Cultivos Tropicales, 2017, vol. 38, no. 3, pp. 129-134 july-september

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

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

EFFECT OF TWO IRRIGATION VARIANTS AND PECTIMORF® FOLIAR APPLICATIONS IN THE DEVELOPMENT OF BEAN (*Phaseolus vulgaris* L.)

Efecto de dos variantes de riego y aplicaciones foliares de pectimorf® en el desarrollo del frijol (*Phaseolus vulgaris* L.)

José Dell'Amico✉, Donaldo Morales, Eduardo Jerez, Pedro Rodríguez, Idioleydis Álvarez, Roberqui Martín and Yusnier Días

ABSTRACT. The effect of two irrigation treatments and two foliar applications of PectiMorf® on the development of bean cultivation was studied. Twelve concrete gutters were planted with the cultivar "Tomeguín 93" to carry out the work. The irrigation treatments consisted of applying 100 and 50 % of the ETc and the foliar applications of PectiMorf® were 150 mg ha^{-1} at 20 and 35 days after sowing (DAS), with four treatments being formed (T100, T100 + P, T50 + P and T50) arranged in a random block design. The soil moisture content was measured on a weekly basis and at 18, 27 and 42 DAS, aerial dry mass; root mass and leaf area of the plants were evaluated. In addition, the yield and its components were calculated at the end of the experiment. The results indicated that the T 50 treatment of ETc and foliar applications of PectiMorf® favored the growth of the crop in terms of aerial dry mass, root and leaf area and the variables number of pods per plant and number of grains per pod were the ones with the highest contribution to the yield and these were favored in the plants of the treatments T100 and T100 + P.

Keys word: growth, oligossacharides, yield

RESUMEN. Se estudió el efecto de dos tratamientos de riego y dos aplicaciones foliares de PectiMorf® en el de sarrollo del cultivo del frijol. Para la realización del trabajo se sembraron 12 canaletas de hormigón con el cultivar "Tomeguín 93". Los tratamientos de riego consistieron en aplicar el 100 y el 50 % de la ETc y las aplicaciones foliares de PectiMorf® fueron de 150 mg há$^{-1}$ a los 20 y 35 días de la siembra (DDS), quedando formados cuatro tratamientos (T100, T100+P, T50+P y T50) dispuestos en un diseño de bloques al azar. Semanalmente se midió el contenido de humedad en el suelo y a los 18, 27 y 42 DDS se evaluó la masa seca aérea, radical y el área foliar de las plantas. Además, se calculó el rendimiento y sus componentes al final del experimento. Los resultados indicaron que el tratamiento T50 de la ETc y aplicaciones foliares de PectiMorf® favorecieron el crecimiento del cultivo en cuanto a la masa seca aérea, de raíz y el área foliar y las variables número de vainas por planta y número de granos por vaina fueron las de mayor contribución al rendimiento y estas fueron favorecidas en las plantas de los tratamientos T100 y T100 +P.

Palabras clave: crecimiento, oligosacáridos, rendimiento

INTRODUCTION

Legumes after cereals are the main source of food of vegetable origin and it is one of the main sources of protein. The common bean (*Phaseolus vulgaris* L.) is the most important food legume in the tropics of Latin America and eastern and southern Africa. It has been traditionally cultivated by small farmers, being among the fundamental crops not only for its high nutritional value but for its high consumption in the population, but its cultivation is generally in unfavorable conditions and with deficit of inputs (1,2).

Climate change is modifying global precipitation patterns and the intensity and frequency of droughts (3). Drought stress is the abiotic factor that most affects the world production of crops and consequently that of food (4). In addition, it negatively affects a large group of morpho-physiological and biochemical processes in plants of great importance (5).

Instituto Nacional de Ciencias Agrícolas, gaveta postal 1, San José de las Lajas, Mayabeque, Cuba, CP 32 700

✉ amico@inca.edu.cu

PectiMorf® is a mixture of oligogalacturonides with a degree of polymerization between 9 and 16 molecules of galacturonide acid, obtained from waste products from the citrus industry. It is a non-traditional growth regulator, which is produced by the partial degradation of the cell wall of the citrus bark. It presents the characteristics of activating the defense mechanisms and modifying the growth and development of the plants. This mixture has a molar fraction that ranges between 10,4 and 7,2 % and it is synthesized in the National Institute of Agricultural Sciences, Mayabeque, Cuba (6).

