DOI: 10.5965/223811712212023001

Revista de Ciências Agroveterinárias 22 (1): 2023
Universidade do Estado de Santa Catarina

Physiological quality of soybean seeds produced under shading

Qualidade fisiológica de sementes de soja produzidas sob sombreamento

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Submission: 24/04/2022 | *Acceptance: 09/08/2022*

ABSTRACT

Low light intensity reduces the production of photoassimilates by plants and consequently the accumulation of reserves in seeds. The objective was to evaluate the physiological quality of soybean seeds produced under shading initiated at different crop phenological stages. In a completely randomized design, the experiment was carried out in a greenhouse, at CAV/UDESC, during the 2018/2019 harvest, with nine treatments and 10 replications. The treatments consisted of nine seed lots, eight of which were obtained from plants submitted to continuous 70% shading, initiated at different phenological stages: stage V6 (Day Julian 07); R1 (JD 14); R2 (JD 21); R3 (JD 28); R4 (JD 35); R5 (JD 42); start of R6 (JD 49); end of R6 (JD 56), and a lot of seeds produced without shading (control). Each repetition consisted of a pot containing a soybean plant. The germination potential and vigor of the seeds produced were evaluated. Soybean seed germination was higher in the lot of seeds from shaded plants from the R4 stage (JD 35), with 98%, but the other lots presented percentages above 87%. The vigor in the accelerated aging test was lower for the lot obtained from shaded plants from V6, with 43%. The dry mass of seedlings showed a 7.0 to 13.3% reduction in relation to the control when the shading was imposed between R3 and R6. It was concluded that the continuous 70% shading in soybeans promoted higher seed germination when imposed from the R4 stage; however, the vigor was dependent on the stage that the shading started and the test used.

KEYWORDS: photosynthesis; germination; *glicyne max*; solar radiation; vigor.

RESUMO

A baixa intensidade luminosa reduz a produção de fotoassimilados pelas plantas e consequentemente o acúmulo de reservas nas sementes. Objetivou-se avaliar a qualidade fisiológica de sementes de soja produzidas sob sombreamento iniciado em diferentes estádios fenológicos da cultura. O experimento foi conduzido em casa de vegetação, no CAV/UDESC, durante a safra 2018/2019, em delineamento inteiramente casualizado, com nove tratamentos e 10 repetições. Os tratamentos foram constituídos por nove lotes de sementes, sendo oito obtidos de plantas submetidas a sombreamento contínuo de 70%, iniciado em diferentes estádios fenológicos: estádio V6 (Dia Juliano 07); R1 (DJ 14); R2 (DJ 21); R3 (DJ 28); R4 (DJ 35); R5 (DJ 42); início de R6 (DJ 49); final de R6 (DJ 56), e um lote de sementes produzidas sem sombreamento (testemunha). Cada repetição foi composta por um vaso contendo uma planta de soja. Avaliou-se o potencial de germinação e vigor das sementes produzidas. A germinação de sementes de soja foi maior no lote de sementes oriundas de plantas sombreadas a partir do estádio R4 (35 DJ), com 98%, mas, os demais lotes apresentaram percentuais acima de 87%. O vigor no teste de envelhecimento acelerado foi inferior para o lote obtido de plantas sombreadas a partir de V6, com 43%. Já a massa seca de plântulas apresentou redução de 7,0 a 13,3% em relação à testemunha, quando o sombreamento foi imposto entre R3 e R6. Concluiu-se que o sombreamento contínuo de 70% em soja promoveu maior germinação de sementes quando imposto a partir do estádio R4, porém, o vigor foi afetado de maneira dependente do estádio que o sombreamento iniciou e do teste utilizado.

PALAVRAS-CHAVE: fotossíntese; germinação; *glicyne max*; radiação solar; vigor.

INTRODUCTION

The soybean crop (*Glycine max* L.) has great global economic importance. Fabaceae production in Brazil in the 2021/2022 crop was 12 4.0 million tons, with an average productivity of 3.0 tons per hectare

(CONAB 2022). Plant growth and its productivity may suffer interference from the environmental factor, such as luminosity intensity. Solar radiation is indispensable in the photosynthetic process, through which plants synthesize carbohydrates used for their vital processes (TAIZ et al. 2017). In addition, the rate of dry matter accumulation and growth of seeds subsequently harvested are proportionally dependent on plants' source and drain ratio, i.e., the production and storage capacity of the photoassimilate during the growth cycle (ASSENG et al. 2017).

