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Productivity and quality of chickpea seeds in Northern Minas Gerais, Brazil

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ABSTRACT

This study evaluated the productive performance, physiological and sanitary quality of the ‘BRS Cícero’ chickpea cultivar seeds at two sites in the municipality of Montes Claros, MG, at different planting times under irrigated system. The production characteristics evaluated were: plant height and weight, harvest index, weight per 100 seeds and productivity. The germination, first germination count and germination speed index were used to evaluate the physiological quality of the seeds, and the freezing filter paper test, to evaluate their sanitary quality. The planting in São Roberto was more favorable for the development of the plants, with higher production (from 2 to 4 t ha^{-1}) and physiological quality of seeds. The best planting time under the soil and climate conditions of Montes Claros, MG varied between sites, with June being the most indicated month for both sites. The ‘BRS Cícero’ cultivar showed high productive performance in the conditions of Montes Claros, MG, during the evaluation period.

Key words: *Cicer arietinum* L.; irrigation; vigor

Produtividade e qualidade de sementes de grão-de-bico no Norte de Minas Gerais

RESUMO

Este estudo avaliou o desempenho produtivo, qualidade fisiológica e sanitária das sementes da cultivar de grão-de-bico ‘BRS Cícero’ em dois locais no município de Montes Claros, MG, em diferentes épocas de plantio sob sistema irrigado. Avaliou-se as características de produção: altura e peso de planta, índice de colheita, peso de 100 sementes e produtividade. Para a qualidade fisiológica das sementes foram avaliados a germinação, primeira contagem de germinação e o índice de velocidade de germinação, para a qualidade sanitária, utilizou-se o teste de papel de filtro com congelamento. O plantio em São Roberto favoreceu o desenvolvimento das plantas, o que proporcionou uma maior produção (de 2 a 4 t ha^{-1}) de sementes; maior qualidade fisiológica das sementes também foi observada. A melhor época de plantio nas condições edafoclimáticas de Montes Claros, MG variou entre os locais, sendo o mês de junho o mais indicado para ambos os locais. A cultivar ‘BRS Cícero’, mostrou alto desempenho produtivo nas condições de Montes Claros, MG, durante a época de avaliação.

Palavras-chave: *Cicer arietinum* L.; irrigação; vigor

Introduction

Chickpeas (Cicer *arietinum* L.) is an important and highly nutritive legume. It is widespread in several parts of the world, with approximately 11 million hectares of cultivated area and a total production of 11.6 million tons, of which 96% comes from developing countries, and is mainly consumed in the countries of the Indian Subcontinen, West Asia, North Africa, South-West Europe and Central America (ICRISAT, 2017).

Chickpea ranks second among the legumes produced for food purposes in the world, with a cultivated area of 14.8 million hectares, production of 14.2 million tons and productivity of 0.96 t ha^{-1} (FAO, 2017). Chickpea is grown in more than 50 countries, of which approximately 90% are located in Asia. Especially in developing Asian countries, chickpea is considered the largest source of protein among the poorest populations, since it has 20 to 22% of protein, besides being rich in fibers, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene (Gaur et al., 2010).

Favorable characteristics confer it high rusticity, including low incidence of pests and diseases and tolerance to water deficit, adapting well in dry and mild climates (Braga et al., 1997). Despite being considered a legume typical of cold climates, it adapts very well to tropical regions, presenting good development and good productivity.

The few studies carried out in Brazil show that the productivity of this grain in the soil and climatic conditions of the country is high when compared to the world average productivity. According to works already carried out, the best planting times in Brazil are in the winter, because its location in a tropical zone, whereas the best planting time in temperate zones are in the spring (Nascimento et al., 1998). However, in each region, the planting can occur at different times of the year. The best season is the one that allows favorable climatic conditions throughout the crop cycle, which depends on the location and altitude.

Cultivation in late summer, under rainfed conditions, is also possible for chickpeas. In the countries that have a traditional production of this legume, the planting is carried out at the end of the rainy season, taking advantage of the residual moisture of the soils and without water supplementation with irrigation. Artiaga et al. (2015) evaluated the productive performance of fifteen chickpea genotypes in rainfed cultivation in Brazil and observed that six genotypes stood out, presenting productive characteristics superior to Brazilian commercial cultivars.

