Fertilizers in the yield of chile habanero (*Capsicum chínense*) in Úrsulo Galván, Veracruz

Fertilizantes en el rendimiento de chile habanero (*Capsicum chínense* Jacq) En Úrsulo Galván, Veracruz

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DOI: 10.35429/JANRE.2021.8.5.22.28 Received March 14, 2021; Accepted June 30, 2021

Abstract

Mexico is the country in the world with the greatest genetic variety of Capsicum: its richness is largely due to the diversity of climates and soils, which is why the commonly called “habanero” pepper is found throughout the peninsula. The objective of this project is to evaluate their adaptation to edaphoclimatic conditions different from those prevailing in their area of origin. As well as different mineral and organic fertilizers, which meet the nutritional needs in the cultivation of habanero pepper to obtain better yields and better profits for the producer. The experiment was carried out at the Tecnológico Nacional de Mexico Campus Úrsulo Galván. The experiment was carried out in a shade mesh cover, the experimental design was completely randomized with 5 treatments and 7 repetitions with a total of 35 experimental units. Therefore, it is expected that fertilizers and fertilizers have a greater significant response in the increase of the habanero pepper (Capsicum chínense Jacq) in Úrsulo Galván, Ver.

Fertilizers, Mineral fertilizers, Increase

Resumen

México es el país en el mundo con mayor variedad genética de *Capsicum*: su riqueza se debe en gran parte a la diversidad de climas y suelos por lo que el comúnmente llamado chile “habanero” se encuentra distribuido en toda la península. El objetivo de este proyecto es evaluar su adaptación a condiciones edafoclimáticas diferentes a las prevalentes en su zona de origen. Así como diferentes fertilizantes minerales y orgánicos, que cumplan con las necesidades nutricionales en el cultivo de chile habanero para la obtención de mejores rendimientos y mejores ganancias para el productor. El experimento se realizó en el Tecnológico Nacional de Mexico Campus Úrsulo Galván. el experimento se realizó en cubierta de malla sombra, el diseño experimental fue completamente al azar con 5 tratamientos y 7 repeticiones con un total de 35 unidades experimentales. Por lo que se espera que los fertilizantes y abonos tengan una mayor respuesta significativa en el incremento del chile habanero (*Capsicum chínense Jacq*) en Úrsulo Galván, Ver.

Abonos, Fertilizantes minerales, Incremento

Citation: GARAY-PERALTA, Ignacio, DÍAZ-CRIOLLO, Alfredo, ESCUDERO-RAMÍREZ, Leira Carol and ELVIRA-RAMÍREZ, Dassael. Fertilizers in the yield of chile habanero (*Capsicum chínense*) in Úrsulo Galván, Veracruz. Journal-Agrarian and Natural Resource Economics. 2021. 5-8: 22-28

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Introduction

North America is where the genus *Capsicum* is considered native, which consists of 27 species, of which five of them are used as fresh vegetables, or as they are also called "species", among which we have: *Capsicum annuumm L., Capsicum chinense*, Jacq, *Capsicum frutescens* L., *Capsicum baccatum* L., *Capsicum pubescens* L. (Ibiza *et al.*, 2012).

Habanero chilli (*Capsicum chinense* Jacq.), is a vegetable of economic importance, due to its fresh consumption and as raw material for the elaboration of industrial products. Traditionally, agronomic management is based on the application of chemical inputs to complete its vegetative cycle, (Castillo-Aguilar *et al.*, 2015).

The irrational or inadequate use of fertilisers is a factor of environmental degradation, hence the importance of NORMA MEXICANA NMX-AA-91-1987. On the one hand, an insufficient dose from a nutritional point of view generates low yields, while an excessive dose generates high economic and environmental costs. For this reason, a balanced fertilisation approach has been promoted in recent decades, which consists of supplying nutrients in the amount and at the time required by the crop (Ryan, 2008). Under this view, knowledge is needed on crop nutrient requirements as well as on nutrient supply, based on chemical analysis of soil and plants, (Alejo-Santiago *et al.*, 2015).

Nowadays it is important to think about crop management with less environmental impact, which could be achieved with the use of rhizospheric micro-organisms, which are beneficial to plants; for example, several *Bacillus* species are plant growth promoting rhizobacteria (PGR). (Sosa-Pech *et al.*, 2019).

Another activity to be carried out in agricultural production is the continuous improvement of irrigation practices and fundamental changes in the application of irrigation water saving methods. Drip irrigation in horticultural crops is the simplest and most efficient method of delivering water and fertilisers to the root zone of plants, (López-López *et al.*, 2018).

