Plant physiology

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Yield components in sesame *Sesamum indicum* L. (Pedaliaceae) cultivars in the department of Sucre (Colombia)

Componentes del rendimiento en cultivares de ajonjolí *Sesamum indicum* L. (Pedaliaceae), en el departamento de Sucre (Colombia)

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Abstract

Sesame *Sesamum indicum* L. (Pedaliaceae) seeds have a great potential for the agricultural sector in the department of Sucre (Colombia), mainly in the elaboration of food products and biofuels, due to its favorable oil and nutrient content. The aim of this study was to establish yield components in sesame through the description of components such as: fertile nodes in stem, capsules per fertile node, seeds per capsule, weight of 1,000 seeds, number of branches and fertile nodes per branch, as well as yield and oil content in seed, for the cultivars Criollo, ICA Matoso and Chino Rojo, in the last quarter of 2015. The variables were analyzed through a randomized complete block design and simple regression models between yield per plant and components. A significant effect of the variety factor was found on the components, except for number of fertile nodes in the branch and greater number of fertile nodes in the stem (30), seeds per capsule (68) and average weight of one thousand seeds (2.86 g) in the Criollo and ICA Matoso cultivars. Likewise, average seed yields of 1,289.8 kg/ha in the Criollo cultivar were found, as well as oil content of ca. 49 % in the cultivar ICA Matoso. Similarly, the yield component with the highest linear association was average seed weight, which allows the selection of the best performing cultivars among the ones studied.

Keywords: crop yield, lipid content, seed, sesame, *Sesamum indicum*, Sucre (Colombia)

Resumen

La semilla de ajonjolí, *Sesamum indicum* L. (Pedaliaceae), presenta un gran potencial para el sector agrícola en el departamento de Sucre (Colombia), principalmente en la elaboración de productos alimenticios y biocombustibles, debido a su contenido de aceite y nutrientes. En consecuencia, el presente estudio buscó determinar los componentes del rendimiento en el ajonjolí, por medio de su descripción. Entre ellos se encuentran nudos fértiles en tallo, cápsulas por nudo fértil, semillas por cápsula, peso de mil semillas, cantidad de ramas y nudos fértiles en rama, así como el rendimiento y el contenido de aceite en semilla, para los cultivares Criollo, ICA Matoso y Chino Rojo, en el último trimestre de 2015. Las variables se analizaron mediante un diseño en bloques completos al azar y modelos de regresión simple entre el rendimiento por planta y los componentes. Se encontró un efecto significativo del factor cultivar en los componentes, excepto en el número de nudos fértiles en rama, y una mayor cantidad promedio de nudos fértiles en tallo (30), semillas por cápsula (68) y peso de mil semillas (2,86 g), en los cultivares Criollo e ICA Matoso. De igual forma, se encontraron rendimientos promedio de semilla de 1.289,8 kg/ha en Criollo, y un contenido de aceite de aproximadamente un 49 % en ICA Matoso. Asimismo, el componente que tuvo una mayor asociación lineal con el rendimiento fue el peso medio de semilla, el cual posibilita seleccionar, entre los estudiados, el cultivar con mejor comportamiento.

Palabras clave: contenido de lípidos, semillas, sésamo, *Sesamum indicum*, Sucre (Colombia)

Introduction

Sesame (*Sesamum indicum* L.) or commonly called *ajonjolí* in Colombia belongs to the Pedaliaceae botanical family and is presumed to be native to the eastern region of Africa and India (Bedigian, 2003). Its outstanding characteristics are the high oil content of the seeds, which represents between 50% and 60% of its weight; in addition, this crop has adequate yields in water deficit environments (Pham, Thi-Nguyen, Carlsson, & Bui, 2010).

In addition to the high oil content, sesame seeds have acceptable calcium, phosphorus, iron content as well as vitamins such as thiamin, rivoflavin and niacin, aspects that demonstrate its high potential for the food industry (Ismaila & Usman, 2012).

On the other hand, in recent years in Brazil, the socioeconomic importance of this crop in agricultural production has been recognized, mainly in programs to substitute fossil fuels for those of vegetable origin (biodiesel) considered as a good alternative (Ahmad, Ullah, Khan, Ali, Zafar, & Sultana, 2011, Andrade, 2008, Dawodu, Ayodele, & Bolanle-Ojo, 2014).

According to the Food and Agriculture Organization of the United Nations (FAO) (2013), an approximatearea of 9,416,369 ha of sesame were planted throughout the world in 2013, yielding 4,847,921 t of seed. However, this area is mainly concentrated in tropical regions where it is widely adapted, and it develops without major difficulties with acceptable seed (514.8 kg/ha) and oil yields (Weiss, 2000).