The oligosaccharins can induce the production of ethylene and in turn generate the synthesis of storage sugar degrading enzymes, such as starch, to increase simple sugars (sucrose), which increase the concentration of soluble solids in ripening fruits. This effect of the oligosaccharins was demonstrated in a study on tomato yield and quality (*Solanum lycopersicum* Mill.) (7). In studies carried out on lettuce plants (*Lactuca sativa*) cv. Chile 1185-3 and radish (*Raphanus sativus* L.) cv. PS-9, showed morphological changes that demonstrate the influence of this mixture on the growth of the part consumed in these vegetables and from the initial stages of their development (8). In Cuba, there is little information about the benefits of the application of PectiMorf® in the cultivation of beans and their potential to alleviate water stress, which is why this work was carried out, with the aim of studying the effect of two variants of irrigation and foliar applications of PectiMorf® in the development of the bean crop.

MATERIALS AND METHODS

The work was carried out during the months of January to April 2013 in the central area of the National Institute of Agricultural Sciences (INCA). To this end, 12 concrete containers of 2,60 m long and 0,60 m wide (1,56 m^2) containing Ferralitic Red Leached soil (9) were planted. In each container were planted 44 plants of black beans (*Phaseolus vulgaris*) cultivar "Tomeguín 93" considered as susceptible to water stress (10), arranged in two rows and with a separation between them of 0,40 m and a spacing between plants of 0,11 m.

Two irrigation treatments were used, in each of them two applications of PectiMorf® were carried out at a rate of 150 mg ha^{-1}, the first at 20 days after sowing (DAS) and the second at the beginning of flowering (35 DAS) according to the manufacturer's suggestions, as well as, there were two treatments in which the product was not applied, giving rise to the following four treatments:

- T100, irrigated at 100 percent ETc (Standard crop evapotranspiration) Culture without water stress.
- T50, irrigated at 50 percent of the ETc. Culture with water stress.
- T100 + PectiMorf®.
- T50 + PectiMorf®.

The treatments were distributed according to an experimental design of random blocks with three repetitions (three containers per treatment).

The irrigation was applied by means of an automated micro spray system and the water delivery was controlled by valves placed in each treatment.

Evapotranspiration of the reference culture (ETo) was calculated using data from a nearby meteorological station (approximately 200 m from the experiment) and the FAO Penman-Monteith method (11) was used. The crop evapotranspiration under standard conditions (ETc.) was calculated by the following equation:

$$ETc. = ETo * Kc. \qquad [1]$$

where:

ETo. Culture evapotranspiration [mm d-1]

Kc Coefficient of the crop [dimensionless]

ETo Evapotranspiration of the reference culture [mm d^{-1}]

The Kc cultivation coefficients used were the following: Kc initial = 0,15, Kc. medium = 1,10 and Kc. final = 0,65

During the period between January 21 and 26, irrigation was 3 mm per day in all treatments to ensure homogeneous germination and initial growth. From that moment, irrigation was applied according to each treatment. Effective rainfall was considered when this was greater than 3 mm. Other cultural attentions were performed equally in both treatments.

The plotted data of the maximum, minimum, solar radiation and rain temperatures correspond to the decennial values obtained.

Evaluation of soil moisture

Soil moisture (%) was evaluated weekly, using a TDR (Time Domain Reflectrometry) Field Scout TDR 100 System, Spectrum Technologies, Inc., in each treatment 30 measurements were made (10 in each container) at 20 cm of depth.

Growth and development evaluations

The variables of growth and development (length of aerial part and root in centimeters, dry mass of aerial part and root in grams and leaf area in cm^2) were evaluated at 18, 27 and 42 DAS. The foliar surface was measured using a foliar area integrator model AMP-300 and the dry masses were obtained by drying in a forced draft oven at 80 ºC until constant weight.

Evaluation of yield and enviroment

For the evaluation of the yield and its components, 10 plants were randomly harvested in each container (30 plants per treatment) which were measured the number of pods per plant, the number of grains per pod, its fresh mass and the mass of 100 grams. In addition, the total yield of each container (kg m^{-2}) was evaluated.

For the processing of the data, the comparison of means and the confidence interval calculation, the Statistical Program SPSS 19.0 for Windows (12) was used. The graphing of the results was done through the SIGMA PLOT 11.0 program (13).