Something that is very important to mention is that despite the fact that the habanero chilli (*Capsicum chinense* Jacq.), is not native to Mexico, it has taken over the Mexican palate because of its extraordinary spiciness: national culinary activity is inconceivable without this exclusive condiment for certain dishes and sauces. Its origin is in South America in the Orinoco basin from where it spread to the Caribbean islands in pre-Columbian times (González et al. 2006). While in the Mexican region, specifically in the Yucatan peninsula, variants of great regional importance are found; sweet, spicy, etc., (Cázares-Sánchez *et al*., 2005).

Regarding the production of chilli in greenhouses, it is mainly carried out to provide a better environment for the growth and development of the plant, due to the fact that wind, radiation and temperature lower than 15 ºC, can affect the yield and quality of the fruit (Flores, 2013). However, under these conditions, according to Uribe, (2008) yields are low due to the lack of adequate production technology in relation to varieties, nutrition, disease prevention, etc.

Greenhouse habanero chili increases fruit yield (Cauich *et al*., 2006), but there are limiting factors such as pollination (Quezada-Euán, 2009), which can be promoted by abiotic means such as the use of hormones and biotic means such as the use of pollinating insects (Dávila, 2011). The use of hormones has advantages, such as higher quality of commercial product, lower risk of pollinating insect bites and greater crop vigour, but it can interact with other foliar chemicals and cause stress to the crop (Tapia-Vargas, 2016). Hence the importance of carrying out this research to generate information that serves as a basis and reference to know how habanero chilli behaves in the region and its production.

Objectives

To identify the fertiliser and/or manure that increases habanero pepper (*Capsicum chínense* Jacq) yield in Úrsulo Galván, Veracruz.

Methodology

The experimental research will be carried out in the municipality of Úrsulo Galván, Ver, Mexico.

Location of the experimental area

The experiment will be carried out in the experimental area of the Technological Institute of Úrsulo Galván, Ver. The experimental plot will be located in the parallels 96° 22' north longitude and 19° 24' west latitude, with an elevation of 20 meters above sea level (masl).

Climatic characteristics

The climatic conditions are of an AW_2 climate (warm sub-humid climate with rainfall in summer) with an annual rainfall of 1350 mm per year distributed in the months of June to September and the dry period from January to May with an average temperature of 24 and 25 °C with a maximum of 35 °C in the hottest months and a minimum of 16 °C in the winter months, the relative humidity is 80 %).

Vegetative characteristics

This zone is dominated by vegetation consisting of induced grassland, low subcaducifolia forest and rainfed agriculture. Subsequently, the vegetation in lesser presence consists of scrubland dominated by leguminous plants to boiling acahuales.

Soil

The soil is predominantly clayey loam with an acidic pH of 5.5 to 5.9.

Description of the experimental area

The place where the experimental research was carried out is in semi-protected conditions (greenhouse) because it has a shade net cover where the plants are located. Temperature and pest control is not possible due to the conditions of the area, but irrigation control is possible because it is manual. Therefore, conditions are like those found outdoors.

Determination of design and treatments

According to the conditions of the crop, mainly the uniformity of the soil (sandy) and the fact that there is a shade net cover on the site, a completely randomised experimental design with 5 treatments was established; based on different fertilisation mixtures, each treatment will have 7 replications, making a total of 35 experimental units.

Description of the treatments

Treatments	Description
T1	Dap (9.6 grams) Urea (6.4 grams)
T2	Dap (14.4 grams) Urea (9.6 grams)
T3	Cow dung 40 grams/plant
T4	Vermicompost (200 grams/plant)
T5	Witness

Table 1 Representation of the different mixtures applied to each treatment
Source: Own Elaboration

Distribution of the treatments in the field.

T1R4	T4R1	T1R5	T3R6	T5R6
T5R1	T1R1	T3R2	T4R5	T2R1
T4R3	T4R2	T1R2	T3R3	T3R1
T5R2	T2R7	T1R7	T4R7	T3R4
T5R7	T4R6	T1R6	T3R6	T5R3
T5R4	T4R4	T2R6	T5R5	T2R3
T2R5	T1R1	T3R7	T2R4	T2R2

Table 2 Shows the distribution of the different treatments in the experimental area located within the Instituto Tecnológico Nacional de México Campus Úrsulo Galván
Source: Own Elaboration

Variables to evaluate:

Plant height: this variable was collected every week, measuring with a metre from the soil surface to the largest leaf of the sub apical meristem.

