Journal of Agricultural, Food and Environmental Sciences Vol 76 No 8 (2022) 28-34
DOI: https://doi.org/10.55302/JAFES22768028a

IMPACT OF THE DIFFERENT VEGETATION SPACES ON THE YIELD COMPONENTS OF SEEDLESS WATERMELON

Rukie Agic[1*], Gordana Popsimonova[1], Zvezda Bogevska[1], Margarita Davitkovska[1], Besnik Zendeli[2]

[1]University of Ss. Cyril and Methodius, Faculty of Agricultural Sciences and Food, Skopje, Republic of North Macedonia
[2]High Agricultural School "Brakja Miladinovci", Skopje, Republic of North Macedonia
[*]e-mail: rukieagic@fznh.ukim.edu.mk

ABSTRACT

Recently seedless watermelon production is becoming popular, especially for export, and has significant potential for larger area production. Although the production practices for growing seedless watermelons are similar to those for the production of seeded watermelons, they still differ in certain views, which should be put into focus. The aim of this research is to determine the best vegetation space for the plants (the use of different row and inter-row distances) on the components of yield. For this purpose, an experiment was set up using seedlings from the seedless hybrid Sinrubita F1. The experiment was set up in the Skopje region with a randomized block design, with three variants in four replications. The treatments were as follows: Treatment 1 (control) (3x1.65 m, 2000 plants ha^{-1}); Treatment 2 (3x1.30 m, 2500 plants ha^{-1}) and Treatment 3 (3x0.96 m, 3500 plants ha^{-1}). Several parameters were analyzed: the average number of fruits per plant, the weight of fruit (kg), the diameter of the fruit (cm), the fruit length (cm), the fruit index, and the total yield (t/ha). The biggest fruit (6.97 kg), fruit diameter (21.77 cm), and fruit length (24.29 cm) were determined in the control treatment while the highest fruit number (4.38) and yield (65.05 t ha^{-1}) were obtained in the treatment 2. The fruits of the three treatments had a slightly elliptical shape.

Key words: fruit number, fruit weight, fruit index, row distance, crop production.

INTRODUCTION

The main goal of horticultural production, which includes the production of a large number of vegetable species, including watermelon, is the intensification of total production. Over time, crop production focused on enhancing the level of phytonutrients, i.e., human wellness compounds in vegetables (Lester, 2006). This can be achieved by optimizing agro-ecological conditions by applying appropriate agro-technical measures.

Watermelon (*Citrulus lanatus* L.) is an important vegetable crop grown for its ripe, sweet, and tasty fruits, with a pleasant aroma and refreshing taste. So far, there are many cultivars and hybrids of seeded and seedless watermelons. In recent years, seedless hybrid watermelons have become more and more attractive to the market, because they meet the needs of consumers on the one hand and the needs of producers and traders on the other. Commercial production of seedless watermelons began in the 1990s (Cushman et al., 2003). Since then, it has been constantly increasing so currently it occupies a significant part of the current offer on the watermelon market. Although the first seedless hybrids were characterized by a much lower level of sugars and a not as sweet taste as the seeded cultivars, the breeders have significantly improved these characteristics, so that this problem does not occur in the new hybrids (Goldy, 2012). The evaluation of thirty-five seedless watermelon varieties produced under local conditions in Central Kentucky showed that Talca and Maxima have consistently performed well for yield and quality (Saha et al., 2017). In southwestern Indiana, a promising standard-size triploid watermelon was Red Amber while Sirius was the best yielding of personal-size triploid watermelon (Guan et al., 2020). Triple Crown, Millionaire, Cooperstown, Summer Sweet 5244, and Crimson trio can be recommended as mid- to late-maturing cultivars while Tri-X 313 and Tri-X Carousel can be recommended as early-maturing cultivars for commercial production in Mississippi (Cushman et al., 2003).

