ISSN impreso: 0258-5936
ISSN digital: 1819-4087
Ministerio de Educación Superior. Cuba
Instituto Nacional de Ciencias Agrícolas
http://ediciones.inca.edu.cu

QUITOMAX® INFLUENCES IN THE PRODUCTION OF POTATO "SEED" TUBERS (*Solanum tuberosum* L.) ROMANO VARIETY

El Quitomax® influye en la producción de tubérculos "semilla" de papa (*Solanum tuberosum* L.) variedad Romano

Eduardo Jerez Mompie✉, Donaldo Morales Guevara, José Dell'Amico Rodríguez and Alejandro Falcón Rodríguez

ABSTRACT. In the production chain of the potato, the production of "seed" tubers is insufficient, so the objective of the work was to evaluate the effect of Quitomax® in the production of seed potato tubers. The plantations was carried out in the years 2015, 2016 and 2017, by means of a random block design with three replicates and three treatments: a control without application and foliar application of two chitosan of different molar mass, it was applied at a rate of 300 mL ha^{-1}, at 30 and 50 days after planting (DAP).The harvest was evaluated at 75 DAP, but in year 2017, at 65 DAP too. All the plants corresponding to two furrows of each treatment were taken in each plot and the tubers were separated by size, weighed and counted.The number of stems and the number of tubers per plant ware evaluated, in addition to estimating yield in t ha^{-1}. A double-ranking ANOVA were used to processing data and the Duncan's test to compare the means. No effects with respect to the control in the number of stems and the number of tubers were detected. The size and distribution of tuber ensured a greater amount of the same in the calibers used as seed in both chitosan, but this result was reached earlier than in the control, the yield was higher in plants sprayed with the bioproduct.

Key words: chitosan, growth, stems, propagules, yield

RESUMEN. En la cadena productiva de la papa la producción de tubérculos "semilla" resulta insuficiente por lo que varias alternativas pudieran emplearse para su incremento, así el objetivo de este trabajo fue evaluar el efecto del Quitomax® en la producción de tubérculos "semilla" de papa. En plantaciones realizadas en los años 2015, 2016 y 2017, mediante un diseño de bloques al azar con tres réplicas y tres tratamientos: un control sin aplicación y aplicación foliar de dos quitosanas de diferente masa molar aplicadas a razón de 300 mL ha^{-1}, a los 30 y 50 días después de la plantación (DDP) se evaluó la cosecha a los 75 DDP y en el 2017, también a los 65 DDP. Se tomaron todas las plantas correspondientes a dos surcos de cada tratamiento en cada parcela y los tubérculos se separaron por tamaño y se pesaron y contaron. Se evaluó el número de tallos, el número de tubérculos por planta y se estimó el rendimiento en t ha^{-1}. Los datos se procesaron mediante un ANOVA doble y las medias se compararon por la prueba de Duncan. No se detectaron efectos en el número de tallos ni en el número de tubérculos con respecto al control, pero sí en la distribución por tamaño, en este sentidose logró una cantidad mayor de los mismos en los calibres adecuados para ser utilizados como propágulos con ambas quitosanas, y este resultado se alcanzó más temprano que en el testigo, el rendimiento resultó mayor en las plantas asperjadas con el bioproducto.

Palabras clave: crecimiento, propágulos, quitosano, rendimiento, tallos

INTRODUCTION

The cultivation of potatoes (*Solanum tuberosum* L.) has been developed and widely studied around the world, is considered one of the main foods for human beings worldwide, surpassed only by rice, wheat and corn [1].

The growth and development, in general, of any plant species, is the result of the interaction between photosynthesis, respiration, transport of assimilates, water relations and mineral nutrition; which translates as the irreversible increase in dry matter, volume, length or area, as a result of cell division, expansion and differentiation [2].

Instituto Nacional de Ciencias Agrícolas (INCA), carretera San José-Tapaste, km 3½, Gaveta Postal 1, San José de las Lajas, Mayabeque, Cuba. CP 32700

✉ ejerez@inca.edu.cu

One of the main links in the potato production chain is the production or importation of the “seeds” that will be used in the new plantations, so it is traditional in the country to obtain national “seed” from the imported, even when the yields reached in this sense are low [3] and do not meet the demand that is needed to cover all areas.

