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Variation in Fiber and Yarn Properties of Identical Checks in Yield Tests and Nursery Plots of Upland Cotton, *Gossypium hirsutum* L.[1]

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ABSTRACT

Fiber strength, fiber length, and yarn strength of the cotton (*Gossypium hirsutum* L.) variety 'Coker 201' and the experimental strain Pee Dee 2165 were significantly higher for 3 of 4 years when grown as checks in yield tests rather than in nursery rows at Florence, S. C. Planting dates and population density caused very little variation in fiber and yarn quality. Under some conditions field location or soil type resulted in variation in fiber and yarn quality, but did not account for differences in fiber properties and yarn strength of each check between yield tests and nursery rows. Most of the variation in fiber properties and yarn strength readings was attributed to sampling method, where 50 boll samples were harvested from one-fourth the area in nursery rows as in yield trial plots. The importance of adequate checks and methods of sampling and measuring quality factors is emphasized when comparisons are made between experimental strains, and particularly across locations and years.

Additional index words: **Fiber length, Fiber strength, Micronaire, Yarn strength, Cotton quality.**

BREEDING for higher-quality fiber in Upland cotton (*Gossypium hirsutum* L.) is an objective in our program. We rely on instruments in the US Fiber and Spinning Laboratories at Knoxville, Tenn. to provide readings on yarn strength and the three components of fiber quality: strength, length, and fineness. Yarn strength, which is largely dependent upon these fiber properties and their interaction, is our best single measure of cotton quality and is a useful measurement in varietal selection. Within the range of variability in this study, we will consider longer fibers, stronger fibers, and higher yarn strength as synonymous with improving quality.

Variation in fiber properties is caused by heredity, environment, and storage (4). Variation in these readings has been attributed to sampling and analytical techniques (7). These factors often cause significant fluctuations in fiber properties and yarn strength. Therefore, adequate checks are necessary to establish the reliability of the estimates and to adjust sample values in regard to locations and years.

We were surprised to find that in most years check varieties had higher yarn strength in yield tests than in nursery rows. The purpose of this paper is to report the differences in fiber and yarn properties of checks in these two plantings, and to discuss some of the environmental and sampling differences that may account for this variation.

MATERIALS AND METHODS

The commercial variety 'Coker 201' and the experimental strain Pee Dee 2165 have been used as checks in nursery plots and yield tests on the Pee Dee Experiment Station, Florence, S.C. since 1966. The nursery is a planting of parental strains, segregating populations, or progeny rows with check rows of Coker 201 and Pee Dee 2165 at intervals of 10 rows. Yield test checks refer to replicated performance trials where the two checks appear as regular entries.

Approximately 50 kg each of Coker 201 and Pee Dee 2165 seed were stored in 1966. Each year about 5 kg of seed were removed from each reserve and grown in semi-isolation for planting seed of the check entries in yield tests and nursery rows for the coming year.

Land preparation and cultural practices in the yield tests and nurseries were identical each year from 1967 to 1970, except for differences in spacings within the row (plant populations), dates of planting, number of bolls/plot harvested for fiber and spinning tests, and location of fields or soil types. There also were differences among some yield tests in planting dates, solid and skip-row (plant two rows, fallow one row) planting patterns, and field locations or soil types. Nursery plots were planted in two replications each year. Replications differed only in dates of planting and field location or soil type.

Check plots in yield tests were two rows, 10.7 m (35 ft) long with 102 cm (40 inches) between rows. Seed were hill-dropped 36 cm (14 inches) apart, and each hill was thinned to two plants at the four- to six-leaf stages. Checks in the nurseries were single rows 10 m (33 ft) long and 102 cm wide. Seed were hill-dropped 56 cm (22 inches) apart, and each hill was thinned to two plants.

A 25-boll sample, consisting of unweathered, perfect open bolls from the middle of the fruiting zone of the plants was picked from each yield test plot (21.4 m of row). Two of these samples (replication 1 and 2, or replication 3 and 4) were combined at ginning to make a 50-boll sample for fiber and spinning tests. Thus, two 50-boll samples of each check variety were drawn from each test each year. The number of tests each year may be determined from the sample number (T) in Table 1.

