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Effect of the dose and form of placement of the potassium about the physical quality of fruits of tomato (*Lycopersicon esculentun* Mill.) stored dos temperatures

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Abstract

The effect of three levels of potassium was studied; 0, 220 and 330 kg.ha^{-1}, placed in three different forms (central, lateral and in the bottom of the furrow) about the physical quality of tomato fruits stored at 10 ± 2ºC and at 15 ± 2ºC. For this reason, plants of tomato cv. "Río Grande" were sowed in the sector *Guarabal*, Municipality Federation of *Falcon* State, and physiologically mature fruits were harvested, which were identified and stored for 21 days under two temperatures, where every 7 days the color was evaluated using a spectrophotometer[1] Colorimeter, which was registered using the system CIE- L a* b*, where L indicates brightness, with values from zero (black) to a hundred (white), a * chromaticity of an axis of green (-) to red (+) and b * chromaticity in an axis of blue (-) to yellow (+), to determine the color predominance. The consistency was evaluated with a Twing Albert. A design was used totally at random with factorial arrangement and three repetitions. Under both conditions of temperature, the averages of L were smaller as storage days passed (DAA) indicating the presence of darker colors. In 330-lateral treatment at 15ºC was found the biggest proportion of red color evaluated as value a*, as well value b*, indicated the smallest proportion of yellow tones. The lowest storage temperature held back the appearance of red colors, characteristic of the maturation of the tomato fruit. The fruits stored at 15ºC presented lower consistency in relation to those stored at 10ºC. The treatments did not influence the consistency but the temperature.

Key words: tomato, potassium, color, physical quality

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Introduction

External color and firmness are, among others, the most important characteristics for quality in tomato fruits, perceived by consumers as maturity indicators (14). Potassium is the most important nutrient in relation to quality and flavor of the fruit; it is required excessively to obtain a good maturation and consistence (1). In this sense, Anac *et al.* (4) revealed that the traditional application of 320 kg.ha^{-1} of K_2O and K_2O foliar applications have a significant effect over parameters of quality of fruits, such as, total soluble solids, good color and a pH near 4.2.

Production and quality of tomato are very influenced by the nutritional state of soils; on the other side, quality of fruits is extremely related to the available level of potassium. Adams and Grimmett (2), testing six concentrations of potassium in recycling nutritive solutions in hydroponic crops, found that the number of fruits tended to increase with the level of potassium, likewise, noticed that the production of empty fruits decreased with the augmentation of K in the solution and eventually those mature fruits at lower concentrations of K were softer than those at higher levels, the reason is mainly the loss of quality in the wall of the tissue. As well, it is being observed that using the fertilizer in a high place with permanent availability of water and an abundant formation of roots, potassium movements to the roots are guaranteed and its absorption in an active way, improving the efficiency in relative outputs (15. 16).

The objective of this research is to evaluate the dose and way to apply potassium over physical quality of tomato fruits, storage at two temperatures.

Materials and methods

Preharvest Management

The experiment took place in the farm Santa Bárbara, located in sector *Guarabal*, Independence Parish, 13 km to the west of *Curuguara*, capital of Federation Municipality in Falcon State, 10° 47' N latitude, 69° 32' W longitude and 685 msnm altitude. The average annual precipitation is between 250 and 550 mm and the temperature is around 28°C, whose absolute maximum is 32°C and the absolute minimum is 18°C. Evapotranspiration overpass 2000 mm.year^{-1} (5).

As vegetal material, the hybrid "Río Grande" was used. It was sowed in seed boxes and transplanted in 35 days, to a distance of 1.20 m between furrow and 0.30 m between plants, for density of 27.000 plants.hectare^{-1}. 150 kg.ha^{-1} of ammonium nitrate were applied fragmented in 3 parts; 80 kg.ha^{-1} of P (phospower), at the moment of the transplant and the potassium at indicated dose (treatments). Irrigation by furrows was utilized, daily in the mornings, the eight first days after the transplant and subsequently every three days.