In Colombia, sesame is mostly cultivated on the Atlantic coast, especially in the departments of Bolívar, Córdoba, Magdalena and Sucre. This region contributes with approximately 50% of the national production (Information and Communication Network of the Colombian Agricultural Sector [Agronet], 2013), which is intended for family consumption and, in a very low percentage for seed commercialization. Nevertheless, according to reports by Agronet (2013), in the last decade (2003-2013) the area devoted to this crop in the department of Sucre decreased from 1,463 to 463 ha, with an average yield of 600 kg/ha (national yield average of 700 kg/ha).

In some cases, this decrease is caused by unawareness of adequate management practices, and lack of studies that help understand plant growth and development in the area (tropical dry forest [bs-T]), based on the recognition and characterization of plant interaction with the environment. This modulates growth patterns that influences fundamental aspects such as fruit physiology, maturity and quality (Fischer, Almanza-Merchán, & Ramírez, 2012).

Sesame cultivation is primarily carried out in environments identified as bs-T or tropical dry forest, with temperatures above 25 °C, and at altitudes between 0 and 1,000 m a.s.l. Furthermore, the annual precipitation ranges between 700 and 2,000 mm with two dry periods in the year causing water deficit (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt [IAVH], 1997).

Moreover, crop dynamics in the department of Sucre, Colombia, shows a planting reduction tendency (Agronet, 2013) caused by multiple factors, among which the limited study availability that help understand the behavior of different sesame cultivars stands out (Caicedo, Valencia, Salamanca, & León, 1998); this is especially the case in terms of yield and aspects that influence yield, particularly in water-deficient environments as bs-T.

Lack of information on these issues has led to less knowledge regarding sesame plant management, which results in the abandonment of the crop in the department, and subsequently production system diversity is reduced, i.e. production systems become predominantly dominated by species as cassava (*Manihot esculenta Crantz* - Euphorbiaceae) and yam (*Dioscorea* spp. - Dioscoreaceae).

In this sense, these crops have not managed to boost the agricultural sector in the region, which has a low participation (4.2%) in the departmental gross domestic product (GDP) (Departamento Administrativo Nacional de Estadística [DANE] & Banco de la República, 2016). For this reason, diversification of agricultural products with high agroindustrial potential such as sesame seeds, contributes to the improvement of the regional agricultural economy.

Plant yield is a quantitative measurement parameter which depends on the interaction of genetic with environmental aspects, and also on many factors called components, whose behavior will determine this performance (Ismaila & Usman, 2012).

Components are classified into primary and secondary according to their relationship with performance. In studies on sesame seed (Aristya, Taryono, & Wulandari, 2017, Ismaila & Usman, 2012, Laurentin, Montilla, & García, 2004, Sankar & Kumar, 2001, Shakeri, Modarres-Sanavy, Amini-Dehaghi, Tabatabaei, & Moradi- Ghahderijani, 2016) under various environmental and genetic conditions, it has been possible to clarify the components that have a greater association with yield. Among these, the weight of a thousand seeds and the number of capsules per plant stand out, meanwhile plant height, number of branches per plant and stem length are associated, to a lesser extent, with production.

It should be noted that variations in primary components are associated more with performance rather than with the secondary components; likewise, performance components do not influence productivity independently, but jointly; thus, the analysis of the relationship between components in recent years has been carried out through simple regression analysis, in which the meaning of this relationship can be established (Fageria, Baligar, & Clark, 2006).

Different models have been studied in which the relationship between performance and its components have been described. For example, in cereals (Fageria, 1992), the relationship is shown by the following expression:

$$\text{GY} = \text{N° P/m}^2 \times \text{N°SK} \times \text{AW1.000 grains} \times \text{PFSK}$$

Where:

GY = grain yield
No P/m² = number of panicles per square meter
No SK = number of spikelets per panicle
AW1,000 grains = average weight of one thousand grains
PFSK = percentage of filled spikelets

On the other hand, in some legumes, the following model is observed (Fageria et al., 2006):

$$\text{Yield (t/ha)} = \text{NoPO/m}^2 \times \text{GP} \times \text{AW1.000 grains}$$

Where:

NoPO/m² = number of pods per square meter

GP = grains per pod

Further, for soybean (*Glycine max* (L.) Merr.) (Fabaceae) cultivation (Akhter & Sneller 1996) the following expression is used:

$$\text{Yield per area} = \text{N.° of plants per area} \times [\text{NMSP} \times \text{PN} \times \text{SP} \times \text{ASW} + (\text{BP} \times \text{PB} \times \text{SP} \times \text{ASW})]$$

