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# Physiology and growth of the watermelon grown under nitrogen, phosphorus and potassium rates via mineral and organic fertilizer

# Fisiologia e crescimento da melancieira cultivada sob doses de nitrogênio, fósforo e potássio via adubo mineral e orgânico

# Fisiología y crecimiento de la sandía cultivada mediante dosis de nitrógeno, fósforo y potasio a través de fertilizantes minerales y orgánicos

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**Abstract**

The aim of this study was to evaluate the physiological and growth responses of watermelon under application of NPK rates using different proportions of mineral and organic fertilizers. The experiment was taken place in an area located at the Federal University of Campina Grande (UFCG), Campus Pombal - PB (6º48'16" S and 37º49'15" W), during the period from June to September 2013. The treatments consisted of three nutrient concentrations of N, P and K (50, 100 and 150% of NPK recommendation for watermelon) and five proportions of mineral and organic fertilizer (100/0, 75/25, 50/50, 25/75 to 0/100). The design was a randomized block in factorial scheme 3 x 5, with four replications. The amount of 100 % was the corresponding NPK 120 kg $ha^{-1}$, respectively, for N, P and K. They were evaluated: gas exchange, leaf dry matter, stem, fruit and leaf area. The concentration of 150 % of the recommended NPK to the culture of watermelon was the most effective in increasing the physiological characteristics and dry matter accumulation in stem, leaf, fruit, and leaf area. The combined application of mineral and organic fertilizer provides equivalent photosynthetic rate isolated application of mineral fertilizer with an 50/50 ratio the most effective for this variable. The proportions 75/25 and 50/50 were the most efficient in dry matter accumulation in watermelon.

**Keywords:** *Citrullus lanatus*; Gas exchanges; Manure; Phytomass; Growth.

**Resumo**

O objetivo do trabalho foi avaliar as respostas fisiológicas e de crescimento da melancieira sob aplicação de doses de NPK, utilizando diferentes proporções de adubos minerais e orgânicos. O experimento foi realizado em área localizada na Universidade Federal de Campina Grande (UFCG), Campus Pombal – PB (6º48’16’’S e 37º49’15’’ W), durante o período de junho a setembro de 2013. Os tratamentos foram constituídos de três concentrações dos nutrientes N, P e K (50, 100 e 150 % da recomendação de NPK para melancieira) e cinco proporções de adubo mineral e orgânico (100/0, 75/25, 50/50, 25/75 e 0/100). O delineamento foi em blocos casualizados, no esquema fatorial 3 x 5, com quatro repetições. A quantidade de NPK correspondente a 100% foi de 120 kg $ha^{-1}$. Foram avaliadas: as trocas gasosas, a matéria seca das folhas, do caule, e dos frutos, e a área foliar. A concentração de 150% da recomendação de NPK para a cultura da melancieira foi a mais eficiente no incremento das características fisiológicas e no acúmulo de matéria seca do caule, da folha, e do fruto, e na área foliar. A aplicação combinada de fertilizante mineral e orgânico proporciona taxa fotossintética equivalente à aplicação isolada de fertilizante mineral, sendo a proporção 50/50 a mais eficiente para essa variável. As proporções 75/25 e 50/50 foram as mais eficientes no acúmulo de massa seca na melancieira.

**Palavras-chave:** *Citrullus lanatus*; Trocas gasosas; Esterco; Fitomassa; Crescimento.

**Resumen**

El objetivo del trabajo fue evaluar las respuestas fisiológicas y de crecimiento de la sandía mediante la aplicación de dosis de NPK, utilizando diferentes proporciones de fertilizantes minerales y orgánicos. El experimento se realizó en un área ubicada en la Universidad Federal de Campina Grande (UFCG), Campus Pombal - PB (6º48'16"S y 37º49'15 " O), de junio a septiembre de 2013. Los tratamientos fueron compuesto por tres concentraciones de nutrientes N, P y K (50, 100 y 150% de la recomendación NPK para sandías) y cinco proporciones de fertilizante mineral y orgánico (100/0, 75/25, 50/50, 25/75 y 0/100). El diseño fue en bloques al azar, en un esquema factorial de 3 x 5, con cuatro repeticiones. La cantidad de NPK correspondiente al 100% fue de 120 kg ha-1. Se evaluaron: intercambio gaseoso, materia seca de hojas, tallo y frutos y área foliar. La concentración de 150% de la recomendación NPK para el cultivo de la sandía fue la más eficiente para incrementar las características fisiológicas y en la acumulación de materia seca del tallo, hoja y fruto, y en el área foliar. La aplicación combinada de fertilizante mineral y orgánico proporciona una tasa fotosintética equivalente a la aplicación aislada de fertilizante mineral, siendo la relación 50/50 la más eficiente para esta variable. Las proporciones 75/25 y 50/50 fueron las más eficientes en la acumulación de masa seca en la sandía.