In the nursery a single sample of 50 bolls was picked from each check plot (10 m of row) for fiber and spinning tests. The number of nursery plots sampled each year is equal to sample number (N) in Table 1.

Although yield tests and nursery plots often differed in planting date and field location or soil type, and yield tests in solid or skip-rows, all fiber and spinning data were averaged by year, test or nursery planting, and variety. The standard error was used to determine significant differences between means.

Several tests and replications of nursery plots were planted on similar soil types and differed only in planting date. A few tests were planted early and late in different fields on different soil types. The number of tests or samples, planting dates, and soil types can be determined from Table 2.

In 1970 three tests were planted solid and three in skip-rows on similar soil types (Table 3). Three samples of each variety (not included with other data) were obtained from a 1969 solid and skip-row study. These tests differed only in planting patterns. Four other 1970 tests were planted solid and three in skip-rows, but the solid and skip-row plantings were on different soil types. All other tests were planted at approximately the same time in solid row-patterns.

Fiber and spinning samples were analyzed by the US Department of Agriculture Fiber Testing and Spinning Laboratories at Knoxville, Tenn. for the following properties: (i) *50% span length* — length in inches at which 50% of the fibers are this length or longer; (ii) *2.5% span length* — length in inches at which 2.5% of the fibers are this length or longer; (iii) *strength* (T_1) — force (gf/tex) necessary to break the fiber bundle with the jaws of the testing instrument set .32 cm (1/8 inches) apart; (iv) *Micronaire (M)* — fineness of the sample measured by the Micronaire and expressed in standard Micronaire units; and (v) *yarn strength* — index of force required to break a skein of yarn in small scale tests as described by Landstreet et al. (5, 6).

Boll sample data consisted of: (i) *percent lint* — weight of lint ginned from a sample of seed cotton, expressed as a percentage of the weight of seed cotton; (ii) *seed index* — weight of 100 seed (g); and (iii) *boll size* — weight/boll (g).

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RESULTS AND DISCUSSION

Coker 201 and Pee Dee 2165 are used for yield and fiber quality checks in all Pee Dee yield tests and nursery plots. Coker 201 usually produces 15 to 20% more lint than Pee Dee 2165, but the latter possesses higher fiber quality (Table 1). From 1967 to 1970, Pee Dee 2165 had significantly longer and stronger fiber (with equal fineness) than Coker 201. Although the fiber is slightly longer, the greater fiber strength (approximately 3 gf/tex) of Pee Dee 2165 is primarily responsible for the yarn strength of 141, 19 units greater than that of Coker 201.

Although there were differences in soil types and cultural practices between yield tests and nursery rows, and in planting dates and row patterns between yield tests and replications in nursery rows, we expected the same check to perform similarly in the two plantings. However, fiber strength and length, and yarn strength were higher in samples drawn from yield test plots than in those drawn from nursery rows (Table 1). Average differences were less than .01 inch in 50.0 and 2.5% span length and 0.5 gf/tex in strength, but sufficient to increase the average yarn strength 5 units. Both Coker 201 and Pee Dee 2165 had longer and stronger fibers and higher yarn strength from samples drawn from yield tests than those drawn from progeny row checks during 3 of the 4 years. Neither check showed an increase in quality when grown in yield tests in 1968. The season was unusually dry and differences between tests and nursery plots were not evident. Shorter, coarser, and stronger fibers that gave high yarn strength were produced in both plantings.

Since the checks were grown from a common seed source, fiber and spinning data could be compared across years. In yield tests yarn strength of Coker 201 and Pee Dee 2165 varied from 120 to 128 and 139 to 149 units, respectively. Similar averages in nursery rows were 116 to 121 and 134 and 146 units. Significant variations in fiber length, strength, and Micronaire from year to year can be attributed primarily to environmental conditions (Table 1).

The effects of several cultural and sampling procedures on fiber and yarn quality of the same checks in yield tests and nursery rows were studied. Differences in planting dates between yield tests and nursery rows had very little effect on fiber and yarn quality. When the checks were grown in nursery rows on two dates in 1969 and 1970, and in yield tests under similar cultural conditions and soil types in 1968, except for Micronaire, date of planting caused no significant differences in fiber and yarn properties. Bridge et al. (1) also found no consistent effect on fiber properties from planting date. Micronaire was slightly reduced in the late plantings. Checks planted on two dates in the yield tests in different fields or soil types in 1969 had longer and coarser fiber. Fiber and yarn strength were higher in the early plantings, but these differences were not significant. The late plantings on heavier soil exhibited severe moisture stress in August that could have decreased quality. Lint percentage also was reduced in late test plantings. We believe these differences are due to field location or soil type rather than planting dates.

