Trends in Horticulture (2022) Volume 5 Issue 2
doi:10.24294/th.v5i2.1830

ORIGINAL RESEARCH ARTICLE

Onion downy mildew severity in no-tillage irrigation under nutrient budgeting and population densities

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ABSTRACT

We analyzed the relationship between nutrient (N and K) parceling and population density on the severity of onion downy mildew under no-tillage fertigation cultivation in the conditions of Alto Vale do Itajaí (Barzil). For this purpose, field trials were conducted in the years 2017, 2018 and 2019, in Ituporanga (Barzil). The treatments corresponded to four population densities (300, 400, 500 and 600 mil plants ha^{-1}) subjected to applications of nitrogen (150 kg N ha^{-1}) and potassium (127.5 kg K_2O ha^{-1}) distributed throughout the vegetative cycle of the crop via fertigation on a weekly, biweekly and monthly basis, based on the absorption curve of these nutrients for the cultivar Empasc 352-Bola Precoce. In fertigated no-tillage systems, nutrient (N and K) tranches do not influence the severity of downy mildew. The severity of downy mildew increases linearly with increasing population density, especially from 500 mil plants per ha^{-1}.

Keywords: Allium Cepa; Plant Population; Peronospora Destructor

ARTICLE INFO

Received: 27 July 2022
Accepted: 20 August 2022
Available online: 6 September 2022

1. Introduction

Onion downy mildew (*Peronospora destructor* (Berk.) Casp.) is considered one of the main diseases of the crop in temperate regions where it has a high destructive potential, with the ability to reduce up to 75% of onion productivity[1]. In Alto Vale do Itajaí (Brazil), downy mildew is a disease that tends to manifest in greater proportions in the post-transplant period, which is due to the coincidence of climatic conditions (high relative humidity, mild temperatures and cloudiness) favorable to the disease in the growing period[2–4].

The sporulation of downy mildew depends on the alternation of day and night periods, with night temperatures of 7 to 22 °C, provided that no precipitation occurs and that the previous day there is an average temperature of 23 °C[5]. The production of sporangia occurs only at night and under favorable conditions (relative humidity above 93% and temperatures between 4 to 24 °C) while daytime temperatures above 25 °C may inhibit sporulation in the following night, and under relative humidity of the air below 80% and temperatures above 24 °C, the development stops and there is no sporulation of *P. destructor*[6,7].

Besides favorable climatic conditions, mildew epidemics tend to be favored by increased plant population, low ventilation between the rows of plants and excessive fertilization with soluble mineral fertilizers, especially nitrogen[8,9]. Other studies indicate that increasing doses of potassium is able to delay the development of the disease[1].

In the literature, there are studies that attempt to relate the severity of downy mildew to plant population and nutrient doses[1,9,10]. However, with rare exception, there is no research available that relates nutrient scheduling with the severity of downy mildew. Furthermore, for the conditions of the Alto Vale do Itajaí-SC, there are no trials that make such relationships for the fertigation no-tillage system.

Considering these aspects, the objective of this work was to study the effect of nutrient (nitrogen and potassium) and plant population scheduling on mildew severity in a fertigation no-tillage system for the conditions of Alto Vale do Itajaí-SC.

2. Methodology

The experiment was conducted over a period of three harvests (2017/18, 2018/19 and 2019/20), in Epagri/Ituporanga Experimental Station (EE), located in the municipality of Ituporanga-SC (27°38′ S, 49°60′ W, with an altitude 475 meters). According to Koeppen's classification, the local climate is Cfa. The cultivar used was Empasc 352-Bola Precoce. The soil of the experimental area is classified as Cambissolo Háplico of clayey texture.

The soil chemical analysis of the experimental area showed samples taken at the depth of 0–20 cm, in the years 2017, 2018 and 2019: clay = 500; 435; 420 g kg^{-1}; pH (H_2O) = 6.0; 5.8; 5.7; pH (SMP index) = 6.1; 6.0; 5.8; M.O. = 37.0; 32.0; 21.5 g kg^{-1}; P (Mehlich^{-1}) = 25.4; 10.5; 21.7 mg dm^{-3}; K = 156.0; 111.0; 152.0 mg dm^{-3}; Ca = 8.3; 7.4; 11.4 cmol. dm^{-3}; Mg = 3.3; 2.8; 5.0 cmol. dm^{-3}; S = 13.0; 40.5; 20.9 mg kg^{-1}; CTC (pH 7.0) = 16.10; 14.84; 22.71 cmol. dm^{-3}; Al = 0.0; 0.0; 0.0 cmol. dm^{-3}; H + Al = 4.1; 4.4; 5.9 cmol. dm^{-3}, Cu = 4.3; 2.0; 2.1 mg dm^{-3}; Zn = 6.9; 4.5; 4.2 mg dm^{-3}; Fe = 87.0; 103.0; 88.0 mg dm^{-3}; Mn = 25.5; 24.2; 32.5 mg dm^{-3}; B = 0.8; 0.3; 0.3 mg dm^{-3}.

