ISSN impreso: 0258-5936
ISSN digital: 1819-4087

Ministerio de Educación Superior. Cuba
Instituto Nacional de Ciencias Agrícolas
http://ediciones.inca.edu.cu

OLIGOSACCHARINES EFFECT ON THE BEHAVIOR OF POTATO (*Solanum tuberosum* L.) VARIETY ROMANO

Efecto de oligosacarinas en el comportamiento de la papa (*Solanum tuberosum* L.) Variedad romano

Eduardo Jerez Mompie✉, Roberqui Martín Martín, Donaldo Morales Guevara and Inés Reynaldo Escobar

ABSTRACT. To evaluate the influence of oligosaccharides in the growth and development of potato plants, two experiments for two years were conducted, one of then consisted in foliar application of Pectimorf® at 20, 25 and 30 days after planting. In these case plants were growing in containers of six liter to meet the potential of Pectimorf® in the possible stolon emission induction, whereas under field conditions, were applieding foliar way two concentrations of Quitomax® in two stages of the crop cycle: 30 and 50 days after planting. In all cases, the imported seeds of Roman variety to planting were used. In the first experiment, the evaluation was ten days after the last application, in the second the evaluation was conducted at harvest, for which the mass of the tubers to the yield and the number of them was determined by size, and the total. The results showed little influence in terms Pectimorf® induction runners, although a greater number of tubers when compared with plants had not been treated. Quitomax® concentrations allowed the plants reached a greater development, which led to a higher yield compared to the untreated control.

Key words: growth, chitosan, yield, tuber

RESUMEN. Para evaluar la influencia de dos oligosacarinas en el crecimiento y desarrollo de plantas de papa, se realizaron dos experimentos durante dos años, que consistieron en aplicar de forma foliar Pectimorf® a los 20, 25 y 30 días después de la plantación, a plantas que se desarrollaron en recipientes de seis litros de capacidad, para conocer su potencialidad en la posible inducción de la emisión de estolones, mientras que en condiciones de campo, se aplicaron de forma foliar dos concentraciones de Quitomax® en dos momentos del ciclo del cultivo: 30 y 50 días después de la plantación. En todos los casos se empleó semilla importada de la variedad Romano para la plantación. En el primer experimento la evaluación se realizó diez días después de la aplicación y en el segundo experimento la evaluación se realizó en la cosecha, para lo cual se determinó la masa de los tubérculos con la que se estimó el rendimiento y el número de los mismos por calibre, así como el total. Los resultados mostraron poca influencia del Pectimorf® en cuanto a la inducción de estolones, aunque sí un mayor número de tubérculos al comparar con las plantas que no se habían tratado. Las concentraciones de Quitomax® permitieron que las plantas alcanzaran un mayor desarrollo, que propició un mayor rendimiento en comparación con el testigo no tratado.

Palabras clave: crecimiento, quitosano, rendimiento, tubérculo

INTRODUCTION

Oligosaccharins are complex carbohydrates capable of modeling the growth and development of plants at low concentrations, some act as elicitors and they are able to promote defense activity in plants in the presence of pathogens (1). At present, it is even a matter of explaining, through mathematical models, the action of these biological compounds on plants (2).

The potato (Solanum tuberosum L.) is a member of the Solanaceae, an economically important family that includes other species.

Instituto Nacional de Ciencias Agrícolas (INCA), Gaveta postal No.1, San José de las Lajas. Mayabeque, Cuba. CP 32700

✉ ejerez@inca.edu.cu

The potato occupies a wide ecogeographic range, and it is one of the most important crops among stolons that under proper environmental conditions generate tubers[A].

Considering the experiences in other regions, where it is sought to increase the productivity of the potato at the cost of a high investment in agrochemicals, which in the long run negatively influences the producer's economy and the environment, is that potato production should have A more ecological approach (3), an aspect that is given great attention at the present time.

