Bulgarian Journal of Agricultural Science, 26 (No 3) 2020, 540–544

Microsprinkling effect on the microclimate in vine nursery

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Abstract

Tsvetanov, E., Koumanov, K., Matev, A. & Prodanova-Marinova, N. (2020). Microsprinkling effect on the microclimate in vine nursery. *Bulg. J. Agric. Sci., 26 (3)*, 540–544

Subject of investigation was the evaporative-cooling effect of microsprinkler irrigation on improving vine production in the nursery. According to the obtained results, microsprinkling reduced the temperature of the aboveground air by 2.1-4.8°C and increased the air relative humidity by 4.4–15.8% on the average. The microsprinkling impact on the grafted cuttings was manifested by average decrease of 1.8°C and 4.2°C in the wax and the leaf temperature respectively. Microsprinkling did not affect the soil-surface temperature, which was dependent on soil moisture – a much more conservative parameter.

Keywords: **v**iticulture; vine nursery; irrigation; microclimate; micro

Introduction

The production of grafted-vine planting material originated from the phylloxera invasion in Europe that reached Bulgaria in 1884 (Lilov & Dimitrov, 1963). The introduction of this new method required developing of specific nursery management procedures. Nowadays, the production of vine planting material from nursery-grown grafted cuttings in open-field conditions gains widest practical application. Its specificity is the graft-zone waxing, which prevents the stock/scion union from drying and allows shallower planting of the cuttings with scion remaining above the soil surface (Virgil, 1977; Mamarov & Neshev, 1977; Gromakovskiy, 1984). A key factor for this technology is the aboveground air humidity, which should not drop below 50-60% during the first 45 days after planting (Radulov, 1979). In the same time, air temperature should not exceed 35°C, because of the heat adverse effect on grapevine photosynthesis (Stoev et al., 1960). The optimum air temperature for vines is considered to be 28-32°C (Slavcheva, 1986; Stoev et al., 1960). Under extreme weather conditions plants quickly lose water, their vascular conductivity is disturbed, and the supply of water and nutrients is hampered (Borodychev, 1989).

Microirrigation has been increasingly used in agriculture and especially in viticulture because of the potentialities for an effective control on the processes taking place in both the irrigation system and the irrigated crop. With microsprinkling, irrigation water is applied over a surface area larger than that under drip irrigation. Microsprinkling meets most of the requirements for optimum irrigation in the nursery, providing: 1) high air humidity (vital for vines, especially during the first two months after planting); 2) uniform wetting of the active soil volume; 3) application of plant protection products, fertilizers and biologically active substances with the irrigation water; and 4) continuous operation of the irrigation system with low rain intensity during the hot hours of the day (Schwankl et al., 1999; Ovchinnikov et al., 2016; Rankova et al., 2016).

The impact of microsprinkling combined with drip irrigation on the yield of vine planting material and the economic effect of this irrigation system is reported by Ovchinnikov et al. (2016). However, the effect of microsprinkling on the microclimate in nurseries has not been studied in our geographical region so far.

Objective

The objective of this study was to determine the microsprinkling impact on both microclimate and grafted cuttings in a grapevine nursery.

Material and Methods

The nursery was located in the experimental field of the Institute of Viticulture and Enology, Pleven (43.42°N 24.62°E and 140 m altitude). The grafted cuttings were grown with scion above the soil surface, which was not mulched with polyethylene foil.

WaterBird VI Classic microsprinklers with flow rate q = 156 l h^{-1}, at 0.2 MPa pressure and radius of operation r = 5.0 m were used for regulating the microclimate parameters within the optimum ranges. Microsprinklers were installed in a square grid (Dzhuninski, 1980), with distance between the sprinklers a = 1.42 r = 7 m, where the area irrigated by one microsprinkler was $F_S = 2r^2 = 50$ m^2, and the rain intensity $i = q/F_S = 3.1$ mm h^{-1}. The evaporative-cooling irrigation was performed in three one-our cycles per day between 9:00 and 16:00 hours. In each cycle, the irrigation system was operated 20 minutes with application rate m = 1 mm.

Two automatic iMetos weather stations were used for estimating the evaporative cooling effect. The first one was placed in the nursery, at the height of the grafted cuttings, in order to record the microsprinkling effect on meteorological parameters. The second weather station was located 500 m away from the nursery to avoid the influence of the irrigation, and its readings were used as controls.

The experiment was carried out in 2016 and 2018. In 2016, the period of observations lasted from 13 June to 26 June and the weather station readings were recorded round-the-clock at 30-minute intervals. In 2018, the period of observations lasted from 29 May to 1 June and the station readings were recorded at 20-minute intervals from 8:00 till 16:00 hours. In 2018, because of safety reasons, the nursery weather station used to be installed at 8:00 hours and stowed at 16:00 hours every day during the experiment.