Spacing between plants within the row varied between yield tests and nursery rows. Yield tests had 55,310 plants/ha (22,400 plants/acre), and nursery rows, 35,200 plants/ha (14,250 plants/acre). Plants in the nursery had additional space for development, which could conceivably increase fiber and yarn quality. In 1969 and 1970 several yield test checks were grown in solid and skip-row patterns on similar soil types (Table 3). Fiber strength and Micronaire were higher in most skip-row plantings, but yarn strength was not significantly different. The increase in Micronaire, which causes a decrease in fibers per cross-section of yarn, could result in equal estimates of yarn strength. These findings do not agree with those of Hawkins and Peacock (3). They found an increase in fiber length, but no differences in fiber strength

Table 1. Fiber, spinning, and boll sample data from Coker 201 and Pee Dee 2165 grown in yield tests (T) and nursery rows (N) from 1967 to 1970 on the Pee Dee Experiment Station, Florence, S. C.

Year, check, or planting		Number samples	Span length 50%	Span length 2.5%	T_1	Micronaire	Yarn strength	Lint %	Boll size	Seed index
			inches	inches	gf/tex	units	units	%	g/boll	g/100
1970 Coker 201	T	28	.57 ± .004	1.17 ± .005	18.30 ± .169	4.81 ± .032	124 ± 0.99	39.1 ± .13	7.61 ± .077	12.5 ± .10
	N	20	.55 ± .005	1.15 ± .005	18.14 ± .164	4.85 ± .032	117 ± 0.75	38.8 ± .20	6.83 ± .208	12.0 ± .14
Pee Dee 2165	T	28	.58 ± .004	1.20 ± .006	21.14 ± .250	4.73 ± .024	141 ± 0.92	37.7 ± .16	7.44 ± .083	13.7 ± .16
	N	20	.56 ± .004	1.17 ± .004	20.57 ± .163	4.68 ± .046	134 ± 1.06	37.6 ± .19	6.80 ± .064	13.0 ± .11
1969 Coker 201	T	20	.55 ± .004	1.16 ± .004	18.01 ± .146	4.64 ± .078	120 ± 0.76	36.8 ± .34	6.30 ± .048	12.2 ± .08
	N	12	.54 ± .009	1.12 ± .009	17.29 ± .139	4.64 ± .131	116 ± 0.96	37.7 ± .44	6.23 ± .043	11.6 ± .10
Pee Dee 2165	T	20	.57 ± .005	1.18 ± .005	20.88 ± .222	4.68 ± .044	139 ± 0.70	36.1 ± .17	6.73 ± .028	13.6 ± .22
	N	12	.56 ± .009	1.16 ± .006	20.12 ± .132	4.68 ± .061	137 ± 1.30	36.7 ± .30	6.37 ± .057	13.2 ± .11
1968 Coker 201	T	22	.51 ± .007	1.11 ± .008	18.84 ± .112	4.80 ± .040	124 ± 0.72	38.1 ± .27	6.11 ± .064	11.4 ± .08