Plant diameter: The measurement of this variable was collected, leaving 5 cm from the soil once a week after transplanting until harvest with a vernier.

Number of leaves: a count was taken once a week after transplanting until the appearance of fruit visually.

Number of fruits: measured once a week after the first appearance of fruits. This was done visually.

Weight of fruits: all fruits were cut per plant and each one was weighed on an analytical scale.

Statistical analysis

The results obtained will be captured and analysed in the SAS programme (Stadistic Analysis System), then a mean comparison test will be carried out to identify the best treatments statistically speaking according to the Tukey 0.05 % mean comparison test.

ISSN 2524-2091

Results

Plant height

In relation to the plant height variable, it can be observed in table 3. After carrying out the ANOVA with the comparison of Tukey's method (0.05%), since these are field conditions and not laboratory conditions, this level of significance is used. In the different dates in which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), that in treatment 2 which consists of the application of DAP (14.4 g) UREA(9.6 g) was better and statistically speaking, superior with respect to the other treatments, that is to say that if this mixture of fertilizers is applied with respect to one of fertilizers a greater response will be observed, but we must remember that fertilizers maintain soil dynamics and macro and microbial life, the above agrees with what was published by Medina, (2015). Where he carried out chemical fertilisations based on nitrogen fertilisers.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	5 A	9.7 A	14.2 B	22.5 BA	32 B	36.4 B	48.8 B	59.1 B
2	Dap (14.4g) urea (9.6 g)	7.1 A	12.4 A	21.1 A	27.4 A	50 A	61.7 A	74.2 A	89.4 A
3	Cow dung (40 g /plant)	6.8 A	10.8 A	15.4 BA	20.8 BA	38.4 BA	50.0 BA	59.4 BA	70.1 BA
4	Vermicompost (200 g/plant)	6.8 A	10.4 A	15.2 BA	21.2 BA	36.1 BA	48.1 BA	54.1 BA	66.2 BA
5	Witness	6.4 A	12.1 A	14.5 B	19.7 B	34.1 BA	46 BA	53.8 BA	64.2 BA

Table 3 Comparison of means of the variable plant height
Source: Own Elaboration

Plant diameter

Regarding the plant diameter variable, it can be observed in table 4. After performing the ANOVA with Tukey's method comparison (0.05%). On the different dates on which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), no statistical difference was obtained in any of the samples, that is to say that if an organic fertilizer or mineral fertilization is applied as well as if nothing is applied in soils with high content of organic matter, no statistical difference will be obtained in terms of this variable,

But it must be taken into account that if organic matter is not incorporated into the soil, this will impoverish until it is no longer able to supply the nutrients that the crop requires, the above agrees with what is published by Medina, (2015). Who carried out the analysis of variance where they indicate (α= 0.05) that there is no significance on the stem diameter of habanero chili plants, due to the combined effect of fifteen fertilisation treatments of nitrogen, phosphorus and potassium.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	1.7 A	2.8 A	3.7 A	5 A	5.1 A	6 A	7 A	7.8 A
2	Dap (14.4g) urea (9.6 g)	2.2 A	2.8 A	4 A	6.2 A	6.5 A	7.8 A	9.2 A	10.2 A
3	Cow dung (40 g /plant)	2 A	2.1 A	3.4 A	4.8 A	5.7 A	6.7 A	8.1 A	8.8 A
4	Vermicompost (200 g/plant)	2.4 A	2.5 A	3.7 A	5.1 A	5.8 A	7.2 A	8.1 A	9.2 A
5	Witness	1.8 A	2.5 A	3.8 A	5.8 A	7.4 A	6.5 A	7.7 A	8.4 A

Table 4 Comparison of means for the variable plant diameter
Source: Own Elaboration

Number of leaves

In relation to the variable number of fruits, it can be observed in table 5. In the different dates in which this variable was sampled (12 October, 19 October, 26 October, 2 November, 9 November, 16 November, 23 November and 30 November 2018), that in none of the samplings statistical difference was obtained, that is to say that if you apply an organic fertilizer or mineral fertilization as well as if nothing is applied in soils with high content of organic matter no statistical difference will be obtained in terms of this variable.

But we must also take into account that it is very important to incorporate organic matter in soils so that they have the capacity to supply the elements that plants require, which is in agreement with what was published by Campos, (2016), who carried out the analysis of variance where they indicate that there is no significance on the number of leaves of habanero peppers.