**Palabras clave:** *Citrullus lanatus*; Intercambio de gases; Estiércol; Fitomasa; Crecimiento.

## 1. Introduction

Fertilization is among the cultural practices that contribute most to the growth and development of crops, however, it is necessary to know about the dynamics of these materials in the soil and in the development of the plant, in order to ensure that the applied nutrients can perform their specific functions in its most diverse operating sites.

In the culture of watermelon (*Citrullus lanatus*), mineral nutrition is a relevant factor that directly influences physiological and growth parameters. Nitrogen, phosphorus and potassium are the most applied nutrients in fertilizers, and must be supplied according to the requirements of each cultivar, technological level, soil fertility, expected production, growth stage and climatic conditions (Silva et al., 2013).

Among the representative characteristics that can be used in the study of cultivated plants, the growth analysis is an important and indispensable method in the evaluation of the behavioral differences of these plants, since it is influenced by agronomic practices and intrinsic factors associated with plant physiology (Costa et al., 2006).

Plant growth follows the dynamics of photosynthetic production and its analysis is vitally important to understand the plant's morphological and physiological processes and their influence on yield (Higaki et al., 1992). When measuring plant growth changes, the accumulation of dry matter is the most significant parameter, since it results from the association of several other components (Peixoto et al., 2006).

The isolated application of industrialized mineral fertilizers is a reality among farmers, whether small, medium or large producers. Several studies have been carried out in Brazil in order to observe the growth responses of vegetables under application of different sources and rates of fertilizers (Costa et al., 2013). Oliveira et al. (2009) when studying the influence of the application of increasing rates of N and K via mineral fertilizers and irrigation levels on the accumulation of dry matter in melon, they concluded that the increase in the rates of these macronutrients together with the increase in the irrigation levels increases the partition of dry matter of the vegetative part in detriment of the fruits dry matter.

Research on the combined use of organic and mineral fertilizers and their effects on short-cycle crops such as watermelons are scarce, but the synergistic effect between them is known (Higashikawa et al., 2010). It is observed that the few existing studies that deal with the use of organic and mineral fertilizers are based solely on the use alone or together of these materials, however, there are no studies that contemplate the use of these fertilizers in different proportions. and, in particular, that take into account the chemical and physical characteristics of organic fertilizers in order to quantify them more precisely, thus increasing the efficiency of their use, and allowing the farmer greater practicality and economy in the use of organomineral fertilization.

Given this scenario, the objective of the work was to evaluate the growth and physiological responses of the watermelon as a function of fertilization with increasing rates of NPK applied via organic and mineral fertilizer in different proportions.

## 2. Metodology

### Location, soil collection and climate

The experiment was installed from June to September 2013 in an area located at the Center for Science and Agri-Food Technology at the Federal University of Campina Grande (CCTA/UFCG), Campus of Pombal, Paraíba State (6º48'16" S and 37º49'15" W, altitude of 144 m). The climate according to the Köppen-Geiger classification is Aw', that is, hot and dry with summer autumn rains (semiarid). The soil was classified as Neossolo Flúvico (Santos et al., 2018).

The average temperature during the conduct of the experiment in the field was 26.0°C, with a maximum of 28.2°C and a minimum of 25.6°C, the daily relative humidity of the air was around 57.0%, the average rainfall was 52.1 mm, and the average Eto was 8.1 mm day$^{-1}$ (AESA, 2013).

Before the installation of the experiment, the soil was collected in the 0 - 20 cm layer, and later, chemical analyzes were performed according to methodologies proposed by Donagema et al. (2017). The chemical characteristics are described in Table 1.

**Table 1**. Chemical characteristics of the soil in the 0 - 20 cm depth layer of the experimental area.

| **pH** | **P** | **$K^+$** | **$Na^+$** | **$Ca^{2+}$** | **$Mg^{2+}$** | **$Al^{3+}$** | **$H^+$+$Al^{3+}$** | **SB** | **CTC** |
|---|---|---|---|---|---|---|---|---|---|
| | mg dm$^{-3}$ | ---------------------------------- cmol$_c$ dm$^{-3}$ ---------------------------------- | | | | | | | |
| 6,8 | 43,6 | 0,35 | 0,41 | 19,6 | 5,28 | 0,0 | 3,05 | 25,7 | 28,7 |

pH in water, in the soil:water ratio (1:2.5); P, K, Na: Mehlich-1 extractor; Al, Ca and Mg: 1 mol L$^{-1}$ KCl extractor; SB = $Ca^{+2}$ + $Mg^{+2}$ + $K^+$ + $Na^+$; H+$Al^{+3}$: 0.5 mol L$^{-1}$ calcium acetate extractor at pH 7.0; CTC = SB + H+$Al^{+3}$; M.O: Walkley-Black - wet digestion. Source: Authors.

