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TESTING THE EFFICACY OF SOME FOOD TRAP PRODUCTS IN MONITORING AND CONTROLLING *DROSOPHILA SUZUKII*

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ABSTRACT

The present study evaluated the effectiveness of three food trap mixtures in two types of traps, uncoloured and coloured (green base, purple-red, and yellow top), in four different orchard types: blueberry, compost zone, mixed fruit tree, and cherry. The aim was to monitor the viability of the *Drosophila suzukii* population in these areas. The study covered two years (2020-2021) and the results showed that the mixture of wine and cider vinegar in uncoloured traps (variant V1) captured the highest number of insects, with a total of 32,479 (43% of the total catch). Variant V3 followed with 28,498 insects (38% of the total catch), while cider vinegar alone (variant V2) was less effective, catching 14,731 insects (19% of the total catch). A total of 61,706 *Drosophila suzukii* were caught in coloured traps over the two years. In this case V3 was the most effective, capturing 41% of the total catch, followed by variant V1 with 39% and variant V2 with 20%. Coloured traps were less effective than uncoloured traps in terms of total catch of *Drosophila suzukii*. However, in the blueberry orchard in 2021, the coloured traps 1325 captured a higher number of insects than the uncoloured traps. The effectiveness of traps for capturing *Drosophila suzukii* is influenced by factors such as placement, trap type, components used, timing, and environmental conditions.

Keywords: Blueberry (*Vaccinium myrtillus*), Cherry (*Prunus avium*), Compost, *Drophila suzukii*, Germany-NRW Region, Monitoring.

1. INTRODUCTION

Due to globalized trade as well as the climate changes that are occurring and are increasingly affecting biodiversity changes, they have facilitated the spread of non-native species across the Earth. The family Drosophilidae is a species-rich taxon within the order Diptera, with over 4500 documented species (Bachli, 2020; Huseiyn et al., 2023) *Drosophila suzukii* is classified in this category because of its high potential to be spread and adapt to new environments. It is a known pest that causes significant damage to soft fruit production worldwide (Garcia et al., 2022; Chacón-Cerdas, R et al., 2024). The species originates from Southeast Asia and was introduced almost simultaneously to America (California) and Europe in 2008 (Hauser 2011, Walsh et al., 2011; Cini et al., 2012; Rota-Stabelli et al., 2013; Rota-Stabelli et al., 2020). *Drosophila suzukii* was first observed in Japan in 1916 and was subsequently found in China and Korea in 1930-1931 (Kanzawa 1936, 1939). The pest was included in the alert list of the European and Mediterranean Organization for Plant Protection (EPPO) (Calabria, 2012). According to the existing literature, Drosophila was first reported in Europe in 2008 in Spain (Calabria et al., 2012, Asplen, M.K et al., 2015), followed by Italy in 2009 (Grassi et al. 2009; Calabria et al., 2012, Asplen, M.K et al., 2015), and subsequently in other European countries in 2011, including Germany (Vogt et al., 2012, Asplen, M.K et al., 2015), Belgium (Mortelmans et al. 2012; Asplen, M.K et al., 2015), Austria (Asplen M.K et al. 2015), Switzerland (Baroffio and Fisher, 2011; Asplen, M.K et al., 2015), Hungary in 2012 (Kiss et al., 2013; Asplen, M.K et al. 2015), and Romania in 2013 (Chireceanu et al., 2015). A damage rate of 100% was reported for Europe in Italy and France on *Prunus avium*, *Vaccinium macrocarpon*, and *Fragaria x annanassa* (Cini et al., 2012; Weydert and Mandrin 2013; Asplen, M.K. et al., 2015). The best integrated pest management strategies should also be implemented to mitigate these threats, which can result in high costs for agricultural production. The literature confirms that *Drosophila suzukii* has a high potential for adaptability and environmental propagation, that means they are an invasive population (Asplen, M.K et al., 2015; Rego et al., 2017; Kwadha et al., 2021; Hulujan et al., 2023; Tungadi et al 2023). The most prevalent method of attracting and assessing the population of *Drosophila suzukii* is the utilisation of apple vinegar (Lee et al., 2012; Wollman et al., 2019). This is also known to represent the basis of different types of bait-mixture. In order to gain a deeper insight into the behaviour of the species in question, an intensive pest management programme has been proposed, utilising a range of food baits (Landolt et al., 2012; Lee et al., 2012; Iglesias et al., 2014; Burrack et al., 2015; Tonina et al., 2017; Wollmann et al., 2019). The role of colour in trapping *D. suzukii* adults has been the subject of much research, but the results have been contradictory (Kirkpatrick et al., 2016; Rice et al., 2016). Some studies have concluded that red and black traps are the most effective in attracting and capturing this insect (Basoalto et al., 2013; Lee et al., 2013; Renkema et al., 2014; Kirkpatrick et al., 2016; Lasa et al., 2017), while others have reported that transparent and yellow traps were similar in performance to red and black traps (Lee et al., 2013; Iglesias et al., 2014; Cha et al., 2017). The study by Iglesias et al. (2014) revealed that the transparent trap containing a yellow card as a visual stimulus baited with apple cider vinegar yielded the highest number of *D. suzukii*. The reflectance of yellow against a green background was found to be more effective in attracting this insect than red and black contrasts (Little et al., 2019), and the high luminosity offered by yellow also provided a visual stimulus (Cruz-Esteban et al., 2021). In temperate regions, Zerulla et al. (2015) found that only a small initial population of *D. suzukii* can be observed in spring. However, Asplen et al. (2015) demonstrated that the population of summer morph flies can increase greatly during summer and fall when environmental conditions, especially temperature, are favourable. The population increase of *D. suzukii* was found to be highest at 21°C (Tochen et al., 2014; Ryan et al., 2016), whereas hot summers with temperatures higher than 30°C (Harris et al., 2014; Kinjo et al., 2014; Tochen et al., 2014; Ryan et al., 2016; Evans et al., 2018) can reduce population size (Gutierrez et al., 2016; Tochen et al., 2016b; Eben et al., 2018) and consequently infestation risk for ripening fruits. The optimal temperature range for successful egg-to-adult development is reported to be approximately 19 to 25°C (Tochen et al., 2014; Ryan et al., 2016; Evans et al., 2018). The lower and upper threshold for this range was defined at 8°C and between 30 and 33°C, respectively, as no complete egg-to-adult development occurred at these temperatures (Tochen et al., 2016). The study further found that no flies survived the exposure period at temperatures below freezing, suggesting that this species is not cold-tolerant (Eben et al., 2018). It has been established those fluctuating temperatures can increase the survival of overwintering insects, as they are able to repair cold injuries during intermittently warmer periods. While the influence of temperature has been extensively researched, the influence of humidity has received comparatively less attention (Guédot et al., 2018; Wong et al., 2018), despite the fact that relative humidity can influence insect development. It has been demonstrated that extremely low relative humidity can exert a detrimental effect on the life cycle of *D. suzukii* (Gutierrez et al., 2016; Tochen et al., 2016; Eben et al. 2018). Consequently, elevated summer temperatures in conjunction with arid conditions can influence the aestivation success of this specimens (Gutierrez et al., 2016; Eben et al., 2018). Additionally, rising humidity levels have been associated with an increase in insect populations (Tochen et al., 2016). However, high relative humidity can disrupt the process of aestivation, potentially affecting the insect's life cycle (Winkler et al. 2020).