On the other hand, the accelerated growth of agriculture has favored the demand for new products of natural origin, which allow the increase of agricultural production, benefit the development of crops and not be a factor of environmental pollution, besides It is necessary to search for new alternatives [4] that allow a more rational use of resources, reduce production costs without affecting the quality and yields of crops, which has led to an increase in the use of biostimulants of the growth of agricultural use.

Thus, several alternatives are necessary to adopt, to guarantee increasing yields in the areas producing “seed” from the possibility of using different bioproducts, including Quitomax® (oligosaccharide from crustacean carapace based on chitosan polymers).) with excellent results in the increase of the yields in areas dedicated to the production of potatoes for consumption [5], while the use of this practice would have a more ecological and friendly approach to the environment; that is to say, decreases in the use of chemical products, other products have also been used to satisfy the nutritional demands of the potato crop [6].

Oligosacarins, specifically chitosan, are complex carbohydrates capable of modeling the growth and development of plants at low concentrations, so the use of these biostimulants allows a more rational use of resources, lower production costs without affect the quality and yields of the crops, in addition to increasing the resistance of the plants to the conditions of water stress, salinity and high temperatures [7-11]; important aspects to consider in our production conditions.

Although the increase of the yields can be feasible to achieve with the use of these biostimulants, it is necessary to achieve an adequate distribution of the size of the tubers towards those calibers more suitable to be used as propagules, for which the objective of the present work was evaluate the effect of Quitomax® applications on the production of “seed” tubers.

MATERIALS AND METHODS

The work was carried out in the experimental areas of the National Institute of Agricultural Sciences (INCA) in Cuba, for which potato plantations were carried out in the second half of January 2015 and 2017 and the first of February 2016, using imported seed for this purpose of the Roman variety of Dutch origin, caliber 35-45 mm, with a planting frame of 0.25 x 0.90 m, taking into account the size of the tubers and the soil corresponds to a Ferralitic Red Eutric [12].

The experiment was developed by means of a randomized block design with three replications and three treatments: a control without application (Control) and the foliar application of two Chitosan® of different molecular mass (Q1 of 66,4 Kd and Q2 of 124 Kd), obtained in the Department of Plant Physiology and Biochemistry of INCA, which were applied at a rate of 300 mL ha^{-1} manually with backpack previously calibrated for the amount of water to be used, at two moments of the crop cycle, at 30 days after the plantation (DAP) and the other at 50 DAP.

The rest of the cultural attentions were carried out as recommended in the Technical Instructions for cultivation (13), while the irrigation was done by spraying, with a Central Pivot machine.

To carry out the harvest, the foliage of two rows was eliminated, manually, in each plot, at 75 DAP and the harvest was made after 10 days, so that the tubers matured so that they did not lose the skin at the time of its manipulation. At the 2017 plantation, a harvest was also made at 65 DAP and proceeded in the same way as described above. The tubers at each harvest were counted and weighed by size (<28 mm, 28-35, 35-45, 45-55 and> 55 mm) and the yield at t ha^{-1} was estimated.

During the development of the plantations the maximum, minimum and average temperatures were recorded and the decadal averages of each variable were calculated, presenting the results in graphic form.

The data were processed by means of a double classification ANOVA, for which the statistical program Statgraphycs v.5.1 was used and the results were plotted using the Sigmaplot v.11 Program.

RESULTS AND DISCUSSION

The number of average stems per plant (Figure 1) was similar in the three plantations carried out, in none of the years evaluated there were significant differences between treatments. It must be borne in mind that the application of the bioproduct (Quitomax®) was carried out 30 days after planting and sprouting occurs much earlier (12-13 days after planting), so it is expected that these applications have no effect on this variable.

