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Population dynamics of thrips (Insecta: Thysanoptera) in cut chrysanthemum cultivated under photoselective screens

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Abstract
The chrysanthemum is one of the main ornamental species in the world, having high relevance in the market of cut flowers and potted plants. Thrips are among the main pests of the chrysanthemum crop, causing direct and indirect damage to plants. The objective of this work was to evaluate the influence of photoselective screens and climatic factors on the population density of different species of thrips chrysanthemum. The study was carried out in the experimental area of the Instituto Federal do Espírito Santo – Campus Itapina, in a randomized complete block design, with split plots in time. The experiment was established in 3 blocks of 12 m in length, with plots of 3 m in length containing the different photoselective screens (red, silver, and black) and the control treatment (open field), which consisted of the primary factor. Repeated evaluations in time (0, 15, 30, 45, and 60 d) consisted of the secondary factor. Data were submitted to Tukey's test ($p < 0.05$) and the multivariate technique of principal component analysis (PCA). The mean of the thrips population at 60 days was statistically higher. The climatic variables rain and average humidity showed a highly significant negative correlation with the population fluctuation of the pest. Black, red, and silver photoselective screens promote significant reductions in thrips populations in chrysanthemums of the Zembla variety in the environmental conditions of southeastern Brazil.

Keywords: Crop protection, ornamentals plants, control of pests

Introduction
The chrysanthemum, *Chrysanthemum morifolium* Ramat., is one of the main ornamental species worldwide and one of the main flower species commercialized in countries such as India, Colombia, and Brazil [1, 2, 3, 4, 5].
The Brazilian ornamental chain is highly diversified, with more than 2.500 species of flowers and plants cultivated by 8.000 producers [6]. In this context, the chrysanthemum stands out as one of the main species cultivated for cut flowers and potted plants in the country, contributing to the expansion and competitiveness of Brazilian commercial floriculture in recent years [7].
The chrysanthemum is an easy-to-grow plant, with durable and beautiful inflorescences, of high commercial value [8]. These characteristics contribute to the worldwide popularity of this ornamental, making it suitable for purposes such as interior and exterior decoration of homes, use in exhibitions, and production of garlands and bouquets [2, 9].
Pests such as thrips, aphids, caterpillars, mites, and flies have affected chrysanthemum crops causing economic losses [10].
Thrips are small insects of the order Thysanoptera that affect several agricultural and ornamental crops, being difficult to control due to their complex lifestyle and their rapid adaptation to chemical insecticides [11, 12,13, 14, 15].
Frankliniella occidentalis (Thysanoptera: Thripidae) is one of the main species of thrips that affect the chrysanthemum crop. Among the damages caused in different cultures, stand out the direct damage to leaves, flowers, and fruits, through tissue perforation and suction of cellular contents, and indirect damage, through the transmission of disease-causing viruses such as tomato spotted wilt virus (TSW) [16, 12, 17].

Biotic and abiotic factors affect the distribution, abundance, intensity, feeding behavior, and population dynamics of insects [18]. Thrips development and reproduction rates are highly dependent on the environment, mainly on the temperature conditions and nutritional quality of the host plant [17].

Crop systems, such as the use of photoselective screens, affect the behavioral action of insects. These screens act as a physical barrier to the entry of pest species and modify the spectrum and scatter light, influencing the behavior of pests [19].

The impact of photoselective screens on populations of various pest species has been evaluated around the world [20, 21]. However, in Brazil, studies with photoselective screens are focused on their impact on plants [22, 23]. There is a gap in relation to the influence of these screens on agricultural pests in the country's conditions.

In this context, it is urgent to understand the population dynamics of different species of thrips in the cultivation of ornamental plants, aiming at the proper management of these pests to minimize losses. The objective of this work was to evaluate the influence of photoselective screens and climatic factors on the population density of different species of thrips in cut chrysanthemum.