Potassium chloride (KC1) was used as K source, being the treatments:

Number	Dose ($kg.ha^{-1}$)	Location
1	220	Central
2	220	Lateral
3	220	bottom of the furrow
4	330	Central
5	330	Lateral
6	330	bottom of the furrow
7	0	Control Plot

Fertilizer was poured manually, for which was necessary to open over the ridge a 10 cm wide and 15 cm deep zone (in both endings sticks were put), then the fertilizer was applied and the ridge set to its original form. Consequently, the transplant was carried out, taking as a guide the sticks that showed where the fertilizer was. In the same way, the potassium was poured next to the plant. While for the other position, the 70% of KC1 was poured in the moment of the transplant into the bottom of the furrow, applying the rest along with irrigation.

Postharvest management

Fruits were chosen in a physiologically mature state, uniform size, harvested 92 days after the transplant (DAA). These fruits were transplanted in boxes (cap. 14 kg); to avoid warming-up the tomatoes, wet cardboard was used to isolate the floor of the vehicle, then the box was covered with a plastic sheet. Transplant was after 5 p.m., fruits were storage at 15°C in the postharvest lab of the UCLA until next morning.

Samples were divided into two groups, which were storaged at different temperatures: 10 and 15±2°C for 21 days. Variables color and consistence were evaluated every seven days.

Evaluation of Fruit Color: A sample of three fruits was taken and identified in each repetition, per treatment, for a total of nine fruits per treatment. For this, a spectrophotometer miniscan model MS/S-4500L from Hunter Lab. Company was used. Color was registered with the system CIE-L a* b*, where L indicates brightness, with values from zero (black) to a hundred (white), a * chromaticity of an axis of green (-) to red (+) and b * chromaticity in an axis of blue (-) to yellow (+). The color was measured putting the equatorial zone of tomatoes over the sensor. The instrument was calibrated with a white porcelain plaque; besides a standard pale green color was chosen from a representative tomato, which represented the following values: L*=6.30, a*=-16.90, b*=6.90. These values were measured during the 0, 7, 14 and 21 days of storage (DAA).

Fruit Consistence: Consistence was evaluated over a sample of three fruits taken at random per treatment. The sampling was performed before and during storage every 7 days; for this a universal instrument, Twing Albert, was used to measure the resistance towards penetration, this reading was repeated at 90º and 180º turn. Results were expressed in Newtons.

Statistical Design and Results Analysis.

The design was chosen at total random, with factorial arrangement and three replications per initial treatment of fertility (7); two temperatures for a total of 42 experimental units, each one of them with 17±2 fruits. The differences were measured with Duncan's multiple range test (MRT) ($P<0.05$). The results were analyzed by the Statistical Analysis System (17).

Results and discussion

Table 1 shows the effect of potassium chloride and the form of placement over the component of brightness (L^*) of the fruits color, storage at 10 and 15 ± 2ºC. As seen, significant differences were not found for the fruits storage at 10 ± 2ºC ,during the first seven days (DAA) treatments kept the L* values, with the exception of the treatment 220 $kg.ha^{-1}$ bottom of the furrow, which moved from 70.93 to 57.30.

At 14 days after the anthesis, the average of all treatments decreased considerably oscillating between 1.74 and 5.89 (220 $kg.ha^{-1}$-lateral and the control plot, respectively). In this moment, the fruit might be in the changing phase, where a mixture of colors is evidenced, which can be perceived when comparing results with the registered after 21 days. During this period, the control plot and the treatment of 220 $kg.ha^{-1}$-central continued decreasing the values of L^*, nevertheless, the rest of treatments showed a slight increased, which augment with the dose of 330 $kg.ha^{-1}$ in the three collocations.