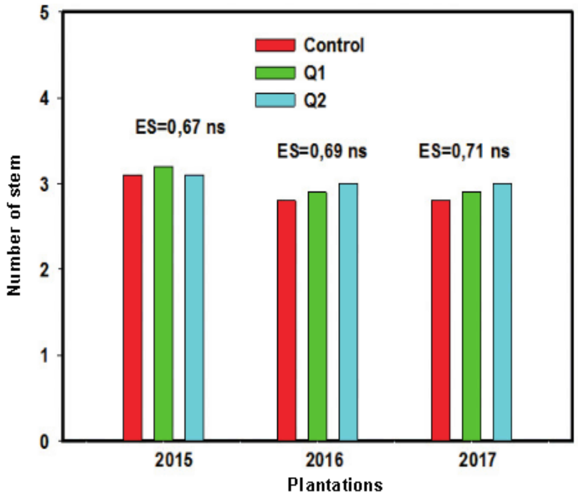

Figure 1. Number of stems per plant in the three plantations carried out

Similar results were indicated previously working with another variety of potato [14], although it has been pointed out that the effect of this variable per seedling is important in the growth and yield achieved by potato plants [8,15,16]; On the other hand, the number of stems, if a stimulating agent has not been used to increase sprouting, will depend on the size of the seed tuber that is planted [17], as well as the differences that may be important present between varieties [18].

The formation of tubers in potatoes depends, among other things, on the availability of compounds made by the plant and the ability of the tubers to accumulate them. Before tuberization, photoassimilates are mainly used for the development of leaves, stems and roots; the strength of the demand for the leaves is greater than that of any other organ. With the beginning of tuberization, this trend changes, because as the tubers grow, their demand for assimilates increases [19].

Figure 2 shows the average number of tubers per plant, variable that was not modified by the effect of the treatments, as there were no differences among them in each plantation, although the amount of these was lower in the 2016 plantation, with respect to the other two.

Regarding yield (Figure 3), it was found that it was higher in plants that were sprayed with Quitomax®, although there were significant differences between the three treatments.

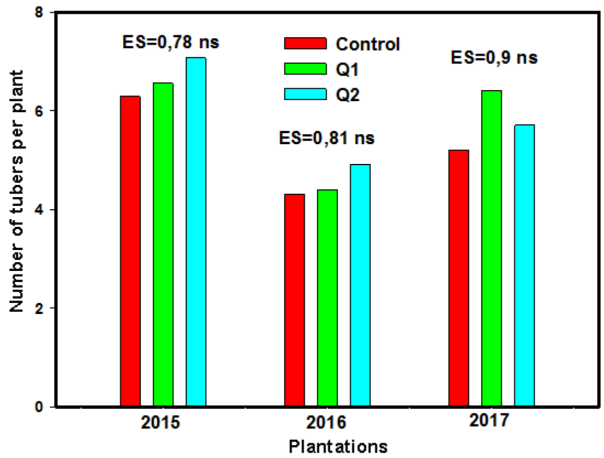

Figure 2. Number of tubers per plant in the three plantations carried out

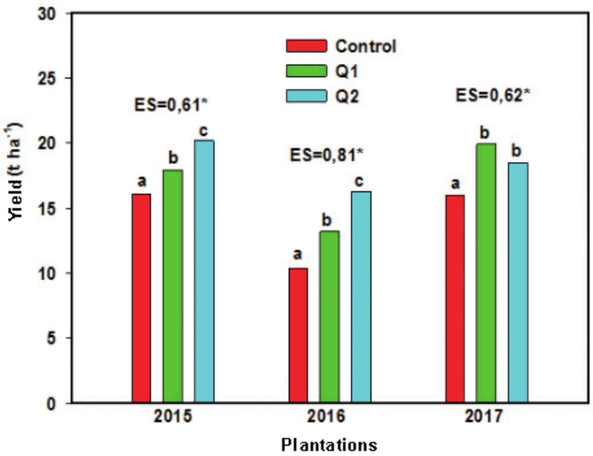

Figure 3. Performance achieved by the plants in the three plantations carried out

The yields were lower in 2016 when compared to the 2015 planting, which is a consequence of a late planting carried out this year as already indicated, in addition to being in correspondence with the number of tubers, previously analyzed and in In this sense, a high correlation between both variables has been found, given that there is a high dependence of one on the other, independently that other factors can influence the result [16,20].

The planting of 2016, coincided with higher temperatures at the time of tuberization and it has morphogenetic effects on the growth and development of the plant, intervenes in the formation of the tuber, since there is an interaction between this environmental variable and the length of the day called photoperiod.

The effects of temperature are crucial at the beginning of the early growth of the tuber and, consequently, it's filling. Favorable conditions for tuberization and tuber increase are short days and low night temperatures, temperatures between 15-19 ºC, they are optimal to initiate tuber growth, 17 ºC is an average value for good potato production.

Under conditions of short days, the proportion of vegetative weight in potato plants is 12 times higher than at high temperatures, but tuber production is 19 times higher at low temperatures [21].

