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# Effects of nitrogen fertilization and hydroretentor gel application in *Capsicum* spp. cultivation

**Lorena B. Carneiro[1], Rogério L. Silva Junior[1], Fábio J. Carvalho[1], Mariana V. Nascimento[1], Ricardo C. Xavier[1], Katiane S. S. Benett[1], Cleiton G. S. Benett[1,2*], Edilson Costa[3]**

**[1]Goiás State University (UEG), Rodovia GO 330, km 241, Anel Viário, Setor Universitário, 75780-000, Ipameri Campus, Goiás, Brasil**
**[2]Goiano Federal Institute (IF Goiano), Urutaí Campus, GO, Brazil**
**[3]Mato Grosso do Sul State University (UEMS), Cassilândia Unit, MS, Brazil**

***Corresponding author: cleiton.benett@gmail.com**

**Abstract**

Pepper cultivation is widely accepted by consumers and is responsible for supporting the establishment of family farming by providing employment for manpower. This study aimed to investigate the effects of nitrogen fertilization and hydroretentor gel application on the development and productivity of *Capsicum* sp. Each experiment applied a 2 x 5 factorial randomized block design, with and without the application of hydroretentor gel (factor A) with five N (factor B) doses (0; 50; 100; 150 and 200 kg $ha^{-1}$), and four replications. Analysis was made of the foliar nitrogen content, chlorophyll content, plant height, stem diameter, fruit length, fruit diameter, fruit number and weight, and productivity. The application of gel hidroretentor only influenced the culture of chilli pepper in the development and productivity. The nitrogen doses increased the productivity of yellow chilli and favored only the development of chilli pepper

**Keywords**: *Capsicum chinensis*; *Capsicum frutescens*; fertilization.

**Abbreviations:** N_nitrogen; SPAD_Soil-Plant Analysis Development.

## Introduction

Peppers (*Capsicum* spp.) are native to South America and belong to the Solanaceae family and Capsicum genus, which consists of approximately 25 species classified according to domestication level. In Brazil, the main species grown include Capsicum frutescens, Capsicum baccatum, Capsicum chinense, Capsicum praetermissum, and Capsicum annuum (Filgueira, 2012; Filgueira, 2003; Reiifschneider, 2000).

Pepper cultivation in Brazil has been increasing in recent years due to growing demand from domestic and foreign markets, and this has caused an expansion of the cultivated area in several Brazilian states, mainly on family farms. Reifschneider and Ribeiro (2008) explain that pepper cultivation is perfectly suited for family farming models and small-farmer agro-industry integration. Despite its recognized economic and social importance, pepper cultivation is poorly studied in Brazil at all phases of the production chain. The search for better quality, prices and costs has demanded greater technical and economic efficiency from producers in managing production systems (Rego et al., 2010). The fertilization programs applied are essential to enhance the crop productivity potential. Among the nutrients, nitrogen is the most required by peppers. Pepper cultivation responds well to nitrogen fertilizer, but this response is dependent on environmental conditions and cultivar types (Reiifschneider, 2000). Lara et al. (2008), while working with the yellow lantern chili, found that growth and productivity were affected by the application of nitrogen and that the accumulation of capsaicin, the starchy group responsible for the fruit's pungency, increased with the application of N.

In addition to proper management techniques such as fertilization programs, technology has also been applied to the production process to supply the demand for vegetables throughout the year. Vegetables require a considerable amount of water to grow, and a hydroretentor gel can ensure water supplies in regions with water shortages. For pepper trees, water deficiency, especially during the flowering and fruit-setting stages, reduces productivity due to falling flowers and fruit abortion (Reiifschneider, 2000). Hydroretentor gel is a polymer consisting of polyacrylamide-based particles of different sizes specific for each application condition. When immersed in water, it absorbs on average 200 to 400 times its weight, increasing in volume up to 100 times. When mixed into the substrate for seedlings in the planting hole, this solution has the capacity to provide water to the roots for a variable time, depending on weather conditions and soil and plant types (Garcia et al., 2011). The state of Goiás stands out in pepper production and consumption, and the culture's success can be largely credited to the management and production technology employed by the producers. In this regard, the use of a fertilization program coupled with hydroretentor gel application could significantly contribute to the success of the productive chain in the state of Goiás, as it would promote better plant development and consequently better fruit quality for both fresh produce consumption and industrial feedstock.

