Scientific Electronic Archives
Issue ID: Sci. Elec. Arch. Vol. 13 (8)
August 2020
DOI: http://dx.doi.org/10.36560/13820201181
Article link
http://sea.ufr.edu.br/index.php?journal=SEA&page=article&op=view&path%5B%5D=1181&path%5B%5D=pdf
Included in DOAJ, AGRIS, Latindex, Journal TOCs, CORE, Discoursio Open Science, Science Gate, GFAR, CIARDRING, Academic Journals Database and NTHRYS Technologies, Portal de Periódicos CAPES.

ISSN 2316-9281

Physiology and morphology of seedlings originating from seeds harvested in different thirds and cotton genotypes cultivated under the edaphoclimatic conditions of Uberlândia - MG.

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Abstract. Cotton has great importance in Brazil. The percentage, speed and uniformity of seedling emergence depend on this potential. The objective of this work was to evaluate the physiological and morphological quality of seeds from different thirds of ten genotypes of white fiber cotton grown in the edaphoclimatic conditions of Uberlândia - MG. The experiment was conducted in the 2017/2018, in an area of 500m². Eight commercial genotypes (BRS 368RF, BRS 372, DP 1228 B2RF, FM 975 WS, FM 982, IMA 5675 B2RF, IMA 8405 GLT, TMG 45 B2RF) and two PROMALG genotypes from the Federal University of Uberlândia - UFU (UFU - H, UFU - P). A randomized block design was used, arranged in a 10x3 factorial scheme, with the first factor being the genotypes and the second being the thirds. After the cotton cycle, the seeds of the genotypes were harvested in each third and the analysis of germination, of normal strong seedlings, and growth of the aerial and root part of plants was carried out. The data were submitted to analysis of variance and average comparison test. It was observed that both genotypes and thirds of cotton influence the physiology and morphology of seedlings. Therefore, the lower third has the best germination index (93 to 98% germination), when compared to the middle (88 to 97%) and upper third (88 to 97%). Indicating that to obtain uniform seed lots, it is necessary to take into account the third and the genetics of the plants. The thirds and the genotypes affect the physiological and morphological quality of the seeds, being the lower third with the best performance among the genotypes.
Keywords: Cottoniculture, position, genetic variable.

Introduction

Cotton (*Gossypium hirsutum L.*) a species of the genus *Gossypium*, belonging to the Malvaceae family (NASCIMENTO, 2019), has great importance in Brazil, where it has gained importance in the national agricultural scenario, becoming one of the main national commodities and guaranteeing the country the title of exporter of feather, main fiber used in the textile industry. Currently, Brazil figures as the 4th largest world producer (ICAC, 2019). The projection of the cultivated area in the 2019/2020 harvest, of 1,562.8 thousand hectares, representing an increase of 21.8% in relation to the previous harvest (CONAB, 2019).

In Brazil, cotton farming represents one of the most modern and promising sectors (CONAB, 2019), giving Brazil the fourth place among the largest world producers, behind only India, China and the USA. In 2027, according to the projections of the Food and Agriculture Organization of the United Nations - FAO (2019), the country will become, according to fiber quality and productivity, the second largest exporter in the world.

Observing the great economic participation in the market and the requirements demanded by them, cotton farmers are increasingly concerned with the need to improve the characteristic of the produced plume, since the high technological quality of the fiber is the primary factor for its commercialization, adding value to the product according to the qualification made in the laboratory of this fiber (CARDOSO, 2015).

The physiological potential of the seeds used for sowing is a crucial factor for the initial establishment of a crop. The percentage, speed and uniformity of seedling emergence depend on this potential. According to Amaro et al. (2015), high quality seeds result in strong, vigorous, well-developed seedlings that are established in different edaphoclimatic conditions, with greater speed of emergence and plant development. As a result, the crop will have fewer problems with weed plants, less use of phytosanitary products, less need for reseeding, among others, which guarantees greater plant performance and greater productivity (BRASIL, 2009).

Approximately 80% of economically significant crops are implanted using seeds, thus, rapid emergence, uniform development generating good yield and product quality are important factors for choosing upper quality seed lots (MARCOS FILHO, 2015). However, the index of emergence and of strong normal seedlings varies between cultivars and between the floral branches of plants, especially those of indeterminate growth such as cotton (NASCIMENTO, 2019).