The microsprinkling effect on the temperature of the leaves, of the wax, and of the soil surface was estimated from readings of an infrared thermometer. The experiment was carried out on 17 June between 13:30 and 14:00 hours. The readings were taken in 10 replicates and the data were statistically processed using analysis of variance of the single-factor experimental reports (Dimova & Marinkov, 1999).

Results and Discussion

Figure 1 shows the air temperature and relative air humidity readings from the both automatic weather stations in 2016. As it is seen, the air humidity and the air temperature

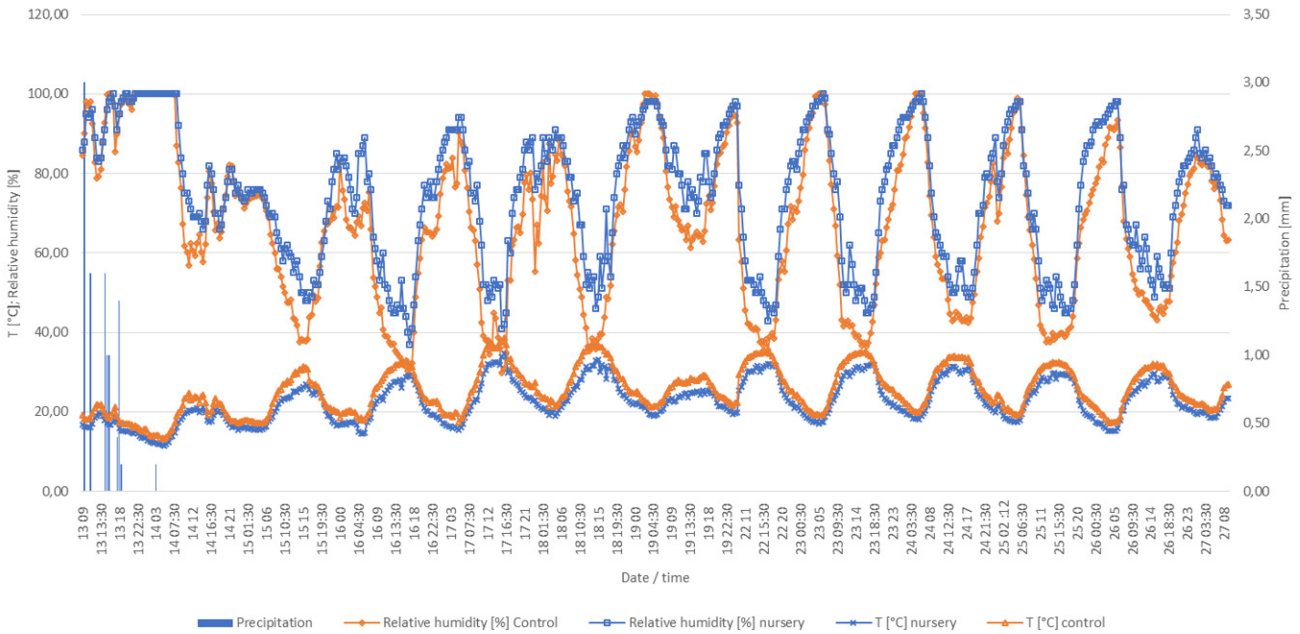

Fig. 1. Precipitations and course of air temperature and relative air humidity during the period 13–26 June 2016

values were almost the same when the microsprinkling was off. During the operation of the microsprinkling system, however, the air humidity in the nursery markedly increased and the temperature decreased.

Figures 2 and 3 shows the relative humidity and the air temperature course in the same period, but only for the hours when the microsprinkling was operated; the means of both parameters are shown close to each daily graph. The optimum range and the critical maximum of the air temperature (35°C), as well as the lower threshold of the optimal air humidity (50%) are indicated as well. Apparently, microsprinkling significantly decreased air temperature and increased air humidity. Under the experimental conditions, microsprinkling maintained the air temperature below the critical maximum for the vines. The air humidity values were maintained in the optimum range.

