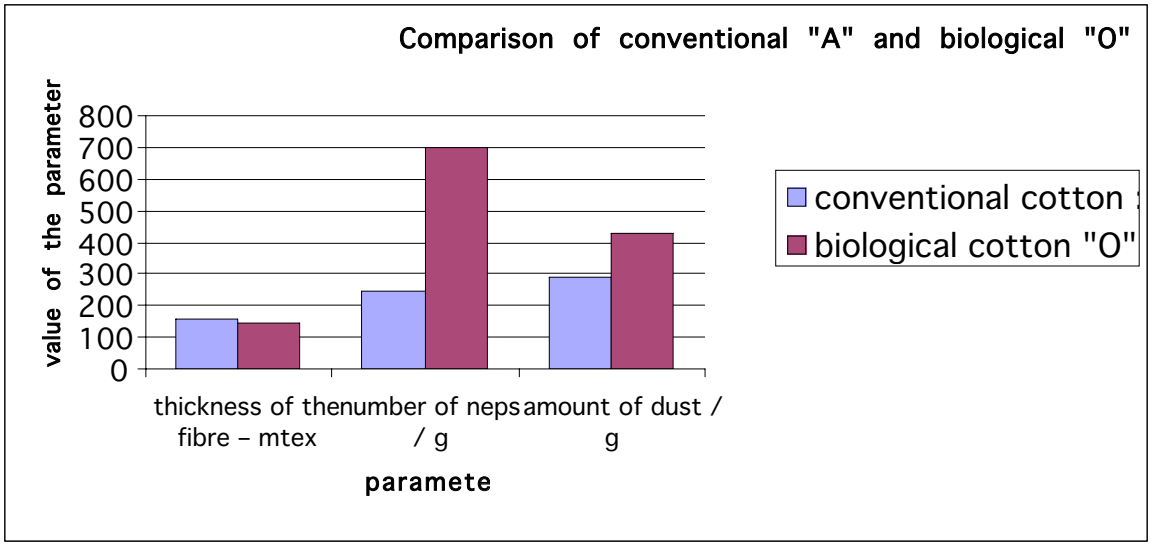
Obtained physical – mechanical parameters of fibres were compared with Uster Statistics 2001 standards. The analysis of the above mentioned indicated the following:

1. Tested samples of fibres had a great number of neps. Contents of neps places tests at the level between 75% and 95% of global fibre production.
2. Cottons of all types were characterised by little contents of short fibres. Only 5% of the global production of cotton reach in that range such good quality parameters.

Lots of biological cotton imported from Benin had in all types of classified length of fibres within the range 1 1/8".
It must be ascertained that tested fibres were characterised by high quality. There can be only reservations to the number of neps but the results oscillating around 700 neps for gram of fibre mass do not depart from the level represented by 95% of cotton global production. According to Uster statistics in proper technological process number of neps in card sliver should be decreased 2-3 times, but after combing 7-9 times in relation to the contents of neps in raw material. In the technological process, having in mind quality of the final product (yarn), attention should be paid to spinning, which decides about removing of neps from the stream of fibres.
In relation to conventional cotton of the same types and the same origin, which was a reference point for comparison purposes, contents of short fibres in biological cotton is slightly higher. Fibres of the length shorter than 12,7 mm make only 9-11% of all mass of fibres which is a good value for the process of thinning of the stream of fibres in drawing mechanisms of spinning machines. Degree of maturity of cotton is at the proper level (Micronaire for all samples was 3,7). The cotton was classified as thin. Also indicator of thinness of fibres for all samples was very close and amounted 16,3÷16,8. Thinness of the fibre is in the required boundaries between 10÷25. Only after exceeding of that value a tendency of knotting appears, i.e. formation of neps.
Examined biological cotton belonged to gossypium hirsutum which fibres are characterised by the linear mass within the range between 140÷220 mtex. The analysed fibres had linear mass exceptionally low 145÷148 mtex. It means that it is possible, in the extreme case, to produce out of them yarns of the linear mass approximately 5 tex in the thin spinning system and approximately 9 tex in mean spinning system.