Little is known about the planting times, seed viability, growing conditions and development of this crop is available; the information available is restricted to certain regions of the country. This makes the establishment of the crop difficult, both for lack of basic planting and management recommendations essential for the cultivation of chickpeas.

The objective of the present study was to evaluate the productive performance and physiological and sanitary quality of the seeds of the 'BRS Cícero' chickpea cultivar in two sites in the municipality of Montes Claros, MG, at different planting times under irrigated system.

Material and Methods

The experiments were carried out from May to December 2013, in the municipality of Montes Claros, Northern Minas Gerais, in the experimental area of the Institute of Agricultural Sciences of UFMG (Local 1) and in the community of São Roberto (Local 2). The municipality of Montes Claros is located in the following geographical coordinates: Latitude 16°40'35.96" South and Longitude 43°50'55.51" West. The climate is Aw according to Köppen's classification, considered tropical savannah, with dry winter and rainy summer. The average annual rainfall is 1100 mm, and the average maximum and minimum annual temperatures range between 27.5 and 30.9°C and 12.2 and 19.0°C, respectively. At the Institute of Agricultural Sciences (site 1), the experimental area is located at 630m altitude and has soil characterized as Yellow Red Argisol, and at São Roberto community (location 2), the altitude of the experimental area is 760m and the soil is characterized as Flossic Neosol. The monthly averages of temperature and precipitation during the trial period at the two growing sites were recorded (Figure 1).

Before preparing the soil, samples were collected from the 0-20 cm soil layer in each area. The results for site 1 were: pH = 6.3; organic matter = 2.93 dag kg^{-1}; P = 3.89 mg dm^{-3}; Remaining P = 44.30; K = 647 mg dm^{-3}; Ca = 5.60 cmolc dm^{-3}; Mg = 2.40 cmolc dm^{-3}; Al = 0.00 cmolc dm^{3}; H+Al = 1.72 cmolc dm^{-3}; SB = 9.66 cmolc dm^{-3}; t = 9.66 cmolc dm^{-3}; m = 0%; T = 11.38 cmolc dm^{-3}; V = 85%; Organic Carbon = 1.70dag kg^{-1}; Thick sand = 19.00 dag kg^{-1}; Fine sand = 15.00 dag kg^{-1}; Silt = 20.00 dag kg^{-1}; Clay = 46.00 dag kg^{-1}. For site 2, the results were: pH = 6.8; organic matter = 3.23 dag kg^{-1}; P = 3.89 mg dm^{-3}; Remaining P = 32.75; K = 298 mg dm^{-3}; Ca = 5.200 cmolc dm^{-3}; Mg = 2.60 cmolc dm^{-3}; Al = 0.00 cmolc dm^{3}; H+Al = 0.95 cmolc dm^{3}; SB = 8.97cmolc dm^{3}; t = 8.97cmolc dm^{3}; m = 0%; T = 9.92cmolc dm^{3}; V= 90%; Organic Carbon = 1.87dag kg^{-1}; Thick sand = 7.30 dag kg^{-1}; Fine sand = 68.00 dag kg^{-1}; Silt = 10.00 dag kg^{-1}; Clay = 14.00 dag kg^{-1}.

For the implementation of the experiment, basic seeds of the 'BRS Cícero' variety, developed by Embrapa Hortaliças