Materials and Methods

This work was developed in the experimental area of the Federal Institute of Espírito Santo - Campus Itapina, located in the district of Itapina in Colatina - ES. This region has a Tropical Aw climate according to the Köppen [24] classification, characterized by seasonal rainfall and the occurrence of high temperatures. The soil of the experimental area is classified as dystrophic Red-Yellow Latosol.

Before installing the experiment, two simple samples were collected at a depth of 0 to 20 cm from each bed with the aid of a probe-type auger. The samples were homogenized in a clean container, forming a composite sample, from which an aliquot was taken for chemical analysis at the Laboratory of Soil Analysis of IFES - Campus Itapina, aiming at the recommendation of fertilization for the cultivation of chrysanthemum in this soil. The Zembla (white) variety of chrysanthemum, acquired from the company Terra Viva located in the municipality of Holambra, São Paulo, was used in the experiment.

The experiment was conducted during the winter, between the months of July and September 2019 (July 24th to September 24th). Climatic data, average humidity, rainfall, solar radiation, wind speed, photoperiod, and average temperature were obtained from an automatic station of the National Institute of Meteorology (Inmet), located in Marilândia - ES, 45 Km away from the study.

The experiment was conducted in a randomized block design, according to a split-plot scheme over time. The primary factor (plots) consisted of 4 different cropping systems: red, silver, and black photoselective shading screens and field (control), and the secondary factor consisted of repeated evaluations over time (0, 15, 30, 45, and 60 d).

Three blocks were established, which consisted of plant beds built with the use of a rotary hoe, 12 m long by 1,20 m wide, and 7 planting lines covered by a 2,10 m high cultivation tunnel (except for the areas referring to the control treatment). The plots for the different treatments were 3m long and had 28 plants, spaced 15 x 15 cm. Lamps of 25W provided light supplementation to plants during the vegetative period for 4 hours a day until the plants reached a commercial stem height of 70 cm. Irrigation of the plants was performed using a micro-sprinkler system. All screens used offered 35% shading.

The infestation of thrips on chrysanthemum plants was natural. To monitor the incidence and population density of this pest, one yellow checkered adhesive trap (10 x 19.5 cm) was used per plot, placed at a height of 10 cm from the plants. Each plot in the block received an equidistantly distributed trap. The evaluations were carried out in the laboratory, counting the insects in the traps.

Data were submitted to analysis of variance and Tukey's test to compare treatment means. The exploratory analysis showed that the data violated the assumption of normality and homogeneity of variance, being necessary to apply the square root transformation to stabilize the variance between treatments. Data were returned to the original scale after processing the analyses.

To relate the thrips population to abiotic factors, the principal component multivariate technique (PCA) was performed, considering the characteristics of rainfall, radiation, wind speed, photoperiod, humidity, and average temperature. A correlation matrix was used for the calculations due to the differences in the units of the variables addressed and the amplitude in the variance of these characteristics.

Analyzes were performed using Software R, version 4.1.2 [25]. The significance adopted in all tests was 5% ($p = 0.05$).

Results and Discussion

The main factors, cultivation system and time of evaluation of the incidence, did not show significant interaction in the population density of thrips in the cultivation of chrysanthemum (*Chrysanthemum morifolium* Ramat. cv. Zembla) by the analysis of variance.

Analyzing the simple effect of the factors, the mean incidence of thrips in the open field treatment differed statistically from the mean values of the other treatments with black, red, and silver screen. Likewise, the mean of the thrips population at 60 days was statistically different by Tukey's test at 5% significance (Fig.1).