For the seed to have a high agronomic performance, it must have attributes of genetic, physical, physiological and sanitary qualities. High quality seeds must have guarantees of physical and varietal purity, they do not have a mixture with seeds of weed plants, they must contain physiological and sanitary characteristics, such as high rates of vigor, germination and health (BRASIL, 2009).

The factors that influence the quality of the seed can occur during the production phase in the field, in the harvesting operation, drying, processing, storage, transport and sowing. Therefore, a quality control must be established, which includes the analysis and certification of the seed in order to guarantee the genetic purity of the cultivars, thus assuring the farmer a pure lot with high vigor, being able to establish a uniform stand in the field (HOOGERHEIDE, 2007).

Quality control must be established by a seed analysis laboratory, where several tests will be applied to assess the viability and vigor of a seed lot before its implantation in the field (KARAEDMIR, 2012). The tests must be fast, reliable and complementary.

The seeds submitted to the germination test in the laboratory, may not reflect the same results that occur in field conditions, where they normally do not have ideal conditions, thus there are variations in the results obtained in the field and in the laboratory (VIEIRA et al., 2003; OLIVEIRA et al., 2009). For Amaro et al. (2015), seeds in the field or in storage, are exposed to several factors that can interfere in the germination process, such as: temperature and humidity of the soil or storage location, sowing depth and availability of water in the soil for hydration of the seed. In addition, the time difference of flowering in the plant promotes differentiation of germination of a seed lot, when this factor is not observed.

The set of properties that determine the activity potential and performance of a seed or seed lot during germination and seedling emergence is called vigor, and its analysis is used to better study the physiological quality of seeds (BRASIL, 2009).

Among the physiological tests, it is possible to classify the seedling vigor through visual observations, regarding the development and integrity of its essential structures, in which intact seedlings (well-developed, complete, proportional and healthy essential structures) are considered normal seedlings strong, but seedlings that have minor defects or secondary infestations are categorized as weak normal. However, when damage is visible in the seedling, such as deformity, primary infection or seedling without chlorophyll (albinos), they are classified as abnormal. Seed lots that produce a higher percentage of strong normal seedlings are considered more vigorous, that is, they will have a greater chance of emerging and producing normal plants in adverse field conditions (OLIVEIRA, 2009). Thus, the test of strong normal seedlings informs the percentage of normal seedlings considered strong (vigorous) among the germinated seeds.

It is known that there is genetic diversity among accessions available on the market, characterizing them as distinct due to the fiber characteristics evaluated, but it is not studied and there is no knowledge about the qualitative differences present in the same plant. According to Soares et al. (1999), the physiological characteristics present in a seed are highly influenced by its location in the plant.

Given the above and the need for clarification regarding seeds harvested from different floral branches of plants of indeterminate growth, the objective of this article was to evaluate the physiological and morphological quality of seeds from different thirds of ten genotypes of white fiber cotton grown in edaphoclimatic conditions in Uberlândia - MG.

Methods

The experiment was carried out in the experimental area of the Programa de Melhoramento Genético do Algodoeiro (PROMALG), located at the Fazenda Capim Branco of the Universidade Federal de Uberlândia (18º52'S; 48º20'W and 805m of altitude), in the municipality of Uberlândia, Minas Gerais, in the period from December 2017 to June 2018 with an area of approximately 500 m².

Eight commercial cotton genotypes (BRS 368RF, BRS 372, DP 1228 B2RF, FM 975 WS, FM 982, IMA 5675 B2RF, IMA 8405 GLT, TMG 45 B2RF) and two PROMALG genotypes from the Federal University of Uberlândia, Minas Gerais, were evaluated General (UFU - H, UFU - P). The experimental design performed in the experiment was randomized blocks design (RBD), with four replications, arranged in a factorial experiment (10x3), with the first factor being the genotypes and the second being the thirds. The experimental plot consisted of four rows of five-meter cotton plants spaced one meter apart. The usable area being composed of the two central lines neglecting 0.5 m from each end of the line.