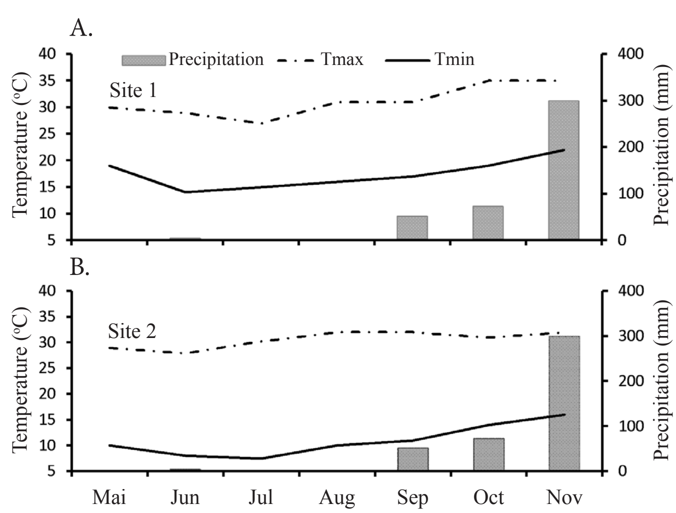

Figure 1. Precipitation and temperature (°C) at the Institute of Agricultural Sciences (Site 1) and the São Roberto community (Site 2), Montes Claros, MG, Brazil.

(Giordano & Nascimento, 1994) were used. The seeds were treated with a product whose active ingredient is Thiamethoxam, in the proportion of 3 ml of the commercial product per kg of seed.

The planting amendment method consisted in 600 kg ha^{-1} of the formula 4-30-16. Sowing was done manually in a 2x3 factorial design (two sites and three planting times). In site 1, the times were: 22/05/2013 (time 1), 20/06/2013 (time 2) and 26/07/2013 (time 3). In site 2, the times were: 05/06/2013 (time 1), 26/06/2013 (time 2) and 24/07/2013 (time 3). Grooves with an average depth of 7 cm were opened with the aid of a hoe. The fertilizer was applied uniformly in the groove and, after its incorporation in the soil, the seeds were sown at the average depth of 3 to 4 cm.

The experiment had a complete randomized block design with three planting times and five replications at both sites. Each experimental unit was composed of a plot with 4 lines of 5 m in length, spaced apart by 0.50 m. The seeding density used was 10 seeds per linear meter, with a final population of 200,000 plants per hectare. The useful area consists of 8 representative plants, located in the central rows of each plot. Manual weeding was carried out whenever necessary throughout the development of the crop. Micro sprinkler irrigation, with one day of irrigation frequency was used. Irrigation was suspended when the plants reached the stage of physiological maturity.

At 30 days after sowing, a cover fertilization of 200 kg ha^{-1} of ammonium sulphate was applied. A systemic insecticide whose active ingredient is a mixture of the chemical group of neonicotinoids (imidacloprid) and pyrethroid (beta-cyfluthrin) was applied after the emergence of the pods to control the caterpillar*Heliothis virescens* (Lepdoptera; Noctuidae). The applications were performed weekly until harvest, at a dose of 700 ml ha^{-1}.

Harvesting of the plants (cut at the ground level) was performed manually when the grains reached humidity close to 14%. At that time, the plants were yellow-brown and dry.

The following agronomic characteristics were evaluated: Plant height (PH), measured as the average of eight representative plants from the ground level up to the insertion of the last leaf or pod on the main stem; seed yield (SY), measured as the total weight (kg ha^{-1}) of the grains harvested in the plot area; Harvest index (HI), measured as the ratio between seed yield and shoot biomass production at harvest; and weight per 100 seeds (P100) in (g). The pods were detached to perform the following evaluations: Number of pods per plant (NPP); average number of pods per plant in the useful area of the plot; number of empty pods (NP0); average number of seedless pods; number of pods with one seed (PN1); and number of pods with two or more seeds (PN2m).

As for physiological and sanitary quality of the seeds, the samples were evaluated as they were collected, without storage. Initially, they were homogenized by a Jones-type divider. The physiological quality was evaluated through the germination and vigor tests, using a completely randomized block design. The substrate used in the germination test was of germitest paper in roll, according to Brasil (2009). The germitest papers and the water were initially autoclaved in order to sterilize the material used in the test. Four replicates with 25 seeds each were used in each of the germitest paper rolls, which were moistened with water at 2.5 times the weight of the paper, and then packed in plastic bags. The seeds were placed to germinate in a germinator previously regulated at a constant temperature of 25°C in the absence of light.