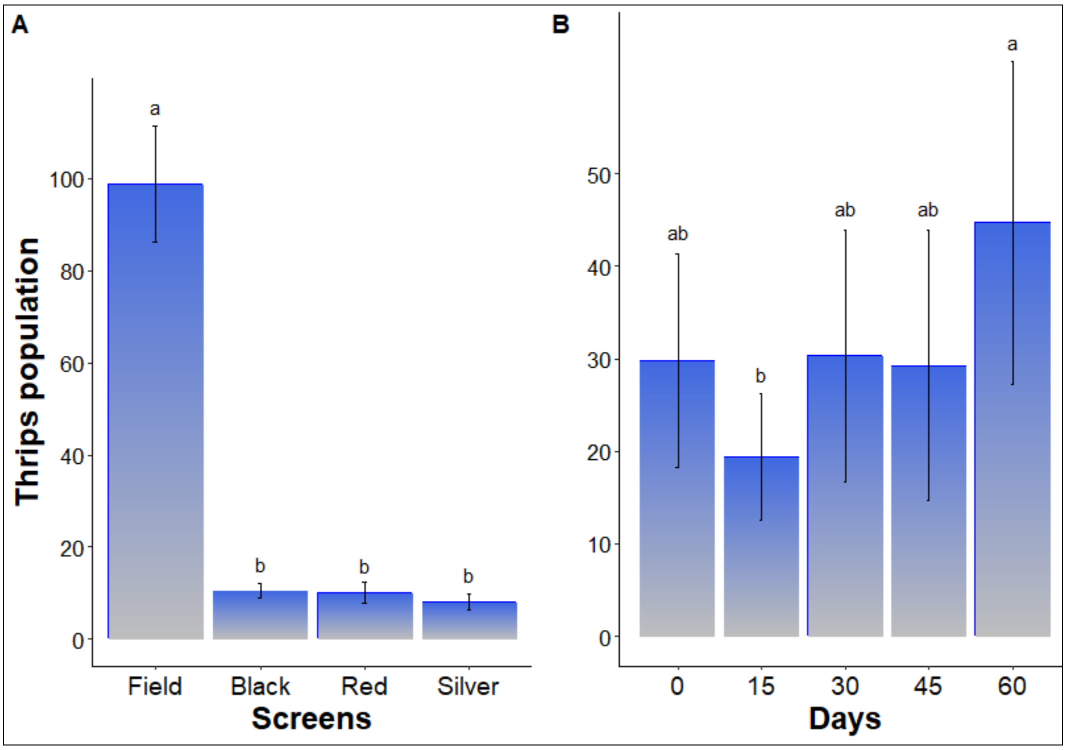

Fig 1: Effect of photoselective screens on thrips population in *Chrysanthemum morifolium* cv. Zembla cultivation (A) and population variation of thrips during the experiment period (July 24th to September 24th) (B). IFES, Colatina-ES (Brazil), 2019. Means followed by the same letter do not differ from each other by the Tukey test at 5% significance. Bars represent the standard error. Results obtained from the transformation of data into square roots and presented in its original form

Black, red, and silver photoselective screens promoted thrips reductions of 89, 90 and 92%, respectively, in chrysanthemum cultivation compared to open field treatment, agreeing with reports of these insects showing different behavioral responses to visual and morphological factors [26, 27, 28]. The reduction of thrips in chrysanthemum cultivation can be explained by photoselective screens that differentially filter solar radiation and modify the spectrum and dispersion of light, which is a fundamental physical signal for navigation, foraging, and flight orientation of insect pests [29]. These screens have chromatic additives and dispersive and reflective elements in their composition, which allow their action on the spectrum and dispersion of light [19, 30].

Photoselective screens physically protect crops from flying pests, but their holes are large enough for smaller insects such as thrips to pass through [31], reinforcing that the reduction of this pest in chrysanthemums was due to the dispersive and reflective effects of these screens and not by physical obstruction.

Artificial modifications in UV photons affect insects' orientation and ability to recognize the plant, explaining the lower incidence of thrips in chrysanthemum cultures with photoselective screens than in those cultivated in open field [32].

Gray and red photoselective screens absorb radiation at frequencies such as the UV, blue, and green region, perceptible by the vision system of insects of the order Thysanoptera [29, 33, 34], corroborating with the reduction of thrips in the cultivation of chrysanthemum with these screens in relation to that in open field.

The reduction of thrips in chrysanthemum cultivation with a black photoselective screen can be explained by the reduction in the amount of light caused by the effect of this screen, as occurred for *Cydia pomonella* (L.) (Lepidoptera: Tortricidae) in apple [35].