Thus, given the current expansion of the pepper market and the inclusion of this vegetable in human diets and other purposes, such as medicine, cosmetics, or ornaments as well as in a mixture with chocolate and pequi (typical Cerrado fruit) widely used in the Goiás, these studies become extremely important for successful cultivation, which will enable producers to achieve greater profitability and production quality.

The present study was designed to investigate the effect of nitrogen fertilization and hydroretentor gel application on the development and productivity of Capsicum sp.

**Results and Discussion**

***Pepper Iracema little-beak (Capsicum chinensis)***

Regarding the effect of the hydroretentor gel on the development of the yellow lantern chili, the average values for plant height, stem diameter, fruit diameter and length showed no significant differences with or without the gel application (Table 1).

The results for plant height obtained in this study diverged from those obtained by Domenico et al. (2012), who reported larger yellow lantern chili plants, with heights ranging from 1.13 to 0.85 m. Overall, although the hydroretentor gel did not have a significant effect on the pepper development, its application was seen to produce higher values in the evaluated characteristics, as shown in Table 1. These results corroborate those of Sayed et al. (1991), who evaluated the hydroretentor gel effect on the cultivation of many horticultural plants and observed a plant mass increase with the incorporation of the polymer, compared to the crop without polymer use. Vlach (1991) noted that the addition of hydroretentor gel to the soil enhanced the development of the plant shoot. When evaluating the effect of the N doses on plant height, stem diameter, fruit diameter and length, there was no interaction of fertilization with the assessed characteristics.

Table 2. presents the results of the fruit average quantity and weight, foliar nitrogen and chlorophyll contents, and productivity. The hydroretentor gel application had no significant effect on the fruit average quantity and weight. The number of fruit obtained in this study was higher than that obtained by Costa et al. (2008), which ranged from 30.0 to 67.8 fruit per plant$^{-1}$. However, the fruit weight obtained in this study was lower than that reported by Domenico et al. (2012), whose yellow lantern chili plants produced fruit weighing between 1.4 and 7.4 g.

The application of hydroretentor gel resulted in higher values for foliar N content, although they did not differ significantly from those of the plants grown without gel (Table 2). Regardless of the gel use, the levels obtained in this study were higher than appropriate – 35 g kg$^{-1}$, according to Moreira et al. (2010) – and similar to those obtained in the long pepper by Wadt et al. (2011) – 33 to 51 g kg$^{-1}$.

The chlorophyll content did not differ significantly with the gel use, ranging from 57-58 SPAD units, but the values were higher than those obtained with the Malagueta pepper by Pagliarini et al. (2012). The yellow lantern chili productivity received no significant effect from the hydroretentor gel application. Nonetheless, the treatment delivered 7.60% higher productivity compared to the plants grown without the gel (Table 2).

The nitrogen doses influenced the number of fruit per plant, and those values fit the quadratic regression with a maximum point at 180 kg ha$^{-1}$ N (Fig. 1A). These results corroborate those obtained by Chaves et al. (2006), who also reported data adjusting to the quadratic regression. According to Silva et al. (2001), nitrogen fertilization has a low influence on the nutrient content in green pepper leaves, but it significantly influences the nutrient accumulation at the end of the crop cycle after 34 weeks.

The foliar N concentration responded to the treatments with and without the hydroretentor gel according to the nitrogen doses (Fig. 1B). In both cases, the values fit the quadratic regression with maximum points at 135 and 164 kg ha$^{-1}$ N, respectively, with and without application. Cardoso et al. (2014), while evaluating the application of limestone doses on the yellow lantern chili found a linear increase in the foliar N content.