Under 15ºC, significant differences where found at 0 and 21 DAA. At 0 days, the highest value was 73.71 of the treatment of 330 $kg.ha^{-1}$ - lateral, and the lowest one was 70.69 of the control plot. At 7th day, the average of all treatments diminished, in some cases, the double of the initial value, having values between 65.63 and 35.60 for treatments of 330 $kg\ ha^{-1}$-bottom of the furrow and of 220 $kg.ha^{-1}$-central, respectively. This difference was even more important at day 14th, when the highest average was 9.09 for 330 $kg.ha^{-1}$-bottom of the furrow and the lowest was 3.55 for 220 $kg.ha^{-1}$-bottom of the furrow. At day 21, values continued changing, except for treatments of 220 $kg.ha^{-1}$-central and of 220 $kg.ha^{-1}$-bottom of the furrow.

It seems that potassium did not influence the behavior of this variable, since in most of the cases statistical differences were not found. Nevertheless, as the storage temperature was higher, it was observed a higher decrease of L* in the first DAA, indicating the presence of darker colors.

These results coincide with those found by Islam *et al.* (10), when he storaged tomato fruits in different sates of maturity and measured the

Table 1. Effect of the dose of potassium chloride and form of placement on soil, over the component of brightness (L*) of color in fruits of tomato, cultivar "Rio Grande", storage at 10 ± 2ºC y 15 ± 2ºC and evaluated at 0, 7, 14 and 21 days.

KCl (kg.ha^{-1}) and position	10 ± 2ºC				15 ± 2ºC			
	0	7	14	21	0	7	14	21
Control plot	70.88[a][1]	71.27[a]	5.89[a]	2.47[a]	70.69[c]	39.44[a]	6.00[a]	5.18[ab]
220-central	70.78[a]	72.18[a]	5.87[a]	3.04[a]	72.22[abc]	35.60[a]	4.89[a]	7.90[a]
220-lateral	70.80[a]	70.52[a]	1.74[a]	4.39[a]	71.05[bc]	38.02[a]	4.00[a]	1.71[a]
220-Bottom of the furrow	70.93[a]	57.30[a]	2.22[a]	3.30[a]	72.86[ab]	41.02[a]	3.55[a]	8.87[a]
330-central	71.14[a]	70.75[a]	3.41[a]	7.58[a]	71.67[abc]	70.97[a]	5.22[a]	3.97[ab]
330-lateral	71.48[a]	72.35[a]	2.08[a]	8.32[a]	73.61[a]	38.02[a]	4.14[a]	0.41[b]
330-Bottom of the furrow	70.93[a]	71.51[a]	5.45[a]	5.51[a]	71.74[abc]	65.63[a]	9.09[a]	0.70[b]
(P<0.05)	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	*

Average of 5 evaluations.

[1]Values among columns followed by different fonts, are statistically different (P<0.05) according to Duncan's Multiple Range Test.

L* values of color under conditions with high concentrations of CO_2.

The value of color L* diminishes as maturity progresses (10); which matches with Shewfelt y Halpin reports (20), who found that this value is reduced when storage temperature increases.

Results of value a* are shown in table 2. At a initial temperature of 10ºC, negative values of a* were registered, which is associated to color green (22, 13), significant differences were only found at 7 DAA, where the lowest value was found in treatment of 330 $kg.ha^{-1}$-lateral with -4, 57 and the highest was for 220 $kg.ha^{-1}$-bottom of the furrow with 0,89. In a general view, all treatments augmented their values progressively with the DAA. At the end of storage, treatments with higher values were for 220 $kg.ha^{-1}$-bottom of the furrow and 330 $kg.ha^{-1}$-central with 6,96 y 6,84, respectively, which indicate a higher proportion of color red. On the contrary, the control plot showed a smaller value (1.44) indicating the predominance of color green.

At 14 days of storage, it was noticed that color green changed to red, but treatment of 330-lateral, kept its green coloration (-); the lowest value was obtained in treatment of 330 $kg.ha^{-1}$-bottom of the furrow, whereas the highest was showed by treatment of 220-bottom of the furrow. At 21 days, all values of a* were positive, which evidenced a predominant color red; the highest value was observed in treatment of 220 $kg.ha^{-1}$-bottom of the furrow, followed by the one of 330-central; lowest values were reported for control plot and the 220-central.