Modifications in pest population by the use of photoselective screens are in agreement with Kigathi and Poehling [36] who observed changes in the dispersion, orientation, and location of hosts of *Frankliniella occidentalis* (Thysanoptera: Thripidae) and, consequently, reductions in pest infestation in protected cultivation, using films and nets capable of absorbing UV light. Ngelenzi, Otieno, and Mwanarusi [20] observed reductions in aphid and whitefly populations in bean plants (*Phaseolus vulgaris* L.) grown under photoselective screens.

Among the climatic factors, average humidity and rainfall showed a significant negative correlation with the thrips population (Fig. 2). These results corroborate those obtained in studies with different thrips species, including *Thrips tabaci* Lindeman, *Megalurothrips usitatus* Bagnall, *Scirtothrips dorsalis* Hood, and *F. occidentalis* (Pergande) [37, 38, 39, 40].

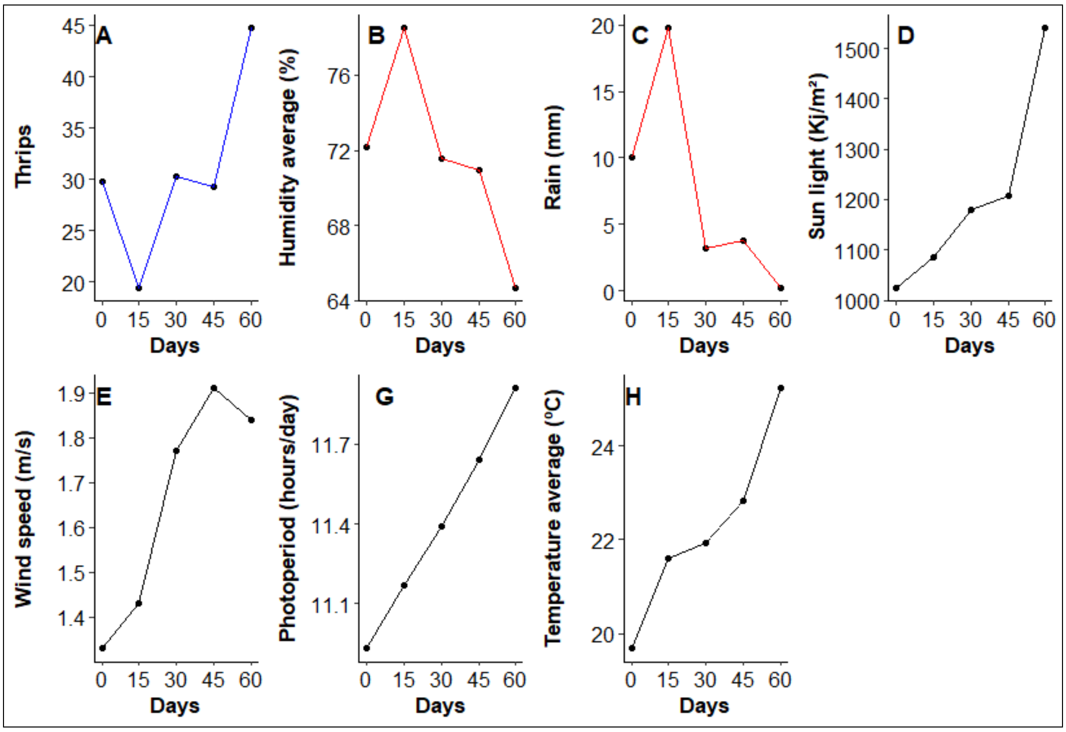

Fig 2: Variation of thrips population (A) and climate variables, average humidity (B), rainfall (C), solar radiation (D), wind speed (E), photoperiod (G), and average temperature (H). IFES, Colatina-ES, 2019.

