

Evaluating the impact of planting density and nitrogen on biometric and production indicators of pepper (*Capsicum annuum L.*)

Thoma Nasto¹, Gjergji Mero², Nevrus Zeka², Ylli Shahinlli³

Department of Horticulture and Landscape Architecture (Agriculture University of Tirana)¹

Department of Agronomy (“Fan S. Noli” University of Korça)²

National Food Agency of Korça³



ABSTRACT— The study is conducted in the conditions of Devoll territory, located in the south eastern part of Albania. The climate of this region is characterized by Mediterranean – continental features. The results obtained from this study offer important indication on the most appropriate selections in determining plant density of plants. The values of plant characteristics indicate a regular decrease when the plant space increases, while it is not the same for the date of flowering. This study provides evidence that plants density (density of six plants: 8.9 – 6.7 – 4.5 – 3.4, 2.7 and 2.3 plants/m²) does not exert any proven influence on the average fruit weight. The average number of the fruits per plant increases starting from the highest to the lowest density, while the production per unit area decreases. The quantity of marketable product is higher in the low - density plant variants, while the total product per unit area results high in variants with higher number of plants. Moreover, the greater the distance between the planted plants is, the smaller will be the percentage of sparse fruits. The plant height of the tested variants increased with greater plant density. The fruits with the highest weight were obtained in the first three harvests, while the diameter of the fruits was larger in the fruits of the second and third harvest. The plant height of the tested variants increased with greater plant density. The green mass remaining after harvest of the product, as well as the amount of dried plant at the end of the product cycle, resulted in higher values in the higher density plant variants, compared to other densities. This research paper contains data on the effects of five levels of nitrogen. The high nitrogen rates of the tested variants increased the weight of the fruit and delayed ripening.

KEYWORDS: Plant density, index, evaluation, total yield, production per surface unit, marketable fruits, fruit weight.

1. INTRODUCTION

The optimal planting density of different vegetables can not be considered as a fixed parameter. It can be influenced by a large number of factors, such as the competitiveness of each pepper, climate, soil, water and nutrient conditions, cultivation period, destination of production, etc. The scientific research for many years has made it possible to determine for each vegetable pepper the appropriate distances, which enable optimal planting density [1]. However, for vegetable pepper, it is considered important to experiment how different vegetable react to different changes in planting density, and how such a reaction may be influenced by other cultivation practices as irrigation, fertilization, etc [2], [3]. Meanwhile, in everyday practice still continue to be used ready-made schemes [4], that are able to explain the functions that link the production parameters, with the density of planting (the distances between and between the planted rows). The study of the distances between and through the rows, as well as the orientation of the rows can help for a more favorable development of the plants, increasing their productivity [5]. In many cases, the proportional distribution of planted plants is considered the factor that determines the least competition of plant growth. On the other hand, the increasing demand for mechanization of various cultural operations, has prompted different studies to find the most

suitable solutions, which do not always coincide with the optimal ones [6], [7]. Regarding the impact per unit area of the number of plants on the pepper culture, the national bibliographic data, sometimes present contradictory and insufficient information. Meanwhile, foreign literature shows that good results can be obtained in cases where the density of plants per unit area varies from 5 - 11 plants/m². [8], [9]. The effects of planting density are studied not only in relation to total production per plant per m², but also in relation to marketable production [10], [11]. Based on the importance of the pepper culture, as well to highlight the impact that planting density has on biometric, quantitative and qualitative indicators of production in the culture of the pepper, cultivar "Gogozhare", enabled the implementation of this study. Data that are related to nitrogen fertilization of the pepper are insufficient for the level of the producer, where this type of fertilizer generally continues to be used empirically. Also, it should be highlighted that the data for this study purpose conducted in our country, sometimes bring contradictory information.

"Bri Dhia" pepper, is considered as a local autochthonous cultivar with special organoleptic qualities, and it is therefore preferred not only by consumers but also by the agro-processing industry, mainly in the south - eastern part of the country [12]. Considering the importance of different pepper located in this area, as well as to contribute to the solution of these issues, this study was conducted with the aim to highlight the impact of nitrogen fertilization and planting density of the pepper, in biometric and production indicators.