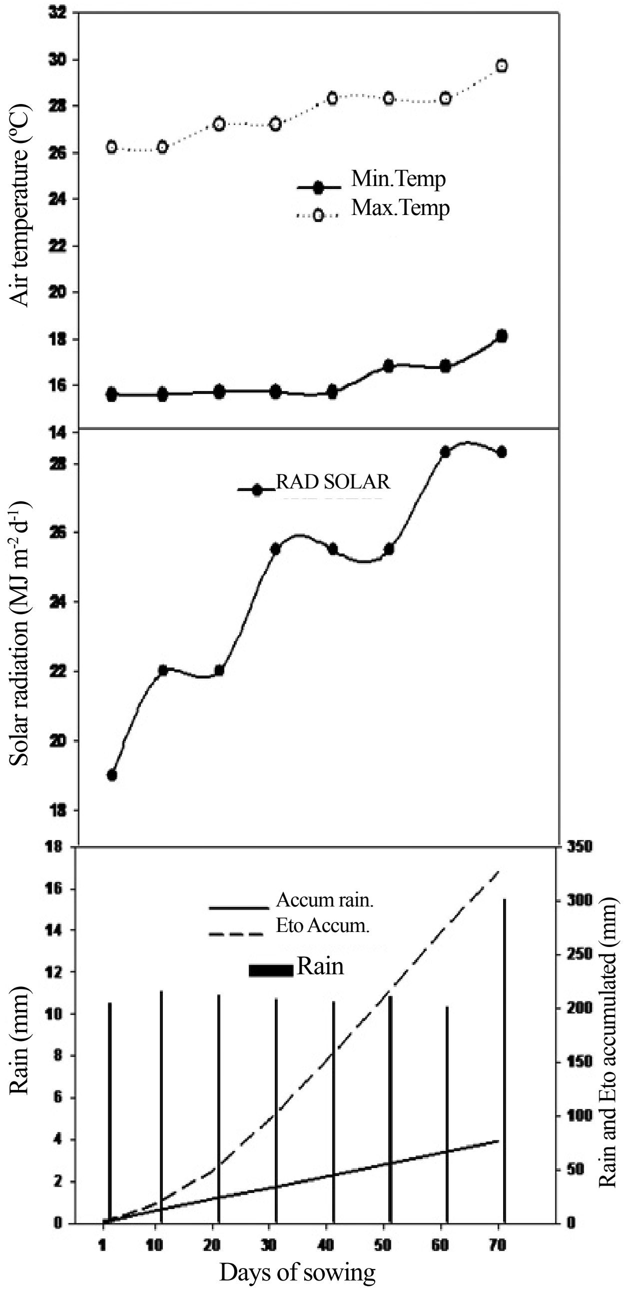
RESULTS AND DISCUSSION

The temperature and rainfall data show that the experimental period was characterized by being relatively hot and dry, as can be seen in the figures (Figure 1A and C), mainly because the minimum and maximum temperatures had very little variation and their ranges of values were between 16 and 18 ºC the minimum and between 26 and 30 ºC the maximum and the cumulative rainfall was 77 mm equivalent to only 6,4 mm per week.

On the other hand, solar radiation (Figure 1B) showed a range of values between 19 and 28 Mj m^{-2} d^{-1} and the highest values were presented at the end of the experiment. Cumulative climatic water demand (ETo) in the period was 327 mm, which represents an average daily evapotranspiration of 5 mm.

In general, climatic variables with the exception of temperatures that were relatively warm, although it is suggested that beans can be grown with average temperatures ranging from 15 to 27 ºC, with an optimum of 25 ºC (4). The values of the precipitations and of ETo are typical of the months in which the experiment was carried out.