	N	7	.50 ± .016	1.09 ± .018	19.40 ± .237	4.67 ± .046	121 ± 2.52	36.6 ± .58	6.05 ± .137	11.2 ± .31
Pee Dee 2165	T	22	.54 ± .004	1.13 ± .005	22.39 ± .103	4.84 ± .048	144 ± 0.86	37.7 ± .21	6.15 ± .069	12.4 ± .09
	N	6	.54 ± .007	1.12 ± .008	23.38 ± .183	4.92 ± .144	146 ± 2.02	37.0 ± .33	6.14 ± .091	12.2 ± .12
1967 Coker 201	T	14	.56 ± .004	1.15 ± .005	18.92 ± .230	4.38 ± .055	128 ± 1.33	39.6 ± .20	6.76 ± .232	11.5 ± .08
	N	7	.54 ± .008	1.12 ± .009	17.91 ± .196	4.56 ± .074	119 ± 1.51	38.5 ± .24	6.79 ± .153	11.5 ± .24
Pee Dee 2165	T	14	.57 ± .007	1.17 ± .006	21.53 ± .305	4.54 ± .041	149 ± 1.05	39.0 ± .22	6.69 ± .067	13.0 ± .10
	N	6	.57 ± .004	1.16 ± .005	21.00 ± .316	4.57 ± .073	145 ± 2.83	38.3 ± .20	6.96 ± .060	12.7 ± .13
Averages										
1970 both checks	T & N	96	.57 ± .002	1.18 ± .001	19.56 ± .170	4.77 ± .018	130 ± 1.06	38.3 ± .11	7.23 ± .052	12.9 ± .09
1969 both checks	T & N	64	.56 ± .003	1.16 ± .004	19.17 ± .205	4.66 ± .035	129 ± 1.34	36.7 ± .16	6.44 ± .032	12.7 ± .11
1968 both checks	T & N	57	.53 ± .004	1.12 ± .004	20.57 ± .279	4.80 ± .032	133 ± 1.53	37.9 ± .15	6.21 ± .050	11.9 ± .08
1967 both checks	T & N	41	.56 ± .005	1.15 ± .006	20.20 ± .232	4.51 ± .098	136 ± 1.95	38.7 ± .21	6.49 ± .060	12.1 ± .13
Coker 201	T	84	.55 ± .004	1.15 ± .004	18.47 ± .089	4.69 ± .030	124 ± 0.54	38.4 ± .16	6.76 ± .077	12.0 ± .07
	N	46	.54 ± .004	1.13 ± .005	18.07 ± .133	4.72 ± .035	118 ± 0.63	38.1 ± .20	6.55 ± .065	11.7 ± .09
Pee Dee 2165	T	84	.56 ± .003	1.17 ± .004	21.47 ± .183	4.72 ± .022	143 ± 0.56	37.5 ± .13	6.81 ± .065	13.2 ± .09
	N	44	.56 ± .004	1.16 ± .004	20.89 ± .182	4.70 ± .036	138 ± 1.02	37.4 ± .15	6.62 ± .056	12.9 ± .08
Both checks	T	168	.56 ± .002	1.16 ± .003	19.97 ± .154	4.70 ± .019	133 ± 0.82	37.9 ± .11	6.79 ± .050	12.6 ± .07
Both checks	N	90	.55 ± .003	1.15 ± .004	19.45 ± .186	4.71 ± .025	128 ± 1.24	37.8 ± .13	6.58 ± .042	12.3 ± .09
Coker 201	T & N	130	.55 ± .003	1.14 ± .003	18.33 ± .076	4.70 ± .023	122 ± 0.49	38.3 ± .13	6.69 ± .056	11.9 ± .06
Pee Dee 2165	T & N	128	.56 ± .003	1.17 ± .003	21.27 ± .137	4.71 ± .019	141 ± 0.54	37.5 ± .10	6.74 ± .047	13.1 ± .07

Table 2. Fiber, spinning, and boll sample data from Coker 201 and Pee Dee 2165 planted on two dates on the Pee Dee Experiment Station, Florence, S. C.