Plant density is a factor determining the degree of competition between plants (López-Elías et al., 2011, Stone et al., 2019). Watermelon yield, fruit weight, and number can be adjusted by in-row spacing (Motsenbocker & Arancibia, 2002; Ramos et al., 2009; López-Elías et al., 2011; Sabo et al., 2013; Oga & Umekwe, 2016; De Paula et al., 2020). If a grower bases the decision on in-row spacing only on maximizing yield, then narrower spacing appears to be optimal (Roberts & Duthie, 1995; Motsenbocker & Arancibia, 2002; Ramos et al., 2009; Campagnol et al., 2012; Stone et al., 2019). Different spacing did not affect the fruit quality (Ramos et al., 2009) although it was found that lower plant spacing provided higher total soluble sugars to the fruits (De Paula et al., 2020). It is very important to note that to achieve optimal yields from triploid watermelons, 20% to 33% of the plants in the field should be diploid in order to provide pollen for pollination of triploid varieties (Parsons et al., 2000; NeSmith & Duval, 2001; Fiacchino & Walters, 2003).

In this study, the main accent was stressed on one of the production aspects that determine the success of seedless watermelon production, i.e. the influence of the vegetation space (different in-row and inter-row spacing) on the yield and yield components was investigated.

MATERIAL AND METHODS

The experiment was set up with grafted seedling of seedless watermelon, Sinrubita F_1 hybrid. The Sinrubita F_1 hybrid is a Miyako type of hybrid, but different from the classic Miyako type. The hybrid is characterized by a light green color of the rind, interspersed with thin dark green stripes. The plants are characterized by medium vigor, but they still branch well, and the skin of the fruits is resistant to cracking. The fruits are of medium size, that is, with an average weight of 4 to 6 kg, and they have excellent taste and a high sweetness index. A positive feature of this hybrid is early maturity.

The seedlings were produced by grafting on a bottle gourd (*Lagenaria siceraria* (Molina) Standl.) in the area of Divjak, Albania.

The seedlings were planted outdoors, on 2. May in Lisice, Skopje, at an altitude of 260 m, on an alluvium soil type. As several authors have stated that in order to achieve pollination in triploid watermelons, it is necessary to plant diploid watermelons in the field. For this purpose in this research, for every 4 seedless watermelon plants, one-seeded watermelon (Paulina F_1) plant was planted.

The experiment set up was a randomized block design, in three treatments, with four replications each. The treatments were arranged depending on the planting density of the seedlings, with the schedule being as follows:

- Treatment 1 (control) - the seedlings were planted at a distance of 1.65 m in the row and 3 m between the rows, with a plant spacing of 2000 plants ha^{-1}, since this arrangement of plants is most often applied in practice among producers, this treatment was taken as a control variant,

- Treatment 2 - the seedlings were planted at a distance of 1.30 m in the row and 3 m between the rows, with a plant spacing of 2500 plants ha^{-1} and
- Treatment 3 - the seedlings were planted at a distance of 0.96 m in the row and 3 m between the rows, with a plant spacing of 3500 plants ha^{-1}.

According to the planting density, in the first treatment one plant occupied a vegetation area of 4.95 m^2, in the second treatment the vegetation area for one plant was 3.90 m^2, while in the third variant 2.88 m^2.

During the growing season, several common agro-technical measures were applied top dressing, plant protection, and regular irrigation.

In order to understand the impact of different densities, the following parameters were measured: the average number of fruits per plant, the weight of fruit (kg), the diameter of the fruit (cm), the fruit length (cm), the fruit index, and total yield (t ha^{-1}).

Obtained data were statistically processed by analysis of variance (ANOVA). The sample means among treatments were compared by least significant difference (LSD) tested at 1 and 5% probability levels.