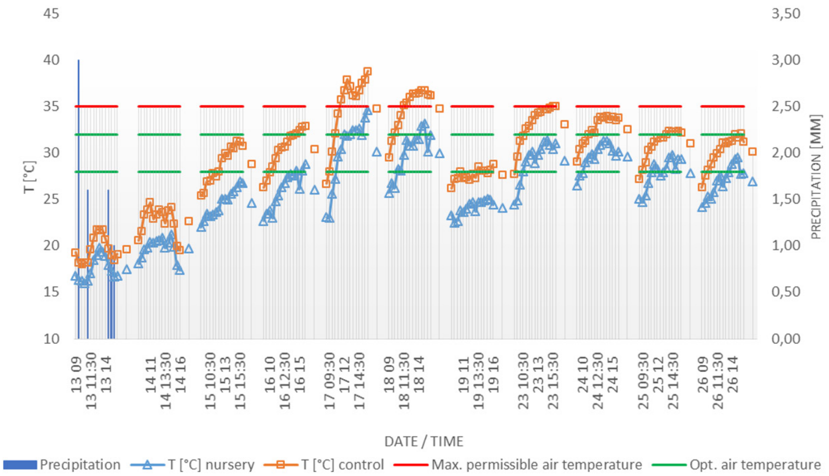

Fig. 2. Precipitations and course of the air temperature between 9.00 and 16:00 hours presented by dates for the period 13–26 June 2016

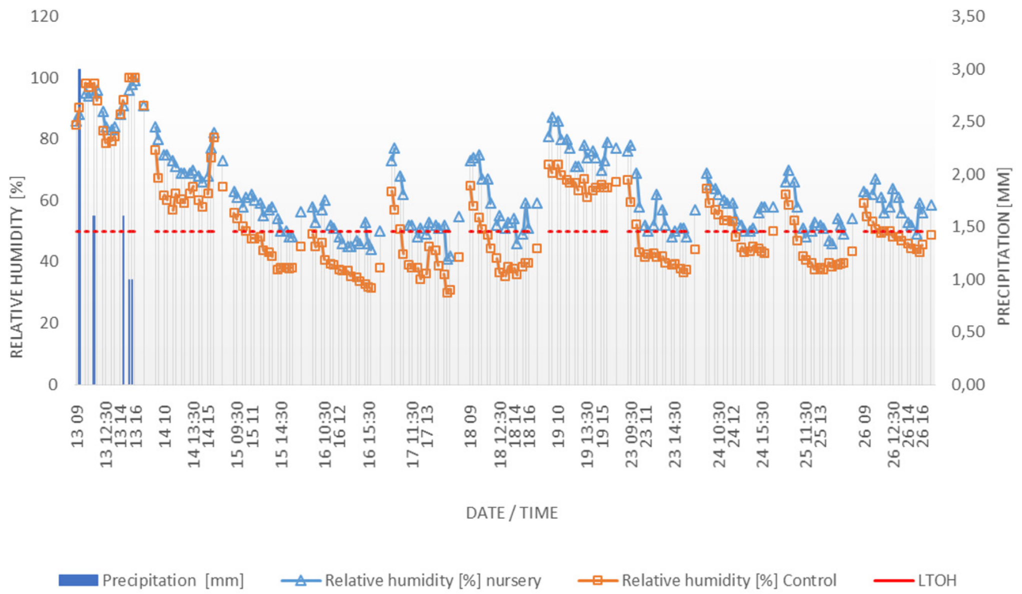

Fig. 3. Precipitations and course of the relative air humidity between 9.00 and 16:00 hours presented by dates for the period 13–26 June 2016; LTOH – lower threshold of the optimal relative humidity

The four-day repetition of the experiment in 2018 confirmed the results for the air temperature obtained in 2016 (Figure 4).

The anomaly observed in air humidity during the initial hours of microsprinkling in 2018 (Figure 5) resulted from the daily cycle of installing and stowing the weather station and the necessary time for its acclimatization. Though microsprinkling increased the air humidity by about 9%, its afternoon values remained below the optimum threshold.

The daily means of both air temperature decrease and air humidity increase, evaluated from the data of the two weather stations for the microsprinkling operation periods, are given in Tables 1 and 2 for 2016 and 2018 respectively. The air temperature decrease of 2.1–4.8°C and the air humidity increase of 4.4–15.8% proved the microsprinkling suitability for microclimate regulation in the vine nursery. Rainy weather on 13 Jun 2016 explains the negligible difference between the nursery and the control air humidity readings.

The cooling effect of microsprinkling on the graft wax, the vine leaves, and the soil surface is shown in Table 3. According to the results, microsprinkling decreased the wax and the leaf temperature by 1.8°C and 4.8°C respectively, but it did not affect the soil-surface temperature, which was dependent on soil moisture – a much more conservative parameter.