Checks and planting dates	Number samples	Span length 50%	Span length 2.5%	T_1	Micro-naire	Yarn strength	Lint %	Boll size	Seed index
		inches	inches	gf/tex	units	units	%	g/boll	g/100
Checks in nursery rows planted on the same soil type on two dates in 1969 and 1970:									
Coker 201 - 4/28 to 5/1	17	.54 ± .007	1.13 ± .007	17.80 ± .194	4.86 ± .038	117 ± 0.78	38.6 ± .20	6.52 ± .079	11.8 ± .18
5/7 to 5/8	15	.56 ± .004	1.15 ± .004	17.84 ± .193	4.66 ± .079	116 ± 0.91	38.1 ± .42	6.69 ± .113	11.9 ± .07
Pee Dee 2165 - 4/28 to 5/1	17	.56 ± .006	1.16 ± .006	20.32 ± .121	4.75 ± .045	135 ± 1.21	37.4 ± .18	6.57 ± .080	13.0 ± .12
5/7 to 5/8	15	.56 ± .006	1.17 ± .004	20.50 ± .215	4.60 ± .051	136 ± 1.20	37.1 ± .33	6.72 ± .083	13.2 ± .08
Both checks - 4/28 to 5/1	34	.55 ± .004	1.15 ± .005	19.06 ± .227	4.80 ± .030	126 ± 1.74	38.0 ± .17	6.55 ± .056	12.4 ± .15
5/7 to 5/8	30	.56 ± .003	1.16 ± .003	19.17 ± .285	4.63 ± .046	126 ± 1.95	37.6 ± .27	6.71 ± .069	12.6 ± .13
Checks in yield tests planted on the same soil type on two dates in 1968:									
Coker 201 - 4/17 to 4/18	6	.50 ± .014	1.10 ± .019	18.84 ± .181	4.83 ± .026	123 ± 1.85	38.7 ± .15	6.10 ± .154	11.4 ± .20
5/1 to 5/3	6	.50 ± .010	1.10 ± .009	18.66 ± .247	4.84 ± .094	123 ± 0.88	37.4 ± .58	5.90 ± .071	11.5 ± .16
Pee Dee 2165 - 4/17 to 4/18	6	.53 ± .011	1.13 ± .009	22.25 ± .271	4.76 ± .077	144 ± 1.96	38.1 ± .26	6.23 ± .177	12.5 ± .20
5/1 to 5/3	6	.53 ± .002	1.12 ± .009	22.36 ± .177	4.94 ± .050	144 ± 1.68	36.8 ± .31	6.15 ± .170	12.6 ± .14
Both checks - 4/17 to 4/18	12	.51 ± .010	1.12 ± .011	20.54 ± .536	4.80 ± .040	133 ± 3.44	38.4 ± .20	6.16 ± .114	12.0 ± .22
5/1 to 5/3	12	.52 ± .007	1.11 ± .007	20.51 ± .575	4.89 ± .053	133 ± 3.22	37.1 ± .30	6.02 ± .056	12.0 ± .19
Checks in yield tests planted on different soil types on two dates in 1969:									
Coker 201 - 4/23 to 4/24	8	.57 ± .004	1.16 ± .005	18.40 ± .202	4.93 ± .055	122 ± 0.68	37.9 ± .25	6.29 ± .073	12.2 ± .18
5/7	6	.54 ± .002	1.15 ± .005	18.03 ± .264	4.22 ± .080	120 ± 2.04	34.8 ± .40	6.26 ± .072	12.2 ± .15
Pee Dee 2165 - 4/23 to 4/24	8	.59 ± .006	1.20 ± .007	21.69 ± .315	4.86 ± .015	140 ± 0.96	36.5 ± .17	6.62 ± .325	13.7 ± .32
5/7	6	.56 ± .002	1.16 ± .007	20.58 ± .236	4.50 ± .021	138 ± 1.24	35.2 ± .26	6.76 ± .082	13.5 ± .19
Both checks - 4/23 to 4/24	16	.58 ± .005	1.18 ± .007	20.04 ± .462	4.90 ± .036	131 ± .247	37.2 ± .23	6.46 ± .075	12.9 ± .22
5/7	12	.55 ± .004	1.16 ± .005	19.30 ± .421	4.36 ± .058	129 ± .294	35.0 ± .24	6.51 ± .092	12.8 ± .22

Table 3. Fiber, spinning, and boll sample data from Coker 201 and Pee Dee 2165 grown in solid (S) and skip-row (SK) plantings in 1969 and 1970 on the Pee Dee Experiment Station, Florence, S. C.

