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DEVELOPMENT AND PRODUCTIVITY OF SOYBEAN SOWN IN THE OFF-SEASON

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ABSTRACT - The objective of this work was to evaluate the influence of different sowing times on plant height and yield of soybean seeds produced in two consecutive years and in two seasons in the off-season period. The experiment was carried out in an open field, at the Federal University of Pelotas, in the municipality of Capão do Leão, RS. The experimental design was completely randomized. In order to evaluate growth attributes and yield characters, the plant height, number of pods, seeds per plant, seed production, number of seeds per pod. Sowing at different times of the off-season affects in a different way the production of soybean seeds. Sowing at the end of February negatively affects plant height and soybean seed production in relation to sowing in early January.
Key-words: morphological components, seed yield components, sowing times, number of grains.

DESENVOLVIMENTO E PRODUTIVIDADE DE SOJA NA ENTRESAFRA

RESUMO - O objetivo deste trabalho foi avaliar a influência de diferentes épocas de semeadura na altura da planta e na produtividade de sementes de soja produzidas em dois anos consecutivos e em duas safras na entressafra. O experimento foi realizado a campo aberto, na Universidade Federal de Pelotas, localizada no Municipio de Capão do Leão. O delineamento experimental foi inteiramente casualizado. A fim de avaliar os atributos de crescimento e caracteres de produção, a altura da planta, número de vagens, sementes por planta, produção de sementes, número de sementes por vagem. A semeadura em diferentes épocas da entressafra afeta de maneira diferente a produção de sementes de soja. A semeadura no final de fevereiro afeta negativamente a altura da planta e a produção de sementes de soja em relação à semeadura no início de janeiro.
Palavras-chaves: Componentes morfolgicos e de rendimentos de sementes, época de semeadura, número de grãos

INTRODUCTION

Currently, Brazil is the second largest soybean producer in the world with a production of 119.2 million tons obtained in the 2017/2018 harvest, only surpassed by the United States. The state of Rio Grande do Sul is the third largest producer of soybean nationwide, behind only the states of Mato Grosso and Paraná. In the 2017/2018 harvest, production reached 17.1 million ton, with an average yield of 3013 kg ha^{-1}, 11% below the national average (CONAB, 2020).

The soybean crop in the southern region of Brazil is carried out in October and November, due to the interference of the photoperiod and agroclimatic conditions favorable to the growth and development of the plants (MEOTTI et al., 2012). For seed production, sowing at this time may result in low seed yield by staying longer in the field, being subject to fluctuations in temperature and relative humidity (CARVALHO et al., 2016; AISENBERG et al., 2018).

The sowing of genotypes at certain times causes changes in the crop cycle due to photoperiod changes, which mainly affect soybean yield (SZARESKI et al., 2018). The photoperiod and temperature influence the number of reproductive primordia and the growth rate of the plants, causing reflexes on plant height, cycle and crop production potential (CARVALHO et al., 2017). In tropical conditions, excess radiation and high temperatures are often the main limiting factors for crop growth and productivity (PACHECO et al., 2011), due to thermal stress, negatively affect liquid photosynthesis, chlorophyll content and stomatal conductance (ECHER, 2014). Therefore, the study of the production variability and the response of the plants to the different photoperiods and temperatures is a determinant factor for the evaluation of the performance of the plants (MEOTTI et al., 2012).

In the last years unfavorable environmental conditions during the spring sowing of the soybean have led to the production of seeds in the time of the off-season, also aiming at the maximization of the use of available resources. Together, it is worth mentioning that in different areas of Rio Grande do Sul, the cultivation in the off-season can present higher yields compared to the regular season. It is believed that if there are more favorable environmental conditions in the off-season, soybean plants may show higher growth and consequently result in higher yields.

The objective of this work was to evaluate the influence of different sowing times on plant height and yield

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of soybean seeds produced in two consecutive years and in two seasons in the off-season period.

MATERIAL AND METHODS

The experiment was carried out in an open field, at the Federal University of Pelotas, in the municipality of Capão do Leão, RS, at latitude 31º52 'S, longitude 52º21' W and altitude of 13 m. The climate of the region is characterized by being temperate with well distributed rains and hot summer, being of type *Cfa*, by the classification of Köppen.

The sowing was carried out in two years and two seasons in the off-season period, the first in the beginning of January (01/03) and the second (01/28). The experimental design was completely randomized. FUNDACEP-64 soybean seeds were planted in polyethylene pots with a volumetric capacity of 10 L, containing as substrate, soil of the A1 horizon from Eutrophic Solodic Haplic Planosol, previously corrected according to soil analysis and based on the Manual of Fertilization (CQFS RS / SC, 2004).

Soil fertility correction was performed according to previous soil analysis, based on the Manual of Fertilization and Liming for the RS and SC States (CQFS, 2004). The irrigation of the plants was done manually, seeking to meet the water requirement of the crop. The data of temperature, relative humidity and solar radiation were obtained from the bulletin of the Agroclimatic Station of Pelotas, located at a hundred meters from the place of cultivation (Table 1). The seeds were harvested at a water content of 16% and, as well as the trail, performed manually. The water content of the seeds, after the processing, was measured by means of the greenhouse method at 105°C for 24 h, reaching 6.5 and 11.8% water content in seeds in the off-season periods of 1 and 2, respectively.