2. MATERIALS AND METHODS

The study was conducted during the time period 2017 – 2019, in the climatic conditions of Devoll region, located in the south - eastern part of Albania. This region is characterized by the peculiarities of the Mediterranean - continental climate. The temperature during the study period, has not deviated from the multi - year average. While the quantity of rainfall has been lower compared to the perennial average. The physical and chemical characteristics of the soil, in the location where the experiment was set up consist as follow: total nitrogen 1.25%; assimilable phosphorus 34.46 ppm; assimilable potassium 153.4 ppm; organic matter 2.65%; total calcium 2.50%; salting 0.60 0/00; aqueous acidity 6.82%; coarse sand 25.45%; fine sand 20.79%; sludge 31.18% and clay 22.58%. The indigenous studied cultivar "Bri Dhia" is characterized by length of fruits over 15 - 20 cm, diameter 2 - 3.5 cm, average pulp thickness and yellow - lemon color. This pepper is widely cultivated farmers of this region and at the same it is highly preferred by consumers and agro-processing industry. The experiment scheme was set up in the form of a randomized block, with four replications and subdivided variants, where nitrogen doses were used in the subdivisions, while density in the variants.

Planting of seedlings was carried out in 20 - 30 May, at distances between rows of 75 cm, while between plants placed in rows were applied distances: 15 cm, 20 cm, 30 cm, 40 cm, 50 cm and 60 cm. As basic fertilization was used mineral fertilizers 150 kg/ha P₂O₅, and 120 kg/ha K₂O, while nitrogen fertilizers were used during the vegetation period according to the scheme 75, 125, 175, 225 and 275 kg/ha. After each nitrogen fertilization, the plants were sprayed in order to cover them and to fight weeds. Also, a plant filling was carried out and necessary antiparasitic treatments were used, in accordance with the needs of the plants. In the meantime, plant irrigation was carried out every 10 - 14 days, depending on plant needs. Five harvests were carried out, with the first harvest taking place in early August while the last in mid - October.

After every harvest, the fruits of the pepper were counted, weighed and divided in two categories: for consumption and out of standard (damaged, rotten fruits or those that do not have the typical shape and color of the cultivar). In the last harvest, unripened (unmatured) fruits with no commercial value were counted and weighed. Their weighing was performed in order to determine the productive potential of the plants. In every five fruits, for each variant and harvest, the following biometric measurements were made: length, diameter,

thickness of the epicarp (fleshy part of the fruit), dry matter of the pericarp and the whole fruit, as well as the percentage of pericarp compared to the ratio of the whole fruit. The average harvest time was calculated according the following formula: KMV (Average Harvest Time) = $(\sum d p)/P$ where d = days of special harvests, calculated starting from the date of the first harvest; p = production of specific harvests and P = total production.

During the vegetation period were obtained other additional data such as: early flowering (expressed in days from transplanting in the field), height and number of flowering internodes in the first and last harvest, the node in which the first flower and fruit has appeared, as well as the height from the ground of the first flower and fruit node. At the last harvest, the plants were pulled out, counted, weighed and also a sample was taken to determine the dry matter. The data obtained were analysed with the variance method and than compared with the established minimum values (MDS).

3. RESULTS AND DISCUSSIONS

The plant density per unit area has significantly influenced the biometric and productive characteristics of the pepper "Bri Dhia". The plants height in the flowering stage (Table 1), has resulted to be higher in the variants with density 8.9 and 6.7 plants/m², compared to the variants with lower density 3.4, 2.7 and 2.3 plants/m². At the end of the vegetative cycle, the plants with higher height were identified in the variants with higher density (76 cm), followed by the variants with lower density 2.7 and 2.3 plants/m² (58 cm). The same results were evidenced for the height of the plants in the first harvest.

Table 1. Effects of plant density on some biometric characteristics of "BRI DHIA" pepper

Measure indicators	Density (plant/m ² /ha)					
	8.9	6.7	4.5	3.4	2.7	2.3
	88889	66667	44445	33334	26667	23334
Plant measurements						
Flowering (days after planting)	29b	30b	31b	32a	32b	33a
Plants height at early flowering (cm)	44A	42A	41AB	39B	38B	37B
Plants height in the first harvest (cm)	60	55	52	50	49	47
Plant height at the end of the cycle (cm)	76A	70A	65B	62BC	59C	58C
Number of ramifications at the end of the cycle (n)	3.8C	4.5C	5.2BC	5.8AB	6.2AB	6.5A
Wet mass at the end of the cycle (t/ha)	14.2	12.5	9.4	8.4	7.6	6.6
Dry matter at the end of the cycle (t/ha)	3.5a	3.1b	2.2b	2.1b	1.9a	1.6a

In terms of flowering time, in higher density variants flowering occurred four days earlier (29 days), compared to lower density variants (33 days). Plant density also affected the number of flowering branches, with larger number of branches appeared in lower density (6.5), compared to smaller number of branches (3.8), in higher density. The results of the study showed that the amount of plant mass that remained in the soil after the last harvest was higher in the variants with higher density (14.2 t / ha) and less in the in variants with lower density (6.6 t/ha). These results are important indicators that enable a better programming for the production of the next crops. Plant dry mass expressed in t/ha at the end of the production cycle resulted higher in density plant variants with a value of 3.5t, and lower in density variants with a value of 3.1t (Table 1).