The objective of this study was twofold: firstly, to assess the development of the species in various types of orchards and compost; and secondly, to evaluate the efficacy of three different mixtures of food traps in two types of traps, one uncoloured and the second coloured, as monitoring tools.

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To gain a deeper understanding of the evolution of the *Drosophila suzukii* infestation in North Rhine-Westphalia, Germany, a series of field surveys were conducted in two localities one near to Köln and one near to Bonn throughout 2020 and 2021.

2. MATERIALS AND METHODS

2.1 Study area Köln

The region is located in western Germany, close to Köln with GPS coordinates 51°00'07.1"N, 6°50'45.7"E. The climate in Köln is characterised by its mild and generally warm and temperate conditions, with a considerable amount of rainfall throughout the year, including during the driest month. The average annual temperature in Köln is 10.7°C, and the city experiences an annual precipitation total of 989 mm. The lowest annual rainfall is typically observed in April, with an average of 59 mm. December has the highest average number of rainy days (16.30). In Köln, the highest average number of daily hours of sunshine is recorded in July, which also has the highest number of hours of sunshine (310.03). The sun shines for an average of 10 hours per day. Köln has year-round sunshine, with an annual total of approximately 2,382.29 hours of pure sunshine. In this area, three experimental fields were established by the Landwirschaftskammer NRW for the purpose of testing the efficacy of drosophila traps. The first field was suited in a blueberry (*Vaccinium myrtillus*) orchard, the second in a compost zone, and the third in an orchard comprising a variety of fruit trees, pear trees (*Pyrus sp*.), apple trees (*Malus domestica*), plum trees (*Prunus domestica*) and two of walnut trees (*Juglans regia*).

2.2 Study area Meckenheim

Meckenheim is located in the northern hemisphere of the world with the GPS coordinators 50°37'54.9"N 7°01'38.4"E. The climate in Meckenheim is mild and generally warm and temperate. Meckenheim receives a considerable amount of precipitation during the year. This also applies to the driest month. The average annual temperature in Meckenheim is 9.9°C. Over year, precipitation totals 847mm. The meteorological summer begins at the end of June and ends in September. The summer months are: June, July, August, and September. In Meckenheim, the highest number of daily hours of sunshine is measured during July, which also has the highest number of hours of sunshine (317.97 hours in total). The sun's presence is more abundant in July, with an average of 10.26 hours of daylight per day, contributing to a total of 317.97 hours of sunshine throughout the month. The region experiences a total of approximately 24338.06 hours of sunshine annually, with the highest number record in July. In this area, it was one experimental field established in a sweet cherry (*Prunus avium*) orchard.

Experimental field Köln- blueberry (*Vaccinium myrtillus*) orchard

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In this experimental field were a variety types of blueberry bushes planted specifically with the cultivars named Last Call, Cargo, Liberty, Draper, Huron, Top Shelf, Valor, Aurora, New Hannover, and Duke. This orchard was conventionally managed, and the bushes were sprayed with insecticides such as Combi-Protect Köderkonzentrat and SpinTor® 2SC. Near the experimental field, there were glasshouses and orchards containing apples (*Malus domestica*) and cherries (*Prunus avium*). The size of the experimental field had approximately 2000m^2 surface.

Experimental field Köln - Compost zone

The compost zone was an area designated for the placement of fruit, vegetables, and other plant material collected from the surrounding fields. The experimental area was approximately 2900m^2. This field was surrounded on one side with Thuja sp., European hornbeam (*Carpinus betulus*) and near these shrubs an experimental field containing a variety of vegetables was established to test different plant protection agents.

Experimental field Köln - orchard comprising a variety of fruit trees

The trial area here was surrounded by different types of agricultural plantations. The orchard in question contained a variety of fruit trees as follow: pear trees (*Pyrus sp*.), apple trees (*Malus domestica*), Plum trees (*Prunus domestica*) and two of Walnut trees (*Juglans regia*). This field it was never treated with any kind of pesticide. The experimental field had a size of approximately 2600m^2 surface.

Experimental field Meckenheim- sweet cherry (*Prunus avium*) orchard

The area in question is located at a distance of 60 km from the two trial areas, the blueberry plantation and the composting plant in Köln. The traps it was located in a sweet cherry orchard with an approximate 10400m^2 surface. The trial was surrounded on one side by wild vegetation and trees, sour cherry (*Prunus cerasus*), and different types of fruit orchards. In the experimental field, there was a variety of sweet cherries planted with the following cultivar names: Kordia, Carmen, Satin Regina, and Canada Giant. Approximately four weeks prior to the anticipated period of ripening, the cherry orchard was enclosed by a netted structure against *Drosophila suzukii*. Concurrently, a spray treatment SpinTor® 2SC was administered to the orchard to combat the *Drosophila suzukii* infestation.

2.3 Sample collection

In this study, the construction of food traps was carried out in collaboration with the Raluca Ripan Cluj Institute of Chemistry, to capture individuals of *Drosophila suzukii*. Plastic jars with a volume of 1 L were utilised for this experimental setup. The plastic jars were filled with three distinct types of food attractants in a volum of 250 mL, produced by the aforementioned institute, which were

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then tested in the field under three variants of food traps. The first types of jars were made of transparent plastic and had a yellow lid (Peter J. Landolt et al., 2011; Landolt et al., 2012). Ten apertures, each 3mm in diameter (see Figure 1. A), were created and positioned in the upper part of the jar close to the lid on one side. The second type of trap was distinguished by a green colouration (Tang and Guo 2001; Yamaguchi et al., 2010; Kelber, et. al., 2013; Paulk et al., 2013; Little, Catherine M., et al., 2019) of the lower part of the plastic jar and the upper part was characterised by a purple-red colour extending to the yellow lid (see Figure 1. B).

Figure 1: Trap types: Trap A transparent (uncoloured) with yellow lid in the first picture and trap B coloured (lower part with green colour and upper part with purple-red colour) and yellow lid in the second picture.

The plastic jar traps were installed in each orchard, with one trap per tree-bush. The traps were placed at a height of 1.0-1.5m above the ground of the tree and a distance of 20m between them. The traps in each orchard were replaced every week. This was done in a systematic rotation. The collected samples were inspected under a stereomicroscope Zeiss with a maximum magnification of 50x, and the Drosophilidae samples were separated into a *Drosophila suzukii* male, female and at the same time it was counted in the laboratory.

The various types of food traps employed in this study were constructed with a mixture comprising the following components:

- V1 - 75% apple vinegar with an acetic concentration of 50g/L (5°) Răureni (Romania) and 25% red wine Merlot, semidry, with 13.5% vol. alcohol. Additionally, it contains one drop of apple-scented dishwashing detergent (Peter J. Landolt et al. 2012)

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- V2 -100% apple vinegar with an acetic concentration of 50g/L (5°) Răureni (Romania) and it was added a teaspoon of brown sugar and a drop of apple-scented dishwashing detergent (Walsh et al., 2010; Burrack H. J. et al., 2015).

- V3 - 50% red wine Merlot semidry, with 13.5% vol. alcohol, and 50% apple vinegar, with an acetic acid concentration of 50 g/L (5°) Răureni (Romania), to which has been added a drop of apple-scented dishwashing detergent (Grassi et al., 2014; Burrack at al., 2015). Each jar was filled to a capacity of 250ml with the aforementioned mixture.