Comparison of quality parameters of biological and conventional cottons are presented on the below charts:





Summarising the results obtained in USTER AFIS apparatus it can be ascertained that the biological cotton imported from Benin, taking under consideration examined parameters, is good for cotton processing in spinning system. During processing of the fibre a special attention was focused on processes in which removal of neps took place i.e. carding and combing. The process of carding was performed on one cylinder carding machines.

3. Examination of physical-mechanical parameters of yarns produced from biological cotton in carded and combed versions.

The aim of the next stage of tests was to produce yarns from biological cotton.
The following assortment of yarns was chosen for examination:
Yarn 15 tex 100% cotton O.combed 18. Tricot par. G-33\Ac,
Yarn 15 tex 100% cotton O.combed 18. Tricot par T\Ac,
Yarn 20 tex 100% cotton O.combed 18. Tricot par G-33\Ac,
Yarn 20 tex 100% cotton O.carded Tricot par G-33\Ac
Notation:
Baw.O – biological cotton (organic)
C 18 – degree of combing
Tr.p – knitting yarn (knitted fabric, paraffin)
G-33\Ac – yarn produced in Rieter type G33 spinning frame and transferred on Autoconer winder
T\Ac – yarn produced in Textima type 2110 B. spinning frame and transferred on Autoconer winder.

The above assortment was produced on machines installed at Spinning Mill Zawiercie S.A.
Produced yarns underwent laboratory analysis of physical-mechanical parameters, which comprised the following measurements:

- linear mass
- twist
- tenacity
- elongation
- irregularity of mass
- blemish (thin places, thick places, neps)
- hairiness

All laboratory tests were performed according to Polish Standard (PN) or its equivalent in ISO. The following apparatus and measuring instruments were used:

- reel and Uster Autosorter – to measure linear mass,
- mechanical twist tester – to measure twist,
- automatic tensile testing machine Uster Tensorapid 3 – to measure tenacity and ultimate elongation
- Uster Tester 3 apparatus – to measure irregularity of linear mass, blemish (thin places, thick places, neps) and hairiness indicator.

At a very beginning two assortments of comb yarn 15 tex were analysed. Differentiation of assortments took place with spinning frames (Rieter G33 and Textima 2110B).
The obtained parameters of yarns produced from biological cotton were compared with parameters of yarns produced from conventional cotton. The results are included in Tables 3.1 and 3.2.

Table 3.1 Comparison of quality parameters of yarns produced from biological cotton and conventional cotton – ring spinning frame Rieter G33 – yarn transferred.

Parameter	DTT quality standards	Biological cotton "O"	Level according to Uster Statistics 2001	Conventional cotton "A"	Level according to Uster Statistics 2001
Tt(tex)	15±3% /14,6-15,4	14,8	-	15,0	-
V_{tex}(%)	max. 3,0/2,8	1,7	25÷50%	1,1	5÷25%
Tenacity W_w(cN/tex)	min.11,0/13,0	17,0	50÷75%	15,2	95%
V_{Ww} (%)	max.12,5/10,5	9,0	50÷75%	7,5	5÷25%
Elongation (%)	---	4,7	95%	4,8	95%
CV % Uster	max.--/13,8	12,2	<5%	12,5	<5%
Thin places (-50 %)	max.--/10	0	5%	2	5÷25%
Thick places (+50%)	max.--/50	22	5%	18	5%
Neps(+200%)	max.--/200	131	25÷50%	68	5÷25%
Hairiness H indicator	---	5,3	50÷75%	5,0	25%

Twist (twist/m)	max.940	879	-	872	-
α_m	max. 115	106,9	-	106,8	-

Table 3.2 Comparison of quality parameters of yarns produced from biological cotton and conventional cotton – ring spinning frame Textima 2110B – yarn transferred.