Where:

NMSP = nodes in main stem per plant
PN = pods per node
SP = seeds per pod
ASW = average seed weight
BP = branches per plant
PB = pods per branch

According to Arcila, Farfán, Moreno, Salazar and Hincapié (2007), in coffee (*Coffea arabica* L.) (Rubiaceae), production per tree in relation to its components is given by:

$$\text{Yield/plant} = \text{NBP} \times \text{NNFB} \times \text{NFN} \times \text{AFW} \times \text{CF}$$

Where:

NBP = number of branches with production
NNFB = number of nodes with fruit per branch
NFN = number of fruits per node
AFW = average fruit weight
CF = conversion factor

In agreement with the above mentioned, the aim of this study was to evaluate seed yield in three sesame cultivars (*Sesamum indicum* L.) in a locality of the department of Sucre, Colombia.

Materials and methods

The trial was conducted in the district of Chochó in the municipality of Sincelejo, Sucre, between October and December 2015, at an altitude of 174 m a.s.l., with an accumulated annual precipitation of 1,200 mm, an average temperature of 27 °C, and an average relative humidity of 75 % (Arrieta, Baquero, & Barrera, 2006). Based on the aforementioned and according to the classification system of life zones, the region ecologically corresponds to a tropical dry forest (Holdridge, 1965).

Soils

Interchangeable bases within the soil (Ca^{+2}, Mg^{+2} and Na^{+}) showed very high contents (table 1), and sufficient K^{+}. In tropical dry forests, high values in these bases, such as Na^{+}, are promoted by annual precipitations that are insufficient to satisfy potential evapotranspiration.

Table 1. Physical and chemical characteristics of the soil in the Chochó district (tropical dry forest) (2015)

Texture	pH	OM (%)	Dap (g/cm3)	CE (dS/m)	CEC (cmol/kg)
Far	6.26	0.80	1.25	0.563	25.7

Interchangeable bases (cmol/kg)				Microelements (mg/kg)					(mg/kg)
Ca	Mg	K	Na	Mn	Fe	Zn	Cu	B	P
25,40	13.16	0.16	2.10	6.20	40.40	3.40	2.20	0.10	12.75

Methods for texture analysis: Bouyoucos; pH: potentiometer, soil-water ratio 1:25; OM: organic matter, modified Walkley-Black; P: Bray II; S and B: monocalcium phosphate; Al: extraction with 1N KCl; exchangable bases: ammonium acetate; microelements: modified Olsen; SOM: soil organic matter; Dap: apparent soil density; CE: electrical ground conductivity; CEC: soil cation exchange capacity.
Source: Elaborated by the authors

Climate

Climatic variables were recorded using a meteorological station located 15 m from the cultivation plot. Environmental variables were quantified as precipitation (resolution of 0.2 mm) and maximum and minimum temperatures (resolution of 1 °C).

As described in figure 1, maximum temperatures (T °C max) showed a higher variability than the minimum ones, since the latter fluctuated between 22 and 25 °C, with an average of 24.5 °C, while the first ones varied from 31 to 37 °C, with an average of 35 °C. Moreover, diurnal maximum temperature stabilized at 35 °C from 51 DAP (days after planting), and reached 37.3 °C at 87 DAP; likewise, the night minimum temperature (21 °C) were observed at 30 and 33 DAP and stabilized at 22 °C after 60 DAP.

Maximum precipitations (greater than 5 mm) were concentrated between 13 and 47 days after crop establishment (figure 2), with an interval of five days between these; in addition, in this period maximum daily precipitation (34 mm) was showed after 30 days. Subsequently, between 48 and 71 days, maximum rainfall decreased drastically.