2.4 Identification

After the collection of the traps at the same time were replaced with new filled jars. Then the samples were morphologically identified under the ZEISS binocular with 20x magnification. In each sample, the female and male were separated and counted. In order to verify our understanding of the morphological identification process, we conducted a PCR test. In the context of identification literature, the following literature was used: Okada T. (1956); Bächli G. und Burla H. (1985); Josh Vlach 2010; Walsch et al. (2011); Dreves at al. (2011); PM 7/115 (1) *Drosophila suzukii*. (2013) EPPO pdf; Photos by Naomi DeLury Agriculture and Agri-Food Canada pdf; Łabanowska B. et al. (2015); Surendra (2017). There have also been various websites used to identify *Drosophila suzukii* (Matsumura, 1931) or another common name SWD- spotted wing drosophila.

2.5 Data analysis

The results of the study were obtained using R4.4.2 (Pile of Leaves) statistical software (R Core Team, 2024) and Microsoft Excel 365. The significance threshold was set at $p = 0.05$, with a 95% confidence level. The normality of the data was tested using the Shapiro-Wilk test, and descriptive statistics were used to analyse the data. The results were presented as the mean (x) and standard deviation (SD) for variables that followed a normal distribution, and as the median with interquartile interval [IQR] for variables that did not follow a Gaussian distribution. To identify significant differences between groups, a series of statistical tests were used, including the Independent T-test, One-Way Anova followed by Tukey post-hoc test, Mann-Whitney U test and Kruskal-Wallis followed by Dunn post-hoc test were used.

3. RESULTS AND DISCUSSIONS

3.1 Results in blueberry (*Vaccinium myrtillus*) orchard

The evolution of the efficacy of simple (uncoloured) and coloured traps can be observed in Figure 2 for the two trial years April-December 2020 and April-December 2021.

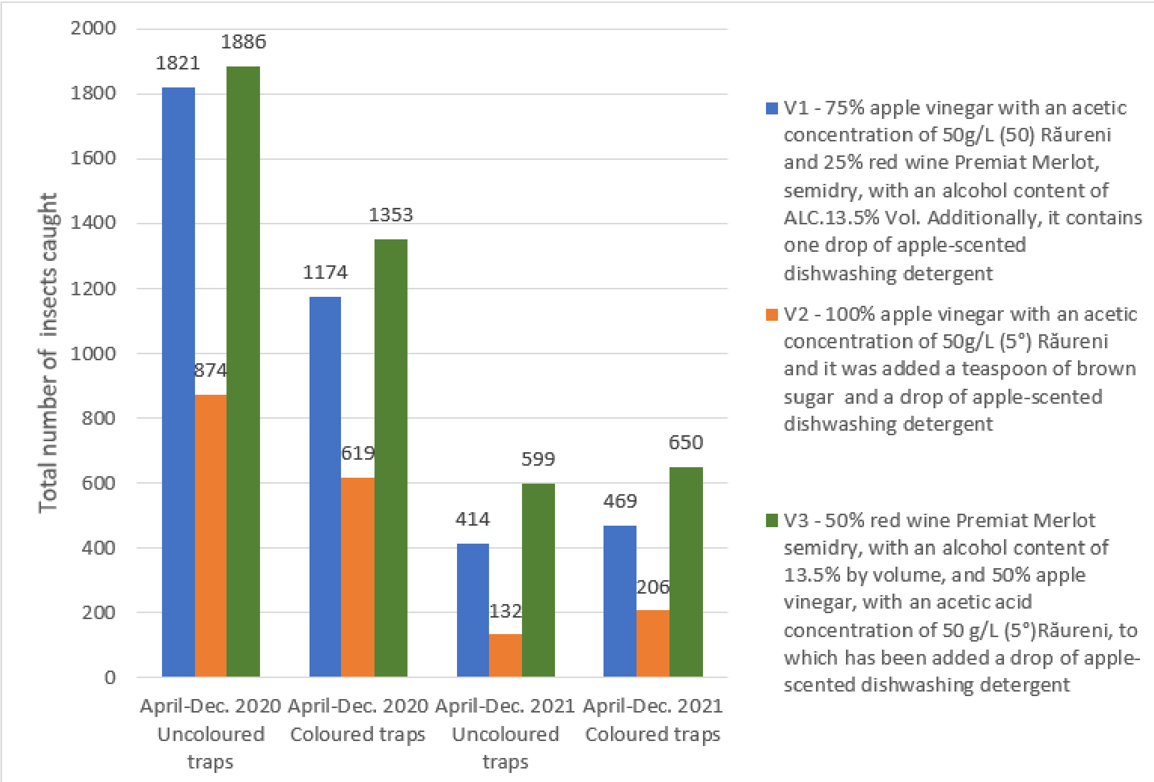

Figure 2: Development of the effectiveness of uncoloured and coloured green and purple-red traps in the blueberry plantation (*Vaccinium myrtillus*) for the two trial years April-December 2020 and April-December 2021.

The highest number of *Dosophila suzukii* insects (see Figure 2.) was caught in trap V3 (green) with a total of 4488 insects. In the year 2020, a total of 1,886 insects were captured by V3 traps utilizing uncoloured traps, constituting 41% of the total catch, while 1353 insects, representing 43% of the total catch, were captured using coloured traps. In the subsequent year, 2021, the number of insects captured by V3 traps using uncoloured traps decreased to 599, representing 52% of the total catch, while the number of insects captured using coloured traps increased to 650, constituting 49% of the total catch. The utilisation of V1 traps (blue) was found to be moderately effective, with a notable increase in insect captures when uncoloured traps were used. In 2020, 1821 insects, constituting 40% of the total catch, were captured using uncoloured traps, while 1174 insects, representing 37% of the total catch, were captured using coloured traps. In the subsequent year, 2021, the number of insects captured using uncoloured traps was 414, constituting 36% of the total catch, while the number of insects captured using coloured traps was 469, representing 35% of the total catch. In the second position, V1 traps (blue) demonstrated moderate effectiveness, with an increase in insect captures when coloured traps were utilised. In 2020, 1821

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insects were captured, representing 40% of the total catch using uncoloured traps, and 1174 insects, representing 37% of the total catch, using coloured traps. In the subsequent year, 2021, 414 insects were captured using uncoloured traps, constituting 36% of the total catch, while 469 insects were captured using coloured traps, representing 35% of the total catch. In a third position, V2 Traps (Orange) were found to be the least effective overall, capturing the fewest insects, especially in coloured traps. In 2020, V2 traps caught 874 insects, representing 19% of the total catch using uncoloured traps, and 619 insects, representing 20% of the total catch using coloured traps. In the subsequent year, 2021, the number of insects caught using uncoloured V2 traps was 132, representing 12% of the total catch, while using coloured V2 traps, the number of insects caught was 206, representing 16% of the total catch. The total number of insects captured in all uncoloured traps (V1, V2 and V3) in 2020 was 4581, which is significantly higher than the 1145 insects recorded in 2021. A significant difference was observed between the two years, with a total number of 3436 insects captured.