TABLE 1 - Agroclimatological Bulletin for values of temperature (T), relative humidity (RH) and solar radiation (SR) incident in Capão do Leão, UFPel. Source: Agroclimatological Bulletin.

Months	T (ºC)		RH (%)		SR (cal cm^{-2} dia^{-1})	
	Harvest 1					
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
January	31.8	10.8	93.3	65.0	665.0	197.0
February	33.3	11.8	94.8	59.5	629.0	171.0
March	32.2	9.6	93.3	72.8	530.0	145.0
April	29.2	7.3	94.0	60.0	433.0	30.8
May	26.2	2.5	96.3	68.0	347.0	98.0
June	24.6	3.8	99.5	61.8	279.0	78.0
	Harvest 2					
January	37.1	14.6	93.3	60.3	687.0	190.0
February	38.0	15.3	95.8	66.3	649.0	168.0
March	31.4	8.7	97.5	76.3	522.0	19.5
April	32.2	8.5	97.0	71.0	428.0	103.0
May	25.6	2.7	97.3	78.8	367.0	82.0
June	24.6	0.8	98.5	78.5	298.0	78.0

In order to evaluate growth attributes and yield characters, the plant height (H) was determined using a tape measure from the ground level to the upper end of the longest stem, and the results were expressed in centimeters. In addition, the number of pods (NP) and seeds per plant (NS), obtained by direct counting, were evaluated. Seed production (P) determined by the seed mass, expressed in grams per plant, the number of seeds per pod (NS/P), which was determined by dividing the total number of seeds by the total number of pods. The data were submitted to analysis of variance and, when significant by the F test, the means were compared by the Tukey test at 5% probability ($p < 0.05$).

RESULTS AND DISCUSSION

From the results obtained it was possible to observe that there were similar results for all variables analyzed, when soybean plants were cultivated in two off-season periods and sowing times (Table 2). The plant height (H) was reduced by the delay of the sowing season. In plants cultivated in both off-season periods, the highest plant height was observed when sowing was performed in the first season. The plant height reduction from the first to the second sowing season was 19.0% in the off-season 1, and 39% in the off-season 2.

The number of pods per plant was reduced by 37.0% in the 2, off-season due to the delay in the sowing season, whereas in the off-season 1, no differences were observed between plants of the two sowing seasons. The number of seeds per plant and seeds per pod decreased in plants whose sowing was delayed in both off-season periods. The off-season of 2 resulted in plants that produced more seeds per pod in the second sowing season, compared to the same time in the off-season 1.

The production of seeds per plant in the two off-season periods was reduced by delaying the sowing season. When analyzing the seed production per plant, in the second sowing season and in the two off-season periods, it was

verified that sowing in the harvest 2 produced 1.6 g of seeds per plant, less than the plants of the sowing carried out in the harvest 2, which corresponds to a reduction of 14%. The reduction of seed production can be attributed to the decrease in plant height, due to the lower number of reproductive nodes. Also, the decrease in solar radiation over time.

The reduction in the production of pods can be attributed to the decrease of solar radiation, the alteration of the favorable conditions to the development of the plants, the photoperiod and the temperature, that influence the number and rate of development of the reproductive primordia (JIANG et al., 2011; MEIER et al., 2016). Temperature, relative humidity and solar radiation influence plant growth and may negatively affect plant production (LARCHER, 2000).

The low in the number of seeds for plant, it is he due to the different sowing times, can be attributed to the environmental conditions, which are important factors for the productive performance of the crop (GABRIEL et al., 2018; VARGAS et al., 2018), which may reflect negatively on the number of pods and seeds.

TABLE 2 - Plant height (H), number of pods per plant (NP), number of seeds per plant (NS), number of seeds per pod (NS/P) and production (P) of soybean plants sown in two years and two seasons in the off-season period.

Times	H (cm)	NP	NS	NS/P	P (g)
			off-season 1		
1st	46.0a[1]	73.2a	161.2a	2.2a	19.5a
2nd	37.3b	68.1a	95.8b	1.4b	11.3b
CV(%)	5.29	8.91	6.21	9.37	6.63
			off-season 2		
1st	56.6a	70.3a	164.9a	2.3a	20.7a
2nd	34.6b	44.0b	95.1b	2.2b	9.7b
CV(%)	5.62	5.87	4.66	5.69	8.49

[1]Means followed by the same letter do not differ by Tukey test ($p < 0.05$).

The delay of sowing time may lead to a reduction of up to 50% in seed productivity (FERRARI et al., 2018), since sowing at the most appropriate time is important for the best vegetal performance and chemical composition of the grain produced (MEIRA et al., 2016; RIGO et al., 2018). In addition, it should be noted that anticipation of sowing may be an alternative to crop rotation, providing a second crop in the same agricultural year, which is important for the maintenance of the seed market, when sowing in October and November suffers from unfavorable environmental conditions.

The soybean seeds yield between off-season periods is mainly due to environmental conditions. This is due to the fact that the development temperature influences the growth, flowering and filling of seeds, for causing changes in the photosynthetic rates, the absorption of water and nutrients (FERREIRA et al., 2007), affecting plant growth and yield of soybean (SZARESKI et al., 2016a; SZARESKI et al., 2016b; STROBEL et al., 2016).

CONCLUSIONS

Sowing at different times of the off-season affects in a different way the production of soybean seeds.

Sowing at the end of February negatively affects plant height and soybean seed production in relation to sowing in early January.

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