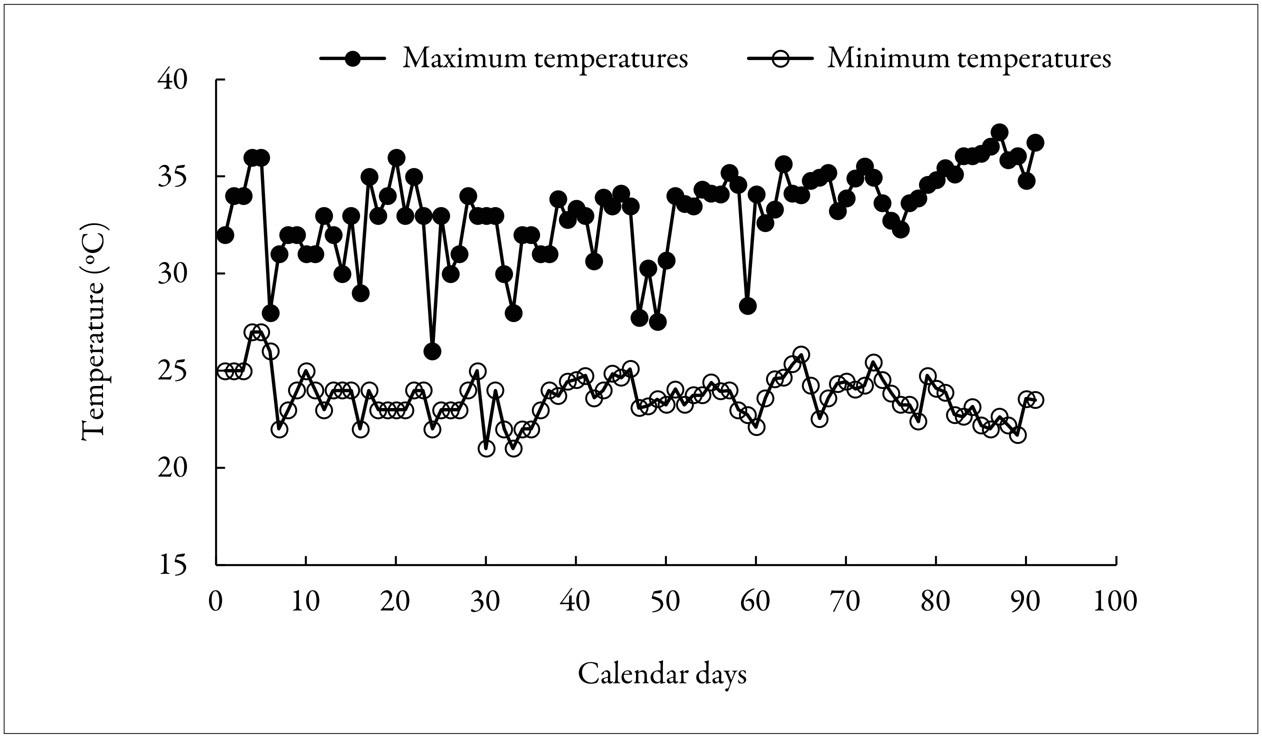

Figure 1. Evolution of maximum and minimum daily temperatures in the district of Chochó (Sincelejo, Colombia). Data recorded between October 1 and December 30, 2015.
Source: Elaborated by the authors