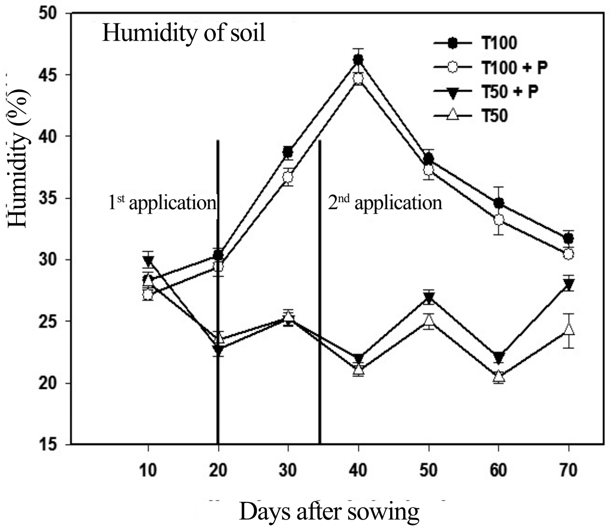
Figure 2 shows the variations in the moisture content of the soil, where it was observed that in the irrigation treatments T100 and T100 + PectiMorf® soil moisture always remained above 27 % and at 40 DAS reached maximum values of around 46 % with very little difference between the two.



Air temperature (A), solar radiation (B), rain, accumulated rain and standard Evapotranspiration (ETo) accumulated (C)

Figure 1. Environmental conditions during the experimental period at INCA, Tapaste, San José de las Lajas, Mayabeque

As for T50 and T50 + PectiMorf® the values of this variable were between 20 and 30 % and only significant differences were found between them from the 40 DAS. These results show the notorious effect of the irrigation treatments applied to the crop.



The bars above the mean values represent the confidence interval of the means, α= 0,05

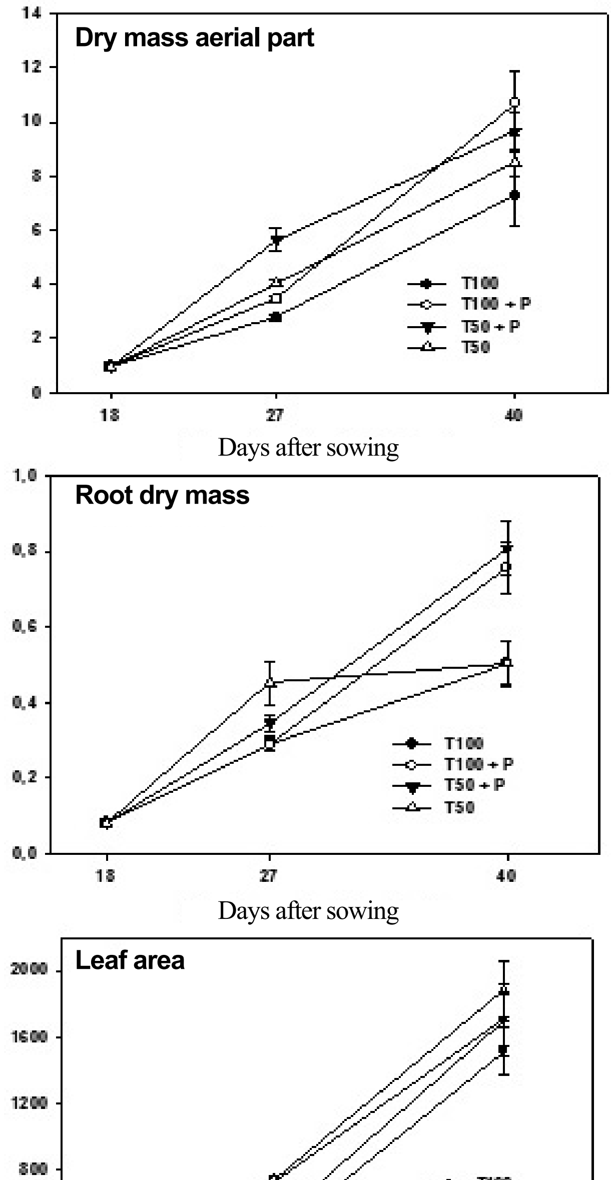
Figure 2. Seasonal variation of soil water content in treatments at 20 cm depth

Regarding the dry mass of the aerial part (Figure 3A), at 27 DAS significant differences were found between all the treatments and the highest values corresponded to the plants of T50 + P followed by those of T50 and the highest values. Low levels were present in the T100 plants. Also, at 40 DAS the lowest aerial dry mass was found in the T100 and T 50 plants without differences between them and the highest in the T100 + P plants followed by the T 50 + P plants, evidencing a positive effect of the foliar applications of PectiMorf® in this variable, independently of the applied irrigation variant.