Parameter	DTT quality standards	Biological cotton "O"	Level according to Uster Statistics 2001	Conventional cotton "A"	Level according to Uster Statistics 2001
Tt(tex)	15±3% /14,6-15,4	14,7	-	15,0	-
V_{tex}(%)	max. 3,0/2,8	2,6	75%	2,3	50÷75%
Tenacity W_w(cN/tex)	min.11,0/13,0	16,0	75÷95%	14,1	>95%
V_{Ww} (%)	max.12,5/10,5	10,1	75÷95%	8,9	50÷75%
Elongation (%)	---	4,7	95%	4,9	75÷95%
CV % Uster	max.--/15,5	12,8	<5%	13,3	5÷25%
Thin places (-50 %)	max.--/30	1	5%	3	25%
Thick places (+50%)	max.--/130	40	5÷25%	35	5÷25%
Neps(+200%)	max.--/200	126	25÷50%	88	25%
Hairiness H indicator	---	5,9	75%	5,8	75%
Twist (twist/m)	max.940	863	-	861	-
α_m	max. 115	104,7	-	105,3	-

The results obtained during laboratory analysis of 15-tex yarn fully confirmed usability of biological cotton to combed spinning system. Linear masses of the intermediate products were contained in the assumed boundaries and their irregularity was lower than the maximum level. Neps were removed in a proper way both in carding and combing machines. Irregularity of drawing frame sliver finally reached the level of 50% according to Uster Statistics 2001.

Comparison of yarns was performed based on Uster statistics for both spinning frames used in test spinning. The following conclusions can be drawn from the analysis:

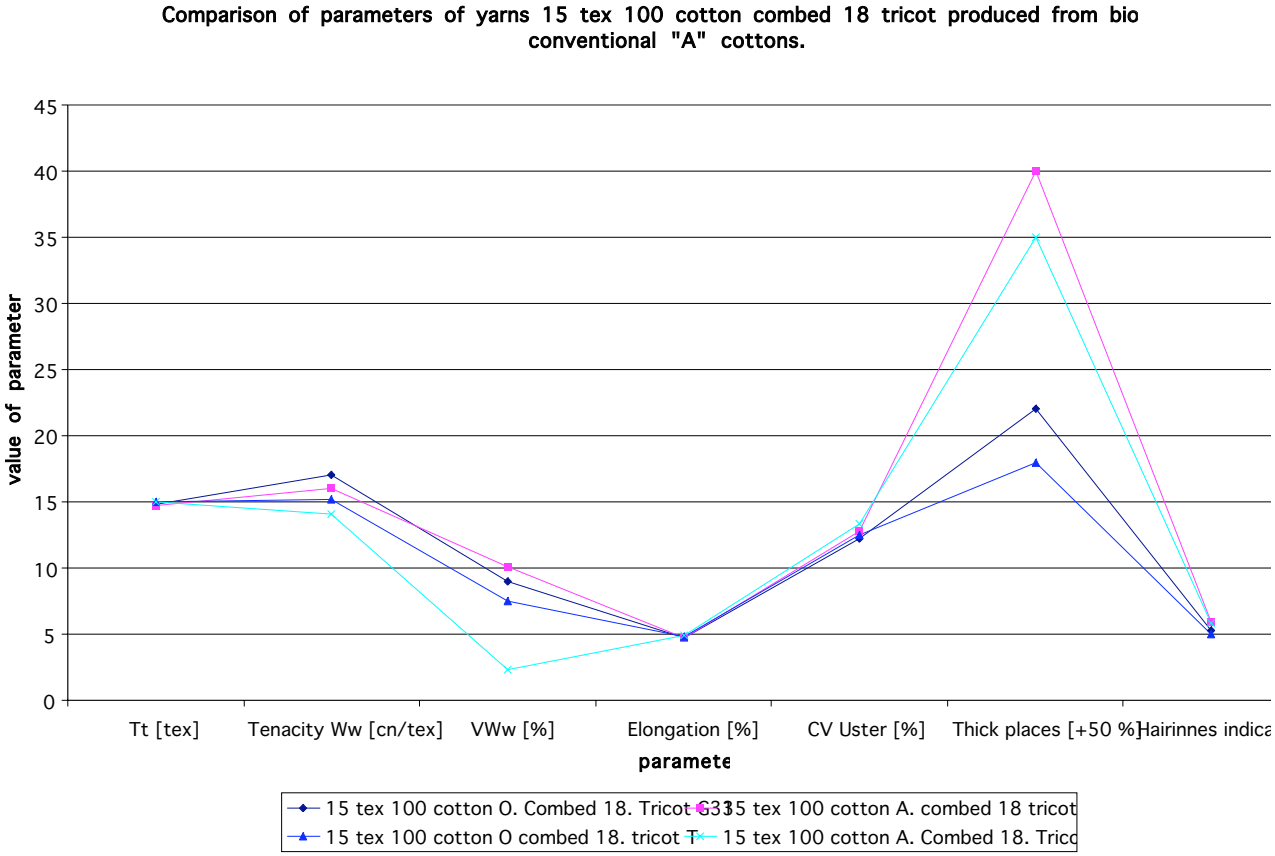
a./for yarn produced by ring spinning frame Rieter type G33:

- irregularity of the linear mass CV% according to Uster of the both yarns reached the level under the line of 5%. That is why the produced yarn is of the high quality (taking under consideration CV)
- yarn produced from biological cotton is characterised by higher tenacity (level 50÷75% according to Uster Statistics 2001) and lower number of thin places (level of 5%) in comparison to yarns produced from conventional cotton,
- slightly worse quality parameters from biological yarns were obtained within the irregularity of tenacity – level 50÷75%, and number of neps – level 25÷50%.

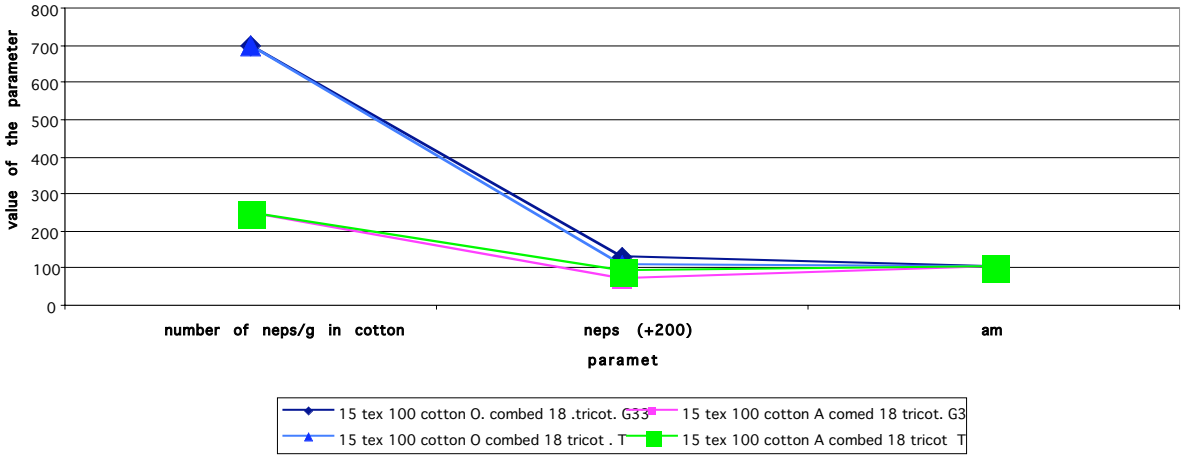
b./ for yarn produced by ring spinning frame Textima type 2110B:

- irregularity of the linear mass CV% according to Uster of the yarn from biological cotton reached the level under the line of 5%. That is why the produced yarn is of the high quality (taking under consideration CV). This is the better result than for the yarn produced from conventional cotton – level 5÷25%,
- yarn from biological cotton is characterised by higher tenacity and lower number of thin places in comparison to the yarn produced from conventional cotton,
- slightly worse quality parameters from biological yarns were obtained within the irregularity of tenacity – level 50÷95%, and number of neps – level 25÷50%.