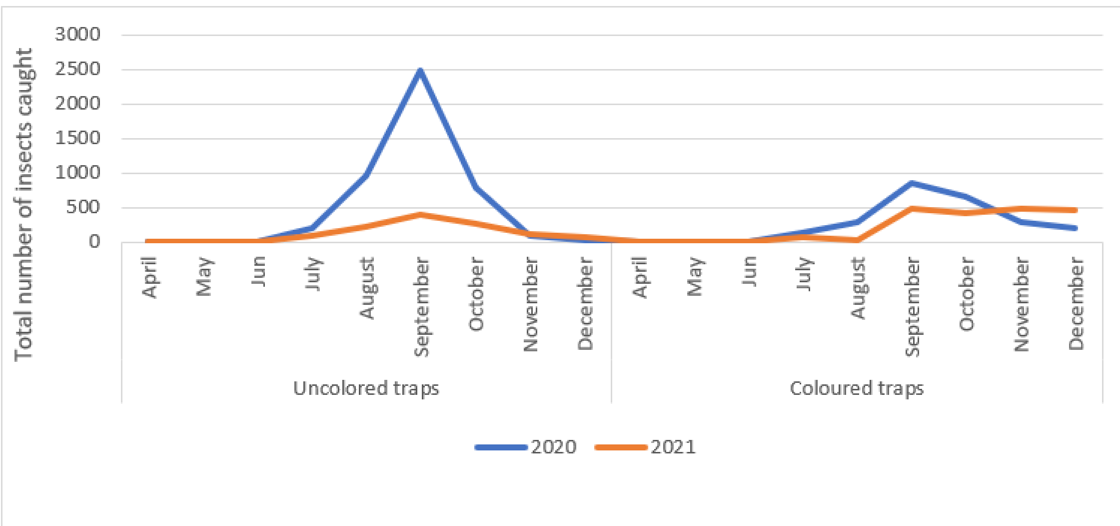

Figure 3: The flight curve of the *Drosophila suzukii* population in the blueberry plantation from April to December for the years 2020 and 2021, using uncolored and colored traps.

In Figure 3. the flight curve activity of *Drosophila suzukii* in the blueberry plantation showed a steady increase from April 2020. The population continued to increase gradually and peaked in September with a total number of 2483 insects captured in 2020. After this peak, the population experienced a noticeable decline, which continued steadily until the end of December. The following observations can be made from the data on population trends for colored traps in the years 2020 and 2021, as illustrated in Figure 4. Firstly, there are smaller peaks in the population compared to uncolored traps. Secondly, the initial peak occurs in September with a total of 860 insects, which is the highest peak level for this year, followed by another in October with a total of 665 insects captured. The data indicates that the population trends for colored traps in 2020 and 2021 are analogous.

3.2 Results in a Compost zone

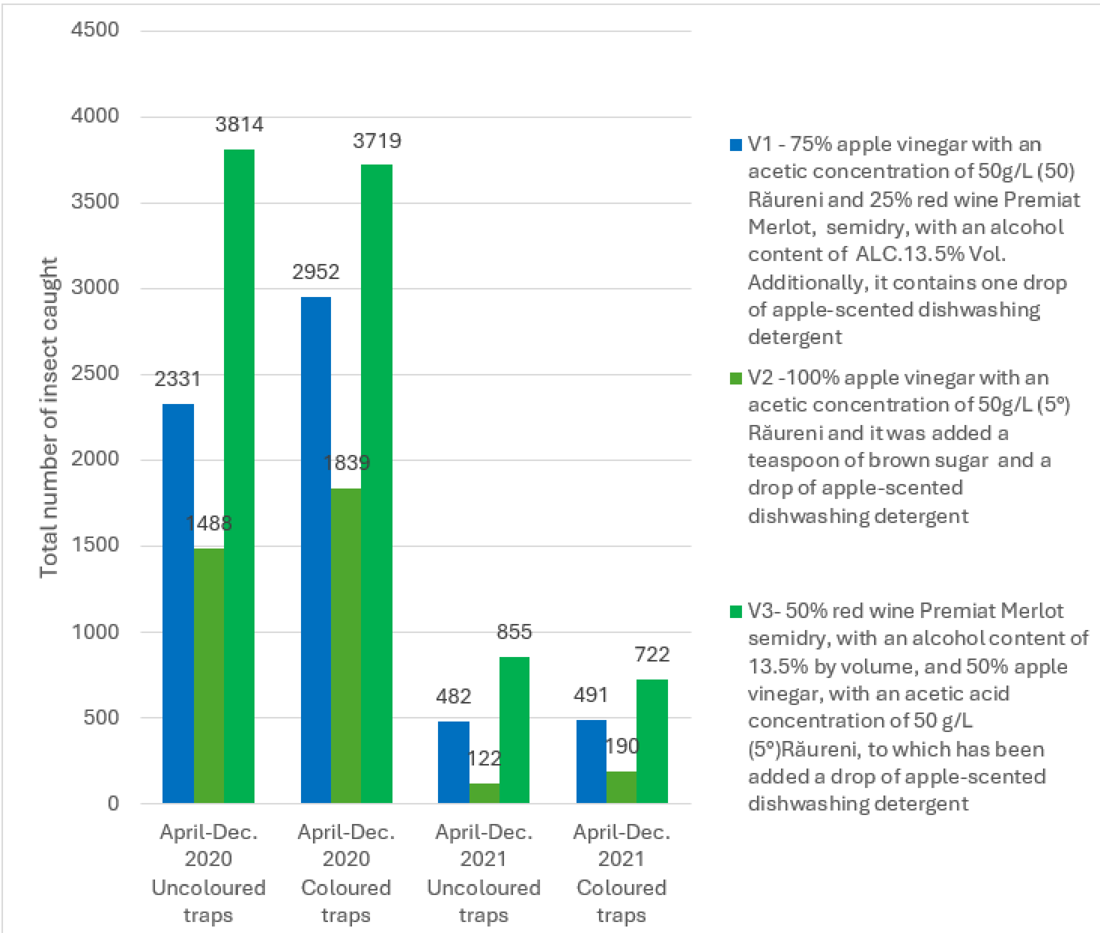

Figure 4: Development of the effectiveness of transparent (uncoloured) and coloured green and purple-red traps in compost zone for the two trial years April-December 2020 and April-December 2021.

As presented in Figure 4. the efficacy of the two types of traps, in both uncolored and colored forms, utilising a distinct food mixture within the compost zone, was examined throughout the two years from April to December in each respective year, spanning from 2020 to 2021. During the two-year monitoring period in the compost zone, a total of 10551 *Drosophila suzukii* specimens were recorded in the uncoloured traps, constituting 49% of the total catches. A similar trend was observed in the coloured traps, with a total of approximately 10000 insects being recorded over the two years, representing 48% of the total catches. In the 2020 study, the efficacy of uncoloured

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traps V3 was found to be the most effective treatment, with a total of 3814 insects captured. This was followed by V1, which captured 2331 insects, and V2, which captured 1488 insects. In the 2020 study, the effectiveness of coloured traps (V1) was found to be the most effective treatment, with a total of 2952 insects captured. V3 followed closely behind, with 3719 insects captured, while V2 captured 1839 insects. In the subsequent years, a decline was observed. In 2021, a substantial decrease in the total number of insects caught was recorded for both uncoloured and coloured traps. The decline was particularly marked in the coloured traps, with V1 capturing 491 insects, representing 35% of the total caught, V2 capturing 190 insects, representing 14% of the total caught, and V3 capturing 722 insects, representing 51% of the total caught. In contrast, the uncoloured traps exhibited a higher catch in 2021 than the coloured traps, with a total of 1515 individuals captured.