It is interesting to analyze the percentage distribution, with respect to the total followed by the number of tubers by size in each of the treatments, which is presented in Figure 4.

According to the results, it is highlighted that the number of tubers in the size of 35-45 mm was higher compared to the next size (45-55 mm) in the first plantation, because in the rest or was very similar or was lower, so that at that time of harvest and the tubers have grown enough to reach sizes greater than those recommended to be used as propagules. The use of foliar applications of Quitomax® did not modify this result because among these treatments the differences were minimal, even with the control treatment, in which only a difference was manifested in the 2017 plantation.

In the plantation carried out that year, a harvest was carried out 65 and 75 days after planting and the results regarding the size distribution of the tubers are presented in Figure 5.

The significant related to the distribution of tubers by size, it turned out that the highest percentage was found in the range that is considered optimal size for the plantation (35-45 mm), which greatly decreases when the harvest is made at 75 DAP, since many of these tubers have reached greater weight and of course size, moving towards the higher calibers.

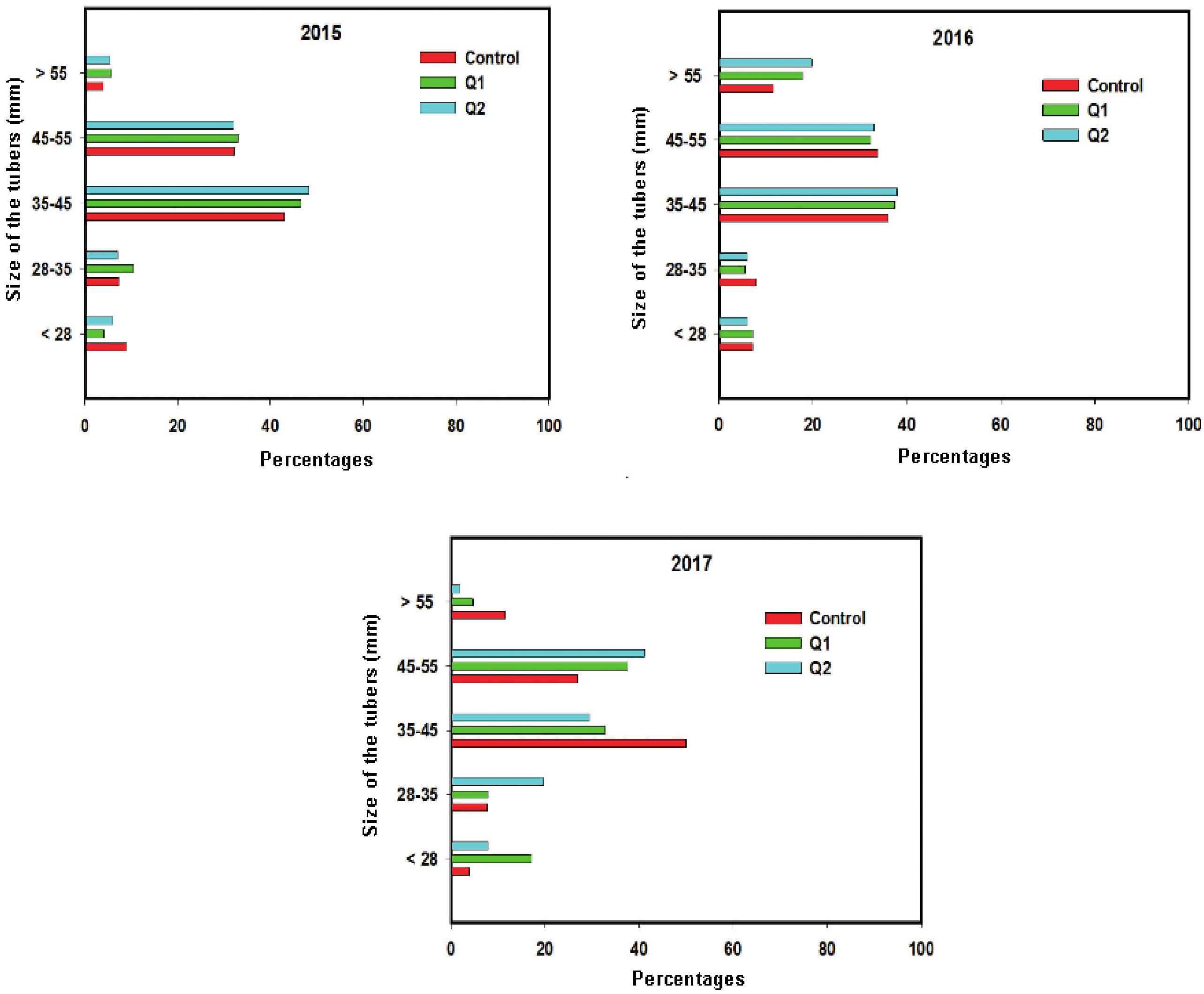

Figure 4. Distribution by size of the number of tubers in the three plantations carried out

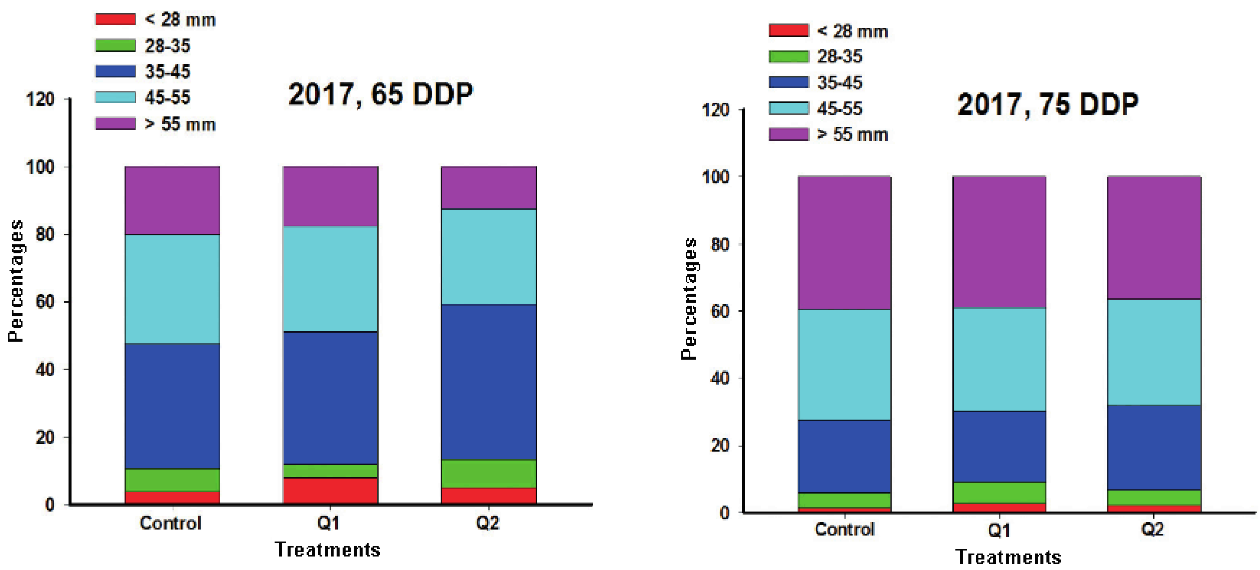

Figure 5. Comparison of the distribution by size of the number of tubers at 65 and 75 DAP in the plantation carried out in 2017

This behavior in the distribution ensures that at 65 DAP there is an important number of tubers that can be used as propagules for the new plantation, without having to wait for 75 days as established and this results in an important practical value, because on the one hand there is a greater number of tubers that will of course allow the planting of a larger area and on the other, it can be harvested before pests and diseases appear that limit the quality and quantity of production.

There are no results in the production of seed in terms of the classification of the tubers, once the plants have been sprayed with chitosan, as their influence has been evaluated to know the responses of the plants, in relation to their growth and performance in a general sense.

On the other hand, Chitosan have had a lot of interest in agriculture because of their excellent biocompatibility, biodegradability and bioactivity (7,9), as well as other bioproducts.

The quality of the tubers obtained valued through the percentage of dry mass in them (Figure 6) was not modified by the effect of the treatments, since no significant differences were found among them in any of the plantations carried out. It was only of interest that the lowest values were found in the 2016 plantation, below 18% in two treatments, which coincides with the time when the lowest yields were reached.

This behavior is a clear response of the yield reached in that plantation, in which the translocation of assimilates produced in the foliage towards the rest of the plant must have been affected, although apparently the power of the demand (tubers) was also low, there is to bear in mind that in this aspect the prevailing climatic conditions play a fundamental role.