On the other hand, it must be meant that potato cultivation is capable of producing a large amount of food in a short period of time, but this will depend on multiple factors, both the environment and plant internal. It has been verified that the treatment to the seed to reach a good grading of the tuber guarantees a greater number of stems, which in turn increase the yields if the post-sowing conditions are not adverse to the crop (4).

The search for new alternatives that allow a more rational use of resources, reduce production costs without affecting the quality and yields of crops, has led to the use of biostimulants of the growth of agricultural use, among other benefits, increase crop yields, crop quality, and resistance to water stress, saline and high temperatures, while reducing the use of chemicals (5).

Taking into account these premises, the present work was carried out with the objective of evaluating the influence of two oligosaccharins (Pectimorf® and QuitoMax®) on the growth and development of potato plants

MATERIALS AND METHODS

The work was carried out in two different experiments during the years 2014 and 2015, using seed tubers of the variety Romano of Dutch origin. One in semi-controlled conditions (containers of six liters capacity with two plants in each), those filled with Ferralitic Red Compacted Eucalyptus soil (6), placed in the environment, while the other was carried out in field conditions, which has the same type of soil, in the experimental areas of the National Institute of Agricultural Sciences.

Cultural attention was given as recommended in the Technical Instruction for cultivation (7), while irrigation under field conditions was performed by spraying with a Central Pivot machine and in the case of containers manually, ensuring that there was no lack of moisture. During the time that the experiments in the field were made, the maximum, minimum and average temperatures were registered in the Meteorological Station bordering the experimental area, processing the data of the three variables in a decennial form.

The containers were divided into four homogeneous groups (10 in each), and applications were made to the Pectimorf® plants at a concentration of 10 mg L^{-1} at 20, 25 and 30 days after planting, while the fourth group corresponded to control without application, constituting the treatments used, which were distributed by a completely randomized design. After 10 days of the last spray, the number of stems per plant, number of stolons per stem and number of tubers per plant were evaluated in each treatment and control. The experiment was planted in January 2014.

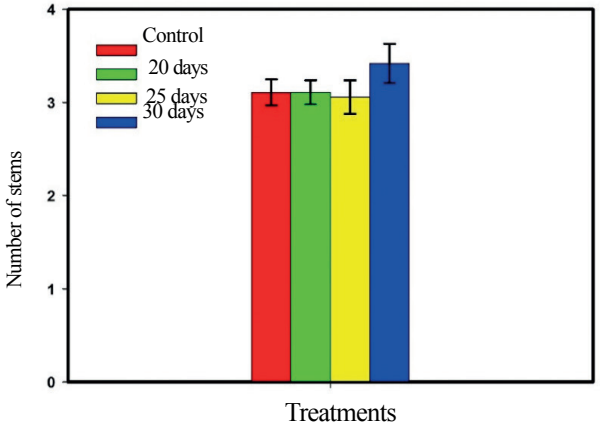
The field experiment was carried out in 2014 and 2015, using a randomized block design with three replicates and consisted in sprinkling the leaves at 30 and 50 days after planting, two preparations of QuitoMax® of different molecular mass (Q1 Of 66,4 Kd and Q2 of 124 Kd) at a rate of 300 mL ha^{-1} and a control without application, which constituted the treatments used. At the time of harvest, the yield was estimated for each treatment, expressed as t ha^{-1} and the composition by number of tubers (<28, 28-35, 35-45, 45-55 and> 55 mm) expressed as percentages of total tubers.

Differences among experimental treatments performed in recipients were evaluated by calculating the confidence interval of the means from their standard error and in the experiment under field conditions using a double-ranked ANOVA and the means were compared by the test of Multiple Duncan ranges after $p < 0,05$ (8). All statistical processing of the data was performed using the Statgraphics Plus v. 5.0 (9) and the graphs were made through the Sigmaplot v. 11.0.