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**Experimental design and conducting the experiment**

The treatments consisted of three percentages (50, 100 and 150%) of the rates of N, $P_2O_5$ and $K_2O$ recommended by Cavalcanti (2008) for watermelon, supplied via mineral and organic fertilizers, respectively, applied in different proportions (0/100, 75/25, 50/50 25/75 and 100/0). The 100% rate was based on the recommendation for the culture of the watermelon, taking as a parameter the chemical analysis of the soil, was 120 kg ha$^{-1}$ for N, $P_2O_5$ and $K_2O$. The experimental design used was in randomized blocks with the treatments distributed in the factorial scheme 3 x 5, with four replications.

The sources of mineral fertilizers used were monoammonium phosphate (MAP) (62% $P_2O_5$ and 12% N), urea (45% N) and potassium chloride (60% $K_2O$). The source of organic fertilizer used was dairy cattle manure, and the contents of nitrogen, phosphorus and potassium were determined by sulfuric digestion, with N determined in Kjedhal distiller, P by photocolorimetry using the "molybdenum blue" method, and K by flame photometry (Donagema et al., 2017) (Table 2).

**Table 2**. Chemical characteristics of dairy cattle manure.

| Dry matter | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| % | -------------------------------- | dag dm$^{-3}$ | -------------------------------- |
| 88 | 10,8 | 0,36 | 1,2 |

Source: Authors.

The amount of organic fertilizer referring to 100% of the NPK recommendation was defined as a function of the total N, P ($P_2O_5$) and K ($K_2O$) contents present in the dry matter of the material. From the values of 100%, quantities were calculated for the other percentages corresponding to the respective treatments.

For calculations regarding the amount of manure was used the expression proposed by Furtini Neto et al. (2001), in which, after calculating the amount of organic fertilizer as a function of the macronutrients N, P and K individually, the average was calculated, whose value was defined as 100% of the recommendation. The amounts of manure as a function of the macronutrient contents observed in this material were 5,263, 87,719 and 13,158 kg ha$^{-1}$ respectively, for the levels of N, P and K, whose average was 36,000 kg ha$^{-1}$.

After defining the amounts of organic fertilizer for each treatment, it was distributed in the planting line and incorporated into the soil in a single time, 15 days before transplanting, and then proceeded with the construction of ridges, whose dimensions were: 0.20 m high, 0.45 m wide and 6 m long. After the incorporation of manure, daily irrigation was started using drip tapes with spacing of 30 cm between emitters and flow rate of 1.7 L per hour.

Mineral fertilizers were applied via fertigation using the 'Venturi' fertilizer injector, split over the crop cycle. The phosphate fertilizer (MAP) was parceled out three times, with the first application being carried out one day before transplanting and the others in the following two weeks.

The remaining amount of N was divided into eight applications over the crop cycle using urea as source. Potassium applied via KCl was distributed in ten applications, 10% in foundation, 10% in the first two weeks (5% per week), 40% in the third to sixth week (10% per week), 30% in the seventh and eighth week (15% per week) and 10% in the ninth and tenth week (5% per week).

Irrigation management was performed based on estimation of daily reference evapotranspiration (ETo), which was obtained from climatic data from the semi-automatic climatological station installed on site. The daily irrigation levels was calculated in order to replace the crop evapotranspiration losses calculated for each stage of plant development. Soil preparation, other crop treatments and phytosanitary control were carried out according to the needs and recommendations for watermelon culture (Puiatti & Silva, 2005).

The seedlings were produced in polystyrene trays of 128 cells, using commercial substrate. The watermelon commercial hybrid 'Olímpia' seeds were used, one per cell. The trays were kept in a greenhouse where they were manually irrigated daily. The transplant was carried out when the seedlings had two well-formed final leaves that occurred 13 days after sowing. The watermelon seedlings were transplanted in the late afternoon, when the transpiration is less, followed by irrigation. The watermelon plants were conducted at a spacing of 2.0 x 0.60 m, with the area of each experimental unit consisting of a 6 m row containing ten plants where eight plants were considered useful.