RESULTS AND DISCUSSIONS

Species grown in high densities, especially cucurbits, produce a large number of fruits per area, but with small size, weight, and number per plant, which may affect their development, and consequently, the final quality of fruits (Sabo et al., 2013; Oga & Umekwe, 2016). The number of fruit per plant decreased significantly as density increased (López-Elías et al., 2011). The same authors stated that the treatment with vegetation space of 2x1.55m gave a significantly higher number of fruits per plant (2.5) in comparison with the treatment of 2x1.25m and control. Ramos et al., 2009 found that plant spacing did not significantly affect the fruit number and was 3.0 (2.0 x 0.5m), 2.9 (2.0 x 0.4m), and 2.5 (2.0 x 0.3m). The number of fruit in Crismon Jewel triploid watermelon differed from 2.1 (0.3 m in-row spacing) to 4.5 (2.4 m in-row spacing) (Motsenbocker & Arancibia, 2002). De Paula et al., 2020 reported that the production attributes, such as number of fruits per plant and yield were not affected by plant spacing or application of plant biostimulant. The number of fruits per plant with the application of biostimulant was 1.16 (2x0.4m), 1.06 (2x0.45), and 1.43 (2x0.5m) while without the application of biostimulant was 0.97 (2x0.4m), 1.39 (2x0.45), and 1.58 (2x0.5m). Plant spacing of 50cm x 60cm at non-pruned treatment produced the highest number of fruits (3.13) while the 50cm x 50cm on the non-pruned plant gave the lowest number of fruits (1.75) (Oga & Umekwe, 2016). Sabo et al., 2013 stated that interaction between the treatments indicated that 150 kg/ha of NPK and a spacing of 1 × 1.5 m gave the highest number of fruit and yield per hectare. The current study showed similar results to previous studies whereas the densest treatment 3 (3x0.96 m) gave a non-significant lower number of fruits (3.94) (Table 1a.)

According to the results (Table 1b.), the fruit weight differed significantly and was from 4.09 kg in treatment 3 (3x0.96 m) to 6.97 kg in treatment 1 - control (3x1.65 m). Fruit weight per plant linearly increased with wider in-row spacing considering that spacing of 1.8-2.4m resulted in heavier "Crismon Jewel" fruits (Motsenbocker & Arancibia, 2002). In the study of López-Elías et al., 2011 the average fruit weight was increased by 10% with plant spacing at 2.00 m. It was confirmed that the fruit weight did not vary significantly with respect to spacing (Ramos et al., 2009; Campagnol et al., 2012; Sabo et al., 2013). De Paula et al., 2020 found that the average weight of fruit (4.02 kg) was higher in the larger spacing without the application of biostimulant.

The variety evaluation in Indiana showed that the average fruit weight varied from 4kg in Eclipse to 8 kg in ORS6375a standard-size triploid watermelon (Guan et al., 2020).

The average value for the diameter of the fruits is directly proportional to the average values for the previously examined parameter the weight of fruits. Thus, treatment 1 - control (3x1.65 m) (21.77 cm) had the highest average value for the diameter, followed by treatment 2 (3x1.30 m), where the average value for the diameter of the fruits was 20.88 cm, and treatment 3 (3x0.96 m) with the lowest average value for the diameter of fruit (19.24 cm). The differences in mean values were significant at the probability level of 0.01 (Table 1c.). The diameter of the fruit of the seedless watermelon hybrid 'Tri-X 313' was from 13.2cm in the control treatment (2x1m) to 20.9 cm in the treatment of 2 m x 1.55 m (López-Elías et al., 2011). Ramos et al., 2009 and Campagnol et al., 2012 found that the mean fruit diameter did not vary significantly. In standard-size triploid watermelon, the diameter of the fruit varied from 20.3 cm in SV0502WA to 25.8 cm in ORS6375a while in personal-size triploid watermelon it was from 16.8 cm in Ocelot to 20.2 cm in Ana (Guan et al., 2020).