RESULTS AND DISCUSSION

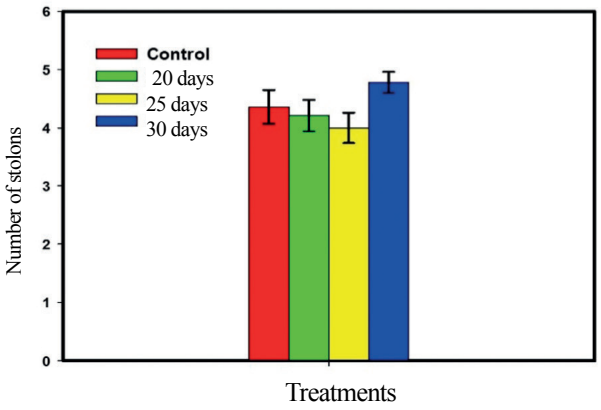
The behavior of stem number (Figure 1) did not show significant differences between treatments, values were between three and four stems per plant, a result that is logical, considering that the applications were made after 20 days after the plantation, when broiler had already taken place, so the effect in this sense must have been little, as the results demonstrate.

[A]Grandellis, C. Identificación de la proteína quinasa dependiente de calcio isoforma 3 de *Solanum tuberosum* (StCDPK3): estudio genómico, transcripcional y bioquímico. Tesis de Doctorado, Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Instituto de Investigaciones en Ingeniería genética y Molecular, 2011, Buenos Aires, 100 p.



Vertical bars (I) indicate the confidence interval for the means in each treatment for 1-α = 0.05. N = 20

Figure 1. Number of average stems per plants sprayed with Pectimorf® at initial stages of the growth cycle]



Vertical bars (I) indicate the confidence interval for the means in each treatment for 1-α = 0.05. N = 20

Figure 2. Number of stolons per stem in plants sprayed with Pectimorf® at initial stages of the growth cycle

The number of stems per plant in potato cultivation is a variable that is largely related to the general growth of plants, both in leaf area and dry mass production, as well as in yield and, although in some works This has not been fully clarified, many authors have corroborated this (5, 10, 11). It should be noted that a greater efficiency should be achieved at all times in this process, which is directly related to the hormonal balance between cytokinins and gibberellins (12).

The number of average stolons per stem (Figure 2) was between four and five, they were higher in the treatment in which the foliar application was performed 30 days after planting, with no differences with respect to control, but with treatments in which the application was made at 20 and 25 days; These last two treatments did not show differences with respect to the control.

It is emphasized that the application to the 30 days stimulated to some extent the emission of stolons, perhaps because it is in that period in which the plants are in that phase and therefore this application exerts a greater effect than when the plants are younger

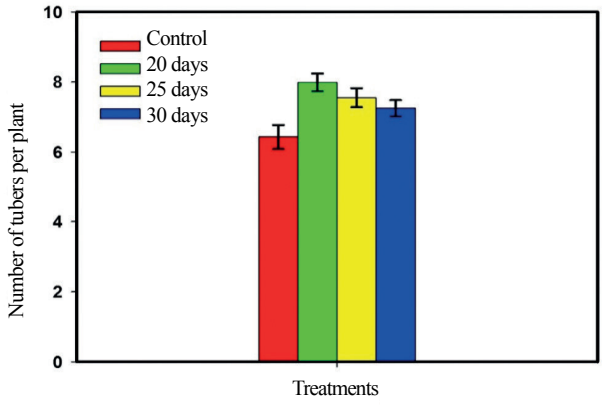
Among the development stages of the potato cycle it is the process of tuberization. This is regulated by the characteristics of the variety, the age of the seed, the environmental factors and the action of phytogulators, among others. The beginning of the tuberization is considered from the widening of the stolons. This process occurs, depending on the precocity of the variety, but in our climatic conditions it is verified in initial growth stages, where the produced assimilates by the foliage are used for the apex thickening of the stolon and initiation of the tuberization (13).

The number of tubers per plant (Figure 3) showed that the application of Pectimorf® at the different times in which it was performed increased the number of the same, with respect to the control, with significant differences in relation to this, but not between the moments of the applications, because between 20 and 25 days after planting no differences were found, neither between 25 and 30 days, but between the latter and the first.