When considering the effect of the nitrogen doses on productivity, the values were found to fit the quadratic regression, with the maximum point estimated at 162 kg ha$^{-1}$ N (Fig. 1C).

***Malagueta pepper (Capsicum frutescens)***

The Malagueta pepper values for plant height, stem diameter, fruit diameter and fruit length are shown in Table 3. The application of the hydroretentor gel significantly influenced the plant height, stem and fruit diameter but did not show any effect on the other evaluations (Table 3). Cruz (2009) obtained Malagueta pepper fruit with diameter, length and weight similar to those found in this study. Evaluation of the nitrogen doses showed no significant effect on the analyzed variables. This may be related to plant genetic factors that cause the plant to fail to absorb available nutrients.

Table 4. presents the results on fruit number and weight, foliar N content, chlorophyll content and productivity. The evaluation showed that fruit number, foliar N concentration and productivity were significantly influenced by the hydroretentor gel application (Table 4).

The fruit number, foliar N content and productivity were found to increase by approximately 40%, 13% and 38%, respectively, with hydroretentor gel use compared to the treatment without gel application (Table 4).

The foliar N concentrations obtained in this study were higher than appropriate – 35 g kg$^{-1}$, according to Moreira et al. (2010) – and similar to those found by Pinto et al. (2012) in the Malagueta pepper. In turn, Silva et al. (2001), working with green peppers, obtained average foliar N contents, measured in newly-matured leaves in early flowering, of 54.3 g kg$^{-1}$. The authors reported that N doses up to 270 kg ha$^{-1}$, corresponding to 26.6 g m$^{-2}$, in green pepper crops were responsible for the increase in the amount of nutrients in the leaves and shoots at the end of the cycle. These results confirm the influence of the hydroretentor gel on the Malagueta pepper crops, by providing the treated plants with a larger volume of available water and thereby influencing their growth and productivity.

Evaluation of the nitrogen levels showed no significant effect on any of the variables. Chaves et al. (2006) observed data fitting a positive linear regression for Capsicum frutescens productivity. The authors also reported that the increase in N in the soil may be important for culture productivity because the laminas are responsible for solar radiation interception and absorption, which enhance the plant's photosynthetic capacity. A significant effect was observed from the gel application and nitrogen doses on the number of fruit and the foliar N content (Fig. 2).

The hydroretentor gel application significantly influenced the number of fruit, with the data fitting the quadratic regression (Fig. 2A) at an estimated maximum value of 139 kg ha$^{-1}$ N,

**Table 1.** Average values of yellow lantern chili plant height, stem diameter, fruit diameter and fruit length with the use of hydroretentor gel. Ipameri, GO, Brazil, 2013.

| Treatments | Plant height | Stem diameter | Fruit diameter | Fruit length |
|---|---|---|---|---|
| | (cm) | -------- (mm) -------- | | (cm) |
| Gel | | | | |
| With | 50.06 a | 14.82 a | 13.97 a | 2.40 a |
| Without | 46.40 a | 15.74 a | 13.89 a | 2.38 a |
| CV (%) | 16.55 | 26.86 | 4.92 | 3.86 |

Averages followed by the same letter in the column do not differ by Tukey test at 5% probability. CV (%): coefficient of variation.