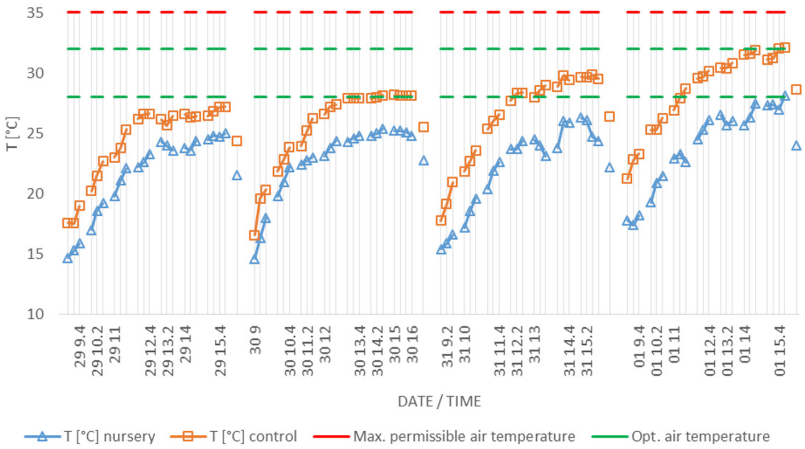

Fig. 4. Course of the air temperature between 9.00 and 16:00 hours presented by dates for the period 29 May – 1 June 2018

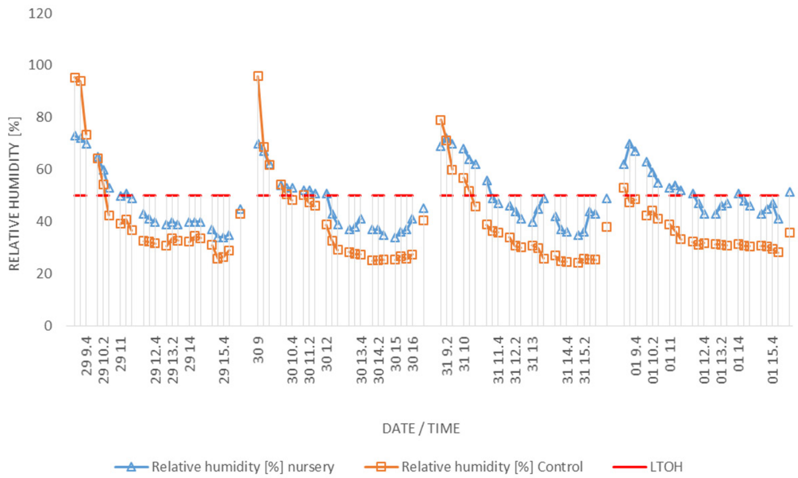

Fig. 5. Course of the relative air humidity between 9.00 and 16:00 hours presented by dates for the period 29 May – 1 June 2018

Table 1. Daily means of both air temperature decrease and air humidity increase during the micro sprinkling operation in the period 13–26 June 2016

Date	Difference	
	T [°C]	Humidity [%]
13 June	-2.13	0.17
14 June	-2.99	8.67
15 June	-4.20	11.40
16 June	-4.39	12.03
17 June	-4.62	13.31
18 June	-4.85	14.74
19 June	-3.56	11.03
23 June	-3.97	12.83
24 June	-2.93	7.73
25 June	-3.21	10.69
26 June	-3.21	9.71
Average	-3.64	10.21

Table 2. Daily means of both air temperature decrease and air humidity increase during the microsprinkling operation in the period 29 May – 1 June 2018

Date	Difference	
	T [°C]	Humidity [%]
29 May	-2.64	4.44
30 May	-2.64	7.47
31 May	-3.93	12.84
1 June	-4.42	15.76
Average	-3.41	10.13

Table 3. Average temperatures of the graft wax, the vine leaves, and the soil surface measured before and after a microsprinkling application, and the evaluated cooling effect of microsprinkling; 17.06.2016

Time	13:30	14:00	
T. [°C]	Before	After	Difference
Wax	37.7	35.9	-1.8(*)
Leaves	38.5	34.3	-4.2(*)
Soil	38.4	39.4	1(n.s.)

(*) – Significant at: 5% – (*); (n.s) – non-significant

Probably, the beneficial effects of microsprinkling could be enhanced by increasing the frequency of applications. In that case, eventual decreasing of the application rate, for avoiding waterlogging, could also be a matter of consideration and further experiments.

Conclusions

Microsprinkling can be successfully used for microclimate regulation in the grapevine nursery.

Microsprinkling decreased the air temperature by 2.1–4.8°C and increased the relative air humidity by 4.4–15.8%.

Microsprinkling decreased the wax and the leaf temperature by 1.8°C and 4.8°C respectively, but it did not affect the soil-surface temperature, which was dependent on soil moisture – a much more conservative parameter.

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Received: February, 7, 2019; *Accepted:* May, 15, 2020; *Published:* June, 30, 2020