Although the experiment did not reach the harvest stage, the fact of showing the treated plants in relation to the control had a higher number of average tubers, without doubt this would ensure a higher yield in those treatments, although it is denoted by the results, which were not They the ones that more stolons emitted. It is noteworthy that the thickening of the stolons was higher when the application was performed in younger stages of the plants, that is, at 20 and 25 days after planting.

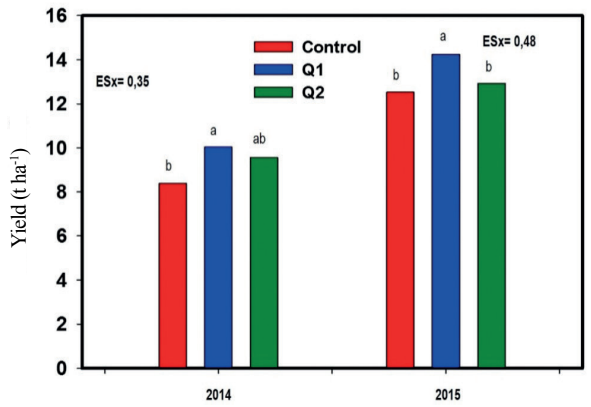
The process of the tuberization can be controlled by modifying the nitrogen supply to the plant. It is known that this nutrient does not affect the induction of tuberization, but if it inhibits tuber formation after induction has occurred, when this element is missing, which should not have occurred in this experiment, since it was followed in the conduct of the same is established in the technical instructions of the crop (10).

[B] Morales, F. S. D. Crecimiento, contenido de azúcares y capacidad de brotación en semilla tubérculo de papa (*Solanum tuberosum* L.). Tesis de Doctorado, Universidad Autónoma Chapingo, Departamento de Fitotecnia, Instituto de Horticultura, 2011, México, 102 p.



Vertical bars (I) indicate the confidence interval for the means in each treatment for 1-α = 0.05. N = 20

Figure 3. Effect of early applications of Pectimorf® at the initial stages of the growth cycle on the number of tubers formed



Averages with different letters above the bars indicate significant differences among treatments, according to Duncan's test at p <0.05

Figure 4. Effect of two QuitoMax® preparations applied to plants at 30 and 50 days after planting

On the other hand, it is known that the largest amount of nitrogen (more than 50 % of the total) is absorbed before filling the tubers (14).

As for the application of products for the tuberization stimulation, it has been proven that the hormonal balance plays a fundamental role in the formation of tubers and growth in general, but they are more effective when they are done in early stages after the planting, not the seed tuber (15). On the other hand, potato plants inoculated with rhizobacteria that promote the growth, exert a strong influence in the tuberization of the plants (16).

The estimated yield of t ha^{-1} is presented in Figure 4, in both years, the highest yield was achieved with the application of preparation one (Q1), which did not show significant differences in the first year with the preparation two (Q2), but in the second year. In both years the preparation two, showed values similar to the control, without significant differences between the two treatments.

It should be noted that the yields achieved in both plantations were low in the first case (planting in 2014) as a result of a late sowing, which coincided with higher temperatures in the initial periods of plant growth (Figure 6), a in spite of being a variety of a high productive potential[C], while in the second plantation (2015) an attack of Phytophtora infestans was presented, a pathogen that causes considerable losses in the yield of the potato and aspect that is given a careful attention in the different producing countries of this tuber[D] based on the biological control of the same and the use of bioproducts.

The application of bioproducts has not only been used for the phytosanitary control of different pathogens, but also, with the objective of obtaining acceptable yields, for which different beneficial microorganisms have been used that contribute to increase crop productivity (3).

The composition by caliber of tuber number (percentage with respect to the total) is presented in Figure 5. It is noted that in the control treatment, almost 50 % of the tubers were found in the size of 35-45 mm, and not there were tubers larger than 55 mm, which were present in the treatments that were sprayed with the two preparations of QuitoMax®, which justifies that in these treatments the yields were higher than the control in the two plantations.