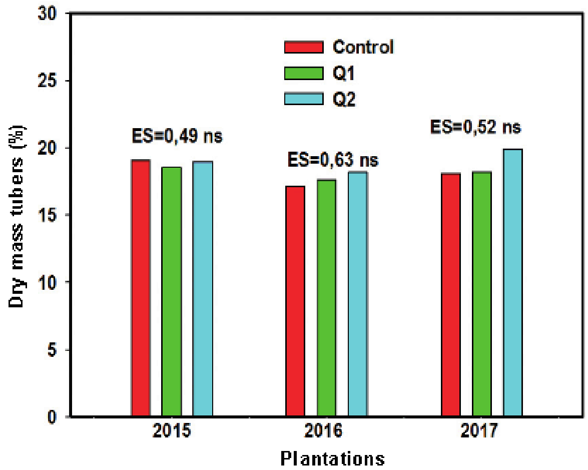

Figure 6. Percentage of dry matter in tubers in the three plantations carried out

Figure 7 shows the maximum, minimum and average temperatures during the development of the experiments.

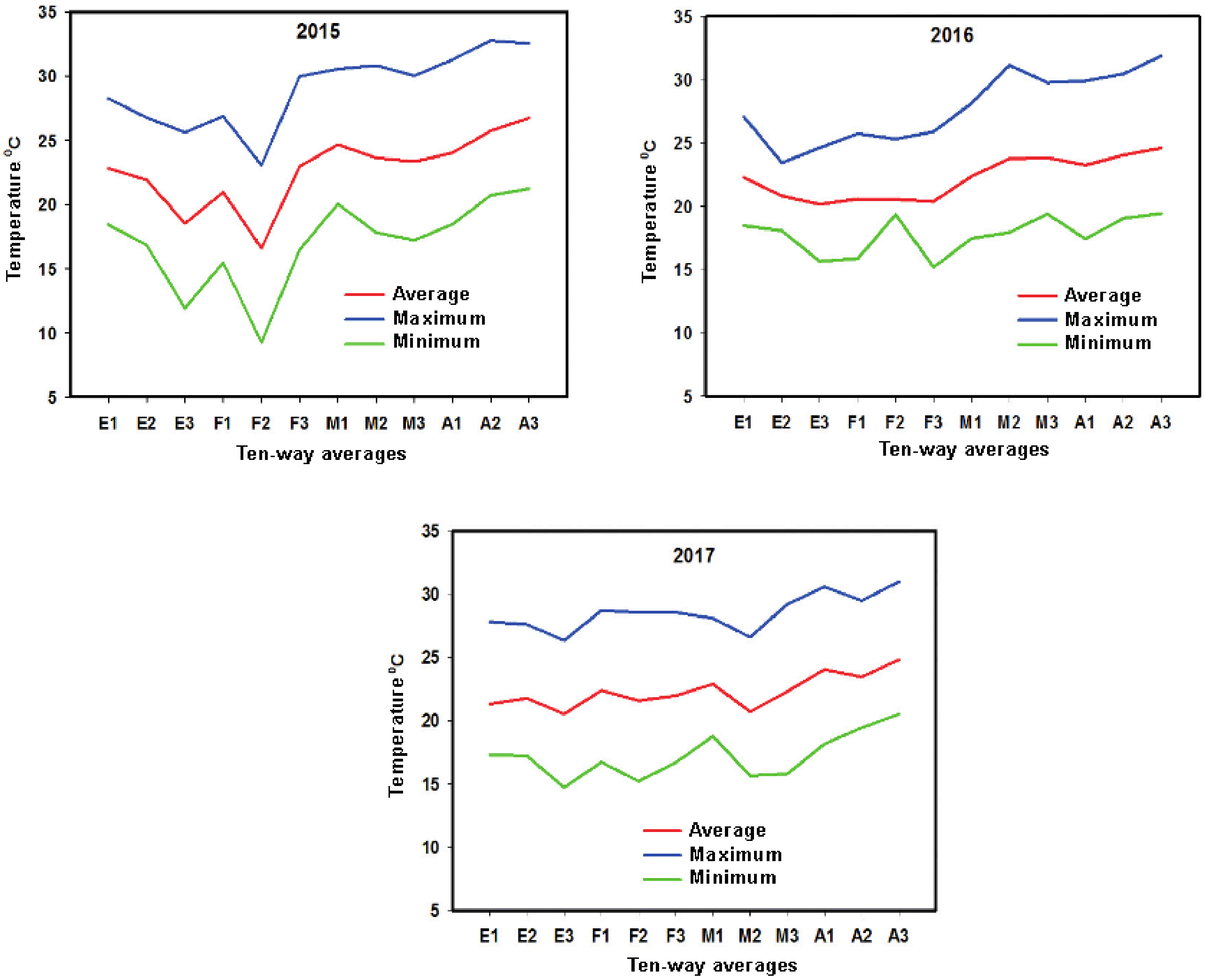

Figure 7. Maximum, minimum and average temperatures in the three plantations carried out

It can be seen that in 2015 there were low temperatures in the period of establishment of the plantation, as in the 2017, which did not occur in 2015, where even at that time, the minimum showed an increase that reached almost 20 ºC.

In this sense, temperature and photoperiod have been pointed out as the most important elements of the climate that influence the growth and development of potatoes (22) and in this specific case, average temperatures were above the established optimum range (23) did not favor a better development of the plantation that allows them to achieve high yields, as happened in the plantation carried out in 2016, since high temperatures delay the formation of tubers (24). On the other hand, the production of dry mass and its mobility within the plant, depending on the demand sites, also depend on the behavior of temperatures (25).

In works developed in Cuba (21) they agree with other authors when stating that under similar conditions of temperature behavior, the crop cycle is shortened, so some physiological processes are produced in an accelerated manner, which has a negative effect on the yields, especially in the 2016 plantation.

On the other hand, it has been corroborated that the overall production of the plantation depends to a large extent on the multiple interactions between climate elements and potato plants (26).

CONCLUSIONS

It was proved that the foliar applications of both chitosans increased the yields and the distribution of the tubers towards the calibers with an adequate size to be used as “seed”, these results are reached in a shorter time in the treated plants.

