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Production performance of sesame cultivars under different nitrogen rates in two crops in the Brazilian semi-arid region

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A B S T R A C T

Sesame is an oleaginous plant that requires suitable management in the field to achieve satisfactory production; however, to better understand the requirements of the culture, it is necessary to obtain more information on the behavior of sesame cultivars, in relation to the nutrition and edaphoclimatic factors that can interfere with its response. Therefore, the aim of this work was to evaluate the production components of fertirrigated sesame cultivars, in the northeastern semi-arid region of Brazil, as a function of nitrogen (N) fertilization in two crops. The experiments were conducted at the Rafael Fernandes Experimental Farm, which belongs to the Universidade Federal Rural do Semi-Árido (UFERSA), from February to May (first crop) and July to October (second crop), in the year 2016. The experimental design was of a randomized complete blocks type with four replications, with the treatments arranged in a split plots scheme, where in the plots were assigned five rates of N (0, 30, 60, 90, and 120 kg ha^{-1}) and in the subplots four sesame cultivars (CNPA G2, CNPA G3, CNPA G4, and BRS Seda). The evaluated variables were N content in the diagnostic leaf (NCDL), number of capsules per plant (NC), plant dry mass (PDM), seed yield (SY), oil content (OC), and protein content (PC). The maximum values of the variables studied were obtained at a rate of 120 kg ha^{-1} of N. The cultivar CNPA G4 presented the highest productive performance in comparison to the other cultivars, and the cultivar BRS Seda had the highest oil content in the seed. The second crop (July to October) obtained the best agronomic performance for the sesame. Regarding the protein content, the cultivars CNPA G3 and CNPA G4 obtained the highest at a rate of 120 kg ha^{-1} of N. The second harvest also provided higher levels of protein in the seed, independent of the cultivar evaluated.

1. Introduction

To obtain satisfactory production from sesame (*Sesamum indicum* L.), it is necessary to carry out adequate field management, based on the requirements of the crop. Good management of fertilization promotes increased agricultural productivity and crop profitability; however, it also represents an expressive cost for the farmer, increasing investment risk when not used properly (Mesquita, 2010). In order to use fertilization efficiently, it is necessary to know the requirements of the crop, in terms of nutrients, as well as the edaphoclimatic factors that can influence it (Arriel et al., 2007). Several factors influence the response of crops to fertilization, such as cultivar, type of fertilizer, season and mode of application, and texture and organic matter (OM) content of the soil (Arriel et al., 2007; Ali and Jan, 2014).

The climate, soil, plant, and their interactions are factors that affect the uptake and utilization of nutrients by the crop. Thus, in order to ensure maximum nutrient efficiency, these factors must be maintained at appropriate levels during the development of the crop, since there is great potential for increasing nutritional efficiency through appropriate management of the components of the production system (Fageria, 1998).

Another important factor in obtaining a good crop response to fertilization, and consequently high productivity, is the appropriate choice of cultivar (El Mahdi et al., 2007). Cultivars can be distinguished by several attributes, such as height, cycle, coloration of the stem, leaves and seeds, type of branching, and resistance to pests and diseases (Silva, 2012), as well as their requirements, in terms of nutrition and production. The CNPA G2, CNPA G3, CNPA G4, and BRS Seda cultivars of sesame are recommended for cultivation in the North East region of Brazil because they are adapted to the prevailing local conditions.

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For sesame to fully express its productive potential, it is necessary that the soil provides nutrients in adequate amounts (Beltrão et al., 2013). Nitrogen is considered to be an essential element for plants, since it contributes to the composition of biomolecules; therefore, variations in accessibility to N, including excesses or deficits, can directly influence the growth and productive performance of a crop (Miflin and Lea, 1976; Harper, 1994). The availability of N to a crop is usually a limiting factor that influences the development of the plants more than any other nutrient (Bredemeier and Mundstock, 2000). Due to its importance for growth, and considering its high mobility in soil, N has been studied in order to maximize, and enable the efficiency of, its use. Consequently, and its availability, uptake and metabolization in the plant can be improved (Bredemeier and Mundstock, 2000).

Sesame responds differently to fertilization at different sites, in different growing seasons, and between cultivars (Mahdi, 2008; Shehu et al., 2010; Shehu, 2014; Kamravaie and Shokohfar, 2015). This demonstrates that the performance of sesame varies according to the complexity of the medium, and that soil–plant–atmosphere relationships are not easy to understand. Nitrogen is one of the nutrients that most limits sesame production, being responsible for important functions in the metabolism and nutrition of the plants. Its deficiency or excess can cause nutritional disorders, with attendant production decrease and reduction in oil content (Biscaro et al., 2008). Therefore, it is extremely important to obtain information about the behavior of sesame cultivars under different fertilization and crop conditions.

Sesame needs high amounts of N that vary according to its productivity, nutritional status, variety used, and part of the plant harvested (Beltrão and Vieira, 2001), being considered to be demanding on soil (Beltrão et al., 1994). In many cases, the availability of N for the crop is a limiting factor that influences the development of the plant more than any other nutrient (Bredemeier and Mundstock, 2000). A number of technologies to overcome this have been studied, but more information is needed on cultivar behavior in relation to fertilization, as well as soil and climatic conditions, considering the potential for the exploitation of sesame (Perin et al., 2010).