The number and size of the tubers is an important variable in the composition of the potato yield, it depends to a large extent on the potato size, even if it is of the seed production, then the productivity must be evaluated in the quantity of tubers with the necessary quality to consider them as propagules for the new plantation (17). It is also necessary to consider the nutrition of the crop, although it has been shown that with different fertilizer applications the extractions have been similar between treatments, not affecting the quality of production (14), so other elements must be taken into account.

[C] MINAGRI. Informe técnico de campaña de papa 2014-2015. 2015, La Habana, Cuba, 60 p.

[D] Bustamante, G. A. E. Control biológico del Tizón tardío *Phytophthora infestans* en papa *Solanum tuberosum* a través de consorcios microbianos formados por hongos nativos del género *Trichoderma* sp. Tesis de Maestría, Universidad Politécnica Saleciana, 2015, Cuenca, Ecuador, 59 p.

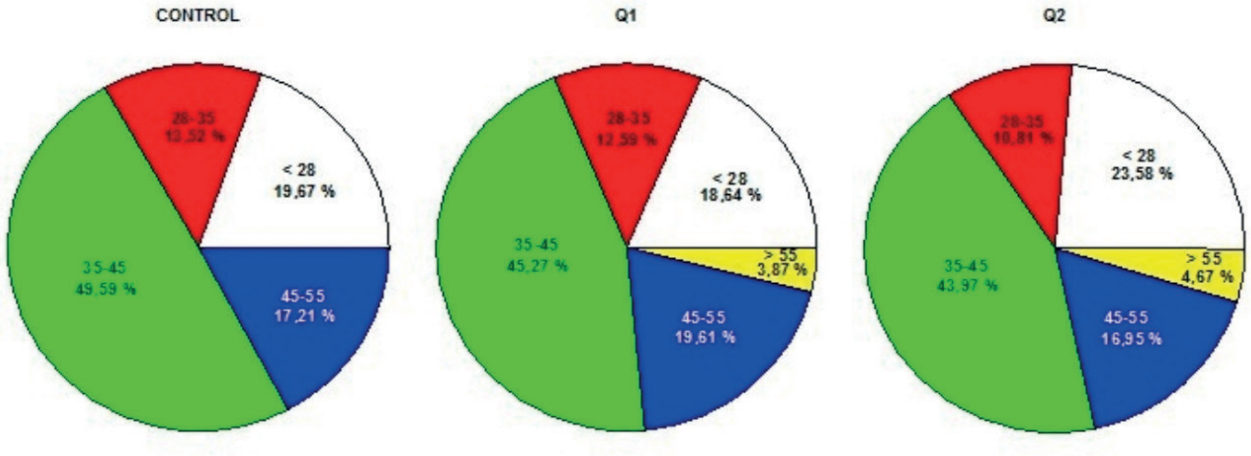


Figure 5. Percentage of the number of tubers with respect to the total in each considered size (average of the two years) for the different treatments