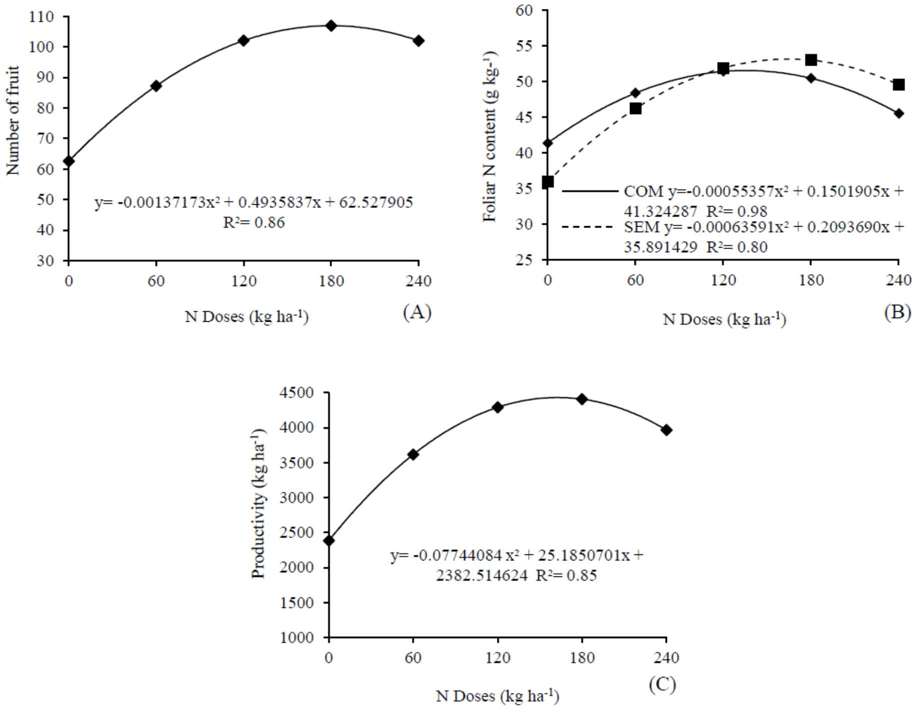


**Fig 1.** Number of fruit per plant depending on nitrogen levels (A), development of the interaction between the hydroretentor gel application and the nitrogen levels with the foliar N concentration (B) and productivity (C) in yellow lantern chili cultivation. Ipameri, GO, Brazil, 2013.

whereas without the gel application, there was a positive linear increase in the fruit number. The evaluation of the foliar N content with and without the application of the hydroretentor gel showed data fitting the quadratic regression with maximum points estimated at 176 and 95 kg ha$^{-1}$ N, respectively (Fig. 2B). According to Chaves et al. (2006), even though N is an essential element for the development and production of plants, there is no consensus regarding the optimal dosage of nitrogen fertilization to obtain maximum productivity in pepper crops. Apparently, the response of pepper trees to different doses of N depends on the cultivar type and on the environmental conditions. Benett et al. (2015) working with the culture of Arugula found influence the application of hidroretentor gel in some variables analyzed.
Research on hydroretentor gel application in oleraceous plants is scarce, making it important to conduct more studies on this polymer to prove the product's efficiency, both on the plant and on the environment.

## Materials and Methods

### *Location and installation of the experiments*

The experiments were conducted in the experimental area of Goiás State University (UEG), Ipameri Campus, located in the municipality of Ipameri, GO (17°43'S and 48°22'W, 800 m altitude). The soil in the area was classified as Distro ferric Oxisol (Embrapa, 2006). Analysis of the soil in the experimental area showed the following chemical composition: pH ($CaCl_2$) = 5.4; H + Al= 29 mmol$_c$ dm$^{-3}$; Ca= 19 mmol$_c$ dm$^{-3}$; Mg= 13 mmol$_c$ dm$^{-3}$; P (resin)= 20 mg dm$^{-3}$; K = 3.2 mmol$_c$ dm$^{-3}$; Organic matter = 26 g dm$^{-3}$; CTC = 64.2 mmol$_c$ dm$^{-3}$; V% = 55; Cu= 1.0 mg dm$^{-3}$, Fe= 57 mg dm$^{-3}$, Mn = 2.9 mg dm$^{-3}$, Zn = 0.3 mg dm$^{-3}$, and B= 0.15 mg dm$^{-3}$. The experiments were conducted using the yellow lantern chili, Iracema, little-beak pepper (*Capsicum chinensis*) and Malagueta pepper (*Capsicum frutescens*).Each experiment applied a 2 x 5 factorial randomized block design, with and without application of hydroretentor gel (300 ml per hole [4 g L$^{-1}$]) and five N doses (0, 50, 100, 150 and 200 kg ha$^{-1}$), using urea as the N source (45% N), with four replications. The treatments with N doses were divided into three equal-coverage applications 20, 40 and 60 days after transplantation. Before the experiment was set up, the experimental area was limed with 1200 kg ha$^{-1}$ limestone application to raise the base saturation to 70%. The parcels consisted of sixteen plants spaced 1.0 x 1.0 m apart, and only the four central plants were considered as the usable area. Seedling transplantation was performed manually into 20 x 20 x 20 cm pits. Maintenance fertilization was accomplished