Treatment	Fertilisation rates	Height of plant in cm (height/plant)							
		12 Oct.	19 Oct.	26 Oct.	2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.
1	Dap (9.6g) urea (6.4 g)	7.2 A	12.1 A	14 A	16.2 A	16.8 A	19.4 A	25.7 A	33.2 A
2	Dap (14.4g) urea (9.6 g)	8.4 A	12.5 A	14.4 A	18.1 A	19 A	23 A	28.7 A	38.4 A
3	Cow dung (40 g /plant)	8.1 A	11.5 A	13.1 A	13.2 A	16.1 A	21.4 A	28.4 A	36.1 A
4	Vermicompost (200 g/plant)	8.7 A	11.8 A	13.4 A	16.2 A	17.2 A	22 A	27.5 A	33.4 A
5	Witness	8 A	10.7 A	12.5 A	14.1 A	18.1 A	21.5 A	30.2 A	37 A

Table 5 Comparison of means for the variable number of leaves
Source: Own Elaboration

Number of fruits per plant

In relation to the variable number of fruits, it can be observed in table 6. After performing the ANOVA with the comparison of Tukey's method (0.05%). In the different dates in which this variable was sampled (28 December 2018, 4 January, 25 January and 8 February 2019), that in the first and third week with respect to treatment 2. Dap (14.4 g) Urea (9. 6 g) was better and statistically superior with respect to the other treatments, statistical difference was obtained in the sampling, that is to say that if you apply a mineral fertilization will have a greater number of fruits compared to an organic application, but we must remember the relationship between number of flowers and a nitrogen fertilization can be affected because factors involved, the above agrees with the published by Salvador, (2016) where he mentions that in relation to the variable number of flowers coincides with the increase in number of fruits where he found statistical difference.

Treatment	Fertilisation rates	Number of fruits production (fruit/plant)			
		28 Dec.	4 Jan.	25 Jan.	8 Feb.
1	Dap (9.6 g) Urea (6.4 g)	6.4 B	14.5 A	17.5 BA	8.4 A
2	Dap (14.4 g) Urea (9.6 g)	17.1 A	24.1 A	20.8 A	11.4 A
3	Cow dung (40 g /plant)	12.7 BA	16 A	14.5 BA	7.1 A
4	Vermicompost (200 g/plant)	9 BA	15 A	10.5 BA	8 A
5	Witness	8.5 BA	11.5 A	9.1 B	3.8 A

Table 6 Comparison of means of the variable number of fruits/plant
Source: Own Elaboration

Fruit weight

In relation to the fruit weight variable, it can be observed in table 7. After carrying out the ANOVA with the comparison of Tukey's method (0.05%).

In the different dates in which this variable was sampled (28 December 2018, 4 January, 25 January and 8 February 2019), that in none of the samplings was statistical difference obtained, that is to say that if you apply an organic fertilizer or mineral fertilization as well as if nothing is applied in soils with high organic matter content no statistical difference will be obtained in terms of this variable, but it must be taken into account that if organic matter is not incorporated into the soil, it will become poorer until it is no longer able to supply the nutrients that the crop requires, which is in agreement with what is published by Campos, (2016). Where he mentions that in relation to the polar diameter variable, no statistical differences were observed.

Treatment	Fertilisation rates	Number of fruits production (fruit/plant)			
		28 Dec.	4 Jan.	25 Jan.	8 Feb.
1	Dap (9.6 g) Urea (6.4 g)	8.0 A	5.8 A	17.5 A	7.0 A
2	Dap (14.4 g) Urea (9.6 g)	9.0 A	8.5 A	20.8 A	7.6 A
3	Cow dung (40 g /plant)	6.4 A	7.2 A	14.5 A	6.3 A
4	Vermicompost (200 g/plant)	6.9 A	5.8 A	10.5 A	5.8 A
5	Witness	7.4 A	6.5 A	9.1 A	6.7 A

Table 7 Comparison of means of the fruit weight variable
Source: Own Elaboration

Conclusions

Based on the results obtained, we could say at first that the results we found are very interesting as we realise that the plant height and number of fruits benefit from treatment 2 (14.4 g of Dap and 9.6 of Urea).

However, this does not influence the yields because, according to the ANOVA carried out, there are no statistical differences.

This information obtained will be very important because it is a spearhead in the production of habanero pepper in the Úrsulo Galván region, because although it is a sugar cane area, this crop can be an option for the diversification of crops in this area.

In spite of the adversities, the plants finished their productive cycle and the phenological or vegetative development was optimal, as it coincides with what has been investigated by other authors for habanero pepper producing regions.

Finally, we can say that the habanero chilli has economic and productive potential for the region according to the data obtained in this experimental work.

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