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EFFECT OF BULB DIAMETER AND PLANTING DENSITY IN SEED ONION PRODUCTION BY THE SEED-BULB-SEED METHOD

Efecto del diámetro del bulbo y la densidad de plantación en la producción de semilla de cebolla, por el método semilla-bulbo-semilla

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ABSTRACT. In this research is presented the results of the interaction between the bulb diameter and plant density in the production of onion seed variety Caribe-71 throught seed- bulb-seed method in "La Esperanza" from Banao community in Ferralitic Red Leached soil. A design plot in strips with three treatments was used. Bulb were evaluated at 95 days for the number of umbels planted per nest; diameter of the umbel; umbels per meter; flower stalk scape height; flower bulbs amount and rate without umbels drops whilst 1 000 seed weight and the total yield at harvest was determined. The results showed that the number of umbels and size of them are directly proportional to the bulb size, but the possibility of increasing population density decreases as the bulb is larger, so if we increase it in the same as the bulb is smaller, increase yields. The treatment that used bulbs 3,0 to 4,0 cm of diameter and a density of 24 bulbs per meter exceeded 35 kg ha^{-1} to treatment of bulbs with larger diameter and in 83 kg ha^{-1} to treatment of smaller bulb in Banao conditions.

Key words: *Allium cepa*, population density, yield, umbel

RESUMEN. En esta investigación se presentan los resultados de la interacción entre el diámetro del bulbo y la densidad de plantación en la producción de semilla de cebolla variedad Caribe 71 por el método semilla-bulbo-semilla en la finca "La Esperanza" de la comunidad Banao en suelo Ferralítico Rojo Lixiviado típico. Se empleó un diseño de parcelas en franjas con tres tratamientos. Se evaluaron a los 95 días de plantado el bulbo la cantidad de umbelas por nido; diámetro de la umbela; umbelas por metro lineal; altura del escapo floral; cantidad de bulbos sin florecer y porcentaje de umbelas caídas, además se determinó el peso de 1 000 semillas y rendimiento total en el momento de la cosecha. Los resultados mostraron que el número de umbelas y el tamaño de estás, son directamente proporcionales al tamaño del bulbo, pero la posibilidad de aumentar la densidad de población disminuye a medida que el bulbo es más grande, por lo que si se aumenta ésta en la misma medida que el bulbo es más pequeño, se incrementan los rendimientos. El tratamiento que utilizó bulbos de 3,0 a 4,0 cm de diámetro y una densidad de 24 bulbos por metro lineal superó en 35 kg ha^{-1} al tratamiento de bulbos de mayor diámetro y en 83 kg ha^{-1} al tratamiento del bulbo más pequeño en las condiciones de Banao.

Palabras clave: *Allium cepa*, densidad de la población, rendimiento, umbela

INTRODUCTION

The onion (*Allium cepa* L.) is one of the most exploited species of vegetables worldwide, its usefulness in food it is actually recognized and no phrase can be enough to praise. Production in Cuba has never reached such levels as to feed themselves and this has forced the country to make annual imports at very high costs to satisfy the needs.

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Domestic production is destined mainly for domestic consumption and it is grown in most of the country[A].

In Cuba, due to unfavorable weather conditions prevailing, onion production is mainly limited to the winter months, as production in other stations is productivity limitings, adaptation and survival of cultures (1). The onion (*Allium cepa* L) is a species with high adaptability, produced and consumed in almost all countries. This is one of the three most important and widely cultivated vegetables in the world (2).

In 2013 about 7 100 ha of onion were planted, 51 % corresponds to the central region, 30 % to the western region and 19 % in the eastern region. The provinces with the largest planted area are Sancti Spiritus with the largest representation in Banao (1500 ha), followed by Artemisa and Mayabeque (1300 ha) and Villa Clara (1100 ha). The average yield of onion stockpiled in the country is 10,6 t ha^{-1}, its behavior by region 10,4 t ha^{-1} in the West, 11,5 t ha^{-1} in the central and eastern 9,0 t ha^{-1}.