Plants can be exposed to low availability of solar radiation, for example, in crop-forest integration systems (ILF) (CORDEIRO et al. 2015); and days with high cloudiness index, as visualized by CUSTÓDIO et al. (2009) in the region of altitude fields of Rio Grande do Sul. Yet, in grain production systems with high sowing densities, a fact that causes a higher rate of self-shading among plants, mainly affecting the leaves of the rascal (SOUZA et al. 2010); and as a function of latitude, in which there is a lower incidence of solar radiation as a function of solar inclination during the winter season.

When evaluating the shading effect of 50% during the development cycle of in soybean crop, BELLALOUI et al. (2012) observed a reduction in protein and lipid content and variation of germination of the seeds produced as a function of the genotype and crop evaluated. However, CHEN et al. (2020) evaluating the shading effect on soybean crop under intercropping with corn crop, found that seeds from the tested cultivars presented radicle protrusion more quickly, longer root length and seedling dry mass. Interestingly, few studies evaluate the physiological responses of soybean seeds from the condition of luminosity attenuation starting at different stages of the development of the mother plant. Therefore, based on the hypothesis that the reduction of the amount of light incident for long periods in soybean crop reduces the quality of the seeds produced, especially when covering the reproductive stages of development, the objective was to evaluate the physiological quality of soybean seeds from plants under shading condition (70%) imposed at different phenological stages.

MATERIAL AND METHODS

Place of study and experimental conditions of obtaining seeds

The experiment was carried out in a greenhouse during the 2018/2019 harvest, at the Center for Agri veterinary Sciences - CAV, State University of Santa Catarina - UDESC, in the municipality of Lages - SC. Soybean cultivar 96Y90 (category C1 seeds), characterized as early cycle, between 130 and 140 days, maturation group 5.9, habit of growth indeterminate and tolerant to bed. Data on temperature and relative humidity during the culture conduction period were recorded by *datalogger* device (TENMARS, TM305U) (Figure 1a).

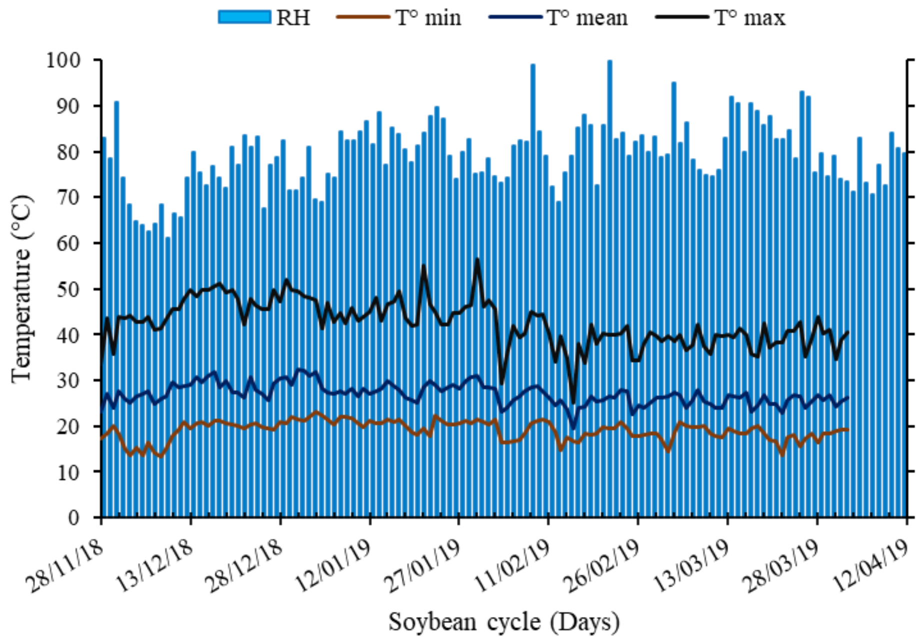
The sowing was carried out on November 28, 2018, corresponding to Julian Day (DJ) number 332. Five seeds were seed per pot, and then thinning and conducting only one plant per pot with a capacity of five liters. For the treatment of seeds, the commercial product based on pyraclostrobin + methyl thyophalate + fipronil (Standak Top, 5.0 g i. a. 100.0 $^{kg-1}$ seeds + 45.0 g i. a. 100.0 $^{kg-1}$ seeds + 50.0 g i. a. 100.0 $^{kg-1}$ seeds) and peat biological inoculant containing *Bradyrhizobium elkanii* and *Bradyrhizobium japonicum*. The irrigation was performed manually and daily according to the needs of the plants, based on the depletion of the gravimetric moisture of the soil contained in the pots.