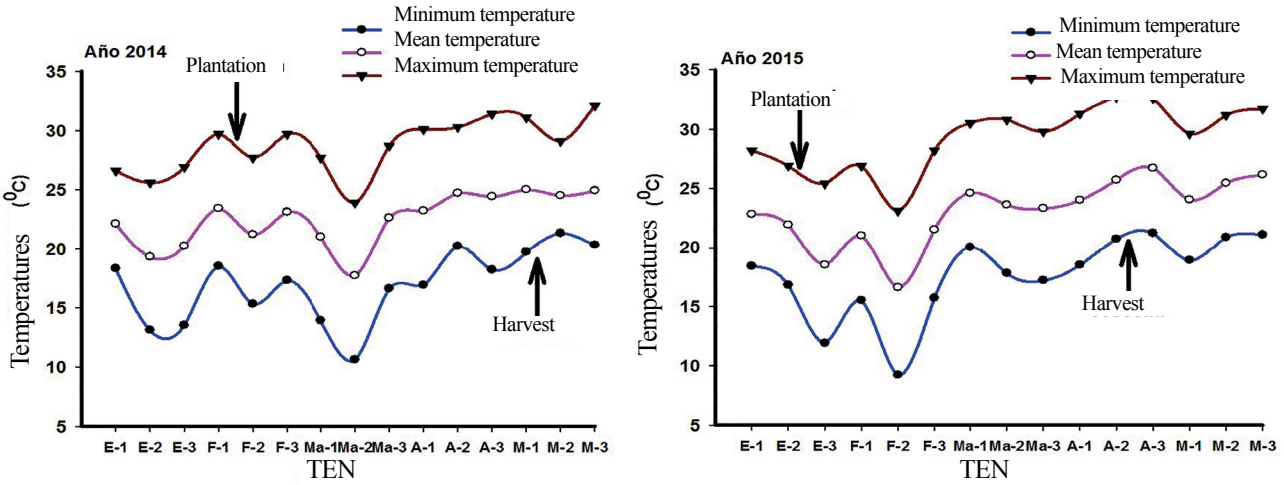


Figure 6. Behavior of the minimum, average and maximum temperatures during the development of the experiments

The climatic conditions of the area in which the experiments were developed are important variables to be evaluated in order to be able to better integrate the results, more if one considers that the first plantation was developed completely out of season, including the experiment carried out in semi-controlled conditions. For this reason, the behavior of the temperatures (minimum, average and maximum) of each period in which the experiments were developed is shown in Figure 6.

It is highlighted that at the time of planting, average and maximum temperatures were higher in 2014 and this condition does not favor the development of the crop in the early stages. Likewise, the minimums in that period were also higher.

It is noted that temperatures above 23 °C delay the onset of tuberization, while greater than 30 °C reduce photosynthesis and rate of carbon assimilation, which limits the achievement of high yields (18).

On the other hand, regardless of the climatic demands of the crop, it has also been proven to be adaptable to non-optimal conditions, which gives it possibilities for planting in different environments (19). In general, it is argued that the potato is influenced by the elements of the climate, being the most important the air and soil temperatures, the photoperiod and the solar radiation (20). However, temperatures during the initial period of the tuberization process were low, which favors this process (18).

From the genetic point of view, genotype-environment response studies are important, with the objective of selecting new varieties and knowing their behavior against different climatic conditions (21, 22).

The biopolymer Chitosan has been of great interest in agriculture due to its excellent biocompatibility, biodegradability and bioactivity (23, 24), as well as other bioproducts. The use of these, is a strategy in capacity to increase productivity and quality of harvestable organs, provided information is available on the physiological processes and hormonal demand that define the performance components of a crop, allowing an exogenous stimulus without Generate an imbalance that triggers negative responses and limits the production potential (25).

In general, a determining factor for tuberization is temperature. When this increases, a greater degree of inhibition occurs, especially in the presence of a long photoperiod (26).

The negative effect of the temperature on the tuberization is different according to whether the stimulus is applied in the canopy or in the substrate. When only the canopy is subjected to temperature increase, the tuberization is severely affected and the increase in the gas level in the meristematic zones is associated with this result. In contrast, when the high temperature stimulus is applied to the substrate, the action of the inducing signal of tuberization is not prevented, but the formation of the tuber is delayed. This aspect could also explain the low yields of the first plantation compared to the second.

CONCLUSIONS

The application of oligosaccharins to some extent stimulates tubercle production and yield as a result of the positive effect on plant growth in general.

RECOMMENDATION

For stimulation of the stolon emission process it is recommended to evaluate other concentrations of Pectimorf® and perhaps also the time to do the same.