In the same way, at 15ºC values of all treatments augmented progressively, reaching values considerably higher than in storage fruits at 10°C. Under this storage condition, differences were found at 7, 14 and 21 days. At the beginning, predominated color green in the fruit (-a), having the highest values treatments of 220 $kg.ha^{-1}$-central, of 220 $kg.ha^{-1}$-lateral, whereas, the lowest corresponded to treatments of 330 $kg.ha^{-1}$-bottom of the furrow and of 220 $kg.ha^{-1}$-bottom of the furrow. At day 7th, the change from green (-) to red (+) was evidenced, but in treatment of control plot and with the 220 kg ha^{-1} -bottom of the furrow, that registered the lowest value with -0.01 and -3.69, respectively. On the other hand, the highest value was reached in treatment of 330 $kg.ha^{-1}$-lateral and of 220 $kg.ha^{-1}$ -lateral (5.89 y 5.14, respectively).

At day 14th was evident the presence of color red. The control plot registered the highest value with 31.89, followed by the treatment of 220 $kg.ha^{-1}$ -bottom of the furrow with 29.15; at the same time, the lowest value was obtained from the treatment of 330 $kg.ha^{-1}$-lateral (20.26). At 21 days, a diminished was observed in values of a*. This might be associated with the influence of storage temperature, since it is known that highest temperatures promote orange tones, value b* is higher, showing as result this coloration, instead of darker reds.

About this, Shewfelt *et al.* quoted by Tijskins y Evelo (19), pointed out that under normal temperatures, between 12 and 25ºC,

Table 2. Effect of the dose of potassium chloride and form of placement on soil, over a* values of tomato fruits color, cultivar "Rio Grande", storage at 10 ± 2 ºC y 15 ± 2ºC and evaluated at 0, 7, 14 and 21 days.

KCl ($kg.ha^{-1}$) and position	10 ± 2ºC				15 ± 2ºC			
	0	7	14	21	0	7	14	21
Control plot	-5.34[a1]	-1.57[ab]	1.60[a]	1.44[a]	-5.23[a]	-0.01[ab]	31.89[a]	16.20[ab]
220-central	-6.51[a]	-4.24[ab]	1.07[a]	2.61[a]	-6.20[a]	3.20[ab]	25.46[ab]	15.99[ab]
220-lateral	-5.62[a]	-4.71[b]	0.10[a]	4.95[a]	-5.79[a]	5.14[a]	28.03[a]	16.77[ab]
220-Bottom of the furrow	-6.21[a]	0.89[a]	1.73[a]	6.96[a]	-4.98[a]	-3.69[b]	29.15[a]	18.91[a]
330-central	-5.69[a]	-4.56[ab]	1.16[a]	6.84[a]	-5.03[a]	1.58[ab]	26.77[a]	14.76[b]
330-lateral	-6.13[a]	-4.57[ab]	-2.12[a]	5.72[a]	-5.76[a]	5.89[a]	20.26[a]	19.07[a]
330-Bottom of the furrow	-5.85[a]	-4.29[ab]	0.05[a]	4.54[a]	-4.17[a]	1.21[ab]	27.73[ab]	17.40[ab]
($P<0.05$)	n.s.	*	n.s.	n.s.	n.s.	*	*	*

Average of 5 evaluations.
[1] Values among columns followed by different fonts, are statistically different ($P<0.05$) according to Duncan's Multiple Range Test.

the chlorophyll is degraded and lycopene and b-carotene is formed, resulting red tomatoes. On the contrary, at high temperatures chlorophyll disappears and b-carotenes are accumulated, but lycopene synthesis is inhibited resulting orange-yellowish fruits.