From the interpretation of the results of the soil analysis, fertilization was performed, following recommendations of the Commission of Soil Chemistry and Fertility (CQFS- RS/SC, 2016) for productivity expectation of 4000 kg $^{ha-1}$, corresponding to the application of 95.0 kg $^{ha-1}$ of K_2O, 30.0 kg $^{ha-1}$ of P_2O_5, and supplementation with 60.0 kg $^{ha-1\ nitrogen}$, divided into three applications, on November 28, December 19, 2018 and January 9, 2019 (JD 323 and 353 - 2018, and 09 - 2019). Dilutions of KH_2PO_4 (anhydrous monobasic potassium phosphate) KCl (potassium chloride) and urea were used for fertilization. For phytosanitary treatment, tebuconazole (Folicur, 150.0 g a.a. $^{ha-1}$) was used on January 10 (JD 10 - 2019) spiromesifen (Oberon, 96.0 g a.i. $^{ha-1}$) on 10 and 27 January (JD 10 and 27), and profenofos + lufenuron (Curyom, 150.0 g a.i. $^{ha-1}$ + 15.0 g a.i. $^{ha-1}$) on 16 January (JD 16).

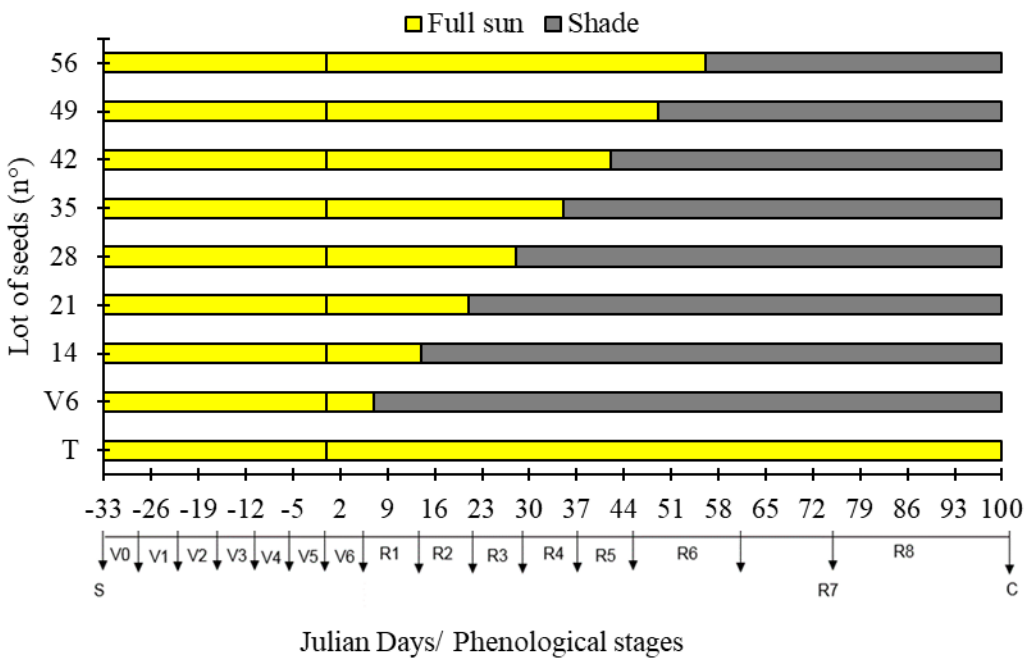
The plants' artificial shading was performed by using black color screen, polypropylene monofilament, with fiber density of 70%, exceeding only 30% of the available solar radiation (checked via ceptometer) Light Sensor Logger LI-1500, LICOR®, Lincoln, NE, USA). The canvas was installed on a wooden structure 1.50 m high, to house the pots containing the plants.

The harvest was carried out when the seeds were in harvest maturation, i.e., stage R8, in which 95% of the pods of the plant's main stem were yellow, on April 10, 2019 or JD 100. After manual threshing of the pods, the seeds were dried in an oven at 35 °C until moisture stabilization (13%). Then, the seeds of the plants of each treatment were homogenized, forming the average sample of each lot, and then separated into four replications to make up the working samples. The size of the seeds used was standardized for seeds larger than 5.0 mm in diameter and circular sieve.

a)



b)



T: Witness. S: Sowing; C: Harvest.