BIBLIOGRAPHY

1. Creelman, R. A. y Mullet, J. E. “Oligosaccharins, brassinolides, and jasmonates: nontraditional regulators of plant growth, development, and gene expression”. *The Plant Cell*, vol. 9, no. 7, 1997, pp. 1211-1223, ISSN 1532-298X, DOI 10.1105/tpc.9.7.1211.
2. Goh, T.; Voβ, U.; Farcot, E.; Bennett, M. J. y Bishopp, A. “Systems biology approaches to understand the role of auxin in root growth and development”. *Physiologia Plantarum*, vol. 151, no. 1, 2014, pp. 73-82, ISSN 1399-3054, DOI 10.1111/ppl.12162.
3. Mamani-Rojas, P.; Limachi-Villalba, J. y Ortuño-Castro, N. “Uso de microorganismos nativos como promotores de crecimiento y supresores de patógenos en el cultivo de la papa en Bolivia”. *Revista Latinoamericana de la Papa*, vol. 17, no. 1, 2012, pp. 74-96, ISSN 1853-4961.
4. Torres, G. S.; Cabrera, M. J. L.; Hernández, A. M.; Portela, D. Y. y García, F. E. “El número de tallos por plantón afecta el crecimiento y rendimiento de la papa variedad Cal White”. *Centro Agrícola*, vol. 39, no. 1, 2012, pp. 11–16, ISSN 0253-5785, 2072-2001.
5. Rodríguez, R. R. C.; Villaverde, F. J. y González, S. P. O. “Influencia de la quitosana en tomate (*Solanum lycopersicum*, Mill) var. «Amalia»”. *Centro Agrícola*, vol. 40, no. 2, 2013, pp. 79-84, ISSN 0253-5785, 2072-2001.
6. Hernández, J. A.; Pérez, J. J. M.; Bosch, I. D. y Castro, S. N. Clasificación de los suelos de Cuba 2015. Ed. Ediciones INCA, 2015, Mayabeque, Cuba, 93 p., ISBN 978-959-7023-77-7.
7. Deroncelé, R. Guía técnica para la producción de papa en Cuba. Ed. Liliana, 2000, La Habana, Cuba, 42 p., ISBN 978-959-7111-05-4.
8. Duncan, D. B. “Multiple Range and Multiple F Tests”. *Biometrics*, vol. 11, no. 1, 1 de marzo de 1955, pp. 1-42, ISSN 0006-341X, DOI 10.2307/3001478.
9. Statistical Graphics Crop. STATGRAPHICS® Plus [en línea]. (ser. Profesional), versión 5.1, [Windows], 2000, Disponible en: <http://www.statgraphics.com/statgraphics/statgraphics.nsf/pd/pdpricing>.
10. Jerez, E. y Martín, R. “Comportamiento del crecimiento y el rendimiento de la variedad de papa (*Solanum tuberosum* L.) Spunta”. *Cultivos Tropicales*, vol. 33, no. 4, 2012, pp. 53-58, ISSN 0258-5936.
11. Rojas, L. P. y Seminario, J. F. “Productividad de diez cultivares promisorios de papa chaucha (*Solanum tuberosum*, grupo Phureja) de la región Cajamarca”. *Scientia Agropecuaria*, vol. 5, no. 4, 2014, pp. 165-175, ISSN 2077-9917.
12. Sonnewald, S. y Sonnewald, U. “Regulation of potato tuber sprouting”. *Planta*, vol. 239, no. 1, 2014, pp. 27-38, ISSN 1432-2048, DOI 10.1007/s00425-013-1968-z.
13. Ortiz, L. Y. y Flórez, V. J. “Comparación cuantitativa de ácido abscísico y citoquininas en la tuberización de *Solanum tuberosum* L. y *Solanum phureja* Juz. et Buk.”. *Agronomía Colombiana*, vol. 26, no. 1, 2008, pp. 32-39, ISSN 2357-3732.
14. Sifuentes, E.; Ojeda, W.; Mendoza, C.; Macías, J.; Rúelas, J. del R. y Inzunza, M. A. “Nutrición del cultivo de papa (*Solanum tuberosum* L.) considerando variabilidad climática en el «Valle del Fuerte», Sinaloa, México”. *Revista Mexicana de Ciencias Agrícolas*, vol. 4, no. 4, 2013, pp. 585-597, ISSN 2007-0934.
15. Pavlista, A. D. “Growth Regulators Increased Yield of Atlantic Potato”. *American Journal of Potato Research*, vol. 88, no. 6, 2011, pp. 479-484, ISSN 1099-209X, 1874-9380, DOI 10.1007/s12230-011-9214-3.