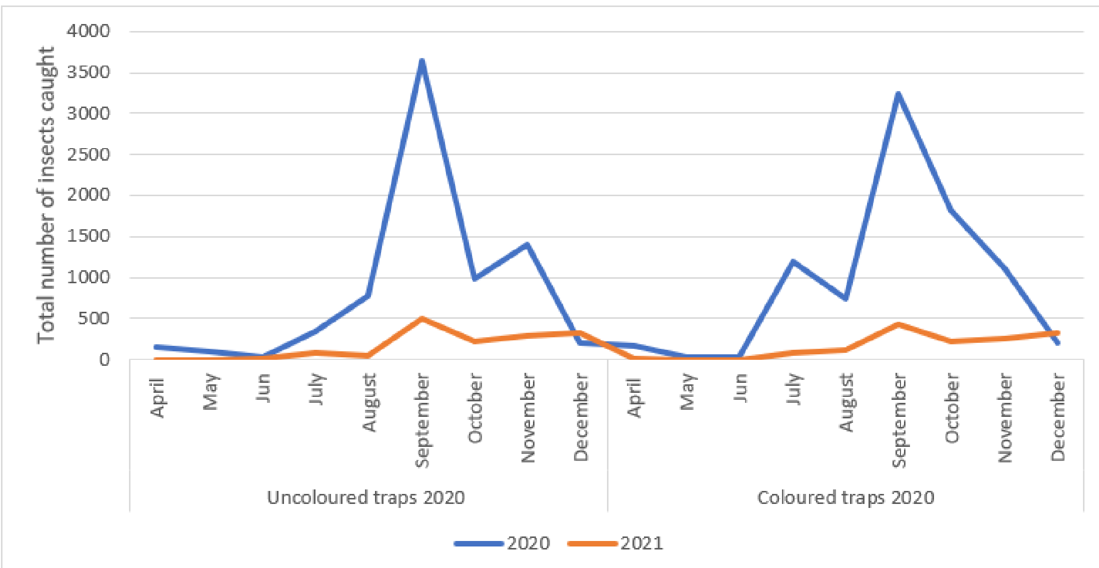

Figure 5: The flight activity of the *Drosophila suzukii* population over the two years of monitoring, from April to December 2020 and 2021, using uncoloured and coloured traps in the compost zone.

The flight curve for the *Drosophila suzukii* population in 2020 is illustrated in Figure 5. Two population peaks were recorded in the uncoloured traps for the year 2020. The first peak was observed in September, with a total of 3,648 specimens representing 48% of the total insects collected. The second peak was observed in November, with a total of 1407 specimens, representing 18% of the total insects collected. Subsequently, a population decline was observed. In 2021, the highest peak was also observed to occur in September, with a total number of 495 insects collected, representing 34% of the total. This peak was lower than the first peak in the 2020 season, which had recorded 3153 insects. The second peak of the 2021 season occurred in

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December when a total of 323 insects were recorded. This number represented 22% of the total insects collected in the uncoloured traps. The data highlight the significant presence of insects during this period, contributing to the overall population trends observed throughout the year. In the case of the coloured traps, the highest number of insects was also recorded in September, with a total of 3688 specimens collected over the two-year period. A slight variation in the population dynamics of the coloured traps was observed across the years. Two peaks in insect abundance were recorded in 2020: the first peak occurred in September with a total of 3,247 insects recorded, representing 38% of the total insects collected, and the second peak occurred in October with a total of 1814 specimens, representing 21% of the total insects collected. A comparison of the insect collections from 2021 and 2020 reveals that the total number of insects collected in 2021 was lower than in the previous year, with a total of 7,107 insects. As illustrated in Figure 5. the highest peak is observed in September, with a total number of 421 specimens, which represent 30% of the total catch of insects for that year.

3.3 Results in orchard comprising a variety of fruit trees

The development of the coloured and uncoloured traps for the two-year period from April to December 2020 is illustrated in Figure 6.

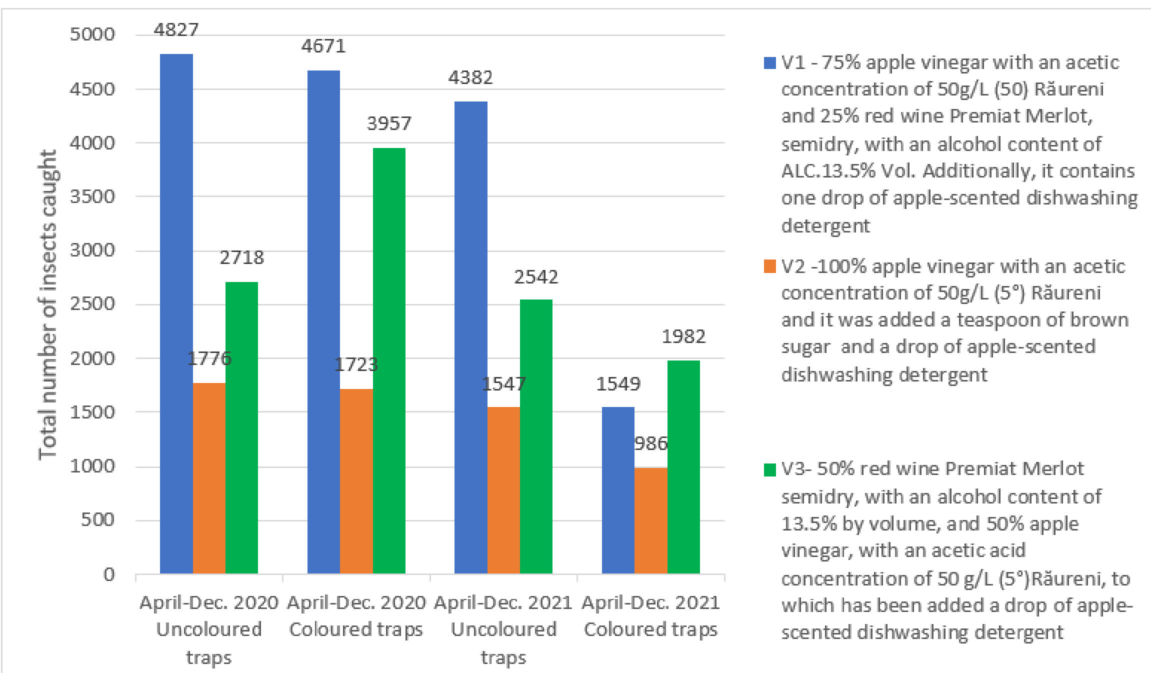

Figure 6: The development of effectiveness of uncoloured and coloured traps was investigated in orchards comprising a variety of fruit-tree species over the two trial years (April-December 2020 and April-December 2021).

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The uncoloured traps captured a total of 9321 insects, constituting 29% of the total catch in 2020. In contrast, the total number of insects captured increased to 10,351, representing 32% of the total catch, by the coloured traps in the same year. In the second year of the study, which ran from April to December 2021, uncoloured traps yielded a total of 8471 insects, constituting 26% of the total catch. In comparison, coloured traps captured a total of 4,517 insects, representing 14% of the overall catch. A notable observation is that uncoloured traps exhibited significantly higher efficiency in 2021, capturing 3954 more insects than coloured traps. In the uncoloured traps, the total number of insects captured decreased from 9321 in 2020 to 8,471 in 2021, representing a reduction of 850 insects. There was a slight decline in the effectiveness of uncoloured traps from 2020 to 2021. In the evolution of the coloured traps for the two monitoring years 2020 and 2021, it was also possible to observe a semi-significant decrease in the number of insects caught. The total number of insects collected in 2020 was 10,351, representing 32% of the total catch. This number decreased to 4517 in 2021, representing 14% of the total catch, with a decrease of 5831 insects.