Seedlings of the Empasc 352 Bola Precoce cultivar were produced based on the technological references proposed by the Onion Production System[11] and Manual of Good Agricultural Practices[12]. The sowings were performed on 04/20/2017, 04/18/2018 and 04/23/2019; the transplants, on 07/20/2017, 07/17/2018 and 07/16/2019; and the harvests, on 11/16/2017, 11/21/18 and 11/11/2019. The experimental areas were sown in late December and April of each year with millet (30 kg seeds ha^{-1}) and radish (10 kg seeds ha^{-1}) + rye (60 kg seeds ha^{-1}), respectively. Before transplanting the seedlings, the cover plants/green manure were desiccated with glyphosate and, after passing a large light, left on the ground. Then, 10 kg boric acid ha^{-1} and 20 kg zinc sulfate ha^{-1} were applied by spraying.

The experimental design was entirely randomized with six repetitions. The total area of each experimental plot was 7.5 m^2 (2.5 × 3.0 m), with a useful area of 3.0 m^2 . The treatments corresponded to four plant densities (300, 400, 500 and 600 mil plants ha^{-1}) subjected to applications of nitrogen (150 kg N ha^{-1}; ammonium nitrate) and potassium (127.5 kg K2O ha^{-1}; potassium chloride). The total dose of these nutrients was distributed throughout the crop cycle via fertigation, weekly, biweekly and monthly, based on the absorption curve of these nutrients for the cultivar Empasc 352-Bola Precoce.

The transplanting furrows were opened with the aid of a mechanical furrow opener. In order to equalize the levels of phosphorus in the soil, the planting fertilizer was applied with simple superphosphate at a dose of 160 kg of P_2O_5 ha^{-1}. At transplanting, the seedlings were arranged in double rows (10 × 10 cm between rows) 40 cm apart from each other. The desired plant density, populations of 300, 400, 500 and 600 mil plants ha^{-1}, was obtained by reducing the spacing between plants in the transplanting line, corresponding to 13.3 cm, 10.0 cm, 8.0 cm and 6.7 cm, respectively.

The fertigation system used for nutrient supply was composed of a motor-pump set, conductor main line (3/4-inch hose) and secondary distributor line (3/4-inch hose) with registers where irrigation strips were adapted with spacing between drippers of 10 cm. The driplines were arranged in the center of the double rows (10 × 10 cm between rows) in order to uniform the supply of water and nutrients. At each weekly fertigation, an irrigation blade corresponding to 6.21 mm was applied.

During the crop cycle, when necessary, undesirable plants were controlled with the herbicides pendimethalin, ioxylin and bentazone at the doses recommended by the manufacturers. For the management of downy mildew, weekly sprays of fungicides registered for the crop were made at the respective doses recommended by the manufacturer. In 2017, fungicides containing the following active ingredients were used: metalaxyl-m + mancozeb, metalaxyl-m + chlorothalonil, mancozeb, and copper oxychloride. In 2018 and 2019, in addition to the active ingredients cited, fungicides were used that contained: propineb, propamocarb hydrochloride + fluopicolide, and cymoxanil + famoxadone.

Downy mildew severity was measured weekly in 2017 and biweekly in 2018 and 2019 using a scale of injured leaf area scores per experimental plot proposed by Mohibullah[13]. The values of the injured leaf area scores were integralized and calculated by the area under the disease progress curve–AACPD[14].

During the 2017, 2018, and 2019 experiments, the weather variables for the different onion development periods were recorded at Epagri's EE Ituporanga Weather Station (**Table 1**, **Figure 1**)[15].

The experimental data were subjected to analysis of variance, regression analysis and Tukey's test at 5% error probability with the statistical program "R"[16].

Table 1. Weather variables occurring in the onion development periods in the agricultural years 2017, 2018 and 2019. Epagri, Ituporanga, SC

Weather Variables	Early Development			Bulb development and maturation			Cycle		
	July to September			October to November			Cycle average		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
T° mean (°C)	16.2	15.3	15.6	18.6	19.3	20.6	17.2	16.9	17.6
T° min average (°C)	11.6	11.3	11.7	14.0	15.8	17.3	12.6	13.1	13.9
Average T° max (°C)	23.3	21.2	21.3	24.9	24.3	25.9	24.0	22.4	23.2
RH%	81.4	86.5	84.8	77.1	87.7	81.1	79.7	87.0	83.3
	July to September			October to November			Sum in cycle		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Precipitation (mm)	214.0	301.2	128.6	176.0	165.4	249.8	390.0	466.6	378.4

Source: Epagri/Ciram[15].