The soil in the test area was classified as a dystrophic typical Latossolo Vermelho with a clay texture, according to the criteria of the Brazilian Soil Classification System SiBCS (EMBRAPA, 2013). Before the implementation of the experiment, a sample composed of soil was collected to carry out chemical analyzes for the purpose of liming and fertilization. The soil preparation was carried out in a conventional manner, with a plowing and two harrows. The area was furrowed and manually fertilized with NPK (20-80-10).

Before sowing, the seeds were treated with Fipronil insecticide, of commercial name Sombrero® and the formulation of systemic fungicide Carboxine, and with contact fungicide Tiram, of commercial name Vitvax®Thiram 200 SC, both used in the dose of 450 mL of the product per 100 kg of seeds.

They were sown in December, with 16 seeds per linear meter at a depth of 2 cm. At 30 days after emergence, thinning was carried out, maintaining eight plants per linear meter and covering fertilization, with 80 kg of N ha^{-1}.

During the culture cycle, common cultural treatments were used for the cultivation of cotton. Among them, the control of weed plants with the application of pre-emergence herbicide, a Dual Gold commercial product at a dose of 1.5 L ha^{-1}. In post-emergence the commercial products Gliover and Gramoxone 200 were used, both at a dose of 1.5 L ha^{-1}, and the applications were made in a directed jet, complemented with manual weeding, picking between plants and between lines, which maintained the competition-free culture until harvest. Phytosanitary management was carried out in order to control pests and diseases according to the need, following the technical recommendations for the crop.

The bio-regulator of growth was used to control the vegetative growth of cotton plants, having the active ingredient mepiquate chloride, of the trade name Pix®HC. In order to condition a greater "setting" of the flowers and good development of the apples, two applications of boric acid solution, H3BO3, were made with the proportion of 2 kg ha^{-1} divided in three times.

At the end of the crop cycle, plumes produced according to each third of the plant were collected separately (Figure 1), with the lower third being the first four reproductive branches close to the soil, the upper third the last four reproductive branches of the canopy and the third middle the interval between the two parts in the median height of the plant.

The bolls were harvested manually plant by plant, and the plumes separated and placed in paper bags duly identified, containing the genotype and the third in which they were inserted. The bags with the plumes were taken to the cotton processing laboratory at Fazenda Capim Branco, processing them in a ginning machine, separating the plumes from the seeds. The weights of the seeds and plumes were subsequently weighed and recorded.

The seeds of each genotype were subjected to the process of removing the adhered fiber and the linter. The delinting consisted of immersing the seeds in sulfuric acid (H_2SO_4) for two minutes; after that time, the mixture of seeds with acid was placed in a sieve, like a strainer, and washed under running water for one minute. In order to neutralize the remaining acid in the seeds, they were inserted in a solution of calcium hydroxide [$Ca(OH)_2$]. At the end of this process, the seeds were spaced and separated, being destined for drying in a covered place (open air).

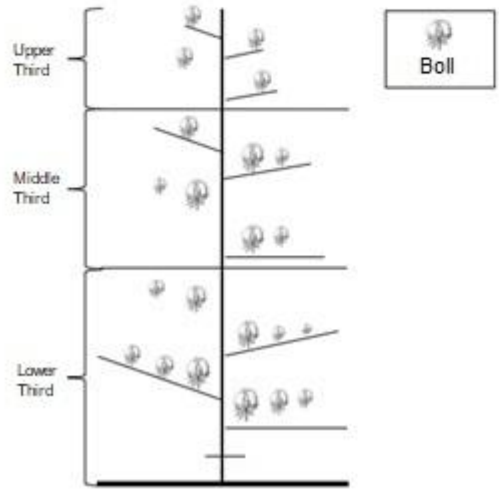

Figure 1. Schematic diagram of a cotton plant, with the development sites of bolls. Source: Soares and Busoli (1996).

The properly dried samples were stored in the cold chamber of the Laboratório de Sementes (LASEM) at the Universidade Federal de Uberlândia (UFU). Subsequently, the stored cultivars were subjected to a germination test, following the standards established by the Rules for Seed Analysis - RSA (BRASIL, 2009). The seeds were placed in blotting paper rolls, moistened with distilled water, with an amount equivalent to 2.5 times its dry weight and subsequently submitted to the germinator at a temperature of 25°C. In this process, four repetitions were performed with 50 seeds, for each sub-lot (thirds and genotypes).