The first germination count was carried out along with the germination test, evaluating, on the fifth day, the normal seedlings, as described in the Rules for Seed Analysis (Brasil, 2009). The results were expressed as percentages.

Daily readings were carried out to determine the germination speed index (GSI), counting the number of seeds with emerged radicles per day until reaching a constant number. At the end of the test, the germination speed index was calculated according to the formula proposed by Maguire (1962):

$$GSI = \frac{E1}{N1} + \frac{E2}{N2} + ... + \frac{En}{Nn}$$

where:

GSI - germination speed index;

E1, E2, ..., En - number of seedlings germinated in the day, computed in the first, second,..., last count; and,

N1, N2, ..., Nn - number of days of sowing at the first, second, ..., last count.

For the evaluation of the sanitary quality of the seeds, the freezing filter paper method was used (Brazil, 2009). Eight replicates of each treatment were used. Replicates consisted in gerbox boxes containing two germitest paper sheets sterilized and moistened with 1% agar-water, and 25 seeds. The seeds were incubated on the first day at 25°C and 12-hour photoperiod, maintained at -20°C on the second day, after freezing on the second day the seeds remained at 25°C and 12-hour photoperiod for another five days. The evaluation was performed by observing the fungal structures under a stereoscopic and optical microscope. Fungi were identified with the aid of the identification key, checking for the presence of fungal structures (spores, fruiting bodies, specialized hyphae) and, when necessary, slides were prepared for observation under an optical microscope.

The data were submitted to Lilliefors tests for normality and Cochram for homogeneity of variances before analysis of variance. The number of branches per plant, number of pods per plant, number of empty pods, number of pods with one seed and number of pods with two seeds or more were transformed $\sqrt{x} + 0.5$ to correct deviations of normality. Data on physiological quality of the seeds expressed as a percentage were arcsine transformed $\sqrt{x}/100$.

An analysis of variance was carried out following the procedures for joint analysis of experiments, considering the “Planting times” and “Experiment sites” as factors in the program SAEG 9.1. The Tukey's test was used at 5% probability for comparison of means.

Data from the sanitary analysis of the most relevant pathogens were presented in a descriptive manner, by means and standard deviations.

Results and Discussion

Production data

The site x planting time interaction was significant in relation to the following characteristics: plant height, number of pods per plant, harvest index, weight per 100 seeds and productivity (Table 1).

Table 1. Productive characteristics of 'Cicero' chickpea seeds according to site and planting time. Montes Claros, MG, 2013.

Site	Times		
	1st	2nd	3rd
	Plant height (cm)		
Montes Claros	48.9 a AB	51.7 a A	45 bB
São Roberto	49.2 a A	47.5 b A	50 a A
	Plant weight (g)		
Montes Claros	38.70 b A	32.05 a AB	20.05 b B
São Roberto	53.95 a A	30.29 a B	35.61 a B
	Number of pods per plant		
Montes Claros	4.9* (25.1**) bB	5.5 (30.6)a A	4.7 (22.7) b B
São Roberto	6.5 (34.4) a A	5.3 (28.9) a B	5.2 (28.0) a B
	Weight per 100 seeds		
Montes Claros	60.0 a A	55.0 a B	42.0 b C
São Roberto	60.0 a A	52.0 a B	53.0 a B
	Harvest index		
Montes Claros	0.33 a B	0.51a A	0.40 a AB
São Roberto	0.37 a B	0.42 a A	0.29 b C
	Productivity (kg ha^{-1})		
Montes Claros	2.540 b B	3.210 a A	2.410 a B
São Roberto	3.970 a A	2.560 a B	2.090 a B

Means followed by the same lowercase letter in the column and upper case in the row do not differ statistically from each other, Tukey test, $p < 0.05$. * Data transformed by $\sqrt{x + 0.5}$; ** non-transformed means. (Means followed by the same letter in the column did not differ significantly from each other, Tukey, $p \geq 0.05$. * Data transformed by $\sqrt{x + 0.5}$; ** non-transformed means).