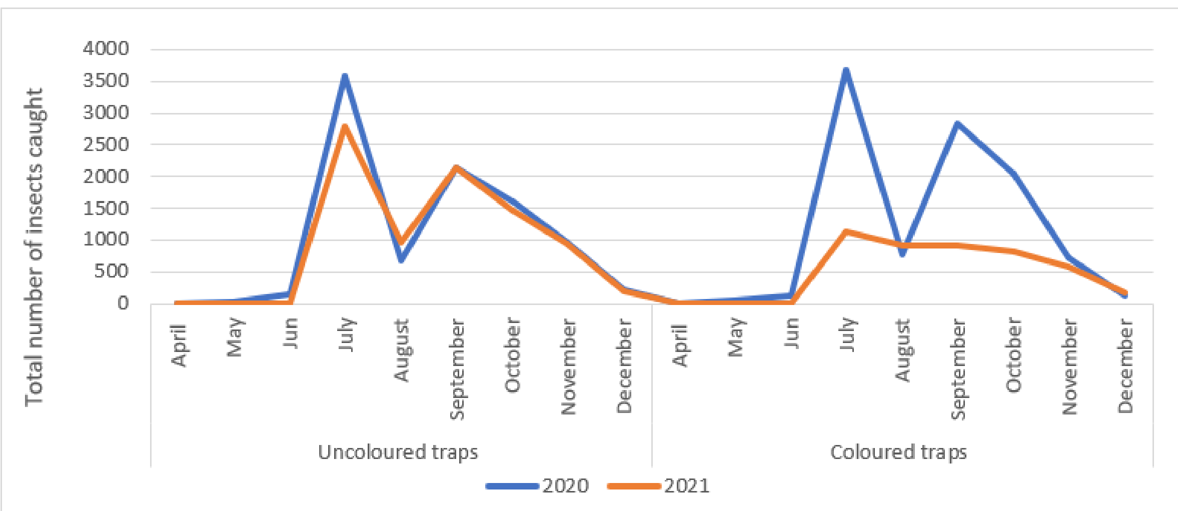

Figure 7: The flight activity of the *Drosophila suzukii* population over the course of two years of monitoring, from April to December 2020 and 2021, using uncoloured and coloured traps across various fruit-tree species orchards.

The months of July in 2020 experienced the highest number of catches in the uncoloured traps, as illustrated in Figure 7. This figure demonstrates a substantial increase in flight activity, with 3575 representing 38% of the total catches of the *Drosophila suzukii*, indicating a high population density during the summer months. The population levels in these months are significantly higher compared to other months. In 2021, the flight activity remains high, though at a lower level compared to 2020 in the uncoloured traps. The population peaks at just over 2786 representing

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33% of the total catch in July and slightly less in August, indicating a decrease in population or activity in 2021 compared to the previous year. In the months of July to August 2020, the population began to decrease, but remained elevated in comparison to earlier months, demonstrating consistent activity even into late summer and early fall. In the months from August to September in 2020 and 2021, a more pronounced decline in flight activity was observed, with numbers falling below 1000 starting from August, indicating that the arthropods population was significantly less active during this period. In the subsequent month, the number of arthropods captured increased to over 2,000 in both 2020 and 2021. In the case of the coloured traps, the peak month was also in July for both 2020 and 2021, with a marked increase in activity, although not to the same level as in the uncoloured traps. The maximum number of flies was recorded in July, with 3673 being the total catch, representing 35% of the total. In 2021, activity was much lower, similar to the uncoloured traps. The population size of insects in July was recorded at 4796, constituting 25% of the total catch, which is 2550 insects less than the previous year. The period from August to September in 2020 was characterised by consistent flight activity with a total of insects 2829 insects representing 27% of the total catch. This period exhibited lower activity levels when compared to the summer months, suggesting the presence of an insect population but with reduced activity. In 2021, the population demonstrated a decline in activity, with catches falling below 1000 in August and continuing to decrease through September.

3.4 Results in a cherry (*Prunus avium*) orchard

The development of effectiveness of uncoloured and coloured traps Figure 11 was investigated in orchards comprising a variety of fruit-tree species over the two trial years (April-December 2020 and April-December 2021.

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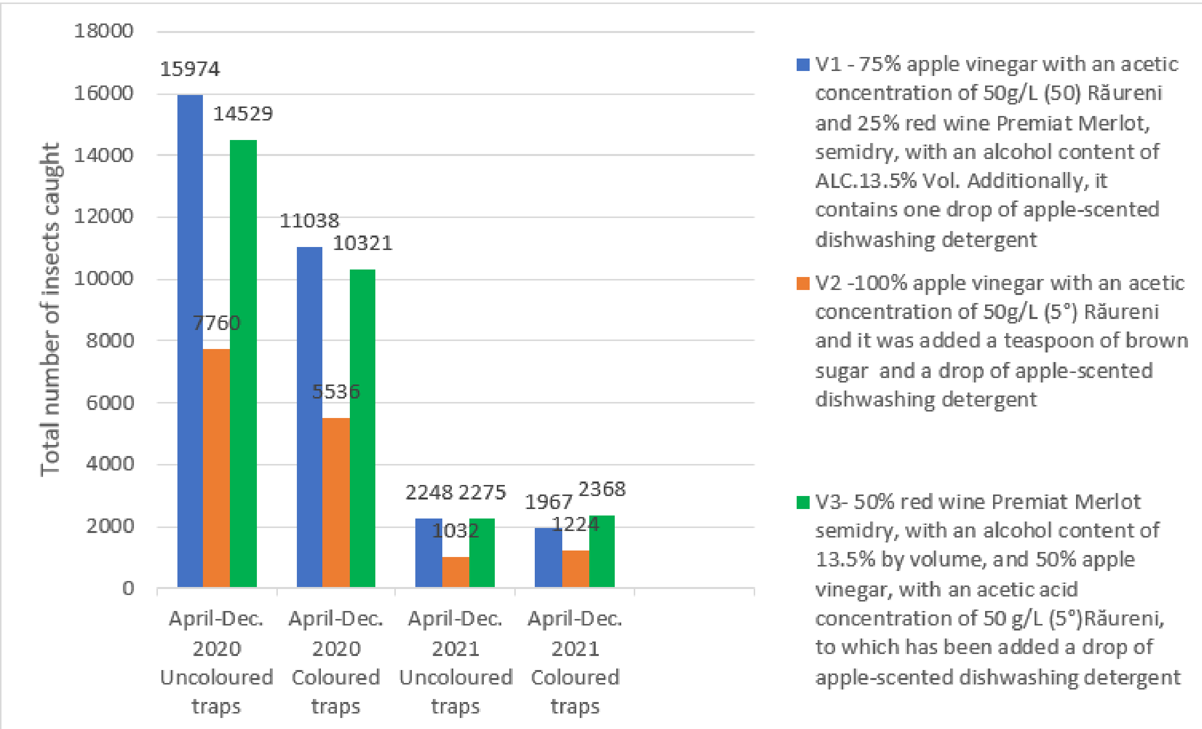

Figure 8: The development of effectiveness of uncoloured and coloured traps was investigated in the cherry orchards over the two trial years (April-December 2020 and April-December 2021.