**Analyzed variables**

The evaluations of the physiological characteristics were carried out at 45 days after transplantation (DAT), which correspond to approximately 80% of the vegetative growth. On this occasion, photosynthetic rate (A), stomatal conductance ($g_s$), transpiration (E) and intercellular $CO_2$ concentration (Ci) were determined, measured with infrared gas analyzer (IRGA) LCpro (Analytical Development, Kings Lynn, UK ) with a constant light source of

1,200 µmol of photons $m^{-2}$ $s^{-1}$. The readings were taken on the fourth leaf of the main branch, counted from the apex, of a plant of the useful area per plot.

Growth analyzes were performed at the end of the culture cycle at 68 DAT. First, we proceeded with the weighing of the fruits, which were collected fruits from six plants per plot. Of these, the most representative fruits, whose weight was the closest to the average of the plot and had no injuries or phytosanitary problems were chosen to remove the sample for drying. For the analysis of the vegetative part, two plants collected per experimental unit were used, cutting them close to the soil, at which time the total fresh matter of the leaves and stem were determined separately. Then samples of the leaves and stems fresh matter were weighed, and were packed in paper bags and taken to dry in an oven with air circulation at 70ºC, for 72 hours. From the dry matter of the samples, the dry matter per plant was calculated for stem, leaves and fruits.

The leaf area, in $cm^2$, was obtained using the disc method, which was determined from the ratio of the dry matter of eight leaf discs of known area with the dry matter of the leaves. The leaf area was calculated using the equation: LA = (LDM x ALD) / DMD, where LA is the estimated leaf area, LDM the total leaves dry matter, ALD the known area of the leaves discs, and DMD the dry matter of discs removed from the leaves.

### Statistical analysis

The data were subjected to analysis of variance, and the means compared by the Tukey test, at 5% probability. SAEG software, Version 9.1 was used.

## 3. Results and Discussion

### Physiological variables

There were isolated effects for the different proportions of mineral and organic fertilizer and the rates of NPK for photosynthesis (A), transpiration (E) and stomatal conductance ($g_s$) (Table 3). There was a significant interaction between the proportions of mineral and organic fertilizer and the concentrations of NPK only for intercellular $CO_2$ concentration (Ci) (Table 3).

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**Table 3**. Summary of the analysis of variance for the values of photosynthetic rate (A), transpiration (E), stomatal conductance (gs) and intercellular $CO_2$ content in watermelon leaves subjected to different proportions and concentrations of mineral and organic fertilizers.

| Variation source | DF | A | E | gs | Ci |
|---|---|---|---|---|---|
| Block | 3 | 1,02$^{ns}$ | 1,29$^{ns}$ | 0,03$^{ns}$ | 1,00$^{ns}$ |
| Proportion (P) | 4 | 2,88* | 3,34** | 1,98$^{ns}$ | 0,99$^{ns}$ |
| Concentration (C) | 2 | 3,51** | 2,32* | 3,14* | 9,32** |
| P x C | 8 | 1,48$^{ns}$ | 1,54$^{ns}$ | 1,98$^{ns}$ | 2,45* |
| CV*(%) | | 29,00 | 12,19 | 18,96 | 12,19 |

*: coefficient of variation; $^{ns}$: non-significant; * and **: significant at 5 and 1% by F-test. DF: degree of freedom. Source: Authors.

The highest photosynthetic rate (17.44 µmol $m^{-2}$ $s^{-1}$) was observed in the treatment where the highest fertilizer concentration was applied (150% of the recommendation for culture) (Figure 1A). Regarding the proportion of fertilizers, it was observed that when applied only mineral fertilizer, the photosynthetic rate was 17.82 µmol $m^{-2}$ $s^{-1}$, being higher than the treatment where only organic fertilizer was applied, whose observed value was 15.2 µmol $m^{-2}$ $s^{-1}$.

The fact that the $Cl^-$ ion is necessary for water molecule breaking reactions in photosynthesis, by which oxygen is produced (Clarke & Eaton Rye, 2000), can explain the higher photosynthetic rate of plants submitted to the highest concentration of nutrients applied via mineral fertilizers, since one of the sources used was KCl.

The use of organic sources increases the N content in the soil, however, its availability is due to mineralization (Eckhardt et al., 2016), which may not occur in sync with the development of culture. However, in the long term and with continuous use of organic fertilizers, the availability of nutrients can be greatly benefited and the immobilization problem reduced (Scotti et al., 2015).

Potassium is also characterized by being an activator of a large number of enzymes, being closely related to the processes of $CO_2$ and N assimilation, favoring the formation of nitrogen compounds (Malavolta & Crocomo, 1982), and in the synthesis, translocation and storage of sugars (Liesche, 2015). In the treatment in which equal proportions of organic and mineral fertilizers (50/50) were applied, the photosynthetic rate did not differ significantly from the treatment composed only of mineral fertilizers (Figure 1B).