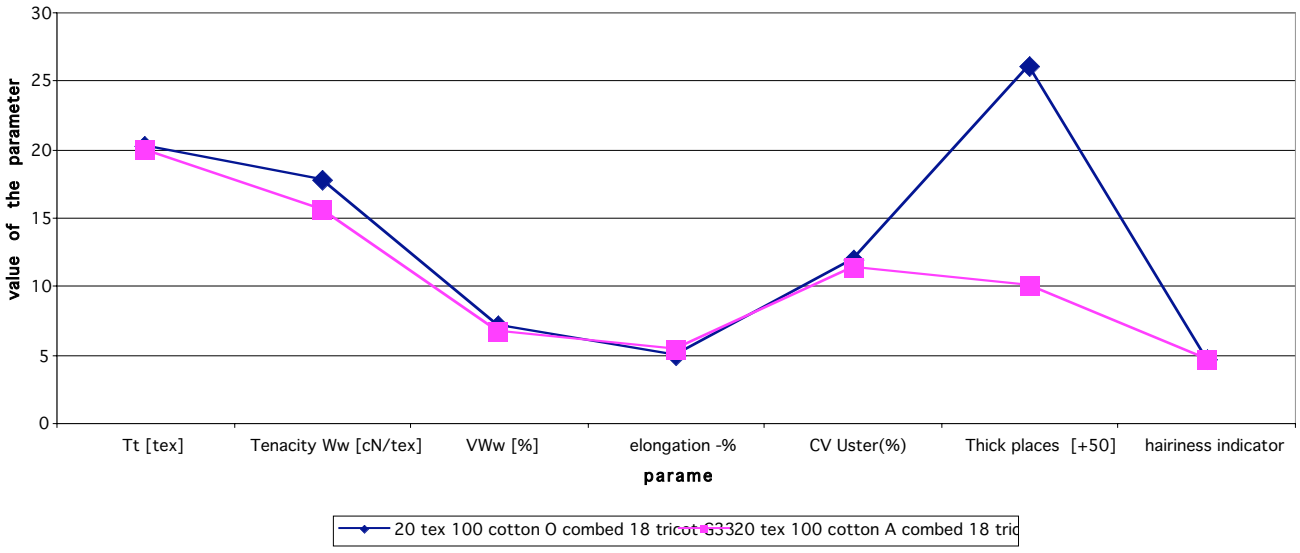
Comparison of quality parameters of yarns produced from biological and conventional cottons are presented on graphs below:



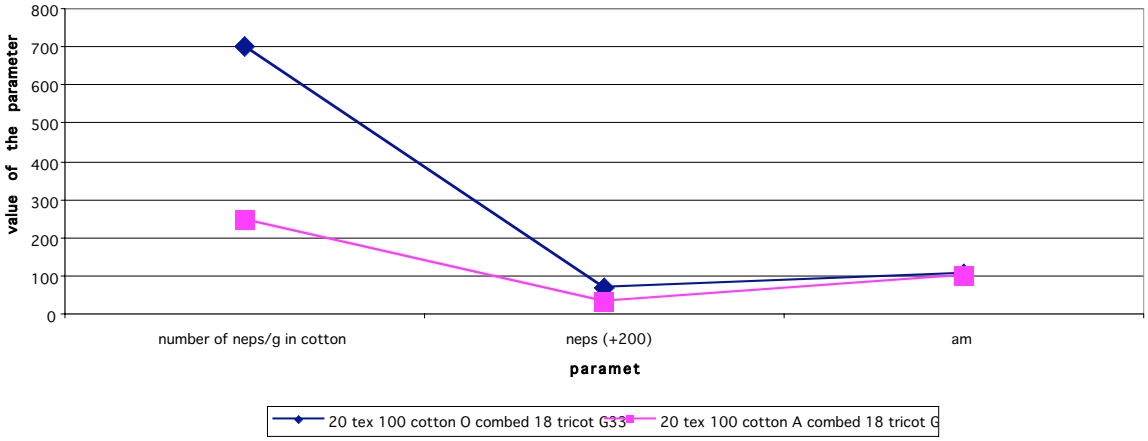
Comparison of quality parameters of the yarn 15 tex 100 cotton combed 18 to the number od neps and alfameter produced from biological "O" and conv " cottons.