Every year imported about 12 tons of seeds with a cost about five million USD. It is also difficult to maintain a stable quality seed varieties and lines that have adapted best to the country (3) supply, which results in induction failures and bulb development at this altitude; as well as problems related to germination, germination energy and varietal purity (1).

In the specific case of onions, according to the comprehensive seed policy of the Ministry of Agriculture (MINAG), it is necessary to maintain imports of different types, such as white, purple and yellow, which together with the domestic production of seeds spicy dwelling type, which is stimulating today, to establish a correct varietal strategy that satisfies the tastes of the population. This varietal policy has forced the country to the creation of varieties (Caribe 71 and Jagua 9-72) that are adapted to our climate conditions and tolerance of major diseases that attack the crop in Cuba increases, goal achieved by INIFAT group of researchers and Horticultural Research Institute "Liliana Dimitrova" (IIHLD) (4).

The Caribe-71 variety classified in the spicy dry type, it is one of the two varieties with vernalized bulb produce seed in Cuba. This strain was obtained by Cuban researchers with the selection method, is the variety Red Creole pattern. The new descendant exceeds its parent in several agronomic and economic characters, which makes possible the production of seeds in the country[B].

The onion is a biennial plant that needs low temperatures to induce differentiation of flower buds to move from the vegetative to the reproductive (5). The method most used seed production in tropical conditions is the seed-bulb-seed which is divided into five stages or steps[B].

Production stage mother bulbs: must be produced by the method of direct seeding or the transplantation and optimal planting months (October-November-December). The harvest is usually done in the months of February-March-April (driest months of the year), when advanced maturity and before they dry completely false foliage and stem loses its rigidity. The bulbs are finished drying in the sun or somewhere ventilated.

Stage storage in environmental conditions: between April and June (90-100 days) bulbs are stored at ambient conditions and during that time they are reviewed periodically to remove some rotting as a result of injury or disease attack (6).

Stage hibernation is performed in cold or similar cameras at temperatures between 4 and 8 °C, for about as long as 70 days, but not more than 110 days, this time is determined by the diameter of the bulb. Relative humidity up to 60 % (when it is higher onion is burned). The period of hibernation takes place from mid-July to October[C].

Planting and development stage of the wintered bulbs: the optimum planting date for the first half of November, with a depth of 8-10 cm planting the mother bulb, with respect to ground level to favor the anchoring and avoid falling the flower stalk. This stage lasts 90 to 110 days after planting. Plays a key role pollinators consider between 30-35 days issued the first flower stalk (7). For every 1% of umbels that pollinate stop you lose up to 5 kg seed ha^{-1}.

Harvest stage and seed benefit: a discoloration of the umbel, green to pale green almost beige is observed and becomes visible around 10 % of the seed. The

[A] Rodríguez, M. *Tecnología para el mejoramiento del riego por surcos asociado al cultivo de la cebolla en suelo Ferralítico Rojo Lixiviado*. Tesis de Doctorado, Universidad Central Marta Abreu de la Villa (UCLV), 2014, Santa Clara, Cuba, 112 p.

[B] Díaz, C. *Cómo plantar y cultivar cebollas. Cultivo de la cebolla* [en línea]. 2012, [Consultado: 29 de mayo de 2012], Disponible en: <http://www.elbatiblog.com/2012/03/como-plantar-ycultivar-cebollas.html>.

[C] Tascón, C. *Informe técnico de Producción de semilla de cebolla* [en línea]. Inst. Oficinas de extensión agraria y desarrollo rural de cabildo de Tenerife, 17 de julio de 2012, Tenerife, España, [Consultado: 5 de marzo de 2015], Disponible en: <http//www.agrocabildo.com>.

flowers are collected in a staggered way, as they're drying (two to four harvests for best performance).

The results depend on the technique used for the development of each of the stages and the factors that limit seed production in the country are losses bulbs in storage stage and hibernation; the required cooling capacity and agricultural techniques mainly on the mother bulb incident management in anchoring the plant avoiding flattens the flower stalk.

According to its physiological and ecological response, onion is a little competitive species. After the emergency has low relative growth rate and its canopy formed by cylindrical leaves, vertically oriented, it is very competitive with weeds plants (8); however, Banao yields achieved in recent years seed production are from 300 to 400 kg ha^{-1} which represents more than 80 % of the variety potential.