In the radical dry mass (Figure 3B) a behavior similar to that of the aerial part was observed, but the action of PectiMorf® was much more evident, where its rooting stimulating effect was demonstrated, property that has been verified in crops such as *Psidium guajava* L. and *Raphanus sativus* L. (14,15) among others.

With respect to the foliar area (Figure 3C) at 27 DAS it was found that the plants of the treatments T50 and T50 + P that received lower water supply by irrigation presented the highest values, without appreciating any noticeable effect of the applications of PectiMorf® in this variable. At 40 DAS the greatest significant difference was found between the plants of the treatments that did not receive applications of PectiMorf® and in favor of T50, while in the remaining treatments the values were similar.

In a similar work with the same species it was found that water stress in plants of *Phaseolus vulgaris* L. did not affect the number of leaves, branches and reproductive structures, except for the treatment of 50 % water. 75 % of water stimulated the foliar area (16).

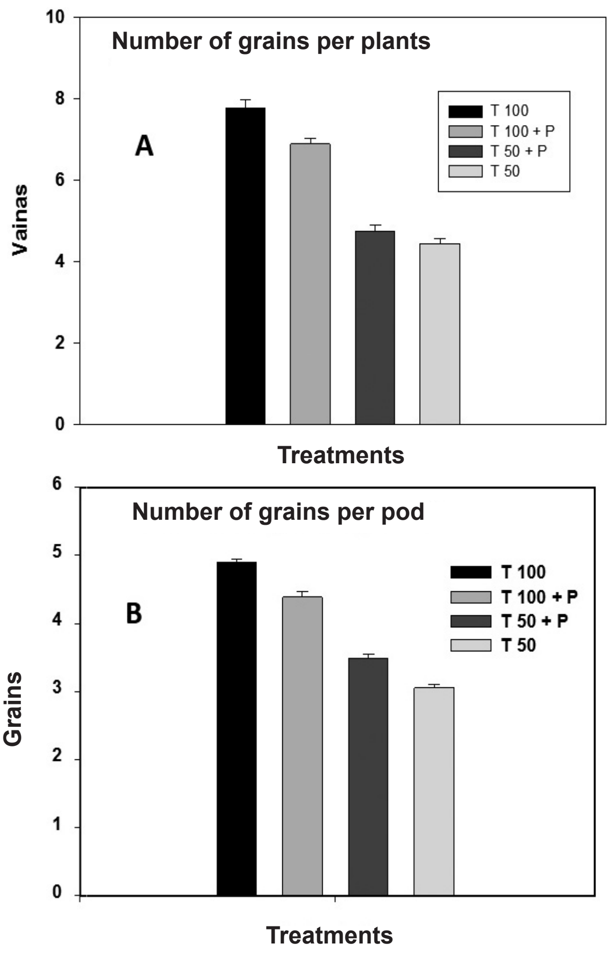


The bars above the mean values represent the confidence interval of the means, α = 0,05

Figure 3. Variations in the dry biomass content in aerial part (A), root (B) and the foliar area (C) of bean plants grown in two variants of irrigation and foliar applications of PectiMorf®

Figure 4A and B show the results obtained in the number of pods per plant and the number of grains per pod, respectively, where it could be seen that the behavior of both variables in the plants was very similar and the higher values of the same corresponded to the