In the principal component analysis, the first dimension (Dim1) represented 82.31% of the total data variation and the first two accumulated dimensions (Dim1 + Dim2) absorbed 93.0% of the total variability existing in the studied phenomenon (Fig. 3). In this way because these two main components represent the largest proportion of the total variation, they are adequate enough to explain the behavior in a reasonable way, without loss of information, in addition to allowing a simpler and more direct graphical interpretation.

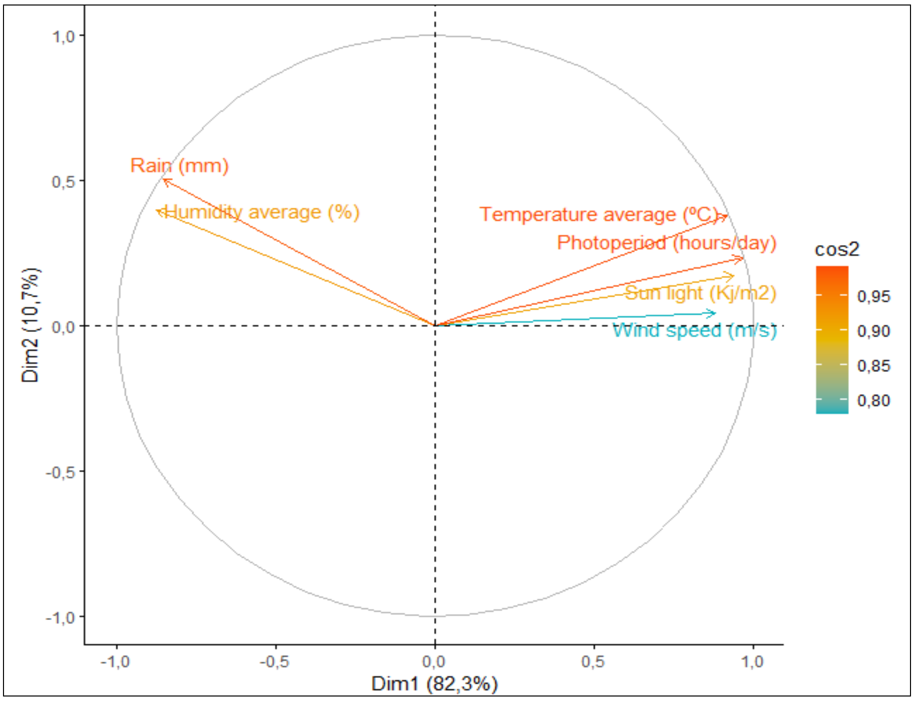

Fig 3: Principal component analysis (PCA) representing the variation between each climate variable and population of thrips in *Chrysanthemum morifolium* cv. Zembla. IFES, Colatina-ES, 2019.

Humidity variation is defined as causing changes in insect population density, as observed in the present work. This climatic factor affecting the thrips population agrees with reports of the fecundity rate, egg incubation period, success of the pupal stage, survival rate, flight activity, and insect development period being modified by moisture [41, 42, 43, 44]. Here, the population of thrips was higher with an average humidity of 64.68%, corroborating the results obtained by Fatnassi *et al.* [45], who obtained the highest population densities of *F. occidentalis* adults at a humidity of 63%.

Rain also has a direct influence on thrips populations, being considered one of the main factors that affect the population dynamics of these insects [46]. Their impact on thrips is mainly associated with the physical washing effect of these insects on plants, affecting their survival in the field [47, 42].

In the present work, an increase in the amount of rain was also associated with a reduction in the thrips population, with the highest and lowest pest populations being obtained when the average rainfall was 0.20 and 19.80 mm, respectively. Such results corroborate with Palomo *et al.* [48], who obtained significant reductions in the population of *F. occidentalis* under frequent rainfall of 20 mm, and Ibrahim and Adesiyun [49], who obtained up to 92% control of *Thrips tabaci* by rain, in onion cultivation.

Conclusion

Black, red, and silver photoselective screens promote significant reductions in thrips populations in chrysanthemums of the Zembla variety in the environmental conditions of southeastern Brazil. Rainfall and relative humidity showed a high negative correlation with thrips population.

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Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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