As a result, basically the lack of seed, the nonexistence of a secure market, leveraging the experience of more than a century in onion production and more than 30 years of botanical seed production of this crop in the Banao area is that it was done this work, with the aim of demonstrating the effect of bulb diameter and planting density on seed production by-bulb-seed seed method in cultivation of Caribe 71 onion variety.

MATERIALS AND METHODS

The research was conducted from November 2014 to February 2015 in the "La Esperanza", belonging to the CCS "Ramón Pando," the Banao community, belonging to Sancti Spiritus province, in a Ferralitic Red Typical Leachate (9), to the production of onion seed (Caribe 71) by the seed-bulb-seed method, with a time for the bulb hibernation in 90 days. The bulbs were selected by size before taking the fridge. An experimental design was used in bands with three treatments (Table I). The experimental unit area is 400 m^2 with plots of 8,0 m^2 and a spatial distribution of four rows, with a wide street use due to common practices of producers in the area.

An element that was considered was the planting depth, being deep with a slight tape and work of hoeing at 22 days to achieve a depth of 8-12 cm and ensure a good anchoring of the plant to support the flower stalk. The cultural care consisted basically of the common practices of producers in the area; irrigation with an interval of two to three days (low and high frequency standards).

Table I. Description of treatments

Treatments	Diameter of the bulb (cm)	Plants per linear meter	Seeding distance(m)
I	>5,0	12	0,45 x 0,08
II	3,0-4,0	24	0,45 x 0,04
III	2,0-3,0	36	0,45 x 0,03

The culture was maintained free of pests and weeds throughout the cycle. Meanwhile, the soil was prepared traditionally in correspondence with the information derived from studies in seed production in Cuba[D].

Field measurement was performed at 95 days after planting the crop, which coincides with the reproductive phase (full bloom). Each sampling was done by cluster, with three particular groups of a meter in length, respectively located in the upper, middle and lower groove. The selection of groups in each sample was random (the number of plants to be evaluated for each meter is determined by the distance of planting (Table I). The variables evaluated in the central rows of each treatment to avoid effect of neighboring variants are the following:

- Number of umbels per nest.
- Diameter of the umbel: in the central area of the scape, expressed in cm; It was taken with a digital calliper Mastercraf with a degree of error of 0,02 mm.
- Umbels per linear meter.
- Height of the flower stalk: from the basal end to the umbel base, expressed in cm (tape measure instrument).
- Number of bulbs without flowering (rebulbs) per nest: it was determined by physical count of all nests per meter with at least one flowering bulb, the sample evaluated was three meters along the groove divided into high, medium and Low Sides.
- Percentage of umbels falls.
- Weight of 1000 seeds: once clean and dry (10-12 % moisture) was determined by weighing the total of 1 000 seeds; This measurement was taken with a professional digital scale model Santorius Max and degree of error of 0,01 g.
- Performance in kg ha^{-1}: seed production per hectare was estimated, based on the production of seeds in the planted area, by referring to an hectare.

[D] Lezcay, E. *Producción de bulbos y semilla sexual de cebolla (Allium cepa, L.) en diferentes localidades de la región oriental de Cuba*. Tesis de Doctorado, Instituto de Investigaciones Agropecuarias ¨Jorge Dimitrov¨, Universidad de Granma, 2005, Granma, Cuba.

The variables evaluated of 1 to 6 were determined by physical count. Data relating to the variables studied for the different treatments were statistically analyzed, from a simple analysis of variance for each variable and multiple range test of Duncan (10) was applied, using SPSS 15.0.1 software (11). Curvilinear regression estimation was also conducted in order to identify the relationship between the dependent variable stalk fall and the independent variable stalk height.

RESULTS AND DISCUSSION

It is known that the number of flower stems (stalk) formed depend on the variety and the diameter of the mother bulb. Currently in Banao larger bulbs are marketed, as demand is greater than supply. In addition, these bulbs themselves represent the greatest losses in the storage and hibernation. The current trend is to produce bulbs small and medium-size (2.0 to 4.5 cm in diameter) for seed production.