Market production expressed in gram/plant appeared higher, while the total market production expressed in ton/ha decreases, when the number of plants per square meter is lower (Table 2). The production oriented for consumption purposes, resulted higher in variants with density 8.9 - 6.7, and 4.5 plants/m² (average 41.6 t/ha), compared to the production obtained in variants with lower density 2.7 and 2.3 plants/m² (average 26.25 t/ha).

Table 2. Effects of plant density on production characteristics of "BRI DHIA" pepper

Measured indicators	Density (plant/m ² /ha)					
	8.9 88889	6.7 66667	4.5 44445	3.4 33334	2.7 26667	2.3 23334
Average weight of fruits (grams)	29	30	30	31	31	32
Fruit diameter (mm)	27B	29B	32A	32B	31B	31AB
Fruit for market (gram/ plant)	522C	660C	780BC	899AB	992A	1120A
Number of fruits for market (no/plants)	18C	22C	26BC	29AB	32A	35A
Number of unripened fruits/plants (no.)	3.3A	2.1A	1.5A	1.3B	0.9A	0.6B
Market production t/ha	46.4A	44.0A	34.5A	29.9A	26.4B	26.1B
Scarce production (% by weight)	20a	18a	17ab	15b	14b	12b
Average harvest time (days)	45	47	48	49	50	51

The number of fruits per market has the same trend as the level of production for each plant, respectively 18 and 35 fruits. In higher density plants, a higher percentage of non-standard fruits are produced (about 20%), compared to the production obtained in lower density varieties 2.7 and 2.3 plants/m² (average 13%). In varieties with density 4.5 and 3.4 plants/m² are identified higher fruit diameter values (about 32 mm), compared to pepper obtained in varieties with higher density (29.5 mm).

In terms of the results obtained in relation to the impact of nitrogen fertilizer doses on the indicators of the pepper "Bri Dhia", it appears that there are some minor changes in morphological and production indicators. In this context, the only exception it is observed on the data related to the production of non-standard fruits in all harvests. These indicators highlight the fact that in the variants where there are higher doses of nitrogen, there are lower production units. Related the ratio between the length of the fruits and their diameter, it results that this ratio is smaller in variants with low and high doses of nitrogen (Table 3).

Table 3. Effects of nitrogen fertilization on the production and biomorphological characteristics of the fruits on "Bri Dhia" pepper

Measured indicators	Nitrogen doses kg/ha				
	75	125	175	225	275
Average weight of fruits in all harvests (gram)	29	31	32	30	28
Average weight of fruit in the third harvest (gr)	40a	42a	43b	39ab	38b
Total market production (t/ha)	30.0	31.5	32.6	31.0	28.3
Total number of fruits on the market for each plant (no)	32	32	33	32	31
Fruit ratio length/diameter in the first harvest.	6.6a	6.9a	7.1b	6.5a	6.3a
Scarce fruit production on the 5th harvest (t/ha)	3.9a	4.1a	4.3a	4.5b	4.8b
Total scarce fruit production (t/ha)	5.4AB	5.8A	6.2A	6.5B	6.8B
<i>N.B The values of this table are statistically verified. Lowercase letters indicate authenticity for level 0.05, while those with uppercase letters indicate level 0.01.</i>					

The results of the study indicate that the average weight of pepper fruits does not differ significantly, ranging from low to high nitrogen fertilizer variants. In plants with low density variants ranging from 2.7 and 2.3 plants/m² has resulted that the average weight of the fruit is lower at the nitrogen dose of 75 kg/ha and higher at a dose of 175 kg/ha. Based on the analysis for assessing the morphological changes of the fruits of the pepper, according to the harvest, it has resulted that the average weight is higher in the third and fourth harvest, compared to fifth and first harvest. The diameter of the fruits had a smaller value in the fruits of the first harvest, compared to other harvests, while the length appears to be statistically different between the harvests, taking higher values in the third and fourth harvest, and lower values in the first and last harvest.