In the same order of ideas, Tijskins y Evelo (19), reported that to predict the change in the color of tomatoes, the a^* value is enough, although to discuss the yellowish phenomenon, value b^* must be included. Likewise, Türk *et al.* (20) reported that tomatoes of cv. "Sunny" storaged at 18°C for three weeks quickly decreased the content of chlorophyll and augmented the content of carotene and lycopene. Young *et al.* (24) found a high correlation between the development of lycopene pigment and the maturity of fruits, expressed in values of a^* in the Hunter scale, with gradual increases from negative values, passing through values near to zero, until positive values (red). Similarly, common red color of tomato, showed a high correlation between the lycopene content, the total content of carotenes and the a^* value of the color of the fruit (11).

Uexkult (21) concluded that potassium plays a really important role in the process of pigmentation of the fruit; the K augment the production of carotenoids, particularly lycopene and chlorophyll decreases.

Equally, Hartz *et al.* (9), found a relation between the low level of K in the fruit and the disorders in coloration; also, they observed a drop of 54% in the incidence of these disorders with the combined application of potassium and gypsum.

In relation to value b^*, table 3 shows that in all cases positive values were registered indicating yellow colors (13). No significant differences were found in any evaluation between the treatments that were storage at 10ºC. At 0 DAA, the highest values of b^* were reached in treatments of 220 $kg.ha^{-1}$-central and of 330 $kg.ha^{-1}$-bottom of the furrow, whereas the lowest ones were found in treatments of 220 kg ha^{-1}-lateral and of 330 $kg.ha^{-1}$-lateral. At 7 DAA, values diminished very slightly, but the treatment of 330 $kg.ha^{-1}$-lateral, which passed from 32.79 to 33.88. On the other hand, at 14 days, the values of b^* augmented, even some treatments overpassed the reached values from the beginning. According to Voss (22), fruits would be turning yellowish green.

On the contrary, at 21 DAA, only 330 $kg.ha^{-1}$-lateral and 330 $kg.ha^{-1}$-bottom of the furrow treatments augmented values of b^* (34.84 and 34.34, respectively) registering a decrease in the rest of the treatments, which obtained values between 19.46 and 33.73 for the 220 $kg.ha^{-1}$-central y 220 $kg.ha^{-1}$-bottom of the furrow, respectively.

For storage fruits at 15ºC, initial values were between 33.12 and 30.53 corresponding treatments of 330 $kg.ha^{-1}$-bottom of the furrow and of 220 $kg.ha^{-1}$-central, respectively. At 7 DAA, significant differences were found, being the highest value for the treatment of 330 $kg.ha^{-1}$-lateral with 34.36 and the lowest value for the treatment of 220 $kg.ha^{-1}$-bottom of the furrow with 31.00; the rest of the

Table 3. Effect of the dose of potassium chloride and form of placement on soil, over value b* of tomato fruits color, cv. "Rio Grande", storage at 10 ± 2ºC y 15 ± 2ºC and evaluated at 0, 7, 14 and 21 days.

KCl (kg.ha^{-1}) and position	10 ± 2ºC				15 ± 2ºC			
	0	7	14	21	0	7	14	21
Control plot	33.44[a1]	32.54[a]	33.85[a]	19.69[a]	31.51[a]	30.81[b]	17.77[a]	4.69[a]
220-central	34.26[a]	32.25[a]	34.22[a]	19.46[a]	30.53[a]	32.05[ab]	16.91[a]	5.46[a]
220-lateral	32.80[a]	32.39[a]	34.12[a]	34.58[a]	32.13[a]	31.00[b]	18.07[a]	1.78[a]
220-Bottom of the furrow	33.39[a]	33.35[a]	33.85[a]	22.73[a]	31.67[a]	33.57[ab]	17.73[a]	3.40[a]
330-central	32.79[a]	32.86[a]	34.25[a]	33.73[a]	32.59[a]	33.17[ab]	19.34[a]	3.15[a]
330-lateral	32.64[a]	33.88[a]	33.64[a]	34.84[a]	30.56[a]	34.36[a]	18.00[a]	1.65[a]
330-Bottom of the furrow	33.92[a]	32.38[a]	32.47[a]	34.34[a]	33.12[a]	32.98[ab]	17.89[a]	5.13[a]
(P<0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.