Figure 1. a) Mean relative humidity (RH) and minimum (T° min), average (T° average) and maximum (T° max) recorded by a Datalogger device, in the greenhouse (unshaded environment) during driving of the experiment. b) Schematic representation of soybean seed lots formed according to phenological stages of shading starts on soybean plants. 2018/2019 growing season.

Experimental design

The experimental design used was completely randomized with nine treatments, consisting of plots of soybean seeds obtained from eight phenological stages of onset of artificial shading imposition of plants, a condition in which they remained until harvest, and the control treatment (plants conducted without shading), with 10 replications. The phenological stages at the beginning of each shading period and Julian Days (DJ) were: V6 stage (six knots on the stem from the unifoliolate node, JD 7); R1 (a flower in any knot, JD 14); R2 (flower in the first knot below the top knot with completely unrolled leaves, JD 21); R3 (pod 0.5 cm long in one of the four upper nodes with unrolled leaf, JD 28); R4 (pod 2 cm long in one of the four upper nodes with unrolled leaf, JD 35); R5 (beginning of development of seeds in one of the top four nodes with unrolled leaf, JD 42); R6 (pod with big green seed on one of the top four knots with unrolled leaf, JD 49); R6 (JD 56) (Figure 1b), whose phenological stages correspond to those described by FEHR & CAVINESS (1971). Each replication was composed of a pot containing a soybean plant of cultivar RR 96Y90.

Evaluation of seed quality

The analyses performed were:

- Weight of One Thousand Seeds (TSW): weighing of eight replicates of 100 seeds. Each repetition was weighed and multiplied by 10 (BRASIL 2009);
- Germination test (G%): 200 seeds for each treatment, divided into eight replicates of 25 seeds, distributed among pre-moistened germination paper sheets with water equivalent to 2.5 times its dough, rolled, taken to the germinator, at a temperature of 25 °C, and evaluated on the eighth day (final count). Results expressed in germination percentage (normal seedlings), abnormal seedlings and dead seeds (BRASIL 2009);
- First Germination Count (FGC): percentage of normal soybean seedlings five days after the beginning of the germination test (KRZYZANOWSKI et al. 1999);
- Accelerated aging (AA): soybean seeds were packed on aluminum canvas, so as not to overlap and use all space, contained in a gerbox under 40 ml of water. These were kept at a temperature of 41 °C for 48 hours and subsequently affected in paper rolls, according to indications for germination test, and evaluated on the eighth day for vigor percentage (KRZYZANOWSKI et al. 1999);
- Electrical Conductivity (EC): four replicates of 50 seeds per treatment, previously weighed, immersed in 75 mL of deionized water, kept at a temperature of 25 °C for 24 hours, and measured the EC of the water with a bench-top conductivity meter (Quimis, Model 0795A2). To obtain the EC of each sample, the formula was used: CE = CEs - CEa/P, being ECs: EC read by the apparatus of samples with seeds, EEC: from the pure water sample, and P: weight. Results expressed in μS g^{-1} cm^{-1} (KRZYZANOWSKI et al. 1999);
- Length of Shoot (LS), Length of Main Root (LMR) and Length of Total Seedling (LTS): evaluation by measuring, with the aid of graduated ruler, of the aerial part, main root and total length of 20 soybean seedlings on the eighth day of the germination test, with four replications per treatment (KRZYZANOWSKI et al. 1999);
- Seedling Dry Weigth (SDW): on the eighth day of the germination test, 20 seedlings were dried per repetition, in a forced air kiln with a temperature of 65 °C until the stabilization of the mass (KRZYZANOWSKI et al. 1999). Results expressed in mg per seedling.

Statistical analysis

The data were submitted to normality and homogeneity tests, and after the analysis of variance by the F test ($p \leq 0.05$). Data that did not meet the assumptions were transformed, being the percentage through sine arc of $(x/100)^{0.5}$, and for abnormal seedlings and dead seeds through sine arc of $[(x+1.5)/100]^{0.5}$. When there was a significant difference, the lot means were grouped by the Skott-Knott test ($p \leq 0.05$) by the Sisvar software (FERREIRA 2011).

RESULTS

The results for TSW, germination and vigor by the tests of first count of germination, accelerated aging, electrical conductivity and performance of soybean seedlings showed variations depending on the stage in which the mother plants were imposed under shading during their development.