Table II shows that there are significant differences among the three treatments, as to the amount of umbels per nest, treatment (I) stands with bulbs of greater diameter than exceeded 1.52 to 2.13 times of the other treatments. This trend is also reflected in the diameter of the inflorescence, where the results indicate that there are significant differences between the three treatments and treatment stands (I), wherein the diameter of the umbel was 1.2 to 1.6 times higher than other treatments. It also highlights that the treatments where smaller bulbs (II and III) were used differ significantly from (I); not between them, surpassing 1.3 to 1.4 times the amount of umbels per linear meter, an indicator that is a staple for performance. That is, although the treatment (I) has a greater number of umbels per nest and larger diameter of the inflorescence in the other two treatments, the effect that the diameter of the bulb and planting density directly affecting shown the amount of umbels per unit area. Similar results were obtained by different authors[C] (6, 12), the latter in terms of Topes de Collantes in the town of Trinidad in Sancti Spiritus, Cuba.

In Table III we can see significant differences between treatment (I) and the rest of the treatments evaluated in the experimental unit as to the height of escape and the amount of rebulbs generated nest, not between treatment (II and III); which do not differ statistically. Treatment (I) outperformed the other two treatments of 1.7 to 2.02 times as the height of the flower stalk. The amount of rebulbs also shows the same trend, the treatment used as material greater planting bulbs generates 1.3 to 1.4 times as many bulbs that fail to bloom than the other two treatments that do not differ.

The results coincide with those proposed by several investigators (13), which demonstrated that larger bulbs greater number of buds is activated, value defining the reproductive rate of the onion. In the case of the Caribbean 71 ranges from 2 to 3.5 buds activated bulb planted. The stability of the flower stems in onion seed production is a limiting factor in some varieties.

They lose their stability very quickly as a result of natural aging[C], affected by pest attack and incidence of physical factors such as the weight of the umbel, the height of the scape, anchoring the plant and accelerate the fall with conjugation of these factors. The end result is the fall of inflorescence, which reduces yield and seed quality.

In Table III it can also be seen that there are significant differences among the three treatments, the percentage of umbels falls, which was less than 30%, accepted by several researchers in the country results for the Caribbean 71 variety and our soil and climatic conditions (6).

Table II. Indicators associated with the variables that determine the quality of the inflorescence

Treatments	Number of umbels per nest			Diameter of the umbel (cm)			Umbels per linear meter (media ± S)
	Media	Mínima	Máxima	Media	Mínima	Máxima	
T (I) 12 bulb/linear m	3,2 a	2,0	4,0	7,5 a	6,4	9,4	38,0 ± 2,1 b
T (II) 24 bulb/linear m	2,1 b	2,0	3,0	6,2 b	5,1	8,6	50,4 ± 2,7 a
T (III) 39 bulb/linear m	1,5 c	1,0	2,0	5,3 c	4,6	5,8	54,0 ± 2,3 a
ESx	0,348			0,760			0,483
CV %	14,7			14,1			16,2

no common letters differ according to the multiple range test of Duncan (p≤0,05)

Tabla III. Caracterización de la producción de flores y bulbos que no florecieron (rebulbos)

Tratamientos	Altura del escapo floral (m)			Cantidad de rebulbos			Porcentaje de umbelas caídas (%) (media ± S)
	Media	Mínima	Máxima	Media	Mínima	Máxima	
T (I). 12 bulbo /m lineal	0,83 a	0,70	0,96	3,8 a	2,0	5,0	27,3 ± 1,9 a
T (II). 24 bulbo /m lineal	0,49 b	0,42	0,56	3,0 a	1,0	4,0	17,2 ± 2,1 b
T (III). 39 bulbo /m lineal	0,41 b	0,32	0,48	2,7 b	2,0	3,0	14,5 ± 2,0 c
ESX	0,741			0,342			0,511
CV %	14,3			15,8			12,5

Letras no comunes difieren según la prueba de rangos múltiples de Duncan (p≤0,05)

Stand in treatments (II and III) that falls umbels were 1,6 to 1,9 times lower than the treatment (I), an element that is closely associated with the height of the floral stalk, at a lower height of the stalk umbels smaller percentage of falls.