The evaluations were carried out after four days, in which the number of germinated seeds was quantified with the aid of a 16 table magnifier (4x), increasing the luminosity for reading. After quantifying the germination index of the seeds of each genotype, the evaluation of strong normal seedlings was carried out, that is, those that presented all essential structures (root system, hypocotyl, cotyledons and radicle) and free from injuries or cracks. The size of the aerial part and root part of the normal strong seedlings was also measured (BRASIL, 2009).

The data were submitted to analysis of variance (Test F) and when significant differences were detected, a mean test (Tukey) was performed, at 5% probability of error, using the software R (R CORE TEAM, 2015).

Results and discussion

From the analysis of variance (Table 1), the test shows that at least one cotton genotype is statistically differentiated by the F test, regarding the germination index and normal strong plants. Like the genetics of the plant, the third also influenced the growth of the aerial part of the seedling. Even though these two factors did not significantly influence the root growth of strong normal seedlings, they promoted unevenness in the physiology and morphology of the seeds. Therefore, special care is needed in the selection of floral branches at the time of seed harvest. It is interesting that the seed lots were formed from each third of the plant. This is due to the fact that cotton begins to ripen fruits from the lower third to the upper third of the crop.

Table 1. Average square of the analysis of variance for germination index (G), strong normal seedling (SNS), aerial length (AL) and root length (RL) of white fiber cotton seedling genotypes in their different thirds. Uberlândia, - MG, 2019.

Variation Source	DF	G -----%------	SNS ------------ % -------------	AL -------- cm -------	RL -------- cm -------
Blocks	3	10,39 ns	482,12 ns	0,22 ns	1,14 ns
Genotypes (G)	9	7,09**	41,5*	0,02 ns	0,74 ns
Thirds (T)	2	59,84**	53,68*	0,32**	0,54 ns
G X T	18	4,82**	19,77 ns	0,07 ns	0,28 ns
Error	58	1,68	18,8	0,06	0,47
Total	89	---	---	---	---

* e ** = significant at the level of 5 and 1% probability, respectively; ns = not significant by the F test; DF = degree of freedom.

It is possible to identify the interaction between genotypes and thirds in germinated seeds, demonstrating that the thirds of seed development in plants are dependent on the genotypes used. Nascimento (2019), when evaluating the divergences found in the technological characteristics of fiber according to the third of development of the plume and identifying genotypes with high fiber quality, obtained results similar to these, proving the existence of variability related to the third of seed development. According to Table 2, it is observed that the lower third has the best germination index (93 to 98% of germination), when compared to the middle (88 to 97%) and upper (88 to 97%), except for exceptions such as the genotypes DP 1228 B2RF and IMA 8405 GLT, in the middle and upper thirds, respectively, which statistically have means equal to those found in the lower third. As it is a culture with an indeterminate growth habit, the fruit maturation has unevenness, where the lower third, due to flowering first, accumulates greater amounts of reserves when compared to the middle and upper thirds, which directly reflects the vigor and development of the seeds that developed in the lower third.

Table 2. Germination index (%) of seeds of ten cotton fiber genotypes harvested in their different thirds. Uberlândia, - MG, 2019.

Genotypes	Lower	Middle	Upper
BRS 368	97,66 Aa	96,32 Aba	87,66 BCb
BRS 372	98,32 Aa	93,33 ABCab	89,32 ABCb
DP 1228	97,66 Aa	97,32 Aa	93,66 Aba
FM 975	95,18 Aa	95,00 ABCa	87,00 Bcb
FM 982	95,66 Aa	96,32 Aba	91,66 ABCa
IMA 5675	97,00 Aa	93,00 ABCa	87,32 BCb
IMA 8405	97,66 Aa	96 Aba	94,66 Aa
TMG 45	94,32 Aa	88,32 Cb	94,66 Aa
UFU - H	93,00 Aa	90,32 BCab	86,32 Cb
UFU - P	97,32 Aa	95,00 ABCab	90,32ABCb

Means followed by the same uppercase letters in the column and lowercase letters in the row do not differ by Tukey's test at 5% probability.