The weight of one thousand seeds (TSW) presented difference between lots. The batch of seeds from shaded plants from stage V6 presented higher TSW (163.2 g), with an increase of 4.3% in relation to the control. The lots from plants shaded in R5 and beginning of R6 presented lower TSW, with 133.5 and 131.9 g, respectively, indicating that the luminosity limitation in this period reduced on average 15.0% the seed mass compared to the control treatment (without shading), and 18.7% in relation to the lot of shaded plants from V6. In relation to lots from shaded plants in stages R2 and R3, these presented an average reduction in TSW of 7.71%, and for R4 and R6 the decrease was 10.8%, compared to the control (156.2 g) (Table 1).

For soybean seed germination, the highest percentage (98%) was obtained for the seed lot from shading imposed under the plants at stage R4, which represented an increase of 5% in relation to the control seed lot (without shading) (93%). However, negative effects of the condition of light limitation imposed from V6, R3, R5 and final of R6 on seed germination were observed, with averages of 87, 91, 89 and 87%, respectively (Table 1). At the same time, the germination test did not check the presence of dead seeds, only abnormal seedlings. Thus, the lowest percentage of abnormal seedlings observed (2%) corresponded to the seed lot with the highest germination percentage (R4) (Table 1).

In relation to the first germination count (FGC) test, higher vigor (96%) was obtained for lots from shaded plants from the phenological stage R4 (pod with 2 cm), representing an increase of 5% in relation to the control lot (91%). The seed lots obtained from shading imposed in V6, R2, R3, R5 and R6 showed lower vigor by the test, with values between 78 and 89% (Table 1).

Table 1. Weight of a thousand seeds (WTS), germination (G), abnormal seedlings (AS), first germination count (FGC) and vigor by accelerated aging (AA) of soybean seeds produced under different phenological stages of shading imposition.

Phenological stage	TSW (g)	G (%)	AS (%)	FGC (%)	AA (%)
V6	163.2 a	87 c	13 a	84 c	43 d
R1	148.3 c	94 b	6 c	92 b	92 a
R2	143.3 c	93 b	7 c	84 c	95 a
R3	145.0 c	91 c	9 b	78 c	96 a
R4	138.8 d	98 a	2 d	96 a	76 b
R5	133.5 e	89 c	11 a	89 c	80 b
R6	131.9 e	92 b	8 b	80 c	94 a
R6	139.9 d	87 c	13 a	80 c	83 b
T	156.2 b	93 b	7 c	91 b	60 c
SMD	6.1	5.2	5.2	8.9	10.6
CV (%)	3.1	4.2	21.5	8.8	10.2
Average	144.4	91	9	86	80

*Equal letters in the column do not differ by the Skott-Knott test at $p \leq 0.05$; T: Witness; SMD: Significant minimum difference; CV (%): Coefficient of variation.

For the vigor of soybean seeds verified through the accelerated aging test (AA) it was observed that the batch of soybean seeds derived from plants shaded from the phenological stage V6, present or lower vigor (43%) compared with the control (60%). However, it was noted that the shading condition imposed from the R1, R2, R3 and beginning of R6 of plant development inferred the production of seeds with greater vigor by the test, with averages of 92, 95, 96 and 94%, respectively (Table 1).

Regarding the vigor of soybean seeds through the electrical conductivity (EC) test, it was observed that the seed lots from shaded plants from stages R1, R2, R4 and R5 presented higher values for the variable, with averages above 59.0 µS cm^{-1} g^{-1}, representing an increase of 6.3 to 17.5% in the EC, compared to the seed lot produced without shading (55.5 µS cm^{-1} g^{-1}). Thus, it is noteworthy that the lots in question, with the highest means of EC, are classified as of lower vigor (Table 2).

The results for seedling shoot length (SL) differed between seed lots. For seedlings derived from shading imposed from stages R1, R3 and R4, they presented higher SL, with an increase of 16.1, 25.1 and 16.6%, respectively, compared with the mean of the control (7.76 cm) (Table 2). Regarding the main root length (LMR), the lowest mean observed was for shading the mother plants from the R2 stage (8.0 cm), representing a decrease of 42.5% in relation to the control (11.4 cm). Moreover, both seed lots from r6 stage (JD 49 and 56) from the beginning of shading showed a reduction of 12.3 and 10.2%, respectively, compared to the control (Table 2).