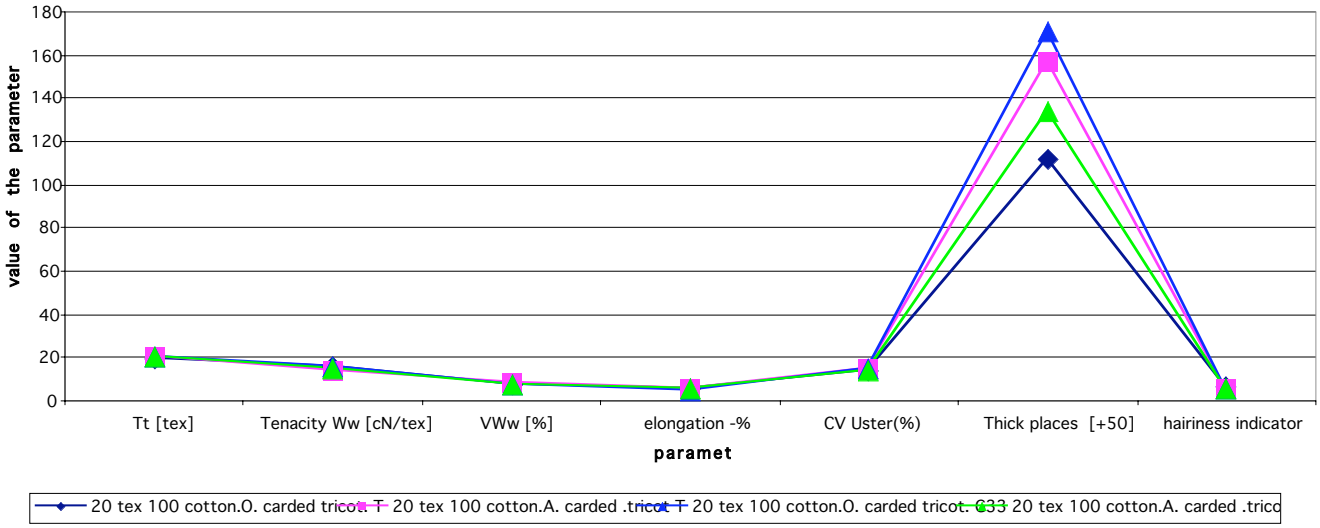
Comparison of parameters of yarn 20 tex 100 cotton combed 18 tricot produced f "O" and conventional "A" cottons.