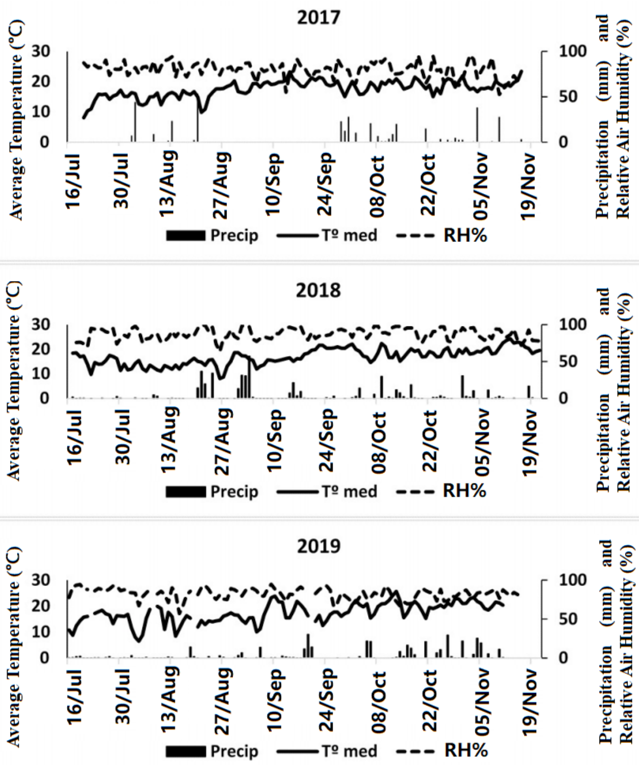

Figure 1. Daily variation of precipitation (in mm), average temperature (°C) and relative humidity (%) in the experimental periods (transplanting to harvest) in 2017, 2018 and 2019. Epagri, Ituporanga, SC.

3. Results and discussion

The experimental data reveal the absence of significant interactions ($p > 0.05$) for downy mildew severity, calculated by AACPD, between nutrient scheduling (nitrogen and potassium) and plant density for the evaluated crops (**Table 2**).

The nutrient parceling did not influence significantly ($p > 0.05$) the AACPD in any of the agricultural years. Therefore, weekly, biweekly and monthly applications of nutrients (nitrogen and potassium) did not interfere with AACPD in fertigated no-tillage onion system.

The epidemics of downy mildew can be favored by excessive fertilization with soluble mineral fertilizers, especially nitrogen[8]. Studies conducted by Acharya & Shrestha[17], revealed that nitrogen doses above 140% of the recommended ones can promote increased severity of downy mildew in onion plants. However, Gonçalves; Souza & Silva; Boff[9] observed no effect of mineral fertilization on downy mildew infestation for doses of N and K between the normal and up to three times the recommended. In the present experiment, the recommendation based on the soil analysis of the Soil Chemistry and Fertility Commission-RS/SC[18] for yields of 30 t ha^{-1} , was 100 kg N ha^{-1} (for 2017 and 2018) and 120 kg N ha^{-1} (for 2019) and for potassium 90 kg K_2O ha^{-1}. In the trial doses of 150 kg N ha^{-1} and 127.5 kg K_2O ha^{-1} were used, therefore doses higher by 50 and 40% than recommended, respectively.

Furthermore, according to Huber[19] and Huber and Watson[20], cited by Huber[21], the increase in AACPD by the addition of nitrogen fertilizers occurs with N in the nitrate form, which is readily available in leaf tissues, where infestation of obligate parasites occurs, whereas N in the ammonium form is primarily metabolized in the roots.

Thus, the absence of a relationship between the nutrient plotting and AACPD may be related both to the dose provided of nutrients, considered low in relation to the doses cited by Acharya & Shrestha[17] that can promote increased severity of downy mildew, and, in the case of nitrogen, to the source used (ammonium nitrate). This indicates that the methodology adopted allowed the nutrients to be supplied in a way that did not interfere with the disease process.

When considering the onion cycle from transplanting to harvest and that the weekly application corresponds to 16 applications of nutrients, the application of nutrients (nitrogen and potassium) in a fertigation system can be done monthly (i.e., on only four occasions) without affecting the occurrence of late blight.

In conventional production systems, nutrient scheduling is commonly performed for nitrogen. For the onion crop, based on soil analysis, it is indicated to apply 15% of the dose at planting and the rest in at least three parcels of the total dose in coverage at 35, 60 and 85 days after transplanting (CQFS-RS/SC[18]. It can be observed, therefore, that there is a certain similarity in plotting between the conventional system, in which nutrients are placed on the soil in solid form, and fertigation. The difference is that in the fertigated system the first dose of nutrients (N and K) is supplied 13 days after transplanting.