Average of 5 evaluations.
[1]Values among columns followed by different fonts, are statistically different (P<0.05) according to Duncan's Multiple Range Test.

treatments showed intermediate values. At 14 days, a remarkable difference was noticed, which showed a decrease of yellow color, having values between16.91 and 19.34 of treatments of 220 kg.ha^{-1}-central and 330 kg.ha^{-1}-central, respectively. This decrease in values continued until the 21st day, where the highest value was for treatment of 220 kg.ha^{-1}-central with 5.46 and the lowest value for the one of 330 kg.ha^{-1}-lateral with 1.65. Likewise, Shewfelt y Halpin (18) studied the effect of Light quality over the color of fruits storage at 4 ± 2ºC and 22 ± 2ºC and found out that color of fruits in state of physiological maturation was influenced by the quality of light to which they were exposed.

In general, the proportion of red color was higher at 15°C, where treatments of 220 and 330-lateral, had the highest values for a^*/b^* with 9,4.2 and 11.56, respectively and 220-central had the lowest value with 2.93 (non shown data). In this sense, it can be said that this treatment was more effective promoting color of the fruit, considering that the lowest temperatures of storage hold back the time of maturation of fruits. On the other hand, Villareal *et al.* (23), establishing optimal relations of N-NH4 and N-NO3 associated to K and Ca by crop growing development stages of a specific hybrid tomato and its influence in profiting and quality of the fruit, did not find a direct relation between intensity of color and dose of K, N-NH4, even when they point out that other researches have found a positive effect in the application of K for the external red color of fruits.

As well, Bugarin-Montoya *et al.* (6) determined the influence of potassic nutrition in hydropony over the profit and quality of tomato fruits; they pointed out that color of fruits determined by the relation between values of a^*/b^* was similar, oscillating from 1.30 to 1.42 in higher an lower dose (9 and 3 meq L^{-1}, respectively. Small values, compared to the ones found in this research, which oscillated between 2.93 and 11.56 (non shown data).

Effect of chloride potassium and collocation form over the consistence of fruits is shown in table 4, at 10 ± 2ºC significant differences were not found in any evaluation. At the beginning the highest value was found in treatment of 220 kg.ha^{-1}-lateral with 31.04 N and the lowest values in treatments of 330 kg.ha^{-1}-bottom of the furrow and of 330 kg.ha^{-1}-lateral with 28.89 and 28.51 N, respectively. At 7 DAA, treatments of 220 kg.ha^{-1}-central y 220 kg.ha^{-1}-lateral, diminished their values compared to the ones in the previous evaluation, whereas the other treatments registered a slight increase. Nevertheless, it can be highlighted that this is a destructive test, which can not be carried out over the same fruit, besides the low temperatures hold back the maturation of fruits.

At 14 DAA, the average of all treatments diminished, having values between 19.57 and 24.67 N, for treatments of 330 kg.ha^{-1}-bottom of the furrow and 220 kg.ha^{-1}-central, respectively. This tendency was observed in most of cases, at 21 DAA, with values between 19.23 N for the control plot and 21.23 N for the treatment of 220 kg.ha^{-1}-lateral.

Table 4. Effect of the dose of potassium chloride and form of placement on soil, over consistence of tomato fruits, cv. "Rio Grande", storage at 10 ± 2ºC y 15 ± 2ºC and evaluated at 0, 7, 14 and 21 days.