Site 1 (Montes Claros)

Seedlings emerged in the first time, six days after planting, and in the second and third times, seven days after planting. The plant cycle was 100, 110 and 105 corresponding to the first, second and third planting times, respectively. The planting time directly interferes with the development and growth of crops, as for example, the cycle of corn crops varies from 80 to 240 days depending on the planting time. Taking into account the FAO method for the Kc coefficient values, an annual crop is divided into four phases according to its phenology (Albuquerque, 2010). In the works that have been conducted in the country with the "Cicero" cultivar, the average cycle was 105 days, similar to the one found in the present work. At this site, the cycle of the plants was possibly shorter as a result of higher temperature that induce the earlier flowering of plants.

Ramamoorthy et al. (2016) studied four seed lots, two of the years 2009-2010 and two of the years 2010-2011, where two lots (one from the lot 2009-2010 and another from the lot 2010-2011) were submitted to stressful conditions while the other two (one from 2009-2010 and another from 2010-2011) were submitted to optimal conditions of water regime through irrigation. The lots that were cultivated under stressful hydric conditions showed earlier flowering, shorter time to reach physiological maturity of seeds and fewer seeds per m².

The number of pods per plant in the first and third planting times was influenced by the temperature; the period of flowering and pod formation coincided with periods of extreme temperature variations. In the first planting time, the flowering phase occurred when the average minimum temperature was 13°C and the absolute minimum was 10°C; in turn, the third planting time coincided with high temperatures, with an average maximum of 31°C and absolute maximum of 33°C. Temperatures below 10°C and above 30°C can cause abortion of floral buds, compromising the formation of pods (Nascimento et al., 1988).

The average productivity was 2.720 kg ha^{-1} in the experiment in the second planting time, which corresponded to the month of June. At this time, the plants had a superior growth, better development, more pods per plant and consequently a superior productivity than the other times, corresponding to an average productivity of the two sites of 3,219 kg ha^{-1}. Soltani et al. (2001) evaluated different irrigation conditions in a chickpea culture in northeastern Iran and the productivity reached 2766 kg ha^{-1} under optimal soil moisture conditions, maintained by frequent irrigations, calling attention to the fact that the area was semi-arid and had mild to cold temperatures. These data show that semi-arid regions that have mild climate in at least one period of the year have a high potential for chickpea production, since they present an average productivity superior to the average world yield of irrigated chickpeas, which is 2.176 kg ha^{-1} (FAOSTAT, 2014).

The early appearance of flowers and formation of seeds in the pods can be caused by abiotic stress conditions. The early development of the tissues leads to the abortion of flower buds, significantly decreasing the number of flowers. Chickpea plants under water stress tend to abort seeds (Vadez et al., 2012).

The first planting time (May) showed higher seed weight than the other times. The third planting time (July) presented lower-weight seeds. The plants of the second planting time presented higher harvest index than those of the other times. The harvest index represents the ration between the weight of the grains and the total weight of the fresh plant. Studies have shown that the harvest index can be influenced by planting density, water and nutrient availability, and temperature in the growing phase (Durães et al., 2002).

Site 2 (São Roberto)

Seedlings emerged at twelve, fifteen and thirteen days after planting, corresponding to the first, second and third planting times, respectively. The emergence of seedlings occurred later than those in the site 1, Montes Claros, where seeds emerged on average seven days after planting. Seedling emergence was influenced by the low temperatures at this site. The mean minimum temperature was 11°C, and the mean absolute minimum temperature was 9°C. The optimal temperature for germination of chickpea seeds varies from 20 to 30°C, and temperatures below 15°C make seedling emergence to delay (Van Der Maesen, 1972).

The cycle was 107 days in the first planting time, 113 days in the second, and 110 days in the third. The chickpea cycle is influenced both by genetic (differences between cultivars) and environmental factors, mainly photoperiod and temperature, which acts directly in all phases of the crop.