There was no interaction between the study factors on transpiration in the watermelon leaves, however, there was a significant effect of the isolated factors. Regarding the concentration of nutrients, the highest transpiration (4.8 mmol $m^{-2}$ $s^{-1}$) was evidenced due to the higher concentration (150%), which differed significantly from the concentrations 50 and 100% whose transpiration values were, respectively, 4.42 and 4.19 mmol $m^{-2}$ $s^{-1}$ (Figure 1C). Transpiration follows the same trend as photosynthesis considering that $CO_2$ assimilation is linked to the loss of water from the plant to the environment (Andrade Junior et al., 2011). Regarding the proportions of fertilizers, it was shown that transpiration was significantly influenced by different treatments, where the proportions 100/0 and 50/50 provided the highest transpiratory rates (4.54 and 4.69 mmol $m^{-2}$ $s^{-1}$) and the lowest 75/25 ratio (4.06 mmol $m^{-2}$ $s^{-1}$) (Figure 1D).

Stomatal conductance was significantly influenced only by the nutrient concentration in which the highest conductance was observed as a function of the highest concentration (150% of the N, P and K recommendation) (Figures 1E and 1F). The increase in stomatal conductance provided by the 150% concentration in relation to the 100% concentration (recommended for watermelon culture) was 31.81%.

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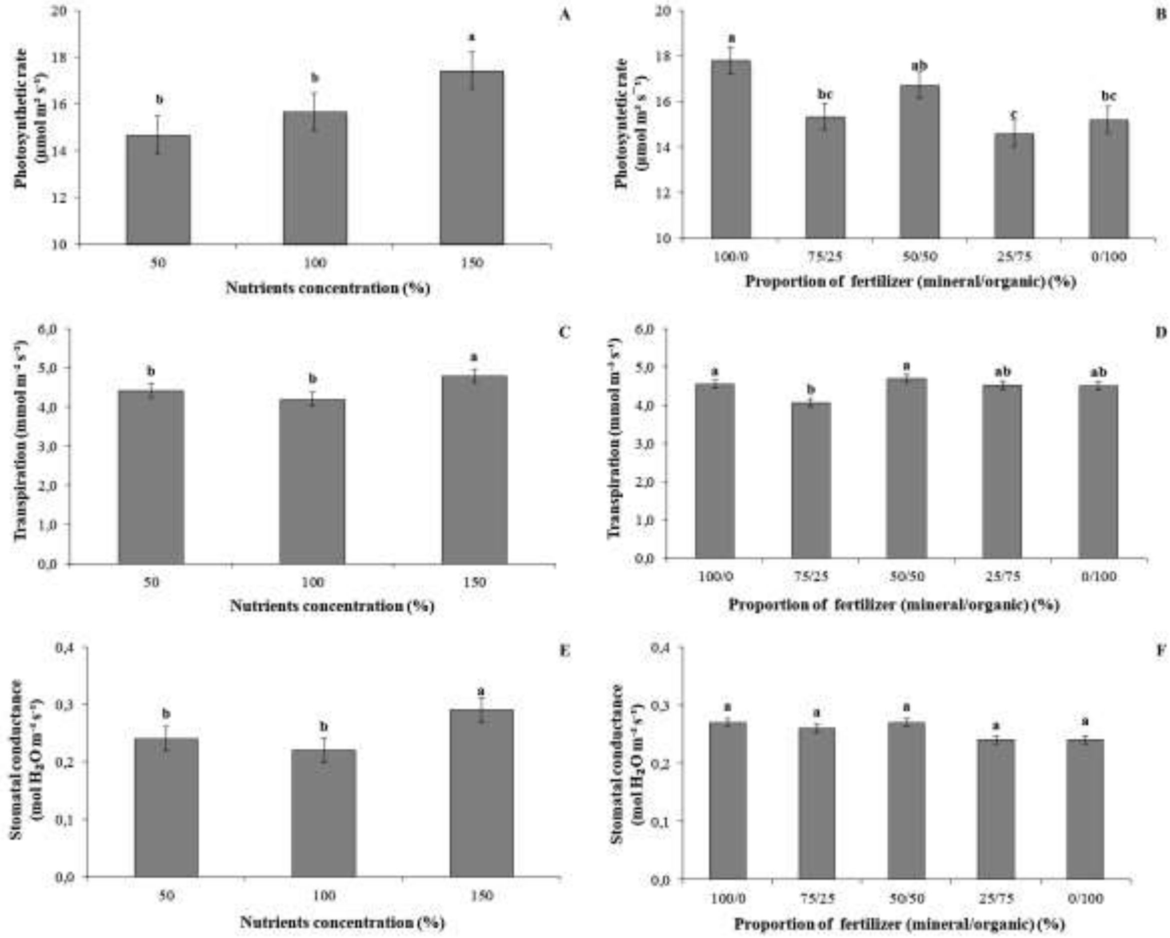
**Figure 1**. Photosynthetic rate (A e B), transpiration (C e D), stomatal conductance (E e F) on watermelon leaves as a function of different concentrations of nutrients applied via mineral and organic fertilization.