A comparison of the two years 2020 and 2021 in Figure 8. reveals that in 2020, the uncoloured traps captured a total number 38,263 of insects, representing 50% of the total catch, while the coloured traps captured a total number 26,895 of insects, representing 35% of the total catch. In 2021, the uncoloured traps captured 5555 insects, representing 7% of the total catch, while the coloured traps captured 5559 insects, representing 7% of the total catch. Furthermore, it was observed that the total number of insects captured in the uncoloured traps during the two-year monitoring period (2020 and 2021) amounted to 43,818, constituting 57% of the total catch. In comparison, the total number of insects captured in the coloured traps was 32,454, representing 43% of the total catch. This finding suggests that the uncoloured traps captured 11,364 more *Drosohila suzukii* during the observed period than the coloured traps. In the year 2020, a greater number of insects were captured, with a total of 65,158 specimens being recorded in uncoloured and coloured traps. When the data from 2020 and 2021 were compared, it was observed that the total number of insects captured in 2021 was 11,114, indicating a decrease in the number of insects captured in 2021 compared to 2020. In variant V1, it was observed that a higher number was recorded in both the uncoloured and coloured traps, with a total number of 27,012 insects caught

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over the 2020-year period. In the subsequent year, a greater number of insects was recorded in the uncoloured traps, with a total of 2248, while a decrease was recorded in the coloured traps, with 1967 specimens, a difference of 281 insects.

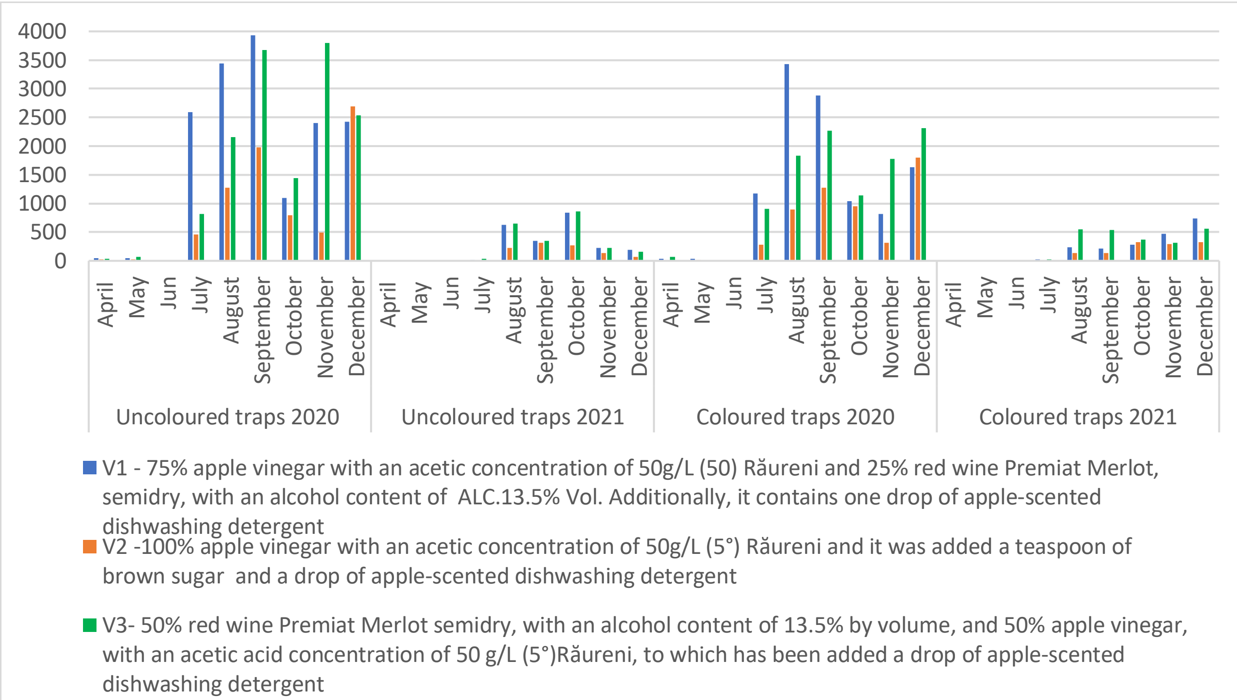

Figure 9: Development of *Drosophila suzukii* in the uncoloured and coloured traps in the cherry tree orchards (*Prunus avium*) in 2020 and 2021.

Uncoloured traps consistently catch more *Drosophila suzukii* see Figure 9. with a total of 43,818 insects caught in 2020 and 2021 compared to coloured traps, where the total number of insects caught in both years was 28,527. The highest catch was recorded in the month of September 2020 with a total of 9586 insects, representing 25% of the total catch. For the second year 2021 in the uncoloured traps, the highest catch was in the month of October with a total of 1,975 insects representing 36% of the total catch. In the case of the coloured traps, it can also be observed that the number of catches in 2020, with a total of 26,895 insects, is higher than the number of catches in 2021. In 2021, a total of 5559 insects were caught, which is a decrease of 21336 insects compared to the first year 2020. For the months of July, August and September, Figure 3 shows that in both years the highest catch value was for the V1 variant in the uncoloured and coloured traps. For the remainder of October and November 2020, the V3 variant had a higher insect catch in the uncoloured traps, with a total of 5237 insects. Comparing the efficacy of the V2 variant, it always had a lower efficacy than the other variants V1 and V3. The only differences observed in

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the month of December were that the V2 had a higher number of insects captured, with a total of 2693, representing 7% of the total number of insects captured in the uncoloured traps in 2020.

3.5 Result statistical analysis

Figure 10: Statistical analyses of the population of *Drosophila suzukii* in the blueberry orchard, compost zone, orchard of fruit varieties trees and in the cherry orchard in the case of uncoloured and coloured traps with a mixture of tree food V1, V2 and V3 for April - December in the years 2020 and 2021.

Variables	Value	Variation limits		p-value
		Min	Max	
Variants, *mean ± SD*				
V1	7135.75 ± 6020 [a]	1657	18377	0.265[A]
V2	3407.75 ± 2923 [a]	832	8883	
V3	6817.50 ± 5253 [a]	2010	16953	
Insect sex, *mean ± SD*				
Male	2652 ± 1991	702	5743	0.874[B]
Female	2825 ± 2287	798	7319	
Trap type, *mean ± SD*				
Uncoloured	6404 ± 5809	1909	14738	0.724[B]
Purple-red colour	5077 ± 4194	1125	10910	
Location, *mean ± SD*				
Blueberry orchard	1517 ± 554 [a]	1125	1909	0.005[A]
Compost zone	3177 ± 197 [a]	3037	3316	
Variety of fruit tress orchard	5444 ± 689 [a]	4957	5931	
Cherry orchard	12824 ± 2707 [b]	10910	14738	
Year, *median [IQR]*				
2020	2972 [2195; 4829]	1049	12754	0.015[C]
2021	996 [461; 1852]	286	2821	

Note: A/B/C – p-values from One-Way Anova/Independent T-test/Mann U test; a,b – Tukey post-hoc test.

Figure 10 presents the statistical analysis of the various factors tested between April and December for the years 2020 and 2021. The study was conducted across different environments, including blueberry orchards, compost zones, varieties of fruit trees, and cherry orchards. The main variables examined were the gender of the insects, the type of trap, location of the trials, and the attractant variants (V1, V2, V3). The results also compare data from 2020 and 2021 to identify any significant differences over the two years. The p-values indicate the statistical significance of the observed differences in the Table 1. The p-value of 0.265 indicates that there is no significant difference between the variants. Also, in case of the p-value of 0.874 indicates that there is no significant difference between the male and female populations. For the types of the traps with a p-value of 0.724 indicates that there is no significant difference between the uncoloured and Purple-red traps. A significant difference it was observed by the p-value of 0.005 indicates a significant difference between the sites, with Cherry orchard having the highest population. Another significant p-value was observed with the p-value of 0.015 indicates a significant difference between the years 2020 and 2021, with higher populations observed in 2020. However, a number of significant differences were observed in relation to the location of the trials and the years in which the study was conducted. In the case of the variants, the highest number of catches was recorded in the V1 version, in the simple traps according to the traps and in the cherry area.