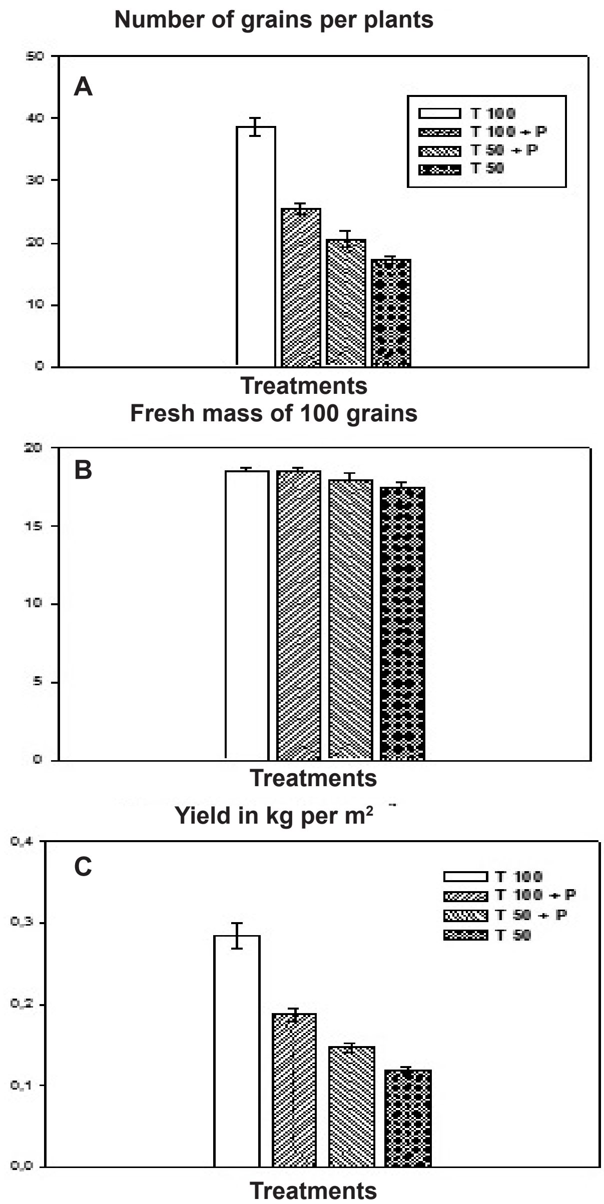
T100 plants, it is interesting to note that in this variant of irrigation, PectiMorf® applications did not produce a positive effect in the production of pods and grains. However, when comparing the values of the number of grains per pod between T50 + P and T50, if a small stimulating effect of PectiMorf® was observed. The fact that in these variables, the best results have been reached in the T100 plants is associated to the lack of water reduces pod production in *P. vulgaris* L. (17,18). These authors affirm that beans are extremely sensitive to water stress in the stages: reproductive of the plant, in the formation of yield, in the beginning of flowering, start of growth of the pods and filling of the grain.



The bars above the mean values represent the confidence interval of the means, α = 0.05

Figure 4. Variations in the number of pods per plant (A) and the number of grains per pod (B) in bean plants grown in two irrigation variants and with foliar applications of PectiMorf®

The results achieved in terms of the number of grains per plant, fresh mass of 100 grains and yield in kg m^{-2} (Figure 5A, B and C, respectively) were found in the variable fresh mass of 100 grains (5B), the most important differences were between the plants of T50 and T100+P with only 1,01 grams of difference, while in the remaining treatments the values were very similar. On the other hand, the variables number of grains per plant (5A) and yield in kg m^{-2} (5C) had a similar behavior among them and with respect to the number of grains per pod (Figure 4B).



The bars above the mean values represent the confidence interval of the means, α= 0,05

Figure 5. Influence of two irrigation variants and applications of PectiMorf® on the number of grains per plant (A) the fresh mass of 100 grains (B) and the yield in kg m^{-2} (C)

Bean yield is a complex variable that depends on direct and indirect factors. Among the direct ones, the most important are: the number of pods per plant, the number of grains per pod and the weight of the grain. In this case, the main contribution to yield corresponded mainly to the number of pods per plant and the number of grains per pod, variables that were favored in the plants of the treatments that received the greatest water supply (T100 and T100+P) and only A beneficial effect of PectiMorf® on these variables was demonstrated in the T50+P plants. These results show that water stress negatively affects yield formation in beans mainly to the number of pods per plant and the number of grains per pod.

CONCLUSIONS

By analyzing the effect of the two irrigation variants studied and the applications of PectiMorf® in the bean crop, it was found that the water stress and the applications of the product favored the growth of the crop in terms of aerial dry matter, root mass and the foliar area. However, the applications of PectiMorf® did not favor the performance of the plants. The major contribution to yield corresponded mainly to the number of pods per plant and the number of grains per pod, variables that were favored in the plants of the treatments that received the greatest water intake.