16. Anand, M.; Prakash, C.; Baskar, V.; Venkatesh, J.; Nookaraju, A. y Park, S. W. "Plant Growth-Promoting Rhizobacteria Enhance Abiotic Stress Tolerance in Solanum tuberosum Through Inducing Changes in the Expression of ROS-Scavenging Enzymes and Improved Photosynthetic Performance". J*ournal of Plant Growth Regulation*, vol. 32, no. 2, 1 de junio de 2013, pp. 245-258, ISSN 0721-7595, 1435-8107, DOI 10.1007/s00344-012-9292-6.
17. Pulido, M. S.; Contrera, G. E. y Perea, J. M. "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*, vol. 4, no. 1, 2014, pp. 7-16, ISSN 1853-5216.
18. Rodríguez-Pérez, L. "Ecofisiología del cultivo de la papa (*Solanum tuberosum* L.)". *Revista Colombiana de Ciencias Hortícolas*, vol. 4, no. 1, 2010, pp. 97-108, ISSN 2011-2173, DOI 10.17584/rcch.2010v4i1.1229.
19. Solís, C. S.; Vanegas, L.; Méndez, J.; Cadenas, W.; Castro, M.; Pavón, W. y Alemán, B. "Comportamiento de tres variedades de papa (*Solanum tuberosum* L.) en zonas de poca altitud de clima cálido en Nicaragua". *Revista Latinoamericana de la Papa*, vol. 18, no. 1, 2014, pp. 157-172, ISSN 1853-4961.
20. Roa, S.; Barboza, C. y Zambrano, A. "Estabilidad del rendimiento de variedades de papa (*Solanum tuberosum* L.) para procesamiento industrial en el estado Táchira, Venezuela". *Revista de la Facultad de Agronomía de la Universidad del Zulia*, vol. 27, no. 2, 2010, pp. 173-192, ISSN 1690-9763.
21. Haynes, K. G.; Gergela, D. M.; Hutchinson, C. M.; Yencho, G. C.; Clough, M. E.; Henninger, M. R.; Halseth, D. E.; Sandsted, E.; Porter, G. A. y Ocaya, P. C. "Early generation selection at multiple locations may identify potato parents that produce more widely adapted progeny". *Euphytica*, vol. 186, no. 2, 2012, pp. 573-583, ISSN 0014-2336, 1573-5060, DOI 10.1007/s10681-012-0685-1.
22. Salomón, J. L.; Castillo, J. G.; Arzuaga, J. A.; Torres, W.; Caballero, A.; Varela, M. y Hernández, V. M. "Análisis de la interacción progenie-ambiente con minitubérculos a partir de semilla sexual de papa (*Solanum tuberosum*, L.) en Cuba". *Cultivos Tropicales*, vol. 36, no. 2, 2015, pp. 83-89, ISSN 0258-5936.
23. Ramos, L. R.; Montenegro, T. y Pereira, N. "Perspectivas para o uso da quitosana na agricultura". *Revista Iberoamericana de Polímeros*, vol. 12, no. 4, 2011, pp. 195–215, ISSN 0121-6651.
24. Katiyar, D.; Hemantaranjan, A. y Singh, B. "Chitosan as a promising natural compound to enhance potential physiological responses in plant: a review". *Indian Journal of Plant Physiology*, vol. 20, no. 1, 2015, pp. 1-9, ISSN 0019-5502, 0974-0252, DOI 10.1007/s40502-015-0139-6.
25. Germán, M. y Orozco, J. "Bioestimulación arysta lifescience. Mensaje hacia la productividad". En: XXVI Congreso Latinoamericano de la Papa-ALAP. «*Papa, alimento ayer, hoy y siempre*», Mar del Plata, 2014, pp. 251-253, ISBN 978-987-45615-0-3.
26. Jackson, N. "Multiple signaling pathways control tuber induction in potato". *Plant Physiology*, vol. 119, no. 1, 1999, pp. 1-8, ISSN 1532-2548.

Received: November 4th, 2015
Accepted 4 de Agosto de 2016