KCl ($kg.ha^{-1}$) and position	10 ± 2ºC				15 ± 2ºC			
	0	7	14	21	0	7	14	21
Control plot	30.44[a1]	51.35[a]	23.49[a]	19.23[a]	39.76[a]	29.26[b]	16.52[ab]	11.24[a]
220-central	29.42[a]	28.53[a]	24.68[a]	20.70[a]	28.97[b]	24.95[b]	15.68[bc]	11.65[a]
220-lateral	31.04[a]	29.75[a]	24.38[a]	21.23[a]	31.43[ab]	26.80[b]	14.39[c]	9.50[a]
220-Bottom of the furrow	29.86[a]	30.61[a]	24.63[a]	20.71[a]	33.38[ab]	27.72[b]	14.86[bc]	9.62[a]
330-central	30.34[a]	30.06[a]	20.54[a]	22.09[a]	30.29[ab]	26.08[b]	17.37[ab]	12.52[a]
330-lateral	28.51[a]	33.19[a]	22.23[a]	20.83[a]	31.91[ab]	24.49[b]	19.26[a]	9.97[a]
330-Bottom of the furrow	28.89[a]	29.55[a]	19.57[a]	21.81[a]	30.81[ab]	26.61[ab]	16.58[ab]	11.20[a]
($P<0.05$)	n.s.	n.s.	n.s.	n.s.	*	*	*	n.s.

Average of 5 evaluations.

[1]Values among columns followed by different fonts, are statistically different ($P<0.05$) according to Duncan's Multiple Range Test.

Nonetheless, treatments of 330 $kg.ha^{-1}$-central and 330 $kg.ha^{-1}$-bottom of the furrow augmented slightly their values in relation to previous evaluation. In a similar way, Bugarin-Montoya *et al.* (6) observed that the applied strength for deformation of tomato fruits was 0.15 and 0.25 times greater with treatments (hypodronic) of 6 and 9 meq L^{-1} de K, respectively, than 3 meq K L^{-1}, but this difference was not significant.

In fruits storage at 15 ± 2ºC, significant differences were observed at 0, 7 and 14 DAA. The control plot at 0 DAA obtained the highest consistence value of 39.76 N, similarly, the control plot registered the highest value at 7 days of 29.26 N, and treatments of 220-central and of 330-lateral the lowest values of 24.95 and 24.49 N, respectively. At 14 days, the lowest value was reached by treatment of 220 $kg.ha^{-1}$-lateral with 14.39 and treatment of 330 $kg.ha^{-1}$-lateral the highest value with 19.26 N.

At 21 days, the highest value corresponded to the treatment of 330 kg ha^{-1} -central with 12.52 N, other treatments kept similar values. As expected, fruits at higher temperatures diminished with greater velocity their consistence. On the other hand, Villareal *et al.* (23) applying in fertirrigation different doses of N, K and Ca, found out that in general, control plot showed a tendency to a minor firmness during the period of marketing simulation, even though, statistically not significant (Tukey, $\alpha = 0.05$). K did not throw any response in any of the two stages of growing crop development and firmness of the fruit.

Alfalluji *et al.* (3) point out that this attribute of quality is under genetic control and differences among used cultivars for genetic improvement. On the other side, Hall *et al.* (8) observed a decrease in consistence as period of maturation progressed, which coincided with results of this research. The highest values in consistence of fruits at low temperatures have been associated to high contents of peptic substances (7).

In the same order of ideas, Lin y Block (12), analyzed the influence of postharvest factors and storage conditions at 4, 13 y 22ºC over green, mature, broken and pink tomatoes, finding that consistence was low in mature red fruits and at high temperatures of storage.

Conclusions

At the end of storage period at 15ºC, the lowest values of L* were found in treatments of 330, lateral and bottom of the furrow positions, which represent darker colors.

In treatment 330-lateral at 15ºC, the highest proportion of red color was found evaluated as value a*, and so the lowest value of b*, indicating a minor proportion of yellow tones, which could result in a fruit with less orange tones.

The lowest temperature of storage held back the arrival of red colors, representative of maturation of the fruit.

At 10ºC the control plot showed the lowest consistence.

Fruits storage at 15ºC, registered a lower consistence compared to the ones storage at 10ºC.

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