BIBLIOGRAPHY

1. Campos G, Garcia M, Perez D, Ramis C. Respuesta de 20 variedades de caraota (*Phaseolus vulgaris* L.) ante el estrés por NaCL durante la germinacion y en fase plantular. Biagro. 2011;23(3):215-24.
2. Boicet T, Secada Y, Chaveco O, Boudet A, Gómez Y, Meriño Y, Reyes JJ, Ojeda CM, Tornes N, Barroso L. Respuesta a la sequía de genotipos de fríjol común utilizando diferentes índices de selección. Centro Agrícola. 2011;38(4):69-73.
3. Urbina I, Sardans J, Beierkuhnlein C, Jentsch A, Backhaus S, Grant K, Kreyling J, Peñuelas J. Shifts in the elemental composition of plants during a very severe drought. Environmental and Experimental Botany. 2015;111:63–73.
4. Barrios EJ, López C, Kohashi J, Acosta JA, Miranda S, Mayek N. Avances en el mejoramiento genético del frijol en México por tolerancia a temperatura alta y a sequía. Revista Fitotecnia Mexicana. 2011;34(4):247–55.
5. Domínguez A, Mita N, Alemán S, Pérez Y, Sosa M, Fuente L. Algunos indicadores morfológicos y bioquímicos de cinco variedades de *Phaseolus vulgaris* L. bajo condiciones de sequía. Revista Avanzada Científica. 2012;15(2):1-18.
6. Cabrera JC, Gómez R, Diosdado E, Hormaza JV, Iglesias R, Gutiérrez A, et al. Procedimiento de obtención de una mezcla de oligosacáridos pécticos estimuladora del enraizamiento vegetal. La Habana, Cuba: Oficina de Registro de Patentes; RES 155/2003, AO1N9/12, CO 7H/033, Certificado 22859, 2003.
7. García L, Martínez V, Avendaño A, Padilla M, Izquierdo H. Acción de los oligosacáridos en el rendimiento y calidad de tomate (*Solanum lycopersicon*), Universidad de Guadalajara, México. Revista Fitotecnia Mexicana. 2009;32(4):295-301.
8. Álvarez I, Reynaldo I, Cartaya O, Terán Z. Efectos de una mezcla de oligogalacturónidos en la morfología de hortalizas de importancia económica. Cultivos Tropicales. 2011;32(3):69-74.
9. Hernández JA, Pérez JJM, Bosch ID, Castro SN. Clasificación de los suelos de Cuba 2015. Mayabeque, Cuba: Ediciones INCA; 2015. 93 p.
10. Tamayo O. Utilización de diferentes índices como criterio de tolerancia a la sequía en frijol común [Tesis de Diploma]. [Granma, Cuba]: Universidad de Granma; 2012.
11. Allen RG, Pereira LS, Raes D, Smith M. Evapotranspiración del cultivo: Guía para la determinación de los requerimientos de agua de los cultivos. Rome: FAO; 2006. 299 p.
12. IBM Corporation. IBM SPSS Statistics [Internet]. U.S: IBM Corporation; 2010. Available from: http://www.ibm.com
13. Systat Software Inc. SigmaPlot® - Scientific Data Analysis and Graphing Software [Internet]. San Jose, CA, US; 2008. Available from: https://www.laboratorynetwork.com/doc/scientific-graphing-software-sigmaplot-0001
14. Ramos L, Arozarena NJ, Lescaille J, García F, Tamayo Y, Castañeda E, Lozano S, Rodríguez-Ortiz G. Dosis de PectiMorf® para enraizamiento de esquejes de guayaba var. Enana Roja Cubana. Revista Mexicana de Ciencias Agrícolas. 2013;(6):1093-1105.
15. Terry E, Ruiz J, Tejeda T, Reynaldo I. Efectividad agrobiológica del producto bioactivo PectiMorf® en el cultivo del rábano (*Raphanus sativus* L.). Cultivos Tropicales. 2014;35(2):105-11.
16. Reyes-Matamoros J, Martínez-Moreno D, Rueda-Luna R, Rodríguez-Ramírez T. Efecto del estrés hídrico en plantas de frijol (*Phaseolus vulgaris* L.) en condiciones de invernadero. Revista Iberoamericana de Ciencias. 2014;1(2):191-203.
17. Acosta JA, Kohashi SJ. Effect of water stress on growth and yield of indeterminate dry-bean (*Phaseolus vulgaris*) cultivars. Field Crops Research. 1989;20:81-93.
18. Porch T, Ramírez V, Santana D, Harmsen E. Evaluation of common bean for drought tolerance in Juana Diaz, Puerto Rico. Journal Agronomy & Crop Science. 2009;195:328-34

Received: January 11th, 2016
Accepted: December 26th, 2016