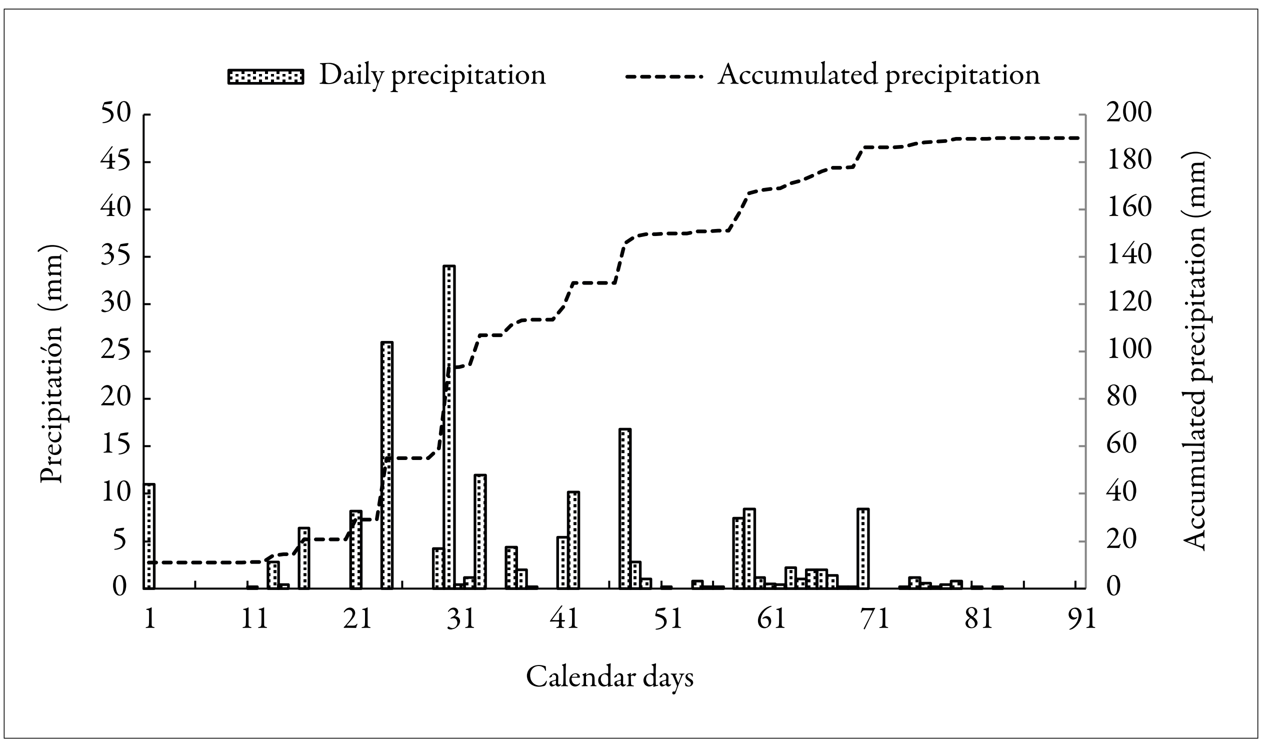

Figure 2. Daily and accumulated rainfall in Chochó district (Sincelejo, Colombia). Data recorded between October 1 and December 30, 2015.
Source: Elaborated by the authors

Plant material

Sesame cultivars that were assessed in this study were introduced in Colombia in the fifties, when the former Instituto de Fomento Algodonero (IFA) was responsible for their promotion and dispersion, distributing various sesame cultivars in the eastern plains and in the Caribbean cost of Colombia (Caicedo et al., 1998). Among these, we find the following cultivars, which are the most common ones found in the study area:

- Chino Rojo: this cultivar tends to branch out and reach a height of approximately 2 m. Flowering begins between 45 and 50 days after planting, depending on environmental factors. It has dehiscent bicarpelar capsules (fruits), with dark brown seeds. This plant is susceptible to the entomopathogenic fungus *Macrophomina* sp. (Caicedo et al., 1998).
- ICA Matoso: this cultivar has short branches and internodes and reaches a height of 1.80 m at maturity. It flowers between 45 and 50 days after planting showing two capsules per node, which are dehiscent, with cream-colored seeds and an approximate oil content of 60 %. This cultivar was released by Instituto Colombiano Agropecuario (ICA), and its main feature is its tolerance to wilt (*Macrophomina* sp.) (Caicedo et al., 1998).
- Criollo: there are not many reports on the physiological characteristics of this cultivar; however, it is the one that local farmers prefer, stating that is has good productive performance in the area, with little maintenance investment.

Planting density was 80,000 plants/ha, distributed in rows at 0.5 m, with 0.25 m between plants. Five to seven seeds were planted per site, from which only three to six of these germinated. Thinning was carried out ten days after planting, leaving only one plant per site. Fifteen experimental plots of 5 m long and 4 m wide were arranged in the field, each of which consisted of nine rows of 25 plants.

Experimental design

The three sesame cultivars described above were used in the treatments considered. Randomization was performed based on an experimental design in randomized complete blocks with five replicates, in which the blocking factor was the terrain slope.

Evaluation of variables

During the physiological maturity of the crop (90 days after planting) the following measurements were made:

- Fertile nodes in the stem (FNS): recorded by counting FNS in five central plants per plot, i.e. in nodes with capsules present.
- Capsules per node (CN): evaluated by counting CN in fertile nodes of five central plants per plot.
- Seeds per fruit (SF): recorded by counting ten capsules per plant (five central plants per plot) in different locations (upper, middle and lower thirds, branches and main stem).
- Average weight of one thousand seeds (AW1000S): obtained by harvesting seeds from ten central plants per plot. Counting and weighing one thousand seeds was carried out, repeating this last procedure five times per experimental plot, and the average value was recorded.
- Number of branches (NB): measured by counting the number of branches in ten central plants per plot.
- Average number of fertile nodes per branch (ANFNB): it was quantified in five central plants by experimental plot. The number of fertile nodes was counted in each branch, and the average was recorded.

In relation to seed yield per hectare (SYH), this measure was established from the average seed weight per plant, found when harvesting ten central plants per plot, and multiplied by the number of plants within the hectare (80,000).

Likewise, oil content (OC) in the seed was obtained through solid-liquid extraction with a crushed seed mass (5 g) through Soxhlet, with ethanol as solvent (100 ml) for eight hours (Carvalho, Galvão, Barros, Conceição, & Sousa, 2012).