Productivity was higher in the first planting time, averaging 3,970 kg ha^{-1}. In Brazil, the yields found with the Cícero cultivar, cultivated under irrigated systems, have varied according to the region. In Brasília-DF, the average production was 2,700 kg ha^{-1}, while in Santo Antônio de Goiás-GO, productivity was 1,600 kg ha^{-1} (Embrapa, 2014). According to Braga et al. (1997), in Coimbra, Zona da Mata, MG, yield varied from 1,031 kg ha^{-1} to 1,463 kg ha^{-1}. In Janaúba, North of Minas, the yield of chickpea cv. Cícero was 1,315 kg ha^{-1}, Vieira et al. (1999). In order to reach the full physiological development of the crop, a precipitation of 350 to 400 mm is necessary, varying according to the variety cultivated. Water stress at different intensities is the primary factor responsible for crop losses, leading to levels as high as 50% of loss. Such losses are estimated annually around 900 million dollars, what have contributed to maintain productivity levels practically the same over the last six decades (Ahmad et al., 2005; Bantilan et al., 2014). In the present work, the average productivity found in São Roberto was higher or similar to the average productivity found in the abovementioned studies. This demonstrates the potential of the region for the production of irrigated chickpea.

The height of plants was similar among the three studied planting times, with an average of 50cm. Plant height can be influenced by soil fertility, climatic conditions, planting density, sowing time, humidity, temperature and photoperiod (Van Der Maesen, 1972).

The first planting time was the one that had greater production of pods per plant. In the second and third times, sporadic rains may have compromised the formation and fixation of pods in plants. Only 20 to 50% of the flowers produced pods; the chickpea can produce from 30 to 300 pods per plant, varying according to the cultivar and the environmental conditions. Environmental stresses such as temperature and relative humidity fluctuation during the beginning of flowering until the beginning of seed formation pose limitations in the formation of pods (Singh et al., 1995).

Besides the highest number of pods per plant, the first planting time also had the highest values of seed weight. In an evaluation of cultivars of the kabuli group, Vieira et al. (1999) observed larger seed weight values in Viçosa (Forest Zone) when compared to Janaúba (North), in Minas Gerais. In the present study, the average seed weight observed in the three planting times was 55g, close to what was observed by Vieira et al. (1999) in Janaúba, MG.

As for the harvest index, the second planting time resulted in more efficient plants at converting photoassimilates into seeds, followed by those of the first and third times.

The productivity obtained in São Roberto was superior to that observed in Montes Claros, and the average obtained in these two places was higher than the averages found in other studies in the country, using the same cultivar. In Montes Claros, the high production may be associated with the good adaptability of the crop in the region, the edaphic characteristics of the experimental areas and the climatic conditions observed during the period of growth and development of the plant.

Variations between sowing times led to differentiated cycles and consequent differences in seed production. The strong influence of the sowing time, one important aspect for the adaptation of chickpea in the region would be the adequacy of cultivars with cycles adjusted to the conditions of temperature and day length, as well as the latitude of the region.

The average height of the plants in this study was 45 to 51 cm, which is lower than the average of the abovementioned works. The sowing density used in this work was 10 seeds per meter, a lower value than that used in other studies. This could explain, therefore, the short height of the plants, because the greater the densification, the greater the competition for light, causing the plants to grow more in the search for light. Artiaga et al. (2015) evaluated chickpea genotypes in a dry crop in Cerrado conditions and concluded that the genotypes are genetically different in terms of plant height, with influence of the planting time. In this study, the height of the plants of the Cícero cultivar varied according to water availability in the soil, since the cultivation occurred in rainfed. Thus, planting in January, the rainy season, resulted in taller plants, with 57cm, when compared with planting in March, with averages of 40 and 33cm.

The harvest index ranged from 29% to 51%. These values are relatively high when compared to those obtained with the Cícero cultivar in Brasília-DF, in the winter with irrigation, which varied from 8.5% to 22.7% (Artiaga, 2012). In a rainfed crop, Artiaga et al. (2015) found an average harvest index of 17.06% for the Cicero cultivar, classifying it as a variety of group 2, with medium performance. The harvest index expresses the efficiency of transport of photoassimilates to seeds; thus the higher the index, the greater the efficiency of conversion of photoassimilates into seeds.