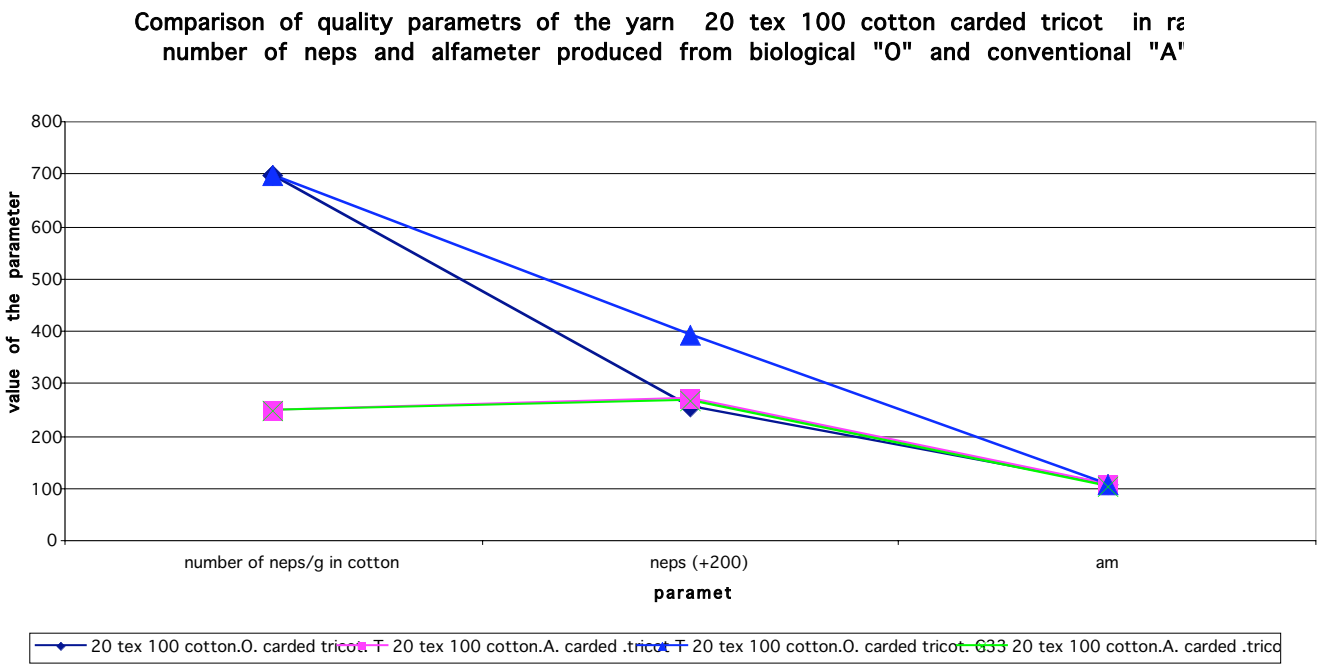


Comarison of quality parameters of the yarn 20 tex 100 cotton combed relation to the of neps and alfameter produced from biological "O" and c "A" cottons.



Comparison of parameters of yarns 20 tex 100 cotton carded tricot produced from and conventional "A" cottons.





It can be ascertained that the yarns produced by Rieter spinning frame achieve better parameters. That is why in the further stage of the tests 20 tex yarns in carded and combed versions produced by the machine were analysed. Examination cycle and methodology of measurements were analogical to those applied in the previous stage of tests.
The results of laboratory analysis obtained for yarns of linear mass amounting to 20 tex in carded and combed versions also confirmed full usability of biological cotton in spinning process.

Linear mass of the produced slivers and roving did not exceed boundaries described by technological strictness. Indicators of irregularity for intermediate products of spinning in any case did not exceed maximal value. Neps were generally removed in the right way but better results were achieved by combing machines. In a few cases lower ability of neps removing from the assumed values for carding machines was noted down.

Summing up the series of yarn tests it should be ascertained with full responsibility that they turned to be successful**.** Biological cotton as a new raw material at the Polish market is good for spinning in classical system with application of ring spinning frame both in the assortment of carded and combed yarns. To find a place for new cotton among clothes offered to indigent Polish customer all efforts should be done to propagate pro-ecological textile products which are environmental and human friendly. Widely understood promotion is needed. Biological cotton should be in particular used in production of baby linen, personal hygiene means or clothing used in hospitals.

From year to year production of biological cotton is growing and it seems that the tendency will go that direction, taking under consideration consumption of wealthier countries. Due to the higher costs of the fibre for the present day, also ready made products must be more expensive. In order to lower the cost of the ready made product new, more efficient or cheaper technologies should be used. For the Polish

market in the present economic depression convincing producer to buy expensive raw material or investing in new and expensive technologies seems to be odd. Nevertheless, nobody is able to foresee how the market of raw materials and textiles will be shaped in the coming years in particular in the aspect of entering Poland to European Community. Creation of demand and likes and dislikes mainly of western customers and thickness of their wallets decides about the trends and directions that extort changes from scientists and technologies.

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