Statistical analysis

The data was analyzed based on the experimental design section using the SAS 9.3 statistical program. To establish the magnitude of the variation between cultivars, comparison of means was made with the Tukey test, with a level of significance of 5 %.

Yield component analysis was performed for each sesame cultivar by a simple linear regression between seed yield per plant (R) and each of the performance components described above ($R = \beta 1 \times CP + \beta 0$, where CP is the specific yield component, and β1 and β0 are the regression coefficients of the model or the slope of the regression line and the intercept, respectively), considering in each of them the significance of the linear model represented by the p-value, which evaluates the hypothesis $\beta 1 \neq 0$ and the R^2 value, which indicates the percentage of the variation of the R explained by the model.

Results and discussion

Number of branches, fertile nodes in stem and average fertile nodes in branches

According to the analysis of variances there was a significant effect of the cultivar on the number of fertile nodes in the main stem (FNMS) ($p < 0.05$), while the average fertile nodes per branch (AFNB) and the number of branches (NB) did not exhibit this effect. It should be noted that in the Chino Rojo cultivar an average number of six branches was observed, and in the others, it was close to four.

Number of branches (NB) is a varietal parameter that is intimately related to genetic and environmental aspects (Langham, 2008, Peter, 2006). In addition, in sesame, it is used to categorize the genotype. In this study, for example, the cultivars used fit into the category of few ramifications in the canopy (as described by Peter [2006]), since this parameter did not exceed three pairs of branches, concentrating a high number of fertile nodes, compared to the stem.

Likewise, the Average number of fertile nodes per branch (ANFNB) of the cultivars Criollo and ICA Matoso was sixteen, while Chino Rojo showed a lower value close to thirteen. Criollo and ICA Matoso cultivars had the highest number of nodes, with ca. 29 productive nodes in the stem, and there was no significant difference between them (table 2); on the contrary, Chino Rojo exhibited a significantly lower number of fertile nodes of ca. 31 % compared to the other cultivars.

In general, Criollo and ICA Matoso cultivars had a lower number of fertile nodes compared to Chino Rojo, and because it was more branched, it had more productive nodes in the stem and branch set. However, the first two showed a greater number of capsules per fertile node (table 2), a strategy that allows plants to compensate for their lower number of fertile nodes.

Capsules per fertile node, seeds per capsule and weight of one thousand seeds

The analysis of variance for the number of capsules per node (CN), seeds per capsule (SC) and the average weight of one thousand seeds (AW1000S) found a significant effect of the cultivar factor in each of these variables ($p < 0.05$), which indicates that at least two cultivars differ in function of these.

The number of capsules per fertile nodes showed higher values in the cultivars Criollo and ICA Matoso, with an average of five capsules (table 2), meanwhile Chino Rojo showed significantly smaller quantities, with a difference of 25 % compared to the others. In sesame, it is common to find between four and six capsules per fertile node, that is, from two to three capsules (fruits) per axilla (Langham, 2008), while the number per fertile nodes can vary from two to eight (Morris, 2009).

Moreover, there was no significant difference in the number of seeds per capsule (SC) among the cultivars studied (table 2), and the general average was close to 68 seeds per fruit, an amount similar to what was published by Sheahan (2014), who reports 70; however, these results are very different from the one found by Morris (2009), who found between 80 and 131 in the evaluation of 192 sesame accessions from 38 countries. The above mentioned shows the wide variability of this parameter, in response to the interaction of genetics with the environment, that in relation to our study, did not show many changes in the cultivars studied.

The average seed weight (ASW) did not differ significantly between Criollo and ICA Matoso, with a value close to 3 g, but it significantly exceeded the value found in Chino Rojo by 26 %. However, according to the above mentioned, the latter had a greater number of fertile nodes and branches in plant, which would indicate a high competition for assimilated between stem and branch capsules, if we consider that in the other cultivars there were fewer ramifications and fertile nodes per plant.

In the evaluation of 17 sesame cultivars, Pham et al. (2010) found that values of weight of one hundred seeds ranged between 0.25 to 0.45 g, while in another study, considering five sesame cultivars, weights of one thousand seeds ranged between 2.4 and 3.9 g (Olowe & Adeoniregun, 2010). Furthermore, ASW found in this study corresponds to what was indicated by these authors.

Yield and oil content

There was a significant effect of the sesame cultivar on seed yield and oil content ($p < 0.05$), which shows differences in these two aspects in at least two cultivars.