BIBLIOGRAPHY

1. Devaux A, Kromann P, Ortiz O. Potatoes for Sustainable Global Food Security. Potato Research. 2014;57(3–4):185–99. doi:10.1007/s11540-014-9265-1
2. Franke AC, Haverkort AJ, Steyn J M. Climate Change and Potato Production in Contrasting South African Agro-Ecosystems 2. Assessing Risks and Opportunities of Adaptation Strategies. Potato Research. 2013;56(1):51–66. doi:10.1007/s11540-013-9229-x
3. MINAG. Informe para la reunión de balance de la campaña de papa 2014-2015. Cuba: Ministerio de la Agricultura; 2015 Jun p. 60.
4. Terry AE, Ruiz PJ, Tejeda PT, Reynaldo EI, Carrillo SY, Morales M HA. Interacción de bioproductos como alternativas para la producción horticultura cubana. Tecnociencia Chihuahua. 2014;8(3):163–74.
5. Morales GD, Hernández LT, Jerez ME, Falcón RA, Dell Amico JR. Efecto del Quitomax en el crecimiento y rendimiento del cultivo de la papa (*Solanum tuberosum* L.). Cultivos Tropicales. 2015;36(3):133–43.
6. Castillo C, Huenchuleo M J, Michaud A, Solano J. Micorrización en un cultivo de papa adicionado del biofertilizante Twin-N establecido en un Andisol de la Región de La Araucanía. Idesia (Arica). 2016;34(1):39–45. doi:10.4067/S0718-34292016000100005
7. Cabrera JC, Wégria G, Onderwater RCA, González G, Nápoles MC, Falcón-Rodríguez AB, *et al*. Practical Use of Oligosaccharins in Agriculture. Acta Horticulturae. 2013;1009:195–212. doi:10.17660/ActaHortic.2013.1009.24
8. Rodríguez RRC, Figueredo V J, González SOP. Influencia de la quitosana en tomate (*Solanum lycopersicum,* Mill) var:" Amalia". Centro Agrícola. 2013;40(2).
9. Katiyar D, Hemantaranjan A, Singh B. Chitosan as a promising natural compound to enhance potential physiological responses in plant: a review. Indian Journal of Plant Physiology. 2015;20(1):1–9. doi:10.1007/s40502-015-0139-6
10. Van Toan N, Hanh TT. Application of chitosan solutions for rice production in Vietnam. African Journal of Biotechnology. 2013;12(4):382–4. doi:10.5897/AJB12.2884
11. Martínez GL, Reyes GY, Falcón RA, Nápoles G MC, Núñez V MC. Efecto de productos bioactivos en plantas de frijol (*Phaseolus vulgaris* L.) biofertilizadas. Cultivos Tropicales. 2016;37(3):165–71. doi:10.13140/RG.2.1.1077.0165
12. Hernández JA, Pérez JM, Bosch ID, Castro SN. Clasificación de los suelos de Cuba. Mayabeque, Cuba: Ediciones INCA; 2015. 93 p.
13. Deroncelé R, Salomón J, Manso F, Linares J, Santo R, Roque R, *et al*. Guía técnica para la producción de papa en Cuba. La Habana , Cuba: Editorial Liliana; 2000. 42 p.
14. Jerez ME, Martín MR. Comportamiento del crecimiento y el rendimiento de la variedad de papa (*Solanum tuberosum* L.) Spunta. Cultivos Tropicales. 2012;33(4):53–8.