In turn, the increase in population density provided significant increases ($p > 0.05$) in AACPD, especially from 500 mil plants ha^{-1} (**Table 2**).

Table 2. Area under the disease progress curve (AACPD) caused by onion downy mildew (Peronospora destructor), in response to nutrient -nitrogen and potassium (Parceling) and plant density (Density). Epagri, Ituporanga, SC

Factors/variables	**AACPD**		
	2017	2018	2019
Installment			
Weekly	335.4^{ns}	174.1^{ns}	133.9^{ns}
Fortnightly	340.7	182.0	135.6
Monthly	342.6	180.5	130.7
Density (plants ha^{-1})			
300,000	328.4 b	169.9 b	122.1 b
400,000	335.2 b	172.7 b	128.3 b
500,000	346.5 a	181.6 a.b	138.8 a
600,000	348.1 a	191.3 a	144.3 a
Average	339.6	178.9	133.4
CV (%)	3.49	8.40	8.88

Means followed by the same letter in the column do not differ, by Tukey's test, at 5% significance level. ns = not significant.
Source: The authors.

Harms *et al.*[22], for two agricultural seasons with the cultivar Bola Precoce in the region of Ponta Grossa/PR, no significant differences were observed for the severity of downy mildew in relation to populations of 363 to 606 mil plants ha^{-1} . However, in the conditions of the Alto Vale do Itajaí, in Ituporanga/SC, similar to the present study, an increase in the severity of downy mildew has been observed when the population density is increased to 500 mil plants ha^{-1}[10].

The meteorological data, recorded in the present work during the experimental years (**Table 1**, **Figure 1**), indicate that the conditions were favorable for mildew incidence[6,7,23]. Added to this, it is important to note that the Alto Vale do Itajaí is the main onion bulb producing region in the state of Santa Catarina, and therefore a high presence of pathogen inoculum is expected during cultivation.

The lowest average AACPD was observed in 2019, when higher rainfall occurred during the development and maturation phase of bulbs (**Table 2**). It is possible that in this year the removal of sporangia, by the impact of raindrops on the leaves, hampered the sporulation to new infection sites and harmed the development of the disease[23,24].

For all experimental years, the increase in plant population linearly increased the AACPD (**Figure 2**). From 300 to 600 mil plants ha^{-1} the increases corresponded to 6, 13 and 18% for the years 2017, 2018 and 2019, respectively. Therefore, in years with lower downy mildew incidence the highest increases in AACPD were observed with increasing plant density. This proves the higher number of plants per area as an additional factor to the weather conditions, which provide a favorable microclimate for the disease.

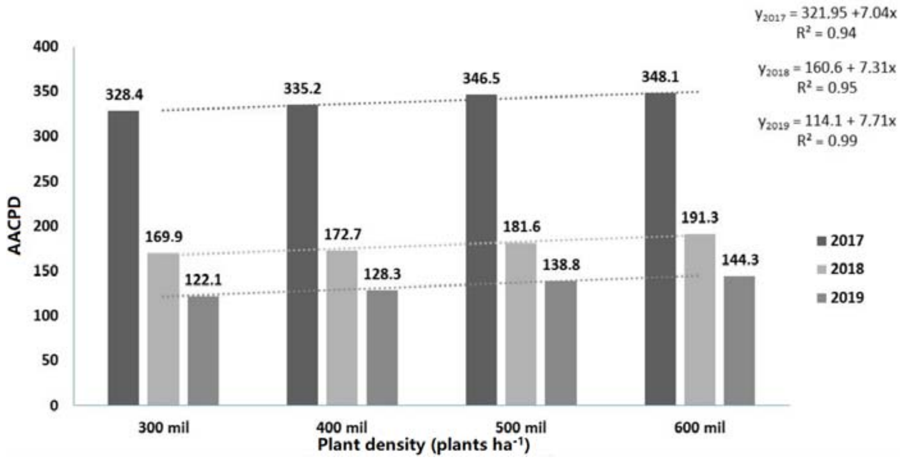

Figure 2. Area under the disease progress curve (AACPD) caused by onion downy mildew (Peronospora destructor), in response to plant density. Epagri, Ituporanga, SC.
Source: The authors.

4. Conclusions

According to the experimental data, it can be seen that, in a fertigation no-tillage system, the nutrient parceling (N and K) did not influence the severity of downy mildew, which increased linearly with increasing population density, especially from 500 mil plants per ha^{-1}.

Conflict of interest

The authors declare that they have no conflict of interest.

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