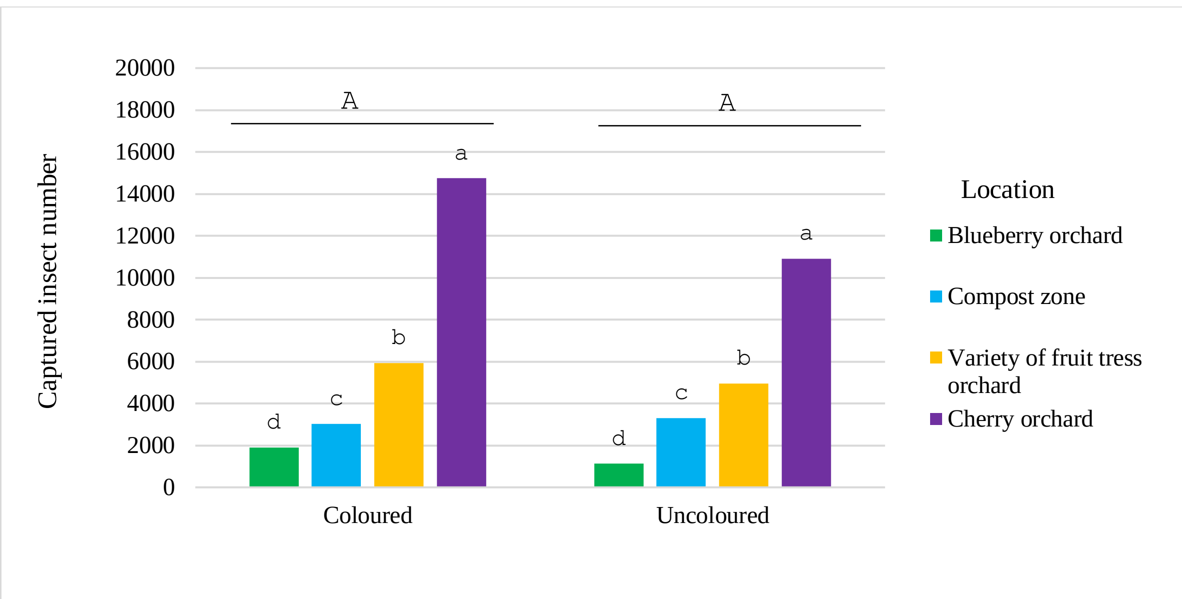

Figure 11: Statistical variations in trap types across various locations.

A statistical analysis Figure 11. was conducted to interpret the differences in trap types and their variations across various locations. The labels (a, b, c, and d), highlighting significant differences in insect capture rates across environments. Within the cherry orchard, label 'a' indicates a notably

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high capture rate. Label 'b' reflects intermediate performance, influenced by the unique variety of trees in the orchard, which differ from those in the cherry orchard (labelled 'a') but outperform the compost zone and blueberry orchard. The compost zone and blueberry orchard (labelled 'c' and 'd') display progressively lower capture rates, underscoring the statistical disparities among the environments. The results highlight significant distinctions in the types of traps used, influenced by geographic and environmental factors in determining trapping success. These variations could potentially reflect adaptations to local conditions or targeted strategies for capturing specific species.

3.6 Discussion

The findings of this study demonstrate that uncoloured traps demonstrate superior performance in all contexts. However, environmental factors, such as those observed in the cherry orchard, have been shown to exert a significant influence on the optimisation of results. To our knowledge, no study has monitored the viability of the *Drosophila suzukii* population in compost plots. This study corroborates earlier research (Dixon et al., 2009; Beers et al., 2010; Becher et al., 2010; Landolt et al., 2011; Cohnstaedt 2012; Lasa, Rodrigo 2017), demonstrating that combining wine and cider vinegar was an efficacious approach for capturing the species of *Drosophila suzukii* in various orchard settings. In the case of the coloured trap, it was observed in this study that it was less effective in trapping *Drosophila suzukii* compared to other studies (Lee et al., 2012; Lee et al., 2013; Renkema et al., 2014; Rice et al., 2016; Cha et al., 2018; Tonina et al., 2018; Little et al., 2019, Little et al., 2021). The coloured trap was studied in the same orchards with the same mixture V1, V2 and, V3 as the uncoloured traps. For the coloured trap it was made a little modification in the colour it was used red purple (Little et al., 2019, Little et al., 2021). However, it should be noted that the specific outcomes observed may be contingent on various factors, including the design of the trap, the type of bait employed, and prevailing environmental conditions. Effectively protecting crops from *D. suzukii* requires an integrated pest management strategy that addresses both the biological and ecological characteristics of this species (Van Timmeren and Isaacs, 2013; Haye et al., 2016; Tochen et al., 2016, Mori et al., 2019). Agronomic and cultural practices play a vital role in limiting the development of this species. These practices include removing plants that can serve as winter shelters for insects, mowing grass, managing orchard edges, and clearing fallen ripe fruit from crops, which act as a source for population growth. Maintaining orchards in optimal phytosanitary conditions is critically important. Strategically placing mass traps in the field is essential for continuous and efficient pest monitoring. This allows for rapid interventions to reduce the pest population and keep it below the economic damage threshold. Such measures significantly contribute to reducing pest density. Additionally, the use of insect-proof nets provides effective control; however, their implementation should be preceded by a thorough economic evaluation to ensure feasibility. The utilisation of insecticides should be limited to periods of severe infestation in order to minimise their residue impact. It is widely acknowledged within the scientific community that in order to control infestations of *D. suzukii*, biotechnological and biological methods must be employed. The effective use of drosophila parasitoids in controlling this species is met with confident optimism for the future, representing a sustainable solution. A comprehensive strategy is imperative for the effective management of the IPM of *D. suzukii*. This strategy must encompass all elements of the food chain, from integrated production to transportation under controlled temperature conditions, and culminating in storage and distribution. It has been observed that brief thermal shocks (0.5°C for 24 hours) can impede current infestations and extend the shelf life of fruits (Saeed et al., 2018). The development of tools to manage the population of *D. suzukii* presents significant challenges due to the species' remarkable biological adaptability. The complete eradication of this pest in areas where it has already established itself is deemed impossible (EPPO, 2018). Consequently, it is crucial to employ a combination of strategies aimed at the continuous suppression of populations to mitigate the risk of further infestations.

4. CONCLUSION

Based on the results of this study it can be concluded that uncoloured traps exhibited superior efficacy in capturing *Drosophila suzukii* during the observed period in 2020 and 2021, as compared to their coloured alternatives. This observation was recorded in the blueberry (*Vaccinium myrtillus*) orchard, the compost zone, the variety of fruit tree orchard and the cherry (*Prunus avium*) orchards. The highest number of captures was observed in 2020, with the highest number of insects being captured in variant V1. The lowest number of *D. suzukii* was captured in the uncoloured and coloured variants of the variant V2. The variant V3, was found to be the most effective. This variant V3 was found to be more effective in the blueberry orchard and the compost zone in both types of traps (uncoloured and coloured) during the two-year period from 2020 to 2021. It can be concluded that the placement, trap type and component used to capture *Drosophila suzukii*, as well as the timing, can influence the number of captured insects and the functionality of the traps. A significant circumstance that can also play an important role in influencing captured insects is the environmental condition.

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