15. Torres GS, Cabrera MJL, Hernández AM, Portela DY, García FE. El número de tallos por plantón afecta el crecimiento y rendimiento de la papa variedad Cal White. Centro Agrícola. 2012;39(1):11–6.
16. Rojas ML P, Seminario CJF. Productividad de diez cultivares promisorios de papa chaucha (*Solanum tuberosum*, grupo Phureja) de la región Cajamarca. Scientia Agropecuaria. 2014;5(4):165–75.
17. Almeida FM, Arzuaga SJ. Effects of different plant spacings and seed tuber sizes on some morpho-productive characteristics of potato in Huambo, Angola. Cultivos Tropicales. 2016;37(2):88–95. doi:10.13140/rg.2.1.1452.1842
18. López ME, Zavaleta SC, Gastelo BM, Siccha RR, Cáceda TJ. Rendimiento Comparativo De Cuatro Variedades Nuevas De Solanum Tuberosum L."papa" En El Anexo Chaquicocha, Distrito Tayabamba, Pataz, La Libertad. Arnaldoa. 2015;20(1):155–70.
19. Jerez ME, Martín MR, Morales GD. Comportamiento de la acumulación y distribución de masa seca en tres variedades de papa (*Solanum tuberosum* L.). Cultivos Tropicales. 2015;36(4):70–6.
20. Pulido MS, Contrera GE, Perea JM. Estudio de los componentes del rendimiento: tamaño de tubérculos y número de tubérculos por planta en cuatro variedades de papa andígena (*Solanum tuberosum spp.* Andígena). Biología en Agronomía. 2014;4(1):7–16.
21. Martín MR, Jeréz ME. Evaluación del rendimiento en papa (*Solanum tuberosum* L.) a partir del comportamiento de las temperaturas. Cultivos Tropicales. 2015;36(1):93–7.
22. Molahlehi L, Steyn JM, Haverkort A J. Potato Crop Response to Genotype and Environment in a Subtropical Highland Agro-ecology. Potato Research. 2013;56(3):237–58. doi:10.1007/s11540-013-9241-1
23. Rykaczewska K. The Effect of High Temperature Occurring in Subsequent Stages of Plant Development on Potato Yield and Tuber Physiological Defects. American Journal of Potato Research. 2015;92(3):339–49. doi:10.1007/s12230-015-9436-x
24. Rodríguez P L. Ecofisiología del cultivo de la papa (*Solanum tuberosum* L.). Revista Colombiana de Ciencias Hortícolas. 2011;4(1):97–108. doi:10.17584/rcch.2010v4i1.1229
25. Haverkort A J, Franke A C, Engelbrecht F A, Steyn J M. Climate Change and Potato Production in Contrasting South African Agro-ecosystems 1. Effects on Land and Water Use Efficiencies. Potato Research. 2013;56(1):31–50. doi:10.1007/s11540-013-9230-4
26. Kharshiing E, Sinha SP. Plant Productivity: Can Photoreceptors Light the Way? Journal of Plant Growth Regulation. 2015;34(1):206–14. doi:10.1007/s00344-014-9454-9

Received: November 15th, 2017
Accepted: June 13th, 2018