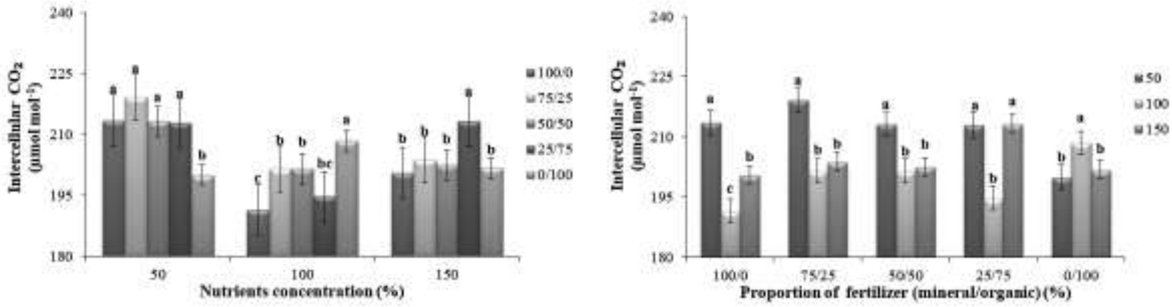

Source: Authors.

The higher stomatal conductance observed due to the higher concentration of nutrients may have a direct relationship, especially with greater availability of $K^+$ and $Cl^-$, since these ions are directly related to the opening of the stomata, in response to changes in the turgor of the guard cells (Kerbauy, 2008).

It was observed that photosynthesis and transpiration were higher in treatments that provided the highest stomatal conductance. According to Koyro et al. (2013), the photosynthetic rate is strongly correlated with stomatal conductance, transpiration and water use efficiency, which in turn are directly correlated with plant growth. These results reveal the possibility of a decrease in the use of mineral fertilizers when planting watermelon under the conditions in which the work was carried out.

For the intercellular $CO_2$ concentration (Ci), a significant interaction was observed between the two study factors, in which the lowest concentration of nutrients (50%) when applied in the proportions 100/0, 75/25, 50/50 and 25/75 (mineral/organic) favored the highest intercellular $CO_2$ concentrations. Although statistically similar to the others, the proportion 75/25 within the 50% concentration was the one that provided the highest intercellular $CO_2$ concentration (219.25 µmol $mol^{-1}$) and the proportion 0/100 the lowest (200 µmol $mol^{-1}$) (Figure 2).

**Figure 2.** Intercellular $CO_2$ concentration in watermelon leaves as a function of the different concentrations of nutrients applied via mineral and organic fertilization.




Source: Authors.

The high Ci values means that the $CO_2$ that is reaching the mesophyll cells is not being fixed in the carboxylative phase of photosynthesis, possibly due to damage to its structure. No relationship was observed between $g_s$ and Ci, reinforcing the idea that the highest Ci at the lowest concentration (50%) is related to the low assimilation of carbon in the carboxylative stage of photosynthesis.

The observed results can infer the reduced availability of nutrients provided by such treatments, a condition that directly reflects in the photosynthetic process both in the photochemical and in the carboxylative stage. Nutrients such as N, constituent of chlorophylls, P, constituent of molecules of ATP, NADPH, RuBP and Rubísco, and K, as an enzyme activator and osmoregulator, are indispensable in the photosynthetic process (Taiz & Zeiger, 2009).

**Production and growth variables**

There was an interaction between the factors nutrient concentration and fertilizer proportions for the variables leaves dry matter (LDM) and stem (STM) and individual effect of the nutrient concentration factor for fruits dry matter (FDM) (Table 4).

**Table 4**. Summary of the analysis of variance for the values leaves dry matter (LDM), stem dry matter (SDM), fruits dry matter (FDM) and leaf area (LA) in watermelon subjected to different proportions and concentrations of mineral and organic fertilizers.

| **Variation source** | **DF** | **LDM** | **SDM** | **FDM** | **LA** |
|---|---|---|---|---|---|
| Block | 3 | $0{,}48^{ns}$ | $0{,}93^{ns}$ | $0{,}73^{ns}$ | $0{,}48^{ns}$ |
| Proportion (P) | 4 | 6,27** | 7,85** | 1,31ns | 6,27** |
| Concentration (C) | 2 | 48,63** | 64,89** | 44,09** | 48,63** |
| P x C | 8 | 7,77** | 9,49** | $1{,}92^{ns}$ | 7,77** |
| CV*(%) | | 16,57 | 13,12 | 25,56 | 16,57 |

*: coefficient of variation; ns: non-significant; * and **: significant at 5 and 1% by F-test. DF: degree of freedom. Source: Authors.