Check or planting		Number samples	Span length 50%	Span length 2.5%	T_1	Micro-naire	Yarn strength	Lint %	Boll size	Seed index
			inches	inches	gf/tex	units	units	%	g/boll	g/100
Grown on comparable soil types:										
Coker 201	S	9	.55 ± .009	1.16 ± .004	17.19 ± .162	4.79 ± .057	120 ± 1.02	38.5 ± .04	7.00 ± .257	12.4 ± .25
	SK	9	.57 ± .010	1.16 ± .009	17.88 ± .276	4.90 ± .052	120 ± 1.89	38.5 ± .30	7.17 ± .233	12.7 ± .22
Pee Dee 2165	S	9	.56 ± .006	1.18 ± .010	19.99 ± .344	4.72 ± .045	138 ± 1.45	37.2 ± .20	7.08 ± .217	13.6 ± .04
	SK	9	.57 ± .008	1.18 ± .010	20.64 ± .085	4.79 ± .066	139 ± 2.18	37.7 ± .26	7.11 ± .183	13.5 ± .19
Average	S	18	.56 ± .005	1.17 ± .009	18.59 ± .387	4.75 ± .036	129 ± 2.36	37.9 ± .24	7.04 ± .163	13.0 ± .28
	SK	18	.57 ± .006	1.17 ± .007	19.26 ± .418	4.84 ± .043	129 ± 2.68	38.1 ± .22	7.14 ± .144	13.1 ± .17
Grown on different soil types:										
Coker 201	S	8	.57 ± .005	1.16 ± .005	18.88 ± .196	4.82 ± .069	127 ± 1.04	38.9 ± .16	7.35 ± .083	12.1 ± .10
	SK	6	.57 ± .009	1.18 ± .014	18.56 ± .141	4.73 ± .057	128 ± 1.93	39.4 ± .14	7.64 ± .076	12.2 ± .15
Pee Dee 2165	S	8	.58 ± .007	1.19 ± .015	21.24 ± .462	4.69 ± .045	141 ± 1.09	36.9 ± .26	7.10 ± .099	13.4 ± .16
	SK	6	.58 ± .010	1.20 ± .010	22.27 ± .406	4.70 ± .045	144 ± 1.11	37.8 ± .34	7.51 ± .107	13.4 ± .21
Average	S	16	.57 ± .004	1. 7 ± .009	20.06 ± .389	4.75 ± .043	134 ± 2.01	37.9 ± .29	7.23 ± .070	12.7 ± .19
	SK	12	.57 ± .007	1.20 ± .009	20.42 ± .596	4.71 ± .035	136 ± 2.59	38.6 ± .30	7.58 ± .066	12.8 ± .22

and Micronaire in skip-row plantings. When checks were grown in similar tests but on different soil types (Table 3), skip-row plantings exhibited longer and sometimes stronger fiber with similar Micronaires. Longer and stronger fibers give higher yarn strength, but we could not show significant differences in our tests. Indications of higher yarn strength may be attributed to field location or soil type rather than to row spacing. Although the low population density in nursery rows might under some conditions increase fiber and yarn quality of the checks, such increases would be inversely related to quality differences found between yield tests and nursery rows in this study.

We believe that most of the variation in fiber and yarn quality between identical checks in yield tests and nursery rows was due to sampling technique. Pressure for picking perfect, unweathered bolls from the middle of the fruiting zone was four times greater (50 bolls/43 m of row in the yield tests compared with 50 bolls/10 m of row in the nursery) in nursery rows than in yield test plots. Boll size and seed index, with lint percent generally unchanged, decreased in nursery rows (Table 1), indicating that smaller bolls nearer the top or bottom of the fruiting zone were picked to obtain the desired sample size. Our hypothesis that shorter and weaker cotton was obtained in the sample from nursery plots is supported by data reported by Graves (2), where fiber and yarn quality decreased drastically from a hand-picked sample compared with the first and second machine pickings of the plots. In Graves' report the average 2.5% span length, T_1, Micronaire, and yarn strength of 24 varieties of the hand-picked sample were 1.20, 20.07, 4.38, and 134 compared with 1.12, 19.24, 4.15, and 117 for the first machine picking at Fort Pillow, Tenn. Similar reductions were found in the second picking and at other locations. The magnitude of these values is in line with the five units in yarn strength that we attribute to sampling.

Although additional research is needed to establish the effects of sampling techniques and boll sample size on fiber and yarn quality, we can draw several conclusions. These include: (i) fiber properties and yarn strength are highly influenced by variety and year; (ii) cultural practices, such as planting dates and population density, have little influence on quality; (iii) field location or soil type increased variation in fiber and yarn quality, but this was not a factor in the differences between checks grown in yield tests and nursery rows, which we attribute to sampling; (iv) identical sampling techniques between experimental strains and adequate checks are necessary to obtain reliable estimates for valid comparisons in the same tests; and (v) comparisons across tests, locations, and years should be conducted with caution.

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