Yield was significantly higher in Criollo with about 1,290 kg/ha (table 2) followed by ICA Matoso, with ca. 95 kg less seeds than the first, while Chino Rojo had the lowest yield, that was significantly lower in 42 % and 32 %, in relation to Criollo and ICA Matoso, respectively.

Oil content in sesame varies according to environmental and genetic factors (Peter, 2006), which was evident in this study, in which statistically, cultivars ICA Matoso and Criollo produced the same content that was higher than in Chino Rojo (table 2). Regarding percentages, ICA Matoso contained around 5 % more oil in seeds than Criollo and Chino Rojo, which did not differ significantly, as did Criollo and ICA Matoso. This suggests some correspondence that was also found in seed production.

In studies carried out on eight genotypes of sesame under water stress conditions (Golestani & Pakniyat, 2015), seed yields were 879.8 kg/ha, while in non-stressed plants, these reached average values of 1,404 kg/ha. This indicates a decrease in plant productivity when faced with water deficit, which could have occurred in this study; this because during the development stage of capsules, when rainfall decreased, environmental temperatures increased, and the study soil showed high content of interchangeable bases (table 1). All this favors water deficit in these environments (Gasca, Menjivar, & Trujillo, 2011), which would affect Chino Rojo more than the other cultivars.

In addition, there is a correspondence between higher yields in those cultivars that had higher average seed weights (ASW) (table 2), fertile nodes in the main stem (FNMS) (table 2) and capsules per fertile node (CFN), despite the fact that no effect of the cultivars on the number of branches (NB) or differences in the amount of seeds per capsule (SC) between them was found.

This indicates that these last variables do not influence seed yield too much, which allowed adequate yields to be produced in Criollo and ICA Matoso, given the positive association between these variables and seed yield per plant (Ismaila & Usman, 2012).

Normally, the oil content in sesame varies between 37 % and 63 % (Peter, 2006). Seeds can be qualified as premium if they have an approximate oil content of 50 % (Bennett, Imrie, Raymond, & Wood, 1998); this implies that the ICA Matoso and Criollo cultivars could have this qualification (table 2).

Regarding the environment and according to studies carried out by Were, Onkware, Gudu, Welander and Carlsson (2006), oil content is influenced by the amount of rainfall received during cultivation, especially in the capsule development stage. It should be noted that in this study rainfall decreased 70 days after planting.

On the other hand, oil content is associated with seed color. Dark seeds contain less oil than light ones (Akinoso, Aboaba, & Olayanju, 2010, Peter, 2006). This could explain the particular case of the cultivar Chino Rojo, which has brown seeds with a low oil content, in comparison with other cultivars, in which light colors predominate.

Yield component analysis

Seed yield per plant (R) showed a significant association ($p = 0.001$) with the number of fertile nodes in the main stem (FNS) in Chino Rojo (table 3), while in the other two cultivars, this type of relationship was not observed. In this cultivar, for each FNS, there is an increase close to 0.08 g in R, which contrasts with the low amount of FNS found, which indicates that in this plant it is important to favor the development of fertile nodes, because an adequate emission of these in the stem is associated with increases in production.

Criollo cultivar showed a linear association ($p = 0.013$) between R and the number of seeds per capsule (SC) (table 3), which makes it possible to explain 38 % of the variations in R compared to those in seeds per fruit (SF), with an increase close to 0.26 g for each SC of this cultivar.

Considering all the cultivars, no significant relationship was found between the number of branches and the seed yield (table 3), which would indicate a greater influence of the stem capsules in R, especially in Chino Rojo, in which the increases of R, are associated in a greater degree ($R^2 = 0.54$) in comparison to those of compared to those of FNS.

Moreover, table 3 shows the non-existence of a significant association ($p > 0.05$) between the average of fertile nodes in branch (AFNB) and R. However, in Chino Rojo, $p = 0.056$ was obtained, suggesting a slight association between these variables, because of the greater number of ramifications in this crop.