The highest accumulation of LDM was observed due to the higher concentration of nutrients (150%) where the proportions 100/0, 75/25 and 50/50 were the ones that provided the largest dry matter accumulation of leaves (110.88, 129.60 e 127.67 g planta$^{-1}$, respectively) (Figure 3A e 3B).

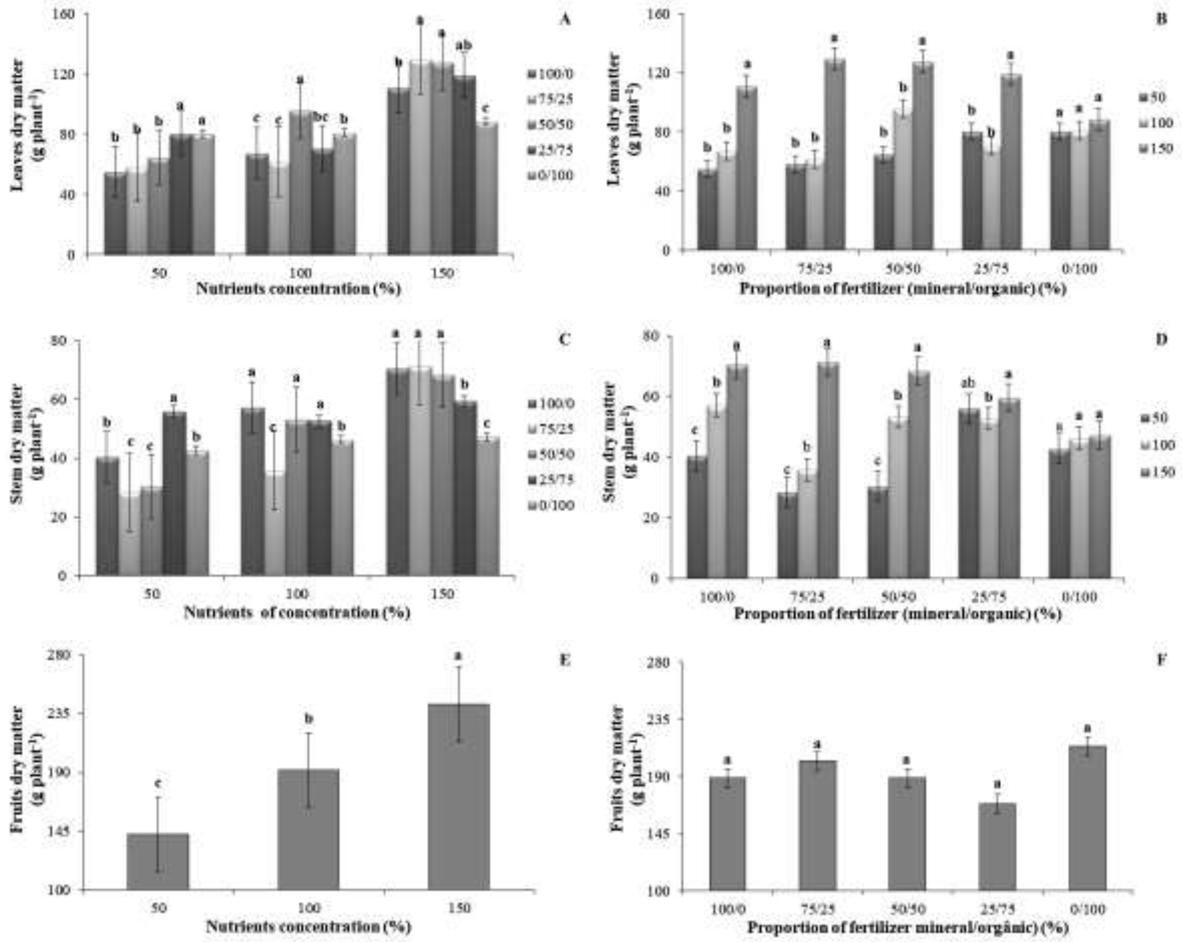
The SDM followed the same trend as LDM, where the largest accumulations of SDM were 71.36, 70.47, 68.26 g plant$^{-1}$, respectively for the proportions of 100/0, 75/25 and 50/50 within the concentration 150% (Figure 3C e 3D). It is observed that the accumulation of LDM was higher than SDM. Studies carried out with other cucurbits have found a certain similarity in the accumulation of matter in different genera. The decrease in mineral fertilization and the increase in organic fertilization did not affect the dry matter accumulation of leaves and stem up to a 50/50 ratio between the two sources.