**Table 2.** Average values of yellow lantern chili fruit number, fruit weight, foliar N concentration, chlorophyll content and productivity with hydroretentor gel application. Ipameri, GO, Brazil, 2013.

| Treatments | Fruit number | Fruit weight | Foliar N concentration | Chlorophyll content | Productivity |
|---|---|---|---|---|---|
| | ---- | (g) | (g kg$^{-1}$) | (SPAD) | (kg ha$^{-1}$) |
| Gel | | | | | |
| With | 94.82 a | 1.14 a | 47.39 | 58.66 a | 3868.89 a |
| Without | 89.43 a | 1.08 a | 47.28 | 57.17 a | 3595.10 a |
| CV (%) | 18.21 | 7.45 | 7.64 | 8.19 | 16.85 |

Averages followed by the same letter in the column do not differ by Tukey test at 5% probability. CV (%): coefficient of variation.

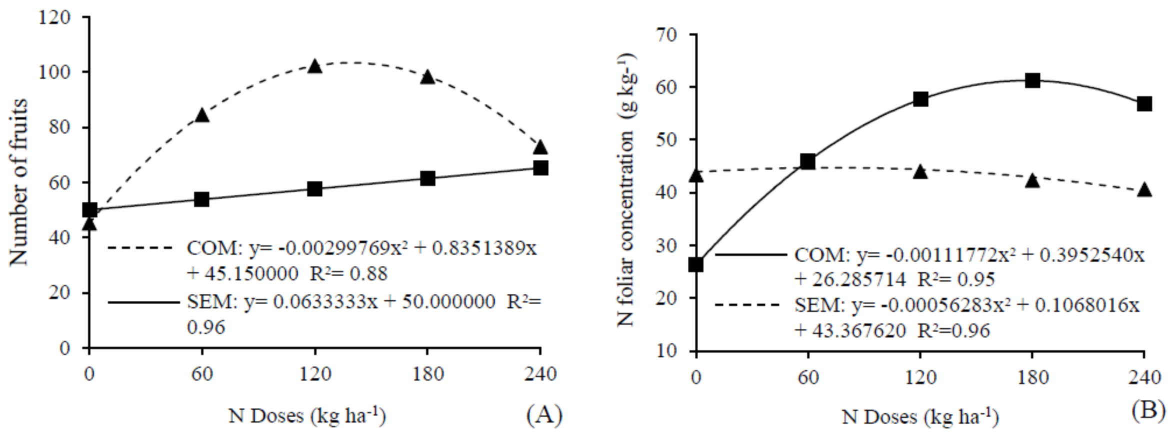


**Fig 2.** Effects of hydroretentor gel application and nitrogen doses on the number of fruit per plant (A) and foliar N concentration (B) in the Malagueta pepper crop. Ipameri, GO, Brazil, 2013.