The assessment of varieties in Indiana showed that the length of the fruit varied from 21.3 cm in Eclipse to 27.9 cm in Red Garnet in standard-size triploid watermelon while in personal-size triploid watermelon it was from 17.8 cm in Ocelot to 21.0 cm in Ana (Guan et al., 2020). Ramos et al., 2009 and Campagnol et al., 2012 also found that the mean fruit length did not vary significantly. According to the obtained results, the length of the fruit varied significantly at the probability level of 0.01 from 22.27 cm in treatment 3 (3x0.96 m) to 24.29 cm in treatment 1 - control (3x1.65 m) (Table 1d.).

The current study (Table 1e.) indicated that the fruits of the three treatments were characterized by a slightly elliptical shape and were affected by the plant spacing. The shape index was calculated by the ratio between the fruit length and diameter (Campagnol et al., 2012). The same authors stated that the fruit shape index of mini watermelon Smile showed that fruits were almost round with an index from 1.01 in 4.76 plants/m^2 to 1.02 in 3.17plants/m^2 but it was not affected by plant spacing. The experimental trial in Mississippi showed that most entries were oval and similar in shape to Tri-X313, however, Constitution and Genesis were more round than oval, and SXW 8062, Summer Sweet 5544, and Wrigley were slightly more oblong than oval.

Ramos et al., 2009 found that the higher density of plants was proportioned to higher yields. On the contrary, grafted watermelon plants of seedless watermelon hybrid Tri-X 313 obtained more yield per plant when planting density was decreased (spaced was increased) (López-Elías et al., 2011). Marketable yield of Crismon Jewel was not affected by in-row spacing while narrower in-row spacing (0.6-1.2m) was optimal for maximum yield of the smaller fruited cultivar Honeyheart (Motsenbocker & Arancibia, 2002). In the research of De Paula et al., 2020, obtained yields were not affected by plant spacing or application of plant biostimulant, and the 50 cm in-row spacing was the recommended plant spacing for Quetzali watermelon plants. Also, the effect of plant spacing, pruning, and their interaction had no significant effect on the production of watermelon whereas plant spacing at 50cm x 60cm on the non-pruned plants produced the highest yield (84.7 t ha^{-1}) while the 50x40cm on the pruned plants (39.6 t ha^{-1}) gave the lowest yield (Oga & Umekwe, 2016). Contrary, Sabo et al., 2013 found that the interaction of NPK fertilizer and spacing on the yield of watermelon was statistically significant.

Table 1. Comparison between different vegetation spaces for the examined traits

Examined traits by treatments	Treatments		
	Treatment 1 - control (3x1.65 m)	Treatment 2 (3x1.30 m)	Treatment 3 (3x0.96 m)
a. The average number of fruits per plant		LSD 0.05=0.47^{a}	LSD 0.01= 0.68^{A}
Treatment 1 - control (3x1.65 m)	**4.06**	-0.32	0.12
Treatment 2 (3x1.30 m)	0.32	**4.38**	0.44
Treatment 3 (3x0.96 m)	-0.12	-0.44	**3.94**
b. The weight of fruit (kg)		LSD 0.05=0.33^{a}	LSD 0.01= 0.48^{A}
Treatment 1 - control (3x1.65 m)	**6.97**	1.02^{A}	2.88^{A}
Treatment 2 (3x1.30 m)	-1.02^{A}	**5.95**	1.86^{A}
Treatment 3 (3x0.96 m)	-2.88^{A}	-1.86^{A}	**4.09**
c. The diameter of the fruit (cm)		LSD 0.05=0.35^{a}	LSD 0.01= 0.50^{A}
Treatment 1 - control (3x1.65 m)	**21.77**	0.89^{A}	2.53^{A}
Treatment 2 (3x1.30 m)	-0.89^{A}	**20.88**	1.64
Treatment 3 (3x0.96 m)	-2.53^{A}	-1.64	**19.24**
d. The fruit length (cm)		LSD 0.05=0.24^{a}	LSD 0.01= 0.35^{A}
Treatment 1 - control (3x1.65 m)	**24.29**	0.40^{A}	2.02^{A}
Treatment 2 (3x1.30 m)	-0.40^{A}	**23.89**	1.62^{A}
Treatment 3 (3x0.96 m)	-2.02^{A}	-1.62^{A}	**22.27**
e. The fruit index		LSD 0.05= 0.01^{a}	LSD 0.01= 0.02^{A}
Treatment 1 - control (3x1.65 m)	**1.12**	-0.02^{A}	-0.04^{A}
Treatment 2 (3x1.30 m)	0.02^{A}	**1.14**	-0.02^{A}
Treatment 3 (3x0.96 m)	0.04^{A}	0.02^{A}	**1.16**