Physiological and sanitary quality of seeds

The interaction between site and planting time was non-significant for the physiological quality characteristics of chickpea seeds. However, there was an effect of the isolated factors (site and planting time) for the first count and percentage of germination ($p \leq 0.05$) (Table 2). No significant differences were found for the other characteristics (abnormal seedlings, non-germinated seeds and emergency speed index).

Normal chickpea seedlings originated in germination tests had the following characteristics: intact plants, with well-developed and healthy cotyledons, hypocotyl and primary and secondary roots; seedlings with minor defects, presenting a poorly developed primary root but with well-developed secondary roots and seedlings with secondary infection presenting all the essential structures, but with deterioration due to the presence of fungi or bacteria. Abnormal seedlings, on the other hand, are those that have no potential to originate normal seedlings under favorable field conditions. The abnormalities manifested in the chickpea seedlings originated in the optimum

Table 2. Averages of germination and first count of 'Cicero' chickpea seeds according to site and planting time in Montes Claros, Minas Gerais, 2013.

Planting times	Germination	First count
1st	1.19* (85.5**)a	1.08 (77.7)a
2nd	0.95(65.5)b	0.88 (59.0)b
3rd	1.09(78.5)a	1.03 (73.2)a
Site	**Germination**	**First count**
Montes Claros	1.03 (72.7)b	0.96 (66.7)b
São Roberto	1.12 (80.3) a	1.03 (73.3) a

Means followed by the same letter in the column do not differ statistically from each other, Tukey test, $p \geq 0.05$. * arcsine transformed data $\sqrt{x/100}$; ** non-transformed means. (Means followed by the same letter in the column did not differ significantly from each other, Tukey, $p < 0.05$. * Arcsine transformed data $\sqrt{x/100}$; ** non-transformed means).

temperature range were: seedlings with deformation and atypical staining, plants with absent root system and seedlings with deteriorated tissue. As for non-germinated seeds, these are classified as dead, hard, dormant and others, including empty and damaged seeds (Brasil, 2009). Dead seeds and hard seeds were found in the test with chickpeas.

The seeds produced in São Roberto showed a higher germination when compared to those produced in Montes Claros. As for the effect of the time on germination, the second planting time was the one with the lowest percentage (65%). According to Van der Maesen (1972), chickpea seeds are considered to have a high germination rate, of 85%. Thus, only the first planting time resulted in high germinative power.

The first count of the germination test is an analysis that indicates seed vigor. The average of normal seedlings in São Roberto varied from 63 to 77%, whereas those produced in Montes Claros varied from 54 to 76%. Araújo et al. (2010), found averages varying from 12 to 43% for the first count of chickpea genotypes. As for the effect of the planting time, the first and third times were the ones with the highest number of normal seedlings. Seed size in many species is indicative of physiological quality, so that small seeds are less vigorous than medium and large ones.

In relation to the fungi detected in the chickpea seeds (Figure 2), there was a higher incidence of the genus *Alternaria* sp. (86%), followed by*Cladosporium* sp. (21%) and *Rhizopus* sp. (17%). Other studies on sanity of chickpea seeds reported the same fungi found in the present study. Dawar *et. al.* (2007) reported that the species that attack the seeds and that most frequently cause economic damages in Pakistan are *Alternaria* spp., *Aspergillus* spp., *Cladosporium* spp., *Curvularia* spp., *Fusarium* spp., *Helminthosporium* spp., *Mucor* spp., *Penicillium* spp., *Rhizoctonia* spp., *Rhizopus* spp. *and Stemphylium* spp.

In the present study, the means of seeds infected by *Alternaria* sp. ranged from 13.4 to 24.6% (Table 3). The first planting time at site 1 had the lowest mean. The second planting time at site 1 and the third planting time at site 2 had practically all the seeds contaminated with this pathogen. In these times, there was an incidence of rainfall concentrated mainly in the final period of the crop cycle, that is, in the harvest phase. Because of this, the pods and seeds were exposed to a higher incidence of the pathogen. Although *Alternaria* sp. is considered a weak or saprophyte parasite, the infected seeds had gray coloration and brown streaks.