When evaluating the total seedling length (LTS), results similar to the LMR were observed. For seedling LTS, there was a reduction of 17.7, 8.6 and 7.1%, for seed lots whose shading started in R2 and R6 (JD 49; 56) respectively, when compared to the control (19.19 cm). For seedling dry weight (SDW) it was detected lower averages for seedlings from lots and m that the shading was imposed in stages R3, R4, R5 and R6, whose decreases ranged between 7.0 and 13.3%, in relation to seedlings whose mother plants were not shaded during their development, with SDW of 116.2 mg (Table 2).

Table 2. Electrical conductivity (EC), shoot length (SL), main root length (LMR), total seedling length (LTS) and seedling dry weight (SDW) of soybean produced under different phenological stages of shading imposition.

Phenological stages	EC ($\mu S\ cm^{-1}\ g^{-1}$)	SL (cm)	LMR (cm)	LTS (cm)	SDW (mg seedling^{-1})
V6	57.3 b	8.1 b	12.3 a	20.4 a	118.4 a
R1	65.2 a	9.0 a	11.5 a	20.5 a	111.5 a
R2	59.0 a	7.8 b	8.0 c	15.8 b	112.2 a
R3	53.6 b	9.7 a	11.2 a	20.9 a	108.1 b
R4	60.8 a	9.1 a	11.4 a	20.4 a	100.8 b
R5	60.4 a	8.3 b	12.5 a	20.9 a	104.5 b
R6	50.2 b	7.5 b	10.0 b	17.6 b	104.1 b
R6	53.7 b	7.6 b	10.3 b	17.8 b	112.7 a
T	55.5 b	7.8 b	11.4 a	19.2 a	116.2 a
SMD	7.2	1.4	1.9	2.6	8.8
CV (%)	6.3	8.2	8.5	6.8	4.0
Average	57.3	8.3	10.9	19.3	109.8

*Equal letters in the column do not differ by the Skott-Knott test at p≤ 0.05; T: Witness; DMS: Significant minimum difference; CV (%): Coefficient of variation.

DISCUSSION

The results for TSW of the seeds derived from plants shaded from the vegetative stage (V6) indicates a possible compensating effect, i.e., a smaller number of seeds (data not presented), but with higher mass (Table 1). Thus, it is possible to affirm the possible interference of plant etiolation induced by shading on the number of seeds produced (YANG et al. 2018). According to FRANKLIN & WHITELAM (2005) the reduction in the amount of assimilates sent to the development of reproductive parts may have been used for the growth of stems, reducing the number of seeds. This fact refers to the compensation event, in which the largest seed mass is related to the smallest number of st, in the conditions in which they were produced (LABRA et al. 2017). According to BORRÁS et al. (2004), the assimilated drained seeds the during filling phase are very dependent on the current photosynthesis. This fact may explain the negative results caused by the limitation of light in the R5 and R6 stages of soybean plant development in the TSW of the seeds (Table 1).

The results corroborate the ones observed by BIANCULLI et al. (2016) whose TSW obtained were between 110 and 130 mg by seeds of shaded plants (80% radiation restriction) during the seed filling phase. Also according to them, these values are lower than those observed for seeds produced without shading, in which the weight of each seed was on average 170 mg. This fact was observed for the other seed lots from shaded plants in the present study (Table 1).

The lots of soybean seeds from the plants submitted to shading and control lot presented germination percentages above the minimum standard required by the legislation for the commercialization of seeds, of 80%, (BRASIL 2013) (Table 1). The results for germination of seed lots of shaded plants from the end of the cell division phase and beginning of the deposition of reserves of seeds in formation (R4) indicated lower sensitivity of these to the imposed condition, a fact not visualized for the other lots. This may possibly be due to lower temperatures in the shaded environment (data not presented), during the seed filling period, and presenting beneficial condition germination (KHAN et al. 2011). Similarly, BELLALOUI et al. (2012) observed an increase in soybean seed germination produced in most genotypes, with percentages between 85 and 92%, when using 50% lumen restriction throughout the crop cycle, referring to the beneficial effect of the 10% reduction in temperature.

In addition, the increase in twinning of seeds produced under shading may be related to changes in gibberellin (GA) and abscisic acid (ABA) levels in seeds, because, according to CHEN et al. (2020), seeds obtained from shaded plants (intercropping system) showed higher expression of GA biosynthesis genes and lower for those related to ABA, during their formation, when compared to seeds produced under the sun (monoculture).