a = significant at 5%. A = highly significant at 1%

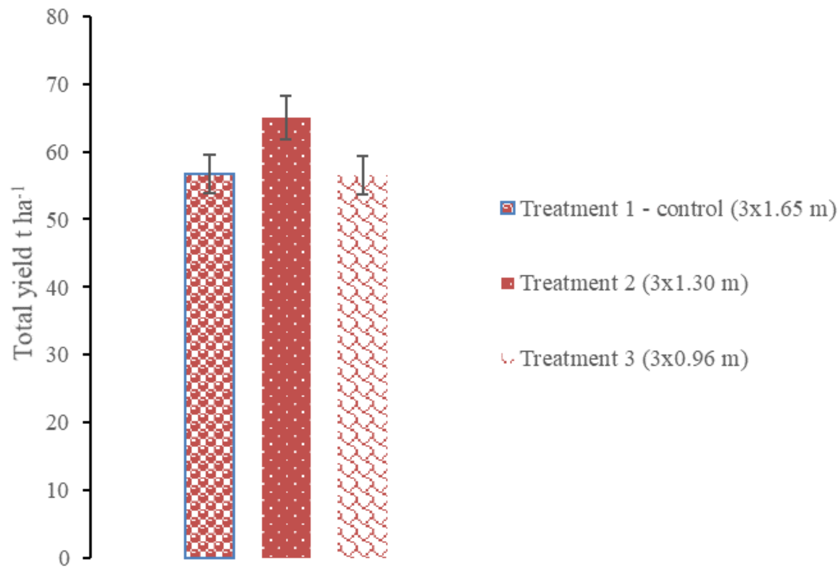

Figure 1. Total yield t ha^{-1}

The highest yield (63.6 t ha^{-1}) was obtained from the combination of 150 kg/ha with 1×1.5 m spacing and the lowest yield (18.3 t ha^{-1}) from the combination of control with 1×1 m spacing. In addition, Campagnol et al., 2012 also confirmed that the total yield was significantly higher in denser spacing 4.76 plants/m^2 (67.68 t ha^{-1}) while in 3.17 plants/m^2 (46.60 t ha^{-1}) it was by 31.15% lower. According to the data presented in Figure 1, treatment 2 (3x1.30 m) had the highest statistically approved average yield of 65.05 t ha^{-1}, while treatment 3 (3x0.96 m) had the lowest yield of 56.44 t ha^{-1}.

CONCLUSIONS

According to the results obtained, it can be concluded that the most optimal density for the production of seedless watermelon was the vegetation space in Treatment 2 of 3.90 m^2, where a distance of 1.30 m in the row and 3 m between the rows was used, with a plant spacing of 2500 plants ha^{-1}. In this treatment, the highest yield was achieved, and the fruits were distinguished by a smaller mass and smaller sizes, which are currently demanded on the market.

REFERENCES

Campagnol, R., Mello, S. C., & Barbosa, J. C., (2012). Vertical growth of mini watermelon according to the training height and plant density. *Horticultura Brasileira 30*(4): 726-732.

Cushman, K. E., Snyder, R. G., Nagel, D. H., & Gerard, P. D., (2003). Yield and Quality of Triploid Watermelon Cultivars and Experimental Hybrids Grown in Mississippi. *HortTechnology 13*(2): 375-380.