In all cultivars, the average weight of one thousand seeds (AW1000S) exhibited a linear association with R (table 3). In ICA Matoso and Chino Rojo the model manages to explain the variability of R, from the variations in the AW1000S, in a percentage higher than 70 %, which also indicates that for each increase per unit gram in the weight of a thousand seeds, R increases between 46.00 and 47.00 g in ICA Matoso, and 18.45 g and 7.60 g in Chino Rojo and Criollo, respectively. Furthermore, this indicates

Table 2. Physiological attributes of yield in sesame cultivars (*Sesamum indicum* L.), in a locality of Sucre (Colombia) (2015)

Cultivar	FNS	CN	SF	ASW (g)	Y (kg/ha)	CA (%)
Criollo	28.26[a]	5.06[a]	67.50[a]	3.12[a]	1,289.81[a]	46.321[ab]
ICA Matoso	30.13[a]	4.93[a]	68.92[a]	3.11[a]	1,195.41[b]	51.407[a]
Chino Rojo	22.26[b]	4.00[b]	68.69[a]	2.37[b]	905.49[c]	44.933[b]

FNS: fertile nodes in the stem; CN: capsules per node; SF: seeds per fruit; ASW: average seed weight; NR: number of branches; PNFR: average of fertile nodes in branch; Y: seed yield per hectare. Averages with the same letter did not show significant differences according to the Tukey test at 5 %.
Source: elaborated by the authors.

that, in the first cultivars, plant yield is more dependent of an adequate accumulation of biomass in seeds, an aspect that is subject, to a large extent, on the relationship between the genotype and the environment.

In general terms, the component with the greatest influence on seed production in sesame seeds is AW1000S, which on average increases seed yield by 24 g per gram of weight in a thousand seeds. On the other hand, elements such as FNS and SC showed influence on particular cultivars: the first one is associated with yield per plant in Chino Rojo, and the second one with those of Criollo.

Similar studies on yield components in sesame (Adebisi, Ajala, Ojo, & Salau, 2005, Ismaila & Usman, 2012) show adequate associations of AW1000S and SC with seed yield, so these elements could be considered primary in seed production.

Similarly, Morris (2009) found a greater influence of the number and weight components of seeds in sesame production and plant height, which is closely related to the number of fertile nodes in the stem.

Table 3. Linear regression models between seed yield per plant and yield components in sesame cultivars, in a locality of Sucre (Colombia) during 2015

Relation between R and FNS			
Cultivar	**Model**	**R^2**	***p* valor**
Criollo	R = -0.0087 × FNS + 16.369	0.0002	0.956
ICA Matoso	R = 0.1330 × FNS + 10.914	0.0700	0.351
Chino Rojo	R = 0.8166 × FNS – 6.863	0.5400	0.001***
Relation between R and SF			
Cultivar	**Model**	**R^2**	***p* valor**
Criollo	R = 0.261 × SF - 1.487	0.380	0.013**
ICA Matoso	R = 0.273 × SF - 3.904	0.183	0.111
Chino Rojo	R = 0.458 × SF - 20.163	0.108	0.230
Relation between R and NB			
Cultivar	**Model**	**R^2**	***p* valor**
Criollo	R = 1.053 × NB + 14.508	0.0400	0.434
ICA Matoso	R = 1.296 × NB + 12.956	0.0430	0.456
Chino Rojo	R = 0.309 × NB + 10.680	0.0032	0.840

(Continue on next page)

(Continuation of table 3)

Relation between R and ANFNB			
Cultivar	**Model**	**R^2**	***p* valor**
Criollo	R = 0.156 × ANFNB + 13.617	0.0400	0.460
ICA Matoso	R = -0.011 × ANFNB + 15.124	0.0002	0.953
Chino Rojo	R = 0.481 × ANFNB + 4.904	0.2520	0.056*
Relation between R and AW1000S			
Cultivar	**Model**	**R^2**	***p* valor**
Criollo	R = 7.645 × AW1000S - 7.720	0.32	0.0350**
ICA Matoso	R = 46.581 × AW1000S - 130.334	0.906	< 0.0001***
Chino Rojo	R = 18.451 × AW1000S - 32.501	0.728	< 0.0001***

*** Significance less than 1 %; ** Significance less than 5 %; * Significance less than 10 %. FNS: fertile nodes per stem; CN: capsules per node; SF: seeds per fruit; AW1000S: average weight of one thousand seeds; NB: number of branches; ANFNB: average number of fertile nodes per branch; R: seed yield per plant.
Source: elaborated by the authors

Conclusions

In tropical dry forest conditions in the department of Sucre, sesame Criollo and ICA Matoso cultivars showed a better productive performance than Chino Rojo, with seed yields and oil contents showing averages of 1,242 kg/ha and 49 %, respectively.

Yield components as fertile nodes per stem, capsules per fertile node and weight of one thousand seeds showed a higher positive correlation in Criollo and ICA Matoso, which allowed a higher production.

In all cultivars assessed, sesame seed yield showed a linear association with average weight of one thousand seeds, and an average increase of 24 g in seed yield expected for each gram of increase in that average weight.

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