In light of this, the present work had the aim of evaluating the components of the production of fertirrigated sesame cultivars in the northeastern Brazil semi-arid region, as a function of N fertilization in two crops.

2. Material and methods

2.1. Conducting the experiment

The experiments were conducted in the municipality of Mossoró, Rio Grande do Norte, Brazil (5°03′37″S, 37°23′50″W, 72 m altitude), from February to May (first crop) and July to October (second crop), in the year 2016. According to the Thornthwaite climate classification (Thorntwaite, 1948), the climate of the site is DdAa – semi-arid, megathermal, and with little or no excess water during the year; in addition, according to Köppen classification (Köppen, 1936), it is BShw – dry and very hot. The average meteorological data for the period of the experiments, as well as soil analyses from the two crops, are presented in Fig. 1 and Table 1. The type of soil in the experimental area is classified as abrupt Eutrophic Red-Yellow Latosol, franc-sand texture (Embrapa, 2013).

2.2. Experimental design and treatments

The experimental design used in each experiment was of a randomized complete blocks type with four replications, with the treatments arranged in a split plots scheme, where in the plots were assigned five rates of N (0, 30, 60, 90, and 120 kg ha^{-1}) and in the subplots four sesame cultivars (CNPA G2, CNPA G3, CNPA G4, and BRS Seda). The total area of the experiment was 576 m^2, and each experimental plot consisted of four rows of plants, totaling an area of 7.2 m^2 (3.0 × 2.4 m). The spacing used was 0.30 × 0.60 m, with two plants per hole, totaling 32 plants in the harvest area of the experimental plot (2.88 m^2), and a population of 111,111 plants ha^{-1}.

2.3. Experiment management

The first crop was planted on 14 February 2016, the second on 19 July 2016. Direct seeding was performed at 0.02 m depth, with eight to 10 seeds being sown per hole. After 10 days of emergence, thinning was performed, leaving two plants per hole.

Drip irrigation was used, with a spacing between ribbons of 0.60 m, and with emitters spaced at 0.30 m. Irrigations were performed daily, based on crop evapotranspiration (Amaral and Silva, 2008). Fertilization was carried out according to the recommendations for the state of Pernambuco (Cavalcanti et al., 2008), except for N fertilization, the concentrations of which were dictated by the experiment. The source of N used was urea, applied to the plots along with the fertilizer, in the amounts of 30, 60, 90, and 120 kg ha^{-1}. Nitrogen fertilization parceling was carried out, according to the recommendations of Kamravaie and Shokohfar (2015), 25% at planting, 50% at the eight-leaf stage, and 25% at the beginning of flowering. Injection of the fertilizers into the irrigation water was performed with the aid of a bypass tank (‘lung’). Culture treatments and phytosanitary control were carried out, according to the technical recommendations and needs of the crop.

2.4. Harvest and evaluated variables

Harvesting of the first and second sesame crops was carried out at 105 days after sowing, following which certain characteristics were evaluated, including: N content in the diagnostic leaf (NCDL); number of capsules per plant (NC); plant dry mass (PDM); seed yield (SY); oil content (OC); and protein content (PC).

The NCDL was collected from the upper third, at the beginning of flowering. A sample of 30 leaves per hectare was washed under running water, then water with detergent, running water, and finally twice with distilled water (Cortez et al., 2014); excess water was removed by laying the samples on paper towel. The samples were conditioned in labeled paper bags, and placed in an oven with a temperature of 65 °C to obtain the dry mass. They were then ground, and packed in sealed containers (Faquin, 2002).

Nitrogen sulfur digestion was performed to determine the N content, the N being quantified by the Kjeldahl semimicro method (Tedesco et al., 1995).

The NC was obtained by counting four plants from the harvest area per plot (Grilo and Azevedo, 2013).

The PDM was obtained by drying four plants collected from the harvest area in an oven at 65 °C, for 48 h, until a constant weight was achieved; the weights are expressed in grams.

Seed yield was determined by weighing seeds from the plants in the harvest area, and making a correction for seed moisture content; the values are expressed in kg ha^{-1} (Grilo and Azevedo, 2013).

For the analyses of sesame seed OC and PC, near-infrared spectroscopy (SpectraStar 2400-RTW), with a spectrum range of 1200–2400 nm, was used. The spectra were obtained from intact seeds, using a quartz cell; two replicates of each sample were obtained (Almeida, 2013).

2.5. Statistical analysis

Analysis of variance of the crops was carried out in isolation for all evaluated characteristics through the application SISVAR v. 5.6 (Ferreira, 2011). After observing the homogeneity of the variances between the crops, a joint analysis of the same characteristics was applied (Ferreira, 2000). The procedure of adjustment of the response curves was performed through the Table Curve 2D program (Systat Software, 2002), with graphs elaborated in SigmaPlot v. 12.0 (Systat