The vigor test through the FGC, together with germination, are performed under conditions considered optimal to the initial development of culture, a fact that can justify results similar behavior between the tests for the tested lots (Table 1). However, according to KRZYZANOWSKI et al. (1999) seed lots with lower percentage of normal seedlings in FGC correspond to lower vigor. PICCININ et al. (2012) observed for the FGC of soybean seeds of different genotypes and sieves, values between 68 and 91% of normal seedlings, without obtaining significant difference between treatments. CHEN et al. (2020), when studying the shading effect of soybean plants through the intercropping with corn on the seeds produced, observed greater speed in radicle emission, when they were produced under shaded condition.

The lower vigor visualized by the accelerated aging test of soybean seed lots from shaded plants from the vegetative stage (longer shaded period) (Table 1) indicates that these presented greater deterioration and lower viability under the condition of high humidity and temperature (KRZYZANOWSKI et al. 1999). According to MATERA et al. (2019) the test can be used as a prediction of the performance of soybean seeds in the field as emergence and vigor of seedlings. When testing the physiological quality of soybean seeds classified in 5.5 and 6.5 mm sieves, PICCININ et al. (2012) observed variation for vigor evaluated by the accelerated aging test only for the genotype factor, whose means varied between 50 and 86 classifying in lots of high and low vigor, as in the present study (Table 1).

Seed vigor can also be evaluated through biochemical electrical conductivity test. The high values for EC the test characterize seed lots with less vigor, that is, lower capacity of reorganization of tegument membranes after intake, and high elimination of exudates and ions from inside cells (MARCOS FILHO 2015). CATÃO & CAIXETA (2019) evaluating the electrical conductivity of soybean seeds from seven lots obtained values between 61.44 and 104.33 μS cm-1 $^{g-1}$, and higher values when testing higher temperatures and different soaking periods, numerically higher results than those observed in the present study (Table 2).

Regarding seedling performance, the low vigor observed for lots may be related to lower tissue transformation capacity in seed reserves, and incorporation into the embryonic axis (BEWLEY et al. 2013). The filling of legume seeds is dependent on the amount of photoassimilate produced during this phase (BORRÁS et al. 2004), a fact that can be observed for the SDW of seed lots from shading imposed on plants during stages R3 to R6. HENNING et al. (2010) observed differences between high and low vigor soybean cultivars related to seedling performance, in which for total length, seeds of higher and lower vigor presented an average of 25.3 and 18.7 cm, and for SDW, they were approximately 46.6 and 39.3 mg, respectively. MATHIAS et al. (2019) verified that soybean seeds of cultivar NA 5909 RG presented higher averages for seedling length, with a value of 19.6 cm, and the cultivar NS 5959 IPRO the lowest averages, of only 15.2 cm, when harvested in different periods after physiological maturity.

Considering the results obtained for germination and vigor of soybean seed lots from shaded plants, in general, it was observed that these presented variation in responses by the condition of imposed lumen restriction. According to CARVALHO & NAKAGAWA (2012) seed lots with the same germination potential may present differences in vigor. Thus, a harmful trend of the condition of lumen restriction in plants during the final stages of seed development was observed, under their vigor. However, the production of photoassimilate carried out by the crop during the seed filling period is mainly destined to these (BORRÁS et al. 2004).

With the reduction of the photosynthetic rate by lumen restriction there is a limitation in the availability of sucrose and lipid formation, which results in the increase of protein content in seeds (DELARMELINO-FERRARESI et al. 2014). This fact may explain the greater vigor obtained from the seed lots of plants imposed on the condition at the beginning of the period in question, because higher protein levels are related to the higher vigor of the seeds (MATHIAS et al. 2019). In addition, the temperature may have positively influenced the germination potential and vigor of the lot of shaded plants from R4 when compared with the control, because under shaded conditions the ambient temperature is lower, according to BELLALOUI et al. (2012) and KHAN et al. (2011), checks in the present study (data not presented).

CONCLUSION

Shading of 70% tax on soybean plants from the stage of development of the beginning of the formation of pod (R4) provided higher germination potential of the seeds produced.

The vigor of soybean seeds, according to phenological stage and test employed, was affected due to the lumen limitation imposed on plants from the seed filling stages.

ACKNOWLEDGEMENTS

We would like to thank CAPES, CNPq, FAPESC, UNIEDU/FUMDES and UDESC.

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