Table 4. Biometric characteristics of the fruits according to harvest

Fruit characteristics	Harvest				
	8/8	24/8	8/9	24/9	10/10
Average weight (gram)	28C	31AB	32.5A	32A	30B
Fruit length (cm)	18C	22A	23B	25	20D
Fruit diameter (mm)	28B	31A	32AB	35C	30A
Ratio length diameter	6.4A	7.1B	7.2B	7.1C	6.7C
Epicarp thickness (mm)	4.2a	4.5c	4.6b	4.4c	4.1b
Pericarp weight (%)	78ab	80ab	81b	79a	77a
Dry pericarp substance (%)	7.5A	8.5A	8.6A	8.0B	7.0C
Dry mass of whole fruit (%)	10A	9.5a	9.4a	9.2A	9.0ab

Even the length/diameter ratio has also resulted in higher values in intermediate density variants, indicating that there are different ratios between them. The diameter of the fruit has generally appeared to be larger in the third harvest. The thickness of the epicarp is greater in the fruits of the third and second harvest. Data on the dry mass of the epicarp of the whole fruit, as well the weight of the pericarp expressed in percentage, showed higher values in the second, third and fourth harvest.

4. CONCLUSIONS

- Plant density per unit area influence significantly the biometric and productive characteristics of the pepper "Bri-Dhia";
- The height of the plants in the flowering stage and at the end of the cycle, is higher in variants with density of plants ranging from 8.9 and 6.7 plants/m², compared to variants with lower density (3.4, 2.7 and 2.3 plants/m²);
- Plant density affect the number of flowering branches, where the largest number of branches (6.5), appears to be in lower density, compared to the number of branches (3.8), in higher density;
- Market production of fruits (gram/plant), increases by reducing the number of plants per square meter, while the total market production expressed in ton/ha, decreases. The number of fruits for consumption purposes has the same trend as the production of fruits per plant;
- At the end of the production cycle, the dry mass of the plant expressed in t/ha, is larger in higher density variants (3.5t) and smaller in low density variants (3.1t) (Table 1);
- The wet plant mass that remains in the soil after the last harvest, is larger in higher density variants (14.2 t/ha) and smaller in lower density variants (6.6 t/ha);
- The level of nitrogen used affect the morphological and production indicators of the "Bri Dhia" pepper, but these changes appear to be minor;
- Based on the assessment of morphological changes of fruit pepper according to the harvest, it results that the average weight is higher in the third and fourth harvest, compared to fifth and first harvest;
- Fruit diameter and epicarp thickness, have higher values in the third and fourth harvest, compared to the first and last harvest. The results obtained in relation to the dry mass of the epicarp, whole fruit and as well the weight of the pericarp, expressed in percentage, show that they have higher values in the fruits of the second, third and fourth harvest.

5. REFERENCE

- [1] Islam, M., Saha, S., Akand, H. and Rahim, A. (2011). Effect of spacing on the growth and yield of sweet pepper (*Capsicum annum* L.) Journal of central European agriculture, 12(2);
- [2] Tesi, R. (1994). - Principi di orticoltura e ortaggi di Italia. Edagricole. Bologna;

- [3] Maniutiu, D., Sima, R., Apahidean, A.S., Apahidean, M. & Ficior, D. (2010). The influence of plant density and shoot pruning on yield of bell pepper cultivated in plastic tunnel. *Bulletin UASVM Horticulture*, 67(1);
- [4] Alam, M.S., Saha, S.R., Salam, M.A. and Alam, M.K. (2011). Effect of sowing time and plant spacing on the yield and yield attributes of sweet pepper (*Capsicum annuum*). *Bangladesh J. Agril. Res.* 36(1);
- [5] Aminifard, M.H., Aroiee, H., Ameri, A. & Fatemi, H. (2012). Effect of plant density and nitrogen fertilizer on growth, yield and fruit quality of sweet pepper (*Capsicum annuum L.*). *African Journal of Agricultural Research*, 7(6);
- [6] Bianco V.V.; Pinpini F. (1990). - *Orticultura*. Bologna;
- [7] Dasgan, H.Y. & Abak, K. (2003). Effects of plant density and number of shoots on yield and fruit characteristics of peppers grown in glasshouses. *Turkish Journal of Agriculture & Forestry*, 27;
- [8] (Srinivas, 1982); [9] (Evert 1984);
- [10] Nasto, Th., Bardhi N. (2004) - *Bazat e perimtarisë dhe prodhimi i perimeve*. Tiranë;
- [11] Tase, Ll, (1986) - *Studimi i dendësisë së mbjelljes së specit tip “Gjelbëroshi”*. B.SH.B. Nr. 4, 1986, Tiranë;
- [12] Nasto, T.H., Balliu, A. and Zeka, N. (2009). The influence of planting density on growth characteristics and fruit yield of pepper (*Capsicum annuum L.*). *J. Acta Hortic.*, 830.



This work is licensed under a Creative Commons Attribution Non-Commercial 4.0 International License.