In the curvilinear regression estimation (Figure) between the amount of stalks fallen as the dependent variable and the height of an independent floral stalk, it was found that the model that was set is linear, with very strong positive trend for a chance 0,001 calculated Pearson correlation coefficient (r = 0,95), where the high degree of linear association of the data set corresponding to observations of continuous variables and significance of 5 % is reflected. The growing trend indicates that the fall of 29,72 % flower stalk varies per unit change in the height of stalk.

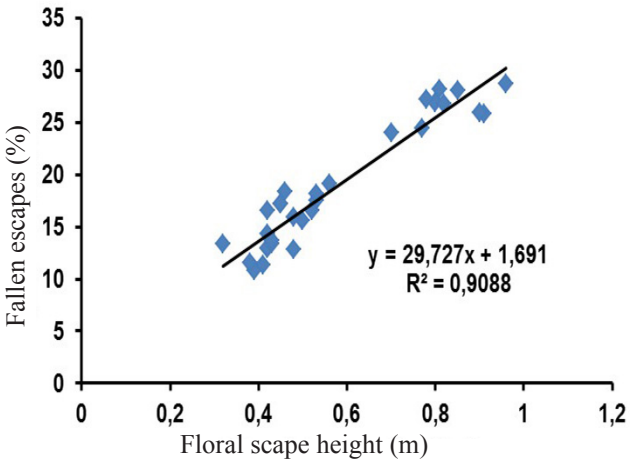

Figure 1. Regression analysis between the variables height fallen stalk and stalk

This variation can be explained by the relationship between the two variables. The results agree with those obtained in Sancti Spiritus province (8, 14), claiming that the lower the height of the escape, the lower the fall thereof. The coefficient of determination (R2 = 0,90) shows a measure of the rate at which the prediction error of the dependent variable is reduced and explains the strong linear functional dependence of the fall of the scape, with respect to height.

Table IV yields achieved by each treatment in the experimental unit, manifesting significant differences among the three are shown. the treatment used bulbs between 3,0 and 4,0 cm in diameter as planting material and planting density of 24 bulbs per meter which exceeded 1,1 to 1,3 times the rest of the treatments was highlighted, equivalent to an increased production of 35-83 kg ha^{-1}.

Table IV. Estimated yield of seed production

Treatments	Weight of 1 000 g	Performance (kg ha^{-1})
T (I) 12 bulb/linear m	3,1	326 ± 3,4 b
T (II) 24bulb/linear m	2,9	361 ± 3,5 a
T (III) 39 bulb/linear m	2,7	278 ± 3,2 c
ESx		0,223
CV %		13,3

no common letters differ according to the multiple range test of Duncan (p ≤ 0,05)

The estimated number of seeds per hectare production is in the range (250-400 kg ha^{-1}) exposed by other authors (6, 12), studies in the conditions of Cuba and the weight of 1 000 seeds is found in correspondence with reportadoC (6, 14), next to three grams.

These results are in line with the views expressed by different authors (3, 14), which suggest that the bulb size and planting density does not affect the quality of the seed, but is directly related to yields, as is evident in this investigation.

The coefficient of variation was within the allowable range for all evaluations for this type of experiment (14, 15) in experimental field conditions must be less than 20%, which represents an estimate of the very good indicator, to allow remove the dimensionality of the variables and take into account the proportion between means and standard deviation of adequate and reliable way.

CONCLUSIONS

- This paper shows that the number and size of umbels, are directly proportional to the size of the bulb, but the possibility of increasing the population density decreases as the bulb is larger; because if it is increased to the same extent that the bulb is smaller, they increase yields per unit area.
- The treatment doubled planting density exceeded 35 kg ha^{-1} treatment to larger diameter bulb and 83 kg ha^{-1} treatment of the smallest bulb, bulbs using 3,0 to 4,0 cm in diameter under the conditions of Banao achieves performance values very close to the potential of the variety.

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