**Table 3.** Average values for Malagueta pepper plant height, stem diameter, fruit diameter (FD) and fruit length (FL) with hydroretentor gel use. Ipameri, GO, Brazil, 2013.

| Treatments | Plant height | Stem diameter | Fruit diameter | Fruit length |
|---|---|---|---|---|
| | (cm) | -------- (mm) -------- | | (cm) |
| Gel | | | | |
| With | 51.04 a | 13.54 a | 5.39 a | 2.30 a |
| Without | 45.68 b | 11.63 b | 4.43 b | 2.17 a |
| CV (%) | 20.82 | 19.42 | 12.30 | 18.53 |

Averages followed by the same letter in the column do not differ by Tukey test at 5% probability. CV (%): coefficient of variation.

**Table 4.** Average values of Malagueta pepper fruit number, fruit weight, foliar N content, chlorophyll content and productivity with the use of hydroretentor gel. Ipameri, GO, Brazil, 2013.

| Treatments | Fruit number | Fruit weight | Foliar N content | Chlorophyll content | Productivity |
|---|---|---|---|---|---|
| | ---- | (g) | (g kg$^{-1}$) | (SPAD) | (kg ha$^{-1}$) |
| Gel | | | | | |
| With | 80.61 a | 0.29 a | 49.57 a | 52.15 a | 2797 a |
| Without | 57.60 b | 0.30 a | 44.02 b | 50.50 a | 2021 b |
| CV (%) | 12.08 | 21.75 | 1.80 | 9.85 | 23.28 |

Averages followed by the same letter in the column do not differ by Tukey test at 5% probability. CV (%): coefficient of variation.

before planting, using 400 kg ha$^{-1}$ of 05-25-15 formula.The seedlings were purchased from a commercial nursery in the city of Uberlandia, Minas Gerais state, and were produced in an agricultural nursery covered with 50% shade monofilament screen, using 128-cell Styrofoam trays with organic-mineral substrate, irrigated daily. The yellow lantern chili and Malagueta pepper seedlings were transplanted 30 days after sowing, when they had approximately four definitive leaves. The water supply was provided through dripping irrigation, with drippers spaced 0.30 m apart. The irrigation was used to maintain soil moisture close to field capacity. The gel application was performed during transplantation. The gel was laid in the pit bottom, and then a layer of soil was placed over it to receive the transplanted seedlings. The same procedure was performed in each hole.

Weeding was accomplished weekly to prevent competition from weeds, and applications of cupric insecticides, fungicides and bactericides for pest and disease control were made when necessary.

***Evaluated characteristics***

The foliar nitrogen content, chlorophyll content and culture productivity factors were evaluated. The foliar N content was measured through the Kjeldahl method by collecting the leaf blades of 20 fully expanded young leaves at the beginning of flowering. The plant material was dried in a forced-air oven at 65°C for approximately 72 h. After drying, the plant material was weighed and ground in a Wiley Mill equipped with a 1-mm mesh sieve and packed into sachets for laboratory analysis, following the methods described by Malavolta et al. (1997).

Indirect chlorophyll measurement was performed using a SPAD Model 502 chlorophyll meter Soil-Plant Analysis Development (SPAD) Section, Minolta Camera Co., Ltd, Japan], which indirectly determines the chlorophyll concentration in the leaves by measuring the green reflectance wavelength at approximately 650 nm (Abreu and Monteiro, 1999). The readings were performed on the middle part of the leaves 30, 60 and 90 days after transplant.

For the productivity components, the following characteristics were evaluated: plant height (cm), stem diameter (mm), fruit length (cm), fruit diameter (mm), fruit number and average weight (g), and yield (kg $ha^{-1}$). Harvest was performed weekly and individually per experimental unit, harvesting all the ripe fruit from the plot's usable area.

### *Statistical analysis*

The data on gel application were submitted to variance analysis (F test at 5% probability), and the data on the N doses were submitted to regression analysis. The statistical analysis was processed using the Sanest program.

## Conclusion

The application of gel hidroretentor only influenced the culture of chilli pepper in the development and productivity. The nitrogen doses increased the productivity of yellow chilli and favored only the development of chilli pepper.

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