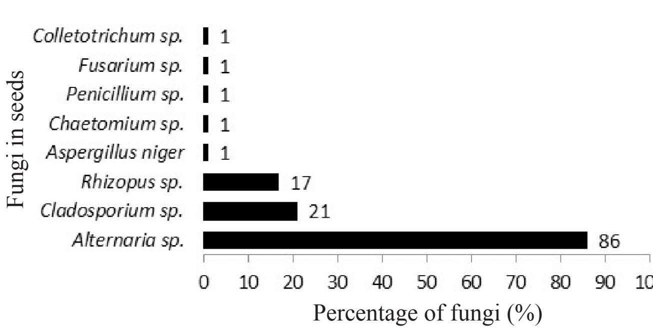

Figure 2. Average percentage of fungi associated with chickpea seeds, Montes Claros, MG, 2013.

Table 3. Incidence of *Alternaria* sp., *Cladosporuim* sp. and *Rhizopus* sp. in 'Cicero' chickpea seeds according to the site and planting time in Montes Claros, MG, 2013.

Site	Times 1st	2nd	3rd
	Alternaria sp.		
1	13.375± 6.63	24.625 ± 0.992	23.875 ± 2.31
2	20.25 ± 3.23	22.125 ± 2.712	24.625 ± 0.695)
	Cladosporuim sp.		
1	17.375± 2.45	3.75 ± 2.16	0.875 ± 1.17
2	1.50 ± 2.12	6.00 ± 3.43	2.375 ± 1.86
	Rhizopus sp.		
1	0.75± 1.64	1.25 ± 2.38	0.875 ± 5.62
2	15.75 ± 5.99	5.875 ± 6.00	2.375 ± 0.33

Although considered a secondary pathogen in chickpea plants, the fungus *Cladosporium* sp. presented a considerable incidence in this study (Table 3). This is a fungus considered saprophytic, opportunistic and part of the microflora of seeds. The symptoms in seeds are spots or greenish growths on the surface, especially in the zone corresponding to the embryo. Plants from the first planting time in the site 1 were the most affected by this pathogen, while plants of the other times did not present a high incidence. This indicates that the manifestation of this fungus was concentrated in the first planting time and in the site 1.

Rhizopus spp. was most frequently detected in chickpea seeds of the site 2, especially in the first planting time (Table 3). This fungus affects the germination of freshly harvested seeds, as seen in non-stored peanut seeds by Lima & Araújo (1999).

In an analysis of seed quality of chickpea genotypes produced in Northern Minas Gerais, Araújo et al. (2010) detected 14 fungi in the seeds. Among these, *Aspergillus niger* was the most incident, followed by *Rhizopus* spp., *Aspergillus flavus*, *Trichordema* sp., *Chaetomium* sp. and *Fusarium* sp.

The efficient control of pathogens associated with seeds should take place during the production of seeds, to keep them free from microorganisms. This can be obtained by choosing the appropriate place and planting time, a balanced fertilization, among other factors. In this present study, it was seen that the third planting time was late, leading the harvest period to coincide with the rainy season and influencing the quality of the seeds that began to deteriorate, becoming moldy, small and wrinkled.

Conclusions

The North of Minas presents a potential to produce chickpeas, because this region has edaphoclimatic conditions favorable to the growth and development and consequent high productivity of this legume.

The best planting times in Northern Minas Gerais should coincide with the winter period in the months of April, May and June.

The best planting time to grow the Cicero chickpea cultivar seeds in Montes Claros was the month of June.

The area of São Roberto, at 760m, presented better edaphoclimatic conditions, which promoted a higher growth, development and productivity, and better physiological quality of the seeds when compared to Montes Claros, at 630m.

The fungi found in the seeds, although considered secondary, weak or opportunistic pathogens, caused damages and compromised the sanitary quality of the seeds.

The Cícero cultivar showed high productive performance under irrigated system in the soil and climate conditions of Montes Claros, MG.

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