Observes that the seed germination index in the lower third of white fiber cotton does not differ statistically between the ten studied genotypes. However, the same does not occur in the middle and upper thirds. This indicates that seed lots must be formed taking into account the genetics and thirds of the crop.

Evaluating the distribution of production, quality of fruits and seeds in different positions of the fruit in the cotton plant, Soares et al. (1999), concluded that more than 80% of the cotton production is distributed in the region of low and middle third of the plant, and that the cotton production together with the physiological characteristics of the seeds depends closely on its location in the plant. Corroborating with the results found in this research of the physiological and morphological quality of seeds in relation to the thirds and genetics of cotton plants grown in the edaphoclimatic conditions of Uberlândia - MG.

It is observed that the FM 982 showed less vigor (68% of normal strong plants) and growth (2.42 cm of shoot growth), than the genetics under study (Table 3). On the other hand, BRS 368 RF was the one that stood out the most in the indexes of normal strong seedlings (84%), and shoot length (2.55 cm), showing greater vigor in relation to the other genotypes used. In general, the cotton genotypes grown in Uberlândia showed an elevated vigor (above 68%), of the seeds that germinated. In addition, there was no significant difference between the morphological attributes of the genotypes under study. So the primary care is with the thirds of the plants at the time of harvesting the seeds.

When observing the physiology and morphology of seedlings within each third of the plant (Table 4), the growth of the aerial part is the only variable that presents a significant difference between the thirds of the plant. Where the seeds harvested in the lower third gave rise to plants with greater shoot growth than the other thirds. This is due to the fact that the feathers are harvested at the same time in all thirds, allowing for a longer physiological maturation time of the seeds of low (lower third of the plant). In addition, the chances of a floral bud becoming a boll in the lower, middle and upper thirds are 60, 30 and 12.5% respectively, therefore, it directly influenced productivity, showing that the position of the boll in the plant directly influences the physiology of the seeds to be obtained (SOARES et al., 1999).

Table 3. Strong Normal Seedlings (5), aerial length (AL) and root length (RL) of ten genotypes of white fiber cotton seedlings. Uberlândia, - MG, 2019.

Genotypes	Strong Normal Seedlings	AL	RL
	%	cm	cm
BRS 368 RF	83,89 a	2,55 a	9,80 a
BRS 372	77,12 ab	2,50 a	9,51 a
DP 1228 B2RF	72,27 ab	2,47 a	9,46 a
FM 975 WS	70,69 ab	2,43 a	9,37 a
FM 982	67,69 b	2,42 a	9,10 a
IMA 5675 B2RF	73,66 ab	2,56 a	8,91 a
IMA 8405 GLT	72,12 ab	2,48 a	9,05 a
TMG 45 B2RF	79,56 ab	2,49 a	9,05 a
UFU - H	74,65 ab	2,51 a	9,15 a
UFU - P	72,98 b	2,52 a	8,97 a

Means followed by letters in the column do not differ statistically between the Tukey test and 5% probability.

Table 4. Strong Normal Seedlings (5), aerial length (AL) and root length (RL) of ten genotypes of white fiber cotton seedlings developed from seeds harvested in different plant stems. Uberlândia, - MG, 2019.

Third	Plântulas Normais Fortes	AL	RL
	%	cm	cm
Lower	71,26 a	2,61 a	9,25 a
Middle	71,20 a	2,45 b	9,36 a
Upper	66,65 a	2,42 b	9,09 a

Means followed by distinct uppercase letters in the column and lowercase letters in the row differ by Tukey's test at 5% probability.

Conclusions

Thirds and genotypes affect the physiological and morphological quality of the seeds, with the lower third having the best performance among the genotypes.

Acknowledgment

The Coordination for the Improvement of Higher-Level Personnel (Capes) and the National Council for Scientific and Technological Development (CNPq), for the granting of scholarships, to the Graduate Program in Agronomy at UFG, Campus Samambaia, and the Federal University of Uberaba - UFU for the physical and intellectual.

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