For the proportions 25/75 and 0/100 the low dry matter observed can be attributed to the slow availability of nutrients from the organic fertilizer, which according to Rodrigues et al. (2008), depends on the degree of decomposition of the material used, which may have an immediate or residual effect. For Sampaio et al. (2007), manure seems to cause immobilization of soil nutrients in the first month after its incorporation and the release after that period occurs gradually reaching the highest amounts between three and six months after incorporation.

The FDM tended to be higher with increased concentrations of nutrients whose values observed were 142.5, 191.5 and 242.0 g plant$^{-1}$, respectively, for concentrations 50, 100 and 150% (N, P and K recommended for culture) (Figure 3E). The observed results reveal that the dry matter accumulation in fruits was superior to the vegetative part.

Similar results were observed by Grangeiro & Cecílio Filho (2005) in the 'Shadow' watermelon hybrid in which, of the total dry mass accumulated during the cycle, the vegetative part was responsible for 34.4% and the fruits for 65.6%. Regarding the proportions between organic and mineral fertilizers, no significant differences were observed, however the highest value was observed in the proportion 0/100 (mineral/organic) (Figure 3F).

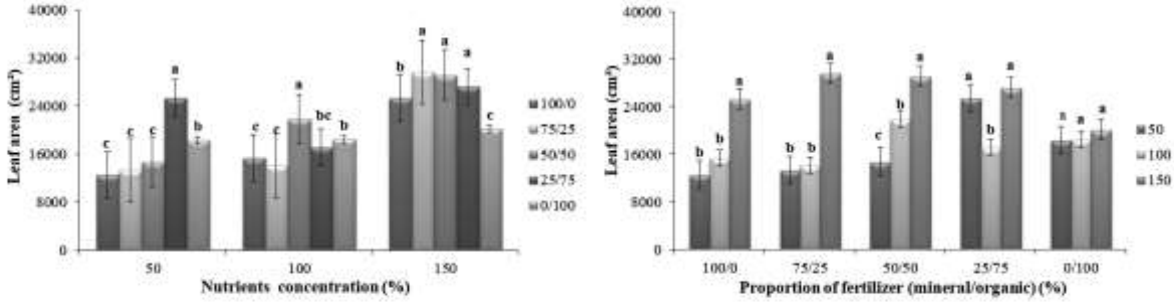
**Figure 3**. Leaves (A e B), stem (C e D), fruits (E e F) dry matter of watermelon as a function of different concentrations of nutrients applied via mineral and organic fertilization.




Source: Authors.

For leaf area (LA) a significant interaction was observed between the concentration of nutrients and the proportions of fertilizers (Figure 5). Within the proportions, the 150% concentration provided the largest leaf area in watermelon plants. The proportion 75/25 (mineral/organic) provided the largest leaf area (29,613.03 $cm^2$) and 0/100 the smallest area (20,183.12 $cm^2$).

**Figure 5**. Leaf area of the watermelon as a function of different concentrations of nutrients applied via mineral and organic fertilization.




Source: Authors.

In view of the results, it can be inferred that, for the conditions in which the experiment was carried out, the use of fertilizer recommendation used regionally may not be providing the watermelon culture to express its maximum genetic potential, highlighting the importance of regional studies in order to increase the efficiency of fertilizer practices. The proposed methodology, in the present work, to quantify the manure to be used in different proportions with mineral fertilizers, provided good results, showing that there is the possibility of adopting this practice at the local level.

## 4. Final Considerations

The 150% concentration of the NPK recommendation for the culture of the watermelon was the most efficient in increasing the physiological characteristics and in the accumulation of leaves, stem and fruits dry matter.

The 100% concentration of the NPK recommendation does not adequately supply the nutritional needs of the 'Olimpia' watermelon crop in the Sertão Paraibano.

A combined application of mineral fertilizer and nutrient offers a photosynthetic rate equivalent to isolated application of mineral fertilizer, with the 50/50 ratio being the most efficient for this variable.

The use of manure alone does not contribute to the increase of dry matter in the vegetative part, when compared to combined use with mineral fertilizers, with the proportions 75/25 and 50/50 being the most efficient in the accumulation of dry mass in the watermelon.

New studies with the use of different sources and rates of organic and mineral fertilizers may contribute to studies on the dynamics of nutrients in agroecosystems and suggestions for fertilization recommendations directed to the watermelon cropping in the edaphoclimatic conditions of this study.

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