De Paula, V. F. S., Vilvert, J. C., De Aráujo, N. O., Do Nascimento, I. B., De Medeiros, J. F., & Aroucha, E. M. M., (2020). Influence of plant biostimulant and spacing on production and postharvest conservation of watermelons cv. Quetzali. *Adv. Hort. Sci., 34*(2): 183-189 DOI: 10.13128/ahsc8306

Fiacchino, D.C., & Walters, S.A. (2003). Influence of diploid pollenizer frequencies on triploid watermelon quality and yields. *HortTechnology 13*:58–61.

Goldy R., (2012). *Seedless watermelon - how do they do that?* Michigan State University Extension. https://www.canr.msu.edu/news/seedless_watermelon_how_do_they_do_that

Guan, W., Nowaskie, D., Haseman, T. D. H., & Egel, D. (2020). *2019 Standard-size and Personal-size Triploid Watermelon Variety Evaluation in Indiana*, Midwest Vegetable Trial Reports. Paper 10. https://docs.lib.purdue.edu/mwvtr/10

Lester, G.E., (2006). Environmental regulation of human health nutrients (ascorbic acid, carotene, and folic acid) in fruits and vegetables. *HortScience 41*:59–64.

López-Elías, J., Huez-López, M. A., Jiménez-León, J., Rodríguez, J. C., Garza-Ortega, S., & Escoboza-García, L. F. (2011). Efecto de la densidad de plantación en sandía sin semilla injertada sobre bule (Lagenaria siceraria (Molina) Standl.). [Effect of plant density on seedless watermelon grafted onto bottle gourd (Lagenaria siceraria (Molina) Standl.) rootstock]. *Tropical and Subtropical Agroecosystems*, *14*: 349-355

Motsenbocker, C. E., & Arancibia R. A., (2002). In-row Spacing Influences Triploid Watermelon Yield and Crop Value. *HortTechnology 12*(3): 437-440.

NeSmith, S., & Duval, J. (2001). Fruit set of triploid watermelon as a function of distance from a diploid pollenizer. *HortScience 36*:60–61.

Oga I. O., & Umekwe P. N., (2016). Effects of pruning and plant spacing on the growth and yield of watermelon (*Citrullus lanatus* L.) in Unwana-Afikpo. *Int. J. Sci. Res., 5*(4): 110-115.

Parsons, J., Stein, L., Longbrake, T., Cotner, S., & Johnson, J. (2000). *Seedless Watermelon Production*. Published by the Texas Agricultural Extension Service.

Ramos, A. R. P., Dias, R. C. S., & Aragão, C. A. (2009). Densidades de plantio na produtividade e qualidade de frutos de melancia (Yield and quality of watermelon fruits cultivated under different planting densities). *Horticultura Brasileira 27*: 560-564.

Roberts, W., & Duthie, J., (1995). Watermelon Yield as Affected by Plant Density and Spatial Arrangement. *HortScience, 30*(4):754

Sabo, M. U., Wailare, M. A., Aliyu, M., Jari, S., & Shuaibu, Y. M., (2013). Effect of NPK fertilizer and spacing on growth and yield of watermelon (*Citrullus lanatus* L.) in Kaltungo local government area of Gombe State, *Nigeria. Scholarly J. Agric. Sci., 3*(8): 325-330.

Saha, S., Snyder, J., & Walsh, J., (2017). *Kentucky Seedless Watermelon Variety Trial, 2016*. Midwest Vegetable Trial Reports. Paper 193. https://docs.lib.purdue.edu/mwvtr/193

Stone, S. P., Boyhan, G. E., & Johnson, W. C. (2019). The Impact of Weeding Regime, Planting Density, and Growth Habits on Watermelon Yield in an Organic System. *HortTechnology 29*(5): 571-577.